MUZAFFARPUR INSTITUTE OF TECHNOLOGY (MIT), MUZAFFARPUR

COURSE FILE

OF

Electrical Instruments and Measurements

Course Code **031x07**

Faculty Name: Dr. R. S. Singh

ASSISTANT PROFESSOR

DEPARTMENT OF ELECTRICAL ENGINEERIN

विज्ञान एवं प्रावैधिकी विभाग
Department of Science and Technology
Government of Bihar

CONTENTS

Govt. of Bihar

MUZAFFARPUR INSTITUTE OF TECHNOLOGY,
MUZAFFARPUR-842003

(Under the Department of Science & Technology Govt. of Bihar, Patna)

VISION STATEMENT OF ELECTRICAL ENGINEERING DEPARTMENT

To produce cutting edge Electrical Engineers, innovators, researchers, and entrepreneurs with high human values to serve society, industry, nation and the world.

MISSION STATEMENT OF ELECTRICAL ENGINEERING DEPARTMENT

M1. To create state-of-the-art facilities for under-graduate, post- graduate and R&D work.

M2. To cater the needs of society with recent technologies, innovative ideas and inculcate ethical responsibilities.

M3. To develop strong collaborative links with premier industries, institutions and the government agencies.

Program Educational Objectives (PEOs) of Electrical Engineering Department:

PEO 1. Students will be able to engage in life-long learning and research including supportive and responsible roles on multi-disciplinary tasks.

PEO 2. Students will acquire, use and develop skills as required for effective professional and societal practices and leadership quality.

PEO 3. Students will be able to create a new dimension of innovation and entrepreneurship.

Program Outcomes (POs) based on Program Educational Objectives (PEOs) of Electrical Engineering Department:

PO 1. Students will be able to apply knowledge of applied mathematics & science in electrical engineering problems.

PO 2. Students will be able to identify, formulate and solve society and industries related problems.

PO 3. Students will be able to apply knowledge to design a system, component or process to meet desired needs within realistic constraints.

PO 4. Students will be able to conduct laboratory experiments and to critically analyze and interpret experimental data.

PO 5. Students will be able to use the recent techniques, skills, and modern tools necessary for engineering practices.

PO 6. Students will be able to understand the impact of engineering problems, solutions in a global and societal context.

PO 7. Students will be able to demonstrate professional and ethical responsibilities.

PO 8. Students will be able to apply leadership quality to work with team in the area of electrical engineering towards the solution of multi-disciplinary tasks.

PO 9. Students will be able to communicate effectively through verbally, technical writing, reports and presentation.

PO 10. Students will be able to develop confidence for self-education and ability to engage in life-long learning.

COURSE DESCRIPTION

This course introduces principle of operation of basic analog and digital measuring instruments for measurement of current, voltage, power, energy etc. Measurement of resistance, inductance and capacitance by using bridge circuits will be discussed in detail. It is expected that student will be thorough with various measuring techniques that are required for an electrical engineer.

COURSE OBJECTIVE

1. To study the principle of operation and working of different types of instruments. Measurement of voltage and current.
2. To study the working principle of operation of different types of instruments for measurement of power and energy.
3. To understand the principle of operation and working of dc and ac potentiometers.
4. To understand the principle of operation and working of various types of bridges for measurement of parameters –resistance, inductance, capacitance and frequency.
5. To study the principle of operation and working of various types of magnetic measuring instruments.

COURSE OUTCOME

Students will be able to:

1. Explain the principle of operation and working of different types of instruments and choose right type of instruments for measurement of current, voltage, power and energy.
2. Use the dc and ac potentiometers in their experimental works and other places also wherever required.
3. Choose right type of bridge for measurement of parameters –resistance, inductance, capacitance and frequency.
4. Use the various types of magnetic measuring instruments appropriately.

CO-PO MAPPING

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO 1	3	2		2	1							
CO 2	3	2	1	3	2							1
CO 3	2	2	1	2	1							
CO 4	2	1	1	2	2							1

B. Tech. VI Semester (ELECTRICAL)
EIM- 306 Electrical Instruments and Measurements

L T P/D Total	Max Marks:	100	
3-1-0 4		Final Exam:	70 Marks
		Sessional:	20 Marks
		Internals:	10 Marks.

Unit 1

Measurements of Voltage, Current, Power and Power factor, Energy and frequency

Unit 2

Range Extension including current and potential transformer

Unit 3

Galvanometer : Dynamics of D' Arsonval galvanometer, Vibration galvanometer , Ballistic galvanometer .

