Course Tittle: Sensors & Transducers
Following documents are available in Course File.

S.No.	Points	Yes	No
1	Institute and Department Vision and Mission Statements	✓	
2	PEO & PO Mapping	✓	
3	Academic Calendar	✓	
4	Subject Allocation Sheet	✓	
5	Class Time Table, Individual Timetable (Single Sheet)	✓	
6	Syllabus Copy	✓	
7	Course Handout	✓	
8	CO-PO Mapping	✓	
9	CO-Cognitive Level Mapping		
10	Lecture Notes	✓	
11	Tutorial Sheets With Solution	✓	
12	Soft Copy of Notes/Ppt/Slides	✓	
13	Sessional Question Paper and Scheme of Evaluation	✓	
14	Best, Average and Weak Answer Scripts for Each Sessional Exam. (Photocopies)		
15	Assignment Questions and Solutions	✓	
16	Previous University Question Papers	✓	
17	Result Analysis	✓	
18	Feedback From Students	✓	
19	Course Exit Survey		
20	CO Attainment for All Mids.	✓	
21	Remedial Action.		

Course Instructor / Course Coordinator (Name)

Course Instructor / Course Coordinator (Signature)

VISION AND MISSION

Vision of the Institute

To be among the best of the institutions for engineers and technologists with attitudes, skills and knowledge and to become an epicentre of creative solutions.

Mission of the Institute

To achieve and impart quality education with an emphasis on practical skills and social relevance.

Vision of the Department

To impart technical knowledge and skills required to succeed in life, career and help society to achieve self sufficiency.

Mission of the Department

To become an internationally leading department for higher learning.
To build upon the culture and values of universal science and contemporary education.
To be a center of research and education generating knowledge and technologies which lay groundwork in shaping the future in the fields of electrical and
electronics engineering.
To develop partnership with industrial, R&D and government agencies and actively participate in conferences, technical and community activities.

GokarajuRangaraju Institute of Engineering and Technology
(Autonomous)
Bachupally, Kukatpally, Hyderabad – 500 090, Telangana, India. (040) 6686 4440

PEO'S AND PO'S MAPPINGS

Programme Educational Objectives (PEOs)	Programme Outcomes (POs)											
	1	2	3	4	5	6	7	8	9	10	11	12
1	M	M	-	-	H	-	-	H	H	-	H	H
2	-	-	M	M	H	H	H	-	-	-	-	H
3	-	-	-	-	H	H	M	M	M	M	H	H
4	-	-	-	M	M	H	M	H	H	-	M	H

GOKARAJU RANGARAJU
INSTITUTE OF ENGINEERING AND TECHNOLOGY
Department of Electrical & Electronics Engineering

ACADEMIC CALENDER

ACADEMIC CALENDAR
Academic Year 2018-19

III & IV B.TECH – FIRST SEMESTER

S. No.	EVENT	PERIOD	DURATION
1	1^{st} Spell of Instructions	02-07-2018 to 01-09-2018	9 Weeks
2	1^{st} Mid-term Examinations	03-09-2018 to 05-09-2018	3 Days
3	2^{nd} Spell of Instructions	06-09-2018 to 24-10-2018	7 Weeks
4	2^{nd} Mid-term Examinations	25-10-2018 to 27-10-2018	3 Days
5	Preparation	29-10-2018 to 06-11-2018	1 Week 3 Days
6	**End Semester Examinations (Theory/ Practicals) Regular/Supplementary**	**08-11-2018 to 08-12-2018**	**4 Weeks 3 Days**
7	Commencement of Second Semester, A.Y 2018-19	10-12-2018	

GOKARAJU RANGARAJU
INSTITUTE OF ENGINEERING AND TECHNOLOGY

Department of Electrical & Electronics Engineering

Gokaraju Rangaraju Institute of Engineering and Technology
Department of Electrical and Electronics Engineering
2018-19 I sem Subject allocation sheet

II YEAR(GR17)	Section-A	Section-B
Special Functions and Complex Variable	Dr GS	Dr GS
Electromagnetic Fields	SN	SN
Network Theory	MS	MS
DC Machines and Transformers	Dr BPB	Dr BPB
Computer Organization	PRK	PRK
DC Machines Lab	MP/DSR	PRK/DSR
Electrical Networks Lab	YSV/GBR	YSV/GBR
Electrical Simulation Lab	GSR/PS	GSR/PS
Environmental Science		
III YEAR (GR15)	Section-A	Section-B
Power Transmission System	VVRR/MP	VVRR/MP
Microcontrollers	PK	PK
Power Electronics	Dr TSK	DKK
Electrical Measurements& Instrumentation (PE-1	UVL	UVL
Solar & Wind Energy Systems (OE-1)	PSVD/Dr JP	PSVD/Dr JP
Sensors/Measurements& Instrumentation Lab	PSVD/PS	UVL/PS
Power Electronics Lab	PPK/MRE	SN/MRE
Microcontrollers Lab	RAK/DKK	PK/DKK

GOKARAJU RANGARAJU
INSTITUTE OF ENGINEERING AND TECHNOLOGY

Department of Electrical & Electronics Engineering

IV YEAR(GR15)	Section-A	Section-B
Power Semiconductor Drives	YSV	Dr DGP
Power System Operation & Control	Dr JSD	Dr JSD
High Voltage DC Transmission Systems	MRE	Dr SVJK
Electrical Distribution Systems (PE-3)	VVSM	
High Voltage Engineering (PE-3)	VUR	
Soft Computing Techniques (OE-3)	RAK	RAK
DSP based Electrical Lab	AVK/DKK	AVK/DKK
Power Systems Simulation Lab	VVSM / GSR	VVSM / GSR
Power Electronic Drives Lab	MP/GBR	MP/GBR
I/I BEE(AICTE)	A/B	C/D/E
BEE	ML	
BEE	KS	
BEE	MK	
BEE	MVK	
BEE	MNSR	
Civil II/I (GR15)	A	B
ET	PPK	PPK
M.Tech (PE)(AICTE)	A	
Electric Drives System	Dr DGP	
Power Electronic Converters	Dr TSK	
Power Quality	AVK	
Electric and Hybrid Vehicles	Dr BPB	
Electrical Drives Laboratory	AVK/GBR	
Power Electronics Lab	SN/MS	

M.Tech (PS)(AICTE)	A	
Power System Analysis	Dr JSD	
Power System Dynamics	Dr SVJK	
Power Quality	AVK	
Electric and Hybrid Vehicles	Dr BPB	
Power System Steady State Analysis Lab	VVSM/VVRR	
Power System Dynamics Lab	Dr SVJK/YSV	

HOD,EEE

GOKARAJU RANGARAJU
INSTITUTE OF ENGINEERING AND TECHNOLOGY

Department of Electrical & Electronics Engineering

GRIET/PRIN/06/G/01/18-19 **Wef : 02 July 2018**

BTech - EEE - A **III year - I Semester**

DAY/ HOUR	9:00 - 9:45	9:45 - 10:30	10:30 - 11:15	11:15-12:00	12:00-12:30	12:30 - 1:20	1:20 - 2:10	2:10 - 3:00
MONDAY	PE		SWE		BREAK	MC	PE	PE
TUESDAY	SMI Lab / PE Lab A1 / A2					SWE	PE	PE
WEDNESDAY	PTS		SWE			MC	MC	EMI
THURSDAY	PE Lab / MC Lab A1 / A2					PTS	PTS	EMI
FRIDAY	MC Lab /SMI Lab A1 / A2					EMI	EMI	MC
SATURDAY	MC		PTS			SWE	EMI	EMI

Room No	
Theory	4501
Lab	SMI Lab - 4507 MC Lab - 4505 PE Lab - 4405

Class Incharge:	M Lohita

Subject Code	Subject Name	Faculty Code	Faculty name
GR15A3016	Power Transmission System	VVRR/MP	V Vijaya Rama Raju/M Prashanth
GR15A2055	Microcontrollers	PK	P Prashanth
GR15A3018	Power Electronics	Dr TSK	Dr T Suresh Kumar
GR15A3017	Electrical Measurements and Instrumentation	UVL	U Vijaya Lakshmi
GR15A3152	Solar & Wind Energy Systems	PSVD/Dr JP	P Sri Vidya Devi/Dr J Praveen
GR15A3019	Sensors/Measurements and Instrumentation Lab	PSVD/PS	P Sri Vidya Devi /P Sirisha
GR15A3020	Power Electronics Lab	PPK/MRE	P Praveen Kumar/M Rekha
GR15A2059	Microcontrollers Lab	RAK/DKK	R Anil Kumar/ D Karuna Kumar

Almanac	
1st Spell of Instructions	02-07-2018 to 01-09-2018
1st Mid-term Examinations	03-09-2018 to 05-09-2018
2nd Spell of Instructions	06-09-2018 to 24-10-2018
2nd Mid-term Examinations	25-10-2018 to 27-10-2018
Preparation	29-10-2018 to 06-11-2018
End Semester Examinations (Theory/ Practicals) Regular / Supplementary	08-11-2018 to 08-12-2018
Commencement of Second Semester, A.Y	12/10/2018

GOKARAJU RANGARAJU
INSTITUTE OF ENGINEERING AND TECHNOLOGY

Department of Electrical & Electronics Engineering

Wef : 02 July 2018

Wef

GRIET/PRIN/06/G/01/18-19

BTech - EEE - B | **III year - I Semester**

DAY/ HOUR	9:00 - 9:50	9:50 - 10:40	10:40 - 11:30	11:30 - 12:00	12:00-12:45	12:45-1:30	1:30 - 2:15	2:15 - 3:00
MONDAY	PE	PE	MC	BREAK	SMI Lab / PE Lab B1/ B2			
TUESDAY	PE	PE	MC		MCLab / SMI Lab B1/ B2			
WEDNESDAY	PE	PE	PTS		EMI		SWE	
THURSDAY	PTS	PTS	EMI		SWE		MC	
FRIDAY	PTS	PTS	EMI		MC		SWE	
SATURDAY	PTS	EMI	EMI		PELab / MC Lab B1/ B2			

Room No	
Theory	4404
Lab	SMI Lab - 4507 MC Lab - 4505 PE Lab - 4405

Class Incharge :	M Lohita

Subject Code	Subject Name	Faculty Code	Faculty name	Almanac	
GR15A3016	Power Transmission System	VVRR/MP	V Vijaya Rama Raju/M Prashanth	1st Spell of Instructions	02-07-2018 to 01-09-2018
GR15A2055	Microcontrollers	PK	P Prashanth	1st Mid-term Examinations	03-09-2018 to 05-09-2018
GR15A3018	Power Electronics	DKK	D Karuna Kumar	2nd Spell of Instructions	06-09-2018 to 24-10-2018
GR15A3017	Electrical Measurements and Instrumentation	UVL	U Vijaya Lakshmi	2nd Mid-term Examinations	25-10-2018 to 27-10-2018
GR15A3152	Solar & Wind Energy Systems	PSVD/Dr JP	P Sri Vidya Devi/Dr J Praveen	Preparation	29-10-2018 to 06-11-2018
GR15A3019	Sensors/Measurements and Instrumentation Lab	UVL/PS	U Vijaya Lakshmi/ P Sirisha	End Semester Examinations (Theory/ Practicals) Regular / Supplementary	08-11-2018 to 08-12-2018
GR15A3020	Power Electronics Lab	SN/MRE	Syed Sarfaraz Nawaz/ M Rekha		
GR15A2059	Microcontrollers Lab	PK/DKK	P Prashanth Kumar/ D Karuna Kumar	Commencement of Second Semester, A.Y	12/10/2018

HOD, EEE

III B.Tech (EEE) I Semester

ELECTRICAL MEASUREMENTS AND INSTRUMENTATION

UNIT-I

Fundamentals of Electrical Measurements: Ammeters& Voltmeters PMMC & Moving Iron Instruments C.T.s and PTsRatio and Phase angle errors. Measurement of Power, energy and power factor. Measurement of Active and Reactive power.

UNIT-II

Measurement of Energy and Other Electrical Qualities: Single phase & Three phase energy meters, Crompton's Potentiometer AC potentiometers.

Measurement of resistance, Inductance and Capacitance by bridges.Wheatstone bridge, Carey Foster Bridge, Maxwell's Bridge, De sauty bridge, Schering Bridge.

UNIT-III

CRO and Digital Voltmeters: Cathode Ray Oscilloscope, Time base Horizontal & Vertical Amplifier, Measurement of phase, frequency, Sampling Oscilloscope, Digital storage Oscilloscope.

Digital Voltmeters- Successive Approximation, Ramp, Dual slope Integration, Micro processor based Ramp type DVM, Digital Frequency and phase Anglemeters.

UNIT-IV

Instrumentation Fundamentals: Transducers, Classification, Resistive Inductive and Capacitive type transducers, LVDT, Strain Gauge, gauge factor, Thermistors, Thermo couples, Piezo electric transducers, Photo- voltaic, photo conductive transducers, and photo diodes

UNIT-V

Measurement of non Electrical Quantities: Measurement of Displacement, Velocity, RPM, Acceleration, Flow.

Text Books

1. Electrical & Electronic Measurement & Instruments by A.K.Shawney Dhanpat Rai & Sons Publications.

2. Electrical Measurements and measuring InstrumentsbyE.W.Golding and

F.C.Widdis, FifthEdition, WheelerPublishing.

Reference Books

1. Electrical Measurementsby Buckingham and Price, PrenticeHall

2. D.V.SMurthy, "Transducers and Instrumentation", Prentice Hall of India, 2nd edition,2009.

3. A.S Morris, "Principles of Measurement and Instrumentation", Pearson/Prentice Hall of India, 2nd edition, 1994.

4. H.S.Kalsi, "Electronic Instrumentation", Tata McGraw-Hill Edition, 1995,1st Edition, 1995

GOKARAJU RANGARAJU
INSTITUTE OF ENGINEERING AND TECHNOLOGY

Department of Electrical & Electronics Engineering

CO'S AND PO'S MAPPINGS

Academic **Y**ear : 2018-2019

Semester : I

Name of the Program: B.Tech……..…**Electrical**……..… Year: ……**III**………..Section: A& B

Course/Subject: …**Electrical Measurements & Instrumentation**…Course Code..GR15A3017..

Name of the Faculty: ……**U.Vijaya Laxmi**...........…………………………..Dept.: …**EEE**………

Designation: ASST.PROFESSOR

GR14A3017	**Electrical Measurements and Instrumenation**	1.Have knowledge, to demonstrate the designing and conducting experiments, to analyze and interpret data.	H	H	H	M	-	H	-	M	H	-	H	H
		2.Provides the ability to visualize and work on laboratory and multidisciplinary tasks.	-	H	H	M	-	H	M	M	H	-	H	H
		3.Measurement of R,L,C , Voltage, Current, Power factor , Power, Energy	H	H	H	M	-	H	-	M	H	-	H	H
		4.Measurement of Magnetic Circuits.	-	H	H	M	-	H	-	M	H	H	H	H
		5.Measurement uses PMMC and Moving Iron type Instruments	H	M	-	H	-	M	H	-	M	-	-	M
		6. Measurement of power using LPF and UPF methods.	H	-	H	M	-	M	H	M	M	-	H	M
		7.Ability to balance AC Bridges to find unknown values.	H	H	M	M	-	H	H	H	-	-	H	M

COURSE OBJECTIVES

Academic **Y**ear : 2018-2019

Semester : I

Name of the Program: B.Tech……..…**Electrical**……..… Year: ……**III**……….. Section: A&B

Course/Subject: …**Electrical Measurements & Instrumentation**…Course Code..GR15A3017..

Name of the Faculty: ……**U.Vijaya Laxmi**....................................……….Dept.: …**EEE**………

Designation: ASST.PROFESSOR

The objective of this course is to provide the student:

S.No.	Course Objectives
1.	An idea to monitor, analyze and control any physical system.
2.	A knowledge of construction and working of different types of meters
3.	Skill to design and create novel products and solutions for real life problems.
4.	Introduction to use modern tools necessary for electrical projects.
5.	Techniques of precise measurement of electrical and non electrical quantities.

GOKARAJU RANGARAJU
INSTITUTE OF ENGINEERING AND TECHNOLOGY

Department of Electrical & Electronics Engineering

COURSE OUTCOMES

Academic **Y**ear : 2018-2019

Semester : I

Name of the Program: B.Tech ……..…**Electrical**……..… Year: ……**III**………..Section: A& B

Course/Subject: …**Electrical Measurements & Instrumentation**…Course Code..GR15A3017..

Name of the Faculty: ……**U.Vijaya Laxmi**...................................………..Dept.: …**EEE**………

Designation: ASST.PROFESSOR

The expected outcomes of the Course/Subject are:

S.No	Outcomes
1.	Analyze the techniques and skills for electrical projects.
2.	Design a system, component or process to meet desired needs in electrical engineering,.
3.	Show Measurement of R,L,C ,Voltage, Current, Power factor , Power, Energy
4.	Calculate unknown values in Bridges.
5.	Indicate Frequency, Phase with Oscilloscope.
6.	Know the usage of Digital Voltneters.
7.	Formulate non electrical quantities

Signature of HOD

Date:

Signature of faculty

Date:

Note: Please refer to Bloom's Taxonomy, to know the illustrative verbs that can be used to state the outcomes.

GOKARAJU RANGARAJU
INSTITUTE OF ENGINEERING AND TECHNOLOGY
Department of Electrical & Electronics Engineering

GUIDELINES TO STUDY THE COURSE/SUBJECT

Academic **Y**ear :2018-2019

Semester : I

Name of the Program: B.Tech……..…**Electrical**……..… Year: ……**III**………..Section: A&B

Course/Subject: …**Electrical Measurements & Instrumentation**…Course Code..GR15A3017..

Name of the Faculty: ……**U.Vijaya Laxmi**.......................................……..Dept.: …**EEE**………
Designation: ASST.PROFESSOR.

Guidelines to study the Course/ Subject:Electrical Measurements & Instrumentation
Course Design and Delivery System (CDD):

- The Course syllabus is written into number of learning objectives and outcomes.
- Every student will be given an assessment plan, criteria for assessment, scheme of evaluation and grading method.
- The Learning Process will be carried out through assessments of Knowledge, Skills and Attitude by various methods and the students will be given guidance to refer to the text books, reference books, journals, etc.

The faculty be able to –

- Understand the principles of Learning
- Understand the psychology of students
- Develop instructional objectives for a given topic
- Prepare course, unit and lesson plans
- Understand different methods of teaching and learning
- Use appropriate teaching and learning aids
- Plan and deliver lectures effectively
- Provide feedback to students using various methods of Assessments and tools of Evaluation
- Act as a guide, advisor, counselor, facilitator, motivator and not just as a teacher alone

Signature of HOD — Signature of faculty

Date: — Date:

COURSE SCHEDULE

Academic **Y**ear :2018-2019

Semester : I

Name of the Program: B.Tech……..…**Electrical**……..… Year: ……**III**………..Section: A&B

Course/Subject: …**Electrical Measurements & Instrumentation**…Course Code: ..GR15A3017..

Name of the Faculty: ……**U.Vijaya Laxmi** ……………………..…………..Dept.: …**EEE**………

Designation: ASST.PROFESSOR

The Schedule for the whole Course / Subject is:

S. No.	Description	Total No. Of Periods
1.	Fundamentals of Electrical Measurements	12
2.	Measurement of Energy and Other Electrical Qualities	15
3.	CRO and Digital Voltmeters	19
4.	Instrumentation Fundamentals	17
5.	Measurement of non Electrical Quantities	17

Total No. of Instructional periods available for the course: ..……80……. Hours / Periods

SCHEDULE OF INSTRUCTIONS

COURSE PLAN

Academic **Y**ear : 2018-2019

Semester : I

Name of the Program: B.Tech……..…**Electrical**……..… Year: ……**III**……….. Section: A&B

Course/Subject: …**Electrical Measurements & Instrumentation**…Course Code: ..GR15A3017..

Name of the Faculty: ……**U.Vijaya Laxmi** ……………….……………..Dept.: …**EEE**………

Designation: ASST.PROFESSOR

Unit No.	Lesson No.	No. of Periods	Topics / Sub-Topics	Objectives & Outcomes Nos.	References (Text Book, Journal…) Page Nos.: ____to ____
1	1	2	Types of measuring Instruments, Torques,	Obj;- 1,3 Out;-1,2	A course in Electrical and Electronic Measurements and Instrumentation-A.K.Shawney Page No 292 to296
	2	2	Ammeters & Voltmeters, PMMC, Torque Derivation	Obj;- 1,3 Out;-1,2	A course in Electrical and Electronic Measurements and Instrumentation-A.K.Shawney Page No 292 to296
	3	2	MI types, Torque derivation, MI as Ammeter & Voltmeter	Obj;- 1,3 Out;-1,2	A course in Electrical and Electronic Measurements and Instrumentation-A.K.Shawney Page No 297 to301 & Page No 315 to319
	4	2	Power factor Meters,	Obj;- 1,3 Out;-1,2	A course in Electrical and Electronic Measurements and Instrumentation-A.K.Shawney Page No 495 to 500 & Page No 430 to 433

	5	2	Measurement of Power, Torque Derivation Poly Phase Systems, VAR Meters, CT & PT	Obj;- 1,3 Out;-1,2	A course in Electrical and Electronic Measurements and Instrumentation- A.K.Shawney Page No 451 to 457 & Page No 384 to412
	6	2	Errors, LPF Meters, Measurement of Power using CT & PT Problems	Obj;- 1,3 Out;-1,2	A course in Electrical and Electronic Measurements and Instrumentation- A.K.Shawney Page No 433 to 438& Page No 444 to 448
2.	1	2	DC Bridges & problems	Obj;- 2,4 Out;- 1,4	A course in Electrical and Electronic Measurements and Instrumentation- A.K.Shawney Page No 585 to 590
	2	2	AC Bridges & problems	Obj;- 2,4 Out;- 1,4	A course in Electrical and Electronic Measurements and Instrumentation- A.K.Shawney Page No 516 to 526
	3	2	Measurement of Energymeter, Torque equation, 3-ph	Obj;- 1,3 Out;-1,3	A course in Electrical and Electronic Measurements and Instrumentation- A.K.Shawney Page No463 to 468
	4	3	DC Potentiometers Applications	Obj;- 1,3,4 Out;-1,3	A course in Electrical and Electronic Measurements and Instrumentation- A.K.Shawney Page No 578 to 579
	5	3	AC Potentiometers & Problems	Obj;- 1,3,4 Out;-1,3	A course in Electrical and Electronic Measurements and Instrumentation- A.K.Shawney Page No 578 to 579
	6	3	Applications of AC Potentiometers & Problems	Obj;- 1,3,4 Out;-1,3	A course in Electrical and Electronic Measurements and Instrumentation- A.K.Shawney Page No 578 to 579

3.	1	3	Cathode Ray Oscilloscope, Cathode Ray Tube	Obj;- 1,2,3,4 Out;-1,3,5	A course in Electrical and Electronic Measurements and Instrumentation- A.K.Shawney Page No 784 to 799
	2	3	Measurement of Phase Frequency ,	Obj;- 1,2,3,4 Out;-1,5	A course in Electrical and Electronic Measurements and Instrumentation- A.K.Shawney Page No 810 to 814, Page No 816 to 819 & Page No 825 to827
	3	3	Sampling Oscilloscope, Digital Storage	Obj;- 1,2,3,4 Out;-1,5	A course in Electrical and Electronic Measurements and Instrumentation- A.K.Shawney Page No 810 to 814, Page No 816 to 819 & Page No 825 to827
	4	3	Digital Voltmeters	Obj;- 1,2,3,4 Out;-1,6	A course in Electrical and Electronic Measurements and Instrumentation- A.K.Shawney
	5	3	Digital Voltmeters	Obj;- 1,2,3,4 Out;-1,6	A course in Electrical and Electronic Measurements and Instrumentation- A.K.Shawney
	6	2	Digital Frequency	Obj;- 1,2,3,4 Out;-1,5	A course in Electrical and Electronic Measurements and Instrumentation- A.K.Shawney
	7	2	Phase Angle Meters	Obj;- 1,2,3,4 Out;-1,5	A course in Electrical and Electronic Measurements and Instrumentation- A.K.Shawney
4	1	3	Transducers, Classification, LVDT	Obj;- 1,2,3,4 Out;-1,2,7	A course in Electrical and Electronic Measurements and Instrumentation- A.K.Shawney

					Page No 935 to 942 Page No 1001 to 1006
	2	3	RLC Transducers	Obj;- 1,2,3,4 Out;- 1,2,7	A course in Electrical and Electronic Measurements and Instrumentation-A.K.Shawney Page No 1001 to 1006
	3	3	Strain Gauge, Gauge Factor	Obj;- 1,2,3,4 Out;- 1,2,7	A course in Electrical and Electronic Measurements and Instrumentation-A.K.Shawney Page No 964 to 974
	4	3	Thermistors, Thermocouples, Synchro	Obj;- 1,2,3,4 Out;- 1,2,7	A course in Electrical and Electronic Measurements and Instrumentation-A.K.Shawney Page No 979 to 991 , Page No 573 to 578, Page No 1008 to 1012
	3	3	Photo Voltaic & Piezoelectric Transducers	Obj;- 1,2,3,4 Out;- 1,2,7	A course in Electrical and Electronic Measurements and Instrumentation-A.K.Shawney Page No 1046 to 1054 & Page No 1028 to 1037
	4	2	Photo Conductive & Photo Diodes	Obj;- 1,2,3,4 Out;- 1,2,7	A course in Electrical and Electronic Measurements and Instrumentation-A.K.Shawney Page No 1046 to 1054 & Page No 1028 to 1037
5	1	3	Introduction, Measurement of Displacement	Obj;- 1,2,3,4 Out;- 1,7	A course in Electrical and Electronic Measurements and Instrumentation-A.K.Shawney Page No 1384 to 1403 & Page No 1354 to 1359

	2	3	Measurement of Velocity	Obj;- 1,2,3,4 Out;-1,7	A course in Electrical and Electronic Measurements and Instrumentation- A.K.Shawney Page No 1333 to 1336, Page No 1333 to 1336& Page No 1362 to 1365
	3	3	Measurement of RPM	Obj;- 1,2,3,4 Out;-1,7	A course in Electrical and Electronic Measurements and Instrumentation- A.K.Shawney Page No 1367 to 1372 & Page No 1380 to 1382
	4	3	Measurement of Acceleration	Obj;- 1,2,3,4 Out;-1,7	A course in Electrical and Electronic Measurements and Instrumentation- A.K.Shawney Page No 1367 to 1372 & Page No 1380 to 1382
	5	3	Measurement of Vacuum, Flow	Obj;- 1,2,3,4 Out;-1,7	A course in Electrical and Electronic Measurements and Instrumentation- A.K.Shawney Page No 1360 to 1362 & Page No 1403 to1412
	6	2	Revision		

Signature of HOD Signature of faculty

SCHEDULE OF INSTRUCTIONS
UNIT PLAN

Academic **Y**ear : 2018-2019

Semester : I UNIT NO.: ………**1**…………

Name of the Program: B.Tech……..…**Electrical**……..… Year: ……**III**……….. Section: A&B

Course/Subject: …**Electrical Measurements & Instrumentation**…Course Code: ..GR15A3017..

Name of the Faculty: ……**U.Vijaya Laxmi** ………………………………..Dept.: …**EEE**………
Designation: ASST.PROFESSOR

Lesson No.	No. of Periods	Topics / Sub - Topics	Objectives	Outcomes	References (Text Book, Journal…) Page Nos.: ____to ____
1	2	Types of measuring Instruments, Torques,	Obj;- 1,3	Out;-1,2	A course in Electrical and Electronic Measurements and Instrumentation- A.K.Shawney Page No 292 to296
2	2	Ammeters & Voltmeters, PMMC, Torque Derivation	Obj;- 1,3	Out;-1,2	A course in Electrical and Electronic Measurements and Instrumentation- A.K.Shawney Page No 292 to296
3	2	MI types, Torque derivation, MI as Ammeter & Voltmeter	Obj;- 1,3	Out;-1,2	A course in Electrical and Electronic Measurements and Instrumentation- A.K.Shawney Page No 297 to301 & Page No 315 to319
4	2	Power factor Meters, Measurement of Power, Torque Derivation	Obj;- 1,3	Out;-1,2	A course in Electrical and Electronic Measurements and Instrumentation- A.K.Shawney Page No 495 to 500 & Page No 430 to 433
5	2	Poly Phase Systems, VAR Meters, CT & PT	Obj;- 1,3	Out;-1,2	A course in Electrical and Electronic Measurements and Instrumentation- A.K.Shawney Page No 451 to 457 & Page No 384 to412
6	2	Errors, LPF Meters, Measurement of Reactive Power Problems	Obj;- 1,3	Out;-1,2	A course in Electrical and Electronic Measurements and Instrumentation- A.K.Shawney

					Page No 433 to 438& Page No 444 to 448

Signature of HOD

Signature of faculty

Date:

Date:

Note: 1. ENSURE THAT ALL TOPICS SPECIFIED IN THE COURSE ARE MENTIONED.
2. ADDITIONAL TOPICS COVERED, IF ANY, MAY ALSO BE SPECIFIED IN BOLD
3. MENTION THE CORRESPONDING COURSE OBJECTIVE AND OUT COME NUMBERS AGAINST EACH TOPIC.

GOKARAJU RANGARAJU
INSTITUTE OF ENGINEERING AND TECHNOLOGY

Department of Electrical & Electronics Engineering

SCHEDULE OF INSTRUCTIONS
UNIT PLAN

Academic **Y**ear : 2018-2019

Semester : I UNIT NO.: ………**2**…………

Name of the Program: B.Tech……..…**Electrical**……..… Year: ……**III**……….. Section: A&B

Course/Subject: …**Electrical Measurements & Instrumentation** …Course Code: ..GR15A3017..

Name of the Faculty: ……**U.Vijaya Laxmi** ………………………………..Dept.: …**EEE**………

Designation: ASST.PROFESSOR

Lesson No.	No. of Periods	Topics / Sub - Topics	Objectives	Outcomes	References (Text Book, Journal…) Page Nos.: ____to ____
1	2	DC Bridges	Obj;- 2,4	Out;-1,4	A course in Electrical and Electronic Measurements and Instrumentation- A.K.Shawney Page No 585 to 590
2	2	AC Bridges,	Obj;- 2 ,4	Out;-1,4	A course in Electrical and Electronic Measurements and Instrumentation- A.K.Shawney Page No 516 to 526
3	2	Measurement of Energymeter, Torque Equation, 3-Ph	Obj;- 1,3	Out;-1,3	A course in Electrical and Electronic Measurements and Instrumentation- A.K.Shawney Page No463 to 468
4	3	DC Potentiometers Applications	Obj;- 1,3,4	Out;-1,3	A course in Electrical and Electronic Measurements and Instrumentation- A.K.Shawney Page No 578 to 579
5	3	AC Potentiometers & Problems	Obj;- 1,3,4	Out;-1,3	A course in Electrical and Electronic Measurements and Instrumentation- A.K.Shawney Page No 578 to 579

6	3	Applications of AC Potentiometers & Problems	Obj;- 1,3,4	Out;-1,3	A course in Electrical and Electronic Measurements and Instrumentation-A.K.Shawney Page No 578 to 579

Signature of HOD

Signature of faculty

Date:

Date:

Note: 1. ENSURE THAT ALL TOPICS SPECIFIED IN THE COURSE ARE MENTIONED.
2. ADDITIONAL TOPICS COVERED, IF ANY, MAY ALSO BE SPECIFIED IN BOLD
3. MENTION THE CORRESPONDING COURSE OBJECTIVE AND OUT COME NUMBERS AGAINST EACH TOPIC.

SCHEDULE OF INSTRUCTIONS
UNIT PLAN

Academic Year : 2018-2019

Semester : I UNIT NO.: ………**3**…………

Name of the Program: B.Tech……..…**Electrical**……..… Year: ……**III**……….. Section: A&B

Course/Subject: …**Electrical Measurements & Instrumentation**……Course Code:..GR15A3017..

Name of the Faculty: ……**U.Vijaya Laxmi** ………………………..………..Dept.: …**EEE**………

Designation: ASST.PROFESSOR

Lesson No.	No. of Periods	Topics / Sub - Topics	Objectives	Outcomes	References (Text Book, Journal…) Page Nos.: ____to ____
1	3	Cathode Ray Oscilloscope, Cathode Ray Tube	Obj;- 1,2,3,4	Out;-1,3,5	A course in Electrical and Electronic Measurements and Instrumentation- A.K.Shawney Page No 784 to 799
2	3	Measurement of Phase Frequency	Obj;- 1,2,3,4	Out;-1,5	A course in Electrical and Electronic Measurements and Instrumentation- A.K.Shawney Page No 810 to 814, Page No 816 to 819 & Page No 825 to827
3	3	Sampling Oscilloscope, Digital Storage	Obj;- 1,2,3,4	Out;-1,5	A course in Electrical and Electronic Measurements and Instrumentation- A.K.Shawney Page No 810 to 814, Page No 816 to 819 & Page No 825 to827
4	3	Digital Voltmeters	Obj;- 1,2,3,4	Out;-1,6	A course in Electrical and Electronic Measurements and Instrumentation- A.K.Shawney
5	3	Digital Voltmeters	Obj;- 1,2,3,4	Out;-1,6	A course in Electrical and Electronic Measurements and Instrumentation- A.K.Shawney

6	2	Digital Frequency	Obj;-1,2,3,4	Out;-1,5	A course in Electrical and Electronic Measurements and Instrumentation-A.K.Shawney
7	2	Phase Angle Meters	Obj;-1,2,3,4	Out;-1,5	A course in Electrical and Electronic Measurements and Instrumentation-A.K.Shawney

Signature of HOD   Signature of faculty

Date: Date:

Note: 1. ENSURE THAT ALL TOPICS SPECIFIED IN THE COURSE ARE MENTIONED.
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3. MENTION THE CORRESPONDING COURSE OBJECTIVE AND OUT COME NUMBERS AGAINST EACH TOPIC.

SCHEDULE OF INSTRUCTIONS
UNIT PLAN

Academic Year : 2018-2019

Semester : I UNIT NO.: ………**4**………….

Name of the Program: B.Tech……..…**Electrical**……..… Year: ……**III**……….. Section: A&B

Course/Subject: …**Electrical Measurements & Instrumentation**……Course Code:..GR15A3017..

Name of the Faculty: ……**U.Vijaya Laxmi** ………………………..…………..Dept.: …**EEE**………
Designation: ASST.PROFESSOR

Lesson No.	No. of Periods	Topics / Sub - Topics	Objectives	Outcomes	References (Text Book, Journal…) Page Nos.: ____to ____
1	3	Transducers, Classification, LVDT	Obj;- 1,2,3,4	Out;- 1,2,7	A course in Electrical and Electronic Measurements and Instrumentation- A.K.Shawney Page No 935 to 942 Page No 1001 to 1006
2	3	RLC Transducers	Obj;- 1,2,3,4	Out;- 1,2,7	A course in Electrical and Electronic Measurements and Instrumentation- A.K.Shawney Page No 1001 to 1006
3	3	,Strain Gauge, Gauge Factor	Obj;- 1,2,3,4	Out;- 1,2,7	A course in Electrical and Electronic Measurements and Instrumentation- A.K.Shawney Page No 964 to 974
4	3	Thermistors, Thermocouples, Synchro	Obj;- 1,2,3,4	Out;- 1,2,7	A course in Electrical and Electronic Measurements and Instrumentation- A.K.Shawney Page No 979 to 991 , Page No 573 to 578, Page No 1008 to 1012
5	3	Photo Voltaic Transducers & Piezoelectric Transducers	Obj;- 1,2,3,4	Out;- 1,2,7	A course in Electrical and Electronic Measurements and Instrumentation- A.K.Shawney Page No 1046 to 1054 &Page No 1028 to 1037

6	2	Photo Conductive Transducers & Photo Diodes	Obj;- 1,2,3,4	Out;-1,3	A course in Electrical and Electronic Measurements and Instrumentation- A.K.Shawney Page No 1046 to 1054 & Page No 1028 to 1037

Signature of HOD

Date:

Signature of faculty

Date:

Note:
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2. ADDITIONAL TOPICS COVERED, IF ANY, MAY ALSO BE SPECIFIED IN BOLD
3. MENTION THE CORRESPONDING COURSE OBJECTIVE AND OUT COME NUMBERS AGAINST EACH TOPIC.

SCHEDULE OF INSTRUCTIONS
UNIT PLAN

Academic **Y**ear : 22018-2019

Semester : I UNIT NO.: ………**5**…………

Name of the Program: B.Tech……..…**Electrical**……..… Year: ……**III**……….. Section: A&B

Course/Subject: …**Electrical Measurements & Instrumentation**…………Course Code:..GR15A3017..

Name of the Faculty: ……**U.Vijaya Laxmi** ……………………………………..Dept.: …**EEE**………
Designation: ASST.PROFESSOR

Lesson No.	No. of Periods	Topics / Sub - Topics	Objectives	Outcomes	References (Text Book, Journal…) Page Nos.: ____to ____
1	3	Introduction, Measurement of Displacement	Obj;-1,2,3,4	Out;-1,7	A course in Electrical and Electronic Measurements and Instrumentation-A.K.Shawney Page No 1384 to 1403 & Page No 1354 to 1359
2	3	Measurement of Velocity	Obj;-1,2,3,4	Out;-1,7	A course in Electrical and Electronic Measurements and Instrumentation-A.K.Shawney Page No 1333 to 1336, Page No 1333 to 1336& Page No 1362 to 1365
3	3	Measurement of RPM	Obj;-1,2,3,4	Out;-1,7	A course in Electrical and Electronic Measurements and Instrumentation-A.K.Shawney Page No 1367 to 1372 & Page No 1380 to 1382
4	3	Measurement of Acceleration	Obj;-1,2,3,4	Out;-1,7	A course in Electrical and Electronic Measurements and Instrumentation-A.K.Shawney Page No 1360 to 1362 & Page No 1403 to1412
5	3	Measurement of Flow	Obj;-1,2,3,4	Out;-1,7	A course in Electrical and Electronic Measurements and Instrumentation-A.K.Shawney Page No 1360 to 1362 &Page No 1403 to1412

6	2	Revision			

Signature of HOD Signature of faculty

Date: Date:

Note: 1. ENSURE THAT ALL TOPICS SPECIFIED IN THE COURSE ARE MENTIONED.
2. ADDITIONAL TOPICS COVERED, IF ANY, MAY ALSO BE SPECIFIED IN BOLD
3. MENTION THE CORRESPONDING COURSE OBJECTIVE AND OUT COME NUMBERS AGAINST EACH TOPIC.

LESSON PLAN

Academic **Y**ear : 2018-2019

Semester : I

Name of the Program: B.Tech ………………..**Electrical**…Year: ………**III**..………....Section: A&B

Course/Subject: ……………**Electrical Measurements & Instrumentation**……………..……………..

Name of the Faculty: ……**U.Vijaya Laxmi** ……………………….……………Dept.:…**EEE**…………

Designation : ASST.PROFESSOR

Lesson No: …………………….1&2…………….Duration of Lesson: ……... 90min……………….

Lesson Title: Types of Torques, Ammeters & Voltmeters

INSTRUCTIONAL/LESSON OBJECTIVES:

On completion of this lesson the student shall be able to:

1. Understand types of Measuring Instruments.

2. Know types of Torques.

3. PMMC working & Torque equation.

TEACHING AIDS : OHP PROJECTOR, WHITEBOARD, MARKER, DUSTER.
TEACHING POINTS :

- 5 min.: Taking attendance
- 15 min.: Re collecting the contents of previous class.
- 90 min.: Introduction to Measuring Instruments, Torques & PMMC.
- 10min.: Doubts clarification and Review of the class.

Assignment / Questions: Derive the equation for Deflection of PMMC. (Obj;- 1,2Out;-1,3

Signature of faculty

LESSON PLAN

Academic **Y**ear 2018-2019

Semester : I

Name of the Program: B.Tech ………………..**Electrical**…Year: ………**III**..………....Section: A&B

Course/Subject: ……………**Electrical Measurements & Instrumentation**……………..……………..

Name of the Faculty: ……**U.Vijaya Laxmi** ……………………..…………..Dept.:…**EEE**…………

Designation : ASST.PROFESSOR

Lesson No: ……………….3,4&5…………….Duration of Lesson: …………… 90min……………….

Lesson Title: Brief explanation of MI Instruments

<u>INSTRUCTIONAL/LESSON OBJECTIVES:</u>

On completion of this lesson the student shall be able to:

1. Determine PMMC as Ammeter & Voltmeter.
2. Explain MI Instruments.
3. Difference different between MI & PMMC.

TEACHING AIDS : OHP PROJECTOR, WHITEBOARD, MARKER, DUSTER
TEACHING POINTS :

- 5 min.: Taking attendance
- 15 min.: Re collecting the contents of previous class.
- 90 min.: MI Instruments and its Torque Derivation.
- 10min.: Doubts clarification and Review of the class.

Assignment / Questions: Derive Deflecting Torque Equation of MI Instrument (Obj;- 1,2Out;-1,3)

Signature of faculty

GOKARAJU RANGARAJU
INSTITUTE OF ENGINEERING AND TECHNOLOGY
Department of Electrical & Electronics Engineering

LESSON PLAN

Academic **Y**ear : 2018-2019

Semester : I

Name of the Program: B.Tech ………………..**Electrical**…Year: ………**III**..………....Section: A&B

Course/Subject: ……………**Electrical Measurements & Instrumentation**……………..……………..

Name of the Faculty: ……**U.Vijaya Laxmi** ……………………..……………..Dept.:…**EEE**…………

Designation : ASST.PROFESSOR

Lesson No: …………6&7…………….Duration of Lesson: ……………. 90min……………….

Lesson Title: MI Instrument

INSTRUCTIONAL/LESSON OBJECTIVES:

On completion of this lesson the student shall be able to:

1. Determine advantages of MI meter.
2. Know working of Moving Iron Meter.
3. Derive the Torque derivation of MI Instrument.

TEACHING AIDS : OHP PROJECTOR, WHITEBOARD, MARKER, DUSTER
TEACHING POINTS :

- 5 min.: Taking attendance
- 15 min.: Re collecting the contents of previous class.
- 90 min.: Types of Powerfactor Meters & Electrodynamometer Wattmeter.
- 10min.: Doubts clarification and Review of the class.

Assignment / Questions: Write a short notes on MI meters. (Obj;- 1,2Out;-1,3)

Signature of faculty

GOKARAJU RANGARAJU
INSTITUTE OF ENGINEERING AND TECHNOLOGY

Department of Electrical & Electronics Engineering

LESSON PLAN

Academic **Y**ear : 2018-2019

Semester : I

Name of the Program: B.Tech ………………..**Electrical**…Year: ………**III**..………....Section: A&B

Course/Subject: ……………**Electrical Measurements & Instrumentation**……………..……………..

Name of the Faculty: ……**U.Vijaya Laxmi** ……………………………………..Dept.:…**EEE**…………

Designation : ASST.PROFESSOR

Lesson No: …………………..8&9…………….Duration of Lesson: ……………. 90min……………….

Lesson Title: Types of Powerfactor Meters, Measurement of Power

INSTRUCTIONAL/LESSON OBJECTIVES:

On completion of this lesson the student shall be able to:

2. Determine different types of Power factor Meters.

2. Know working of Electrodynamometer Wattmeter.

3. Derive the Torque derivation of wattmeter.

TEACHING AIDS : OHP PROJECTOR, WHITEBOARD, MARKER, DUSTER
TEACHING POINTS :

- 5 min.: Taking attendance
- 15 min.: Re collecting the contents of previous class.
- 90 min.: Types of Powerfactor Meters & Electrodynamometer Wattmeter.
- 10min.: Doubts clarification and Review of the class.

Assignment / Questions: Write a short notes on Power factor meters. (Obj;- 1,2Out;-1,3)

Signature of faculty

LESSON PLAN

Academic **Y**ear : 2018-2019

Semester : I

Name of the Program: B.Tech ………………..**Electrical**…Year: ………**III**..………...Section: A&B

Course/Subject: ……………**Electrical Measurements & Instrumentation**……………..……………..

Name of the Faculty: ……**U.Vijaya Laxmi** ………………..…………………..Dept.:…**EEE**…………

Designation : ASST.PROFESSOR

Lesson No: ……………….10&11…………….Duration of Lesson: ……….. 90min……………….

Lesson Title: Poly Phase Systems, CT & PT

INSTRUCTIONAL/LESSON OBJECTIVES:

On completion of this lesson the student shall be able to:

1.Implement the Poly Phase Systems.

2. Understand and explain the operation of CT & PT.

3.explain the operation of PT

TEACHING AIDS : OHP PROJECTOR, WHITEBOARD, MARKER, DUSTER
TEACHING POINTS :

- 5 min.: Taking attendance
- 15 min.: Re collecting the contents of previous class.
- 90 min.: General implementations Poly Phase Systems.
- 10min.: Doubts clarification and Review of the class.

Assignment / Questions: Derive the Total Power Consumed by load is equal to Wattmeter reading in Poly Phase Systems. (Obj;- 1,2Out;-1,3)

Signature of faculty

LESSON PLAN

Academic **Y**ear : 2018-2019

Semester : I

Name of the Program: B.Tech ………………..**Electrical**…Year: ………**III**..………...Section: A&B

Course/Subject: ……………**Electrical Measurements & Instrumentation**……………..……………..

Name of the Faculty: ……**U.Vijaya Laxmi** ………………………..…………..Dept.:…**EEE**…………

Designation : ASST.PROFESSOR

Lesson No: …………………….12…………….Duration of Lesson: …………… 90min……………….

Lesson Title:Reactive Power.

<u>INSTRUCTIONAL/LESSON OBJECTIVES:</u>

On completion of this lesson the student shall be able to:

1. Explain the operation of VAR Meters

TEACHING AIDS : OHP PROJECTOR, WHITEBOARD, MARKER, DUSTER
TEACHING POINTS :

- 5 min.: Taking attendance
- 15 min.: Re collecting the contents of previous class.
- 90 min.: Explain VAR meters.
- 10min.: Doubts clarification and Review of the class.

Assignment / Questions:Write about the VAR Meters(Obj;- 1,2Out;-1,3)

Signature of faculty

LESSON PLAN

Academic **Y**ear : 2018-2019

Semester : I

Name of the Program: B.Tech ………………..**Electrical**…Year: ………**III**..………....Section: A&B

Course/Subject: ……………**Electrical Measurements & Instrumentation**……………..……………..

Name of the Faculty: ……**U.Vijaya Laxmi** ……………………..……………..Dept.:…**EEE**…………

Designation : ASST.PROFESSOR

Lesson No: …………….13&14…………….Duration of Lesson: …………… 90min……………….

Lesson Title: DC Bridges.

INSTRUCTIONAL/LESSON OBJECTIVES:

On completion of this lesson the student shall be able to:

1. Identify different Bridges.

2. Discuss Bridges work.

3. Determine the working Carey Foster Bridge

TEACHING AIDS : OHP PROJECTOR, WHITEBOARD, MARKER, DUSTER
TEACHING POINTS :

- 5 min.: Taking attendance
- 15 min.: Re collecting the contents of previous class.
- 90 min.: Explain the working of DC Bridges.
- 10min.: Doubts clarification and Review of the class.

Assignment / Questions: Explain about Wheat stone Bridge.. (Obj;- 2,4Out;-1,4)

Signature of faculty

LESSON PLAN

Academic **Y**ear : 2018-2019

Semester : I

Name of the Program: B.Tech ………………..**Electrical**…Year: ………**III**..………....Section: A&B

Course/Subject: ……………**Electrical Measurements & Instrumentation**……………..……………..

Name of the Faculty: ……**U.Vijaya Laxmi** ……….……………..…………….Dept.:…**EEE**…………

Designation : ASST.PROFESSOR

Lesson No: ………….15,16 &17 …………….Duration of Lesson: …………… 90min ……………….

Lesson Title: AC Bridges.

INSTRUCTIONAL/LESSON OBJECTIVES:

On completion of this lesson the student shall be able to:

1. Identify different Bridges.

2. Discuss Bridges work.

3. Determine the working Desauty Bridge

TEACHING AIDS : OHP PROJECTOR, WHITEBOARD, MARKER, DUSTER
TEACHING POINTS :

- 5 min.: Taking attendance
- 15 min.: Re collecting the contents of previous class.
- 90 min.: Explain the working of AC Bridges.
- 10min.: Doubts clarification and Review of the class.

Assignment / Questions: Explain about Maxwell Inductance Bridge. (Obj;- 2,4Out;-1,4)

Signature of faculty

GOKARAJU RANGARAJU
INSTITUTE OF ENGINEERING AND TECHNOLOGY

Department of Electrical & Electronics Engineering

LESSON PLAN

Academic **Y**ear : 2018-2019

Semester : I

Name of the Program: B.Tech ………………..**Electrical**…Year: ………**III**..………....Section: A&B

Course/Subject: ……………**Electrical Measurements & Instrumentation**……………..……………..

Name of the Faculty: ……**U.Vijaya Laxmi** …………….……….…………..Dept.:…**EEE**…………

Designation : ASST.PROFESSOR

Lesson No: …………….18,19& 20…………….Duration of Lesson: …………… 90min ………………

Lesson Title: Induction type Energymeter

INSTRUCTIONAL/LESSON OBJECTIVES:

On completion of this lesson the student shall be able to:

1. Identify and explain Errors in Energymeter

2. Explain the operation of Energymeter

3. Derive Torque equation for Energymeter

TEACHING AIDS : OHP PROJECTOR, WHITEBOARD, MARKER, DUSTER
TEACHING POINTS :

- 5 min.: Taking attendance
- 15 min.: Re collecting the contents of previous class.
- 90 min.: Explain Induction type Energymeter
- 10min.: Doubts clarification and Review of the class.

Assignment / Questions:Write about the errors in Energymeter(Obj;- 1,3Out;-1,3)

Signature of faculty

LESSON PLAN

Academic **Y**ear : 2018-2019

Semester : I

Name of the Program: B.Tech ………………..**Electrical**…Year: ………**III**..………....Section: A&B

Course/Subject: ……………**Electrical Measurements & Instrumentation**……………..……………..

Name of the Faculty: ……**U.Vijaya Laxmi** …..…………………….…………..Dept.:…**EEE**…………

Designation : ASST.PROFESSOR

Lesson No: ……………….21,22 &23…………Duration of Lesson: ………… 135min ……………….

Lesson Title: DC Potentiometers

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INSTRUCTIONAL/LESSON OBJECTIVES:

On completion of this lesson the student shall be able to:

1. Explain Applications of DC Potentiometers.

2. Write a short notes on DC Potentiometers.

TEACHING AIDS :OHP PROJECTOR, WHITEBOARD, MARKER, DUSTER
TEACHING POINTS :

- 5 min.: Taking attendance
- 15 min.: Re collecting the contents of previous class.
- 90 min.: AC Potentiometers.
- 10min.: Doubts clarification and Review of the class.

Assignment / Questions:Explian about DC Potentiometers (Obj;- 1,3,4 Out;-1,3)

Signature of faculty

LESSON PLAN

Academic **Y**ear : 2018-2019

Semester : I

Name of the Program: B.Tech ………………..**Electrical**…Year: ………**III**..………...Section: A&B

Course/Subject: ……………**Electrical Measurements & Instrumentation**……………..……………..

Name of the Faculty: ……**U.Vijaya Laxmi …**………………..………………..Dept.:…**EEE**…………

Designation : ASST.PROFESSOR

Lesson No: ………………24,25 &26 ……….Duration of Lesson: …………… 135min……………….

Lesson Title: AC Potentiometers applications
.

INSTRUCTIONAL/LESSON OBJECTIVES:

On completion of this lesson the student shall be able to:

1. Explain the working of Polar type AC Potentiometers.

2. Explain the working of Coordinate type AC Potentiometers.

TEACHING AIDS : OHP PROJECTOR, WHITEBOARD, MARKER, DUSTER
TEACHING POINTS :

- 5 min.: Taking attendance
- 15 min.: Re collecting the contents of previous class.
- 90 min.: Classification, Working & Applications of AC Potentiometers.
- 10min.: Doubts clarification and Review of the class.

Assignment / Questions: Explain indetail about applications of AC Potentiometers.(Obj;- 1,3,4Out;-1,3)

Signature of faculty

LESSON PLAN

Academic **Y**ear : 2018-2019

Semester : I

Name of the Program: B.Tech ………………..**Electrical**…Year: ………**III**..………....Section: A&B

Course/Subject: ……………**Electrical Measurements & Instrumentation**……………..……………..

Name of the Faculty: ……**U.Vijaya Laxmi …**………………..………………..Dept.:…**EEE**…………

Designation : ASST.PROFESSOR

Lesson No: ………………27……….. ……….Duration of Lesson: …………… 90min……………….

Lesson Title: AC Potentiometers applications
.

INSTRUCTIONAL/LESSON OBJECTIVES:

On completion of this lesson the student shall be able to:

1. Determine the applications of AC Potentiometers.

TEACHING AIDS : OHP PROJECTOR, WHITEBOARD, MARKER, DUSTER
TEACHING POINTS :

- 5 min.: Taking attendance
- 15 min.: Re collecting the contents of previous class.
- 90 min.: Classification, Working & Applications of AC Potentiometers.
- 10min.: Doubts clarification and Review of the class.

Assignment / Questions: Explain indetail about applications of AC Potentiometers.(Obj;- 1,3,4Out;-1,3)

Signature of faculty

GOKARAJU RANGARAJU
INSTITUTE OF ENGINEERING AND TECHNOLOGY

Department of Electrical & Electronics Engineering

LESSON PLAN

Academic **Y**ear : 2018-2019

Semester : I

Name of the Program: B.Tech ………………..**Electrical**…Year: ………**III**..………....Section: A&B

Course/Subject: ……………**Electrical Measurements & Instrumentation**……………..……………..

Name of the Faculty: ……**U.Vijaya Laxmi** …………………………………….Dept.:…**EEE**…………

Designation : ASST.PROFESSOR/

Lesson No: ……………….28&29…………….Duration of Lesson: …………… 135min……………….

Lesson Title: CRO & CRT

.

INSTRUCTIONAL/LESSON OBJECTIVES:

On completion of this lesson the student shall be able to:

1. Explain the working operation of CRO.

2. Explain the significance of CRT.

3. Determine the difference between CRO & CRT.

TEACHING AIDS : LCD PROJECTOR, WHITEBOARD, MARKER, DUSTER

TEACHING POINTS :

- 5 min.: Taking attendance
- 15 min.: Re collecting the contents of previous class.
- 90 min.: Explain the operation CRO & CRT.
- 10min.: Doubts clarification and Review of the class.