Unit 4

Bridges : D.C bridge, Wheatstone bridge, sensitive and its application bridge .Type of bridge for measure

Unit 5

Standard A.C and D.C potentiometer, Principle and standardization and application

Unit 6

Magnetic measurements : D.C and A.C .Testing of magnetic materials

Unit 7

Digital measurements

Gate Syllabus

1 Bridges and Potentiometers,

2 Measurement of voltage, current, power, energy and power factor

3 Instrument transformers,

4 Digital voltmeters and multimeters,

5 Phase, Time and Frequency measurement;

6 Oscilloscopes,

7 Error analysis.

Student List

S. NO.	Roll No	Name of Students
1.	15E01	PRASOON BALA
2.	15E02	SUMI SINGH
3.	15E03	SURYA SINGH
4.	15E04	BINDIA RANI
5.	15E06	MADHU KUMARI
6.	15E07	VIVEK KUMAR
7.	15E08	KAJAL RAJ
8.	15E09	ANKITA KUMARI SINDURIYA
9.	15E10	NIRAJ KUMAR
10.	15E11	SANDEEP KUMAR SITESH
11.	15E12	NISHANT GUPTA
12.	15E13	PRAKASH KUMAR
13.	15E14	PRADEEP KUMAR
14.	15E15	RAVI RANJAN
15.	15E16	RAVI SHANKAR SAH
16.	15E17	ALOK KUMAR
17.	15E18	RAVI KANT SINGH
18.	15E19	OM PRAKASH CHAUDHARY
19.	15E20	AMAN KUMAR
20.	15E21	MD SARFARAJ AHMAD
21.	15E22	AZIM ANSARI
22.	15E23	NAYAN PRIYA
23.	15E24	JYOTI KUMARI
24.	15E25	SUJEET KUMAR
25.	15E26	ATUL SHAKTI
26.	15E27	RAHUL KUMAR

27.	15E28	ABHISHEK KISHORE
28.	15E29	RUHI KUMARI
29.	15E30	RAJEEV KUMAR CHOUDHARY
30.	15E31	SAURAV KUMAR
31.	15E32	KISHAN KUMAR
32.	15E33	MANISH KUMAR
33.	15E34	AMIT KUMAR
34.	15E35	HAPPY KUMAR
35.	15E36	RAVI RANJAN
36.	15E37	SHASHANK SUDHANSHU
37.	15E38	NEHA GUPTA
38.	15E39	SWETA JAMUAR
39.	15E40	SURUCHI KUMARI
40.	15E41	SOURAV SRIKANT
41.	15E42	TAHA ALAM
42.	15E44	NIKET NIRAJ
43.	15E45	MAYANK KASHYAP
44.	15E46	SATISH KUMAR
45.	15E47	ASHUTOSH SHIVAM
46.	15E48	PAVAN KUMAR
47.	15E49	MEDHA CHAUDHARY
48.	15E50	NAGESHWAR SHARMA
49.	15E51	PRIYANKA SUMAN
50.	15E52	PALLAVI KUMARI
51.	15E54	SHASHI RANJAN
52.	15E55	DEO
53.	15E56	KRISHNA KUMAR
54.	15E57	RAJLAXMI KUMARI
55.	15E59	AJIT KUMAR
56.	15E61	NAYAN Kr NAYAN
57.	15E62	SUDEEP KUMAR
58.	15E63	RAJU KUMAR

59.	15E64	PREM N CHAUDHARY
60.	15E65	PRIYANKA KUMARI
61.	15E66	DEEPAK KUMAR SINGH
62.	16(LE)E01	SHAFAQUE NAZREEN
63.	16(LE)E02	PAVAN KUMAR
64.	16(LE)E03	PRIYANKA KUMARI
65.	16(LE)E04	ROHAN RAJ
66.	16(LE)E06	SHEKHAR KUMAR
67.	16(LE)E07	MD MOIN
68.	16(LE)E09	PINTU KUMAR
69.	16(LE)E10	GAUTAM BHARTI

COURSE HANDOUT

Institute / College Name :	Muzaffarpur Institute of Technology , Bihar		
Program Name	**B.Tech. (ELECTRICAL ENGINEERING)**		
Course Code	EIM - 306		
Course Name	Electrical Measurements and Instruments		
Lecture / Tutorial (per week):	4/1	**Course Credits**	5
Course Coordinator Name	Dr. R. S. Singh		

Scope and Objectives of the Course

This course introduces principle of operation of basic analog and digital measuring instruments for measurement of current, voltage, power, energy etc. Measurement of resistance, inductance and capacitance by using bridge circuits will be discussed in detail. It is expected that student will be thorough with various measuring techniques that are required for an electrical engineer.

Learning Objectives:

1. To study the principle of operation and working of different types of instruments. Measurement of voltage and current.
2. To study the working principle of operation of different types of instruments for measurement of power and energy.
3. To understand the principle of operation and working of dc and ac potentiometers.
4. To understand the principle of operation and working of various types of bridges for measurement of parameters –resistance, inductance, capacitance and frequency.
5. To study the principle of operation and working of various types of magnetic measuring instruments.

6. Textbooks

TB1: Electrical & Electronic Measurement & Instruments by A.K.Sawhney Dhanpat Rai & Co. Publications.

TB2: Electrical and Electronic Measurements and instrumentation by R.K.Rajput, S.Chand

7. Reference Books

RB1: Electrical Measurements and measuring Instruments – by E.W. Golding and F.C.Widdis, fifth Edition, Wheeler Publishing.

RB2: Electrical Measurements: Fundamentals, Concepts, Applications – by Reissland, M.U, New Age International (P) Limited, Publishers.

RB3: Electrical and Electronic Measurements –by G.K.Banerjee, PHI Learning Private Ltd., New Delhi–2012.

Other readings and relevant websites

S.No.	**Link of Journals, Magazines, websites and Research Papers**
1.	http://digital-library.theiet.org/content/journals
2.	http://ieeexplore.ieee.org
3.	https://www.sciencedirect.com
4.	https://journals.indexcopernicus.com

Course Plan

ecture Number	Date of Lecture	Topics	**Web Links for video lectures**	**Text Book / Reference Book / Other reading material**
		Bridges		
1-3		Introduction to bridges, types of Bridges :- AC bridge and DC Bridge, Basic bridge network : its derivation DC Bridge : Wheatstone Bridge-its derivation and introduction to bridge sensitivity	https://www.youtube.com/watch?v=A6cLuHeYiuQ&t=588s	TB1
4-6		Wheatsone bridge sensitivity-its derivation, importance and parameters involved		

		Galvanometer current calculation and numerical practice on wheatstone bridge Kelvin Double bridge		
7-8		Measurement of Voltage : Introduction, PMMC Instruments - construction, torque equation, range		
9-10		Multirange Voltmeter, effect of temperature changes, voltmeter sensitivity, loading effects, advantages and disadvantages		
11-12		Measurement of Current : Introduction, ammeters, ammeter shunts, arrangement for temperature effect correction, multirange ammeter		
13-15		Measurement of Power : Power in DC circuits, Power in AC circuits, electrodynamometer wattmeter - construction, theory, wattmeter errors, Hall effect, Power Factor measurement		TB1
16-17		Measurement of energy and frequency : Energy meters for AC circuits, types of frequency meters		
18-19		Range extension including current and potential transformer : Specifications of CT, connection		

		diagram, symbol, construction		
20-22		Specifications of PT, Connection diagram, symbol, construction, CT and PT ratio for range extension, CT and PT as measuring instruments		
23-27		Galvanometer : Dynamics of D' Arsonval Galvanometer - Construction, torque equation, dynamic behaviour of galvanometer, equation of motion, underdamped,undamped, critically damped and overdamped motion of galvanometer, damping sensitivity Vibration galvanometer, Ballastic galvanometer		
28-30		DC Potentiometer : Introduction, basic circuit, Laboratory type (Crompton's) Potentiometer, Multiple range potentiometer, construction, application of DC		TB1, RB1

		potentiometer		
31-32		AC Potetiometer: Introduction, standardization of AC potentiometer, types AC potentiometer, application of AC potentiometer		TB1
33-34		Magnetic measurements : DC and AC		
35-36		Testing of magnetic materials.		
37-41		Digital measurements : Concept of digital measurement, block diagram Study of digital voltmeter, frequency meter Power Analyzer and Harmonics Analyzer; Electronic Multimeter.		TB1, RB1

1. **Evaluation Scheme:**

Component 1	Mid Semester Exam	20
Component 2	Assignment Evaluation	10
Component 3**	End Term Examination**	70
	Total	**100**

****** The End Term Comprehensive examination will be held at the end of semester. The mandatory requirement of 75% attendance in all theory classes is to be met for being eligible to appear in this component.

SYLLABUS

Topics	No of lectures	Weightage
Measurements of Voltage, Current, Power and Power factor, Energy and frequency	10	24%
Range Extension including current and potential transformer	4	9%
G**alvanometer :**Dynamics of D' Arsonval galvanometer, Vibration galvanometer , Ballistic galvanometer ..	6	14%
Bridges :D.C bridge, Wheatstone bridge, sensitive and its application bridge .Type of bridge for measure	7	17%
StandardA.C and D.C potentiometer, Principle and standardization and application.	5	12%
Magnetic measurements :D.C and A.C .Testing of magnetic materials.	5	12%
Digital measurements.	5	12%

This Document is approved by:

Designation	Name	Signature
Course Coordinator		
H.O.D		
Principal		
Date		

Evaluation and Examination Blue Print:

Internal assessment is done through quiz tests, presentations, assignments and project work. Two sets of question papers are asked from each faculty and out of these two, without the knowledge of faculty, one question paper is chosen for the concerned examination. Evaluation is a very transparent process and the answer sheets of sessional tests, internal assessment assignments are returned back to the students.

The components of evaluations along with their weightage followed by the University is given below.

Mid semester exam	20%
Assignments/Quiz Tests/Seminars	10%
End term examination	70%

Lecture Plan

Topics	**No of lectures**
Measurements of Voltage, Current, Power and Power factor, Energy and frequency	10
Range Extension including current and potential transformer	4
G**alvanometer :**Dynamics of D' Arsonval galvanometer, Vibration galvanometer , Ballistic galvanometer ..	6
Bridges :D.C bridge, Wheatstone bridge, sensitive and its application bridge .Type of bridge for measure	7
Standard A.C and D.C potentiometer, Principle and standardization and application.	5
Magnetic measurements :D.C and A.C .Testing of magnetic materials.	5
Digital measurements.	5

Department of Electrical Engineering

Electrical Instruments and measurements

Assignment 1

1. Draw the circuit of a Wheatstone bridge and derive its condition of balance.

2. Derive the expression for bridge sensitivity for a Wheatstone bridge with equal arms.

3. Derive the expression for current through the galvanometer for a small unbalance.

4. Describe the principle, construction and working of Kelvin Double bridge.

5. Describe the construction and working of PMMC instruments. Derive its torque equation and discuss the method of damping used in it.