Assignment / Questions: Explain the operation of CRO(Obj;- 1,2,3,4Out;-1,3,5)

Signature of faculty

LESSON PLAN

Academic **Y**ear : 2018-2019

Semester : I

Name of the Program: B.Tech ………………..**Electrical**…Year: ………**III**..………....Section: A&B

Course/Subject: ……………**Electrical Measurements & Instrumentation**……………..……………..

Name of the Faculty: ……**U.Vijaya Laxmi** …………………..…..……………Dept.:…**EEE**…………

Designation : ASST.PROFESSOR

Lesson No: …………….30 & 31…………….Duration of Lesson: …………… 135min……………….

Lesson Title: Measurement of Phase& Frequency,

<u>INSTRUCTIONAL/LESSON OBJECTIVES:</u>

On completion of this lesson the student shall be able to:

1. Explain the Measurement of Phase .

3. Describe in brief about Measurement of frequency.

TEACHING AIDS : LCD PROJECTOR, WHITEBOARD, MARKER, DUSTER
TEACHING POINTS :

- 5 min.: Taking attendance
- 15 min.: Re collecting the contents of previous class.
- 90 min.: Explain the Measurement of Phase & Frequency
- 10min.: Doubts clarification and Review of the class.

Assignment / Questions: Explain Phase & Frequency(Obj;- 1,2,3,4Out;-1,5)

Signature of faculty

GOKARAJU RANGARAJU
INSTITUTE OF ENGINEERING AND TECHNOLOGY

Department of Electrical & Electronics Engineering

LESSON PLAN

Academic **Y**ear : 2018-2019

Semester : I

Name of the Program: B.Tech ………………..**Electrical**…Year: ………**III**..………...Section: A&B

Course/Subject: ……………**Electrical Measurements & Instrumentation**……………..……………..

Name of the Faculty: ……**U.Vijaya Laxmi** …………..…………….…………..Dept.:…**EEE**…………

Designation : ASST.PROFESSOR

Lesson No: ………………32& 33…………….Duration of Lesson: …………… 135min……………….

Lesson Title: Measurement of Phase Fequency, Sampling Oscilloscope & Digital Storage.
.

INSTRUCTIONAL/LESSON OBJECTIVES:

On completion of this lesson the student shall be able to:

1. Describe and analyze the operation Sampling Oscilloscope.

2. Describe in brief about Digital Storage.

TEACHING AIDS : LCD PROJECTOR, WHITEBOARD, MARKER, DUSTER
TEACHING POINTS :

- 5 min.: Taking attendance
- 15 min.: Re collecting the contents of previous class.
- 90 min.: Explain the working operation of Sampling Oscilloscope and Digital Storage.
- 10min.: Doubts clarification and Review of the class.

Assignment / Questions: Explain Sampling Oscilloscope (Obj;- 1,2,3,4Out;-1,5)

Signature of faculty

LESSON PLAN

Academic **Y**ear : 2018-2019

Semester : I

Name of the Program: B.Tech ………………..**Electrical**…Year: ………**III**..………....Section: A&B

Course/Subject: ……………**Electrical Measurements & Instrumentation**……………..……………..

Name of the Faculty: ……**U.Vijaya Laxmi** ……………………..…………..Dept.:…**EEE**…………

Designation : ASST.PROFESSOR

Lesson No: ………34,35,36 & 37…………….Duration of Lesson: …………… 135min……………….

Lesson Title: Digital Voltmetes.

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INSTRUCTIONAL/LESSON OBJECTIVES:

On completion of this lesson the student shall be able to:

1. Derive the relationship for deflection sensitivity of a CRT.

2. What is RAMP type DVM.

3. Discuss the operation of DVM.

TEACHING AIDS : LCD PROJECTOR, WHITEBOARD, MARKER, DUSTER

TEACHING POINTS :

- 5 min.: Taking attendance
- 15 min.: Re collecting the contents of previous class.
- 60 min.: Explain the working operation of DVM
- 10min.: Doubts clarification and Review of the class.

Assignment / QuestionsClassify DVMs. (Obj;- 1,2,3,4Out;-1,6)

Signature of faculty

LESSON PLAN

Academic **Y**ear : 2018-2019

Semester : I

Name of the Program: B.Tech ………………..**Electrical**…Year: ………**III**..………....Section: A&B

Course/Subject: ……………**Electrical Measurements & Instrumentation**……………..……………..

Name of the Faculty: ……**U.Vijaya Laxmi** ……………………………..……..Dept.:…**EEE**…………

Designation : ASST.PROFESSOR

Lesson No: ……….38,39,40 & 41……………Duration of Lesson: …………… 135min……………….

Lesson Title: Digital Voltmetes.

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INSTRUCTIONAL/LESSON OBJECTIVES:

On completion of this lesson the student shall be able to:

1.Explain about advantages of DVM

2. What Stair Case DVM

3. Discuss the operation of Dual Slope DVM.

TEACHING AIDS : LCD PROJECTOR, WHITEBOARD, MARKER, DUSTER
TEACHING POINTS :

- 5 min.: Taking attendance
- 15 min.: Re collecting the contents of previous class.
- 60 min.: Explain the working operation of DVM
- 10min.: Doubts clarification and Review of the class.

Assignment / QuestionsDisadvantages of DVMs. (Obj;- 1,2,3,4Out;-1,6)

Signature of faculty

GOKARAJU RANGARAJU
INSTITUTE OF ENGINEERING AND TECHNOLOGY

Department of Electrical & Electronics Engineering

LESSON PLAN

Academic **Y**ear : 2018-2019

Semester : I

Name of the Program: B.Tech ………………..**Electrical**…Year: ………**III**..……….....Section: A&B

Course/Subject: ……………**Electrical Measurements & Instrumentation**……………..……………..

Name of the Faculty: ……**U.Vijaya Laxmi** ……………………………..……….Dept.:…**EEE**…………

Designation : ASST.PROFESSOR

Lesson No: …………….42,43 & 44……………Duration of Lesson: …………… 90min……………….

Lesson Title: Digital Frequency & Phase Angle Meters

INSTRUCTIONAL/LESSON OBJECTIVES:

On completion of this lesson the student shall be able to:

1. Explain how a Digital Frequency works.

TEACHING AIDS : LCD PROJECTOR, WHITEBOARD, MARKER, DUSTER
TEACHING POINTS :

- 5 min.: Taking attendance
- 15 min.: Re collecting the contents of previous class.
- 60 min.: Explain about Digital Frequency & Phase Angle Meters.
- 10min.: Doubts clarification and Review of the class.

Assignment / Questions:. Explain the construction, principle of working of Digital Frequency Meter.(Obj;-1,2,3,4Out;-1,5)

Signature of faculty

GOKARAJU RANGARAJU
INSTITUTE OF ENGINEERING AND TECHNOLOGY

Department of Electrical & Electronics Engineering

LESSON PLAN

Academic **Y**ear : 2018-2019

Semester : I

Name of the Program: B.Tech ………………..**Electrical**…Year: ………**III**..………....Section: A&B

Course/Subject: ……………**Electrical Measurements & Instrumentation**……………..……………..

Name of the Faculty: ……**U.Vijaya Laxmi** ………………………….……….Dept.:…**EEE**…………

Designation : ASST.PROFESSOR

Lesson No: ……………….45 & 46…………Duration of Lesson: …………… 90min……………….

Lesson Title: Digital Frequency & Phase Angle Meters

INSTRUCTIONAL/LESSON OBJECTIVES:

On completion of this lesson the student shall be able to:

1.Explain in detail about Phase Angle Meters

TEACHING AIDS : LCD PROJECTOR, WHITEBOARD, MARKER, DUSTER
TEACHING POINTS :

- 5 min.: Taking attendance
- 15 min.: Re collecting the contents of previous class.
- 60 min.: Explain about Digital Frequency & Phase Angle Meters.
- 10min.: Doubts clarification and Review of the class.

Assignment / Questions:. Explain the construction, principle of working of Phase Angle Meter.(Obj;-1,2,3,4Out;-1,5)

Signature of faculty

LESSON PLAN

Academic **Y**ear : 2018-2019

Semester : I

Name of the Program: B.Tech ………………..**Electrical**…Year: ………**III**..………....Section: A&B

Course/Subject: ……………**Electrical Measurements & Instrumentation**……………..……………..

Name of the Faculty: ……**U.Vijaya Laxmi** ……………………………..……..Dept.:…**EEE**…………

Designation : ASST.PROFESSOR

Lesson No: …………….47,48 & 49…………….Duration of Lesson: ………… 135min……………….

Lesson Title: Transducers.

INSTRUCTIONAL/LESSON OBJECTIVES:

On completion of this lesson the student shall be able to:

1. Classification of Transducers.

2. LVDT operation.

3. Explain in detail about Strain Gauge.

TEACHING AIDS : LCD PROJECTOR, WHITEBOARD, MARKER, DUSTER
TEACHING POINTS :

- 5 min.: Taking attendance
- 15 min.: Re collecting the contents of previous class.
- 60 min.: Explain about different types of Transducers.
- 10min.: Doubts clarification and Review of the class.

Assignment / Questions:. Explain the construction, principle of working of Transducers.(Obj;- 1,2,3,4Out;- 1,2,7)

Signature of faculty

LESSON PLAN

Academic **Y**ear : 2018-2019

Semester : I

Name of the Program: B.Tech ………………..**Electrical**…Year: ………**III**..………....Section: A&B

Course/Subject: ……………**Electrical Measurements & Instrumentation**……………..……………..

Name of the Faculty: ……**U.Vijaya Laxmi** ……………………………………Dept.:…**EEE**…………

Designation : ASST.PROFESSOR

Lesson No: …………50,51 & 52…………….Duration of Lesson: …………… 135min……………….

Lesson Title: RLC Transducers

INSTRUCTIONAL/LESSON OBJECTIVES:

On completion of this lesson the student shall be able to:

1. Explain about working of R Transducers.

2. Explain about working of L Transducers.

3. Discuss about CTransducers.

TEACHING AIDS : LCD PROJECTOR, WHITEBOARD, MARKER, DUSTER
TEACHING POINTS :

- 5 min.: Taking attendance
- 15 min.: Re collecting the contents of previous class.
- 60 min.: Explain the working operation of C Transducers.
- 10min.: Doubts clarification and Review of the class.

Assignment / Questions: Explain the operation of L Transducers (Obj;- 1,2,3,4Out;-1,2,7)

Signature of faculty

LESSON PLAN

Academic **Y**ear : 2018-2019

Semester : I

Name of the Program: B.Tech ………………..**Electrical**…Year: ………**III**..………....Section: A&B

Course/Subject: ……………**Electrical Measurements & Instrumentation**……………..……………..

Name of the Faculty: ……**U.Vijaya Laxmi** ……………………..……………..Dept.:…**EEE**…………

Designation : ASST.PROFESSOR

Lesson No: ………….53,54,55 & 56…………….Duration of Lesson: ………… 135min……………….

Lesson Title:Strain Gauge, Gauge Factor

INSTRUCTIONAL/LESSON OBJECTIVES:

On completion of this lesson the student shall be able to:

1. Explain about Strain Gauge

2. Derive Guage Factor.

3. Discuss about advantages of Strain Guage.

TEACHING AIDS : LCD PROJECTOR, WHITEBOARD, MARKER, DUSTER
TEACHING POINTS :

- 5 min.: Taking attendance
- 15 min.: Re collecting the contents of previous class.
- 60 min.: Explain the working operation of Strain Guage.
- 10min.: Doubts clarification and Review of the class.

Assignment / Questions: Explain the operation of Strain Guage(Obj;- 1,2,3,4Out;-1,2,7)

Signature of faculty

GOKARAJU RANGARAJU
INSTITUTE OF ENGINEERING AND TECHNOLOGY

Department of Electrical & Electronics Engineering

LESSON PLAN

Academic **Y**ear : 2018-2019

Semester : I

Name of the Program: B.Tech ………………..**Electrical**…Year: ………**III**..………....Section: A&B

Course/Subject: ……………**Electrical Measurements & Instrumentation**……………..……………..

Name of the Faculty: ……**U.Vijaya Laxmi** …………………………………..Dept.:…**EEE**…………

Designation : ASST.PROFESSOR

Lesson No: …………….57,58 &59…………….Duration of Lesson: …………… 135min……………….

Lesson Title: Thermistors & Thermocouples

INSTRUCTIONAL/LESSON OBJECTIVES:

On completion of this lesson the student shall be able to:

1. Explain about working of Thermistors.

2. Explain about working of Thermocouples.

3. Discuss about Piezoelectric Transducers.

TEACHING AIDS : LCD PROJECTOR, WHITEBOARD, MARKER, DUSTER
TEACHING POINTS :

- 5 min.: Taking attendance
- 15 min.: Re collecting the contents of previous class.
- 60 min.: Explain the working operation of Thermistors & Thermocouples.
- 10min.: Doubts clarification and Review of the class.

Assignment / Questions: Explain the operation of Thermocouple. (Obj;- 1,2,3,4Out;-1,2,7)

Signature of faculty

LESSON PLAN

Academic **Y**ear : 2018-2019

Semester : I

Name of the Program: B.Tech ………………..**Electrical**…Year: ………**III**..………....Section: A&B

Course/Subject: ……………**Electrical Measurements & Instrumentation**……………..……………..

Name of the Faculty: ……**U.Vijaya Laxmi** …………………………..………..Dept.:…**EEE**…………

Designation : ASST.PROFESSOR

Lesson No: ……………….60 &61…………….Duration of Lesson: …………… 135min………………

Lesson Title: Photo Electric Transducers & Photo Diodes

INSTRUCTIONAL/LESSON OBJECTIVES:

On completion of this lesson the student shall be able to:

1. Explain indetail about a Photo Electric Transducers.

2. Explain the operation of Photo Diode.

TEACHING AIDS : LCD PROJECTOR, WHITEBOARD, MARKER, DUSTER
TEACHING POINTS :

- 5 min.: Taking attendance
- 15 min.: Re collecting the contents of previous class.
- 60 min.: Explain the working operation of Photo Electric Transducers.
- 10min.: Doubts clarification and Review of the class.

Assignment / Questions:Explain the principle of working of PhotoElectric Transducers(Obj;- 1,2,3,4Out;- 1,2,7)

Signature of faculty

GOKARAJU RANGARAJU
INSTITUTE OF ENGINEERING AND TECHNOLOGY

Department of Electrical & Electronics Engineering

LESSON PLAN

Academic **Y**ear : 2018-2019

Semester : I

Name of the Program: B.Tech ………………..**Electrical**…Year: ………**III**..………....Section: A&B

Course/Subject: ……………**Electrical Measurements & Instrumentation**……………..……………..

Name of the Faculty: ……**U.Vijaya Laxmi** …………………………………….Dept.:…**EEE**…………

Designation : ASST.PROFESSOR

Lesson No: …………………62 &63…………….Duration of Lesson: …………… 90min……………….

Lesson Title: Photo Conductive Transducers & Photo Diodes

INSTRUCTIONAL/LESSON OBJECTIVES:

On completion of this lesson the student shall be able to:

1. Explain indetail about a Photo Conductive Transducers.

2. Explain the operation of Photo Diode.

3. Differentiate Photo Diodes & Conductive Transducers.

TEACHING AIDS : LCD PROJECTOR, WHITEBOARD, MARKER, DUSTER
TEACHING POINTS :

- 5 min.: Taking attendance
- 15 min.: Re collecting the contents of previous class.
- 60 min.: Explain the working operation of Photo Conductive Diode.
- 10min.: Doubts clarification and Review of the class.

Assignment / Questions:Explain the principle of working of photo Diode (Obj;- 1,2,3,4Out;-1,2,7)

Signature of faculty

LESSON PLAN

Academic **Y**ear : 2018-2019

Semester : I

Name of the Program: B.Tech ………………..**Electrical**…Year: ………**III**..………....Section: A&B

Course/Subject: ……………**Electrical Measurements & Instrumentation**……………..……………..

Name of the Faculty: ……**U.Vijaya Laxmi** …………………………………….Dept.:…**EEE**…………

Designation : ASST.PROFESSOR

Lesson No: ……………64,65 & 66…………….Duration of Lesson: …………… 135min……………….

Lesson Title: Measurement of Displacement.

INSTRUCTIONAL/LESSON OBJECTIVES:

On completion of this lesson the student shall be able to:

1. Discuss about measurement of Displacement.

TEACHING AIDS : LCD PROJECTOR, WHITEBOARD, MARKER, DUSTER
TEACHING POINTS :

- 5 min.: Taking attendance
- 15 min.: Re collecting the contents of previous class.
- 90 min.: Explain Measurement of Displacement.
- 10min.: Doubts clarification and Review of the class.

Assignment / Questions: Explain about Measurement of Displacement(Obj;- 1,2,3,4Out;-1,7)

Signature of faculty

LESSON PLAN

Academic **Y**ear : 2018-2019

Semester : I

Name of the Program: B.Tech ………………..**Electrical**…Year: ………**III**..………....Section: A&B

Course/Subject: ……………**Electrical Measurements & Instrumentation**……………..……………..

Name of the Faculty: ……**U.Vijaya Laxmi** ……………………..………………Dept.:…**EEE**…………

Designation : ASST.PROFESSOR

Lesson No: …………….67,68 & 69…………….Duration of Lesson: ………… 135min……………….

Lesson Title: Measurement of Velocity.

INSTRUCTIONAL/LESSON OBJECTIVES:

On completion of this lesson the student shall be able to:

1. Discuss about measurement of Velocity

TEACHING AIDS : LCD PROJECTOR, WHITEBOARD, MARKER, DUSTER
TEACHING POINTS :

- 5 min.: Taking attendance
- 15 min.: Re collecting the contents of previous class.
- 90 min.: Explain Measurement of Velocity.
- 10min.: Doubts clarification and Review of the class.

Assignment / Questions: Explain about Measurement of Velocity(Obj;- 1,2,3,4Out;-1,7)

Signature of faculty

LESSON PLAN

Academic **Y**ear : 2018-2019

Semester : I

Name of the Program: B.Tech ………………..**Electrical**…Year: ………**III**..………....Section: A&B

Course/Subject: ……………**Electrical Measurements & Instrumentation**……………..……………..

Name of the Faculty: ……**U.Vijaya Laxmi** ………..…………………………..Dept.:…**EEE**…………

Designation : ASST.PROFESSOR

Lesson No: ………….70,71,72 &73………….Duration of Lesson: …………… 135min……………….

Lesson Title: Measurement of RPM.

INSTRUCTIONAL/LESSON OBJECTIVES:

On completion of this lesson the student shall be able to:

2. Discuss about measurement of RPM

TEACHING AIDS : LCD PROJECTOR, WHITEBOARD, MARKER, DUSTER
TEACHING POINTS :

- 5 min.: Taking attendance
- 15 min.: Re collecting the contents of previous class.
- 90 min.: Explain Measurement of RPM.
- 10min.: Doubts clarification and Review of the class.

Assignment / Questions: Explain about Measurement of RPM(Obj;- 1,2,3,4Out;-1,7)

Signature of faculty

LESSON PLAN

Academic **Y**ear : 2018-2019

Semester : I

Name of the Program: B.Tech ………………..**Electrical**…Year: ………**III**..………....Section: A&B

Course/Subject: ……………**Electrical Measurements & Instrumentation**……………..……………..

Name of the Faculty: ……**U.Vijaya Laxmi** ……………………..……………..Dept.:…**EEE**…………

Designation : ASST.PROFESSOR

Lesson No: ………….74,75,76 &77………….Duration of Lesson: …………… 135min……………….

Lesson Title: Measurement of Acceleration.

INSTRUCTIONAL/LESSON OBJECTIVES:

On completion of this lesson the student shall be able to:

1. Discuss about measurement of Acceleration

TEACHING AIDS : LCD PROJECTOR, WHITEBOARD, MARKER, DUSTER
TEACHING POINTS :

- 5 min.: Taking attendance
- 15 min.: Re collecting the contents of previous class.
- 90 min.: Explain Measurement of Acceleration
- 10min.: Doubts clarification and Review of the class.

Assignment / Questions: Explain about Measurement of Acceleration (Obj;- 1,2,3,4Out;-1,7)

Signature of faculty

GOKARAJU RANGARAJU
INSTITUTE OF ENGINEERING AND TECHNOLOGY

Department of Electrical & Electronics Engineering

LESSON PLAN

Academic **Y**ear : 2018-2019

Semester : I

Name of the Program: B.Tech ………………..**Electrical**…Year: ………**III**..………....Section: A&B

Course/Subject: ……………**Electrical Measurements & Instrumentation**……………..……………..

Name of the Faculty: ……**U.Vijaya Laxmi** ………..…………………………..Dept.:…**EEE**…………

Designation : ASST.PROFESSOR

Lesson No: …………78, 79 & 80…………….Duration of Lesson: …………… 135min……………….

Lesson Title: Measurement of Flow.

<u>INSTRUCTIONAL/LESSON OBJECTIVES:</u>

On completion of this lesson the student shall be able to:

1.Discuss about measurement of Flow

TEACHING AIDS : LCD PROJECTOR, WHITEBOARD, MARKER, DUSTER

TEACHING POINTS :

- 5 min.: Taking attendance
- 15 min.: Re collecting the contents of previous class.
- 90 min.: Explain Measurement of Flow
- 10min.: Doubts clarification and Review of the class.

Assignment / Questions: Explain about Measurement of Flow (Obj;- 1,2,3,4Out;-1,2,7)

Signature of faculty

ASSIGNMENT SHEET – 1

Academic **Y**ear : 2018-2019

Semester : I

Name of the Program: B.Tech……..…**Electrical**……..… Year: ……**III**……….. Section: A&B

Course/Subject: …**Electrical Measurements & Instrumentation**…Course Code: ..GR15A3017..

Name of the Faculty: ……**U.Vijaya Laxmi** ………………..……………..Dept.: …**EEE**………

Designation: ASST.PROFESSOR

This Assignment corresponds to Unit No. / Lesson ………………**1**………………………….

Q1. Explain about different types of Torques.

Q2. Derive Deflecting Torque Equation of MI Instrument.

Q3. Write a Short Notes on Power Factor Meters.

Objective Nos.: ……………………1,2……………………………………………………….

Outcome Nos.: ……………………1,3…………………………………………………………

Signature of HOD Signature of faculty

Date: Date:

ASSIGNMENT SHEET – 2

GOKARAJU RANGARAJU
INSTITUTE OF ENGINEERING AND TECHNOLOGY

Department of Electrical & Electronics Engineering

Academic **Y**ear : 2018-2019

Semester : I

Name of the Program: B.Tech……..…**Electrical**……..… Year: ……**III**……….. Section: A&B

Course/Subject: …**Electrical Measurements & Instrumentation**…Course Code: ..GR15A3017..

Name of the Faculty: ……**U.Vijaya Laxmi** ………………..……………..Dept.: …**EEE**………

Designation: ASST.PROFESSOR

This Assignment corresponds to Unit No. / Lesson ………………**2**………………………….

Q1.Explain about Maxwell Inductance & Maxwell Inductance and Capacitance Bridge.

Q2. Derive Torque Equation of Energy Meter.

Q3. Write about applications of AC Potentiometers.

Objective Nos.: ………………………….1,2,3,4……………………………………………………….

Outcome Nos.: ……………………1,3,5,6……………………………………………………….

Signature of HOD   Signature of faculty

Date: Date:

ASSIGNMENT SHEET – 3

Academic **Y**ear : 2018-2019

Semester : I

Name of the Program: B.Tech……..…**Electrical**……..… Year: ……**III**……….. Section: A&B

Course/Subject: …**Electrical Measurements & Instrumentation**…Course Code: ..GR15A3017..

Name of the Faculty: ……**U.Vijaya Laxmi** ……………………..…………..Dept.: …**EEE**………

Designation: ASST.PROFESSOR
This Assignment corresponds to Unit No. / Lesson ………………**3**………………………….

Q1. Derive the relationship for deflection sensitivity of a CRT.

Q2. What are Lissajous Patterns. How can they be created. Explain

Q3. Explain a) Sampling Oscilloscope b) CRO probes

Objective Nos.: 1,2,3,4……………………………………………………….

Outcome Nos.: ……………………1,3,5,6……………………………………………………….

Signature of HOD | Signature of faculty

Date: | Date:

ASSIGNMENT SHEET – 4

Academic **Y**ear : 2018-2019

Semester : I

GOKARAJU RANGARAJU
INSTITUTE OF ENGINEERING AND TECHNOLOGY

Department of Electrical & Electronics Engineering

Name of the Program: B.Tech……..…**Electrical**……..… Year: ……**III**……….. Section: A&B

Course/Subject: …**Electrical Measurements & Instrumentation**…Course Code: ..GR15A3017..

Name of the Faculty: ……**U.Vijaya Laxmi** ………..………………………..Dept.: …**EEE**………

Designation: ASST.PROFESSOR

This Assignment corresponds to Unit No. / Lesson ………………**4**………………………….

Q1. Explain the construction, principle of working of LVDT.

Q2. Explain the principle of working of photo voltaic cell and explain why it is useful for space applications.

Q3.Explain the construction and operation of Pirani Guage used for the low pressure measurement.

Objective Nos.: ……………………1,2,3,4……………………………………………………….

Outcome Nos.: ……………………..1,2,7……………………………………………………….

Signature of HOD

Date:

Signature of faculty

Date:

GOKARAJU RANGARAJU
INSTITUTE OF ENGINEERING AND TECHNOLOGY
Department of Electrical & Electronics Engineering

ASSIGNMENT SHEET – 5

Academic **Y**ear : 2018-2019

Semester : I

Name of the Program: B.Tech……..…**Electrical**……..… Year: ……**III**……….. Section: A&B

Course/Subject: …**Electrical Measurements & Instrumentation**…Course Code: ..GR15A3017..

Name of the Faculty: ……**U.Vijaya Laxmi** ………..………………………..Dept.: …**EEE**………

Designation: ASST.PROFESSOR/

This Assignment corresponds to Unit No. / Lesson ………………**5**………………………….

Q1.Describe the Construction & Working principle of Electromagnetic Flow Meter with advantages & disadvantages.

Q2. Explain the Flow direction measurement using Hot Wire Anemometer. Give a neat sketch.

Q3. Explain Displacement Measurement.

Objective Nos.: ……………………………………1,2,3,4…………………………………………….

Outcome Nos.: ………………………………………….1,7……………………………………….

Signature of HOD   Signature of faculty

Date: Date:

TUTOTIAL SHEET - 1

Department of Electrical & Electronics Engineering

Academic **Y**ear : 2018-2019

Semester : I

Name of the Program: B.Tech……..…**Electrical**……..… Year: ……**III**……….. Section: A&B

Course/Subject: …**Electrical Measurements & Instrumentation**…Course Code: ..GR15A3017..

Name of the Faculty: ……**U.Vijaya Laxmi** ……………….……………..Dept.: …**EEE**………

Designation: ASST.PROFESSOR

This Tutorial corresponds to Unit No. / Lesson ………1…………………………….

Q1. A PMMC instrument has a coil of dimensions 10mmX8mm. The flux density in the air gap is 0.15 Wb/m^2. If the coil is wound for 100 turns, carrying a current of 5mA then calculate the deflecting torque. Calculate the deflection if the spring constant is 0.2 X 10^{-6} Nm/degree.

Q2. A moving coil ammeter has fixed shunt of 0.01 Ohm. With a coil resistance of 750 Ohm and a voltage drop of 400mV across it, the full scale deflection is obtained.

a) Calculate the current through shunt.
b) Calculate the resistance of meter to give full scale deflection if the shunted current is 50A.

Q3. Design a multirange d.c. milliammeter with a basic meter having a resistance 75 Ohm and full scale deflection for the current of 2mA. The required ranges are 0-10mA, 0-50mA and 0-100mA.

Please write the Questions / Problems / Exercises which you would like to give to the students and also mention the Objectives/Outcomes to which these Questions / Problems / Exercises are related.

Objective Nos.: …………………………1,2…………………………………………………………….

Outcome Nos.: ……………………..………1,3…………………………………………………………….

Signature of HOD　　　　　　　　　　　　　　　　　　Signature of faculty

Date:　　　　　　　　　　　　　　　　　　　　　　　　Date:

TUTOTIAL SHEET - 2

Academic **Y**ear : 2018-2019

Semester : I

Name of the Program: B.Tech……..…**Electrical**……..… Year: ……**III**……….. Section: A&B

Course/Subject: …**Electrical Measurements & Instrumentation**…Course Code: ..GR15A3017..

Name of the Faculty: ……**U.Vijaya Laxmi** ………………..……………..Dept.: …**EEE**………

Designation: ASST.PROFESSOR

This Tutorial corresponds to Unit No. / Lesson ………2…………………………….

Q1.The wheatstone bridge is shown in the figure below. The galvanometer has a current sensitivity of 12 mm/μA. the internal resistance of galvanometer is 200 Ohm. Calculate the deflection of the galvanometer caused due to 5 Ohm unbalance in the arm BD.

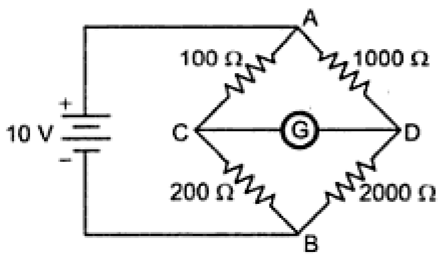


Fig.

Q2. The four arms of the Wheatstone bridge have the following resistances, AB =1000Ω, BC = 1000Ω, CD = 120Ω, DA =120Ω. The bridge is used for strain measurement and supplied from 5 V ideal battery. The galvanometer has sensitivity of 1mm/μA with internal resistance of 200Ω. Determine the deflection of the galvanometer if arm DA increase to 121Ω and arm CD decreases to 119Ω.

Q3. Two wattmeters connected to measure the input to a balanced 3Φ circuit indicate 2000W and 500W respectively. Find the power factor of the circuit when

i) When both readings are positive.
ii) When the latter is obtained after reversing the connection to the current coil of one instrument.

Please write the Questions / Problems / Exercises which you would like to give to the students and also mention the Objectives/Outcomes to which these Questions / Problems / Exercises are related.

Objective Nos.: ………………………1,2,3,4……………………………………………………………….

Outcome Nos.: ……………………..……1,3,5,6……………………………………………………………….

Signature of HOD Signature of faculty

Date: Date:

TUTOTIAL SHEET - 3

Academic **Y**ear : 2018-2019

GOKARAJU RANGARAJU
INSTITUTE OF ENGINEERING AND TECHNOLOGY

Department of Electrical & Electronics Engineering

Semester : I

Name of the Program: B.Tech……..…**Electrical**……..… Year: ……**III**……….. Section: A&B

Course/Subject: …**Electrical Measurements & Instrumentation**…Course Code: ..GR15A3017..

Name of the Faculty: …………..…**U.Vijaya Laxmi** ………………………..Dept.: …**EEE**………

Designation: ASST.PROFESSOR

This Tutorial corresponds to Unit No. / Lesson ………3…………………………….

Q1. Derive the relationship for deflection sensitivity of a CRT.

Q2. What are Lissajous Patterns. How can they be created. Explain

Q3. Explain a) Sampling Oscilloscope b) CRO probes

Please write the Questions / Problems / Exercises which you would like to give to the students and also mention the Objectives/Outcomes to which these Questions / Problems / Exercises are related.

Objective Nos.: ……………………………1,2,3,4………………………………………………………….

Outcome Nos.: ………………….…………1,3,5.6………………………………………………………….

Signature of HOD

Date:

Signature of faculty

Date:

TUTOTIAL SHEET - 4

Academic **Y**ear : 2018-2019

Semester : I

Name of the Program: B.Tech……..…**Electrical**……..… Year: ……**III**……….. Section: A&B

Course/Subject: …**Electrical Measurements & Instrumentation**…Course Code: ..GR15A3017..

Name of the Faculty: …………….**U.Vijaya Laxmi** ………..………………..Dept.: …**EEE**………

Designation: ASST.PROFESSOR

This Tutorial corresponds to Unit No. / Lesson ………4…………………………….

Q1. Explain the construction, principle of working of LVDT.

Q2. Explain the principle of working of photo voltaic cell and explain why it is useful for space applications.

Q3.Explain the construction and operation of Pirani Guage used for the low pressure measurement.

Please write the Questions / Problems / Exercises which you would like to give to the students and also mention the Objectives/Outcomes to which these Questions / Problems / Exercises are related.

Objective Nos.: ……………1,2,3,4……………………………………………………………………….

Outcome Nos.: ……………1,2,7……..…………………………………………………………………….

Signature of HOD　　　　　　　　　　　　　　　　　　　Signature of faculty

Date:　　　　　　　　　　　　　　　　　　　　　　　　　Date:

TUTOTIAL SHEET - 5

Academic **Y**ear : 2018-2019

Semester : I

Name of the Program: B.Tech……..…**Electrical**……..… Year: ……**III**……….. Section: A&B

Course/Subject: …**Electrical Measurements & Instrumentation**…Course Code: ..GR15A3017..

Name of the Faculty: …………..…**U.Vijaya Laxmi............**………………..Dept.: …**EEE**………

Designation: ASST.PROFESSOR
This Tutorial corresponds to Unit No. / Lesson ………5…………………………….

Q1.Describe the Construction & Working principle of Electromagnetic Flow Meter with advantages & disadvantages.
Q2. Explain the Flow direction measurement using Hot Wire Anemometer. Give a neat sketch.

Q3. Explain Vaccum Measurement.

Please write the Questions / Problems / Exercises which you would like to give to the students and also mention the Objectives/Outcomes to which these Questions / Problems / Exercises are related.

Objective Nos.: …………………1,2,3,4……………………………………………………………….

Outcome Nos.: ……………………..………1,7……………………………………………………………….

Signature of HOD   Signature of faculty

Date: Date:

EVALUATION STRATEGY

Academic **Y**ear : 2018-2019

Semester : I

Name of the Program: B.Tech……..…**Electrical**……..… Year: ……**III**……….. Section: A&B

Course/Subject: …**Electrical Measurements & Instrumentation**…Course Code: ..GR15A3017..

Name of the Faculty: ……………..…**U.Vijaya Laxmi** ………….…………..Dept.: …**EEE**………

Designation: ASST.PROFESSOR

1. TARGET:

A) Percentage for pass: 40%

b) Percentage of class: 85%

2. COURSE PLAN& CONTENT DELIVERY:

- OHP presentation of the Lectures
- Solving exercise problems
- Model questions

3. METHOD OF EVALUATION

3.1 Continuous Assessment Examinations (CAE-I, CAE-II)

3.2 Assignments

3.3 Seminars

3.4 Quiz

3.5 Semester/End Examination

Signature of HOD Signature of faculty

Date: Date:

Cognitive Level Mapping

Subject :EMI

CO	Cognitive Learning Level					
	1	2	3	4	5	6
1					X	
2	X					
3		X				
4					X	
5			X			
6			X			
7			X			

Cognitive Learning Levels:

CLL1: Remembering

CLL2: Understanding

CLL3: Applying

CLL4: Analyzing

CLL5: Evaluating

CLL6: Creating

FEED BACK

Gokaraju Rangaraju Institute of Engineering & Technology
(Autonomous)

Summation of Teacher Appraisal by Student
Academic Year 2018-19

Name of the Instructor	U. Vijaya Lakshmi
Faculty ID	692
Branch	EEE
Class and Semester/Section	III / I / A
Academic Year	2018-19
Subject Title	SMI Lab
Total No. of Responses/class strength	45/71

Average rating on a scale of 4 for the responses considered:

S. No	Questions of Feedback	Average
1	How do the teacher explain the subject?	3.5434782608695654
2	The teacher pays attention to	3.5434782608695654
3	The Language and communication skills of the teacher is	3.5217391304347827
4	Is the session Interactive?	3.4782608695652173
5	Rate your teacher's explanation in clearing the doubts	3.5869565217391304
6	Rate your teachers commitment in completing the syllabus	3.5434782608695654
7	Rate your teachers punctuality	3.5434782608695654
8	Rate your teachers use of teaching aids	3.5652173913043477
9	Rate your teacher's guidance in other activities like NPTEL, Moodle, Swayam, Projects.	3.4782608695652173
10	What is your overall opinion about the teacher?	3.5217391304347827

Net Feedback on a scale of 1 to 4: 3.5326086956521743

Remarks by HOD:

Remarks by Principal:

Remarks by Director:

Gokaraju Rangaraju Institute of Engineering & Technology
(Autonomous)

Summation of Teacher Appraisal by Student
Academic Year 2018-19

Name of the Instructor	U. Vijaya Lakshmi
Faculty ID	692
Branch	EEE
Class and Semester/Section	III / I / B
Academic Year	2018-19
Subject Title	EMI
Total No. of Responses/class strength	52/71

Average rating on a scale of 4 for the responses considered:

S. No	Questions of Feedback	Average
1	How do the teacher explain the subject?	3.0930232558139537
2	The teacher pays attention to	3.0465116279069768
3	The Language and communication skills of the teacher is	3.1860465116279069
4	Is the session Interactive?	3
5	Rate your teacher's explanation in clearing the doubts	3.0697674418604652
6	Rate your teachers commitment in completing the syllabus	2.9767441860465116
7	Rate your teachers punctuality	3.0232558139534884
8	Rate your teachers use of teaching aids	3.0930232558139537
9	Rate your teacher's guidance in other activities like NPTEL, Moodle, Swayam, Projects.	2.9534883720930232
10	What is your overall opinion about the teacher?	3.1162790697674421

Net Feedback on a scale of 1 to 4: 3.0558139534883724

Remarks by HOD:

Remarks by Principal:

Remarks by Director:

HOD,EEE

Department of Electrical & Electronics Engineering

B.Tech EEE IIIYEAR I SEM **RESULT ANALYSIS OF 2018-2019 BATCH**

Gokaraju Rangaraju Institute of Engineering and Technology
Department of Electrical and Electronics Engineering
B.Tech EEE IIIYEAR I SEM RESULT ANALYSIS OF 2016-2020 BATCH
ACADEMIC YEAR 2018-2019 TOTAL. NO. OF STUDENTS REGISTERED = 142

Subject	Total No. of students appeared	No. of students passed	No. of students failed	Grade Points							Pass percentage
				< 5	5	6	7	8	9	10	
MC	142	116	26	07	13	15	20	32	27	02	81.69%
MC Lab	142	141	01	00	01	00	00	09	26	105	99.29%
PTS	142	128	14	01	12	12	14	30	34	25	90.14%
EMI	142	128	14	08	11	08	12	32	31	26	90.14%
PE	142	135	07	03	08	11	08	27	37	41	95.07%
SMI Lab	142	140	02	06	10	02	04	12	17	89	98.59%
PE Lab	142	140	02	00	01	02	07	27	31	72	98.59%
SWE	142	125	17	06	11	16	09	44	29	10	88.02%

Overall pass (passed in all subjects) = 107/142 (75.35%)

Faculty

Power Transmission System	V Vijaya Rama Raju, M Prashanth
Microcontrollers	P Prashanth Kumar
Electrical Measurements& Instrumentation	U Vijaya Lakshmi
Power Electronics	Dr T Suresh Kumar,D Karuna Kumar
Solar and Wind Energy Systems	P Sri Vidya Devi /Dr J Praveen
Sensors/Measurements& Instrumentation Lab	P Srividya Devi/U Vijaya Lakshmi/P Sirisha
Power Electronics Lab	Dr T Suresh Kumar/Syed Sarfaraz Nawaz/M Rekha
Microcontrollers Lab	R Anil Kumar/MN Sandhya Rani

HOD,EEE

MAPPIN GS

1. **Program Educational Objectives (PEOs) – Vision/Mission Matrix** (Indicate the relationships by mark "X")

PEOs	**Mission of department**			
	Higher Learning	Contemporar y Education	Technical knowledge	Research
1	H	H	H	H
2	H	H	H	M
3	H	M	H	M
4	H	M	H	H

2. **Program Educational Objectives(PEOs)-Program Outcomes(POs) Relationship Matrix** (Indicate the relationships by mark "X")

P-Outcomes / PEOs	a	b	c	d	e	f	g	h	i	j	k	l
1	M	M			H			H		H	H	H
2	M	M			H			H			H	
3			M	M	H	H	H					H
4					H	H	M	M	M	M	H	H

GOKARAJU RANGARAJU
INSTITUTE OF ENGINEERING AND TECHNOLOGY

Department of Electrical & Electronics Engineering

CO Attainment for all Mid Exams

I mid COS

S.NO	ROLL NO.	Name of the Student	1[CO1]	2[CO3]	3[CO3]	4a[CO2]	4b[CO4]	total	quiz	final
1	16241A0201	AARE UPENDRA				4		4	1	5
2	16241A0202	AENUGULA RAJENDHAR	5			2.5	2.5	10	3	13
3	16241A0203	ALLA NAGA SAI KEERTHI		1	1	2.5	2.5	7	4	11
4	16241A0204	ANNAMARAJU SAI KRISHNA KARTHIKEY				4		4	1	5
5	16241A0205	APPALA BHAVANI SRIJA	1				2.5	3.5	3	7
6	16241A0206	ARUKALA PRANATHI	1			2.5	2.5	6	3	9
7	16241A0207	BADDAM ARUN				2.5		2.5	2	5
8	16241A0208	BANDHARI GALLA ROHIT RAO					2.5	2.5	1	4
9	16241A0209	BHAIRISHETTI HEMANTHKUMAR	5			2.5	2	9.5	4	14
10	16241A0210	BHUKYA KOUSHIK ARYAN	3					3	2	5
11	16241A0211	CHALLA SAI SURESH REDDY				2.5		2.5	2	5
12	16241A0212	CHUPPALA ROHITH RAVI RAJA	0					1	4	5
13	16241A0213	DESABATHINA TEJASWI		1		2.5	2.5	6	4	10
14	16241A0214	GEORGE MICHAEL		3			0.5	3.5	1	5
15	16241A0216	GADDEY MOHAN KRISHNA SAI						0		0
16	16241A0217	GADEELA VISHAL		5		2.5	2.5	10	3	13
17	16241A0218	GARLAPATI VARUN GUPTA						0		0
18	16241A0219	GUGULOTH SUMAN		5		2.5		7.5	3	11
19	16241A0220	GUNDA SAITEJA					4	4	1	5
20	16241A0221	JAGARAPU SIDDI SAI SATVIK					1.5	1.5	2	4
21	16241A0222	K TONISHA		0.5		2.5		3	3	6
22	16241A0223	K. VIKAS		3		2.5	2.5	8	4	12
23	16241A0224	KONDEPUDI LAKSHMI GANESH		2				2	3	5
24	16241A0225	KALYANAMPUDI VINOD KUMAR	4	2		2.5	2.5	11	3	14
25	16241A0226	KAMMARI HARISH	4				2.5	6.5	3	10
25	16241A0226	KAMMARI HARISH	4				2.5	6.5	3	10
26	16241A0227	KARIVEDA ANJALI		1		0.5	2.5	4	3	7
27	16241A0228	KOTHA RMAYA SREE					2.5	2.5	2	5
28	16241A0229	KUMMARI LAKSHMI NARAYANA		2.5				2.5	2	5
29	16241A0230	LYADELLA SAINATH	4	1				5	3	8
30	16241A0231	M. VENUGOPAL		0.5		2.5		3	4	7
31	16241A0232	M.NITIN KUMAR						0		0
32	16241A0233	MANDARI RUPESH	3					3	2	5
33	16241A0234	M MANIKANTA					2.5	2.5	4	7
34	16241A0235	MARELLA V RAJ KUMAR				2		2	3	5
35	16241A0236	MATTA SESHU KUMAR	4			2.5	2	8.5	4	13
36	16241A0237	MD AKEEM PARVEZ		2.5				2.5	2	5
37	16241A0238	MEENUGU REVANTH		3		2.5		5.5	3	9
38	16241A0239	MOHAMMED KHALEEF				2.5	2.5	5	4	9
39	16241A0240	MOKA DURGA PRASHANTH				2.5	2.5	5	3	8
40	16241A0241	MOOD SUMAN			1	2.5		3.5	3	7
41	16241A0242	MUNAGALA KARUNYA	2	5		2		9	4	13
42	16241A0243	NALAGAMA MALATHI					2	2	3	5
43	16241A0244	P SHRAVAN KUMAR				2.5		2.5	4	7
44	16241A0245	PENAGANTI SURYA SRIRAM				2.5	2.5	5	4	9
45	16241A0246	RAMPALLY SURYA TEJA				2.5	2.5	5	4	9
46	16241A0247	REKULGI MANISHA	2	4		2.5	2.5	11	3	14
47	16241A0248	RIMAH		5			2	7	3	10
48	16241A0249	SAI HAVANIKA		2			2.5	4.5	4	9
49	16241A0250	SANKATALA PRANAY KUMAR	5	5			1	11	2	13
50	16241A0251	SHIVEN GOYEL		4			2.5	6.5	5	12
51	16241A0252	SIMRAN AGARWAL	5	3			2	10	3	13

GOKARAJU RANGARAJU
INSTITUTE OF ENGINEERING AND TECHNOLOGY

Department of Electrical & Electronics Engineering

52	16241A0253	TETALA SURYA VENKATA NAGASAI PRANEETH REDDY	2					2	3	5
53	16241A0254	T SRIVASTAVI				2.5		2.5	3	6
54	16241A0255	THUMU MANIDEEP				2		2	3	5
55	16241A0256	TUMULA SRIVIDYA	5			2.5	1	8.5	2	11
56	16241A0257	UNDETY MOUNIKA	5	4		2.5	2.5	14	3	17
57	16241A0258	VEGESNA NAGA MEGHANA		0.5		2.5		3	1	4
58	16241A0259	VIPPARTHI SOWMYA	5	5		2.5	2.5	15	5	20
59	16241A0260	YELLOJU BHARATH RAJKUMAR	3					3	2	5
60	17245A0201	AKULA CHANDANA	5	5		2.5	2.5	15	3	18
61	17245A0202	A IRMIA	3	5		2.5	2.5	13	4	17
62	17245A0203	BODDU SHASHANK						0		0
63	17245A0204	CHATLA SUDHIR KUMAR		4.0		2.5	2.5	9	4	13
64	17245A0205	CHILUKA PRANAVI		4.0		2.5	2	8.5	4	13
65	17245A0206	DEVATH SRIKANTH		2.0		2.5	2	6.5	2	9
66	17245A0207	DULLA AKSHAY KUMAR YADAV		2		2.5	2.5	7	3	10
67	17245A0208	DUNNA SRIKANTH		4		2.5	2	8.5	4	13
68	17245A0209	GARIKAPATI ANNAPURNA KARTHIKA		4		2.5	2.5	9	3	12
69	17245A0210	GOPANAPELLY SHRAVANI		3		2.5	2	7.5	3	11
70	17245A0211	G SANDEEP KUMAR						0		0
71	17245A0212	G VASAVI		3			2	5	3	8

	1[CO1]	2[CO3]	3[CO3]	4a[CO2]	4b[CO4]
Grand Total	76	106.5	2	104.5	95.5
NSA	22	35	2	42	42
Attempt %=(NSA/Total no of students)*100	30.98592	49.29577	2.816901	59.15493	59.15493
Average (attainment)= Total/NSA	3.454545	3.042857	1	2.488095	2.27381
Attainment % = (Total/no.of max marks*no.of	21.40845	30	0.56338	58.87324	53.80282

S.NO	ROLL NO.	Name of the Student	1[CO1]	2[CO3]	3[CO3]	4a[CO2]	4b[CO4]	total	quiz	final
1	16241A0261	A PRASHANTH		3		2	2.5	7.5	2	10
2	16241A0262	ADEPU SOWMYA	5	5		2.5	2.5	15	3	18
3	16241A0263	AMGOTH RISHITHA PAMAAR		2		2.5	2.5	7	3	10
4	16241A0264	ARVIND NAIDU		2	2			4	3	7
5	16241A0265	BOLISHETTI SAIJEEVAN	0					0	5	5
6	16241A0266	BOLLUR YASHWANT		4		2.5	2.5	9	4	13
7	16241A0267	BOMRASPET PHANIDER	5	4		2.5	2.5	14	4	18
8	16241A0268	CHALLAGUNDLA SOWMYA		4		2.5	2.5	9	3	12
9	16241A0269	CHINTAPOOLA SWATHI	4	4		2.5	2.5	13	4	17
10	16241A0270	DESHPANDE PRAVALIKA	2				2	4	3	7
11	16241A0271	GONE SOWMYA					2	2	3	5
12	16241A0272	GOPIDI VENKAT REDDY	3	1		2.5	2.5	9	4	13
13	16241A0273	GORENKALA MEGHA SAIKRISHNA		1				1	4	5
14	16241A0274	INDURI PAVANI	5	5		2.5	2.5	15	4	19
15	16241A0275	JALAMANCHILI RAMA SURYAM	2			2.5	2.5	7	4	11
16	16241A0276	JONNAVALASA DEVI PRASAD		4		2.5	2	8.5	3	12
17	16241A0277	K V S SANDEEP	1		5			6	5	11
18	16241A0278	KALYANAPU VENUGOPAL		4		2.5	2	8.5	5	14
19	16241A0279	KANNE SACHIN				2.5		2.5	4	7
20	16241A0280	KARAM SANDHYARANI	5	2		2.5	2.5	12	1	13
21	16241A0281	KATTA MOUNIKA		5		2.5	2	9.5	4	14

GOKARAJU RANGARAJU
INSTITUTE OF ENGINEERING AND TECHNOLOGY
Department of Electrical & Electronics Engineering

22	16241A0282	KIDAMBI SREE GOVIND		4		2.5	2	8.5	3	12
23	16241A0283	KOLLIPARA CHAITANYA SAI				2.5	2	4.5	5	10
24	16241A0284	KONDA ANIL KUMAR	1		1	2.5		4.5	5	10
25	16241A0285	KUNCHALA MOHANBABU	5	4		2.5	2.5	14	4	18
26	16241A0286	LANKA ROHITHA SRI	5		1	2.5	2.5	11	3	14
27	16241A0287	MADAPATHI SACHIN						0		0
28	16241A0288	MALAKA UDAYASAGAR				2.5	2.5	5	3	8
29	16241A0289	MALAVATH JAIPAL		2		2.5	2.5	7	5	12
30	16241A0290	MANGANAPALLY ROOPA	5	4		2.5	2.5	14	1	15
31	16241A0291	MOHAMMED KHALEEL	5	5		2.5	2.5	15	5	20
32	16241A0292	MUKKAMULA RAMYA SREE	5			2.5		7.5	3	11
33	16241A0293	MUNDRA SUBHASHINI	5			2.5	2.5	10	3	13
34	16241A0294	MYSA VINOD KUMAR	3					3	2	5
35	16241A0295	NAGARAM VAMSHI	2					2	3	5
36	16241A0296	NAGARAPU PRADEEP	1			2.5	2.5	6	3	9
37	16241A0297	PATHAPATI DIVYA	5	4		2.5		11.5	4	16
38	16241A0298	POTTA SURYATEJA			3			3	2	5
39	16241A0299	PRODDUTUR MOHAN SAI		3				3	2	5
40	16241A02A0	PUDOTA ADITYA CECIL RAJ	3					3	2	5
41	16241A02A2	SADANAVENA RAHUL	4	3		2.5		9.5	4	14
42	16241A02A3	SAI TEJASWI NOOKA		4		2.5	2.5	9	3	12
43	16241A02A4	SAKETH M				2.5	2.5	5	3	8
44	16241A02A5	SANGEM SOUJANYA	5			2.5	2.5	10	2	12
45	16241A02A6	SANGISETTY RAKESH SAGAR		2		2	1	5	4	9
46	16241A02A7	SHASTRALA SRAVYA		4		2.5	1	7.5	4	12
47	16241A02A8	SURAM SHIRISHA	5	5		2.5	2.5	15	4	19
48	16241A02A9	SURYA SANJAY BANDARI		4		2.5	2.5	9	3	12
49	16241A02B0	T LAKSHMI ASRITH		2		2.5	2.5	7	3	10
50	16241A02B1	TERATPALLY YESHWANTH	5	4		2.5	2.5	14	3	17
51	16241A02B2	THELLA SAI KRISHNA	5			2.5		7.5	3	11
52	16241A02B3	THOTAKURI VISHAL				2.5		2.5	4	7
53	16241A02B4	TUMMALACHARLA PRAVEEN		4		2.5	2.5	9	4	13
54	16241A02B5	VANGA RITHVIKA		4		2.5	2.5	9	3	12
55	16241A02B6	VIDYA KANURI		1		2	1	4	3	7
56	16241A02B7	VINEESHA SRAVYA LAKSHMI . B	5	3		2.5	2.5	13	3	16
57	16241A02B8	VUJJINI HARSHITHA		3		2.5	1.5	7	3	10
58	16241A02B9	BHANU KAUSTUBA WALTATI				2.5		2.5	2	5
59	17245A0213	K RAGHAVENDER	5			2.5	2.5	10	3	13
60	17245A0214	K VAISHNAVI		3		2.50	2	7.5	4	12
61	17245A0215	MANNELI KRANTHI KUMAR		**3**		**2.5**		5.5	3	9
62	17245A0216	MARTHA REVAN KUMAR	2	2		2.5	2.5	9	4	13
63	17245A0217	MASANNAGARI RAKESH REDDY	4	3				7	4	11
64	17245A0218	NARSING SHRAVANI	2	5		2.5	1	10.5	4	15
65	17245A0219	PONNAM ADITHYA		4		2.5		6.5	3	10
66	17245A0220	POOSALA NAVYARANI		3		2.5		5.5	5	11
67	17245A0221	P SWATHI	0.5	5		2.5	2	10	3	13
68	17245A0222	SABAVATH PARAMESH		2		2.5	2.5	7	3	10