6. Discuss the following types of errors in Moving Iron instruments.

i) Hysteresis error

ii) Temperature error

Department of Electrical Engineering

Electrical Instruments and measurements

Assignment 2

1. Explain why Electrodynamometer type instrument can be used on both A.C and D.C?
2. Derive the equation for deflecting torque of power factor meter and draw its phasor diagram.
3. Describe the construction and working of a single phase induction type energy meter.
4. Explain how the following adjustments are made in a single phase induction type energy meter:

   i) Overload Compensation

   ii) Friction Compensation
5. Describe in brief mechanical resonance type frequency meter.
6. Describe a method of reducing errors due to temperature changes in the shunt connected instruments.

Tutorial Sheet 1

1. A PMMC ammeter has the following specification:

   Coil dimension are 1cm× 1cm. Spring constant is 0.15×10^{-6} *N - m / rad*, Flux density is 1.5 ×10- *wb / m* .Determine the no. of turns required to produce a deflection of 90 degree when a current 2mA flows through the coil.

2. The pointer of a moving coil instrument gives full scale deflection of 20mA. The potential

   difference across the meter when carrying 20mA is 400mV.The instrument to be used is 200A

   for full scale deflection. Find the shunt resistance required to achieve this, if the instrument to be used as a voltmeter for full scale reading with 1000V. Find the series resistance to be connected it?

3. A 150 v moving iron voltmeter is intended for 50HZ, has a resistance of 3kΩ. Find the series resistance required to extent the range of instrument to 300v. If the 300V instrument is used to measure a d.c. voltage of 200V. Find the voltage across the meter?

4. A moving coil instrument whose resistance is 25Ω gives a full scale deflection with a current of1mA. This instrument is to be used with a manganin shunt, to extent its range to 100mA

   Calculate the error caused by a 100C rise in temperature when:
   (a) Copper moving coil is connected directly across the manganin shunt.
   (b) A 75 ohm manganin resistance is used in series with the instrument moving coil.
   The temperature co-efficient of copper is 0.004/0C and that of manganin is 0.00015^0/C.

5. The coil of a 600V M.I meter has an inductance of 1 henery. It gives correct reading at 50HZ and requires 100mA. For its full scale deflection, what is % error in the meter when connected to 200V D.C. by comparing with 200V A.C?

6. A 250V M.I. voltmeter has coil resistance of 500Ω, coil inductance 0f 1.04 H and series resistance of 2kΩ. The meter reads correctively at 250V D.C. What will be the value of capacitance to be used for shunting the series resistance to make the meter read correctly at 50HZ? What is the reading of voltmeter on A.C. without capacitance?

7. The inductance of a moving iron ammeter with a full scale deflection of 900 at 1.5A, is given by the expression $L = 200 + 40\theta - 4\theta^2 - \theta^3 \propto H$, where θ is deflection in radian from the zero position. Estimate the angular deflection of the pointer for a current of 1.0A
8. In an electrostatic voltmeter the full scale deflection is obtained when the moving plate turns through 900. The torsional constant is 10x10$^{\square\square}$ $N \square\square m / rad$. The relation between the angle of deflection and capacitance between the fixed and moving plates is given by

Deflection (degree)	0	10	20	30	40	50	60	70	80	90
Capacitance (PF)	81.4	121	156	189.2	220	246	272	294	316	334

   Find the voltage applied to the instrument when the deflection is 90^0?
9. A basic d' Arsonval meter movement with an internal resistance =100& *Rm* and a full scale current of *I mA m* =1 is to be converted in to a multi range d.c. voltmeter with ranges of 0-10V, 0- 50V, 0-250V, 0-500V. Find the values of various resistances using the potential divider arrangement.

University Question Papers

8. Describe the major differences between analog and digital quantities in brief. Discuss analog-to-digital converter.

9. Write notes on any *two* of the following :

(a) Frequency meter

(b) PMMC instrument

(c) Lloyd-Fisher square method

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Code : 031607

B.Tech. 6th Semester Exam., 2014

ELECTRICAL INSTRUMENT AND MEASUREMENT

Time : 3 hours *Full Marks* : 70

Instructions :

(i) ***All*** *questions carry equal marks.*

(ii) There are ***NINE*** *questions in this paper.*

(iii) Attempt ***FIVE*** *questions in all.*

(iv) Question No. ***1*** *is compulsory.*

1. Choose the correct answer (any *seven*) :

(a) Which of the following decides the time response of indicating instrument?

(i) Deflecting system

(ii) Controlling system

(iii) Damping system

(iv) Pivot and jewel bearings

(b) Which of the following meters is an integrating-type instrument?

(i) Ammeter

(ii) Voltmeter

(iii) Wattmeter

(iv) Energy meter

(c) moving-coil galvanometer is made into a d.c. ammeter by connecting

(i) a low resistance across the meter

(ii) a high resistance in series with the meter

(iii) a pure inductance across the meter

(iv) a capacitor in series with the meter

(d) Electrodynamometer type of instruments can be used to measure

(i) a.c. only

(ii) d.c. only

(iii) both a.c. and d.c.

(iv) None of the above

(e) For a given frequency, the deflecting torque of an induction ammeter is directly proportional to

(i) current^2 (ii) current^3

(iii) $\sqrt{\text{current}}$ (iv) current

(f) The secondary of a CT is never left open-circuited because otherwise

(i) heat dissipation in the core will be very large

(ii) the core will be saturated and permanently magnetised rendering it useless

(iii) dangerously high e.m.f.s will be induced in the secondary

(iv) All of the above

(g) In a low p.f. wattmeter, the compensating coil employed is

(i) in series with the current coil

(ii) in series with the pressure coil

(iii) across the current coil

(iv) across the potential coil

(h) If the readings of the two wattmeters are equal and positive in two wattmeter methods, the load p.f. in a balanced 3-phase, 3-wire circuit will be

(i) zero (ii) 0·5

(iii) 0·866 (iv) unity

(i) The voltage coil of a single-phase house energy meter

(i) is highly resistive

(ii) is highly inductive

(iii) is highly capacitive

(iv) has a phase angle equal to a load power factor angle

(j) The stator of a phase shifting transformer for use in conjunction with an a.c. potentiometer is usually a —— winding.

(i) single-phase

(ii) two-phase

(iii) three-phase

(iv) six-phase

2. Explain the principle and working of repulsion-type moving iron instrument. The coil of a moving coil meter has 200 turns, wound on a non-inductive former, its width being 2 cm and height 2·5 cm. It works in a constant field of 0·1 T. The moment of inertia of the moving parts is 3×10^{-7} kg-m^2 and the control spring produces a torque of 100×10^{-7} nm per radian. Calculate the current in the coil to produce a deflection of 120°.

3. Discuss in detail the torque equation involved in dynamometer-type ammeter and voltmeter. A 50 V range spring controlled electrodynamic voltmeter has an initial inductance of 0·25, the full-scale deflection torque of $0 \cdot 4 \times 10^{-4}$ nm and the full-scale deflection current of 50 mA. Determine the difference between d.c. and 50 Hz a.c. readings at 50 V if the voltmeter inductance increases uniformly over the full scale of 90°.

4. Describe with neat circuit diagram operation of polar-type a.c. potentiometer. Calculate the inductance of a coil from the following measurement on an a.c. potentiometer :

Voltage drop across a 0·1 Ω standard resistor connected in series with the coil is $0 \cdot 613 \angle 12°6'$, voltage across the test coil through a 100/1 volt-ratio box is $0 \cdot 781 \angle 50°48'$ V, frequency is 50 Hz

5. Explain with the help of circuit and vector diagrams the Anderson bridge method for measurement of inductance. A four-terminal resistance of approximately 50 μΩ was measured with the help of Kelvin double-bridge under the following conditions :

Resistance of inner ratio arms = 100·31 Ω and 200·0 Ω

Resistance of outer ratio arms = 100·24 Ω and 200·0 Ω

Value of low resistance link = 700 μΩ

Calculate the magnitude of error in the measurement.

6. Explain the principle of working of fluxmeter. Show that for a fluxmeter $N\phi = k(\theta_2 - \theta_1)$, where N is the number of turns of search coil, ϕ is the change in flux, θ_1 and θ_2 are the initial and final readings of the fluxmeter and k is constant. Describe the method for the measurement of *B-H* curve of a magnetic substance of bar form.

7. Discuss the wattmeter errors due to inductance and capacitance of pressure coil of wattmeter. A 1000/5, 50 Hz bar primary-type current transformer has a secondary burden of 1·5 Ω (non-inductive). Calculate the flux in the core and the ratio error at rated condition of the current transformer. Assume iron loss in the core to be 1·5 watt. Neglect leakage flux and magnetizing current.

Code : 031507

B.Tech 5th Semester Exam., 2015

ELECTRICAL INSTRUMENTS AND MEASUREMENTS

Time : 3 hours *Full Marks* : 70

Instructions :

(i) The marks are indicated in the right-hand margin.

*(ii) There are **NINE** questions in this paper.*

*(iii) Attempt **FIVE** questions in all.*

*(iv) Question No. **1** is compulsory.*

1. Answer any *seven* of the following questions : 2×7=14

(a) Define *(i)* true value and *(ii)* accuracy.

(b) What do you understand by measurement?

(c) What is a transfer instrument?

(d) What are different effects used in producing deflecting torque in an analog instrument?

(e) What is volt ratio box?

(f) What is permeameter?

(g) What is digital instrument?

(h) Define unit. Explain the base and supplementary units of SI system.

(i) A moving-coil instrument has a resistance of 10 ohm and gives full-scale deflection when carrying a current of 50 mA. Show how it can be adopted to measure voltage up to 750 V.

(j) What is the reason for using ring-type specimen for ballistic tests?