69	17245A0223	SHAIK ASIF AHMED		2		2.5	2.5	7	4	11
70	17245A0224	SHAIK SOHEL	3			2	2.5	7.5	4	12
			1[CO1]	2[CO3]	3[CO3]	4a[CO2]	4b[CO4]			
	Grand Total		122.5	151	12	140.5	108.5			
	NSA		34	45	5	57	48			
	Attempt %=(NSA/Total no of students)*100		48.57143	64.28571	7.142857	81.42857	68.57143			
	Average (attainment)= Total/NSA		3.602941	3.355556	2.4	2.464912	2.260417			
	Attainment % = (Total/no.of max marks*no.of		35	43.14286	3.428571	80.28571	62			

co1	25
co2	44
co3	18
co4	56.5

II MID

S.NO	ROLL NO.	Name of the Student	1[CO6]	2[CO5]	3[CO7]	4[CO7]	total
	15241A0243	R.Raashik Arun			3	2	5
1	16241A0201	AARE UPENDRA			1		1
2	16241A0202	AENUGULA RAJENDHAR	5	5			10
3	16241A0203	ALLA NAGA SAI KEERTHI					ab
5	16241A0205	APPALA BHAVANI SRIJA	5	5			10
6	16241A0206	ARUKALA PRANATHI	5	5			10
7	16241A0207	BADDAM ARUN	2	5			7
8	16241A0208	BANDHARI GALLA ROHIT RAO	1				1
9	16241A0209	BHAIRISHETTI HEMANTHKUMAR		5	5		10
10	16241A0210	BHUKYA KOUSHIK ARYAN	5				5
11	16241A0211	CHALLA SAI SURESH REDDY	5	2			7
12	16241A0212	CHUPPALA ROHITH RAVI RAJA	5				5
13	16241A0213	DESABATHINA TEJASWI	5	5			10
14	16241A0214	GEORGE MICHAEL		5			5
15	16241A0216	GADDEY MOHAN KRISHNA SAI	1				1
16	16241A0217	GADEELA VISHAL	5	5	5		15
17	16241A0218	GARLAPATI VARUN GUPTA	2				2
18	16241A0219	GUGULOTH SUMAN		5			5
19	16241A0220	GUNDA SAITEJA		5			5
20	16241A0221	JAGARAPU SIDDI SAI SATVIK		5			5
21	16241A0222	K TONISHA		5			5

22	16241A0223	K. VIKAS		5	5	5	15
23	16241A0224	KONDEPUDI LAKSHMI GANESH			5		5
24	16241A0225	KALYANAMPUDI VINOD KUMAR	5	5	5		15
25	16241A0226	KAMMARI HARISH	3		5	3	11
26	16241A0227	KARIVEDA ANJALI	2	5			7
27	16241A0228	KOTHA RMAYA SREE	5	5			10
28	16241A0229	KUMMARI LAKSHMI NARAYANA	2				2
29	16241A0230	LYADELLA SAINATH		5			5
30	16241A0231	M. VENUGOPAL		5		5	10
31	16241A0232	M.NITIN KUMAR					ab
32	16241A0233	MANDARI RUPESH		5			5
33	16241A0234	M MANIKANTA		3	2		5
34	16241A0235	MARELLA V RAJ KUMAR	5				5
35	16241A0236	MATTA SESHU KUMAR		5			5
36	16241A0237	MD AKEEM PARVEZ				1	1
37	16241A0238	MEENUGU REVANTH			1		1
38	16241A0239	MOHAMMED KHALEEF	5		5		10
39	16241A0240	MOKA DURGA PRASHANTH		5			5
40	16241A0241	MOOD SUMAN	5	5		2	12
41	16241A0242	MUNAGALA KARUNYA	5	5			10

42	16241A0243	NALAGAMA MALATHI	2		3	3	8
43	16241A0244	P SHRAVAN KUMAR	3	5			8
44	16241A0245	PENAGANTI SURYA SRIRAM		5			5
45	16241A0246	RAMPALLY SURYA TEJA		5			5
46	16241A0247	REKULGI MANISHA	5	5			10
47	16241A0248	RIMAH	5	5			10
48	16241A0249	SAI HAVANIKA	2	5			7
49	16241A0250	SANKATALA PRANAY KUMAR	2	5			7
50	16241A0251	SHIVEN GOYEL		5			5
51	16241A0252	SIMRAN AGARWAL		5	3	5	13
52	16241A0253	TETALA SURYA VENKATA NAGASAI PRANEETH REDDY	3		2		5
53	16241A0254	T SRIVASTAVI	3		5		8
54	16241A0255	THUMU MANIDEEP		3			3
55	16241A0256	TUMULA SRIVIDYA		3	2		5
56	16241A0257	UNDETY MOUNIKA	5	5			10
57	16241A0258	VEGESNA NAGA MEGHANA		3			3
58	16241A0259	VIPPARTHI SOWMYA	5	5			10
59	16241A0260	YELLOJU BHARATH RAJKUMAR	1	1			2
60	17245A0201	AKULA CHANDANA	5	5	3		13
61	17245A0202	A IRMIA			1		1
62	17245A0203	BODDU SHASHANK	3	5			8
63	17245A0204	CHATLA SUDHIR KUMAR	5.0	5.0			10
64	17245A0205	CHILUKA PRANAVI	5.0	5.0			10
65	17245A0206	DEVATH SRIKANTH	3.0	5.0			8
66	17245A0207	DULLA AKSHAY KUMAR YADAV	0				0
67	17245A0208	DUNNA SRIKANTH	2				2
68	17245A0209	GARIKAPATI ANNAPURNA KARTHIKA	5	5			10
69	17245A0210	GOPANAPELLY SHRAVANI	5	5			10
70	17245A0211	G SANDEEP KUMAR	5				5
71	17245A0212	G VASAVI	5	5			10

Grand Total	162	225	58	24
NSA	43	48	17	7
Attempt %=(NSA/Total no of students)*100	60.56338	67.60563	23.94366	9.859155
Average (attainment)= Total/NSA	3.767442	4.6875	3.411765	3.428571
Attainment % = (Total/no.of max marks*no.of	45.6338	63.38028	16.33803	13.52113

GOKARAJU RANGARAJU
INSTITUTE OF ENGINEERING AND TECHNOLOGY

Department of Electrical & Electronics Engineering

S.NO	ROLL NO.	Name of the Student	1[CO6]	2[CO5]	3[CO7]	4[CO7]	total
1	16241A0261	A PRASHANTH	5	5			10
2	16241A0262	ADEPU SOWMYA	5	5	3		13
3	16241A0263	AMGOTH RISHITHA PAMAAR	5	5			10
4	16241A0264	ARVIND NAIDU					ab
5	16241A0265	BOLISHETTI SAIJEEVAN	2	5			7
6	16241A0266	BOLLUR YASHWANT		5			5
7	16241A0267	BOMRASPET PHANIDER	5	5			10
8	16241A0268	CHALLAGUNDLA SOWMYA	5	5			10
9	16241A0269	CHINTAPOOLA SWATHI	5	5			10
10	16241A0270	DESHPANDE PRAVALIKA	1				1
11	16241A0271	GONE SOWMYA			1	1	2
12	16241A0272	GOPIDI VENKAT REDDY	3	5		2	10
13	16241A0273	GORENKALA MEGHA SAIKRISHNA	3	2			5
14	16241A0274	INDURI PAVANI	5	5			10
15	16241A0275	JALAMANCHILI RAMA SURYAM		5	3		8
16	16241A0276	JONNAVALASA DEVI PRASAD	5	5			10
17	16241A0277	K V S SANDEEP		5		3	8
18	16241A0278	KALYANAPU VENUGOPAL	2	5		3	10
19	16241A0279	KANNE SACHIN	3	2			5
20	16241A0280	KARAM SANDHYARANI	5	5	3		13
21	16241A0281	KATTA MOUNIKA	3	5			8
22	16241A0282	KIDAMBI SREE GOVIND	5	5			10
23	16241A0283	KOLLIPARA CHAITANYA SAI	2	3			5
24	16241A0284	KONDA ANIL KUMAR	3	5	2		10
25	16241A0285	KUNCHALA MOHANBABU	5	5	1		11
26	16241A0286	LANKA ROHITHA SRI	2	5	1		8
27	16241A0287	MADAPATHI SACHIN					ab
28	16241A0288	MALAKA UDAYASAGAR	1				1
29	16241A0289	MALAVATH JAIPAL	2	5			7
30	16241A0290	MANGANAPALLY ROOPA	4	5			9
31	16241A0291	MOHAMMED KHALEEL	2	5			7
32	16241A0292	MUKKAMULA RAMYA SREE	4	5			9
33	16241A0293	MUNDRA SUBHASHINI	2	3			5
34	16241A0294	MYSA VINOD KUMAR	2				2
35	16241A0295	NAGARAM VAMSHI	4				4
36	16241A0296	NAGARAPU PRADEEP	3	5			8
37	16241A0297	PATHAPATI DIVYA	3	2			5
38	16241A0298	POTTA SURYATEJA	2				2
39	16241A0299	PRODDUTUR MOHAN SAI				3	3

40	16241A02A0	PUDOTA ADITYA CECIL RAJ	0				0
41	16241A02A2	SADANAVENA RAHUL	5	5	3		13
42	16241A02A3	SAI TEJASWI NOOKA	5	5			10
43	16241A02A4	SAKETH M	1	5			6
44	16241A02A5	SANGEM SOUJANYA	3	2			5
45	16241A02A6	SANGISETTY RAKESH SAGAR	1				1
46	16241A02A7	SHASTRALA SRAVYA	4	5			9
47	16241A02A8	SURAM SHIRISHA	5	5			10
48	16241A02A9	SURYA SANJAY BANDARI	1				1
49	16241A02B0	T LAKSHMI ASRITH	3	5			8
50	16241A02B1	TERATPALLY YESHWANTH	5	5	1		11
51	16241A02B2	THELLA SAI KRISHNA		5			5
52	16241A02B3	THOTAKURI VISHAL	1		2		3
53	16241A02B4	TUMMALACHARLA PRAVEEN	3	5	2		10
54	16241A02B5	VANGA RITHVIKA	5				5
55	16241A02B6	VIDYA KANURI	3	3			6
56	16241A02B7	VINEESHA SRAVYA LAKSHMI . B	5	5	3		13
57	16241A02B8	VUJJINI HARSHITHA	5	5			10
58	16241A02B9	BHANU KAUSTUBA WALTATI		1	1		2
59	17245A0213	K RAGHAVENDER	3	5.00			8
60	17245A0214	K VAISHNAVI	5.00	5	2.00		12

61	17245A0215	MANNELI KRANTHI KUMAR	**3**	**5**	**1**		9
62	17245A0216	MARTHA REVAN KUMAR		2			2
63	17245A0217	MASANNAGARI RAKESH REDDY			1		1
64	17245A0218	NARSING SHRAVANI	2	5	3		10
65	17245A0219	PONNAM ADITHYA		5			5
66	17245A0220	POOSALA NAVYARANI	5	5			10
67	17245A0221	P SWATHI	5	5	5		15
68	17245A0222	SABAVATH PARAMESH	3	5	2		10
69	17245A0223	SHAIK ASIF AHMED	3	2			5
70	17245A0224	SHAIK SOHEL	2				2
71	18248A0201	K.Akhila	5				5
	Grand Total		194	242	40	12	
	NSA		58	54	19	5	
	Attempt %=(NSA/Total no of students)*100		81.69014	76.05634	26.76056	7.042254	
	Average (attainment)= Total/NSA		3.344828	4.481481	2.105263	2.4	
	Attainment % = (Total/no.of max marks*no.of		55.42857	69.14286	11.42857	6.857143	

co5	66
co6	50
co7	12

Introduction

The digital voltmeters generally referred as DVM, convert the analog signals into digital and display the voltages to be measured as discrete numericals instead of pointer deflc :tion, on the digital displays. Such voltmeters can be used to measure a.c. and d.c. voltages and also to measure the quantities like pressure, temperature, stress etc. using proper transducer and signal conditioning circuit. The transducer converts the quantity into the proportional voltage signal and signal conditioning circuit brings the signal into the proper limits which can be easily measured by the digital voltmeter. The output voltage is displayed on the digital display on the front panel. Such a digital output reduces the human reading and interpolation errors and parallax errors.

The DVMs have various features and the advantages, over the conventional analog voltmeters having pointer deflection on the continuous scale.

Advantages of Digital Voltmeters

The DVMs have number of advantages over conventional analog voltmeters, which are,

1. Due to the digital display, the human reading errors, interpolation errors and parallax errors are reduced.
2. They have input range from +1.000 V to +1000 V with the automatic range selection and the overload indication.
3. The accuracy is high upto ± 0.005 % of the reading.
4. The resolution is better as 1 μV reading can be measured on 1 V range.
5. The input impedance is as high as 10 MΩ.
6. The reading speed is very high due to digital display.
7. They can be programmed and well suited for computerised control.
8. The output in digital form can be directly recorded and it is suitable for further processing also.
9. With the development of IC chips, the cost of DVMs, size and power requirements of DVMs are drastically reduced.
10. Due to small size, they are portable.
11. The internal calibration does not depend on the measuring circuit.
12. The BCD output can be printed or used for digital processing.
13. The inclusion of additional circuitry make them suitable for the measurement of quantities like current, impedance, capacitance, temperature, pressure etc.

Classification of Digital Voltmeters

The digital voltmeters are classified mainly based on the technique used for the analog to digital conversion. Depending on this, the digital voltmeters are mainly classified as,

i) Non-integrating type and ii) Integrating type

The non-integrating type digital voltmeters are further classified as,

a) Potentiometric type : These are subclassified as,

1) Servo potentiometric type
2) Successive approximation type
3) Null balance type

b) Ramp type : These are subclassified as,

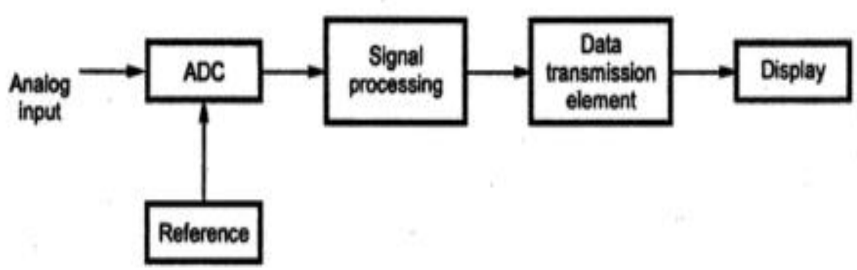
1) Linear type
2) Staircase type

The integrating type digital voltmeters are classified as :

a) Voltage to frequency converter type
b) Potentiometric type
c) Dual slope integrating type

Basic Block Diagram of DVM

Any digital instrument requires analog to digital converter at its input. Hence first block in a general DVM is ADC as shown in the Fig. 3.1.



Basic block diagram of DVM

Every ADC requires a reference. The reference is generated internally and reference generator circuitry depends on the type of ADC technique used. The output of ADC is decoded and signal is processed in the decoding stage. Such a decoding is necessary to drive the seven segment display. The data from decoder is then transmitted to the display. The data transmission element may be a latches, counters etc. as per the requirement. A digital display shows the necessary digital result of the measurement.

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1) Linear type

2) Staircase type

The integrating type digital voltmeters are classified as :

a) Voltage to frequency converter type

b) Potentiometric type

c) Dual slope integrating type

Successive Approximation Type DVM

The potentiometer used in the servo balancing type DVM is a linear divider but in successive approximation type a digital divider is used. The digital divider is nothing but a digital to analog (D/A) converter. The servomotor is replaced by an electronic logic.

The basic principle of measurement by this method is similar to the simple example of determination of weight of the object. The object is placed on one side of the balance and the approximate weight is placed on other side. If weight placed is more, the weight is removed and smaller weight is placed. If this weight is smaller than the object, another small weight is added, to the weight present. If now the total weight is higher than the object, the added weight is removed and smaller weight is added. Thus by such successive procedure of adding and removing, the weight of the object is determined. The successive approximation type DVM works exactly on the same principle.

In successive approximation type DVM, the comparator compares the output of digital to analog converter with the unknown voltage. Accordingly, the comparator provides logic high or low signals. The digital to analog converter successively generates the set pattern of signals. The procedure continues till the output of the digital to analog converter becomes equal to the unknown voltage.

The Fig. shows the block diagram of successive approximation type DVM.

The capacitor is connected at the input of the comparator. The output of the digital to analog converter is compared with the unknown voltage, by the comparator. The output of the comparator is given to the logic control and sequencer. This unit generates the sequence of code which is applied to digital to analog converter. The position 2 of the switch S_1 receives the output from digital to analog converter. The unknown voltage is available at the position 1 of the switch S_1. The logic control also drives the clock which is used to alternate the switch S_1 between the positions 1 and 2, as per the requirement.

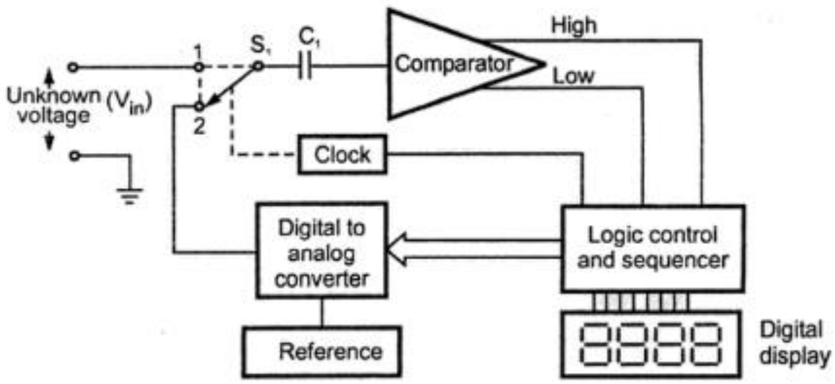


Fig. Successive approximation type DVM

Consider the voltage to be measured is 3.7924 V. The set pattern of digital to analog converter is say 8-4-2-1. At the start, the converter generates 8 V and switch is at the position 2. The capacitor C_1 charges to 8 V. The clock is used to change the switch position. So during next time interval, switch position is 1 and unknown input is applied to the capacitor. As capacitor is charged to 8 V which is more than the input voltage 3.7924 V, the comparator sends HIGH signal to the logic control and sequencer circuit. This HIGH signal resets the digital to analog converter which generates its next step of 4 V. This again generates HIGH signal. This again resets the converter to generate the next step of 2 V.

Now 2 V is less than the input voltage. The comparator generates LOW signal and sends it to logic control and sequence circuit. During the generation of LOW signal, the generated signal by the converter is retained. Thus the 2 V step gets stored in the converter. In addition to this, next step of 1 V is generated. Thus the total voltage level becomes, stored 2 + generated 1 i.e. 3 V. This is again less than the input and generates LOW signal. Due to low signal, this gets stored. After this 0.8 V step is generated for the second digit approximation.

Thus the process of successive approximation continues till the converter generates 3.7924 V. This voltage is then displayed on the digital display.

At each low signal, there is an incremental change in the output of the digital to analog converter. This output voltage approaches the value of the unknown voltage. The limit to how close this output can approach to the unknown voltage, depends on the level of noise at the input of comparator and the stability of the input switch. To reduce the noise, filters may be used but it reduces the speed of measurement. These limiting factors usually determine the number of digits of resolution of an instrument. The general range of digits is 3 to 5. The speed depends upon the type of switches used in digital to analog converter and comparator circuitry. If solid state switches are used, the high speed can be obtained. For electromechanical switches, the speed is few readings per second.

The accuracy depends on the internal reference supply associated with the digital to analog converter and the accuracy of the converter itself.

Advantages

The advantages of successive approximation DVM are,

1. Very high speed of the order of 100 readings per second possible.
2. The method of ADC is inexpensive.
3. The resolution upto 5 significant digits is possible.
4. The accuracy is high.

Disadvantages

The disadvantages of successive approximation DVM are,

1. The circuit is complex.
2. The DAC is also required.
3. The input impedance is variable.
4. The noise can cause error due to incorrect decisions made by comparator.

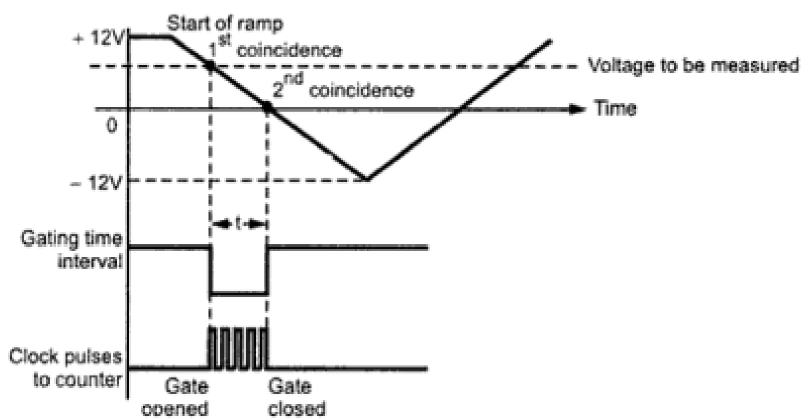
Ramp Type DVM

It uses a linear ramp technique or staircase ramp technique. The staircase ramp technique is simpler than the linear ramp technique. Let us discuss both the techniques.

Linear Ramp Technique

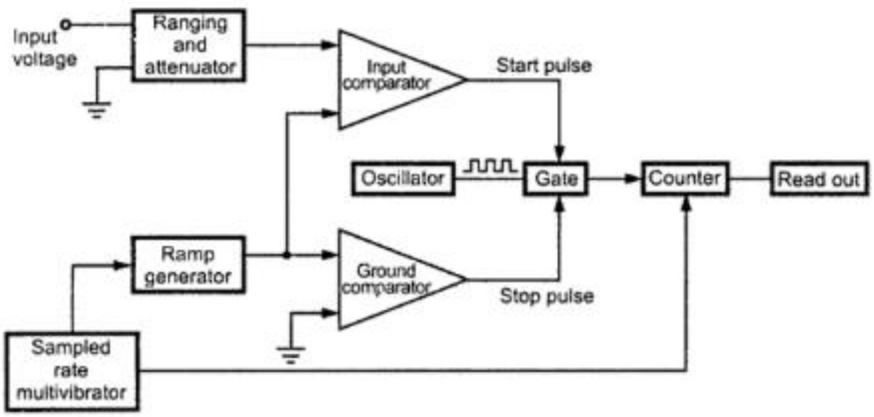
The basic principle of such measurement is based on the measurement of the time taken by a linear ramp to rise from 0V to the level of the input voltage or to decrease from the level of the input voltage to zero. This time is measured with the help of electronic time interval counter and the count is displayed in the numeric form with the help of a digital display.

Basically it consists of a linear ramp which is positive going or negative going. The range of the ramp is ± 12 V while the base range is ± 10 V. The conversion from a voltage to a time interval is shown in the Fig.



Voltage to time conversion

At the start of measurement, a ramp voltage is initiated which is continuously compared with the input voltage. When these two voltages are same, the comparator generates a pulse which opens a gate i.e. the input comparator generates a start pulse. The ramp continues to decrease and finally reaches to 0 V or ground potential. This is sensed by the second comparator or ground comparator. At exactly 0V, this comparator produces a stop pulse which closes the gate. The number of clock pulses are measured by the counter. Thus the time duration for which the gate is opened, is proportional to the input voltage. In the time interval between start and stop pulses, the gate remains open and the oscillator circuit drives the counter. The magnitude of the count indicates the magnitude of the input voltage, which is displayed by the display. The block diagram of linear ramp DVM is shown in the Fig.



Linear ramp type DVM

Properly attenuated input signal is applied as one input to the input comparator. The ramp generator generates the proper linear ramp signal which is applied to both the comparators. Initially the logic circuit sends a reset signal to the counter and the readout. The comparators are designed in such a way that when both the input signals of comparator are equal then only the comparator changes its state. The input comparator is used to send the start pulse while the ground comparator is used to send the stop pulse.

When the input and ramp are applied to the input comparator, and at the point when negative going ramp becomes equal to input voltages the comparator sends start pulse, due to which gate opens. The oscillator drives the counter. The counter starts counting the pulses received from the oscillator. Now the same ramp is applied to the ground comparator and it is decreasing. Thus when ramp becomes zero, both the inputs of ground comparator becomes zero (grounded) i.e. equal and it sends a stop pulse to the gate due to which gate gets closed. Thus the counter stops receiving the pulses from the local oscillator. A definite number of pulses will be counted by the counter, during the start and stop pulses which is measure of the input voltage. This is displayed by the digital readout.

The sample rate multivibrator determines the rate at which the measurement cycles are initiated. The oscillation of this multivibrator is usually adjusted by a front panel control named **rate,** from few cycles per second to as high as 1000 or more cycles per second. The typical value is 5 measuring cycles/second with an accuracy of ± 0.005 % of the reading. The sample rate provides an initiating pulse to the ramp generator to start its next ramp voltage. At the same time, a reset pulse is also generated which resets the counter to the zero state.

The **advantages** of this technique are :

i) The circuit is easy to design.

ii) The cost is low.

iii) The output pulse can be transferred over long feeder lines without loss of information.

iv) The input signal is converted to time, which is easy to digitise.

v) By adding external logic, the polarity of the input also can be displayed.

vi) The resolution of the readout is directly proportional to the frequency of the local oscillator. So adjusting the frequency of the local oscillator, better resolution can be obtained.

The **disadvantages** of this technique are :

i) The ramp requires excellent characteristics regarding its linearity.

ii) The accuracy depends on slope of the ramp and stability of the local oscillator.

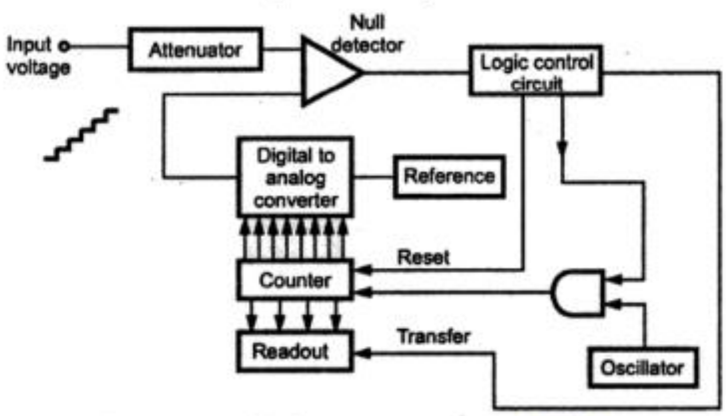
iii) Large errors are possible if noise is superimposed on the input signal.

iv) The offsets and drifts in the two comparators may cause errors.

v) The speed of measurement is low.

vi) The swing of the ramp is ± 12 V, this limits the base range of measurement to ± 10 V.

Staircase Ramp Technique



Staircase ramp type DVM

In this type of DVM, instead of linear ramp, the staircase ramp is used. The staircase ramp is generated by the digital to analog converter. The block diagam of staircase ramp type DVM is shown in the Fig.

The technique of using staircase ramp is also called

null balance technique. The input voltage is properly attenuated and is applied to a null detector. The another input to null detector is the staircase ramp generated by digital to analog converter. The ramp is continuously compared with the input signal.

Initially the logical control circuit sends a reset signal. This signal resets the counter. The digital to analog converter is also resetted by same signal.

At the start of the measurement, the logic control circuit sends a starting pulse which opens the gate. The counter starts counting the pulses generated by the local oscillator.

The output of counter is given to the digital to analog converter which generates the ramp signal. At every count there is an incremental change in the ramp generated. Thus the staircase ramp is generated at the output of the digital to analog converter. This is given as the second input of the null detector. The increase in ramp continues till it achieves the voltage equal to input voltage.

When the two voltages are equal, the null detector generates a signal which in turn initiates the logic control circuit. Thus logic control circuit sends a stop pulse, which closes the gate and the counter stops counting.

At the same time, the logic control circuit generates a transfer signal due to which the counter information is transferred to the readout. The readout shows the digital result of the count.

The **advantages** of this technique are :

i) The greater accuracy is obtained than the linear ramp technique.

ii) The overall design is more simple hence economical.

iii) The input impedance of the digital to analog converter is high when the compensation is reached.

The **disadvantages** of this technique are :

i) Though accuracy is higher than linear ramp, it is dependent on the accuracy of digital to analog converter and its internal reference.

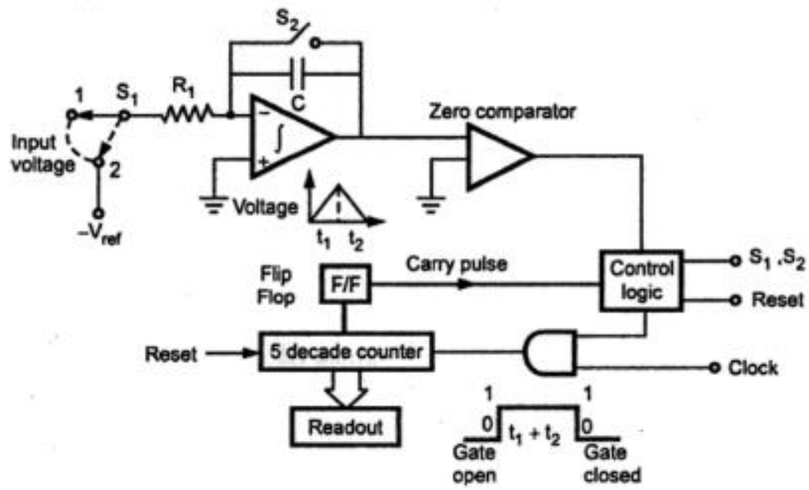
ii) The speed is limited upto 10 readings per second.

After the discussion of the non-integrating type of DVMs, let us see the operation and features of integrating type of DVMs.

Dual Slope Integrating Type DVM

This is the most popular method of analog to digital conversion. In the ramp techniques, the noise can cause large errors but in dual slope method the noise is averaged out by the positive and negative ramps using the process of integration. The basic principle of this method is that the input signal is integrated for a fixed interval of time. And then the same integrator is used to integrate the reference voltage with reverse slope. Hence the name given to the technique is **dual slope integration technique.**

The block diagram of dual slope integrating type DVM is shown in the Fig. . It consists of five blocks, an op-amp used as an integrator, a zero comparator, clock pulse generator, a set of decimal counters and a block of control logic.



Dual slope integrating type DVM

When the switch S_1 is in position 1, the capacitor C starts charging from zero level. The rate of charging is proportional to the input voltage level. The output of the op-amp is given by,

$$V_{out} = -\frac{1}{R_1 C}\int_0^{t_1} V_{in}\, dt$$

$$\therefore \quad \boxed{V_{out} = -\frac{V_{in}\, t_1}{R_1\, C}} \qquad \dots (1)$$

where t_1 = Time for which capacitor is charged

V_{in} = Input voltage

R_1 = Series resistance

C = Capacitor in feedback path

After the interval t_1, the input voltage is disconnected and a negative voltage $-V_{ref}$ is connected by throwing the switch S_1 in position 2. In this position, the output of the op-amp is given by,

$$V_{out} = \frac{1}{R_1 C}\int_0^{t_2} -V_{ref}\, dt$$

$$\therefore \quad \boxed{V_{out} = -\frac{V_{ref}\, t_2}{R_1\, C}} \qquad \dots (2)$$

Subtracting equation (1) from equation (2),

$$V_{out} - V_{out} = 0 = \frac{-V_{ref}\ t_2}{R_1\ C} - \left(\frac{-V_{in}\ t_1}{R_1\ C}\right)$$

$$\therefore \qquad \frac{V_{ref}\ t_2}{R_1\ C} = \frac{V_{in}\ t_1}{R_1\ C}$$

$$\therefore \qquad V_{ref}\ t_2 = V_{in}\ t_1$$

$$\therefore \qquad \boxed{V_{in} = V_{ref} \cdot \frac{t_2}{t_1}} \qquad \dots (3)$$

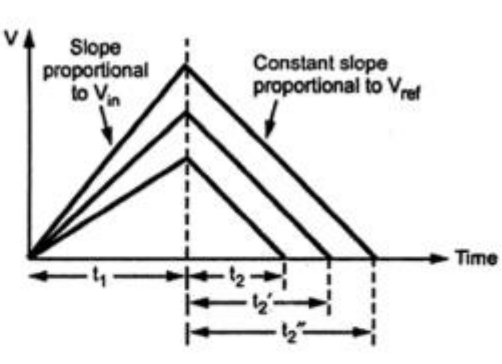


Fig. Basic principle of dual slope method

Thus the input voltage is dependent on the time periods t_1 and t_2 and not on the values of R_1 and C.

This basic principle of this method is shown in the Fig.

At the start of the measurement, the counter is resetted to zero. The output of the flip-flop is also zero. This is given to the control logic. This control sends a signal so as to close an electronic switch to position 1 and integration of the input voltage starts. It continues till the time period t_1. As the output of the integrator changes from its zero value, the zero comparator output changes its state. This provides a signal to control logic which inturn opens the gate and the counting of the clock pulses starts.

The counter counts the pulses and when it reaches to 9999, it generates a carry pulse and all digits go to zero. The flip flop output gets activated to the logic level '1'. This activates the control logic. This sends a signal which changes the switch S_1 position from 1 to 2. Thus $-V_{ref}$ gets connected to op-amp. As V_{ref} polarity is opposite, the capacitor starts discharging. The integrator output will have constant negative slope as shown in the Fig. 3.6. The output decreases linearly and after the interval t_2, attains zero value, when the capacitor C gets fully discharged.

At this instant, the output of zero comparator changes its state. This inturn sends a signal to the control logic and the gate gets closed. Thus gate remains open for the period $t_1 + t_2$. The counting operation stops at this instant. The pulses counted by the counter thus have a direct relation with the input voltage. The counts are then transferred to the readout.

From equation (3) we can write,

$$V_{in} = V_{ref} \cdot \frac{t_2}{t_1}$$

Let time period of clock oscillator be T and digital counter has counted the counts n_1 and n_2 during the period t_1 and t_2 respectively.

$$\therefore \qquad \boxed{V_{in} = V_{ref} \cdot \frac{n_2 T}{n_1 T} = V_{ref} \cdot \frac{n_2}{n_1}} \qquad \ldots (3)$$

Thus the unknown voltage measurement is not dependent on the clock frequency, but dependent on the counts measured by the counter.

The **advantages** of this technique are :

i) Excellent noise rejection as noise and superimposed a.c. are averaged out during the process of integration.

ii) The RC time constant does not affect the input voltage measurement.

iii) The capacitor is connected via an electronic switch. This capacitor is an **auto zero capacitor** and avoids the effects of offset voltage.

iv) The integrator responds to the average value of the input hence sample and hold circuit is not necessary.

v) The accuracy is high and can be readily varied according to the specific requirements.

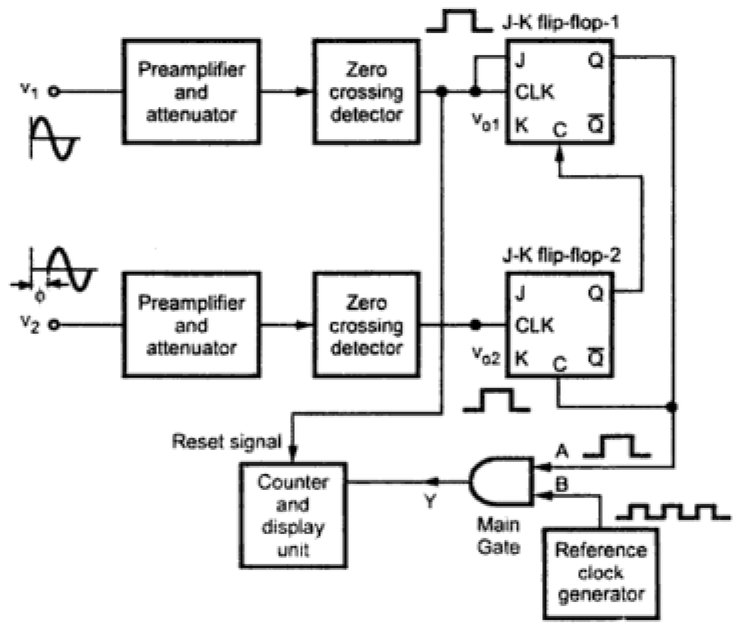
The only disadvantage of this type of DVM is its slow speed.

Digital Phase Meter

This phase meter uses two flip-flops. The two signals, having some phase difference, must have same frequency. In this meter, both the signals are shaped to a square waveform without any change in their phase relationship.

The function of the two flip-flops is to generate gate controlling signals. One of the flip-flops enables the gate, while other flip-flop disables the gate. The number of pulses allowed to pass during the period of enabling and disabling the gate are counted which are proportional to the phase difference between the two signals.

The schematic block diagram of the phase meter using flip-flops is as shown in the Fig.

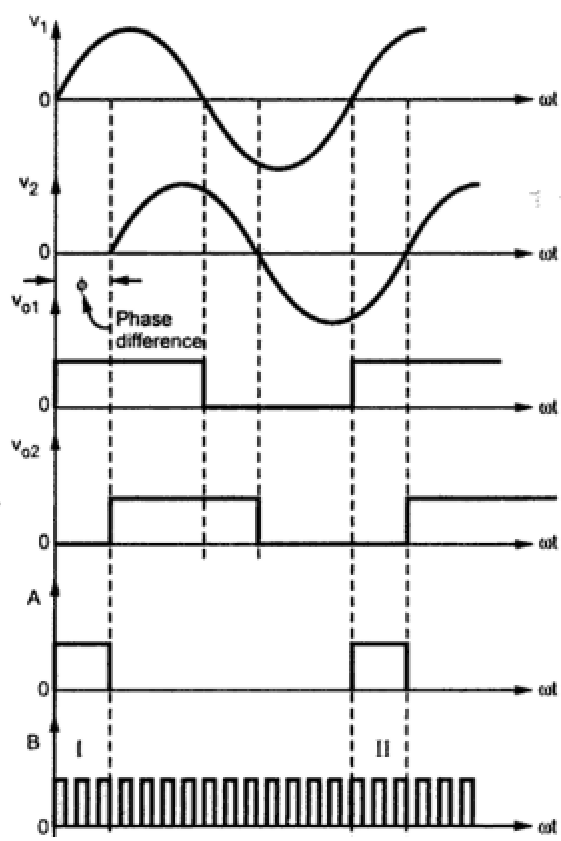


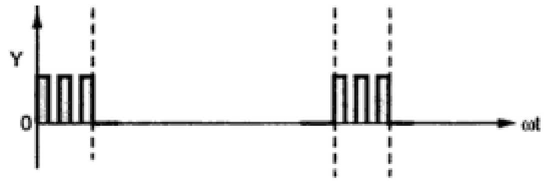
Phase meter using flip-flops

The phase meter consists of two preamplifiers, zero crossing detectors, J-K flip flops and output control gate. Let the phase difference between the two input signals be ϕ. Note that the frequency of the two signal is exactly same.

During the positive half cycle, when the amplitude of singal v_1 crosses zero, the zero crossing detector senses the zero crossing and changes its state. This causes first J-K flip-flop to be set. This enables the AND gate and allows the reference clock pulses to fed directly to the counter. Now second signal v_2 is having same frequency but its phase is lagging than that of the signal v_1 by $\phi°$. Thus during positive half cycle, when the amplitude of the signal v_2 crosses zero, the second zero crossing detector senses it and changes the state of second J-K flip-flop. This sets second J-K flip-flop. The output of second J-K flip-flop is used to clear the first J-K flip-flop. Thus output of the first J-K flip-flop goes low. This disables AND gate and counter stops counting.

Thus the total number of pulses counted is directly proportional to the phase difference. The waveforms for the phase meter with flip-flops are as shown in the Fig.





Waveforms of phase meter with flip-flop

The counter latches the count. For every new measurement of phase difference, the counter must be reset to get the accurate answer. The reset signal of the counter is obtained from the output of first zero crossing detector.

The **advantages** of the phase meter using flip-flop are :

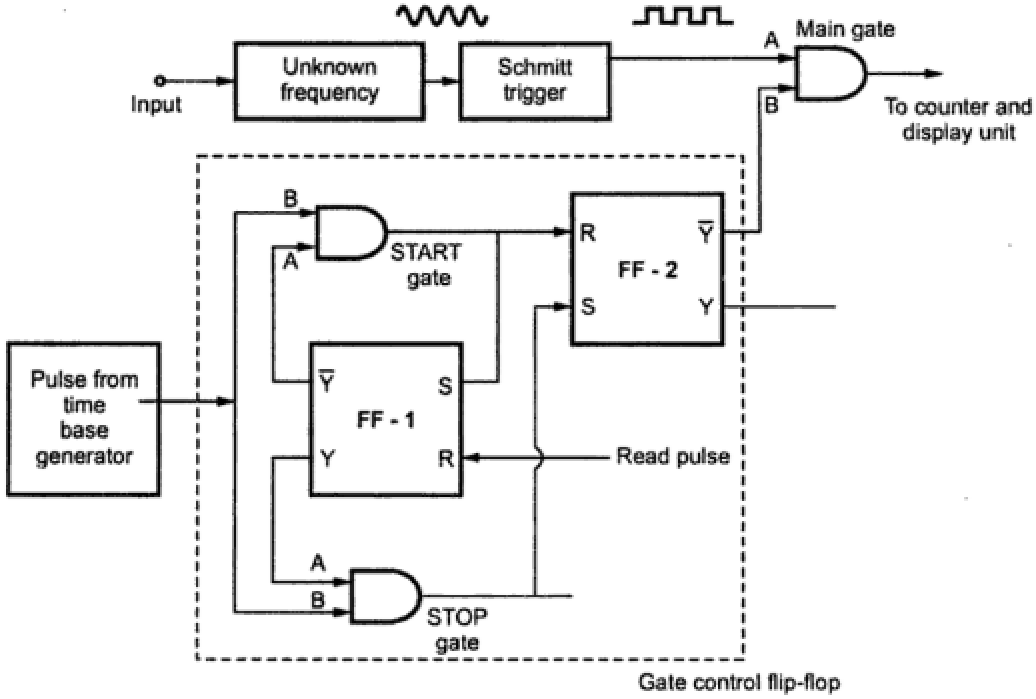
1. High accuracy.
2. Any phase difference i.e. leading or lagging can be detected and measured.
3. Circuit design is simple and speed of operation is fast.
4. Applicable for wide frequency range with higher reliability that the analog phase meter.

The **disadvantages** of the phase meter using flip-flop are :

1. The frequency of both the input signals must be same.
2. It is difficult to measure small phase differences.
3. For accurate results, the clock frequency should be 360 times the input frequency.
4. Errors are encorporated due to false triggering.
5. At low frequency operations, gating errors are included.
6. For accurate reference clock oscillator needs to be frequently calibrated.

Basic Circuit of Digital Frequency Meter

The basic circuit of digital frequency meter used for the measurement of frequency consists two R-S flip flops. The basic circuit for measurement of frequency is as shown in the Fig.



The output of unknown frequency is applied to the schmitt trigger which produces positive pulse at the output. These are **counted pulses** present at A of the main gate. The time base selector provides positive pulses at B of the START gate and STOP gate, both.

Initially FF - 1 is at LOGIC 1 state. The voltage from Y output is applied to A of the STOP gate which enables this gate. The LOGIC 0 state of the output $\overline{Y}$ is applied to input A of START gate which disables this gate.

When STOP gate enables, positive pulses from the time base pass through STOP gate to S input of FF - 2, setting FF - 2 to LOGIC 1 state.

The LOGIC 0 level of $\overline{Y}$ of **FF - 2** is connected to B of main gate, which confirms that pulses from unknown frequency source can't pass through the main gate.

By applying a positive pulse to R input of FF - 1, the operation is started. This changes states of the FF - 1 to $\overline{Y} = 1$ and $Y = 0$. Due to this, STOP gate gets disabled, while START gate gets enabled. The same pulse is simultaneously applied to all decade counters to reset all of them, to start new counting.

With the next pulse from the time base passes through START gate reseting FF - 2 and it changes state from LOGIC 0 to LOGIC 1. As $\overline{Y}$ changes from 0 to 1, the gating signal is applied to input B of the main gate which enables the main gate.

Now the pulses from source can pass through the main gate to the counter. The counter counts pulses. The state of FF - 1 changes from 0 to 1 by applying same pulse from START gate to S input of FF - 1. Now the START gate gets disabled, while STOP gate gets enabled. It is important that the pulses of unknown frequency pass through the main gate to counter till the main gate is enabled.

The next pulse from the time base generator passes through STOP Gate to S input of FF - 2. This sets output back to 1 and $\overline{Y} = 0$. Now main gate gets disabled. The source supplying pulses of unknown frequency gets disconnected. In between this pulse and previous pulse from the time base selector, the number of pulses are counted by the counter. When the interval of time between two pulses is 1 second, then the count of pulses indicates the frequency of the unknown frequency source.

Microprocessor Based Ramp Type DVM

The Fig. shows the block diagram of microprocessor based ramp type digital voltmeter.

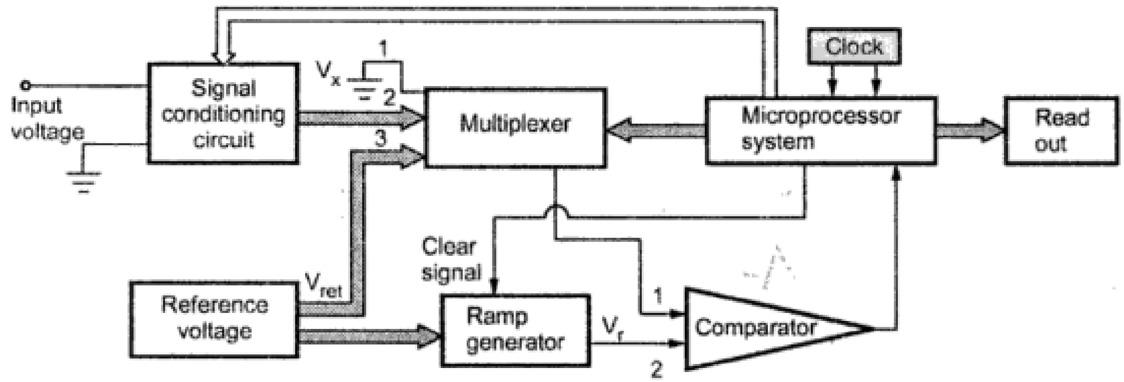


Fig. Block diagram of microprocessor based ramp type DVM

4.12.1 Operation

The multiplexer has three inputs,

1. The input 1 for ground potential.
2. The input 2 for unknown voltage V_x to be measured.
3. The input 3 for full scale reference voltage V_{ref}.

The comparator has two inputs,

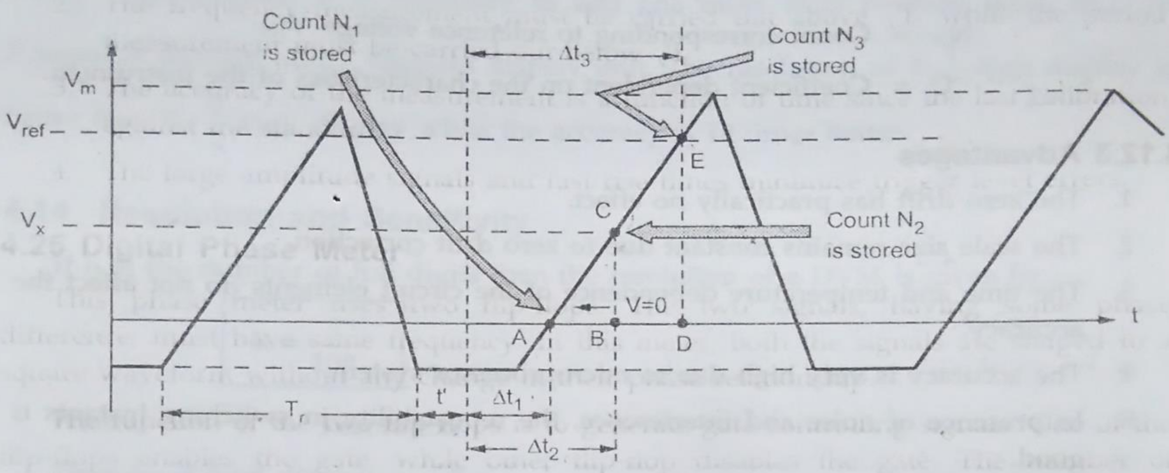
1. The input 1 as the output of the multiplexer.
2. The input 2 as the output of the ramp generator (V_r).

When microprocessor is in rest condition, it continuously sents clear signals to the ramp generator. For each clear signal, the capacitor of ramp generator discharges. It produces a ramp signal of time period T_r and amplitude V_m which remains constant.

When microprocessor receives conversion command at time t', then input 1 of multiplexer which is connected to ground decides the output of the multiplexer. This gets connected to input 1 of the comparator and brings it to ground potential. The microprocessor is in wait state till another sawtooth pulse begins.

The comparator compares the ramp voltage with ground potential (V = 0) from multiplexer and sends signal to the microprocessor, when two are equal. This is indication to the microprocessor that ramp voltage is zero. The corresponding time interval Δt_1 is measured by the microprocessor interms of number of clock pulses supplied by the clock generator during this time interval. This count is N_1 which is stored by the microprocessor.

Now microprocessor sends a command which connects input 2 of multiplexer which is signal to be measured to the input 1 of comparator. The comparator starts comparing this V_x with the ramp available at its input 2. When the ramp voltage equals the voltage V_x, comparator sends a signal to the microprocessor which then measures the time interval Δt_2 as shown in the Fig. . The count N_2 corresponding to the interval Δt_2 is stored in the microprocessor.



Waveforms of microprocessor based ramp type DVM

The microprocessor sends command to connect comparator input 1 to the multiplexer input 3 which is V_{ref}. When ramp voltage becomes equal to V_{ref} which is full scale value, the pulse is given to the microprocessor due to which it measures time interval Δt_3. It stores the corresponding count N_3.

Expression for the Voltage V_x

In the Fig. the triangles ADE and ABC are similar triangles.

$$\therefore \quad \frac{DE}{AD} = \frac{BC}{AB}$$

$$\therefore \quad \frac{V_{ref}}{\Delta t_3 - \Delta t_1} = \frac{V_x}{\Delta t_2 - \Delta t_1}$$

$$\therefore \quad \boxed{V_x = V_{ref}\left[\frac{\Delta t_2 - \Delta t_1}{\Delta t_3 - \Delta t_1}\right]} \quad \text{.... (1)}$$

Practically clock pulse repetition frequency f_c and reference voltage V_{ref} are maintained constant with high level of stability. Hence the above equation is expressed interms of the counts N_1, N_2 and N_3 measured by the microprocessor as,

$$\therefore \quad \boxed{V_x = C\left[\frac{N_2 - N_1}{N_3 - N_1}\right]} \qquad \text{... (2)}$$

Where N_1 = Count corresponding to zero drift.

N_2 = Count corresponding to unknown voltage V_x.

N_3 = Count corresponding to reference voltage V_{ref}.

C = Coefficient dependent on the characteristics of the instrument.

Advantages

1. The zero drift has practically no effect.
2. The scale size remains constant due to zero drift correction.
3. The time and temperature dependence of the circuit elements do not affect the accuracy.
4. The accuracy is very high due to microprocessor system.
5. In presence of noise and interference, the repeatability in switching instants is good.

Disadvantage

The main disadvantage is that the noise and interference cannot be suppressed.

Introduction

In many industrial applications, it is required to measure large number of meachanical quantities like temperature, pressure, flow, velocity acceleration and so on. These quantities are measured with high degree of accuracy by using primary measuring system which is made up of primary sensing element or sensor and additional supporting elements. To measure above mentioned mechanical quantities, the mechanical transducers are used. These are primary sensing elements which are in direct contact with system and follow the changes in system during measurement. The mechanical transducers converts the physical quantity. Measured into some other form of energy. The main difference between the mechanical and electrical transducers is that the electrical transducers respond to non-electrical quantities by delivering output signal which is electrical in nature. But the mechanical transducers respond to the mechanical quantities and developes output signal which is also mechanical by nature. For example diaphragms, capsules or bellows are used as pressure transducer or sensors. All these pressure sensors produce output signal in the form of displacement. So the quantity measured by the pressure transducer and the corresponding output signal both are of mechanical type. In this chapter, we will discuss measurement of various mechanical quantities such as displacement, velocity, angular velocity, acceleration, force torque etc.

Measurement of Displacement

In general, displacement can be classified as

a) Translational displacement, and

b) Rotational displacement.

The motion of a body in a straight line between two points is called **translational displacement.**

The motion of a body of angular type, about some rotation axis is called **rotational displacement.**

In practice different variety of translational displacement transducers and rotational displacement transducers are available. The translational displacement transducers are useful not only to measure the translational motion but can be used as secondary transducers in measurement systems which are used to measure various physical quantities like pressure, force acceleration and temperature. In such systems, the basic physical quantities are translated into a translational motion by promary transducers and then the quantity is sensed by the translational displacement transducers. Similarly the rotational displacement transducers measures not only the rotational displacement of the body but also the translational displacement of a body by converting translational motion into rotary form.

Translational Displacement Transducers

In practice, wide range of translational displacement transducer is available. Let us discuss few translational displacement transducers one by one.

Resistive Potentiometer Translational Displacement Transducer

A simple resistive potentiometric translational displacement transducer consists of a resistive element along with a sliding contact which is movable in nature as shown in the Fig.

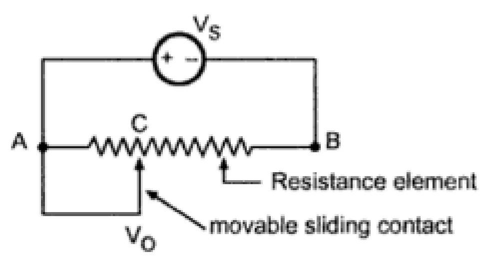


Fig. Simple Resistance Potentiometer

The supply voltage V_S is applied across terminals AB. i.e. across the resistance element. The voltage measured across the sliding contact is output voltage V_O which is measured between contacts A and C. The relationship between voltages and distances is given by,

$$\frac{V_O}{V_S} = \frac{AC}{AB} \qquad \text{... (1)}$$

The body whose motion is to be measured is connected to the sliding element, so when the body moves translationally and it causes equal magnitude slide movement and corresponding change is output voltage V_O.

Depending upon material used for the construction of resistance element, the potentiometers are classified as wire wound, carbon film and plastic film potentiometers out of these three resistive potentiometers, wire wound resistive potentiometer is made up of a coil of resistance wound on a non-conducting former. It has lesser resolution as compared with other potentiometer types. The selection of potentiometer depends on the range of instruments along with power rating and linearity considerations. The life of such potentiometers depends on the number of times the slider moved backward and forward along the slide. The life time and resolution both are better in the carbon film and the conducting plastic film resistive potentiometers.

Linear Variable Differential Transformer

The **linear variable differential transformer** is also called **linear variable displacement transducer (LVDT).** It consists of a transformer with single primary winding and two secondary windings. The secondary windings are connected in series opposition as shown in the Fig.

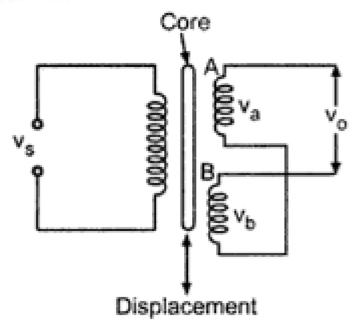


Fig. LVDT

The object whose translational displacement is to be measured is physically attached to the central core which is usually an iron core. The core moves linearly, when the translational displacement is attached to it. When the core moves forward or backward, then depending on that output voltage changes. When the core is at central position, the e.m.f. induced in both the secondaries is of same amplitude and phase hence both cancel out and output becomes zero. This is called **null position.** The null position is important in case of the measurement of displacement on both the sides of the null position. The displacement can be found out by measuring amplitude and phase of the output voltage. The magnitude of the output voltage indicates how much displacement takes place, while the phase of output voltage indicates the direction of the displacement.

This type of transducer is most widely used to measure linear displacements because the only moving part of the transducer i.e. iron core moves in the air gap between winding without any friction or wear during operation. Alongwith this, as compared with other translational displacement transducer, LVDT has high accuracy and almost infinite resolution. The major advantage of this transducer is its insensetivity to mechanical shocks and vibrations. The drawback of LVDT is that its accuracy gets affected due to the hormonics in the supply voltage and the stray capacitances.

Variable Inductance Translational Displacement Transducers

There are three important types of the inductive transducer which are used for the measurement of linear displacement. Such transducers are based on

A) Change in inductance of coil with number of turns :

This is the simplest form of the linear displacement transducer which is based on the principle that when the number of turns are changed, the self inductance of coil changes and thus output also changes accordingly. Such transducers use air core.

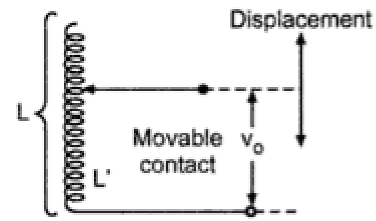


Fig. Linear Inductive Transducer

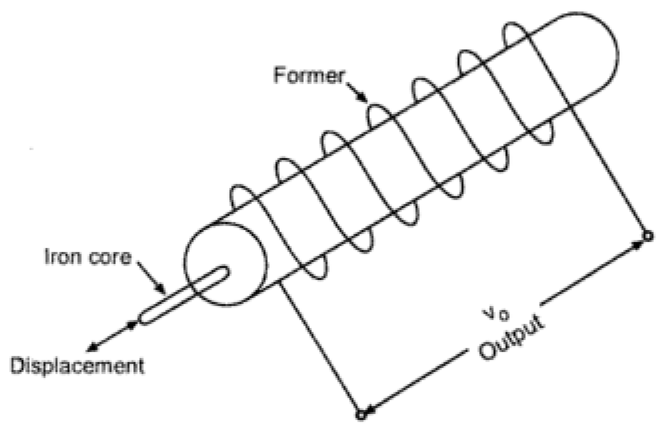


Fig. Linear Displacement Inductive Transducer

B) Change in Inductance With Change in Permeability

Such inductive transducer consists ferromagnetic former surrounded by coil. The iron core moves inside and outside winding. Due to this permeability changes and so the inductance changes. Thus the output voltage also changes.

C) Change in Reluctance

In this type of inductive transducer, a coil is wound on the ferromagnetic core. The displacement to be measured is applied to the target which is mode up of iron. This iron target which is made up of iron. This iron target is physically separted from the ferromagnetic core by air gap. The self inductance of coil is inversely proportional to the air gap. When the target is very close to the core, the air gap is least, so the inductance of coil is highest. As the target moves away from core, the air gap increases in length and thus self inductance of coil decreases.

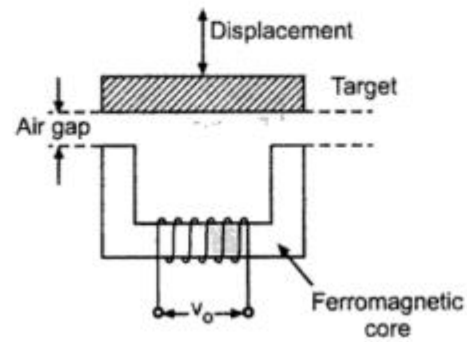


Fig. Linear Displacement Inductive Transducer Based on Variable Reluctance

Let L be the self inductance of the coil which is given by,

$$L = \frac{N^2}{R_I + R_{AG}}$$

Where N = number of turns

R_I = reluctance of iron parts

R_{AG} = reluctance of air gap.

Note that the reluctance of iron parts is negligible as compared with that of air gap. Hence we can assume

$$L = \frac{N^2}{R_{AG}}$$

But the reluctance of air gap is given by,

$$R_{AG} = \frac{l_g}{(\mu_0)(A_g)}$$

Where l_g = length of air gap

A_g = area of flux path

But μ_0 and A_g are constants, so we can assume R_{AG} is directly proportional to the length of air gap. Hence the self inductance of the coil is proportional to the length of air gap inversely i.e. $L \propto \frac{1}{l_g}$.

Variable Capacitance Displacement Transducers

The linear dispalcement measurement is also possible on the basis of principle of variable capacitance similar to variable inductance.

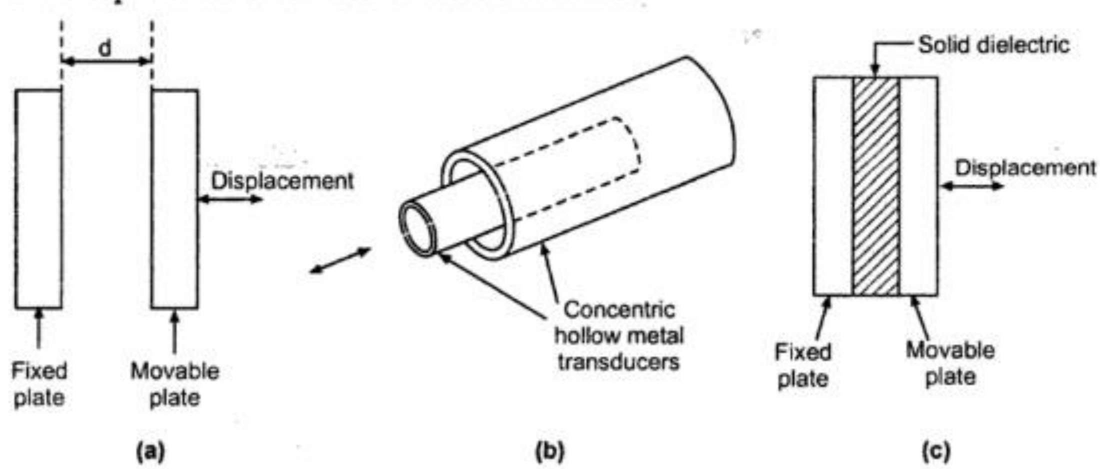


Fig. Variable Capacitance Displacement Transducer

The Capacitive transducers shown in the figures (a) & (b) above uses air as dielectric while the transducer shown in (c) uses solid dielectric. When the inner conductor is moved inside outer conductor due to the displacement applied to the inner conductor due to the displacement applied to the inner conductor, the capacitance changes. Such capacitive transducer with two concentric hollow cylinders is as shown in the figure (b). In other two types, out of two plates one is fixed while other is movable, to the movable plate.

With the displacement movable plate moves and so the distance of separation between two plates varies and thus in turn capacitance value also varies.

Optical Fiber Displacement Sensor

The displacement sensor in the fiber optics are of extrinsic type. For the measurement of the displacement, the intensity modulation of the transmitted light beam is used in the extrinsic reflective or fotonic photo sensor as shown in Fig.

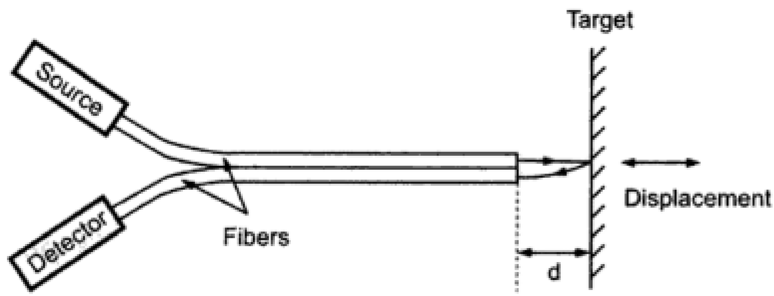


Fig. Relative or fotonic type optical displacement sensor

The light reflected from the target is collected by a return fiber or fiber bundle. The reflected light is the function of distance between the fiber ends and the target. Hence we must mark the position or the displacement of the target at the optical detector. The sensitivity of this displacement sensor may be further increased by placing the axes of the feed fiber and the return fiber at some finite angle to one another and to the axis of target as well. The main disadvantage of this technique is that its accuracy is less due to source, detector and fiber cable instabilities. This is the common feature of the intensity modulated fiber sensors.

Above drawback can be overcome by using digital measurement techniques. Fig. shows a typical displacement measurement technique using a Moire fringe modulator.

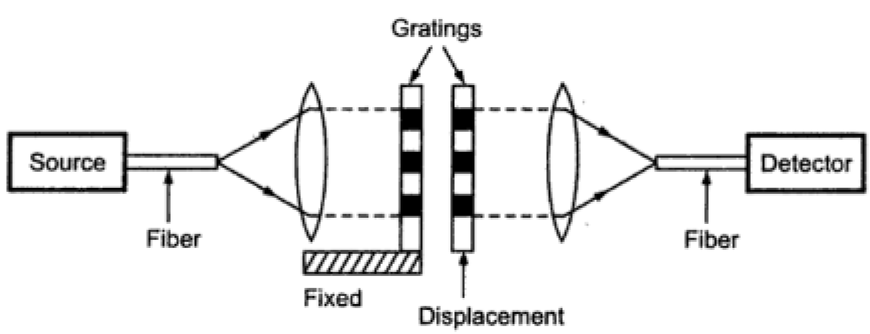


Fig. Moire fringe modulation displacement sensor

In this case two gratings are used. One is kept fixed while the displacement is given to the other movable grating. The alternating transparent and opaque lines are present on the gratings.

The alternating transparent and opaque lines are present on the gratings. The opaque lined grating provides dark Moire fringes. The transverse movement of one movable grating with respect to the other fixed grating gives rise to up and down movement of fringes. Thus, the count of the fringes as the gratings are moved provides measurement of displacement. In this sensor, the sensitivity is more as the fringe counting is independent of instabilities within the system. However, the mechanical vibrations affect the accuracy of measurement. There is main disadvantage of this system such as the count may be lost if the optical power to the sensor is interrupted.

Optical Encoders for Linear and Rotary Displacement

A typical sector may be designed with a pattern of alternate or may be randomly placed opaque and transparent areas. Alight source and photo sensor working as a detector, both are placed on the two sides of the sector. Then the displacement is applied to the sector. This changes the amount of light falling on the photo electric sensor because of opaque and transparent areas on the sector. The pattern of illuminated sensor is then carried to the location of sector. These gives clear true digital readout. As there are no mechanical contracts, the wear and tear and alignment problems are not present.

These encoders converts linear or the angular position of shaft into corresponding digital signal. Here mechanical motion acts as a analog signal, thus it acts as a analog to digital converter. These encoders are known as special encoders.

There are basic two types of special encoders. The encoder that is used to convert or encode the mechanical motion or position along straight line is called as linear position or displacement encoder. The encoder that provides the conversion of rotating shaft position into digital signal is called as shaft encoder or rotary encoder. Th angular velocity encoder is called as a tachometer while linear encoder is called as a linear velocity transducer (LVT).

Linear Encoder

The principle of the linear encoder is based on the ON or OFF switching of multiple tracks. Each slot represents a bit either in BCD or binary format. The format may be natural binary or Gray code. The tracks on sector are either opaque or transparent.

The opaque parts are the shaded areas which are made up of conducting material while the transparent parts are the unshaded areas which are made up of non-conducting material. The transducer are having brushes. These brushes act as sliding contact. When the conducting material comes in contact with the sliding contact, the circuit gets completed. While for the non-conducting material contact with the sliding contact, the circuit cannot be completed. In this way the encoder gives out a digital output which is the indication of position and hence the displacement is determined.

The linear encoder rely on the use of Moire's fringe techniques. The Moire fringe technique is capable of much higher resolution for the incremental measurement.

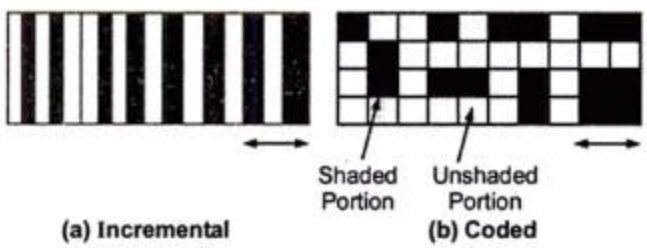


Fig. Types of linear encoder

Advantages

1. These are relatively inexpensive.
2. These are very much suitable for slowly moving systems.
3. The desired accuracy can be obtained by using sector accommodating rows for binary numbers.

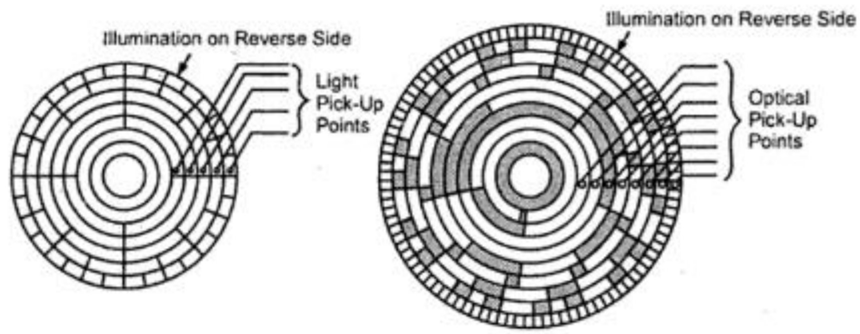
Disadvantages

1. The main disadvantage is of the wear of contractors.
2. The maintenance of the contractor is required.
3. There is often an ambiguity of one digit in least significant binary digits.

Rotary Encoders

These are also called as shaft encoders. This rotary encoder is used for measurement of the angular position.

In rotary encoders, the sensing is done with large number of gear teeth. The sensing can be done either by direct electrical contact or by electromagnetic induction pickup mechanism. Using this angular measurement is also possible. Sometimes, there is a glass disk mounted actually on the shaft, on the disk, the special coding pattern is printed, as per the output required. The pattern is made with either ink or paint which is opaque to the infrared. The older shaft encoders used mechanical contacts using wire brushes and conductive disks. But the disadvantages of mechanical contacts are more wear and tear of the contacts, mechanical drag on encoder, electrically very noisy and may get damaged due to rough use. But the encoders which are in most



(a) Special binary counting system encoder **(b) Binary coded decimal disk converter**

Fig. Special rotary encoders

widely use are of optical type so that there are no contacting parts so the wearing of contacts is avoided.

As per the requirement of code, the pattern is generated by concentric rings on the disk. For the angular displacement, instead of length of a scale, we have to consider the circumference of a circle on a flat disk. Disk is then divided into concentric circular tracks. Then each track is again divided into segments in accordance with the code being used.

For binary coding, the innermost track is divided into two equal parts. The next track is divided into four equal parts and so on. The alternate segments on each track are made transparent and other as opaque. Because of the opaque and transparent , the light and photo calls are used. The segments may be reflecting or non-reflecting or conducting and non-conducting. The accuracy depends upon the number of tracks.

Encoder For Clockwise and Anticlockwise Direction

The incremental encoder is used to measure the motion in both directions i.e., clockwise or anticlockwise.

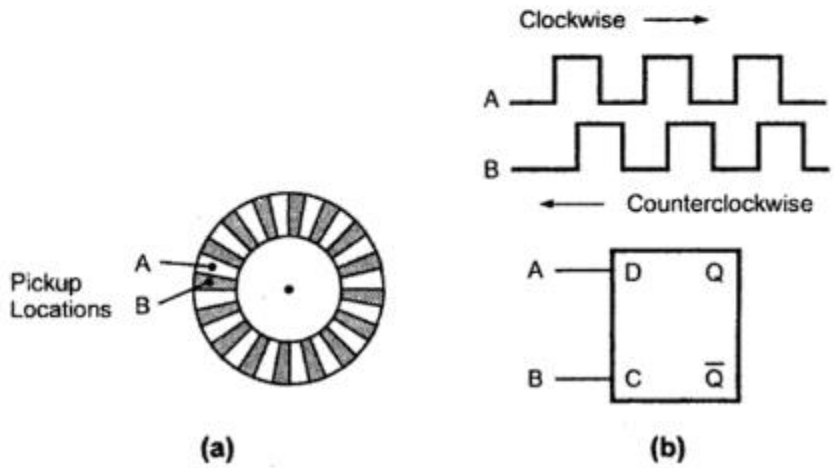


Fig. Incremental shaft encoder and logic

The square waves shown can be traversed in either direction i.e. for clockwise and anticlockwise. The lower waveform is given as a clock input to D flip flop. When we have clockwise rotation, the positive transistors always give clock as 1 state of upper waveform.

In opposite direction, the positive transition of lower waveform clock in a logic 0 state into the D flip-flop. Thus the Q output indicate direction of rotation.

Velocity Transducers

With the help of velocity transducers it is possible to measure linear velocity as well as angular velocity. Many times to measure linear velocity, it is first converted into angular velocity and then it is measured. Let us study linear velocity and angular velocity measurement techniques in detail.

Linear Velocity Transducers

In linear velocity transducers, the mechanical vibrations are converted into alternating voltages based on the principle of electromagnetic induction. Hence these transducers are also called **Electro-magnetic transducers**. There are two types of the electro-magnetic transducers.

i) Moving coil type and ii) Moving magnet type

Moving Coil Type Velocity Transducer

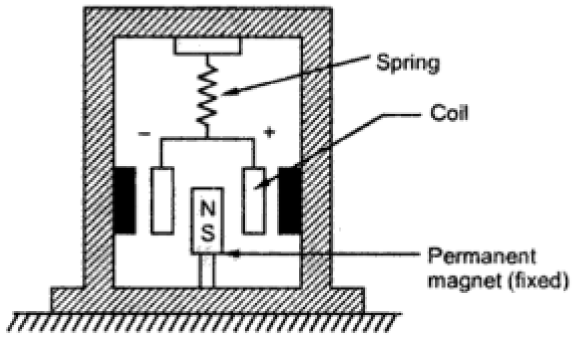


Fig. Moving coil type velocity transducer

The moving coil type velocity transducer operation is based on the action of the moving coil in a magnetic field. The construction of such transducer is as shown below in Fig.

In this transducer, a coil is suspended between the pole pieces of the permanent magnet with the help of the spring assembly. The voltage is generated due to the motion of the coil in the magnetic field. Hence the output is proportional to the velocity of the coil. But this is the relative velocity of the coil with repect to the permanent magnet. Above system is also termed as electro dynamic pick-up system. This system is useful in the measurement of linear, sinusoidal or random velocities.

The voltage induced in the coil at any instant of time is given by.

$$e_0 = B \cdot l \cdot v \qquad \text{... (1)}$$

where e_0 is the output voltage, B is the flux density, l is the length of coil and v is the relative velocity of the coil with respect to the permanent magnet which is fixed.

Advantages :

i) The system forms closed magnetic circuit with constant air gap.

ii) The assembly is kept inside antimagnetic material case, hence the effects of stray magnetic fields are reduced.

iii) Damping is achieved by an electrical means, hence under varying temperature conditions the system provides high stability.

Moving Magnet Type Velocity Transducers

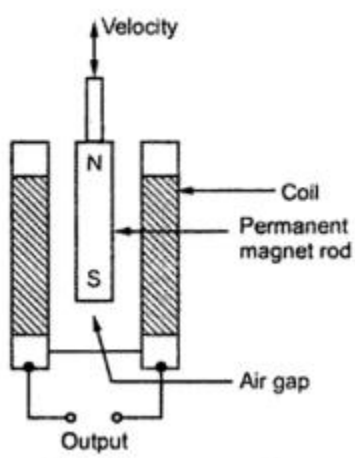


Fig. Moving magnet type velocity transducer

In this transducer, a constant polarized field is obtained with the help of permanent magnet. The construction of the transducer is as shown in the Fig.

A coil surrounds a permanent magnet rod whose velocity is to be measured. The motion of rod induces a voltage in the coil whose amplitude is proportional to the velocity of the rod. The polarity of the output voltage determines the direction of motion.

Advantages :

i) There are no mechanical surfaces or contacts, hence the maintenance required is negligible.

ii) The output voltage is linearly proportional to the velocity .

iii) Robust and less expensive.

Disadvantages :

i) The stray magnetic fields affects the performance of these transducers.

ii) Limited frequency response.

iii) As the contacts with steel wools demagnetize progressively deterioting the calibration, hence these transducers are not very useful for the vibration measurements.

Angular Velocity Transducers :

The main disadvantage of the linear velocity measurement is that for large distance travel it is very difficult to detect the fixed reference. In such cases, angular velocity transducers are used and linear velocity is measured by converting it into angular velocity.

The measurement of speed can be done with the help of tachogenerator. The tachogenerators are of two types.

i) Electrical type tachogenerators.

ii) Mechanical type of tachogenerators.

But electrical type tachogenerators are prefered over mechanical type tachogenerators as the electrical transducers are always advantageous as compared to mechanical type tachogenerators.

Let us discuss electrical type tachogenerators.

D.C. Tachogenerators

The d.c. tachogenerator is as shown in the Fig. 7.14.

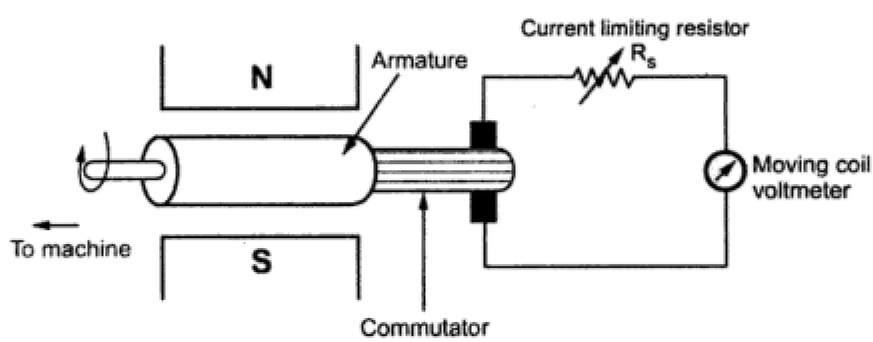


Fig. D.C. Tachogenerator

The armature of the d.c. tachogenerator is kept in the permanent magnetic field. The armature of the tachogenerator is coupled to the machine whose speed is to be measured. When the shaft of the machine revolves, the armature of the tachogenerator revolves in the magnetic field producing an e.m.f. which is proportional to the product of the flux and speed to be measured. Now as the field of permanent magnet is fixed, the e.m.f. generated is proportional to the speed directly. The e.m.f. induced is measured using moving coil voltmeter with uniform scale calibrated in speed directly. The series resistance is used to limit the current under output short circuit condition. The polarity of output voltage indicates the direction of rotation. The commutator collects current from armature conductors and converts internally induced a.c. e.m.f. into d.c. (unidirectional) e.m.f. While the brushes are used to collect current from commutator and make it available to external circuitry of the d.c. tachogenerator.

Advantages :

The advantages of d.c. tachogenerator are as follows :

i) The output voltage is small enough to measure it with conventional d.c. voltmeters.

ii) The polarity of output voltage directly indicates the direction of rotation.

Disadvantages :

The disadvantages of d.c. tachogenerator are as follows.

i) Because of variations in contact resistances, considerable error is introduced in the output voltage. Hence periodic maintenance of the commutator and brushes is required.

ii) Non-linearity in the output of the d.c. tachogenerator occurs because of distortions in the permanent magnetic field due to large armature currents. Hence input resistance of meter should be very high as compared to the output resistance of the generator.

A.C. Tachogenerator

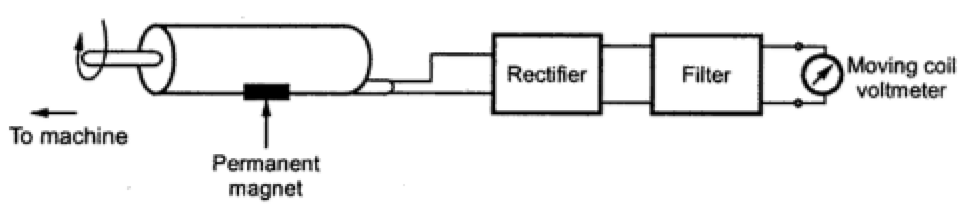


Fig. A.C. tachogenerator

The coil is wound on stator itself. In this tachogenerator, the magnetic field is rotating. The magnetic field can be obtained by using electromagnet or permanent magnet. Due to rotation of magnet, an e.m.f. induces in the stator coil which has amplitude and frequency directly proportional to the speed of rotation. Thus the speed of rotation can be calibrated in terms of either amplitude or frequency of the induced voltage.

In the circuit shown in the Fig. 5.80 , the amplitude of the induced voltage is used to measure speed. A rectifier and filter are used to get constant d.c. voltage which can be measured with the help of the moving coil voltmeter.

Advantages :

The advantages of a.c. tachogenerator are as follows.

i) The output can be calibrated in terms of two parameters namely amplitude and frequency of induced voltage.

ii) Commutator and brush contact resistance problems are eliminated as the coil is wound on stator.

Disadvantages :

The disadvantages of a.c. tachogenerator are as follows.

i) For very low speed rotation, the frequency of the induced voltage is also very low, thus the ripple in the output increases. To overcome this the number of poles of stator are increased, so that the frequney of the induced voltage increases even at low speeds of rotation.

ii) At high speeds, the frequency of the induced voltage is also very high. Thus the coil impedance increases. This effects linearity of the output. To maintain the good linearity, the display device used should have input impedance greater than that of the coil.

Eddy Current Tachometer

This is the simplest form of the speed measurement. A permanent magnet with N and S poles is coupled with test shaft mechanically. An aluminium disc is placed facing the poles of the magnet as shown in the Fig.

The disc is mounted on another shaft using spring. At the end of the shaft a point is connected which gives directly speed reading.

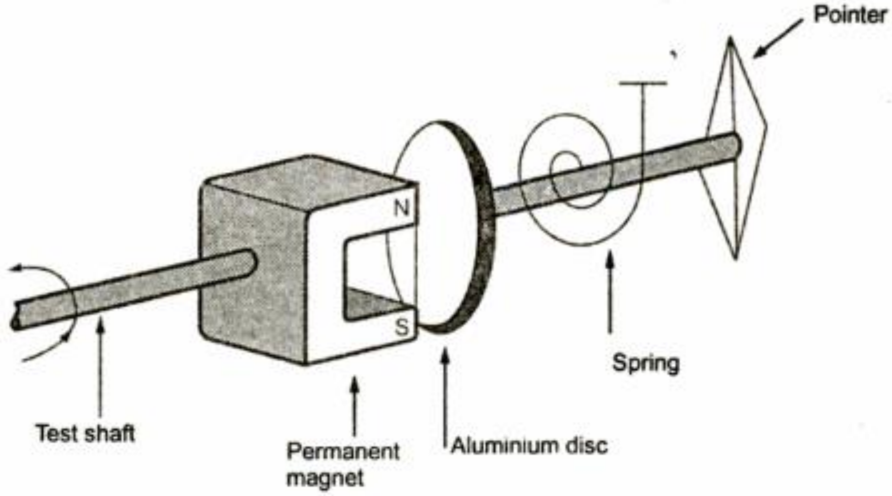


Fig. Eddy current tachometer

When the permanent magnet is rotated using test shaft, the e.m.f. gets induced in to the disc. Due to the induced e.m.f. in disc, the eddy currents start circulating. But these eddy currents interact with the magnetic field of the permanent magnet producing deflecting torque. Due to this deflection torque, the disc rotates. But as it is connected with spring, the balanced condition is obtained when deflection torque is balanced by the restoring torque produced by the spring. As pointer is attached to the shaft at the end of it, it directly gives the speed of rotation.

Thus the angular velocity is directly proportional to the speed of shaft i.e. speed of rotation being measured.

Drag Cup Rotor A.C. Tachogenerator

A drag cup rotor a.c. tachogenerator consists a stator and rotor as shown in the Fig. The stator has two windings placed perpendicular to each other. The stator windings are called

i) Excitation winding

ii) Sensing winding

The **excitation winding** is one at which a.c. voltage is applied while the **sensing winding** is that across which output is measured.

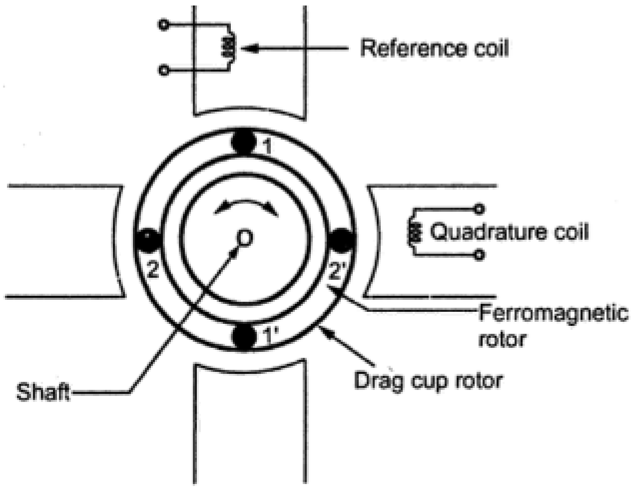


Fig. Drag cup rotor a.c. tachogenerator

The rotor is made up of copper or aluminium. It is of thin cylinder type which is hollow inside. It is called **drag cup**. This drag cup is connected to the tachometer through the iron shaft rotating at speed under measurement. This light inertia rotor is highly conducting. Thus it acts as short circuited secondary winding.

With a.c. voltage applied to the excitation winding, an alternating magnetic field is produced. Due to this magnetic field, eddy currents induced in the drag cup rotor. Due to the induced eddy currents armature reaction field is produced at right angles to the field set up by the excitation winding. This field induces e.m.f. in the output winding. When rotor is in stationary condition, the output is zero. The rotation in any direction produces a.c. output voltage which is frequency same as that of the excitation voltage. Only the difference is that if in one direction of rotor rotation, output voltage and excitation voltage are in phase, then for other direction, the phase of the output voltage is reversed as compared with previous. **The amplitude of the output voltage is proportional to the instantaneous speed for both orientations of rotation of rotor. This indicates that the drag cup rotor a.c. tachogenerator indicates the speed of rotation and the direction of rotation.**

Advantages :

i) Simple rugged construction.

ii) Low cost instrument with less maintenance.

iii) Output is ripple free.

iv) The output voltage has linear relationship with speed if the input frequency is large about 400 Hz.

Disadvantages :

i) It is required to maintain input excitation absolutely constant.

ii) It is very difficult to calibrate tachometer.

iii) At very high frequencies, above 400 Hz, the relationship between the speed and the output voltage becomes non-linear.

7.5.5 Digital Methods for Measurement of Angular Velocity

In previous sections, we discussed electromechanical methods for the measurement of angular velocity. These methods can be used effectively for speeds of 10,000 r.p.m. or less. For higher speeds, the electromechanical transducers are not the best options. Instead, various **digital methods in which digital pick-ups used with digital frequency counters** are used. The main advantages of using these digital methods is that there is no physical contact between the shaft whose speed to be measured and the measuring device and thus the loading of shaft is avoided. There are two main types of digital methods or pick-ups namely,

A) Photoelectric type tachometer and B) Inductive type tachometer

A) Photoelectric tachometer : In this method, an opaque disc is mounted on a rotating shaft. Along the periphery of the disc, there are equidistant holes several in number. At one of the sides of a disc, a light source is fixed. Along the same axis, on other side of the disc a light sensor is placed on the line of light source. Typically light sensor used is phototub or any photosensetive semiconductor device. When shaft rotates at an unknown speed, the disc with equidistant holes also rotates with same speed. When a hole comes infront of light source, the light passes through it and falls on the light sensor which ultimately produces a pulse. But when an opaque portion of the disc in between two holes comes in front of light source, no light can pass through it hence the light sensor remain unilluminated and thus no output is produced. The output pulses produced with hole in between light source and light sensor are connected to the electronic counter which is calibrated interms of speed rotation directly. The number of pulses produced depends on the number of holes on disc and the angular speed. As the number of holes on a disc is constant, the pulses produced are directly the function of rotational speed. The set-up a photoelectric tachometer is as shown in the Fig. 7.17.

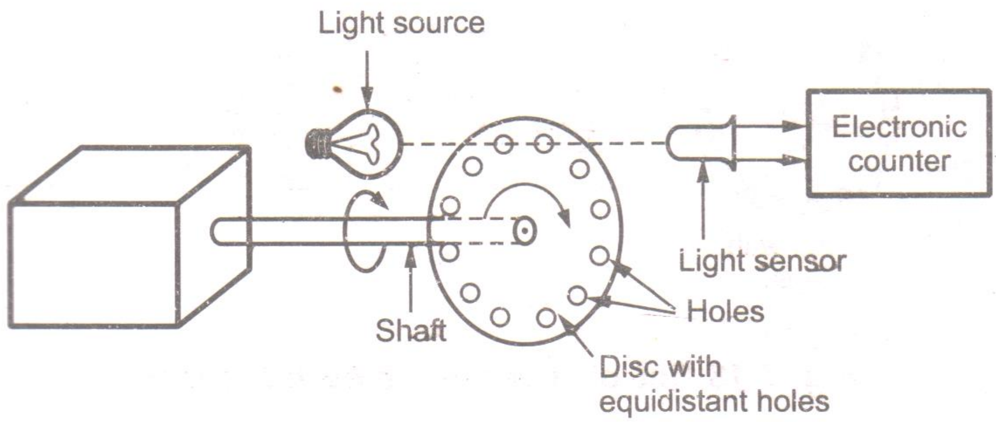


Fig. 7.17 Photoelectric tachometer

Advantages

i) The output of a tachometer is pulsed output. That means the output is in digital form. So when such photoelectric transducer is used in any digital instrumentation system, no additional ADC (analog to digital signal converter) is required.

ii) The amplitude of pulses produced everytime is constant, hence complex electronic circuitary is not required.

Disadvantages

i) The life time of a light source is the major drawback. Typically the life time of a light source is 50,000 to 60,000 hours. Hence it is necessary to replace light source time to time.

ii) The accuracy of the method depends on error represented by one pulse. If the period during which frequency is measured by counting pulses i.e. **gating period** is too short, a serious error is caused. Hence gating period should be selected so that large count is obtained.

3) Toothed rotor variable reluctance tachometer - inductive type tachoemeter

A toothed rotor variable reluctance tachometer is an inductive type tachometer. In this tachometer, a metalic rotor with number of tooth is mounted on a shaft whose speed is to be measured.

A magnetic pick-up is placed near toothed rotor. A magnetic pick-up consists a small permanent magnet with a coil wound around it as shown in the Fig. 7.18. When the shaft rotates, the toothed rotor also rotates. When rotor rotates, the reluctance of air gap between it and a magnetic pick up changes. This ultimately induces e.m.f. in the coil present around the permanent magnet. The output is obtained in pulsed form

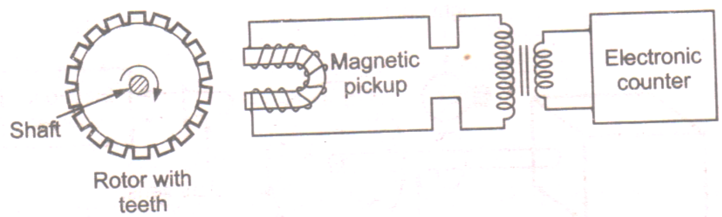


Fig. 7.18 Set of inductive type tachometer

and then using appropriate circuitary the number of pulses are counted by an electronic counter.

The frequency of pulses depends on the number of teeth of rotor and speed of rotation. But the number of teeth is fixed then the rotational speed can be measured directly by counting the frequency of pulses using electronic counters.

Suppose rotor has N teeth and suppose speed of rotation is n in rps, the number of pulses in one second is P, then

Number of pulses per revolution = N

Thus the speed is given by,

$$\text{Speed} = n = \frac{\text{Pulses per second}}{\text{Number of teeth}} = \frac{P}{N} \text{ r.p.s.} = \left(\frac{P}{N}\right) 60 \text{ r.p.m.}$$

Advantages

i) Simple is construction and rugged in construction.

ii) Maintenance free tachometer.

iii) Calibration of tachometer is simple.

iv) The transmission of output of tachometer is easy.

7.6 Acceleration Transducers

The device used for the measurement of acceleration is called **accelerometer**. The accelerometers are widely used for the measurement of general purpose motion such as measurement of acceleration, velocity and displacement. Besides this application, the accelerometers are also used for the measuremnt of mechanical shocks and vibrations.

7.6.1 Principle of Operation of Accelerometer

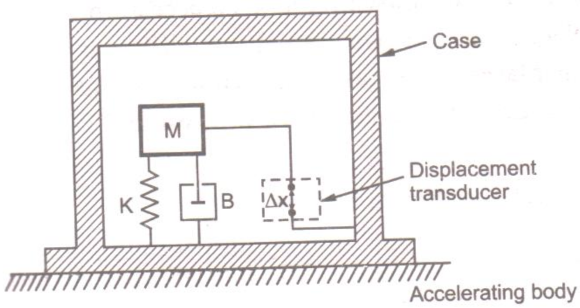


Fig. 7.19 Basic structure of accelerometer

The design of an accelerometer is based on Newton's law of mass acceleration and Hooke's law of spring action. The basic structure is as shown in the Fig. 7.19. The accelerometer is fastened to the body undergoing acceleration.

According to Newton's law, if mass m is undergoing acceleration a, exerts a force F_a on a mass given by

$$F_a = m \cdot a \quad \text{..... (i)}$$

This force is opposed by the restraining effect of a spring. Let spring constant be k. If mass m is displaced from its original position by a distance Δ x, then according to Hooke's law, the force exerted is given by,

$$F_s = k \cdot \Delta x \quad \text{... (ii)}$$

In a steady state, when the acceleration of mass and accelerometer case is same then we can write,

$$F_a = F_s \quad \text{.... (iii)}$$

$$\therefore \quad m \cdot a = k \cdot \Delta x$$

$$\therefore \quad a = \frac{k \cdot \Delta x}{m} \quad \text{.... (iv)}$$

The above equation represents second order system. So in such systems if damping is not provided, the output of the accelerometer undergo non-decaying sustained oscillations. Hence to overcome this generally a damper is used in the system which exerts a force F_d proportional to the velocity of mass. The damping force is given by,

$$F_d = B \cdot v \quad \text{.... (v) where v is the velocity of mass.}$$

Thus the modified equation of motion is given by

$$F_s + F_d = F_a$$

$$\therefore \quad k \cdot \Delta x + B \cdot v = m \cdot a \qquad \text{....... (vi)}$$

The mass that converts acceleration to the spring displacement is called **test mass or seismic mass.**

7.6.2 Types of Accelerometers

In the previous section, we studied that the measurement of acceleration reduces to the measurement of linear displacement. So we can have different types of accelerometers based on the diferent displacement measuring techniques. Based on the type of spring element and the form of damping used, there are number of types of accelerometer.

Let us study some of the types of accelerometer in brief.

7.6.2.1 Potentiometric Type Accelerometer

It is the simplest form of accelerometer. The basic structure of a potentiometric accelerometer is as shown in the Fig. 7.20.

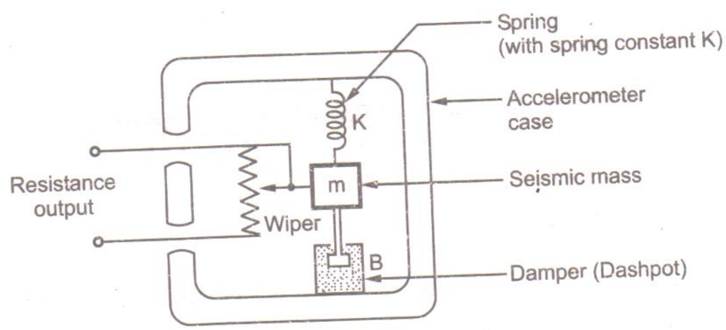


Fig. 7.20 Basic structure of potentiometric accelerometer

The seismic mass is attached to the wiper arm of the potentiometer. The change in position of mass relative to accelerometer case is converted directly into change in resistance at the output terminals. By using different signal conditioning circuits, change in resistance can be converted into corresponding voltage or current signal.

In this type of accelerometer, damping is provided by either filling the space inside the case with a viscous fluid of providing dashpot.

Inspite of being simple in construction, the use of the potentiometric accelerometer is limited. Firstly its natural frequency is very less and it is of the order of 30 Hz. Hence the application of the accelerometer is limited to very low frequency vibration measurement or steady state acceleration. Secondly number of signal conditioning systems are required to convert the variation of resistance into either voltage or current signal. Then lastly the sliding contacts in the system introduce errors in the output progressively.

7.6.2.2 LVDT Accelerometer

The basic structure of LVDT accelerometer is as shown in the Fig. 7.21.

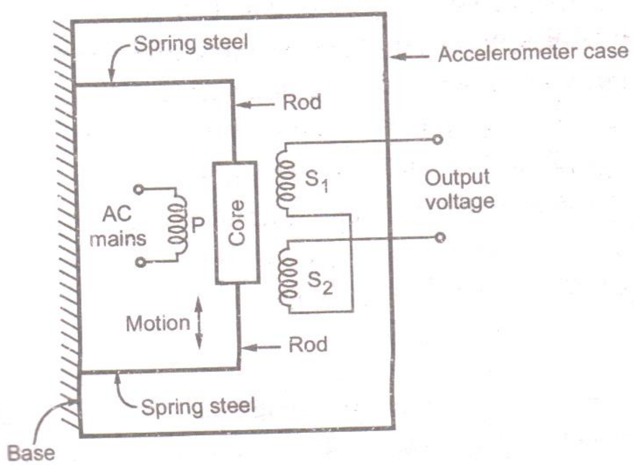


Fig. 7.21 Basic structure of LVDT accelerometer

In LVDT accelerometer, the core of LVDT itself acts as a seismic mass. The core is attached to two spring steel one at top and other at bottom with the help of rods as shown. The spring steels are attached to the case firmly. With the help of this arrangement null position of the core of LVDT is maintained. Both the spring steel provide necessary spring action.

When the instrument is subjected to vibrations, the core moves up and down. Thus voltage induces in the secondaries, thus at the output terminals we get output voltage having amplitude directly proportional to the magnitude of the vibrations.

As compared to the potentiometric type accelerometer, the natural frequency of LVDT accelerometer is higher and it is around 80 Hz. It offers lower resistance to the motion, so the resolution is better compared with the potentiometric type accelerometer. No errors due to the moving contacts as there are no sliding contacts in the instrument.

Due to low natural frequency, the application is again limited to steady state acceleration or low frequency vibration measurements.

7.6.2.3 Piezoelectric Accelerometer

The piezoelectric accelerometer is based on a property of certain crystals that when it is subjected to stress, a voltage is generated across the crystal.

The basic structure of the piezoelectric accelerometer is as shown in the Fig. 7.22.

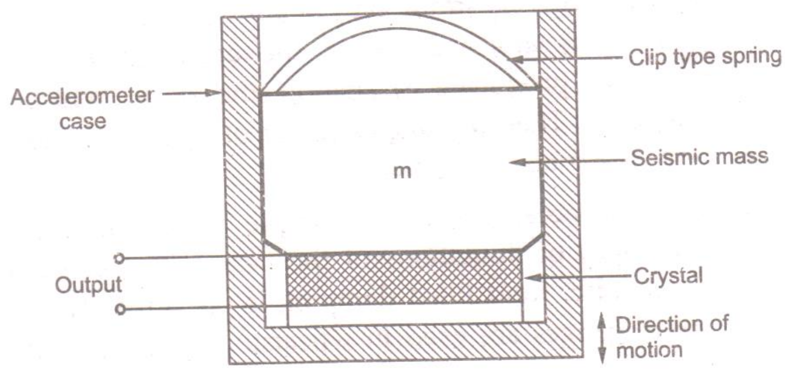


Fig. 7.22 Basic structure of piezoelectric accelerometer

In the piezoelectric accelerometer, a spring loaded crystal is placed toching the seismic mass as shown in above figure. When accelerometer is subjected to an acceleration, the seismic mass stresses the crystal by a force equal to $(F = m \cdot a)$. This generates voltage across crystal which is directly proportional to the acceleration.

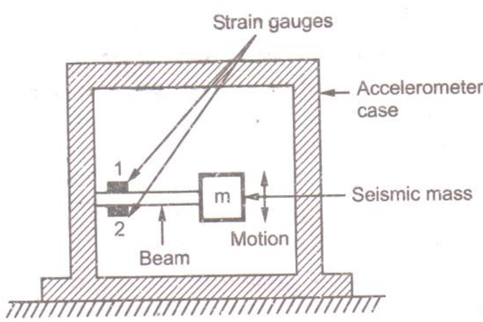
The main advantage of the piezoelectric accelerometer is that the crystal acts as a spring and damper in the instrument. The natural frequency of the crystal is very high, hence it can be used for very high frequency vibration measurements.

The disadvantage of such accelerometer is that the output voltage must be measured with a instrument having very high impedance to avoid loading effect as the electrical impedance of the piezoelectric crystal is very high.

7.6.2.4 Strain Gauge Accelerometer

Similar to the piezoelectric crystals, strain gauge elements also act as spring element and mass displacement measuring element. The main advantage of this fact is that, the construction of the strain gauge accelerometer is simple.

The basic structure of the strain gauge accelerometer is as shown in the Fig. 7.23 (a). This type accelerometer is called cantilever beam type accelerometer.



(a) Cantilever beam type accelerometer

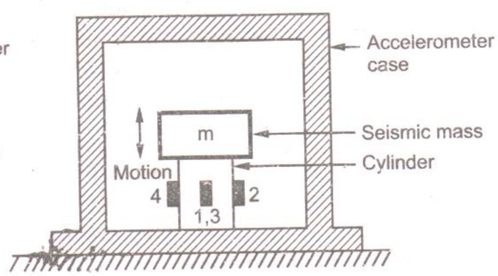


Fig. 7.23

As shown in the Fig. 7.23 (a), $+\omega_0$ strain gauges are mounted on the beam. At one end of the seismic mass m is attached. When the accelerometer is subjected to acceleration, the beam bends producing strains in the beam which are directly proportional to the acceleration. Then the displacement of mass with respect to case is directly proportional to the force acting on mass.

Eventhough this type of accelerometer is simple in construction, its natural frequency is very low because of limitations of the beam size on which gauges are mounted. To increase bandwidth, fluid filled damping is provided. The standard wire, foil or semiconductor strain gauges are used in wheatstone's bridge, with two gauges in compression and remaining two in tension. To have higher frequency response, generally a cylinder type accelerometer is used. The cylinder type accelerometer is as shown in Fig. 7.23. In the basic structure of a cylinder type accelerometer the seismic mass is supported by a solid cylindrical structure. The supporting structure acts as a spring. The strain gauges bonded on the surface of the cylindrical support are arranged in Wheatston's bridge with four arms. These gauges measure strain in the cylindrical support due to acceleration. It is observed that the deflection is relatively small but the natural frequency is much higher as compared to the cantilever type accelerometer discussed earlier. With this structure the natural frequencies of the order of few thousands with higher sensitivities can be obtained. To get even higher sensitivities, semiconductor type strain gauges can be used in the same structure.

Flow Measurement

In many process industries, measurement of flow is an important aspect. Depending on the quantity flowing such as solid, liquid, gaseous, appropriate method of flow rate measurement is used. In case of solids, rate of mass flow is measured while in the case of liquids and gases flow is usually measured in terms of volume flow rated.

8.14.1 Mass Flow Rate

In the process industries, measurement of mass flow rate of solids is concerned with solids transported from one point to another by some conveyor as shown in the Fig. 8.19. In such systems, the mass flow rate is expressed in terms of mass of the solid along the length of conveyor multiplied by speed of conveyor.

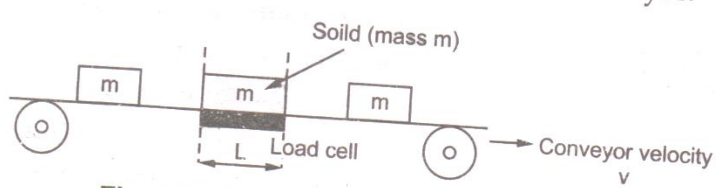


Fig. 8.19 Mass flow rate measurement

The mass of solid along the length of conveyor, L, is measured with the help of load cell. Let it be m. If the conveyor velocity is v, then the mass flow rate Q is given by

$$Q = (m \cdot v) / L \quad .... (i)$$

The mass flow rate of fluids is measured with simultaneous measurement of volume flow rate and the fluid density.

8.14.2 Volume Flow Rate

The volume flow rate measurement is the correct way of finding flow of materials which are in liquid, gaseous or semi-liquid forms. The devices measuring the volume flow rate are flowmeters and these are classified as mechanical and electrical type flowmeters.

In mechanical type flowmeters, an obstruction is placed in the flow pipe and the secondary effect of the obstruction such as torque developed on vens or differential pressure across plate is measured. In electrical type flowmeters, the frequency of rotation of a turbine, change in velocity of sound in fluid, change in resistance of an element, an electrical potential developed in a coil by liquid moving in a magnetic field are measured. The instruments used for the measurement of volume flow rate are as follows.

i) Head-type flowmeters (based on differential pressure measurement)

ii) Variable area meters (Rotameters)

iii) Mechanical flowmeters (Turbine flowmeter)

iv) Electromagnetic flowmeter

v) Anemometer

vi) Ultrasonic flowmeter

vii) Vertex flow meter.

8.14.2.1 Head Type Flow Meters (Based on Differential Pressure Measurement)

In these types of flow meters, some devices is inserted into a pipe carrying fluid. It obstructs the flow of fluid and creates a pressure difference on either side of the device. The most commonly used devices are as follows :

i) Orifice Plate

ii) Venturi Tube

iii) Flow Nozzle

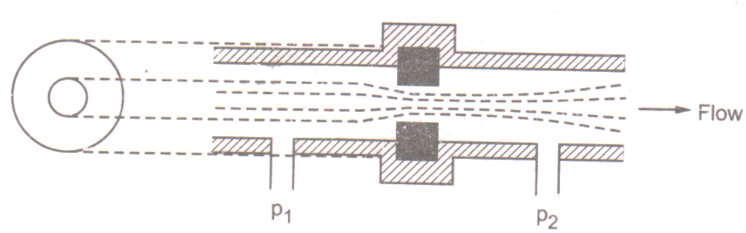
iv) Doll Flow Tube

v) Pitot Tube

The basic principle of all such devices is that due to obstruction, the velocity of the fluid increases and the pressure decreases. Then the volume flow rate is proportional to the square root of pressure difference across the obstruction. To measure pressure difference, diaphragm based differential pressure transducer is used.

i) Orifice Plate :

The orifice plate is a metal disk with a concentric hole as shown in the Fig. 8.20 (a). It is the simplest device used in almost all industrial application because of cheapness and availability in wide range of sizes.



(a) Orifice plate (b) Flow across

There are certain limitations of the orifice plate. For very high flow rates, the permanent pressure losses are very high. Over a period of time, the sharp edges of the hole wear out and the particles in the flowing fluid build up behind the hole reducing diameter. Hence discharge coefficient gradually changes. This problem can be eliminated by using eccentric hole near the bottom of the pipe which sweeps out built-up particles behind the plate. Sometimes bubbles of vapour or gas tend to build up behind plate and obstruct the flow. This can be avoided by mounting the orifice plate in the vertical run of the pipe.

ii) Flow Nozzle :

As compared to the orifice plate, flow nozzle is better option as no possibility of solid particles or bubbles of gas sticking in the flow restriction. The flow across nozzle is as shown in the Fig. 8.21.

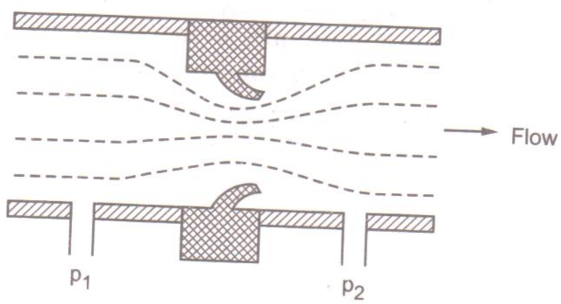


Fig. 8.21 Flow across flow nozzle

The measurement accuracy of the flow nozzle is very high as no harm of getting warned out. But the cost is comparatively higher as fabrication of flow nozzle is difficult. Also permanent pressure losses are also high similar to the orifice plate. The flow nozzles are typically used for the steam flow measurement.

iii) Venturi Tube :

It is a special shaped tube having flow across it as shown in the Fig. 8.22.

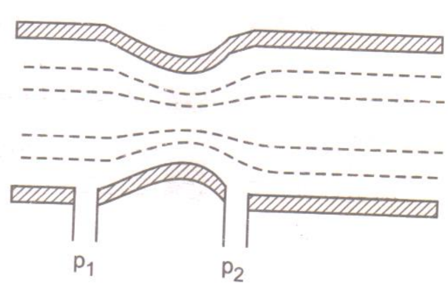


Fig. 8.22 Flow across the venturi tube

This device is also free from depositing and restricting solid particles and bubbles of gases in the flowing fluids. The maintenance required is negligible and the working life is very long. It provides very good accuracy. Because of its special smooth shape, it is very expensive. The venturi tube is specially used for the measurement of flow of semi liquids with dilute slurries.

iv) Doll Flow Tube :

The doll flow tube consists of two conical restricters inserted into the fluid carrying pipe as shown in the Fig. 8.23.

It is having construction similar to the venturi tube, but it is very easy to manufacture hence comparatively cheaper. The length of the doll flowtube is shorter hence insertion into the flow line is easier. Another important advantage is that in the

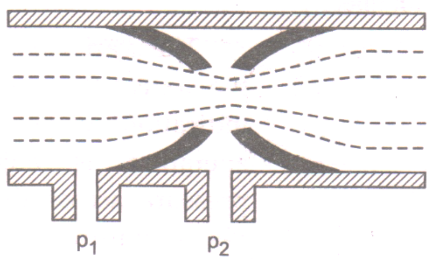


Fig. 8.23

doll flow tube, the premanent pressure loss is only 5 % of the pressure difference measured. The permanent pressure loss in the venturi tube is about 10 to 15 % while in the orifice tube and the flow nozzle it is about 50 to 70 % of the pressure difference measure. Also in the doll flow tube no maintenance is required and the working life is very long. The only disadvantage as compared to the venturi tube is that the accuracy is not good.

v) Pitot Tube :

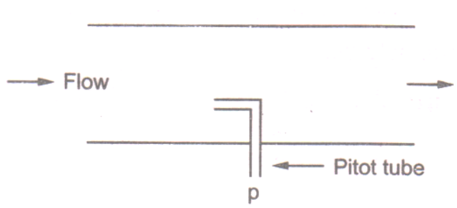


Fig. 8.24 Pitot tube for measurement of local velocity of flow

It is generally used to measure flow rates temporarily. It is best suited for the measurement of the local velocity of flow at a particular point within a pipe instead of average flow velocity.