2. (a) Draw a neat diagram of a permanent-magnet moving-coil instrument and derive the expression for its deflecting torque. 7

(b) A 230-V single-phase energy meter has a constant load of 4 A passing through it for 6 hours at unity power factor. If the disc makes 2280 revolutions during this period, what is the meter constant? Calculate the power factor of the load, when it completes 1472 revolutions, operating at 230 V and 5 A for 4 hours. 7

3. (a) Prove that phase angle error in current transformer is I_m / nI_s. 7

(b) A moving coil instrument gives a full-scale deflection of 24 mA when the potential difference across its terminal is 72 V. Calculate the shunt resistance for a full-scale deflection corresponding to 120 A and the series resistance for full-scale reading with 600 V. 7

4. (a) Explain the construction and working of vibration galvanometer. How is a vibration galvanometer tuned? 7

(b) Derive the expression for steady-state deflection of a vibration galvanometer when a sinusoidal voltage is applied to its coil. Explain the means employed to increase the amplitude of vibration. 7

5. (a) A bridge is balanced at 1000 Hz and has the following constants :

For *AB*—0·2 microfarad pure capacitance
For *BC*—500 ohm pure resistance
For *CD*—unknown
For *DA*—*R* = 300 ohm in parallel with *C* = 0·1 microfarad

Find the *R* and *C* or *L* constants of arm *CD*, considered as a series circuit. 7

(b) How does an AC bridge differ from a DC bridge? Why is it preferable in bridge that the equation of balance be independent of frequency? 7

6. (a) The e.m.f. of a standard cell is measured with a potentiometer which gives a reading of 1·01892 V. When 1 Mohm resister is connected across the standard cell terminals, the potentiometer reading drops to 1·01874 V. Calculate the internal resistance of the cell. 7

(b) Describe the construction and working of a polar-type AC potentiometer. How is it standardized? 7

7. (a) Explain the method of separation of iron losses into their two components. 7

(b) In at test on a specimen of total weight 13 kg, the measured values of iron at a given value of peak flux density were 17·2 W at 40 Hz and 23·9 W at 60 Hz. Estimate the values of hysteresis and eddy-current losses in W/kg at 50 Hz for the some values of peak flux density. 7

8. (a) Draw a basic circuit of a digital frequency meter using various sections. Explain the function of each section. 7

(b) With the help of block diagram, describe the working of ramp-type digital voltmeter. 7

9. Write short notes on any *two* of the following : 7×2=14

(a) Induction-type energy meter

(b) Vibration galvanometer

(c) Duo range potentiometer

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Code : 031607

8. (a) What is digital instrument? Explain briefly the following :
   (i) Binary counters
   (ii) Decimal counting units (DCUs)
   (iii) Display devices

   (b) With the help of a block diagram, describe briefly the working of successive approximation digital voltmeter.

9. Write short notes on any *two* of the following :
   (a) PMMC instrument
   (b) DC bridge
   (c) DC potentiometer

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B.Tech. 6th Semester Exam., 2015

ELECTRICAL INSTRUMENTS AND MEASUREMENTS

Time : 3 hours *Full Marks* : 70

Instructions :

(i) ***All*** *questions carry equal marks.*
(ii) *There are* ***NINE*** *questions in this paper.*
(iii) *Attempt* ***FIVE*** *questions in all.*
(iv) *Question No.* ***1*** *is compulsory.*

1. Fill in the blank/Answer any *seven* of the following :
   (a) What is the purpose of an instrument?
   (b) Explain eddy-current damping.
   (c) What is galvanometer?
   (d) From the point of view of safety, the resistance of earthing electrode, should be low, why?
   (e) What is the function of a digital voltmeter?
   (f) Name the types of wattmeter.
   (g) Name any two methods for measurement of iron loss.

(h) Define the term 'damping ratio'.

(i) In an induction type of meter, the maximum torque is produced when the phase angle between the two fluxes is _____.

(j) What is the application of Megger?

5. (a) Describe the principle of operation, construction, main features and applications of a moving-coil instrument.

(b) A moving-coil milli-ammeter having a resistance of 10 ohm gives full-scale deflection when a current of 5 mA is passed through it. Explain how this instrument can be used for measurement of voltage up to 5 volt.

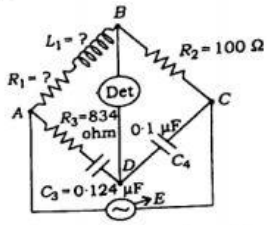
6. Draw the wiring diagrams for current and potential transformers. How can errors be reduced in instrument transformers?

7. Describe the construction and working of a ballistic galvanometer. Explain different constructional details of ballistic galvanometer and d'Arsonval galvanometer.

8. What do you understand by low, medium and high resistances? Describe Kelvin's double-bridge method for measurement of small resistances.

6. (a) Describe how magnetizing and loss components of no-load current of a transformer can be determined by using an AC potentiometer.

(b) The following figure shows an Owen bridge to measure the properties of a sample of sheet at 2 kHz. At balance, arm AB is the test specimen :



Calculate the effective impedance of the specimen under test conditions ($R_2 = 100\ \Omega$; $C_4 = 0 \cdot 1\ \mu F$; $C_3 = 0 \cdot 124\ \mu F$; $R_3 = 834$ ohm).

7. (a) Describe a method for the measurement of B-H curve of a magnetic substance of a bar form.

(b) The iron loss in a sample is 300 watts at 50 Hz with the eddy-current component 5 times as big as the hysteresis loss component. At what frequency will the iron loss be double if the flux density is kept same?

7. (a) Explain the working principle of Schering bridge and derive an expression for measurement of unknown capacitance. Draw the phasor diagram under null condition and explain how dissipation factor of the capacitor can be calculated.

(b) The four arms of a HAY's bridge are arranged as follows: AB is a coil of unknown impedance; BC is 1000 Ω : CD is 833 Ω in series with 0.38 μ F; DA is 16800 Ω. If the supply frequency is 50 Hz, determine L and R in balanced condition. Derive the condition for balance and draw the phasor diagram under balanced conditions. 7+7

8. (a) Discuss the advantages of electronic voltmeters as compared with conventional type voltmeter. Explain the construction and principle of operation of a thermocouple type R.M.S. responding voltmeter.

(b) Explain the working principle of Ballistic galvanometer. Mention how it is calibrated. 7+7

9. (a) Discuss in detail the principle of operation of electronic voltmeter with the help of a circuit diagram.

(b) Name the different types of digital voltmetes. Explain the working principle of "successive approximation type" of DVMs. Discuss its important features. 7+7

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Code : 031507

B.Tech 5th Semester Examination, 2016

Electrical Instruments & Measurements

Time : 3 hours *Full Marks : 70*

Instructions :

(i) There are Nine Questions in this paper.

(ii) Attempt Five questions in all.

(iii) Question No. 1 is compulsory.

(iv) The marks are indicated in the right-hand margin.

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1. Answer any Seven of the following questions: 2×7=14

(a) What will happen if a voltmeter is connected in place of an ammeter?

(b) Write the expression to find the value of shunt resistance for range extension of an ammeter.

(c) What are the sources of error in the wattmeter? How can they be minimized?

(d) What is the difference between wattmeter and energy meter?

(e) How does vibration galvanometer differ from D'Arsonval galvanometer?

(f) What is difference between a slide wire potentiometer and direct potentiometer?

(g) Describe the application of ac potentiometer.

(h) Why magnetic measurements are not as accurate other types of measurement in electrical engineering?

(i) Discuss the advantages of electronic voltmeters.

(j) What is A/D converter?

(k) CRO should always be calibrated before using.

2. (a) Show the constructional features of moving iron (attraction type) instruments. Explain its working principle. Also discuss its important features.

(b) An PMMC instrument has a 0.12 T magnetic flux density in its air gaps. The coil dimensions are D=1.5 cm and 1=2.25 cm. Determine the number of coil turns required to give a torque of 4.5 μN -m when the coil current is 100 μ A. 7+7

3. (a) Explain the principle of operation of an electrodynamics type instrument. What is the type of damping device used in this type of instrument.

(b) A wattmeter has a current coil of 0.1 Ω resistance and pressure coil of 6500 Ω. Calculate the percentage error due to resistance only with each of the methods of connection, when reading the input to an apparatus which takes 12 A at 250 V with 0.4 p.f. 7+7

4. (a) Draw the circuit of a compensated wattmeter, and explain how it eliminates the measurement error.
The inductive reactance of pressure coil circuit of a dynamometer wattmeter is 0.4% of its resistance at normal frequency. Calculate the percentage error and correction factor due to inductive reactance for a load at 0.707 p.f. lagging.

(b) What are the errors in energy meter and how they are compensated in 3-phase energy meters? 7+7

5. (a) Explain the configuration and working of Crompton potentiometer. How it can be used for calibration of ammeters and voltmeters?

(b) With the help of circuit diagram describe the procedure to draw the complete B-H loop of a ring specimen. 7+7

6. (a) Discuss the use of instrument transformer. Explain why the secondary of C.T. should not be open-circuited when primary is connected. Also differentiate between current transformer and potential transformer.

(b) A current transformer with turn-ratio of 1:201 is rated as 1000/5 A, 25 V A. The core loss and magnetising component of primary currents are 3 A and 7 A under rated condition. Find the ratio and phase angle errors for full burden at 0.8 p.f. leading. 7+7

Code : 031507

B.Tech 5th Semester Exam., 2017

ELECTRICAL INSTRUMENTS AND MEASUREMENTS

Time : 3 hours *Full Marks* : 70

Instructions :

(i) The marks are indicated in the right-hand margin.

*(ii) There are **NINE** questions in this paper.*

*(iii) Attempt **FIVE** questions in all.*

*(iv) Question No. **1** is compulsory.*

1. Choose the correct option (any *seven*) : 2×7=14

(a) In a Kelvin's double bridge, two sets of readings are taken when measuring a low resistance, one with the current in one direction and the other with direction of current reversed. This is done to

(i) eliminate the effect of contact resistance

  (Turn Over)

(ii) eliminate the effect of resistance of leads

(iii) correct for changes in battery voltage

(iv) eliminate the effect of thermoelectric e.m.fs

(b) If the damping in a d'Arsonval galvanometer is only due to electromagnetic effects, the resistence required for critical damping is

(i) $\frac{G^2}{\sqrt{kJ}}$

(ii) $\frac{G}{\sqrt{kJ}}$

(iii) $\frac{G}{2\sqrt{kJ}}$

(iv) $\frac{G^2}{2\sqrt{kJ}}$

(c) In ratio-error, k_n stands for

(i) nominal ratio

(ii) actual ratio

(iii) ratio error

(iv) ratio correction factor

  (Continued)