This method is based on the principle that the tube with its open end placed in a flow brings the fluid to the rest which impinges on it and the loss of kinetic energy is converted to the increase in a pressure inside tube. The flow velocity can be calculated by using expression.

$$v = c[2.g\cdot(p_1 - p_2)]^{\frac{1}{2}} \quad \text{... (i)}$$

where c is constant called **pitot tube coefficient.**

Then the flow rate of fluid can be calculated by multiplying velocity v by the the area of cross-section of the pipe.

It is cheap with simple installation efforts and also having negligible pressure losss in the flow.

The accuracy is poor and sensitivity is less. This can be overcome by using annubar having multiple ports distributed across the cross section of the pipe.

8.14.2.2 Variable Area Meter (Rotameter)

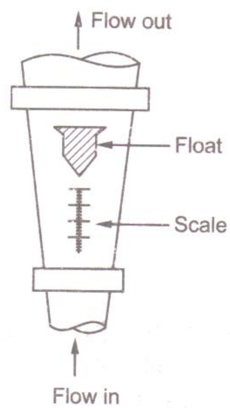


Fig. 8.25 Variable area flow meter

The variable area meter or rotameter is the only flow meter which gives visual indication of flow. In this meter the area of aperature is adjusted by a differential pressure across the variable aperature. Then the aperature area directly gives the flow rate.

The instrument consists of a glass tube tapered at one end and consisting a float in a vertical position as shown in the Fig. 8.25. The float is made up of brass, steel, monel or special plastic.

The float assumes stable vertical position as its submerged weight is balanced by upthrust due to the differential pressure across it. The position of the float is a measure of effective annular area of passage of the flow and hence the flow rate. The accuracy of rotameter is moderate. The main disadvantage of rotameter is that it can be used in the automatic control schemes in the processs industries. But it is cheaper and reliable, hence it is extensively used in the industries.

The rotameters are also called **constant pressure drop meters** or **variable aperature meters**

8.14.2.3 Mechanical Flow Meter

It extensively uses multibladed turbine. The basic structure of the turbine flow meter is as shown in the Fig. 8.26.

It consists of multibladed wheel mounted in side pipe along the axis parallel to the direction of the flow of fluid. When the flow of the fluid passes the wheel, the wheel starts rotating at a rate proportional to the volume flow rate. The flowmeter is constructed such that it acts as variable reluctance tachogenerator and then the rate of rotation of wheel is measured using tachogenerator. For that turbine blades are made of ferromagnetic material. During fabrication only the permanent magnet and coil are placed properly inside the flowmeter. When each blade on the turbine passes the coil, a voltage pulse induces in the coil. Then by counting these pulses, we can calculate frequency of pulse and hence flow rate. Now a days, fiber optics are used which count rotations by detecting reflections off the tip of the blades of turbine.

The turbine flowmeter provides high accuracy when the turbine wheel is mounted on low friction bearing. This meter is less rugged and reliable than restriction type flow meters. There are large permanent pressure losses as bearing wears out

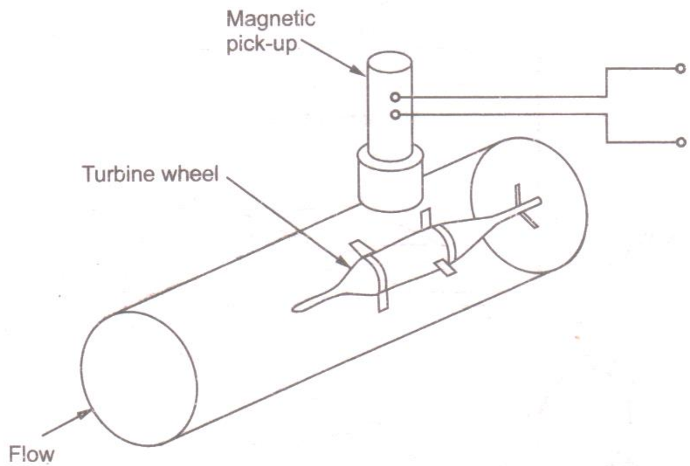


Fig. 8.26 The turbine flowmeter

progressively Turbine flow meters are lighter and preferred mostly in oil-industries, for low viscosity, high flow measurements.

8.14.2.4 Electromagnetic Flow Meters

Using electromagnetic flowmeters only the volume flow rates of electrically conductive fluids can be measured. The basic structure of this instrument is as shown in the Fig. 8.27.

The instrument consists of a stainless steel cylinderical tube. The tube is fitted with an insulating linear which carries a fluid. Typically the lining materials used are neoprene, polyurethane. The coils are placed on either side of the tube. By energizing the coils, the magnetic field is created in the tube. The voltage induced in the fluid is measured with the help of two electrodes inserted into opposite sides of the tube. The electrodes are manufactured from a material such as stainless steel, platinum-iridium alloys, titanium and tantalum, which is unaffected by the most types of flowing fluids.

According to Faraday's law of electromagnetic induction, the voltage V induced across length l of the flowing fluid with velocity v in the magnetic flux density B is given by

$$V = B \cdot l \cdot v \quad \text{.... (i)}$$

where l is the distance between two electrodes i.e. the diameter of the tube and B is the flux density which is constant. Hence induced voltage V is directly proportional to the velocity v of the flowing fluid. Then volume flow rate can be calculated by multiplying the velocity by the area of cross section of the tube.

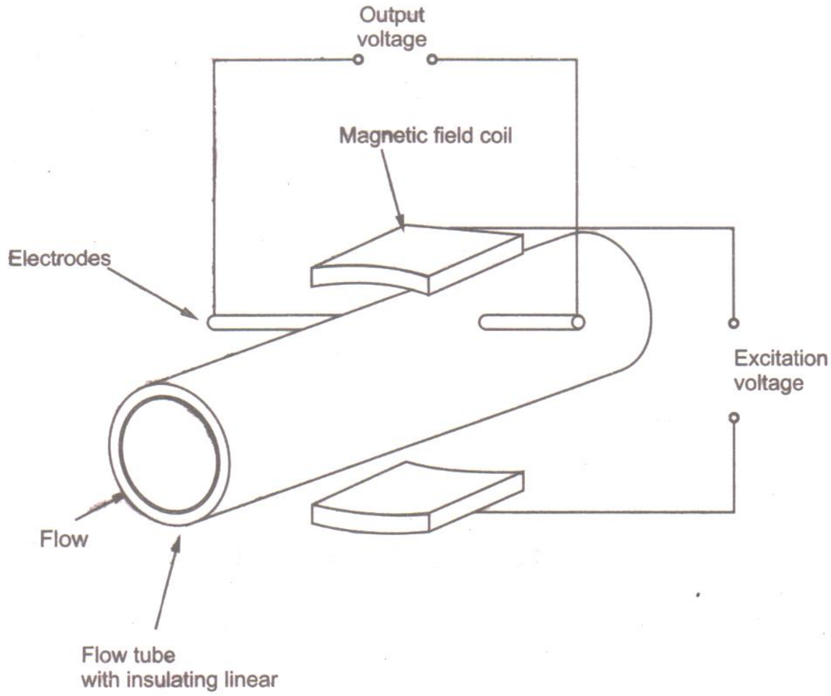


Fig. 8.27 Electromagnetic flowmeter

In this flow meter, as there is no obstruction in the fluid flow, no pressure loss associated with the measurement. It also requires minimum length of the tube so that the accuracy of measurement is increased. These meters are useful for the measurement of flow of slurries in which the liquid part is electrically conductive. By using appropriate lining material, it can be used to handle corrosive fluids.

The main drawback is its application is limited for electrically conductive fluids. It is very expensive. Its electrodes are very costly which increases total cost of instrument significantly. Another reason for high cost is that each instrument needs calibration which varies with the variations in the properties of the magnetic materials. As electricity is required for proper use of meter, its running cost is also high.

8.14.2.5 Anemometers (Hot Wire Anemometer)

Anemometer is a device used for the measurement of velocity of fluid stream such as air flow in a duct or wind tunnel, wind speeds. Hot wire anemometer is based on the principles of heat transfer. The principle of heat transfer used in hot wire anemometer is that when a fluid flows over a heated surface, the heat transfers from surface and hence the temperature of the surface reduces. The rate of the change in temperature is related to the flow rate.

The basic arrangement of the hot wire anemometer is as shown in the Fig. 8.28.

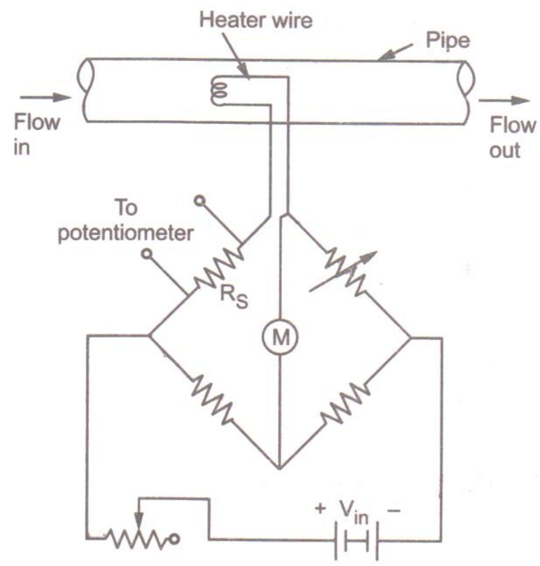


Fig. 8.28 Hot wire anemometer

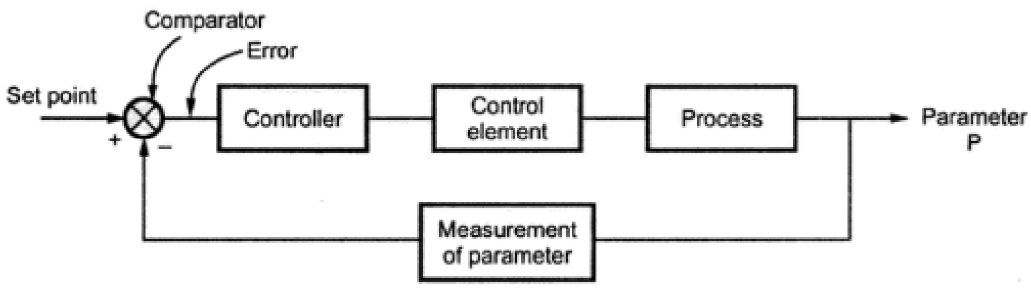
The heat is supplied electrically to a fine wire which is placed in a flow stream. The temperature of the wire is obtained by measuring resistance of wire with the help of Wheatstone's bridge. In other method, temperature is kept constant by adjusting current flowing through the wire. Then heating current is calculated by measuring a voltage drop across standard resistance Rs which is connected in series with the heating wire. If the resistance and temperature of the wire is kept constant then the rate of flow of the fluid is measured by measuring the current I through the heater wire.

Introduction

The primary objective of process control is to control the physical parameters such as temperature, pressure, flow rate, force, level etc. The system used to maintain these parameters constant, close to some desired specific value is called **process control system.** These parameters may change because of internal and external disturbances hence a constant corrective action is required to keep these parameters constant or within the specified range.

The Fig. 9.1 shows the general arrangement of a process loop. It consists of four elements,

1. Process 2. Measurement 3. Controller 4. Control element.



Process control loop

For the proper feedback, it is necessary to measure the value of the actual parameter P. Most of the controllers are electronic in nature and hence require electrical input. Hence feedback signal required is in electrical form in most of the practical process loops. But actual parameter is temperature, pressure, level etc. Hence a device is required in the feedback path which will not only measure the output parameter but will produce proportional analog signal in the electric form. Many times the device is required to measure the physical parameter and produce the proportional signal which is also nonelectric such as pneumatic pressure. So in broad sense a transducer converts one form of energy to another form. But the electrical transducer produces an electrical signal proportional to the nonelectrical quantity to be measured. But as we are interested in the electrical instrumentation, a transducer can be defined as,

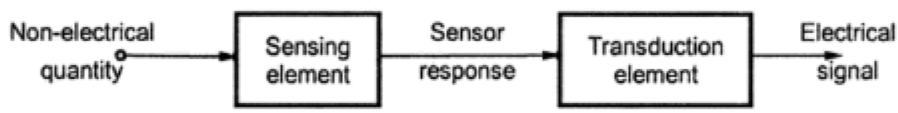
A device which converts a physical quantity into the proportional electrical signal is called a transducer.

The electrical signal produced may be a voltage, current or frequency. A transducer uses many effects to produce such conversion. The process of transforming signal from one form to other is called **transduction.** A transducer is also called **pick up.**

Actually, electrical transducer consists of two parts which are very closely related to each other. These two parts are sensing or detecting element and transduction element. The sensing or detecting element is commonly known as **sensor**.

Definition states that **sensor** is a device that produces a measurable response to a change in a physical condition.

The transduction element transforms the output of the sensor to an electrical output, as shown in the Fig.



Transducer elements in cascade

The common range of an electrical signal used to represent analog signal in the industrial environment is 0 to 5 V or 4 to 20 mA. In industrial applications, now-a-days, 4 to 20 mA range is most commonly used to represent analog signal. A current of 4 mA represents a zero output and current of 20 mA represents a full scale value i.e. 5 V in case of voltage representation. The zero current condition represents open circuit in the signal transmission line. Hence the standard range is offset from zero.

Many a times, the transducer is a part of a circuit and works with other elements of that circuit to produce the required output. Such a circuit is called signal conditioning circuit.

Classification of Transducers

A transducer is a device that receives energy from one system and transmits it to another in different form. Basically there are two types of transducers; namely **electrical and mechanical.** The **mechanical** transducers are those primary sensing elements that respond to changes in the physical condition of a system and gives output in different form. For example, when a bimetallic strip is subjected to a temperature change then the output is the mechanical displacement of the strip. The mechanical transducers are distinguished from the electrical transducers on the basis of the output signal generated. The mechanical transducers generate output signal which is mechanical by nature. The **electrical transducers** respond to non-electrical quantities but generate output signal which is electrical by nature. It is practically always possible to use either mechanical or electrical transducer for the measurement of any physical parameter. **But it is observed that for each measurand, an electrical transducers are prefered over the mechanical transducers.**

The various advantages of electrical transducers are,

1. Electrical signals can be easily attenuated or amplified and can be brought upto a level suitable for various devices, with the help of static devices FGK.
2. The power requirement of transducers is very small. The electrical systems can be controlled with a small level of power.
3. The electrical output of the transducer can be easily used, transmitted and processed for the purpose of measurement.
4. The reduced effects of friction and other mechanical nonlinearities.
5. Due to the integrated circuit technology, the electrical and electronic systems are compact, having less weight and portable.
6. The data transmission through mechanical means is eliminated. Thus no mechanical wear and tear and no possibility of mechanical failures exist.
7. The reduced effects of mass inertia problems.

In the modern world, the use of electrical transducers is must.

The main disadvantage of an electrical transducers is its cost. And while designing the circuit the effects of ageing and drifts of parameters of active components must be considered. This makes the design complicated.

In general the **electrical transducers** are classified according to their structures, application area, method of energy conversion, output signal nature etc. Thus the electrical transducers are classified.

i) As active and passive transducers,

ii) On the basis of transduction principle used,

iii) As analog and digital transducers,

iv) As primary and secondary transducers, and

v) As transducer and inverse transducer.

Let us discuss the classification of the electric transducers in brief.

Active and Passive Transducer

Active Transducers

Active transducers are self generating type of transducers. These transducers develop an electrical parameter (i.e. voltage or current) which is proportional to the quantity under measurement. These transducers do not require any external source or power for their operation. They can be subdivided into the following commonly used types :

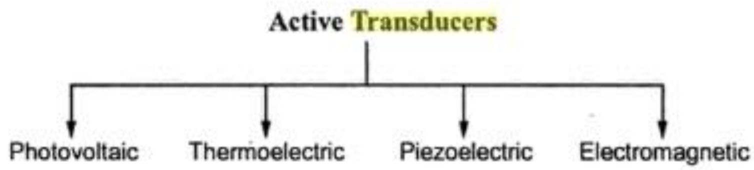
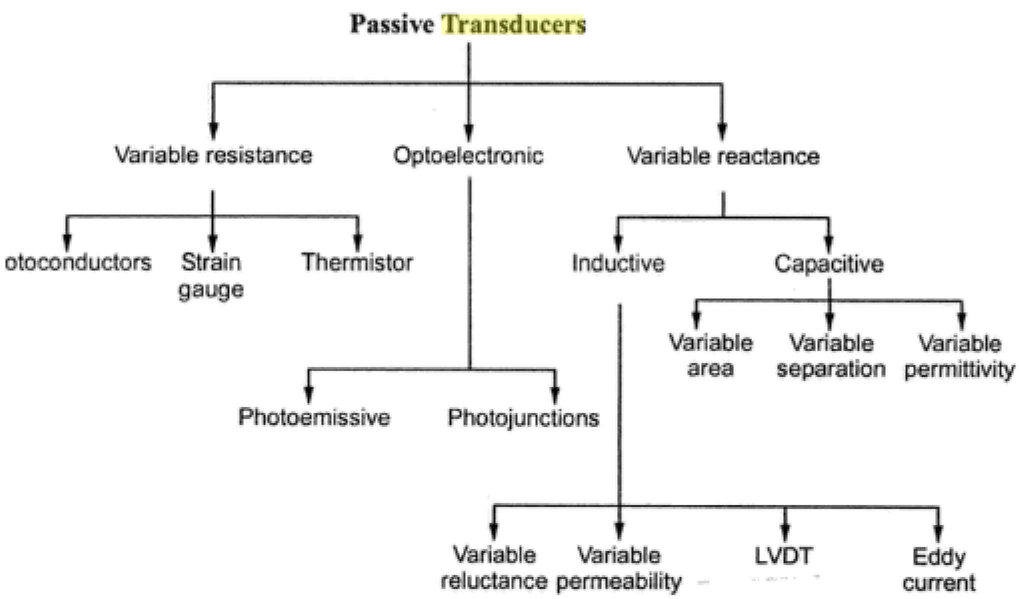


Fig.

Passive Transducers

Passive transducers do not generate any electrical signal by themselves. To obtain an electrical signal from such transducers, an external source of power is essential. Passive transducers depend upon the change in an electrical parameter (R, L, or C). They are also known as **externally power driven** transducers. They can be subdivided into the following commonly used types.

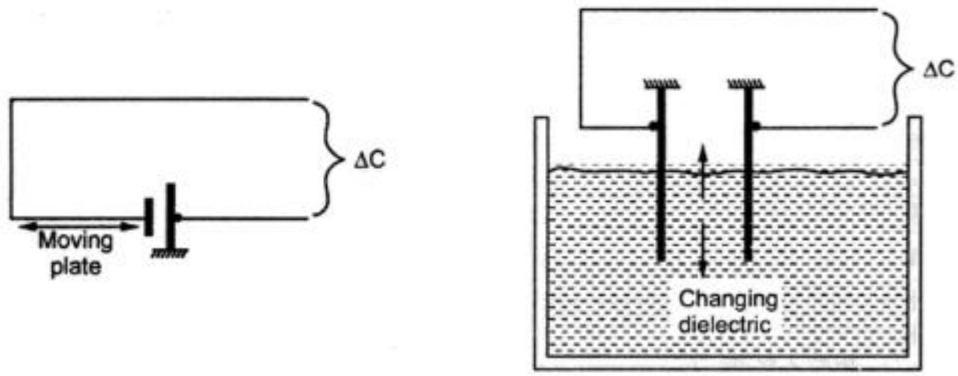


According to Transduction Principle

The transducers can be classified according to principle used in transduction. Let us see few of them.

Capacitive Transduction

In capacitive transduction, measurand is converted into a change in capacitance. A capacitor basically consists of two conductors (plates) separated by an insulator (dielectric). A change in the capacitor occurs either by changing the distance between two plates or by a change in the dielectric, as shown in the Fig.



(a) Fig. Capacitive transduction (b)

Electromagnetic Transduction

In electromagnetic transduction, measurand is converted into an electromotive force (voltage) induced in a conductor by change in the magnetic flux, in the absence of excitation. Thus these types of transducers are self-generating active type transducers. The relative motion between a magnet or a piece of magnetic material and an electromagnet brings out the change in the magnetic flux as shown in the Fig.

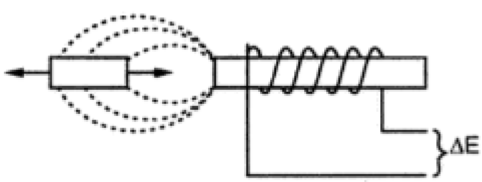


Fig. Electromagnetic transduction

Inductive Transduction

In inductive transduction, the measurand is converted into a change in the self inductance of a single coil. This is accomplished by displacing the coil's core, which is linked or attached to a mechanical sensing element, as shown in the Fig.

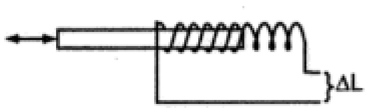
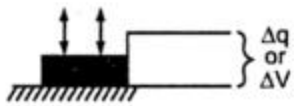
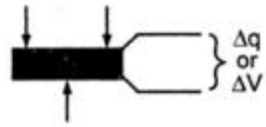


Fig. Inductive transduction

9.2.2.4 Piezoelectric Transduction



(a) Compression



(b) Bending

Fig. 9.8 Piezoelectric transduction

In piezoelectric transduction, measurand is converted into a change in electrostatic charge, q or voltage, V generated by crystals when mechanically stressed.

9.2.2.5 Photovoltaic Transduction

In photovoltaic transduction, the measurand is converted in the voltage generated when a junction between dissimilar materials is illuminated, as shown in the Fig. 9.9.

9.2.2.6 Photoconductive Transduction

In photoconductive transduction, the measurand is converted into a change in resistance (conductance) of a semiconductor material by a change in the amount of illumination incident on the material, as shown in the Fig. 9.10.

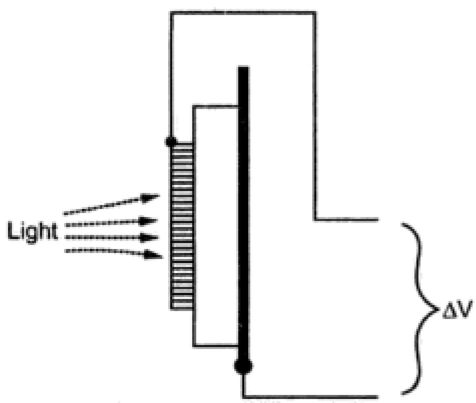


Fig. 9.9 Photovoltaic transduction

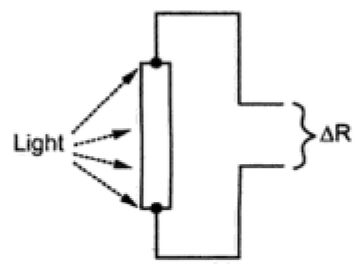


Fig. 9.10 Photoconductive transduction

9.2.3 Analog and Digital Transducers

The transducers can be classified on the basis of the output which may be a continuous function of time or the output may be in discrete steps.

9.2.3.1 Analog Transducers

These transducers convert the input quantity into an analog output which is a continuous function of time. A strain gauge, LVDT, thermocouples or thermistors are called analog transducers as they produce an output which is a continuous function of time.

9.2.3.2 Digital Transducers

Digital transducers produce an electrical output in the form of pulses which forms an unique code. Unique code is generated for each discrete value sensed.

9.2.4 Primary or Secondary

Some transducers consist of mechanical device along with the electrical device. In such transducers mechanical device acts as a primary transducer and converts physical quantity into mechanical signal. The electrical device then converts mechanical signal produced by primary transducer into an electrical signal. Therefore, electrical device acts as a secondary transducer. For an example, in pressure measurement Bourdon's tube acts as a primary transducer which converts a pressure into displacement and LVDT acts as a secondary transducer which converts this displacement into an equivalent electrical signal.

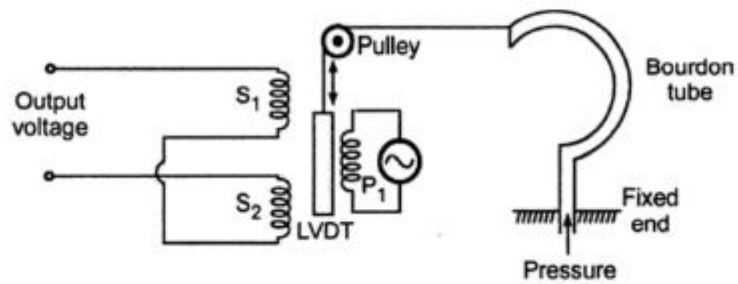


Fig. 9.11 Pressure measurement (example of primary and secondary transducer)

9.2.5 Transducer and Inverse Transducer

Transducers convert non-electrical quantity into electrical quantity whereas inverse transducer converts electrical quantity into non-electrical quantity. For example, microphone is a transducer which converts sound signal into an electrical signal whereas loudspeaker is an inverse transducer which converts electrical signal into sound signal.

9.3 Characteristics of Transducers

1. **Accuracy :** It is defined as the closeness with which the reading approaches an accepted standard value or ideal value or true value, of the variable being measured.
2. **Ruggedness :** The transducer should be mechanically rugged to withstand overloads. It should have overload protection.
3. **Linearity :** The output of the transducer should be linearily proportional to the input quantity under measurement. It should have linear input - output characteristic.

4. **Repeatability** : The output of the transducer must be exactly the same, under same environmental conditions, when the same quantity is applied at the input repeatedly.

5. **High output** : The transducer should give reasonably high output signal so that it can be easily processed and measured. The output must be much larger than noise. Now-a-days, digital output is preferred in many applications.

6. **High stability and reliability** : The output of the transducer should be highly stable and reliable so that there will be minimum error in measurement. The output must remain unaffected by environmental conditions such as change in temperature, pressure, etc.

7. **Sensitivity** : The sensitivity of the electrical transducer is defined as the electrical output obtained per unit change in the physical parameter of the input quantity. For example, for a transducer used for temperature measurement, sensitivity will be expressed in mV/°C. A high sensitivity is always desirable for a given transducer.

8. **Dynamic range** : For a transducer, the operating range should be wide, so that it can be used over a wide range of measurement conditions.

9. **Size** : The transducer should have smallest possible size and shape with minimal weight and volume. This will make the measurement system very compact.

10. **Speed of response** : It is the rapidity with which the transducer responds to changes in the measured quantity. The speed of response of the transducer should be as high as practicable.

9.4 Transducer Selection Factors

Picking the right transducer for a given measurement application involves considering the transducer's characteristics, desired system performance, and input requirements. Because there are so many kinds of transducers, proper selection requires careful consideration.

1. **Nature of measurement** : The selection of transducer will naturally depend upon the nature of quantity to be measured. For example, for temperature measurement, temperature sensors will be used; for measuring stress or strain, strain gauges will be utilized.

2. **Loading effect** : If the transducer in any way affects or changes the value of the parameter under measurement, errors may be introduced. The transducer is selected to have minimum loading effect to keep the errors to minimum.

3. **Environmental considerations** : A careful study be made of the conditions under which a transducer is expected to give satisfactory output. The troublesome aspects of the transducer location are the temperature changes, shock and vibration, and electromagnetic interference.

4. **Measuring system compatibility** : The transducer selected and the electrical system used for measurement should be compatible. The output impedance of the transducer and the impedance imposed by the **measuring** system must be such that one does not adversely affect the other.

5. **Cost and availability** : General factors involved in selection are cost, availability, basic simplicity, reliability, and low maintenance.

9.5 Passive Transducers

In electrical circuits, there are combinations of three passive elements : resistor, inductor and capacitor. These three passive elements are described with the help of the primary parameters such as resistance, self or mutual inductance and capacitance respectively. Any change in these parameters can be observed only if they are externally powered. We have studied that the passive transducers do not generate any electrical signal by themselves and they require some external power to generate an electrical signal. The transducers based on variation of parameters such as resistance, self or mutual inductance capacitance, due to an external power are known as **passive transducers**. Hence resistive transducer, inductive transducer and capacitive transducer are the basic passive transducers.

9.6 Resistive Transducers

In general, the resistance of a metal conductor is given by,

$$R = \frac{\rho L}{A}$$

where ρ = Resistivity of conductor (Ω m)

L = Length of conductor (m)

A = Area of cross-section of conductor (m^2)

The electrical resistive transducers are designed on the basis of the methods of variation of any one of the quantities in above equation; such as change in length, change in area of cross-section and change in resistivity.

The resistive transducers can be used either as primary transducers or secondary transducers. The methods based on measurement of the resistance change are most widely used in various industrial applications as,

i) Both a.c. and d.c. voltages and currents are suitable for the measurement of resistance change.

ii) The speed of response of the resistive transducers is high.

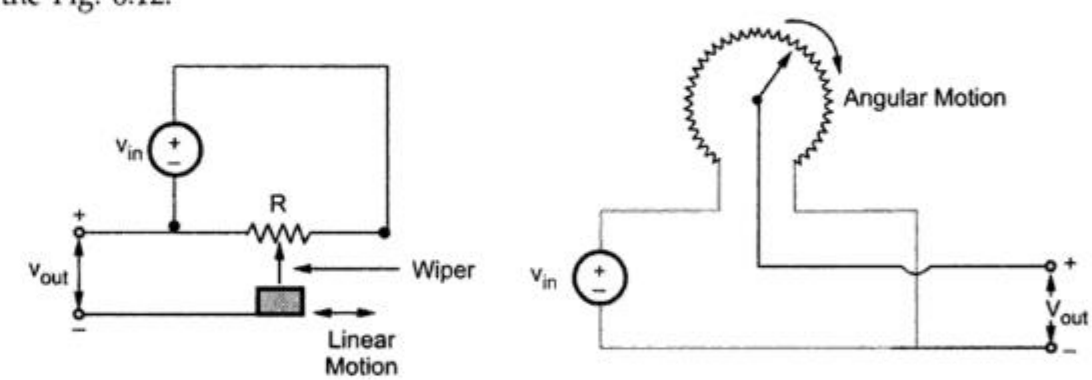
iii) They are available in various sizes with wide range of resistance value.

iv) High resolution in measurements can be achieved as large variety of electrical circuits are available.

The resistance change due to the change in the length of the conductor is used in translational or rotational potentiometers to measure linear or rotational displacement. The change in resistance of conductor or semiconductor due to the strain applied is the working principle of the strain gauge which is used to measure various physical quantities such as pressure, displacement and force. The change in resistivity of conductor due to the temperature variations causes change in resistance. This principle is used to measure temperature.

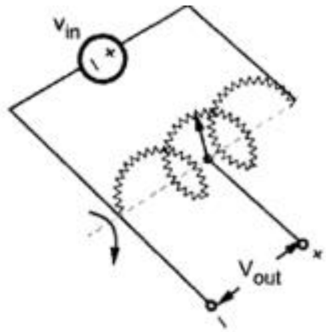
6.7 Potentiometric Resistance Transducers

A potentiometric resistance transducer (or simply potentiometer) is generally used to measure linear or angular displacement. A resistance potentiometer consists a wire wound resistive element along with a sliding contact which is called as **wiper.** A wire is made up of platinum or nickel alloy with diameter as small as 0.01 mm. The resistive element is made up of cement, hot moulded carbon or carbon film. The wire is wound on an insulating former. The linear and rotary potentiometers are as shown in the Fig. 6.12.



(a) Linear vin

(b) Rotary



(c) Helipot

Fig. 6.12 Resistance potentiometers

Using resistance potentiometers mechanical displacement is converted into an electrical output. Linear or angular displacement is applied to the sliding contact and then the corresponding change in resistance is converted into voltage or current. Note that the resistance potentiometers shown in the Fig. 6.12 may be excited by either a.c. voltage or d.c. voltage. To measure combination of linear (translational) and angular (rotational) motion, the helipots are used. As the resistive element in such potentiometer is in the form of helix, it is called **helipot.**

6.7.1 Advantages and Disadvantages of Resistance Potentiometers

The **advantages** of resistance potentiometers are as follows.

i) Simple in construction and operation.

ii) Best suitable for measurements in the systems with least requirements.

iii) High electrical efficiency and provides sufficient output for further control operations.

iv) Useful for displacement measurements of large amplitudes.

v) Inexpensive.

The **disadvantages** of resistance potentiometers are as follows,

i) In linear potentiometers, large force is required to move wiper.

ii) Suffer from mechanical wear and misallignment of wiper.

iii) Limited resolution and high electronic noise in output.

9.8 Inductive Transducer

Inductive transducer is a simple and most popular type of displacement transducer in which variation of inductance as a function of displacement is achieved by variation in self inductance or mutual inductance.

In general the value of self inductance of an inductor is given by,

$$L = \frac{N^2}{S} \qquad .....(1)$$

where, N = Number of the coil

S = Reluctance of the coil (A/Wb)

But the reluctance S is given by

$$S = \frac{l}{\mu a} \qquad .... (2)$$

Hence self inductance L is given by,

$$L = \frac{N^2 \mu a}{l} \qquad ....(3)$$

where N = Number of turns of coil.

μ = Permeability of core (H/m)

a = Area of magnetic circuit through which flux is passing (m^2)

l = Length of the magnetic circuit (m)

Thus the variation in the self inductance may be due to

i) Change in number of turns

ii) Change in reluctance

iii) Change in permeability.

The mutual inductance between the two coils is given by

$$M = k\sqrt{L_1 \cdot L_2} \qquad .... (4)$$

where M = mutual inductance between two coils.

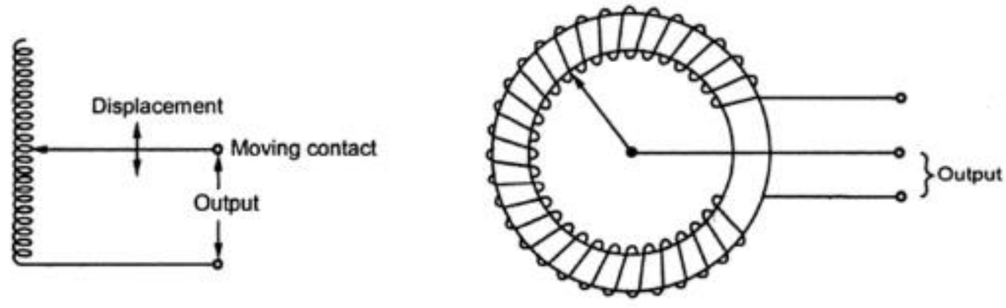
k = coefficient of coupling

The mutual inductance between two coils can be varied by varying either self inductances of the coils or coefficient of coupling.

In general, inductive transducers are used for the measurement of physical quantities such as displacement, force, pressure, velocity, position, vibration etc. Let us study few types of inductive transducers.

9.8.1 Transducer Based on Principle of Change in Self Inductance with Number of Turns

From the expression of the self inductance it is clear that L is directly proportional to N^2 i.e. square of the number of turns. This property can be used to measure linear as well as angular displacement as shown in the Fig. 9.13.



(a) Linear displacement **(b) Angular displacement**

Fig. 9.13 Inductive transducer based on change in self inductance

In both the cases, as number of turns changes, the value of self inductance changes and hence the output voltage also changes.

9.8.2 Variable Permeability Inductive Transducer

The value of self inductance of a coil also depends on the permeability μ. The transducer based on variable permeability is as shown in the Fig. 9.14.

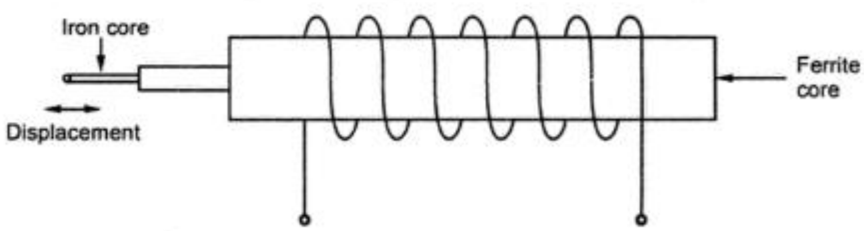


Fig. 9.14 Variable permeability inductive transducer.

In this transducer, the displacement to be measured is applied to the rod which moves in and out of ferrite core according to the direction of the displacement. When iron core moves in, the effective permeability increases, while when iron core moves out, the effective permeability decreases and accordingly output voltage changes.

9.8.3 Variable Reluctance Inductive Transducer

The self inductance L is inversely proportional to the reluctance S. A variable reluctance type inductive transducer is as shown in the Fig. 9.15. It is a self generating type transducer.

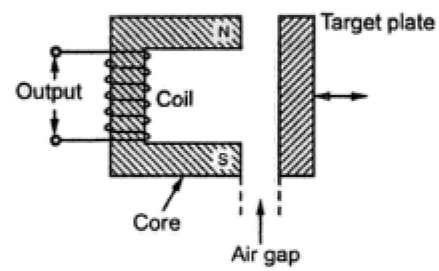


Fig. 9.15 Variable reluctance inductive transducer

A coil is wound by C shaped ferromagnetic core with a target plate placed above core with a small air gap. The size of this air gap determines the reluctance of the magnetic circuit, which inturn decides the self inductance. The displacement to be measured is applied to the target plate. According to the displacement, the target plate moves which chages the air gap and hence the self inductance. Thus for different air gaps we get different values of inductance hence we get different output voltage.

9.8.4 Eddy Current Type Inductive Transducer

An eddy current type inductive transducer is as shown in the Fig. 9.16. It is a self generating type transducer.

A non-ferrous plate moves in a direction perpendicular to the lines of flux of a magnet. The eddy currents are generated in a plate which are proportional to the velocity of the plate. These currents set up a magnetic field in a direction opposing the magnetic field productiong these currents. Thus the output is proportional to the change in eddy current or the acceleration of the plate. As the air gap between the magnet and the plate remains constant, the transducer characteristics are linear.

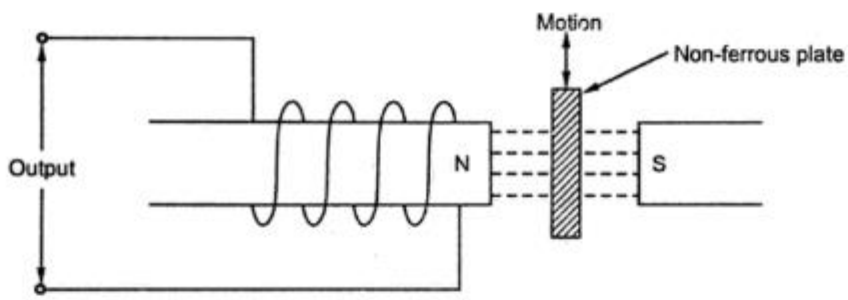


Fig. 9.16 Eddy current type inductive transducer

9.9 Linear Variable Displacement Transducer (LVDT)

Displacement is a vector quantity representing a change in position of a body or a point with respect to a reference. It can be linear or angular (rotational) motion. With the help of displacement transducer, many other quantities, such as force, stress, pressure, velocity, and acceleration can be found. In case of linear displacement, the magnitude of measurement may range from a few micrometer to a few centimeters. A majority of displacement transducers detect the static or dynamic displacement by means of suitable mechanical links coupled to the point or body whose displacement is to be measured.

The main electrical displacement transducers work on the principle of :

1. Variable resistance : transducer is strain gauge.
2. Variable inductance : transducer is linear variable differential transformer
3. Variable capacitance : transducer is parallel plate capacitor with variable gap
4. Synchros and resolvers : used to measure angular displacement.

A simple and more popular type of displacement transducer is the variable inductance type wherein the inductance is varied according to the displacement. This is achieved either by varying the mutual inductance between the two coils (linear variable differential transformer) or by varying self inductances (variable reluctance sensor).

The very fine resolution, high accuracy, and good stability make LVDT most suitable as a position - measuring device. LVDT forms the basic sensing element in the measurement of pressure, load, and acceleration. It is also a basic element of electronic comparators, thickness - measuring units, and level indicators.

9.9.1 Construction and Working of LVDT

As illustrated in the Fig. 9.17, the linear variable differential transformer consists of a single primary winding P_1 and two secondary windings S_1 and S_2 wound on a hollow cylindrical former. The secondaries have an equal number of turns but they are connected in series opposition so that the e.m.f.s induced in the coils oppose each other. The primary winding is connected to an a.c. source, whose frequency may range from 50 Hz to 20 kHz. A movable soft iron core slides inside the hollow former. The position of the movable core determines the flux linkage between the a.c. excited primary winding and each of the two secondary windings. The core made up of nickel-iron alloy is slotted longitudinally to reduce eddy current losses. The displacement to be measured is applied to an arm attached to the core. With the core in the center, or reference, position, the induced e.m.f.s in the secondaries are equal, and since they oppose each other, the output voltage will be zero volt.

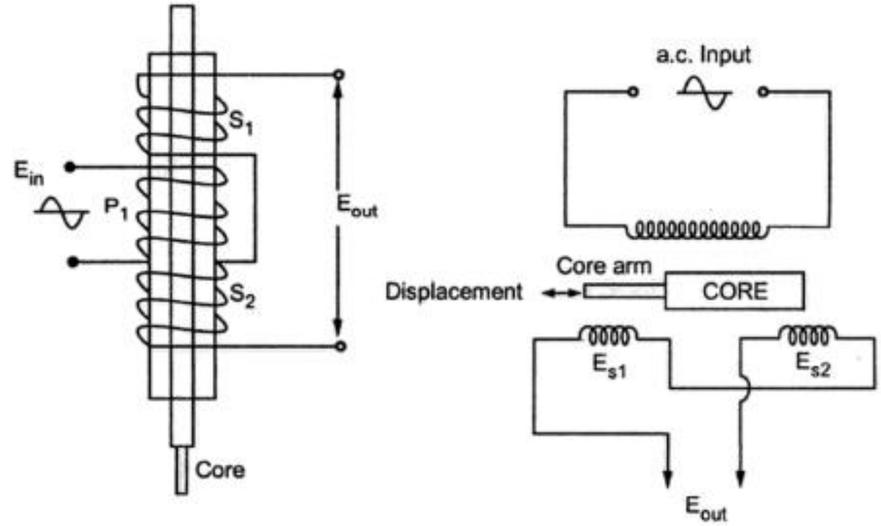


Fig. 9.17 Linear variable differential transformer

When an externally applied force moves the core to the left-hand position, more magnetic flux links the left-hand coil than the right-hand coil. The e.m.f. induced in the left-hand coil, E_{s1}, is therefore larger than the induced e.m.f. of the right-hand coil, E_{s2}. The magnitude of the output voltage is then equal to the difference between the two secondary voltages and it is in phase with the voltage of the left-hand coil.

Similarly, when the core is forced to move to the right, more flux links the right-hand coil than the left-hand coil and the resulting output voltage, which is the difference between E_{s2} and E_{s1}, is now in phase with the e.m.f. of the right-hand coil.

Thus the LVDT output voltage is a function of the core position. The amount of a voltage change in either secondary winding is proportional to the amount of movement of the core. By noting which output is increasing or decreasing, the direction of motion can be determined. The output a.c. voltage inverts in phase as the core passes through the central null position. Further as the core moves from the center, the greater is the difference in value between E_{s1} and E_{s2} and consequently the greater the output voltage. Therefore the amplitude of the output voltage is a function of the distance the core moves, while the polarity or phase indicates the direction of the motion.

The amount of output voltage of an LVDT is a linear function of the core displacement within a limited range of motion.

9.9.2 Advantages and Disadvantages of LVDT

Advantages of LVDT

1. **Linearity :** The output voltage of LVDT is almost linear for displacement upto 5 mm.
2. **Infinite resolution :** The change in output voltage is continuous, stepless. The effective resolution depends more on the equipment used for the measurement rather than on the LVDT.
3. **High output :** LVDT gives reasonably high output, and hence requires less amplification afterwards.

5. **Ruggedness :** LVDT is mechanically rugged and can withstand mechanical shock and vibrations.
6. **Less Friction :** Since there are no sliding contacts, the friction is very less.
7. **Low Hysteresis :** LVDT has a low hysteresis, hence its repeatability is extremely good under all conditions.
8. **Low Power Consumption :** Most LVDTs consume less than 1 W of power.
9. The LVDT transducers are small, simple, and light in weight. They are stable and easy to align and maintain.

Disadvantages of LVDT :

1. Comparatively large displacements are necessary for appreciable differential output.
2. They are sensitive to stray magnetic fields. However, this interference can be reduced by shielding.
3. The dynamic response is limited by the mass of the core.
4. Temperature affects the transducer.

6.13 Capacitive Transducer

The capacitive transducers work on the fundamental principle of electrical capacitance. The capacitance C of a system depends on the dielectric medium used and properties of a capacitive system.

The important capacitances used in the capacitive transducers are,

1. **Parallel plate capacitor :** The capacitance of a parallel plate capacitor is given by,

$$C = \frac{\varepsilon A}{d} \text{ F}$$

where $\varepsilon = \varepsilon_0 \varepsilon_r$, $\varepsilon_0 = 8.85 \times 10^{-12}$ F/m

Where $\varepsilon = \varepsilon_0 \varepsilon_r$, $\varepsilon_0 = 8.85 \times 10^{-12}$ F/m

ε_r = Relative permittivity of material

A = Cross-sectional common area of plates

d = Plate separation

The arrangement is shown in the Fig. 9.19.

By using simple methods, the capacitance of the capacitor can be varied and change in its value can be used for transduction in a transducer.

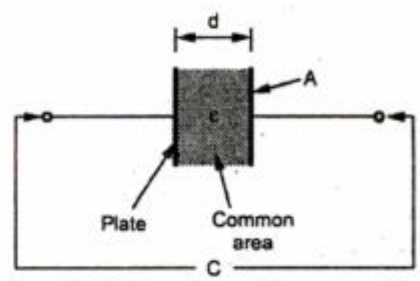


Fig. 9.19 Parallel plate capacitor

2. **Composite capacitor :** This capacitance consists of more than one dielectric medium in between the plates as shown in the Fig. 9.20.

It consists of three layers of dielectrics having relative permittivities ε_1, ε_2 and ε_3. The layers having thicknesses d_1, d_2 and d_3. The capacitance of a system is given by,

$$C = \frac{\varepsilon_0 A}{\frac{d_1}{\varepsilon_1} + \frac{d_2}{\varepsilon_2} + \frac{d_3}{\varepsilon_3}}$$

The system creates the effect of three capacitances connected in series.

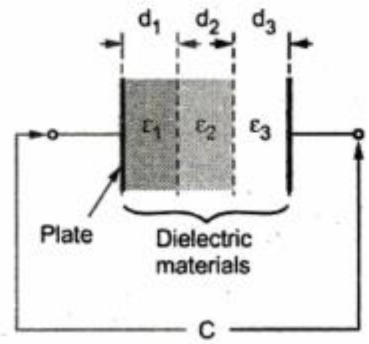


Fig. 9.20 Composite capacitor

3. Cylindrical capacitor : In this system, the plates are cylindrical separated by a dielectric as shown in the Fig. 9.21.

Let r = Outer radius of inner cylinder

R = Inner radius of outer cylinder

Then its capacitance is given by,

$$C = \frac{2\pi\varepsilon l}{ln\left(\frac{R}{r}\right)} \text{ F}$$

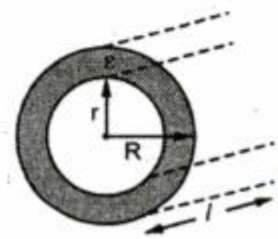


Fig. 9.21 Cylindrical capacitance

and l is length of the cylinders.

9.10.1 Variation in Capacitance

To have capacitive system to be used as a sensor, it is necessary to change the value of capacitance proportional to the action to be measured or detected. Such a variation of capacitance is achieved in four ways.

1. Change of distance :

The capacitance C depends on separation between the plates. Thus by varying the distance of separation, C can be varied. The system is shown in the Fig. 9.22 (a) in which distance is varied by keeping one plate fixed and other plate moving. As the distance increases from d to d′ the capacitance decreases from C to C′.

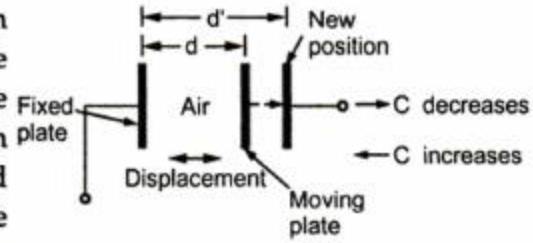


Fig. 9.22 (a) Change in separation

Another method of varying the distance is employing cantilever spring plate as shown in the Fig. 9.22 (b).

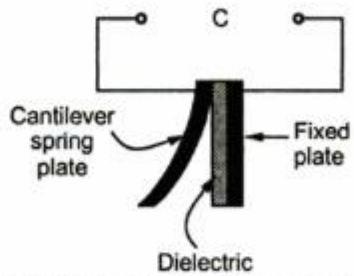


Fig. 9.22 (b) Use of cantilever spring plate

2. Change in common plate area : By keeping the one plate moving and changing its position parallel to the other plate, common plate area can be varied. This is shown in the Fig. 9.23. By varying area A, the capacitance can be varied.

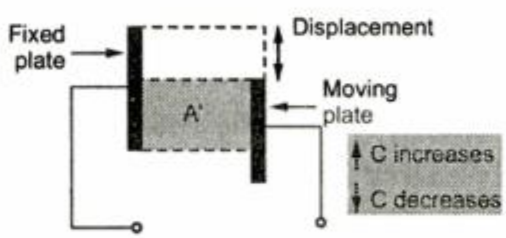
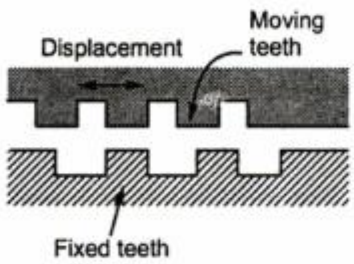


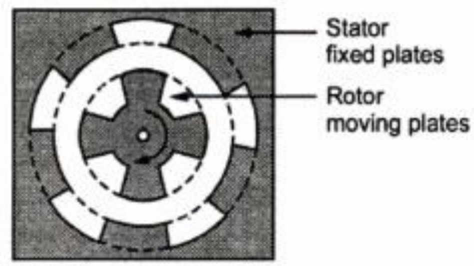
Fig. 9.23 Change in common plate area

The common area can be changed by employing the serrated electrodes as shown in the Fig. 9.24.

This method is suitable in the measurements of rotational displacement. The arrangement is employed in the form of slotted rotor and stator as shown in the Fig. 9.24 (b). As the rotor plates of the capacitor are rotated, the capacitance varies proportional to the angular displacement of the rotor plates. This method can be used to measure the torques.



(a) Change in area



(b) Measurement of angular displacement

Fig. 9.24

3. Change in dielectric : By inserting a slab of variable permittivity, the capacitance can be varied. Introduction of slab of variable permittivity gives rise to a composite capacitor. This is shown in the Fig. 9.25. This method is used in capacitance type level meter.

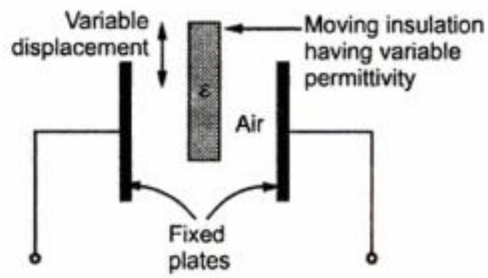


Fig. 9.25 Change in dielectric

9.10.2 Capacitance Type Level Meter

The capacitive transducer using the method of change in dielectric is used for the measurement of the liquid levels.

The Fig. 9.27 shows the capacitance type level meter.

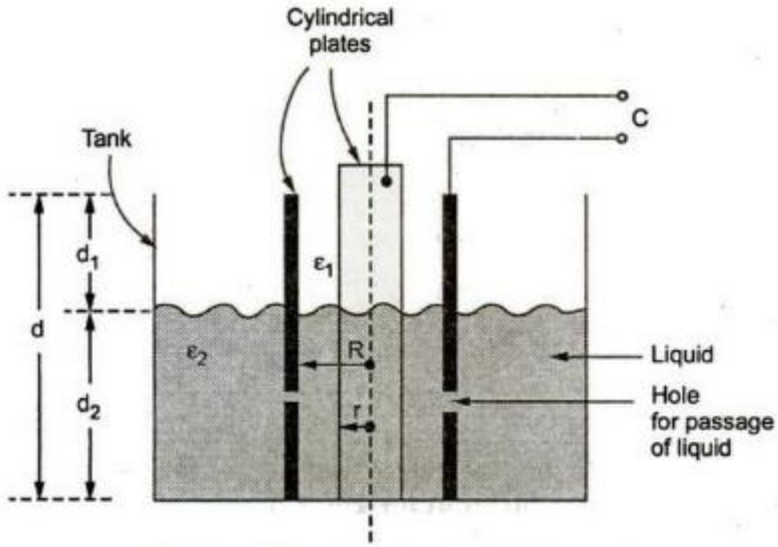


Fig. 9.27 Capacitance type level meter

It is uses concentric cylindrical capacitor. The two plates are cylindrical using the dielectric material with a permittivity ε_1. Most of the times, this dielectric is an air with $\varepsilon_r = 1$ and $\varepsilon = \varepsilon_0$. The outer cylindrical plates have holes at the bottom through which passage of liquid is possible between the plates.

Let r = Outer radius of inner cylinder

R = Inner radius of outer cylinder

d = Height of tank

d_2 = Level of liquid in tank

ε_2 = Permittivity of liquid

As the liquid level d_2 changes, the composite capacitor formed experiences change in its value. The value of the capacitance is given by,

$$C = \frac{2\pi\varepsilon_0 [\varepsilon_1 d_1 + \varepsilon_2 d_2]}{ln\left[\frac{R}{r}\right]}$$

Thus, change in the liquid level causes the change in the capacitance measured between the cylinders.

This change in capacitance is detected by some other circuit with which the electrical signal proportional to the liquid level can be obtained.

9.10.3 Capacitive Pressure Transducer

The capacitive pressure transducer is based on the principle that when the distance between the two parallel plates changes, capacitance of the parallel plate capacitor changes. The capacitive pressure transducer is as shown in the Fig. 9.28.