(b) A moving-coil instrument has a resistance of 3 Ω and gives full-scale reading of 25 mA. Calculate *(i)* the shunt resistance for a full-scale deflection corresponding to 125 A and *(ii)* the series resistance for full-scale reading will be 625 V. Also find power consumption in each case. 7

3. Explain the construction and working of a ballistic galvanometer and prove

$$Q = \frac{G}{J} Q e^{-\frac{D}{2J}t} \sqrt{\frac{J}{S}} \sin \sqrt{\frac{S}{J}}\, t$$

14

4. (a) What do you understand by low, medium and high resistance? Explain Wheatstone bridge. 7

(b) A 150 V moving-iron voltmeter has an inductance of 0·75 henry and a total resistance of 2000 ohm. It is calibrated to read correctly on a 50 Hz circuit. What series resistance would be necessary to increase its range to 600 V? 7

5. Explain moving-iron instrument. Explain any one type of moving irons. 14

6. (a) Explain digital multimeter with the help of block diagram. 7

(b) Explain digital voltmeter with the help of block diagram. 7

7. (a) Explain B-H curve with the help of diagram. 7

(b) The coil of a moving-coil voltmeter is 40 mm long and 30 mm wide and has 100 turns on it. The control spring exerts a torque of 240×10^{-6} N-m when the deflection is 100 divisions on full scale. If the flux density of the magnetic field in the air gap is 1·0 Wb/m^2, estimate the resistance that must be put in series with the coil to give one volt per division. The resistance of the voltmeter coil may be neglected. 7

8. Explain wattmeter. Explain any one type of wattmeters. 14

9. Write short notes on the following (any *two*) : 7×2=14

(a) Volt-ratio box

(b) Current transformer

(c) d'Arsonval galvanometer

(d) A/D converters

★ ★ ★

Question Bank

1. Classify instruments based on their functions.
2. **What is the precaution to be followed while using current transformer?**
3. **What is the reason for using MI instruments on both AC and DC?**
4. **What is the need to evaluate phase angle error in instrument transformer?**
5. **Give the advantages of moving iron meters?**
6. **How are the analog instruments classified on the basis of method used for comparing the unknown quantity?**
7. **Give the advantages of moving iron instruments?**
8. **Derive the torque equation of electrodynamometer type instrument.**
9. **Explain the working of attraction type and repulsion type moving iron instruments with neat diagrams.**
10. **Give the construction and principle of operation of single phase induction type energy meter.**
11. **Describe the construction and functioning of mechanical type frequency meter.**
12. **Describe the construction and working of PMMC instrument. Derive the equation for deflection if the instruments is spring controlled.**
13. **With neat figures explain the construction, working principle of a three phase wattmeter. What is the importance of deflecting torque in these analog instruments.**
14. **State the applications of AC potentiometers.**
15. **What are the practical difficulties in AC potentiometer?**
16. **State the advantage of AC potentiometers.**
17. **How the current transformer and potential transformer are connected in a circuit?**
18. Describe with help of suitable diagrams low a DC potentiometer can be used for calibration of voltmeter, ammeter and wattmeter.
19. **Explain voltage sensitive self-balancing bridge, and derive the bridge sensitivity of voltage sensitive bridge with fundamentals.**
20. **Describe the circuit of Kelvin double bridge used for measurement of low resistance. Derive the conditions for balance.**
21. State the principle of digital voltmeter.
22. Give the importance of iron loss measurement.
23. List two instruments for measurement of frequency.
24. Brief the principle of digital phase meter.
25. Write any two advantages and disadvantages of digital voltmeter.
26. Explain the purpose of Schmitt trigger in digital frequency meter.
27. Which torque is absent in energy meter? Why?
28. What are the errors that take place in moving iron instrument?
29. Explain the principle of analog type electrical instruments.

30. How a PMMC meter can be used as voltmeter and ammeter?
31. What is loading effect?
32. State the basic principle of moving iron instrument.
33. Why an ammeter should have a low resistance?
34. Define the sensitivity of a moving coil meter.
35. What are the precautions taken while using a DC voltmeter and DC Ammeter?
36. What is the use of Multimeter? Write its advantages and disadvantages.
37. Voltmeter has high resistance, why it is connected in series?
38. What is an energy meter? Mention some advantages and disadvantages of energy meter.
39. What is meant by creep adjustment in three phase energy meter?

Reference Materials

Textbooks

1. **TB1:** Electrical & Electronic Measurement & Instruments by A.K.Sawhney Dhanpat Rai & Co. Publications.
2. **TB2**: Electrical and Electronic Measurements and instrumentation by R.K.Rajput, S.Chand

Reference Books

1. **RB1:** Electrical Measurements and measuring Instruments – by E.W. Golding and F.C.Widdis, fifth Edition, Wheeler Publishing.
2. **RB2:** Electrical Measurements: Fundamentals, Concepts, Applications – by Reissland, M.U, New Age International (P) Limited, Publishers.
3. **RB3:** Electrical and Electronic Measurements –by G.K.Banerjee, PHI Learning Private Ltd., New Delhi–2012.

Other readings and relevant websites

S.No.	**Link of Journals, Magazines, websites and Research Papers**
1.	http://digital-library.theiet.org/content/journals
2.	http://ieeexplore.ieee.org
3.	https://www.sciencedirect.com
4.	https://journals.indexcopernicus.com