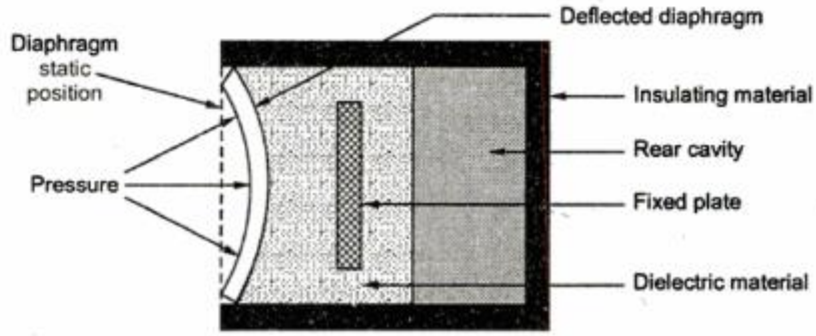


Fig. 9.28 Capacitive pressure transducer

In capacitive pressure transducer diaphragm acts as one of the plates of a two plate capacitor while other plate is fixed. The fixed plate and the diaphragm are separated by a dielectric material. When the force is applied to the diaphragm, it changes its position from initial static position obtained with no force applied. Due to this, the distance of separation between the fixed plate and the diaphragm changes, hence the capacitance also changes. The change in the capacitance can be measured by using any simple a.c. bridge. But practically the change in capacitance is measured using an oscillator circuit where capacitive transducer is part of that circuit. Hence when capacitance changes, the oscillator frequency changes accordingly. In this way, by using capacitive transducer, applied force can be measured interms of change in the capacitance.

9.10.4 Advantages and Disadvantages of Capacitive Transducers

The **advantages** of the capacitive transducers are as follows,

i) The force requirement is very small, hence the power required to operate is small and very useful in small systems.

ii) They are highly sensitive.

iii) They have good frequency response and very high input impedance, so loading effects are minimum.

iv) They are useful in the applications where stray magnetic fields affect performance of the inductive transducers.

The **disadvantages** of the capacitive transducers are as follows :

i) Proper insulation is required between the metallic parts of the capacitive transducers.

ii) The stray capacitances affect the performance of the transducer. It can be overcome by properly earthing the frame of the transducer.

iii) They show non-linear behaviour due to edge effects and stray electric fields. These can be eliminated by using guard rings.

iv) Due to long leads and the cables used, loading effect makes low frequency response poor and reduces sensitivity.

v) For low value capacitances (of the order of pico-farads) the output impedance tend to very high value which causes loading effects.

9.11 Strain Gauge Transducers

The strain gauge is a passive resistive transducer which is based on the principle of conversion of mechanical displacement into the resistance change.

A knowledge of strength of the material is essential in the design and construction of machines and structures. The strength of the material is normally characterized in terms of stress, which is defined as the force experienced per unit area, and is expressed in pressure units. **Stress** as such cannot be directly measured. It is normally deduced from the changes in mechanical dimensions and the applied load. The mechanical deformation is measured with strain-gauge elements. The **strain** is defined as the change, (Δl), in length, (l), per unit length and is expressed as $\Delta l / l$ in microstrains.

The stress-strain curve for a typical metal specimen is shown in Fig. 9.29.

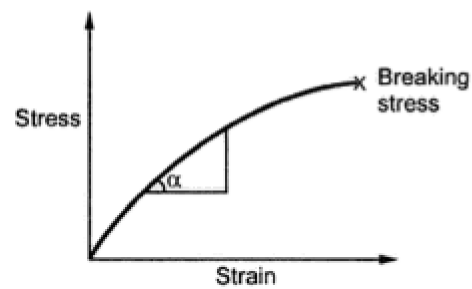


Fig. 9.29 Stress-strain curves for typical metal specimen

It is observed that the curve is linear as long as the stress is kept below the elastic limits. Strain measurements are usually carried out on the free surface of a body. Normally the strain magnitude is of the order of a few micrometers per meter, which is expressed as microstrains. Since the magnitude of strain is extremely small, it is practically difficult to measure it directly. Hence, a gauge which can yield strain directly is used. Such a gauge is known as **strain gauge**.

The desirable characteristics of the strain gauge are gauge sensitivity, range of measurement, accuracy, frequency response, and the ambient environmental conditions it can withstand. **Sensitivity** is defined as the smallest value of strain that can be measured. The maximum strain measurable and the accuracy achievable depend upon the type of gauges used and the method of gauging used.

Basically stress and strain both are directly related to the modulus of elasticity. But strain can be measured easily as compared to stress, using variable resistance transducer, the resistive transducer is commonly called **strain gauge.**

9.11.1 Principle of Operation and Construction of Strain Gauges

The basic principle of operation of an electrical resistance strain gauge is the fact that the resistance of the wire changes as a function of strain, increasing with tension and reducing with compression. The change in resistance is measured with a Wheatstone bridge. The strain gauge is bonded to the specimen and hence the gauge is subjected to the same strain as that of the specimen under test.

The materials used for fabrication of electrical strain gauges must possess some basic qualities to achieve high accuracy, excellent reproducibility, good sensitivity, long life and ability to operate under the required environmental conditions. Some of these qualities are attained by selecting materials with high specific resistance, low temperature coefficient of resistance, constant gauge factor, and constant strain sensitivity over a wide range of strain values. The bonding cement should have high insulation resistance and excellent transmissibility of strain, and must be immune to moisture effects.

The most common materials used for wire strain gauges are constantan alloys containing 45% nickel and 55% copper, as they exhibit high specific resistance, constant gauge factor over a wide strain range, and good stability over a reasonably large temperature range (from 0°C to 300°C). For dynamic strain measurements, nichrome alloys, containing 80% nickel and 20% chromium are used. They can be compensated for temperature with platinum.

Bonding cements are adhesives used to fix the strain gauge onto the test specimen. This cement serves the important function of transmitting the strain from the specimen to the gauge-sensing element. Improper bonding of the gauge can cause many errors.

Basically, the cement can be classified under two categories, viz, solvent-setting cement and chemically-reacting cement. Duco cement is an example of solvent-setting cements which is cured by solvent evaporation. Epoxies and phenolic bakelite cement are chemically-reacting cements which are cured by polymerization. Acrylic cements are contact cements that get cured almost instantaneously.

The proper functioning of a strain gauge is wholly dependent on the quality of bonding which holds the gauge to the surface of the structure undergoing the test.

9.11.2 Derivation of Gauge Factor

The gauge factor is defined as the unit change in resistance per unit change in length. It is denoted as K or S. It is also called **sensitivity** of the strain gauge.

$$S = \frac{\Delta R/R}{\Delta l/l}$$

where S = Gauge factor or sensitivity

R = Gauge wire resistance

ΔR = Change in wire resistance

l = Length of the gauge wire in unstressed condition

Δl = Change in length in stressed condition.

Derivation : Consider that the resistance wire is under tensile stress and it is deformed by Δl as shown in the Fig. 9.30.

Let ρ = Specific resistance of wire material in Ω-m

l = Length of the wire in m

A = Cross-section of the wire in m^2

When uniform stress σ is applied to this wire along the length, the resistance R changes to $R + \Delta R$ because of change in length and cross-sectional area.

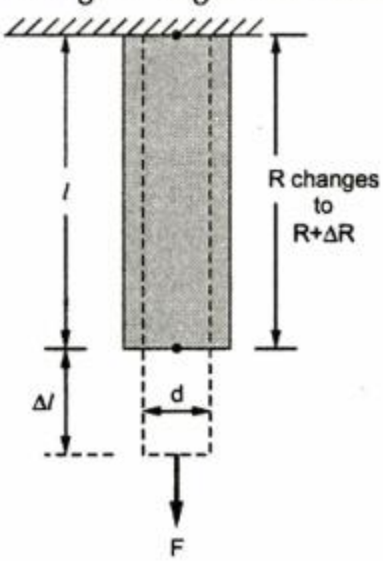


Fig. 9.30 Deformed resistance wire

Let ρ = Specific resistance of wire material in Ω-m

l = Length of the wire in m

A = Cross-section of the wire in m^2

When uniform stress σ is applied to this wire along the length, the resistance R changes to R + ΔR because of change in length and cross-sectional area.

$$\sigma = \text{Stress} = \frac{\Delta l}{l}$$

$\Delta l / l$ = Per unit change in length

$\Delta A / A$ = Per unit change in area

$\Delta\rho/\rho$ = Per unit change in resistivity (specific resistance)

Now
$$R = \frac{\rho l}{A}$$

∴
$$\frac{dR}{d\sigma} = \frac{d\left(\frac{\rho l}{A}\right)}{d\sigma} = \frac{\rho}{A}\frac{\partial l}{\partial\sigma} - \frac{\rho l}{A^2}\frac{\partial A}{\partial\sigma} + \frac{l}{A}\frac{\partial\rho}{\partial\sigma}$$

Note that
$$\frac{\partial}{\partial\sigma}\left(\frac{1}{A}\right) = -\frac{1}{A^2}\frac{\partial A}{\partial\sigma}$$

Multiplying R on Both sides

Canceling $\partial\sigma$ from both sides,

$$\frac{dR}{R} = \frac{dl}{l} - \frac{dA}{A} + \frac{\partial\rho}{\rho}$$

i.e.
$$\frac{\Delta R}{R} = \frac{\Delta l}{l} - \frac{\Delta A}{A} + \frac{\Delta\rho}{\rho} \qquad \text{.. (1)}$$

Key Point : *Thus for finite stress, total change in resistance is due to fractional change in length, area and resistivity.*

For a circular wire,
$$A = \frac{\pi}{4}d^2$$

∴
$$\frac{\partial A}{\partial s} = \frac{\pi}{4}(2d)\frac{\partial d}{\partial s}$$

∴
$$\frac{1}{A}\frac{\partial A}{\partial s} = \frac{1}{A}\frac{\pi}{4}(2d)\frac{\partial d}{\partial s}$$

$$\frac{1}{A}\frac{\partial A}{\partial s} = \frac{1}{(d^2)}(2d)\frac{\partial d}{\partial s}$$

Cancelling ∂s,
$$\frac{\partial A}{A} = \frac{2}{d}\partial d \qquad \text{i.e.} \qquad \frac{\Delta A}{A} = \frac{2\Delta d}{d} \qquad \text{... (2)}$$

Now the **Poisson's ratio** μ for the wire is defined as the ratio of strain in lateral direction to strain in the axial direction.

$$\therefore \quad \mu = -\frac{\Delta d/d}{\Delta l/l} = \text{Poisson's ratio}$$

$$\therefore \quad \frac{\Delta d}{d} = -\mu\left(\frac{\Delta l}{l}\right) \qquad \ldots (3)$$

Using (2) and (3) in (1),

$$\frac{\Delta R}{R} = \frac{\Delta l}{l} - \frac{2\Delta d}{d} + \frac{\Delta \rho}{\rho} = \frac{\Delta l}{l} - 2\left[-\mu\frac{\Delta l}{l}\right] + \frac{\Delta \rho}{\rho}$$

$$\therefore \quad \frac{\Delta R}{R} = \frac{\Delta l}{l}[1 + 2\mu] + \frac{\Delta \rho}{\rho}$$

Neglecting piezoelectric effect, $\frac{\Delta \rho}{\rho}$ can be neglected.

$$\therefore \quad \frac{\Delta R}{R} = \frac{\Delta l}{l}[1 + 2\mu]$$

$$\therefore \quad S = \text{gauge factor} = \frac{\Delta R/R}{\Delta l/l} = 1 + 2\mu$$

11.8.4 Basic Forms of Resistance Wire Strain Gauges

The resistance wire strain gauges of metallic type are available in two basic forms; bonded and unbonded type. The bonded metallic strain gauges are further classified as flat grid, helical grid and thin foil type strain gauges.

A. Bonded Resistance Wire Strain Gauge

In bonded resistance wire strain gauge resistive element is cemented to the base which may be a thin sheet of paper, a thin sheet of bakelite or a sheet of teflon. The resistive element may be in the form of wire, foil or film of the material. The most common types of bonded strain gauges are as shown in the Fig. 11.15.

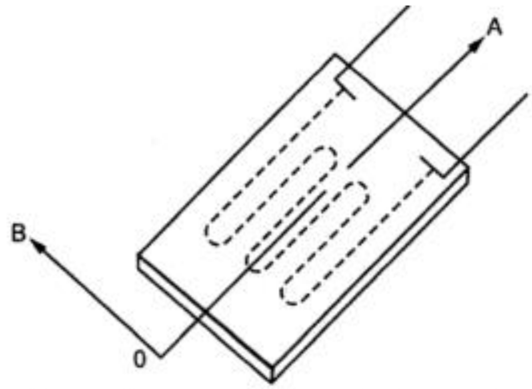


Fig. 11.15 Bonded type strain gauges

In metallic bonded strain gauge a fine wire element about 25 μm or less in diameter is looped back and forth on a base (carrier) or mounting plate. The base is cemented to the member subjected to stress. The grid of fine wire is cemented on a carrier which may be a thinsheet of paper, bakelite or teflon.

A *tensile stress* tends to elongate the wire and thereby increase its length and decreases its cross-sectional area. The combined effect is an increase in resistance.

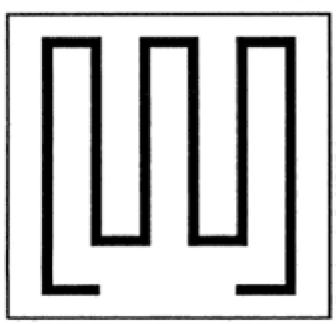
Foil Strain Gauges

In this gauge, the strain is detected using a metal foil. The metals and alloys used for the foil and wire are nichrome, constantan, isoelastic (Ni + Cr + Mo), nickel and platinum.

On account of their larger surface area, foil gauges have a much greater dissipation capacity. Therefore they can be used at a higher operating temperature range. The characteristics of foil type strain gauges and wire type strain gauges are similar, including almost the same gauge factor.

The advantage of foil type strain gauge is that they can be fabricated on a large scale and in any shape. The foil can be etched on the base.

The Fig. 11.16 shows the foil type strain gauge.



Foil type gauge

Fig. 11.16 Foil strain gauge

The etched foil strain gauges can be made thinner than comparable wire units. Also they are more flexible. Because of these properties, the etched foil can be mounted in remote and restricted places and especially on curved surfaces.

The resistance film formed is typically 0.2 mm thick. The resistance value of commercial foil gauges is between 50 and 1000 Ω.

B. Unbonded Resistance Wire Strain Gauge

In general, the basic usage of the unbonded strain gauge is as displacement transducer. It can be constructed in variety of configuration. The unbonded strain gauge consists of a stationary frame with an armature supported at the centre of the frame as shown in the Fig. 11.17.

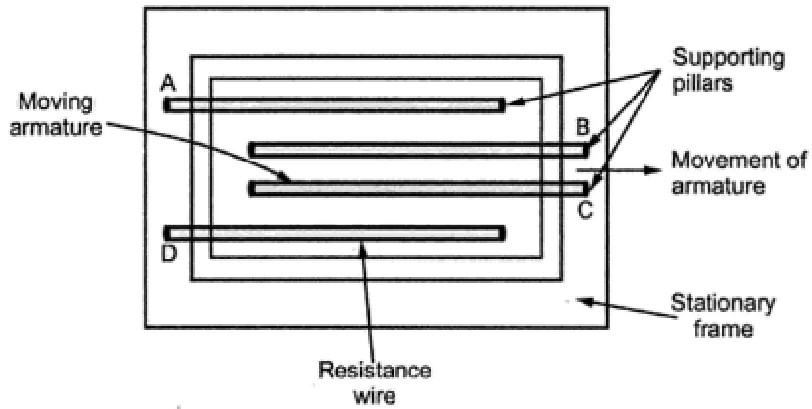


Fig. 11.17 Unbonded strain gauge

The strain gauge is constructed such that an armature can move only in one direction. Its travel in that direction is limited by four filaments of strain sensitive wires. These wires are wound on the rigid insulators. These insulators are mounted on the frame and on the armature.

6.10 Thermistors

Basically thermister is a contraction of a word **'thermal resistors'.** The resistors depending on temperature are thermal resistors. Thus resistance thermometers are also thermistors having positive temperature coefficients. But generally the resistors having **negative temperature coefficients (NTC)** are called **thermistors.** The resistance of a thermistor decreases as temperature increases. The NTC of thermistors can be as large as few percent per degree celcius change in temperature. Thus the thermistors are very sensitive and can detect very small changes in temperature too.

6.10.1 Construction of Thermistor

Thermistors are composed of a sintered mixture of metallic oxides, such as manganese, nickel, cobalt, copper, iron, and uranium. Their resistances at ambient temperature may range from 100 Ω to 100 kΩ. Thermisters are available in a wide variety of shapes and sizes as shown in the Fig. 6.22.

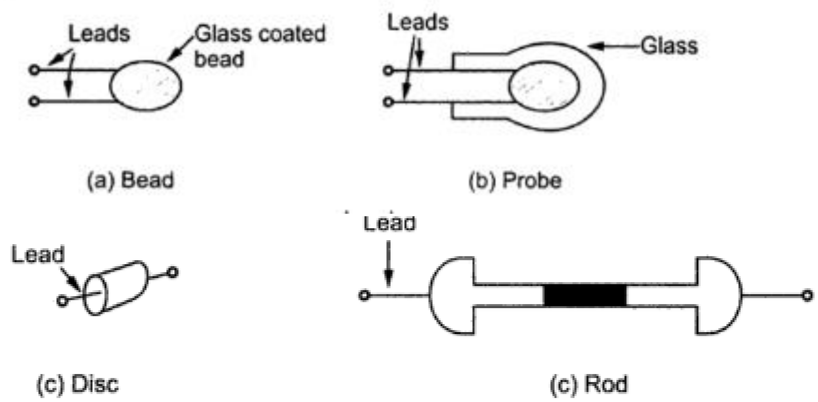


Fig. 6.22 Different forms of construction of thermistors

Smallest in size are the beads with a diameter of 0.15 mm to 1.25 mm. Beads may be sealed in the tips of solid glass rods to form probes. Disks and washers are made by pressing **thermistor** material under high pressure into flat cylindrical shapes. Washers can be placed in series or in parallel to increase power dissipation rating.

Thermistors are well suited for precision temperature measurement, temperature control, and temperature compensation, because of their very large change in resistance with temperature. They are widely used for measurements in the temperature range – 100°C to +200°C. The measurement of the change in resistance with temperature is carried out with a Wheatstone bridge.

6.15 Thermoelectric Transducer - Thermocouple

Thermoelectric transducer is a temperature transducer which converts thermal energy into an electrical energy. The most commonly used thermoelectic transducer is **thermocouple.** Thermocouple is generally used as a primary transducer for temperature measurement in which changes in temperature are directly converted into an electrical signal. The thermocouple behaviour can be explained on the basis of thermoelectric phenomena namely seebeck effect, Peltier effect and Thompson effect. Let us study the thermoelectric phenomena in brief.

6.15.1 Thermoelectric Phenomena

In 1821, the great scientist **Prof. Seebeck** discovered that if the two wires of different metals are joined together forming closed circuit and if the two junctions formed are at different temperatures, an electric current flows around a closed circuit. This is called **Seedbeck effect.** He also observed that if the two metals used are copper and iron, then the current flows from copper to iron at hot junction and from iron to copper at cold junction as shown in the Fig. 6.44.

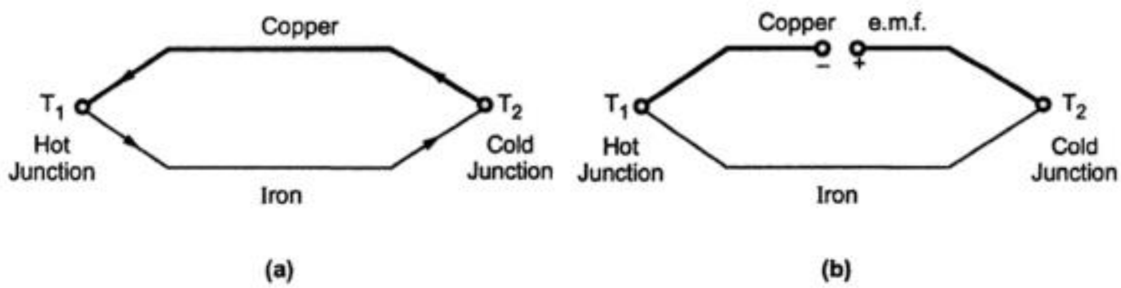


Fig. 6.44 Seebeck effect

If the copper wire is cut, the e.m.f appears across the open circuit as shown in the Fig. 6.44(b). This e.m.f. is commonly known as **Seebeck e.m.f.** This Seebeck e.m.f. is proportional to the difference in the temperatures of the two junctions.

In 1824, **Prof. Peltier** discovered a reverse phenomenon. He observed that when two dissimilar metals form two junctions as shown in the Fig. 6.45, and if an external e.m.f. is connected as shown, then the current flows through the junctions. When current flows through copper-iron junction (T_1) from copper to iron, heat is absorbed making junction T_1 hot and when current flows through iron-copper junction (T_2) from iron to copper, heat is liberated or liberated making junction T_2 cold. This is called **Peltier effect.** The amount of heat absorbed or liberated when unit current flows for unit time is called Peltier coefficient.

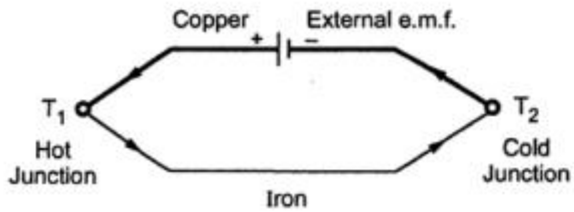
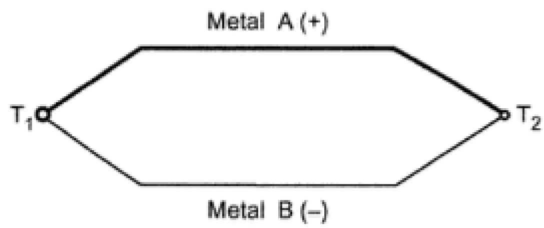


Fig. 6.45 Peltier effect

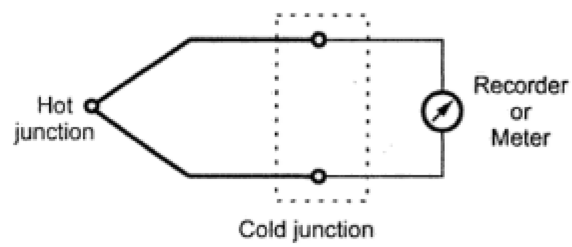
Prof. Thompson postulated another reversible heat flow effect, known as **Thompson effect.** According to the Thompson effect, when a current flows through a copper conductor having thermal gradient along length of the conductor, heat is released at a point where current is in the direction same as the heat flow; while heat is absorbed at a point where current flows in the direction opposite to that of heat flow.

6.15.2 Construction of Thermocouple

A **thermocouple** is the most commonly used thermoelectric transducer. Thermocouple is made up of two wires of dissimilar metals joined together to form two junctions as shown in the Fig. 6.46(a).



(a) Basic thermocouple circuit



(b) Practical thermocouple circuit

Fig. 6.46

Out of two junctions T_1 and T_2, T_2 is kept at constant reference temperature. Hence it is refered as **cold junction.** While the temperature changes to be measured are subjected to the junction T_1 which is refered as **hot junction.** When the hot junction temperature is greater as compared to the cold junction, e.m.f. is generated due to the temperature gradient. The magnitude of the e.m.f. generated depends on the material used for the wires and temperature difference between the two junctions. Generally a meter or recorder is used to measure e.m.f. as shown in the Fig. 6.46(b). The hot junction is sometimes called **measuring junction** while the cold junction is called **reference junction.**

The two wires of the thermocouple are generally twisted and welded together. In general a junction may be formed by two methods; namely twisted weld and Butt weld. In twisted weld, two wires are twisted together in several turns and welded together. This type of welding is used for larger sized wires which gives mechanical strength. In Butt weld, two wires of comparatively smaller sizes are fused into a round bend.

To measure higher temperature, the wire used should be heavier. But if the size of the wire increases, the response time of the thermocouple increases. So size of the wire is selected such that above mentioned two conditions are compromised. Usually for noble metals, the wire of diameter 0.5 mm is selected; while for the base metals, the diameter of the wire ranges from 1.5 to 3 mm.

6.15.2.1 Materials used for Thermocouples

The thermocouples are made from a number of different metals including copper-constant, iron-constantan chromel - constantan, platinum-platinum-rhodium, etc. They cover wide range of temperature. Say from $-200\,^\circ C$ to $2800\,^\circ C$.

Following is the table illustrating the ranges of temperature measurements in the thermocouples of different materials.

Material used	Types of Thermocouple	Temperature range
Copper-constantan	T	– 250 °C to 400 °C
Iron-constantan	J	–200 °C to 850 °C
Chromel-Alumel	K	–200 °C to 110 °C
Chromel-constantan	E	–200 °C to 850 °C
Platinum-platinum-rhodium	S	0 °C to 1400 °C
Tungsten-Molybdenum	–	0 °C to 2700 °C
Tungsten-Rhenium	–	0 °C to 2600 °C

Table 6.5 Thermocouples and temperature ranges

Out of all the materials used in thermocouples, platinum is the most stable material even in the oxidizing atmosphere. Its sensitivity is very high. Constantan (Ni–40 % and Cu – 60%) is another alloy that can be used with copper, iron and chromel (Ni–90% and Cr–10%). Copper-constantan thermocouple gives highest output with maximum sensitivity. Also it is inexpensive. Iron-constantan is another inexpensive thermocouple which is most widely used in industrial applications. But the disadvantage of iron-constantan thermocouple is that iron oxidizes rapidly above 750°C temperature. Chromel-alumel thermocouple is very resistant to oxidation within 700 °C to 1300 °C non reducing environment temperature. For higher temperature measurements, tungsten and molybdenum is used. Sometimes alloys of tungsten and rhenium are also used upto 2600 °C temperatures.

The two conductors or wires of thermocouple must be insulated from each other at cold junction. Also hot junction must be insulated from the measuring instrument. Hence according to different temperature ranges suitable insulating materials are used. Some of the insulating materials with temperature ranges are as follows.

Insulating material	Temperature limit
Enamel and cotton	250 °F
Asbestos	900 °F
Glass	900 °F
Ceramic Insulators	2600 °F

Table 6.6

As the thermocopule measures the temperature difference between the hot and cold junction temperatures, the reference junction or cold junction temperature must be maintained accurately. For the reference junction, generally ice both technique is used. It is a tradition method used to produce accurate measurement. For the most accurate measurements, the reference junction is kept in a triple-point-of-water apparatus.

6.16 Piezoelectric Transducer

In 1880, **J. Cuire** showed that when two opposite faces of a thin slice of certain crystals are subjected to a mechanical force, then opposite charges are developed on the two faces of the slice. The magnitude of the electric potential between the two faces is proportional to the deformation produced.

It is interesting to note that the polarity of the potential produced across the faces gets reversed if the direction of deformation is reversed.

Conversely if varying potential is applied to the axis of the crystal, the dimensions are changed and the crystal deforms.

This phenomenon is called **piezoelectric effect** and the materials exhibiting this effect are called **piezoelectric materials.**

The main substances exhibiting piezo-electric effect are quartz, Rochelle salts and tourmaline. Rochelle salts show greatest piezo-electric activity. But mechanically they are weakest as they break easily. Tourmaline is the strongest of the three but it exhibits least piezoelectric activity. It is very expensive. Quartz is a compromise between the piezoelectric activity of Rochelle salts and the strength of tourmaline. It is readily available in nature and it is inexpensive. Rochelle salts are used to make microphones, headsets, loudspeakers and phonograph pickups. Quartz is used for RF oscillators and filters. The quartz and tourmaline are natural crystals while Rochelle salts are synthetic crystals. Other synthetic crystals are Barium Titanate, Dipotassium Tartarate, Lithium sulphate, ceramics A and B etc. The natural crytals have the advantage of very low leakage and allows measurements of slowly varying parameters. While the synthetic crystals have the advantages of higher output, high sensitivity and capability to withstand high mechanical stresses.

A piezoelectric quartz crystal is hexagonal prism shaped crystal, which has pyramids at both ends. This is shown in the Fig. 9.47 (a). The marking of co-ordinate axes are fixed for such crystals. The axis passing through the end points of pyramids is called **optic axis** or z axis. The axis passing through corners is called **electrical axis** or x axis while the axis passing through midpoints of opposite sides is called **mechanical axis** or y axis. The axes are shown in the Fig. 9.47 (b).

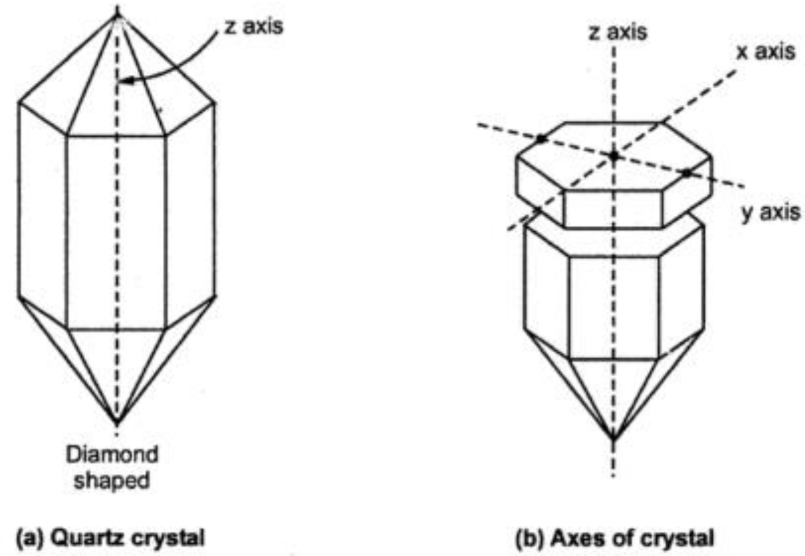


Fig. 9.47

9.17.1 Basic Piezoelectric Pressure Transducer

The construction of basic piezoelectric pressure transducer is shown in the Fig. 9.48 (a).

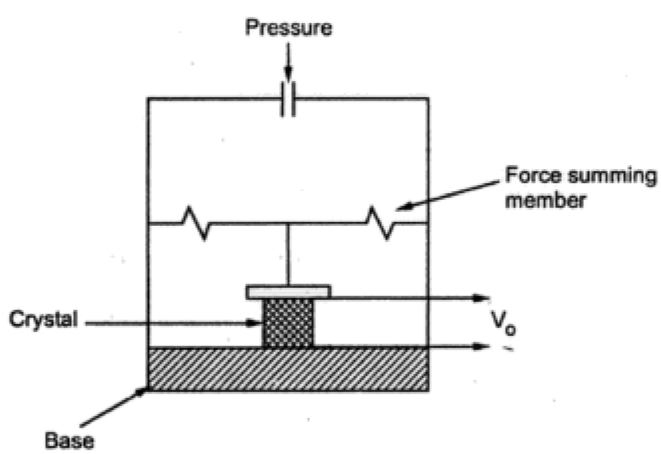


Fig. 9.48 (a) Piezoelectric transducer

A crystal is placed between solid base and force summing member. Metal electrodes plated onto faces of piezoelectric crystal are taken out to measure output. The electrodes become plates of the parallel plate capacitor. Thus it can be considered as charge generator. The output voltage is given by

$$V_o = \frac{Q}{C}$$

The output is very high about 1 to 30 mV. No external power supply is required. High frequency response is excellent. Its size is small and construction is simple.

But these crystals are water soluble and hence dissolve in a humid environment. The output voltage is affected by temperature variations. It is not useful in measuring static conditions.

Practically the sensitive piezoelectric element of a piezoelectric pressure transducer is in the form of pile of pairs of quartz discs. These discs are held in such a way that their optically flat faces are between a flat metal face called **load plate** on one side and transducer housing on other side. For this purpose preloading spring of stiffness K_2 is used. The stiffness of crystal is denoted as K_1. This arrangement is shown in the Fig. 9.48 (b).

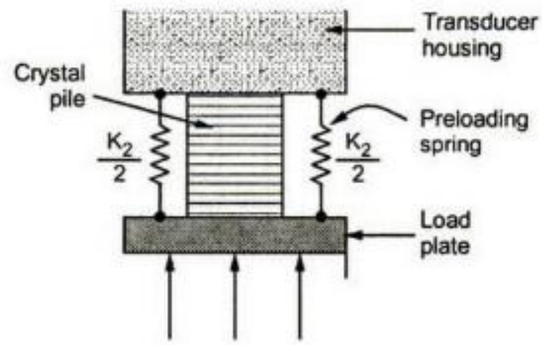
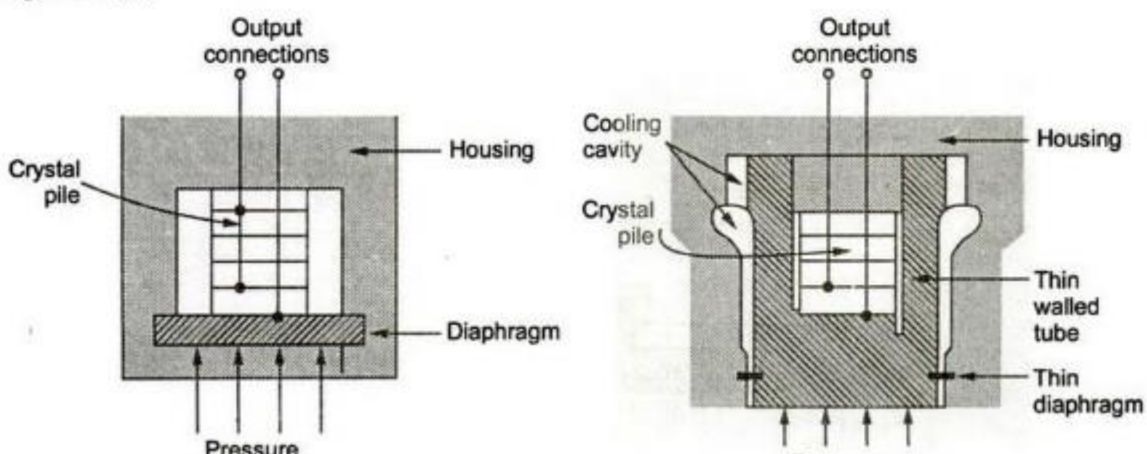


Fig. 9.48 (b) Crystal pile in a piezoelectric pressure transducer

In earlier designs, the preloading is obtained by using the stiff diaphragm. This is shown in the Fig. 9.49 (a). But the changes in stiffness constant due to temperature, nonlinearity at high values of preloads are disadvantages of diaphragm.

Hence the diaphragm is replaced by thin walled tube under tension. A very thin diaphragm of flexible material is used for sealing purpose. This is shown in the Fig. 9.49 (b).



(a) Diaphragm loaded (b) Tube loaded

Fig. 9.49 Piezoelectric pressure transducers

11.18.1.1 Advantages and Limitations of Piezoelectric Pressure Transducer

The **advantages** of piezoelectric pressure transducer are as follows.

1) Rugged construction and small size.
2) High output with negligible phase shift.
3) Excellent frequency response.

The **limitations** of piezoelectric pressure transducer are as follows.

1) Piezoelectric crystals are water soluble. Hence in a high humidity environment gets dissolved.
2) Temperature sensitive.
3) It can be used for dynamic measurements only.

11.18.2 Applications of Piezoelectric Transducer

1. The piezoelectric transducer is used for measurements of non-electrical quantities such as acceleration, vibration, sound intensity and dynamic pressures.
2. The piezoelectric transducer is used widely in aerodynamics, supersonic wind tunnels, in the study of extremely high speed phenomena such as explosions, bomb blasts etc.
3. It is used in ultrasonic, non-destructive test equipments, ultrasonic flowmeters, micromotion actuators.
4. It is also used in spark ignition engines and electrostatica dust filters producing high voltage low current electric power.

11.19 Photoelectric Transducers

In instrumentation, the transducers based on effects of physical radiation of matter are used extensively. Optoelectric devices are designed for the emission and absorption of the optical radiations. While the photoelectric transducers are used for producing photoelectric effect which is the effect of visible radiations.

The photoelectric transducers include photoemissive, photoconductive and photvoltaic transducers. In **photoemissive transducers,** when radiation falls on cathode, electrons are emitted from cathode. While in **photoconductive transducers,** an electrical output is produced due to the change in resistance of the material when light falls on that material. While the **photovoltaic transducers** produce an output voltage proportional to the radiation intensity. Let us discuss photoelectric transducers in detail.

11.19.1 Photoemissive Transducers

In some materials, when light radiation strucks the surface, electrons are emitted. When the photons of the incident light with sufficient energy incident on the surface, the electrons break their atomic bonds as well as the forces of the entire material lattice. This phenomenon is observed are called photoemissive materials. The common photoemissive material is cesium-antimony. Generally the photoemissive material is housed in a glass tube, the photoemissive devices are also called **phototubes.** There are three types of phototubes.

i) Vacuum phototube

ii) Gas-filled phototube

iii) Photomultiplier Tube

9.19.1.1 Vacuum Phototube

The Vacuum phototube is as shown in the Fig. 9.53.

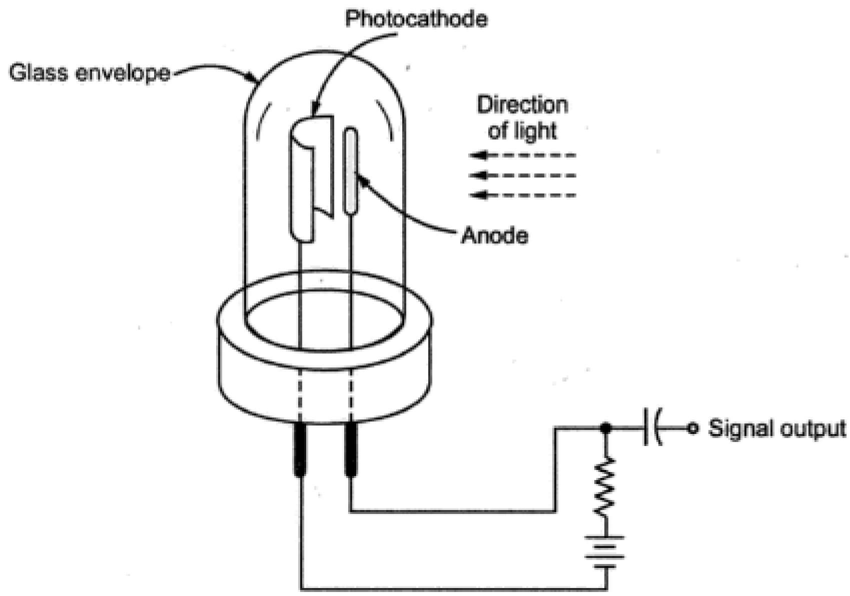


Fig. 9.53 Vacuum phototube

A surface of specially shaped cathode is coated with some photoemissive material. This photocathode is housed in a sealed glass tube along with another electrode called anode. A vacuum exists within the glass tube. A voltage is created between the photocathode and anode with anode having positive voltage level while photocathode having negative voltage level.

When light strikes the photocathode, the photons impart sufficient energy to the electrons, the electrons are emitted from the photocathode and collected by the positive anode. If the intensity of light incident is stronger, more number of electrons are emitted. Hence the magnitude of the current flowing in the circuit is directly proportional to the intensity of the light incident on the photocathode. For sufficiently high voltage between anode and photocathode, the current characteristics are linear over wide range of the light levels as shown in the Fig. 9.53.

The response time of phototubes to the incident light is so rapid that they are used in the applications where short duration light pulses are to be observed.

9.19.1.2 Gas-Filled Phototubes

In this type of the phototubes, the tube enclosing photocathode and anode is filled with an inert gas such as argon. The basic construction of phototube remains same. When light strikes the photocathode, the electrons are emitted and they are accelerated towards the anode due to the voltage difference. The emitted electrons collide with the argon gas atoms. If the energy of the electron is high sufficiently, it ionises argon atom during collision. Hence collision gives positive ions and additional free electrons. As a result cathode attracts positive ions while anode collects free electrons. Hence current in the external circuit increases. Thus due to collisions of emitted electrons with an argon atoms, large current flows in the circuit. So additional amplification of current is not required which makes gas-filled phototube simple and inexpensive. The response time of the gas-filled phototubes is slow as compared to the vacuum phototubes as positive ions move relatively slowly towards the photocathode.

9.19.1.3 Photomultiplier Tube

It is the most widely used photoemissive device having the better characteristics to detect the very low intensity light. The photomultiplier tube is actually amplifying device.

The basic principle of photomultiplier tube is as shown in the Fig. 9.54.

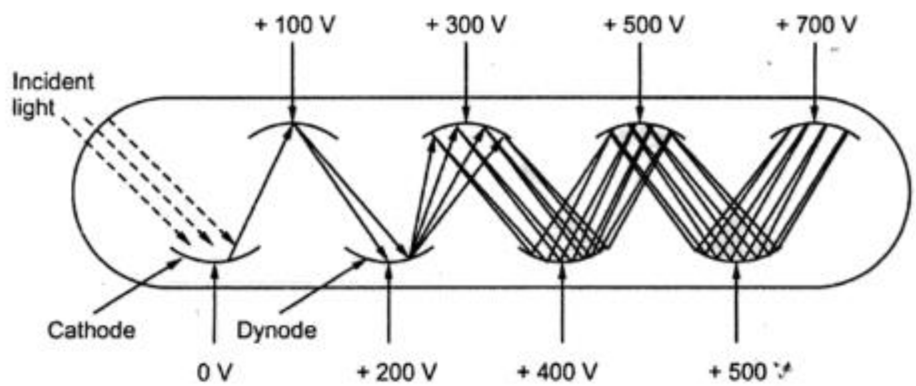


Fig. 9.54 Photomultiplier tube

The beam of incident light is first made to strike a photoemissive material coated photocathode similar to the ordinary vacuum phototube. As a result, the electrons are emitted. But the emitted electrons are not immediately drawn to the anode. Instead, they are further attracted to another electrode called **dynode.**

When the electron beam strikes dynode, it emits secondary electrons. Thus each individual photoelectron is accelerated by an electric field externally applied and strikes several secondary electrons out of the dynode. The dynode is designed such that it forms electric field lines which direct the emitted secondary electrons of previous dynode to itself.

Thus at each dynode, the electrons are multiplied in numbers and finally all are collected by anode. Thus a multiplication factor over 10^6 can be achieved in some of the commercial tubes.

The photomultiplier tube has really very rapid response time and can follow frequencies of upto several hundreds of megacycles. The photomultiplier tube is not suitable for detecting infrared radiation because materials are not photoemissive in response to infrared radiation.

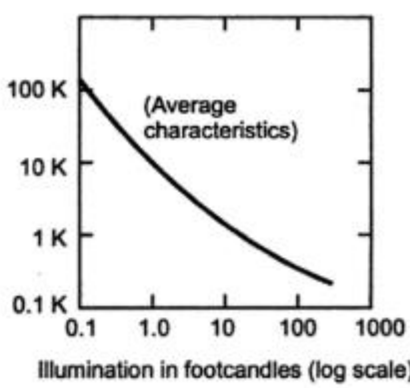
9.19.2 Photoconductive Transducers

When light falls on a material, the energy in the radiation ionizes the covalent bonds. Thus the bonds are broken and large number of electron-hole pairs are generated. This increases number of current carrier and decreases the resistance of the material. The phenomenon is called **photoconductive effect.** As in such devices, the change in conductivity appears as a change in resistance, the devices are also called **photoresistors** or **photoconductors.**

The major difference between photomultiplier and photoresistor is that in photoresistor an electron is excited in the conduction band rather than being removed as free electron out of lattice.

In visible light detectors, the semiconductor materials used are cadmium sulphide (CdS), cadmium selenide (CdSe). Both these materials have energy gap (E_g) between valence band and covalent band of 2.42 eV approximately. The materials used in infrared detectors are lead sulphide (PbS), lead selenide (PbSe), indium antimony (InSb) and mercury or copper dopped germanium (Ge). In all these materials, the thermally induced current must be much smaller than the optically induced current. It is achieved by cooling the detectors with liquid nitrogen.

The typical characteristics are as shown in Fig. 9.55.



Resistance versus illumination curve

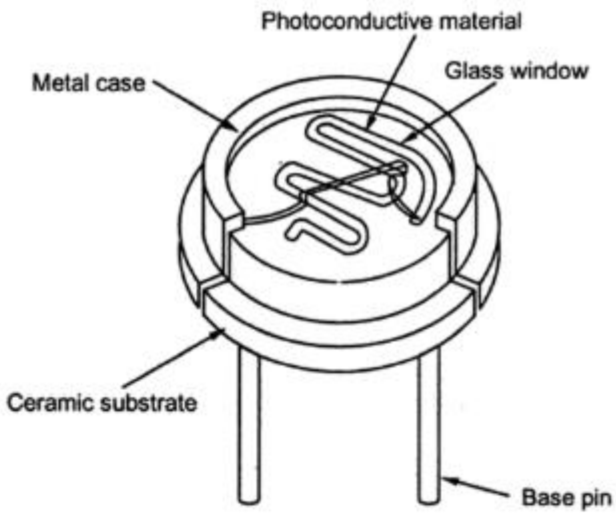
Fig. 9.55 Characteristics of photoconductive transducer

The photoconductors are constructed by applying a thin layer of a semiconductor material on a substrate of either ceramic or silicon. In photoconductors, juction is not required hence they are also called **junctionless detectors.**

Depending on device, the dark resistance changes from 10 kΩ to 200 MΩ. One can get ratio of dark to light resistance as high as 10,000. The switching time of the photoconductors is relatively slow and it ranges from 1 ms to 100 ms.

9.19.2.1 Photoconductive Cell

It is the commonly used photosensetive element in the relays and proximity switches. It is also used in intrusion alarms and a counters as sensor. In photoconductive cell, light sensitive material is applied on disc in zigzag shape as shown in the Fig. 9.56 (a). The symbol is as shown in the Fig. 9.56 (b).



(a)

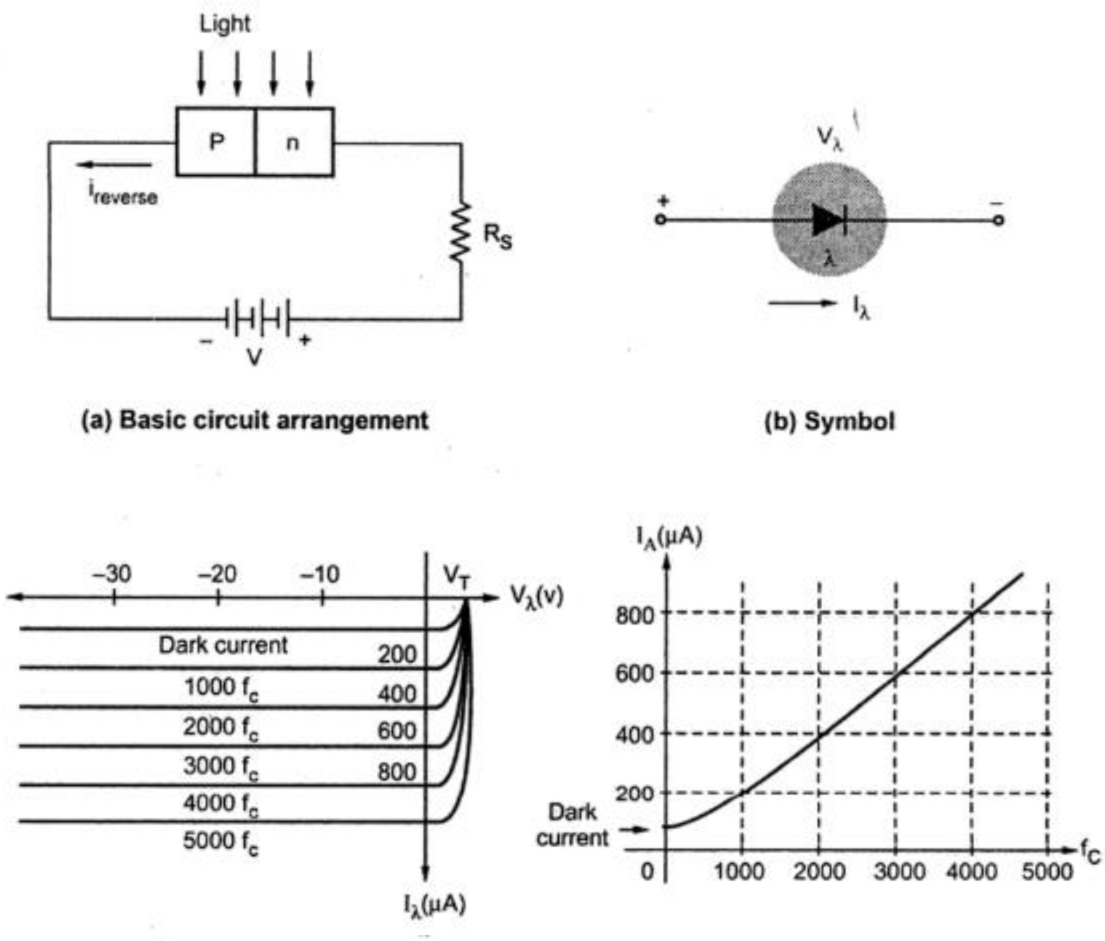
(b)

Fig. 9.56

The most commonly used materials are cadmium sulphide (CdS) and Cadmium selenide (CdSe). The peak spectral response of CdS occurs at approximately 5100 A° while that of CdSe at A°. When the intensity of illumination increases, the number of photons increases giving large number of free electrons which inturns decreases resistivity.

9.19.2.2 Photodiodes

The photodiode is a diode which is used to detect light and its operation is limited in reverse bias region only. The basic circuit arrangement and symbol are as shown in the Fig. 9.57 (a) and 9.57 (b) respectively.



(c) Characteristics (d)

Fig. 9.57 Photodiode and its characteristics

In a normal diode, under reverse biased condition, the reverse current is due to the minority charge carriers in p-type and n-type regions. This current is limited to few microamperes. In photodiode, when light falls on it, the energy in the form of photons is transfer to the atomic structure. It results in increasing the number of minority charge carriers in both the region and increasing reverse current level. The variation in the reverse current with increase in light intensity is as shown in the Fig. 9.57 (c) The dark current is the reverse current in photodiode when no illumination. From the characteristics it is clear that for same increment in luminous flux, there is same increase in the reverse current (I_x). Thus the characteristics of I_λ versus luminious flux are linear as shown in the Fig. 9.57 (d).

The rise and fall time in photodiodes is very small (typically of the order of nanoseconds), they are most widely used in the high speed switching and counting applications. The semiconductors used are Ge and Si. Out of these two, the spectrum of wavelength is wider in Ge. Hence Ge can be used to detect infrared light. It also has higher level of reverse current as compared to Si but the dark current in Ge is higher than that in Si.

When a photodiode is illuminated without applying reverse biasing voltage, it acts as a voltage source with p-region positive and n-region negative. In this mode of operation it is called **photovoltaic diode** or **solar cell**. In general, the materials used in the solar cells are silicon (Si) and selenium (Se). Some other materials such as gallium arsenide (GaAs), cadmium sulphide (CdS) and indium arsenide (IdAs) are less commonly used.

9.19.3 Photovoltaic Transducers

When an open circuited p-n junction is illuminated, large number of electron-hole pairs are generated in the region near junction. Typically a small voltage appears across its terminals, hence acts as a voltage source. This phenomenon in which light energy is converted to electrical energy is called **photovoltaic effect.** Photovoltaic cell is the common example of this type.

9.19.3.1 Photovoltaic cell

Fig. 9.58 shows structure of photovoltaic cell. It shows that cell is actually a PN-junction diode with appropriately doped semiconductors. When photons strike on the thin p-doped upper layer, they are absorbed by the electrons in the n-layer; which causes formation of conduction electrons and holes. These conduction electrons and holes are separated by depletion region potential of the p-n junction. When a load is connected across the cell, the depletion region potential causes the photocurrent to flow through the load.

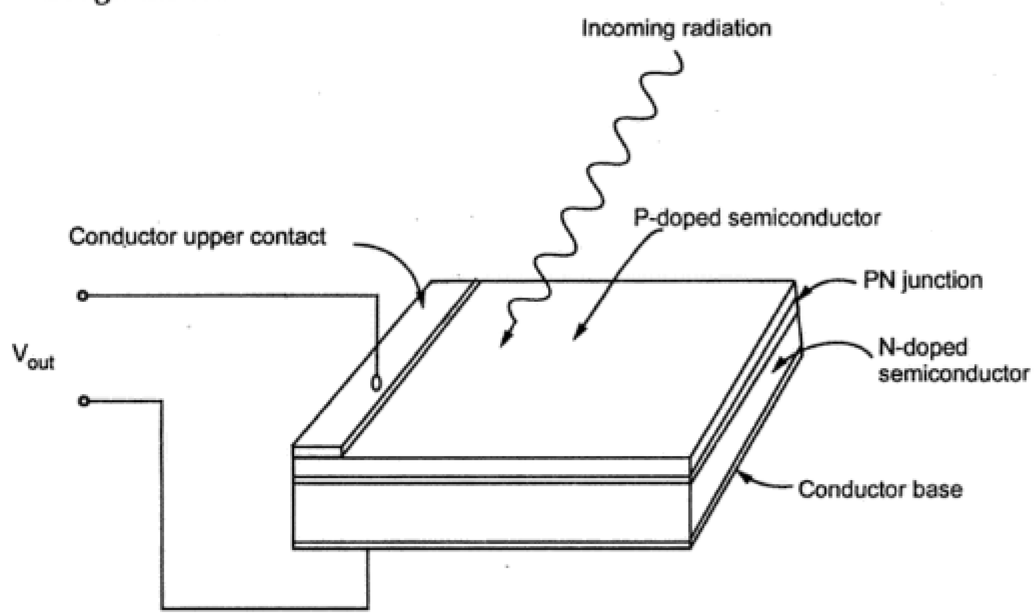


Fig. 9.58 Structure of photovoltaic cell

6.19.3.2 Phototransistors

In phototransistors, reverse biased collector base junction is nothing but photodiode. The base terminal is kept floating. The reverse leakage current in the transistor is the diode current which increases with increase in intensity of light. According to the transistor action, the base current increases by 100 to 1000 times. The symbol of phototransistor is as shown in the Fig. 6.64.

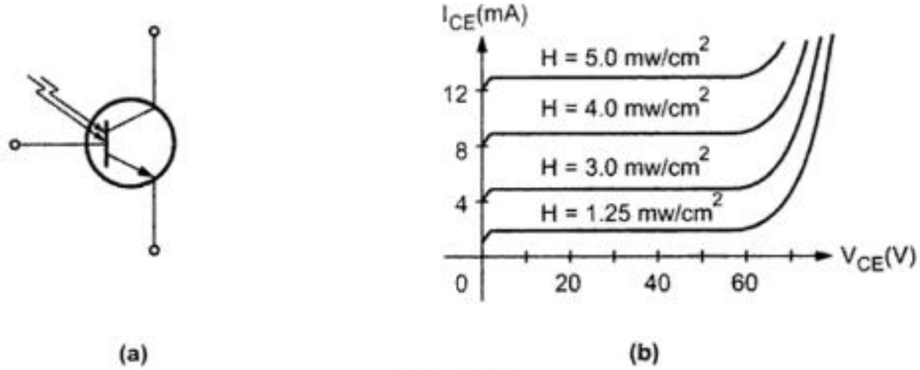


Fig. 6.64

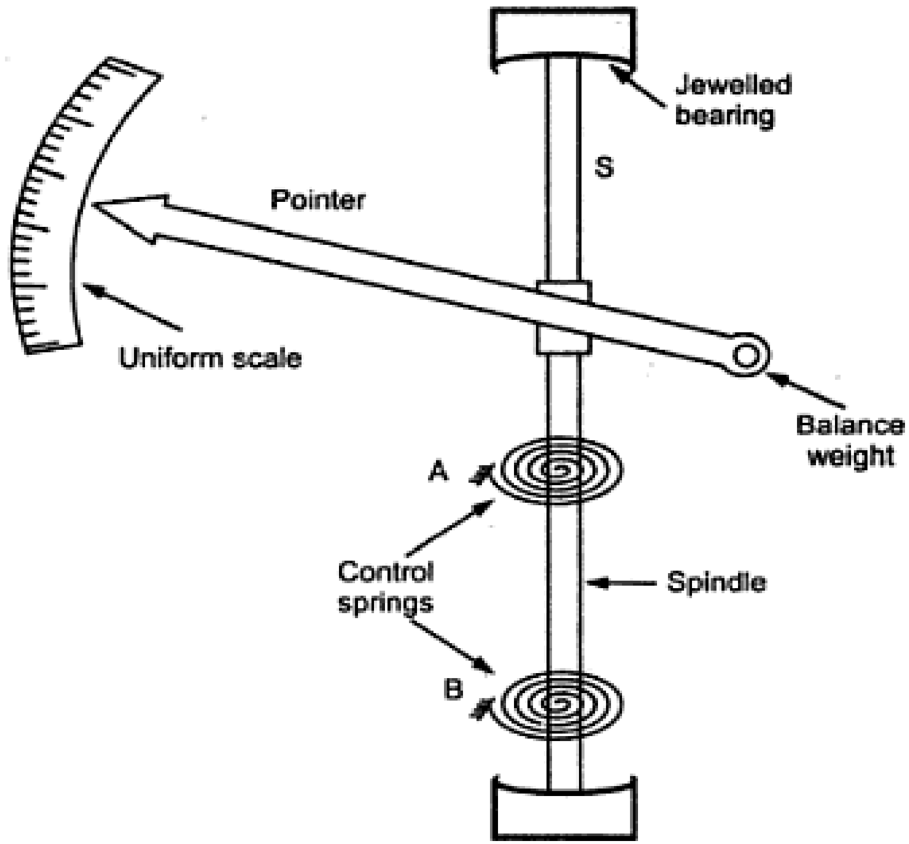
As base current increases, collector current also increases. The typical characteristics of the phototransistor are as shown in the Fig. 6.64 (b).

The phototransistor and infrared emitting diodes are used in combination to give **optocoupler** or **optoisolator.** To get proper output of the device, the wavelength of the emitting diode and receiving photo transistors are matched.

Types of Torques

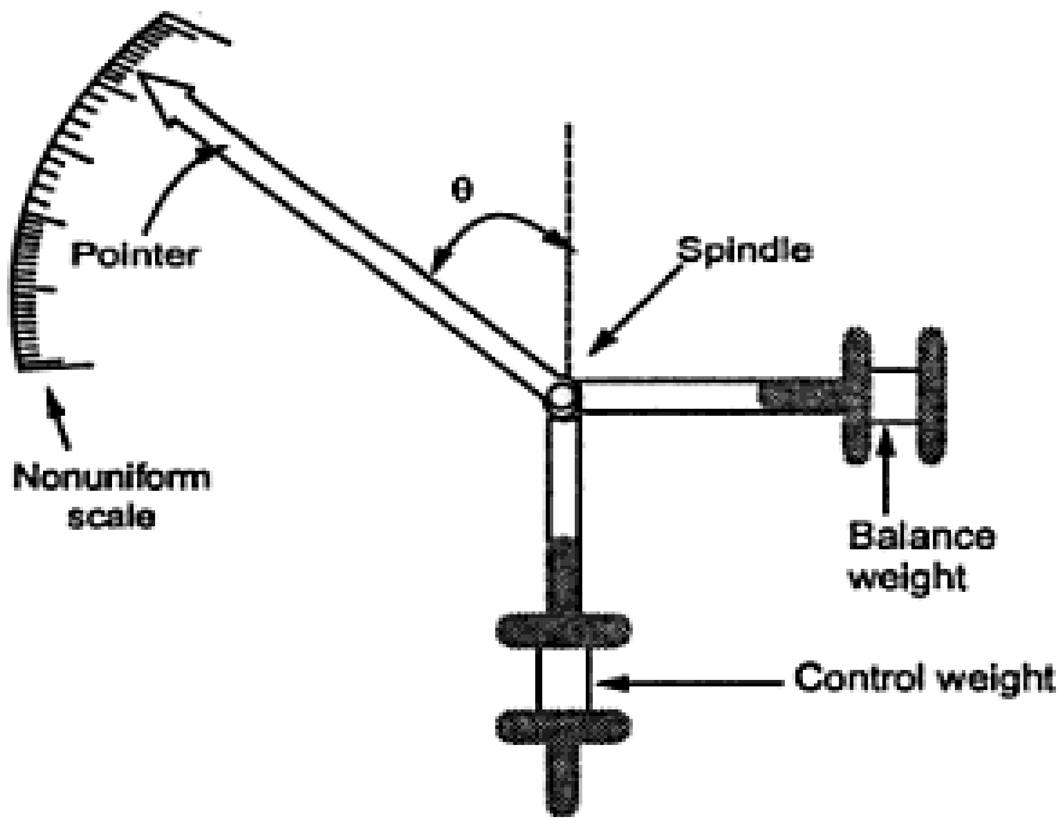
- Deflecting Torque
- Controlling Torque
  a) Spring Control
  b) Gravity Control
- Damping Torque
  a) Air Friction Damping
  b) Fluid Friction Damping
  c) Eddy Current Damping

Spring Control



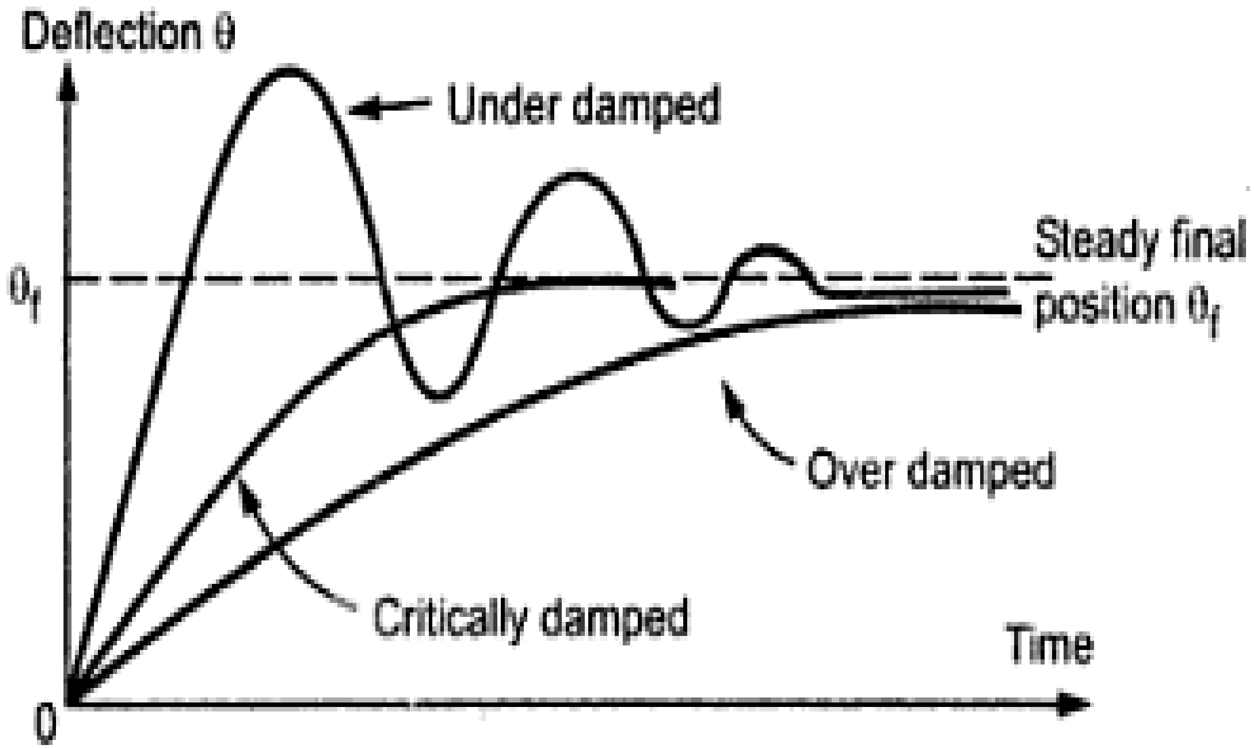
Spring control

Gravity Control

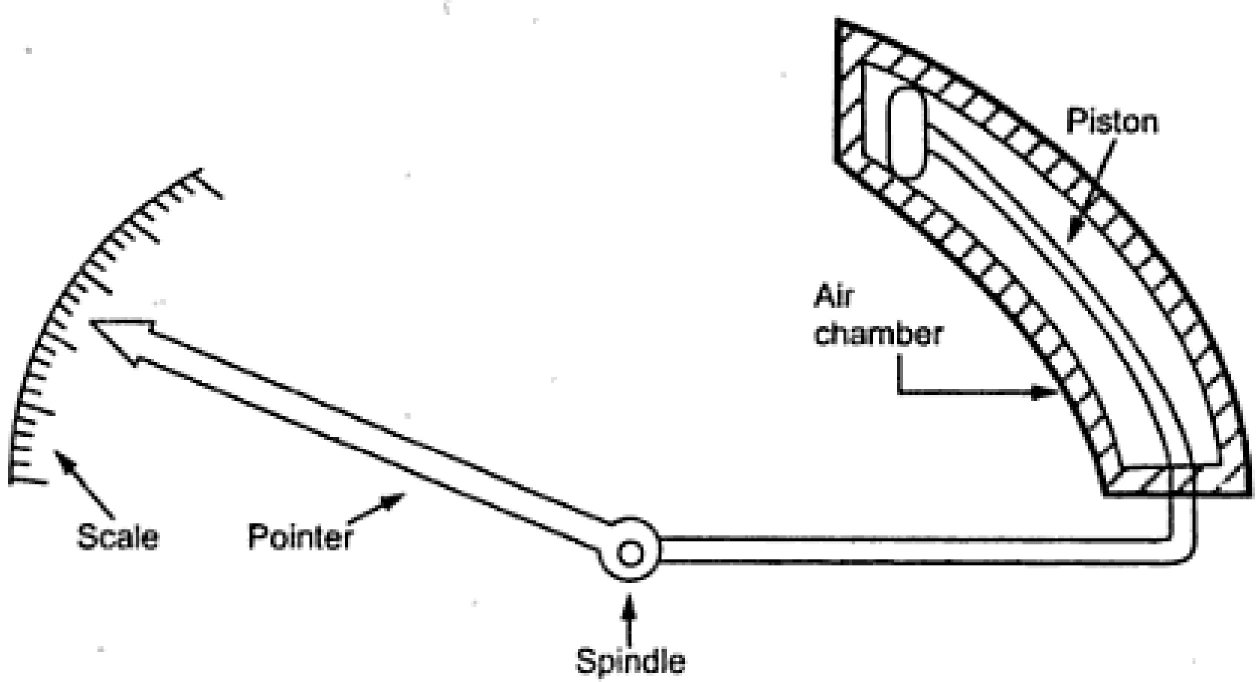


Gravity control

Damping Torque

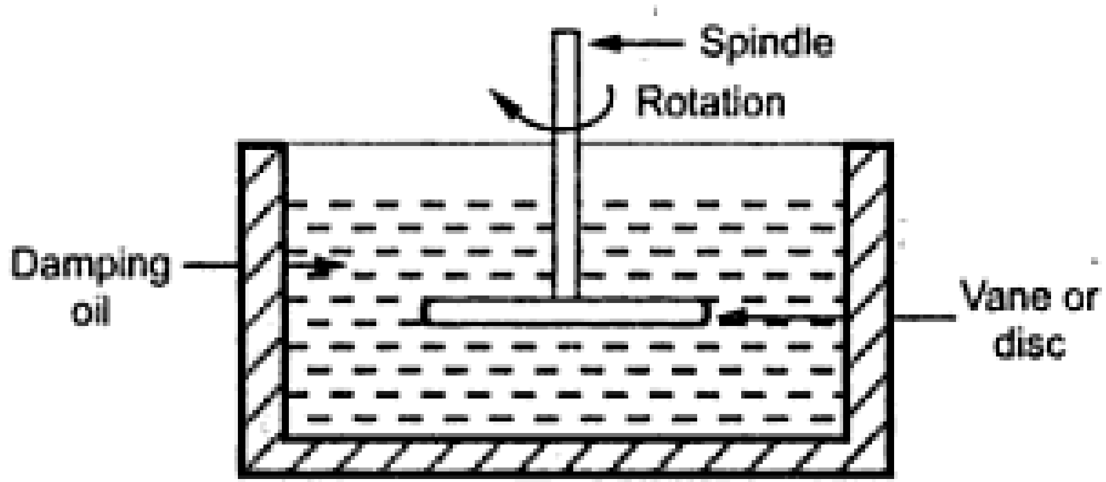


Air Friction Damping



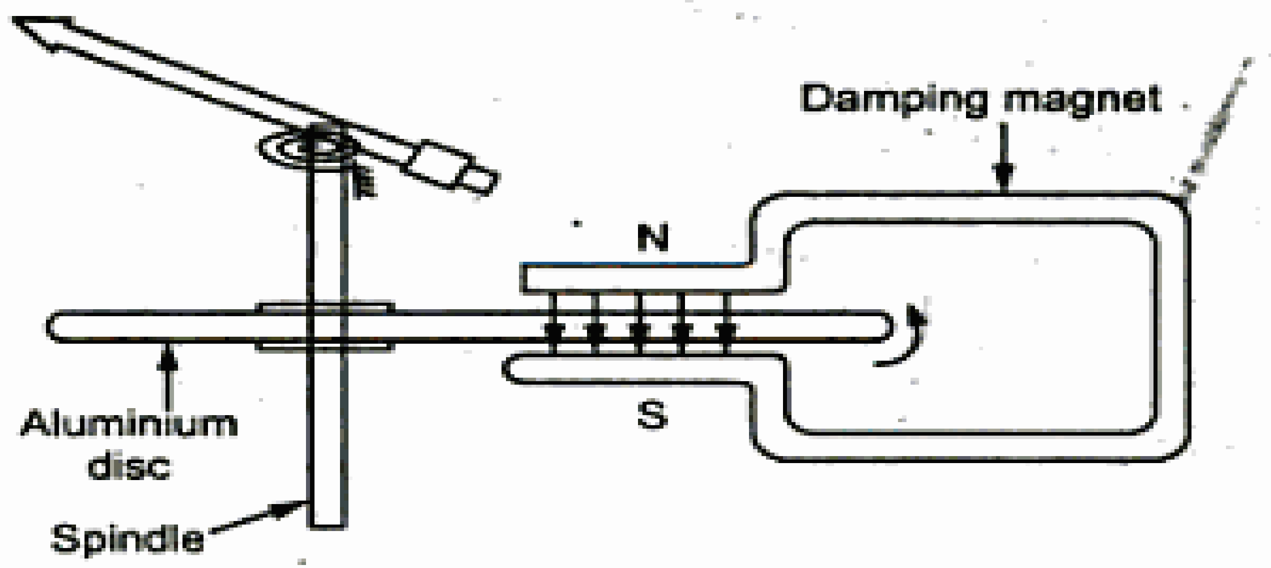
Air friction damping

Fluid Friction Damping

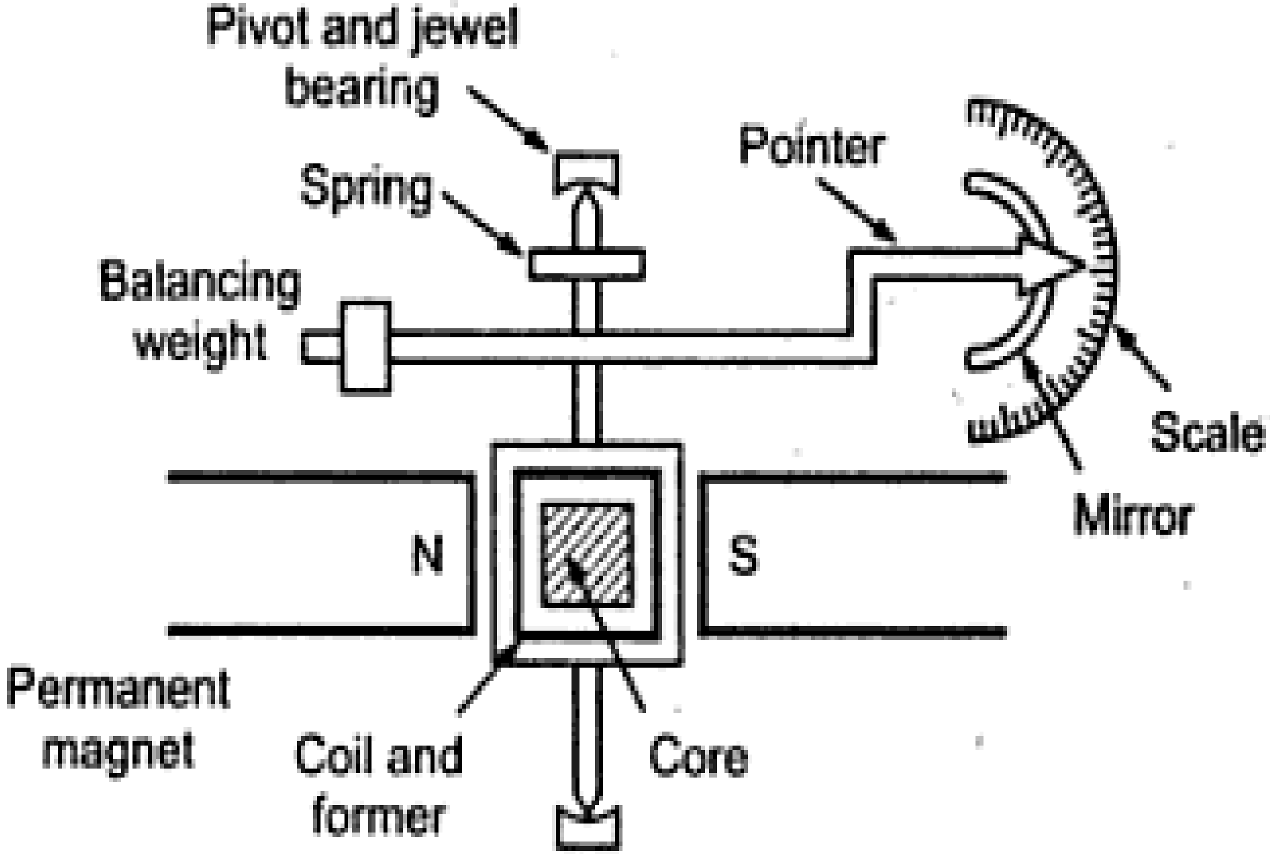


Fluid friction damping

Eddy Current Damping



Eddy current damping



Construction of PMMC instrument

Advantages

The various advantages of PMMC instruments are,

1) It has uniform scale.
2) With a powerful magnet, its torque to weight ratio is very high. So operating current is small.
3) The sensitivity is high.
4) The eddy currents induced in the metallic former over which coil is wound, provide effective damping.
5) It consumes low power, of the order of 25 W to 200 μW.
6) It has high accuracy.
7) Instrument is free from hysteresis error.
8) Extension of instrument range is possible.
9) Not affected by external magnetic fields called stray magnetic fields.

Disadvantages

The various disadvantages of PMMC instruments are,

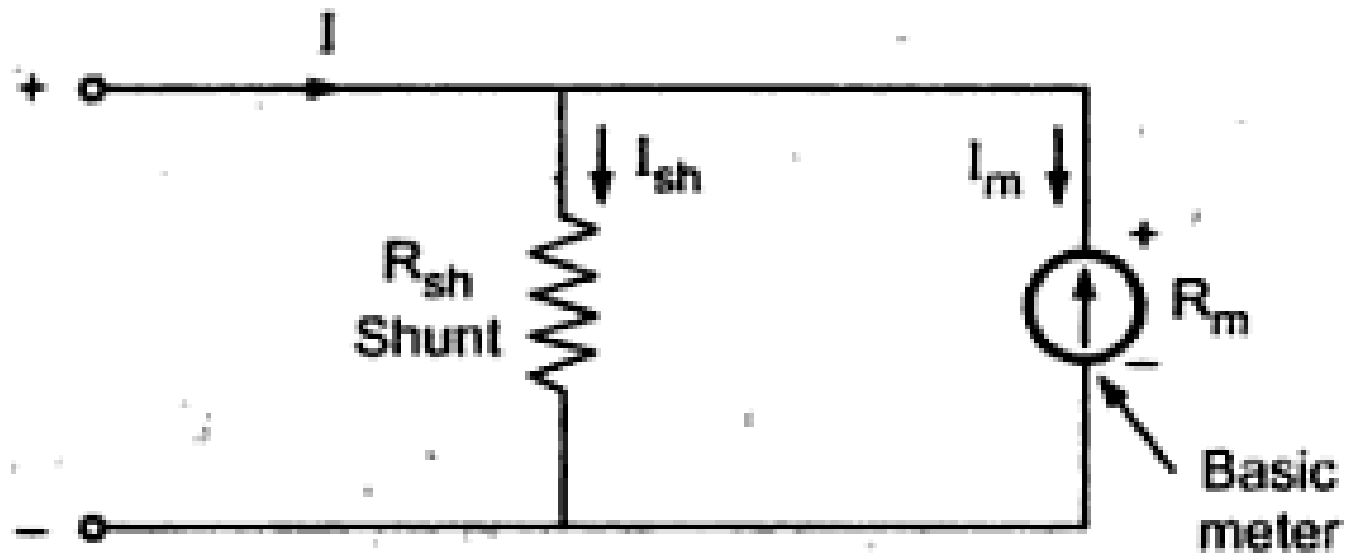
1) Suitable for d.c. measurements only.

2) Ageing of permanent magnet and the control springs introduces the errors.

3) The cost is high due to delicate construction and accurate machining.

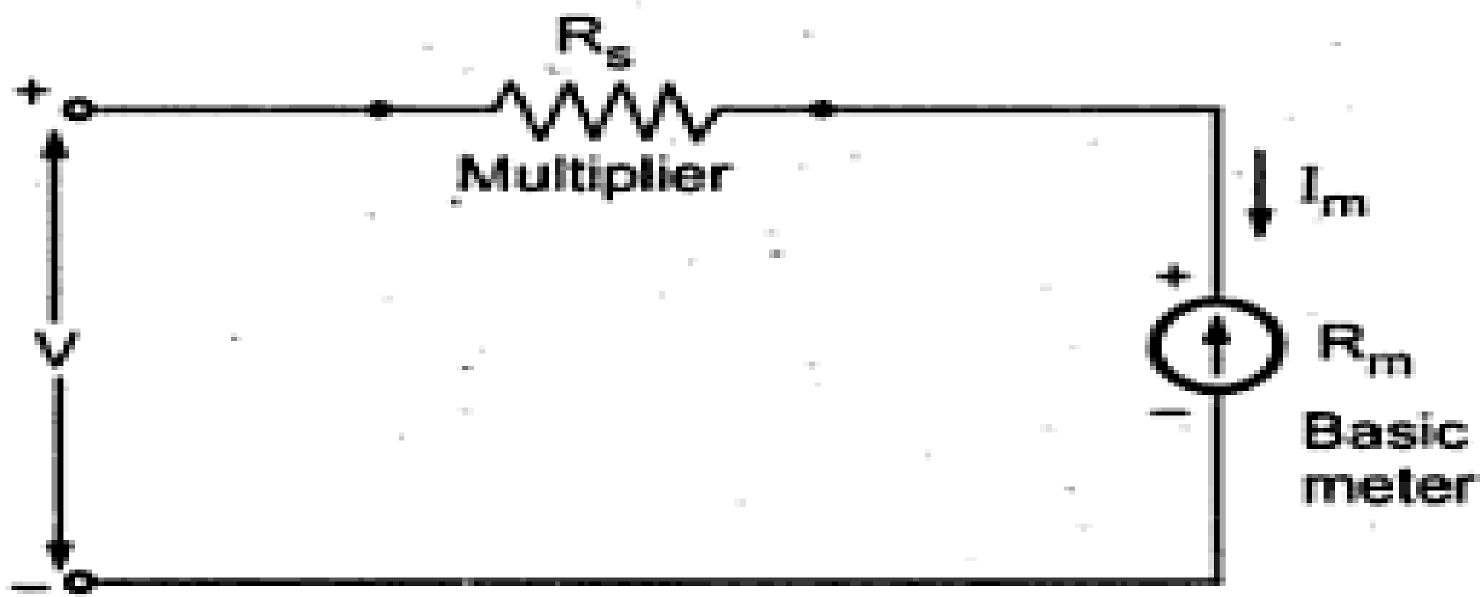
4) The friction due to jewel-pivot suspension.

PMMC as Ammeter

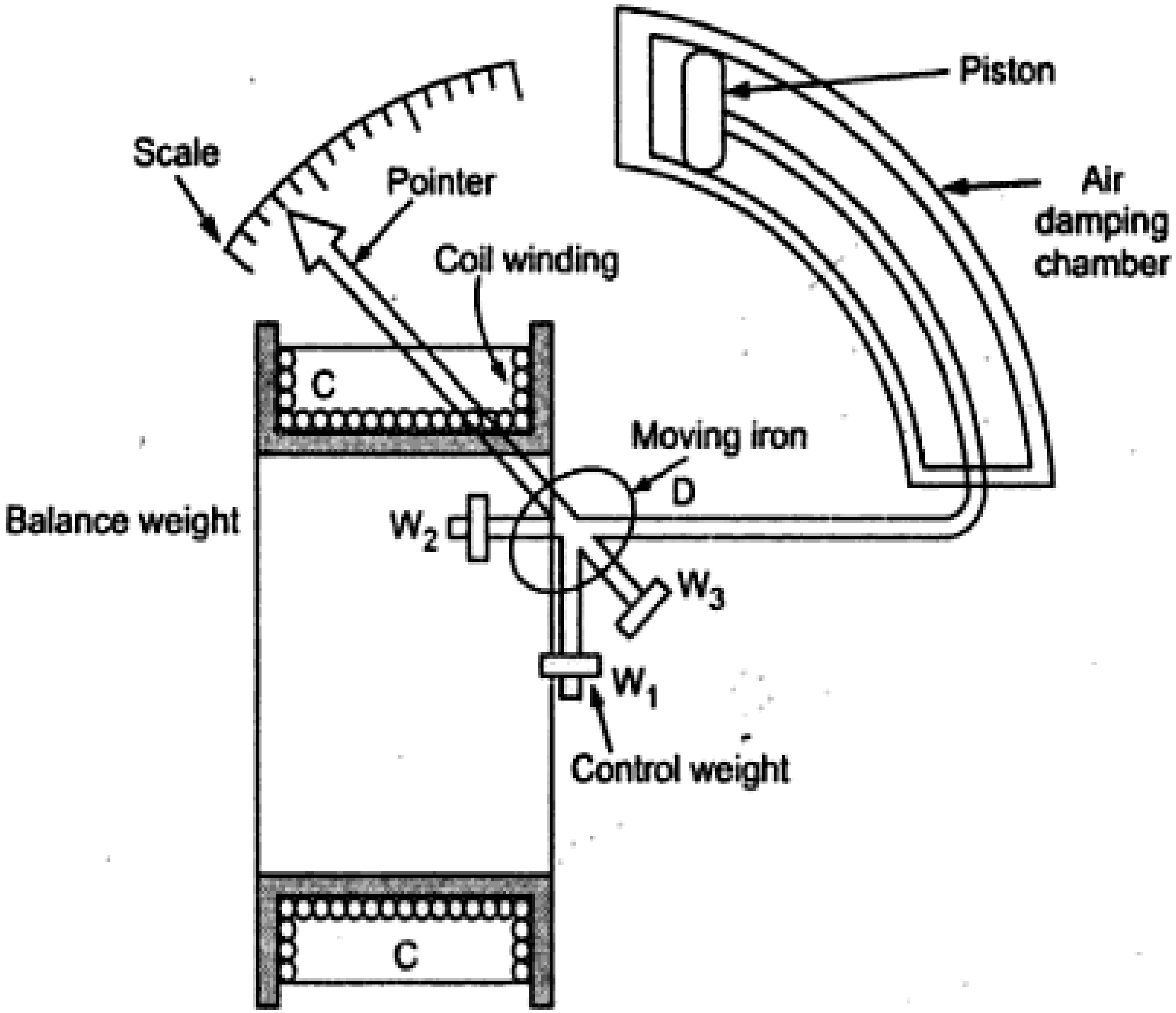


Basic d.c. ammeter

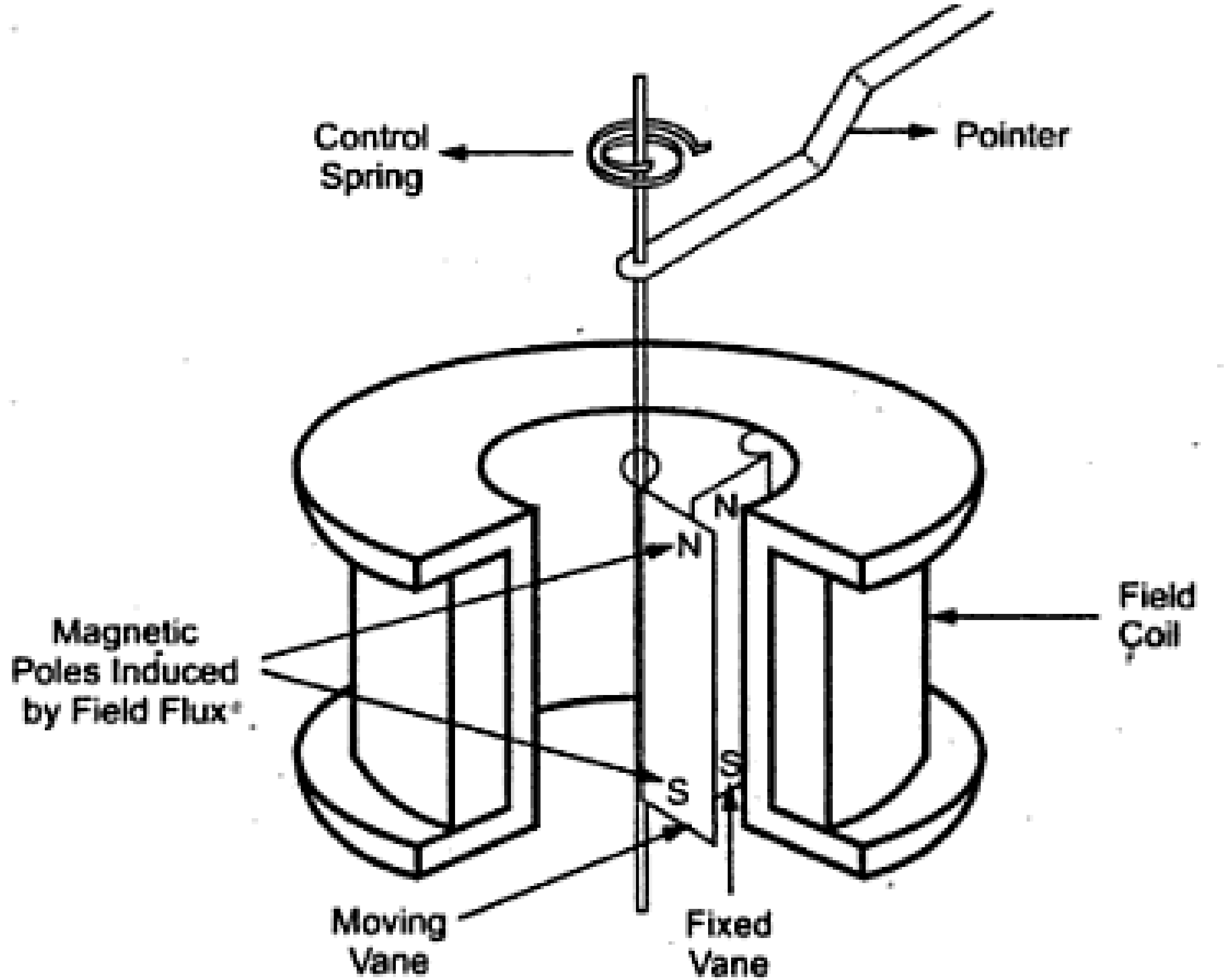
PMMC as Voltmeter



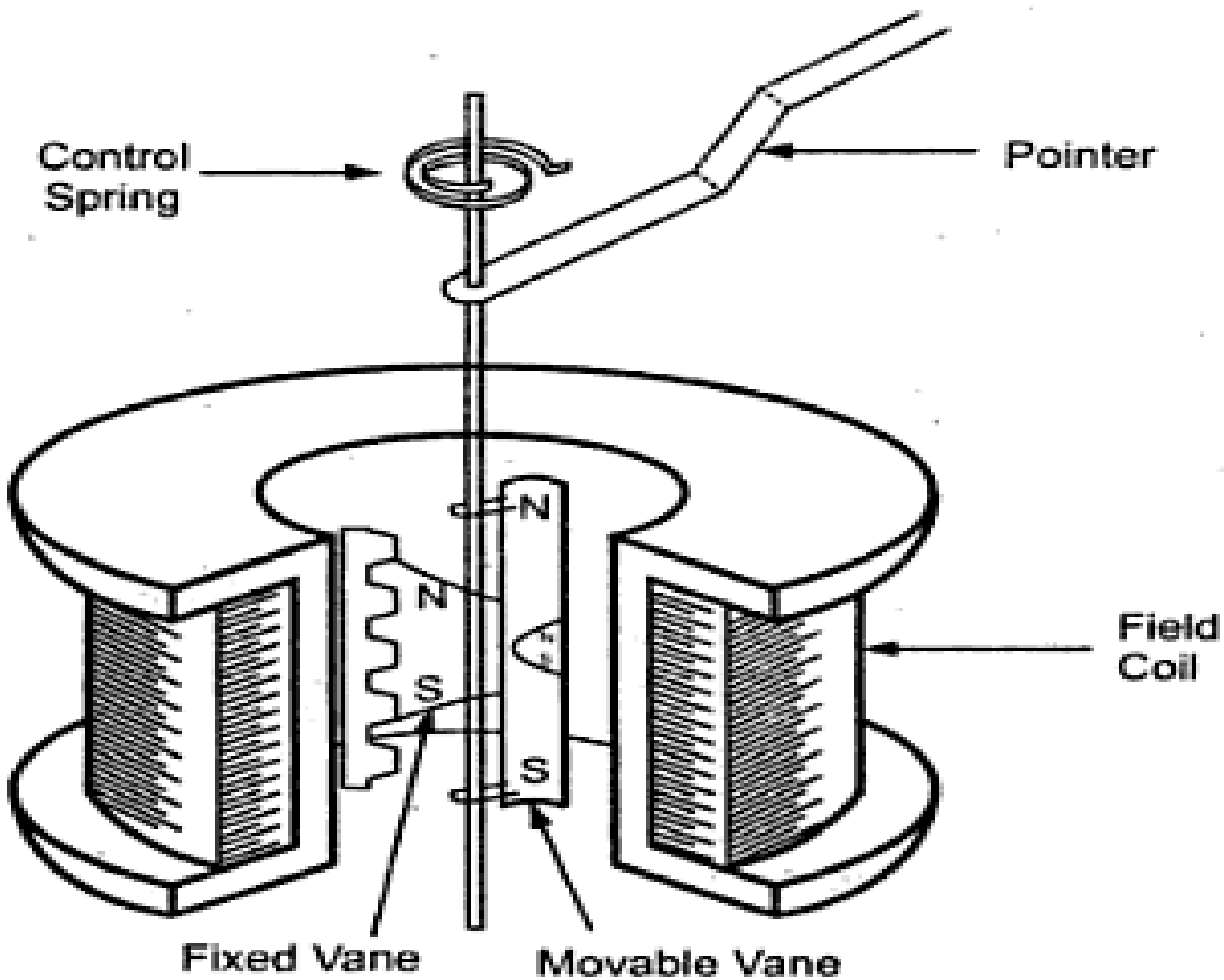
Basic d.c. voltmeter



Moving iron attraction type instrument



Radial vane repulsion type instrument



Concentric vane repulsion type instrument

Advantages

The various advantages of moving iron instruments are,

1) The instruments can be used for both a.c. and d.c. measurements.
2) As the torque to weight ratio is high, errors due to the friction are very less.
3) A single type of moving element can cover the wide range hence these instruments are cheaper than other types of instruments.
4) There are no current carrying parts in the moving system hence these meters are extremely rugged and reliable.
5) These are capable of giving good accuracy. Modern moving iron instruments have a d.c. error of 2% or less.
6) These can withstand large loads and are not damaged even under severe overload conditions.
7) The range of instruments can be extended.

Disadvantages

The various disadvantages of moving iron instruments are,

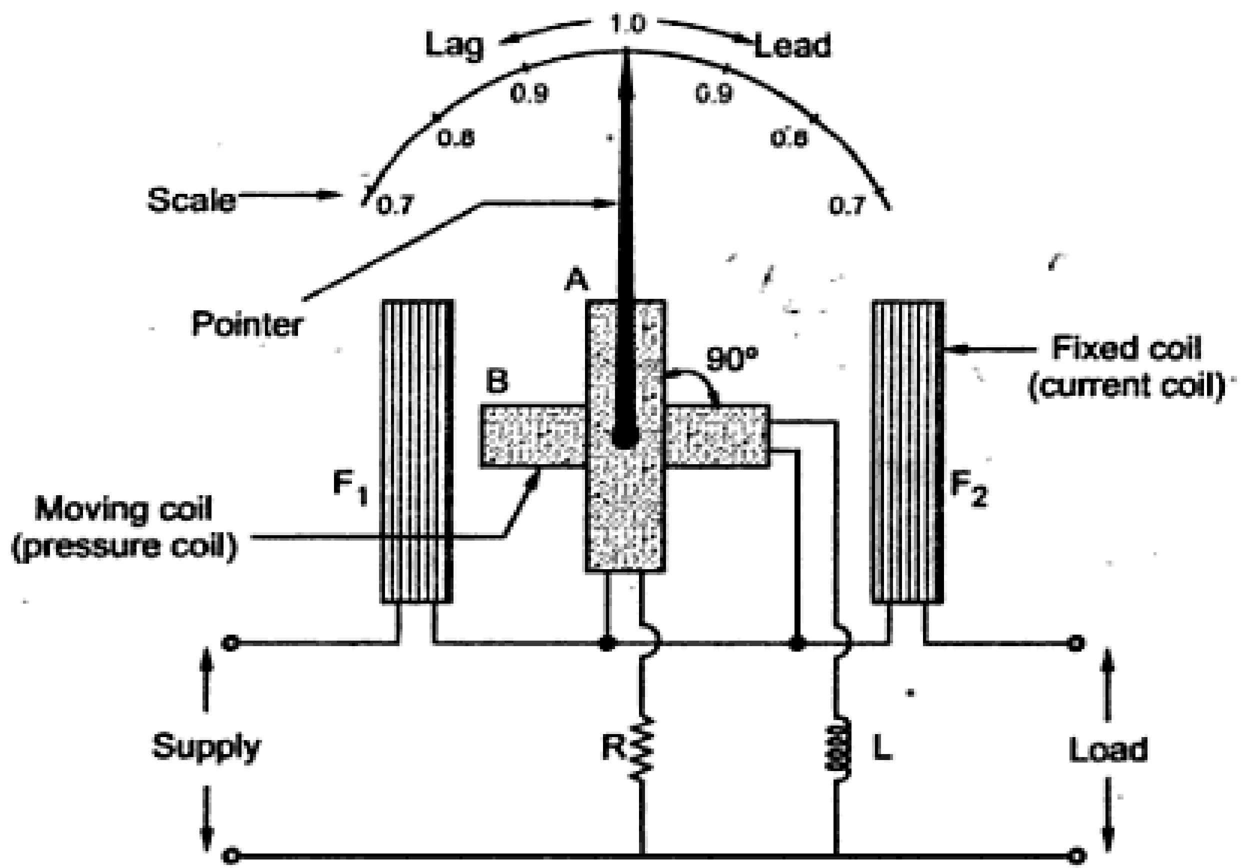
1) The scale of the moving iron instruments is not uniform and is cramped at the lower end. Hence accurate readings are not possible at this end.
2) There are serious errors due to hysteresis, frequency changes and stray magnetic fields.
3) The increase in temperature increases the resistance of coil, decreases stiffness of the springs, decreases the permeability and hence affect the reading severely.
4) Due to the non linearity of B-H curve, the deflecting torque is not exactly proportional to the square of the current.
5) There is a difference between a.c. and d.c. calibrations on account of the effect of inductance of the meter. Hence these meters must always be calibrated at the frequency at which they are to be used. The usual commercial moving iron instrument may be used within its specified accuracy from 25 to 125 Hz frequency range.
6) Power consumption is on higher side.

Power Factor Meter

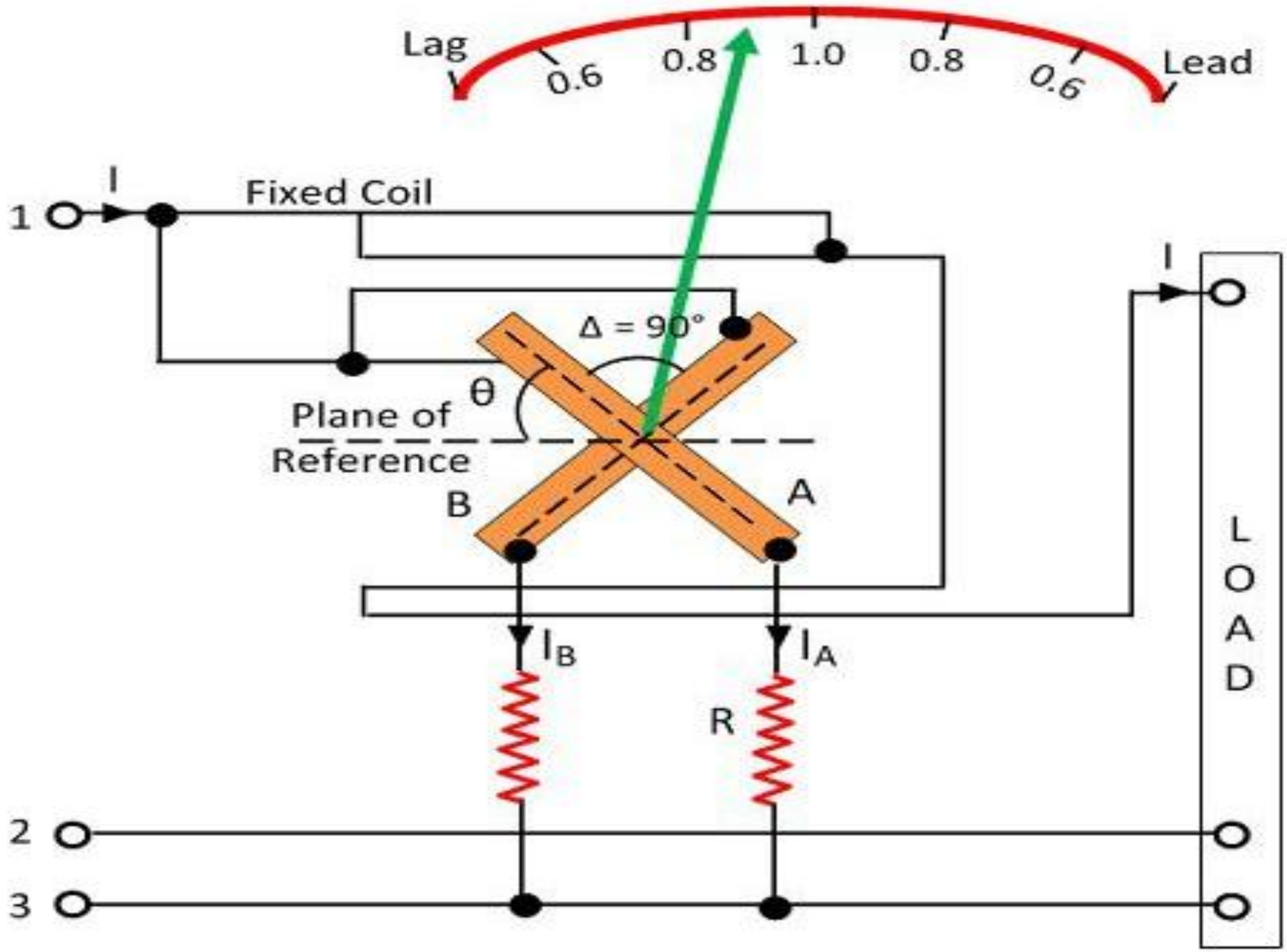
- Electrodynamometer Type
- Moving Iron Type

  Rotating Field Type

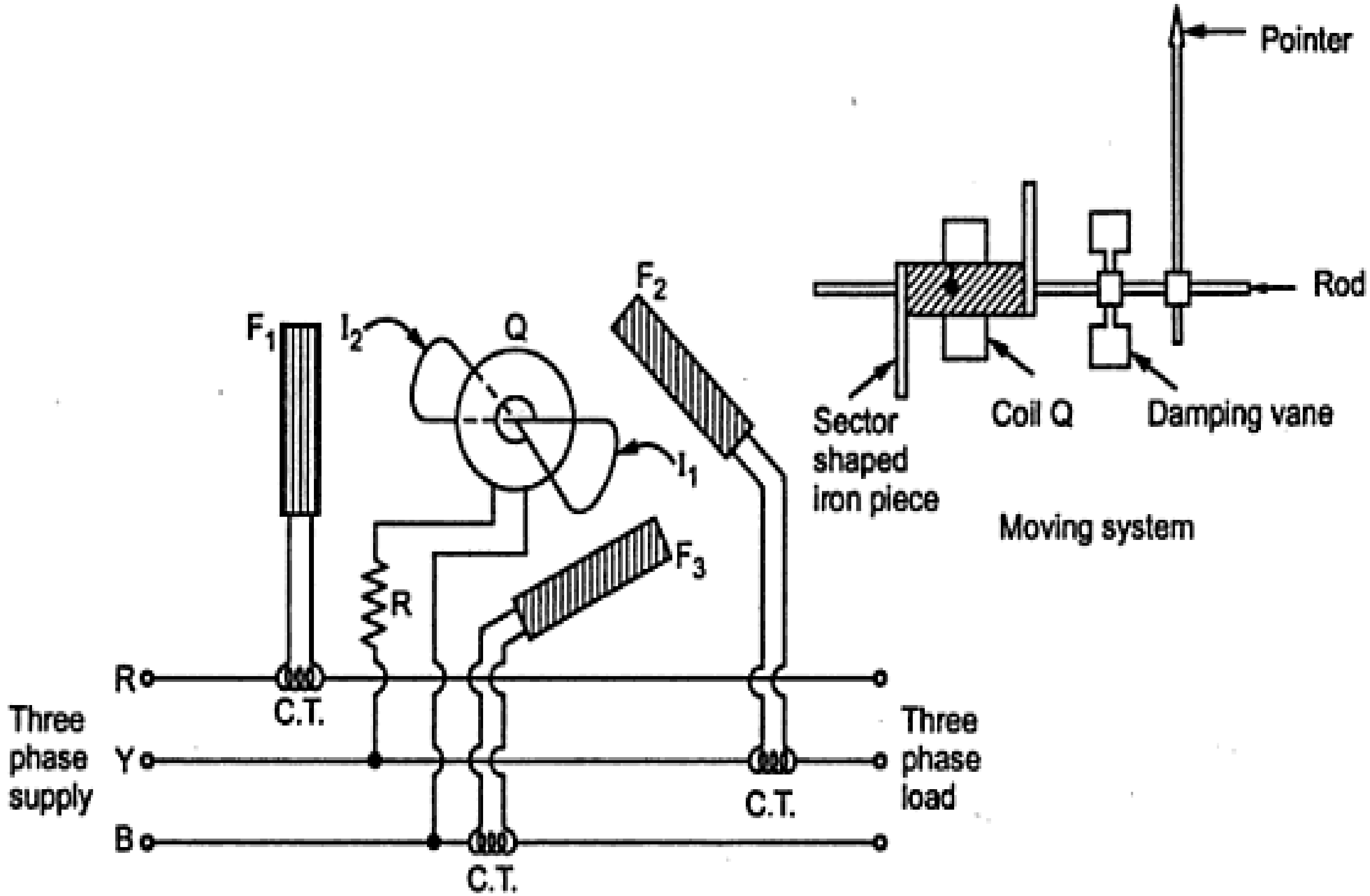
  Alternating Field Type(Nalder Lipman Type)



Single phase electrodynamometer type power factor meter

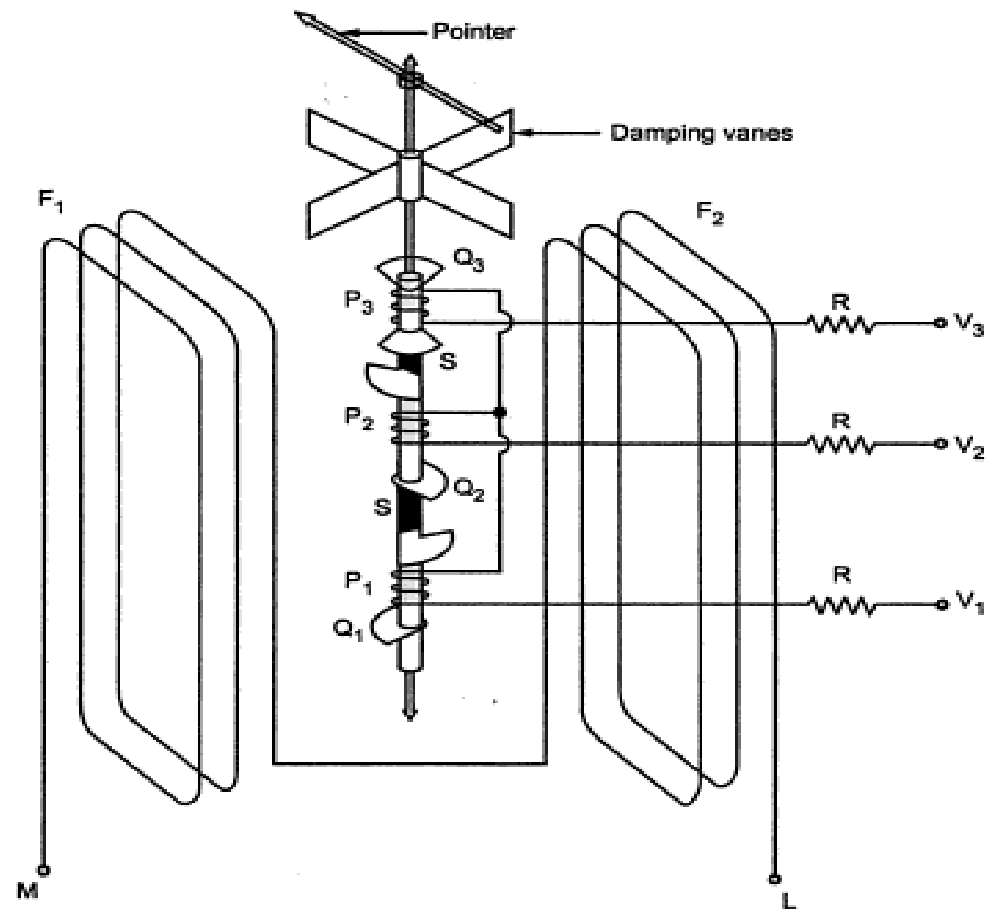


Three Phase Dynamo Type Factor Meter

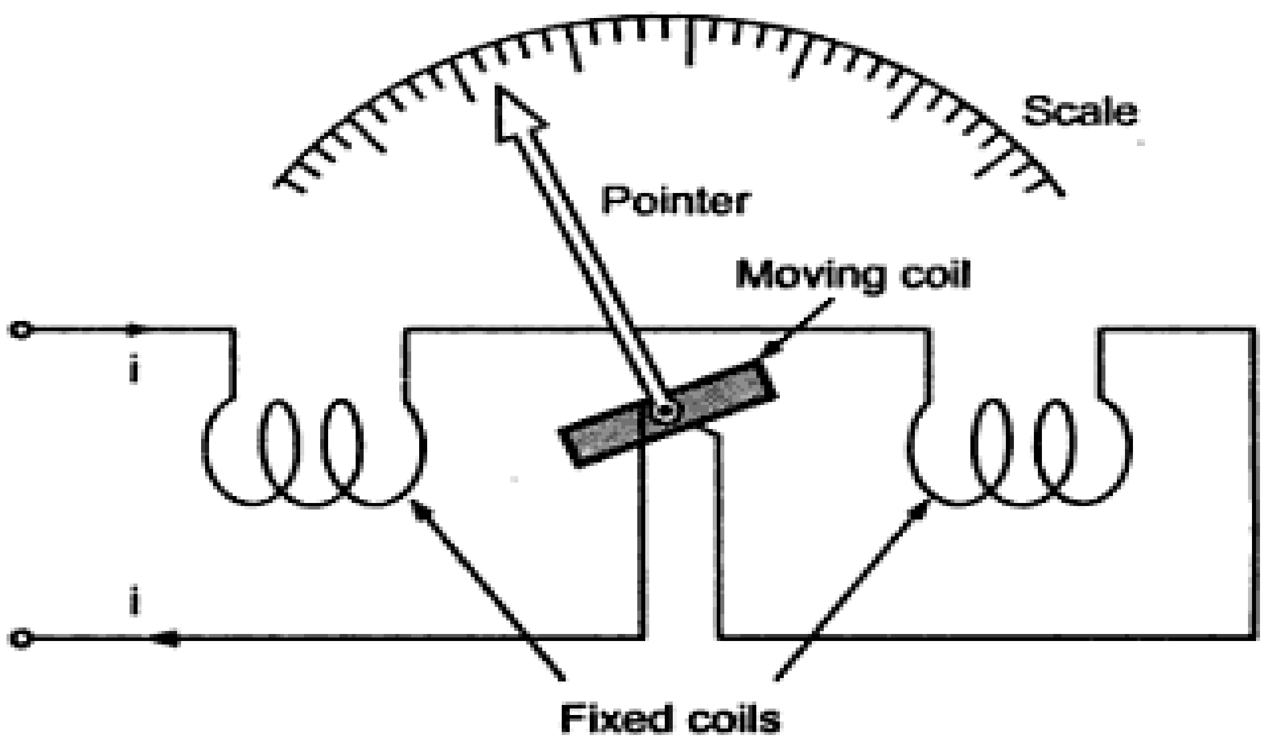


Rotating field type moving iron power factor meter

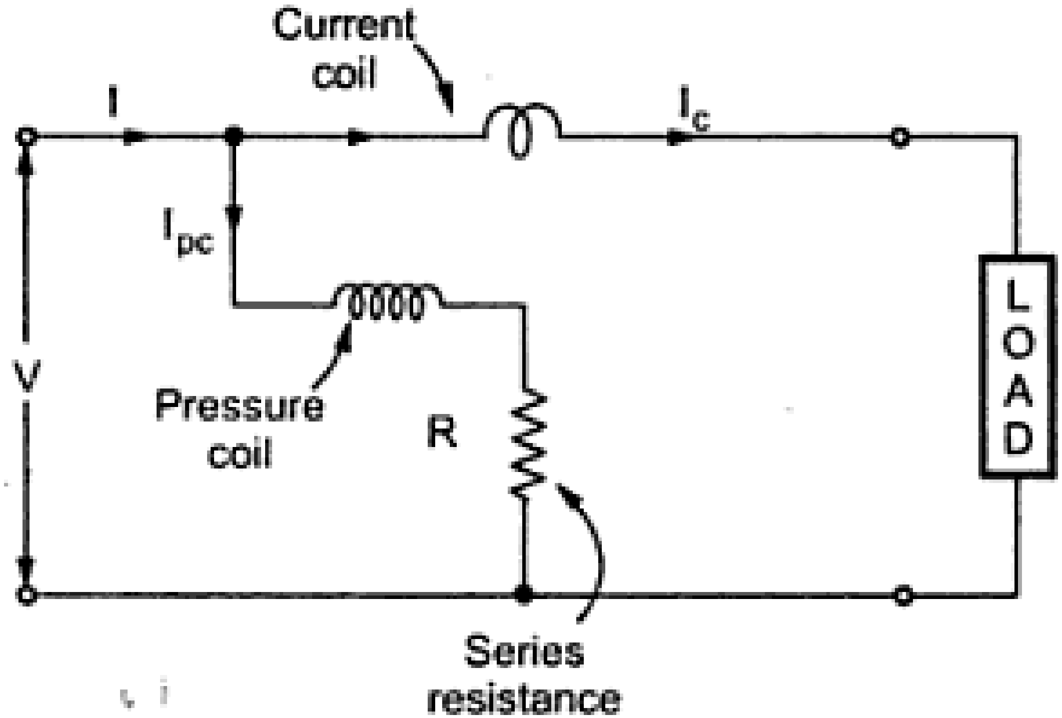
Alternating Field Type Moving Iron PF meter



Measurement of Power



Electrodynamometer type instrument



Electrodynamometer wattmeter

Low Power Factor Electrodynamic Type Wattmeter

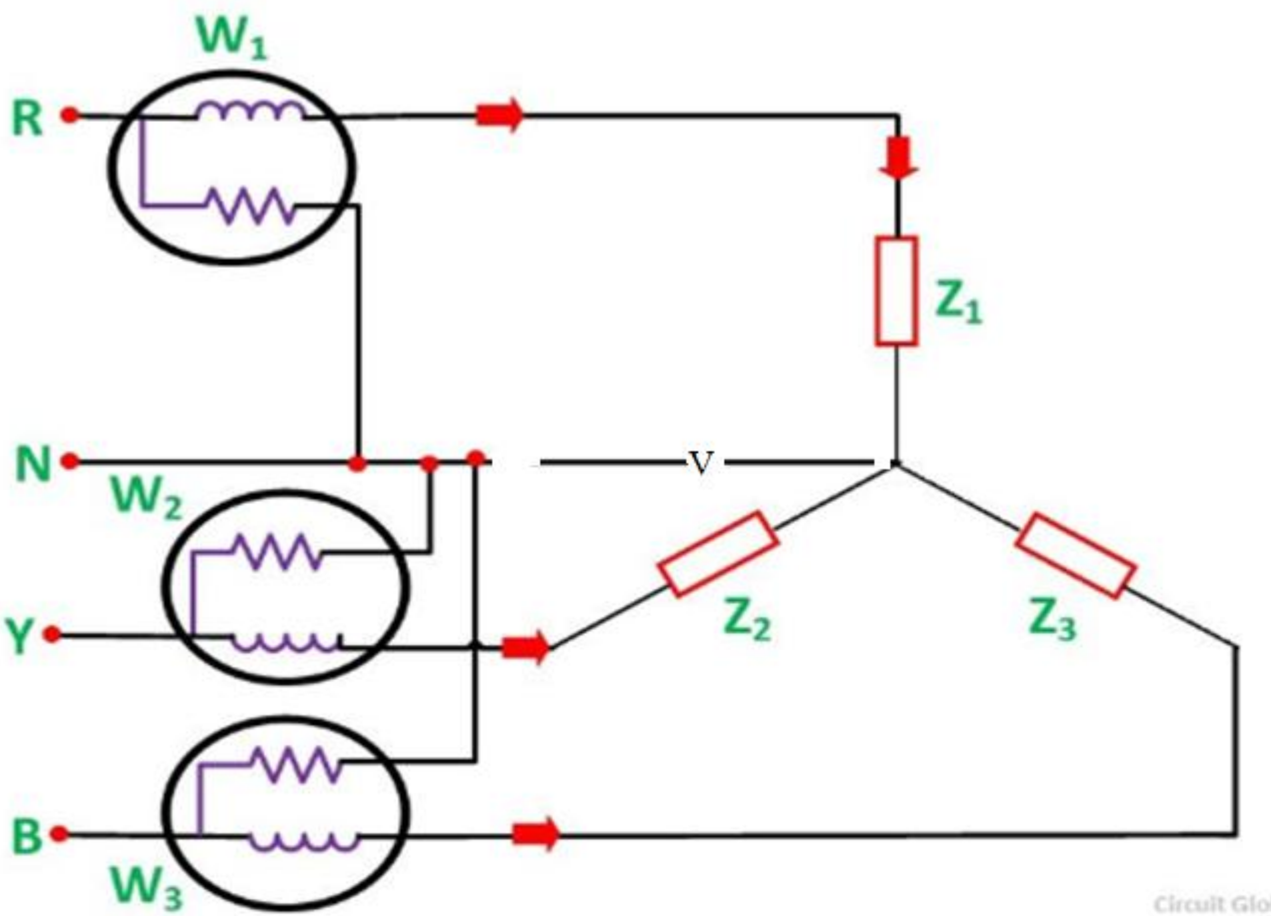
If any circuit is operating at low power factor then power in that circuit is difficult to measure with ordinary electrodynamometer wattmeters. The reading of the wattmeter is inaccurate on account of following reasons,

1. The deflecting torque on the moving system is small as the power factor is low even though the current and pressure coils are fully excited.

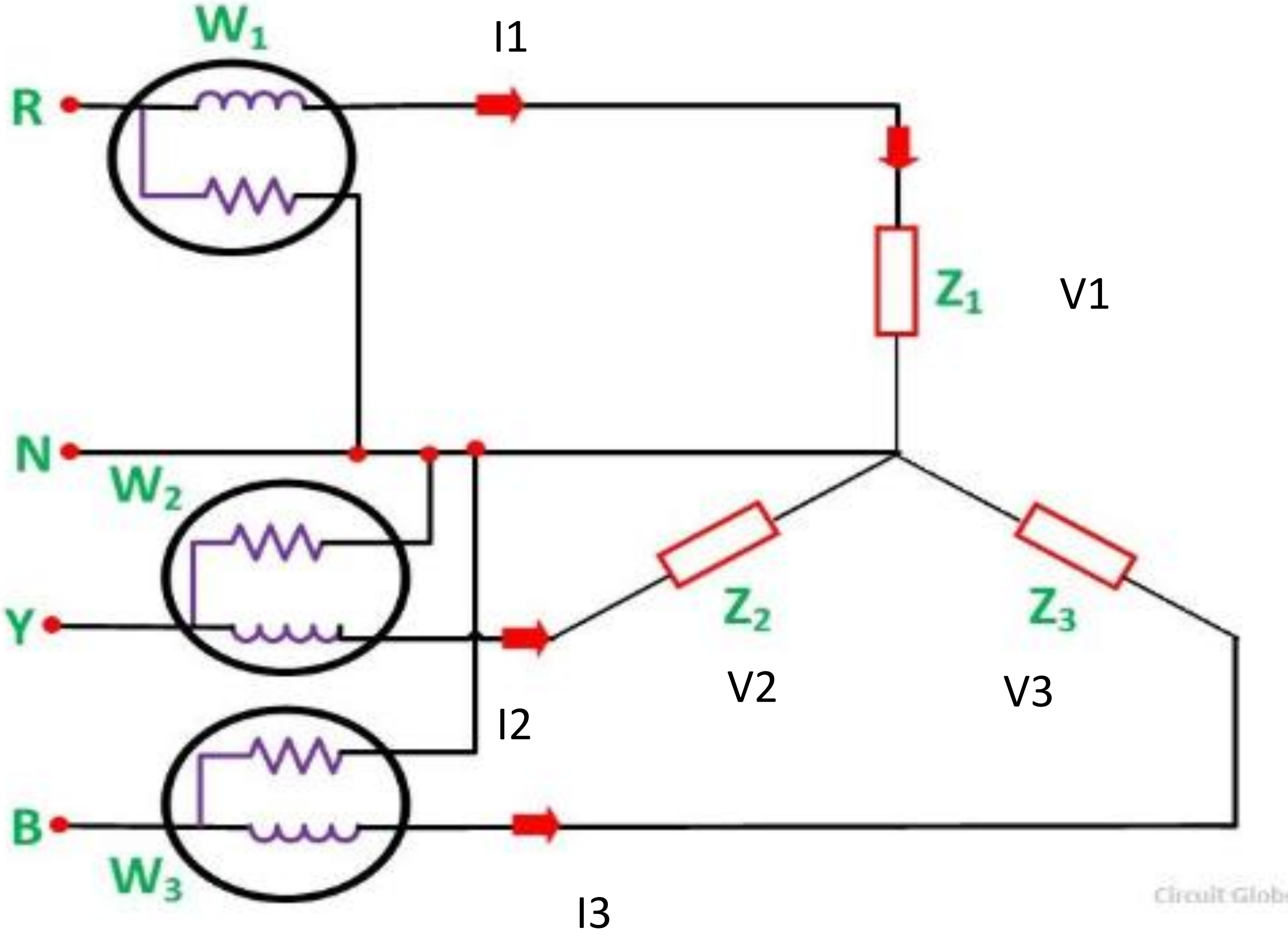
2. The inductance of pressure coil introduces considerable error at low power factors.

In order to get accurate reading from the wattmeter when it is measuring low power, extra adjustments are required to be made so that there will be compensation of the errors.

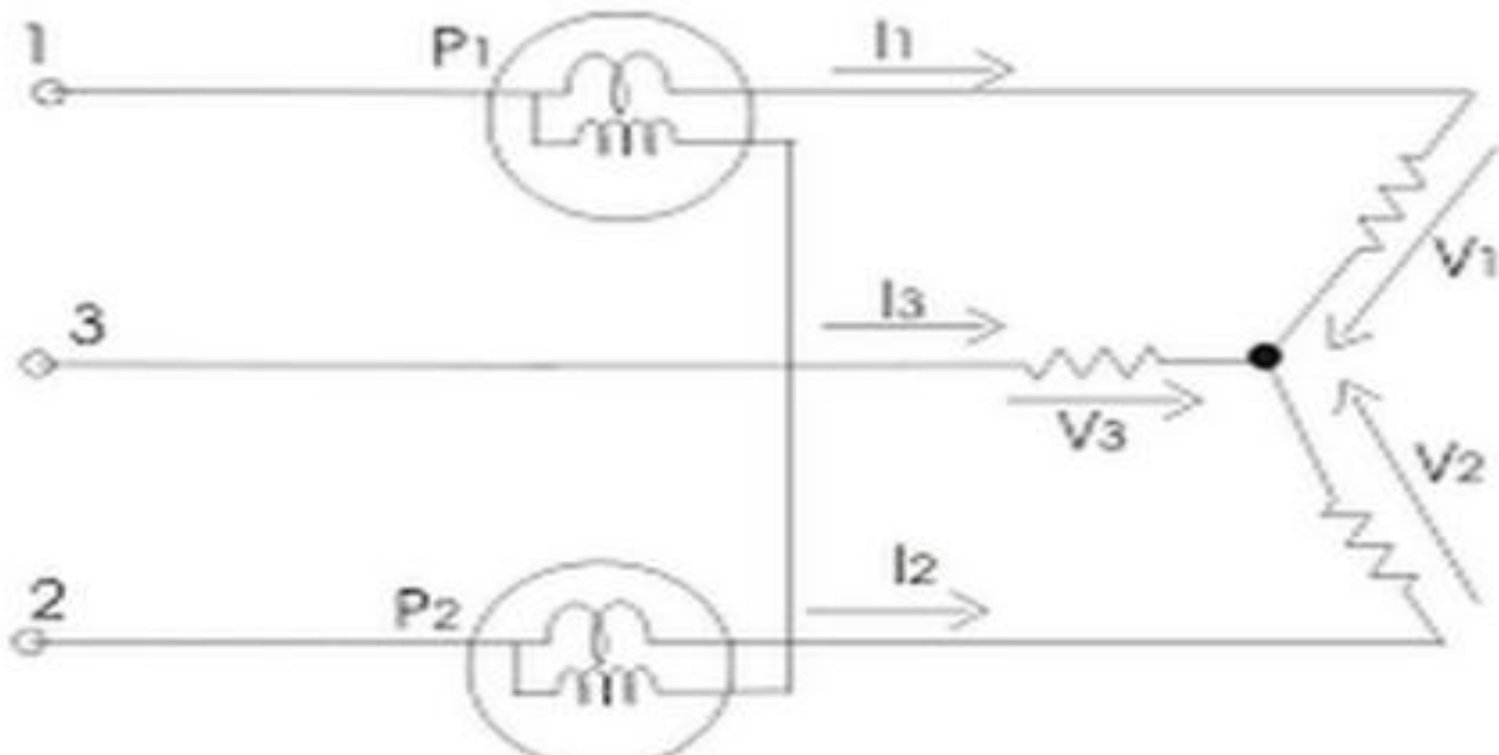
Three-Wattmeter Method of Three Phase Power Measurement



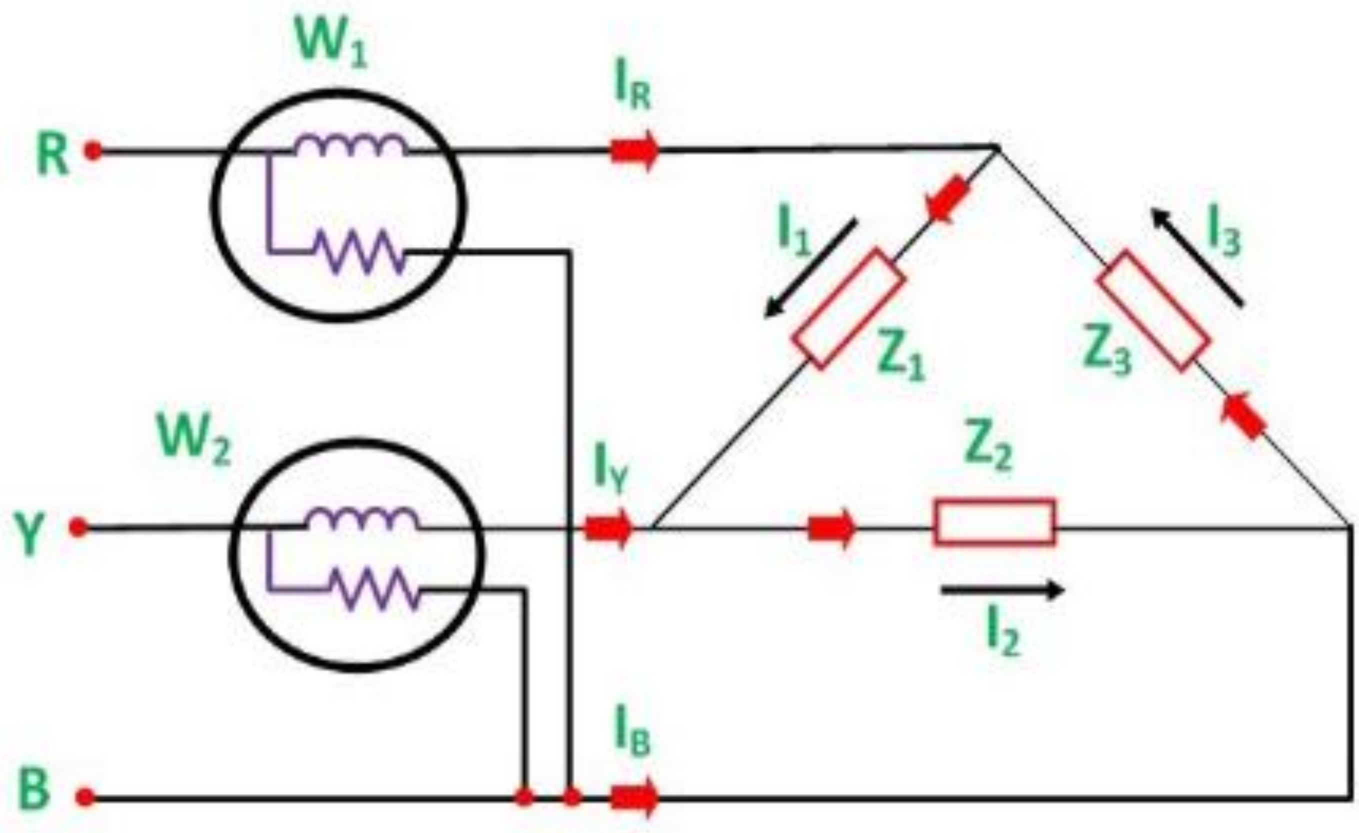
Three-Wattmeter Method of Three Phase Power Measurement



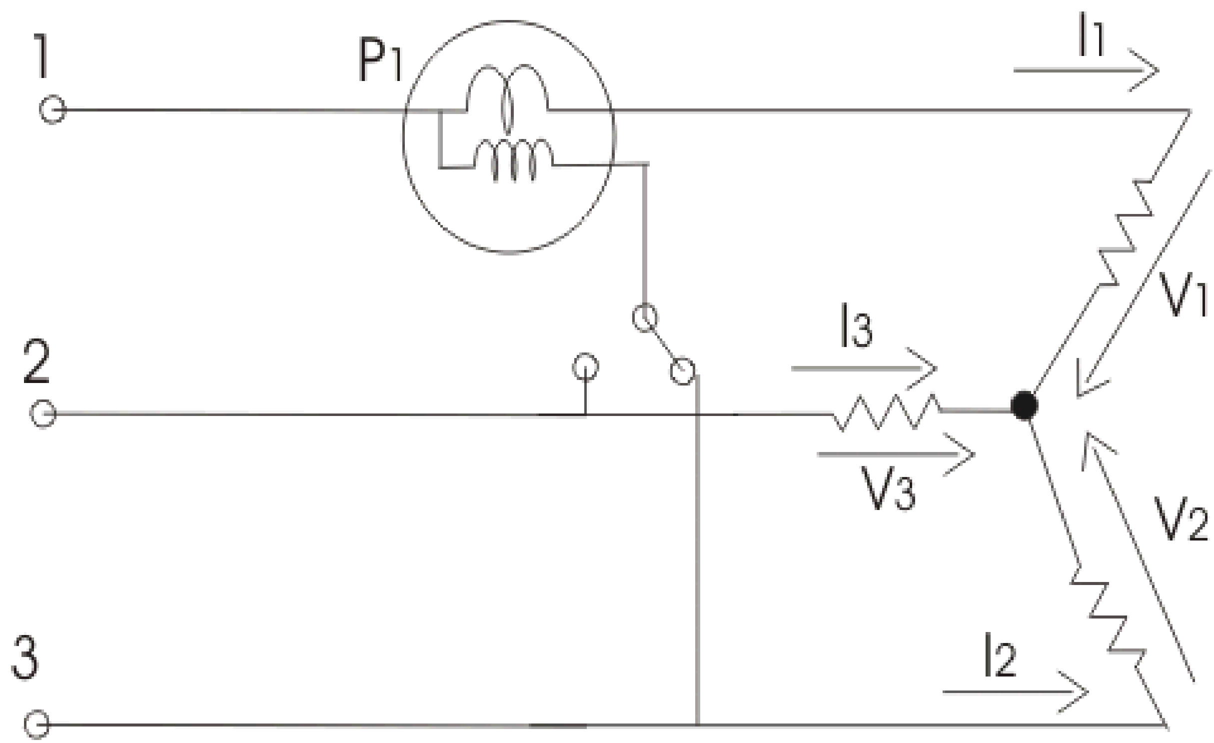
Two Wattmeter Method of Power Measurement



Two Wattmeter Method in Delta Connection



One Wattmeter Method



VAR Meters

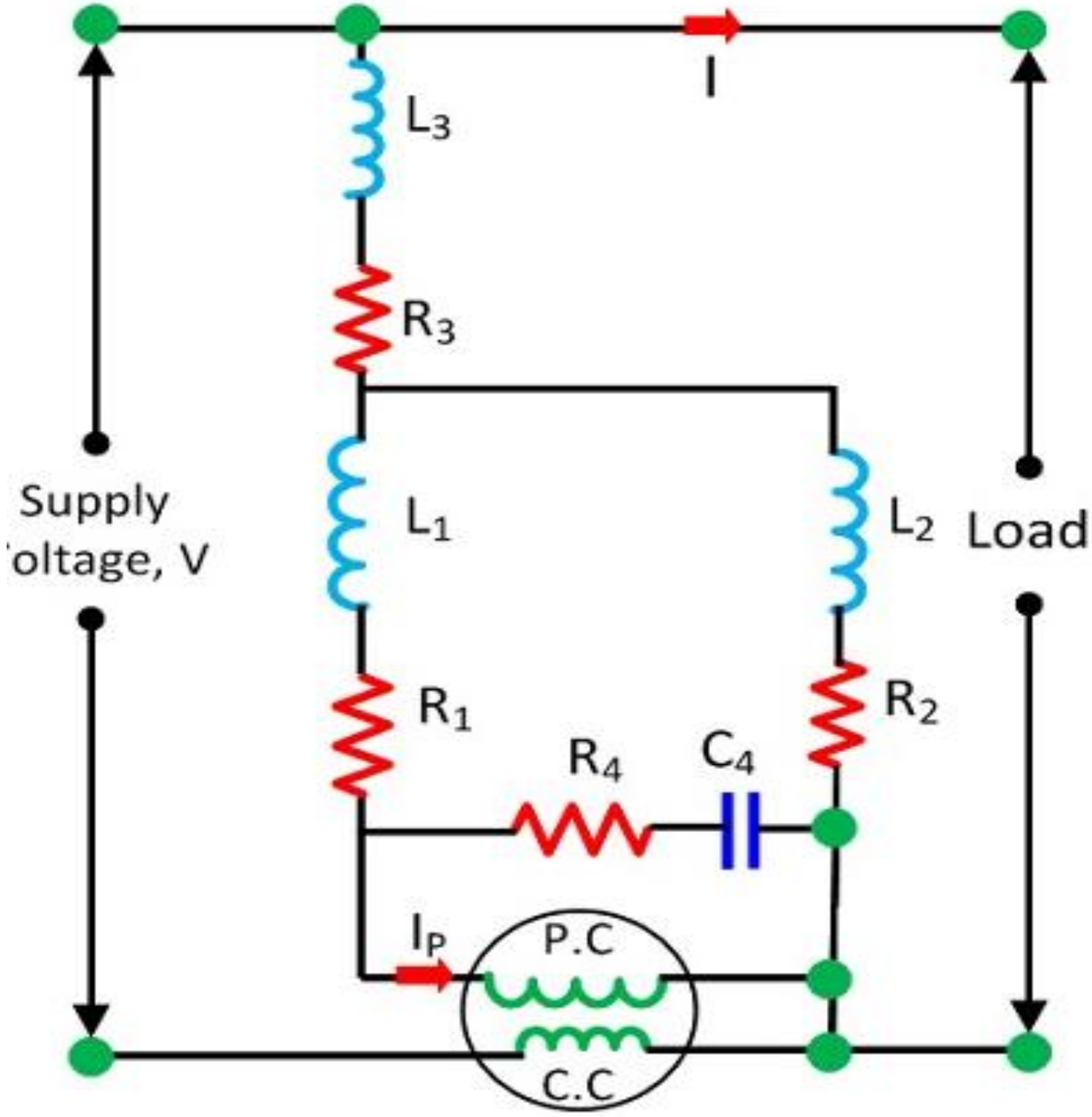
Measurement of volt-ampere hours reactive (VARh)

Sometimes the metering of volt-ampere hours *reactive* (*VARh*) of a circuit is necessary in connection with electricity tariffs. For this, a meter is required whose motoring action is proportional to $VI \sin \phi$ or $VI \cos (90° - \phi)$, where ϕ is the power factor angle. The measurement of *VARh* may, therefore, be affected by employing a watt-hour meter, in which either the voltage flux or current flux is given a phase displacement of 90°. Thus an induction watt-hour meter with voltage flux in phase with the voltage and current flux in phase with the current will register *VARh*.

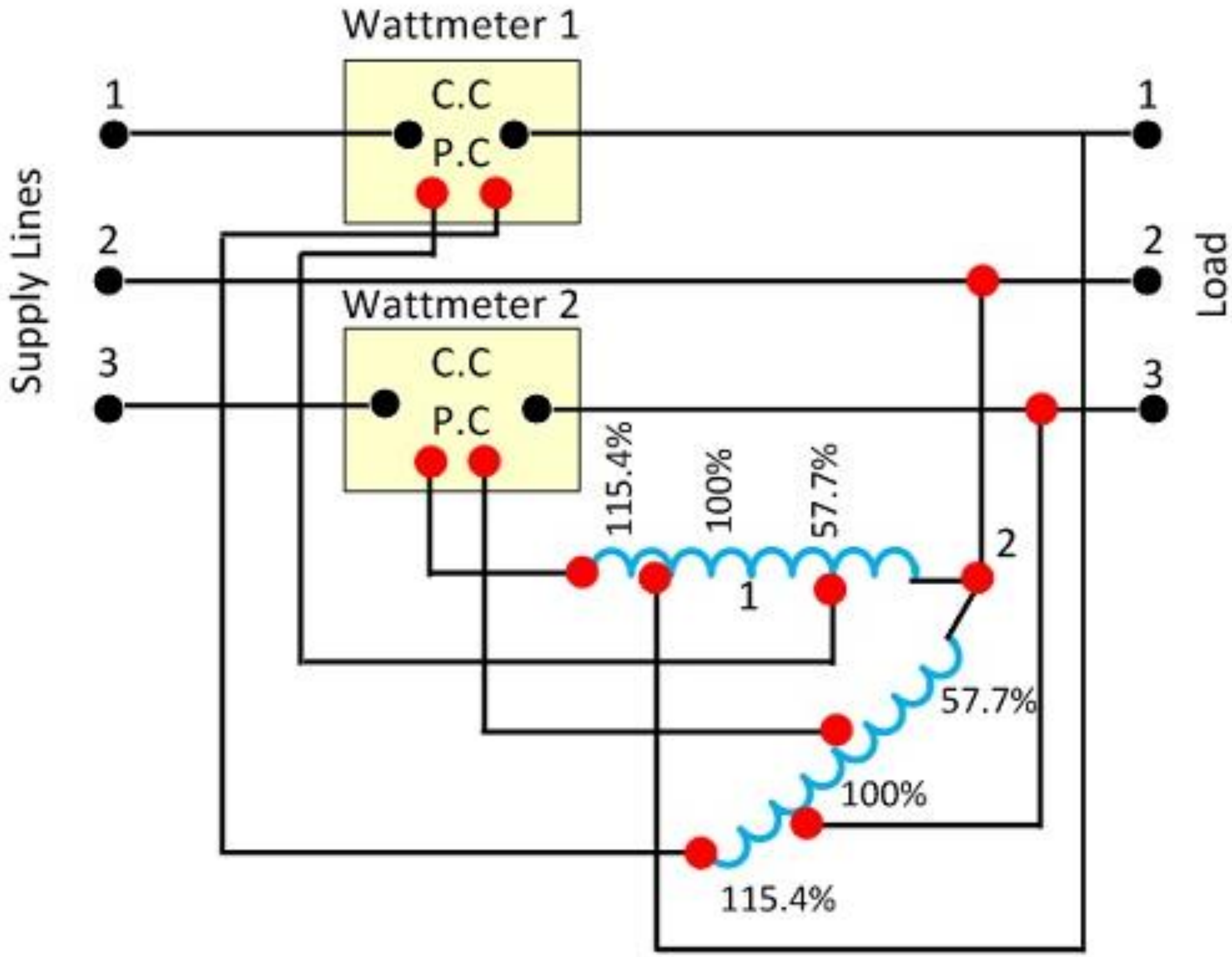
- In order to measure VARh in single-phase circuits, use of specially compensated watt-hour meter is made. *Phase compensation is accomplished by suitable combination of resistance, capacitance and inductance.*

Normal induction type energy meter can be used to register *VARh* with the help of following schemes, these schemes apply to 3-phase, 3-wire system :

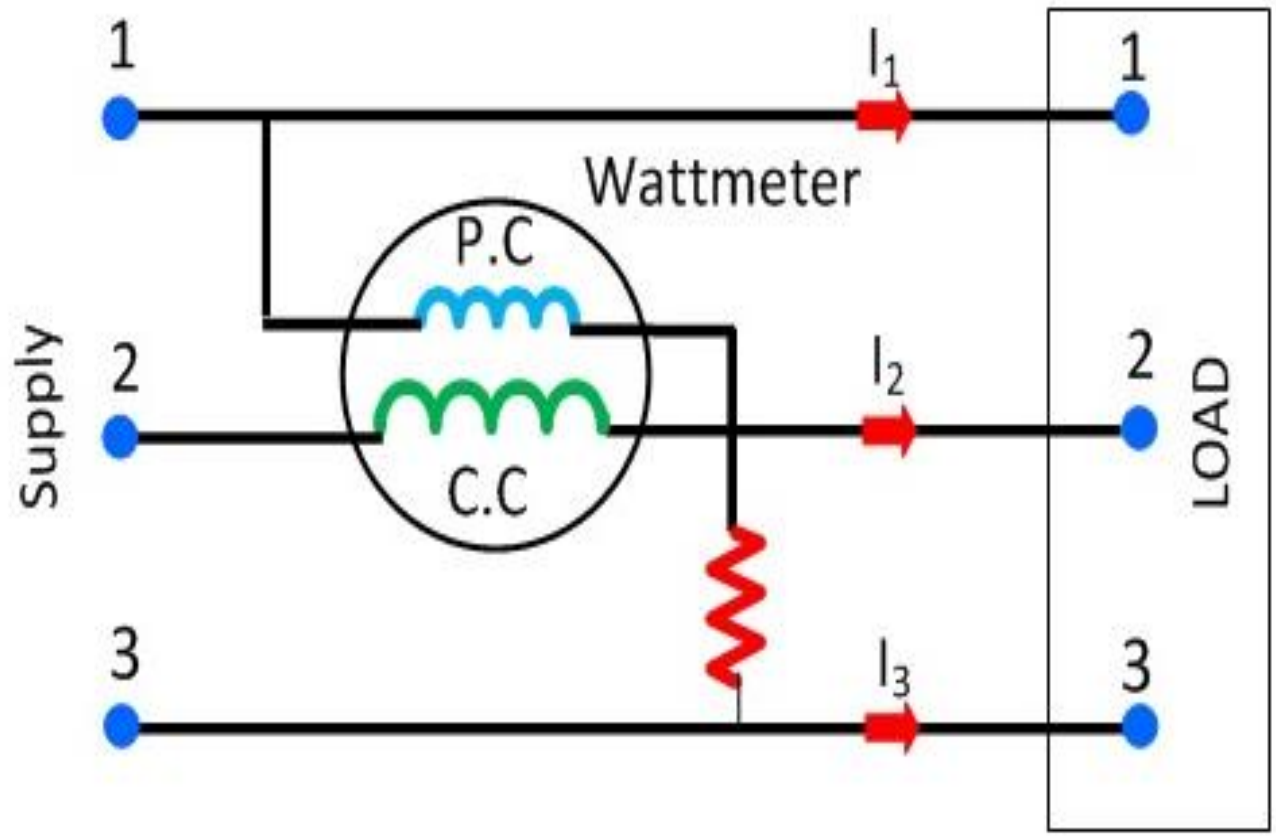
1. Single element method.
2. Crossed phase method.
3. Auto-transformer method.



Single phase Varmeter



Reactive Power Measurement with Two Auto-Transformer



Reactive Power Measurement with One Wattmeter

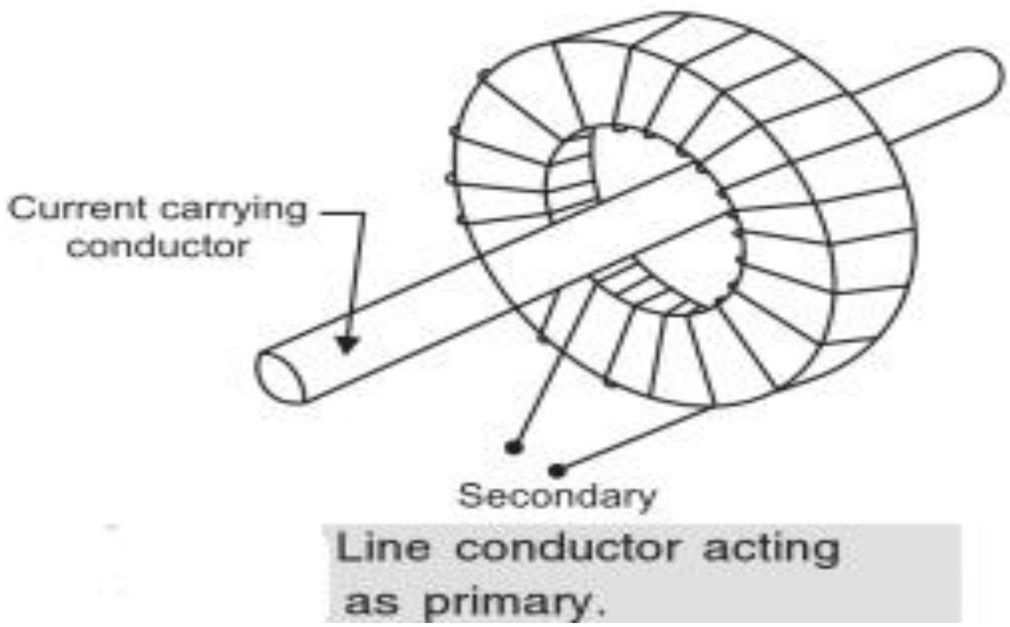
Current Transformer

Introduction

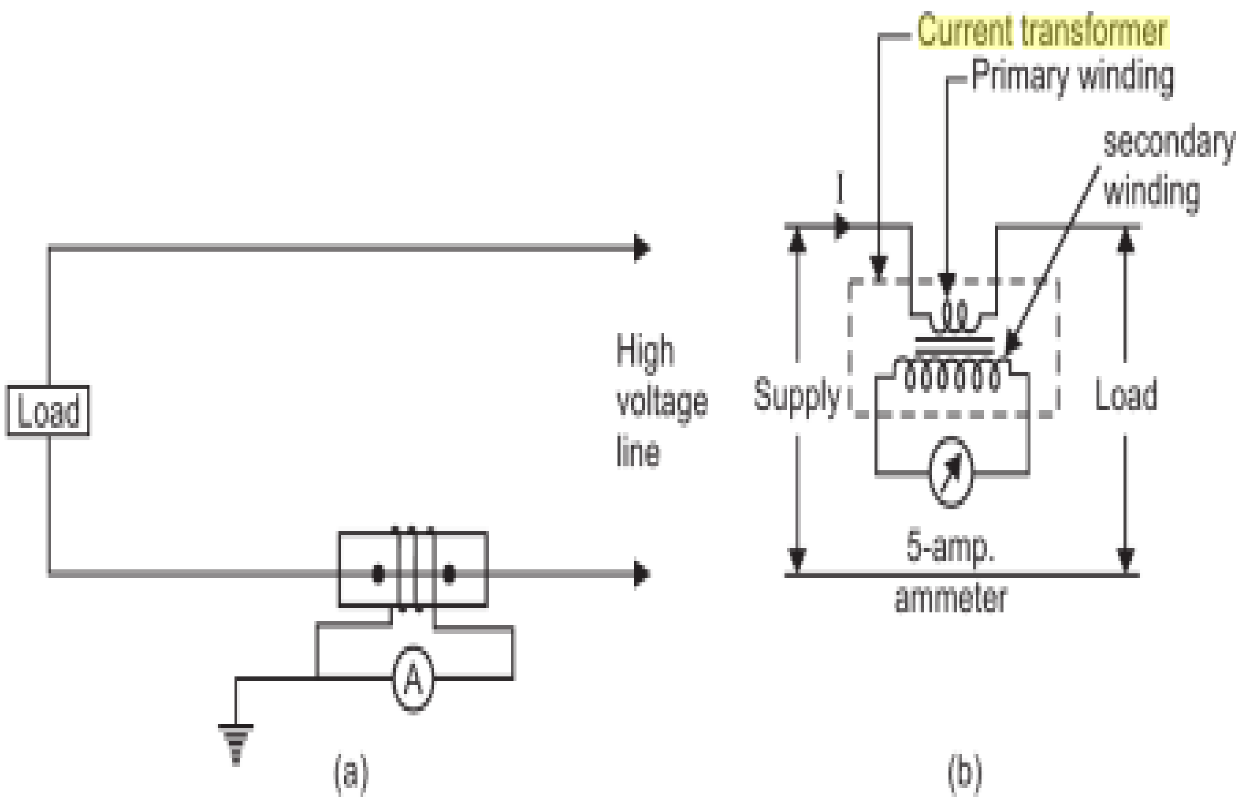
In heavy currents and high voltage a.c. circuits, the measurement can not be done by using the method of extension of ranges of low range meters by providing suitable shunts. In such conditions, specially constructed accurate ratio transformers called **instrument transformers**. These can be used, irrespective of the voltage and current ratings of the a.c. circuits. These transformers not only extend the range of the low range instruments but also isolate them from high current and high voltage a.c. circuits. This makes their handling very safe. These are generally classified as

(i) current transformers and (ii) potential transformers.

Current Transformer

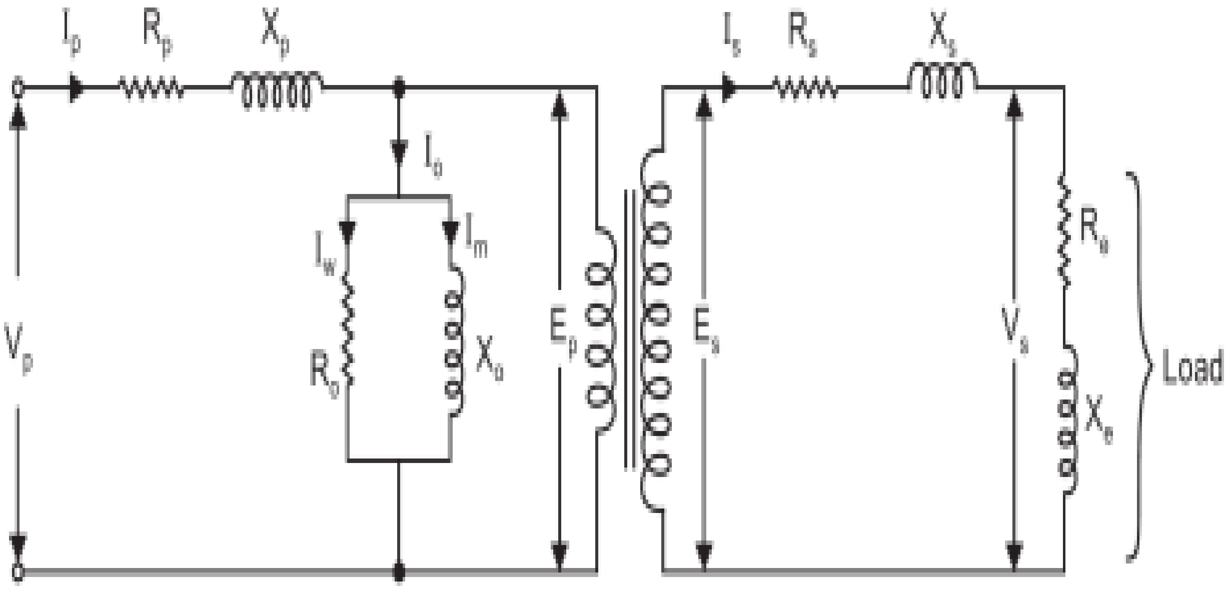


Current Transformer



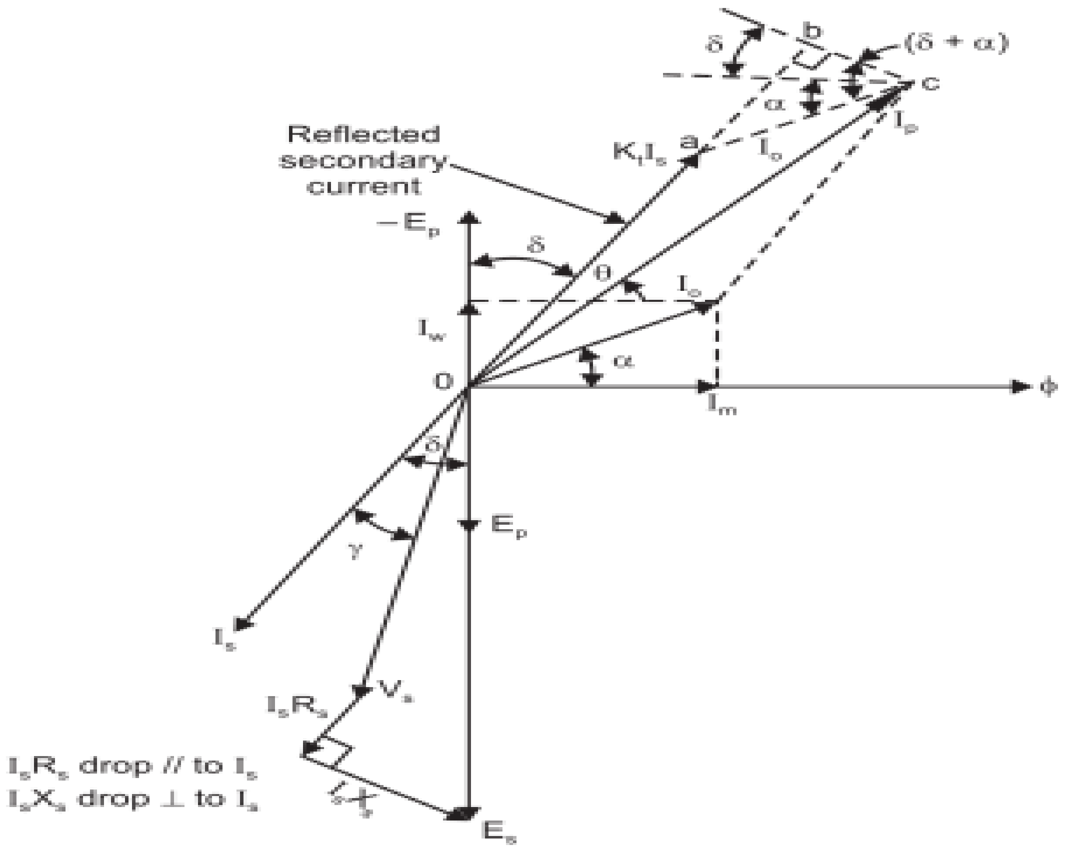
Current transformer connections.

Current Transformer



(a) Equivalent circuit

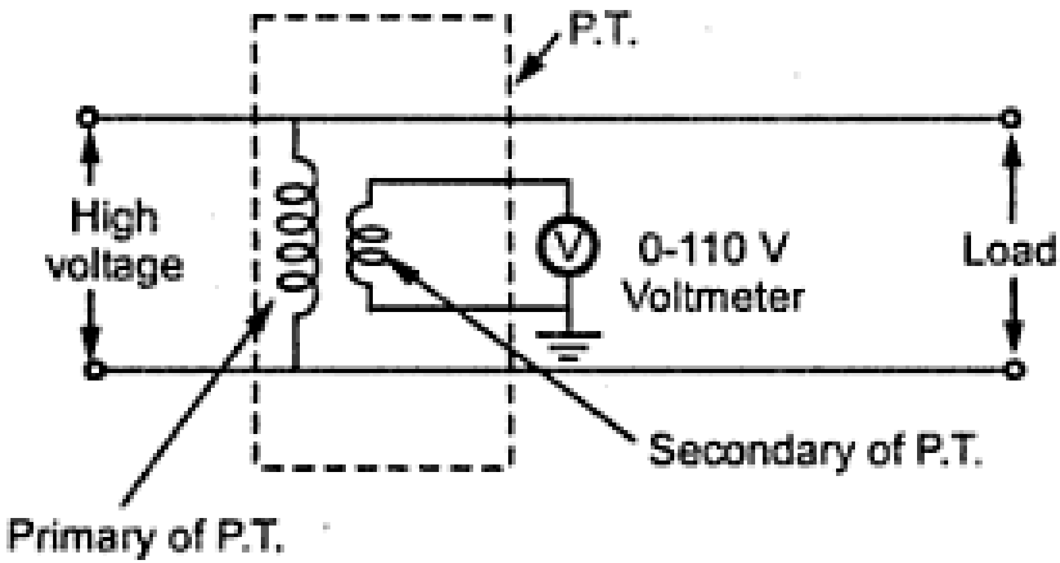
Current Transformer



(b) Phase diagram (Not to scale)

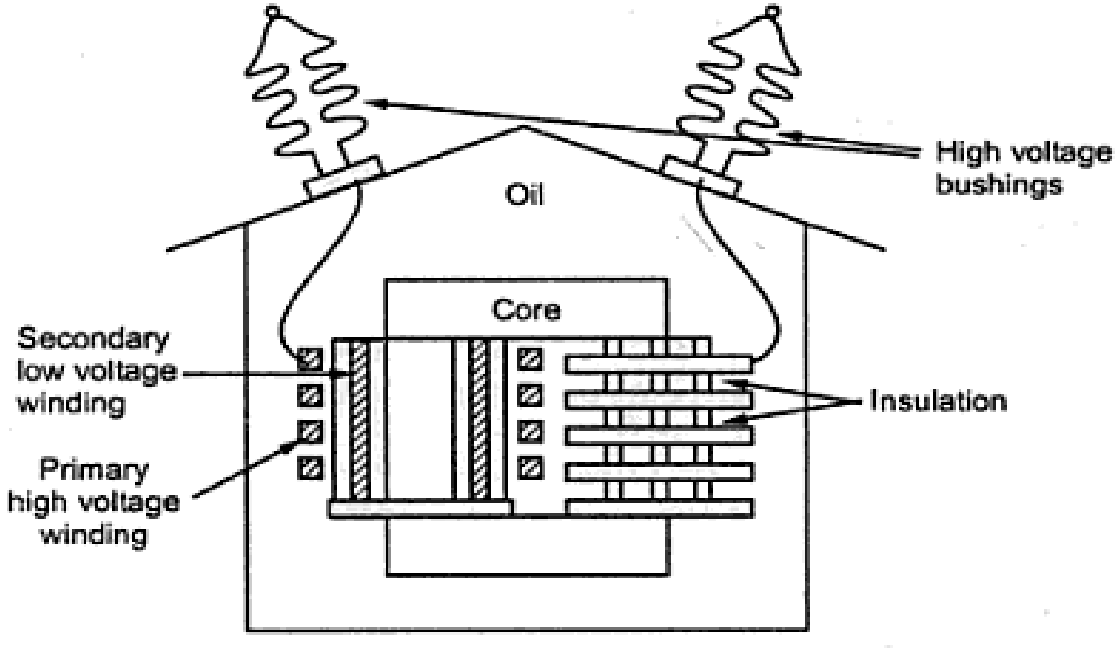
Current transformer (CT).

Potential Transformer



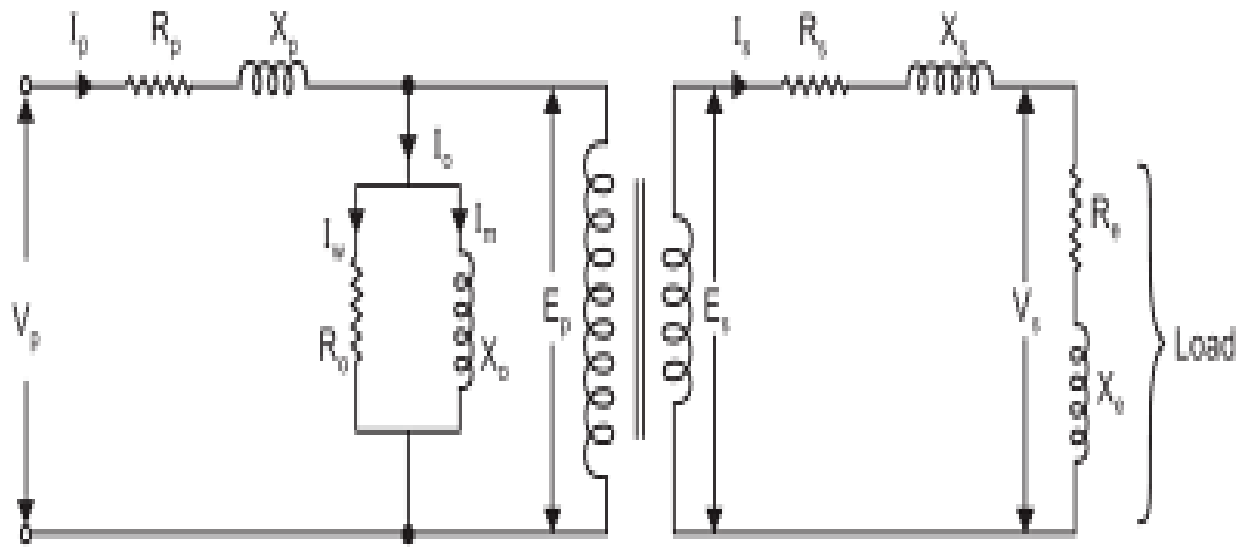
Potential transformer

Potential Transformer



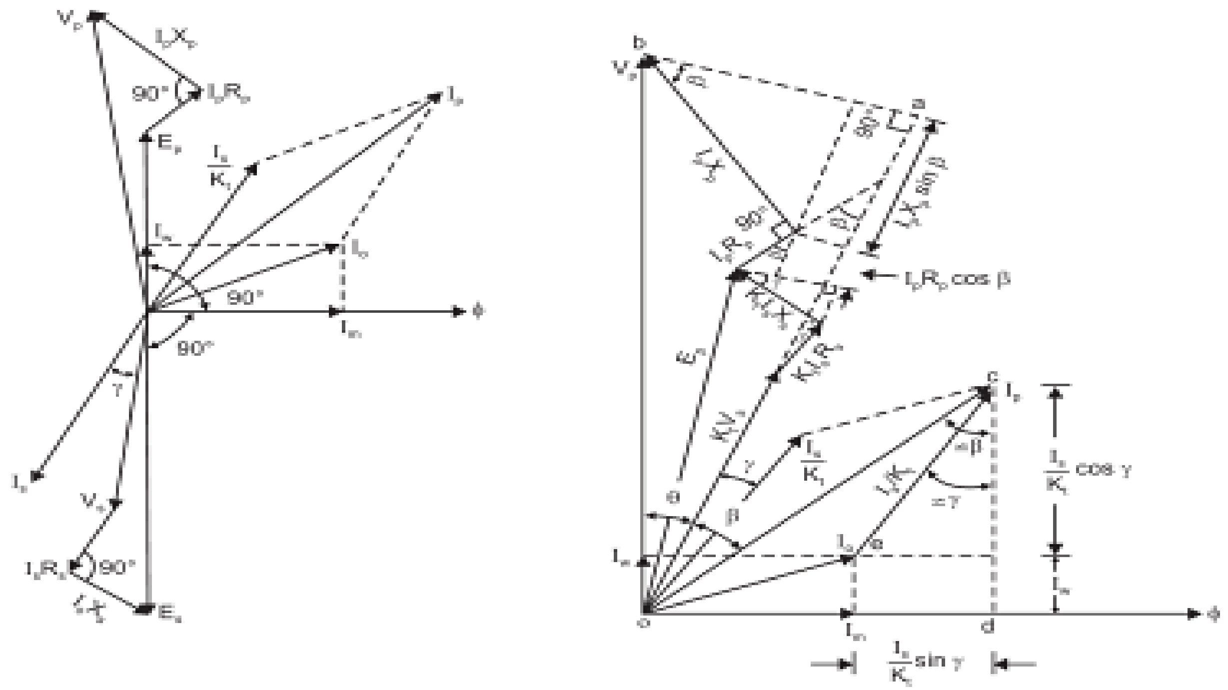
Single phase potential transformer

Potential Transformer



(a) Equivalent circuit

Potential Transformer



(b) Phasor diagram

(c) Enlarged and concise phasor diagram of a PT (referred to primary)

Potential transformer (PT).

Potential Transformer

Comparison of Current and Potential Transformers

The comparison between current and potential transformers is given in the table below :

S.No.	Current transformer (CT)	Potential transformer (PT)
1.	Secondary must *always be shorted.*	Secondary is *nearly under open circuit conditions.*
2.	The winding carries *full-line current.*	The winding is impressed with *full-line voltage.*
3.	The primary current is *independent* of the secondary circuit conditions.	The primary current depends on the secondary circuit conditions.
4.	It can be treated as series transformer under short circuit conditions.	It can be treated as parallel transformer under open circuit secondary.
5.	A small voltage exists across its terminals as connected in series.	Full line voltage appears across its terminals.
4.	The primary current and excitation varies over a wide range.	The line voltage is almost constant hence exciting current and flux density varies over a limited range.

Measurement of Energy

Introduction

The energy is defined as the power delivered over a time interval.

$$\text{Energy} = \text{Power} \times \text{Time}$$

The electrical energy is defined as the work done over a time interval t and mathematically expressed as,

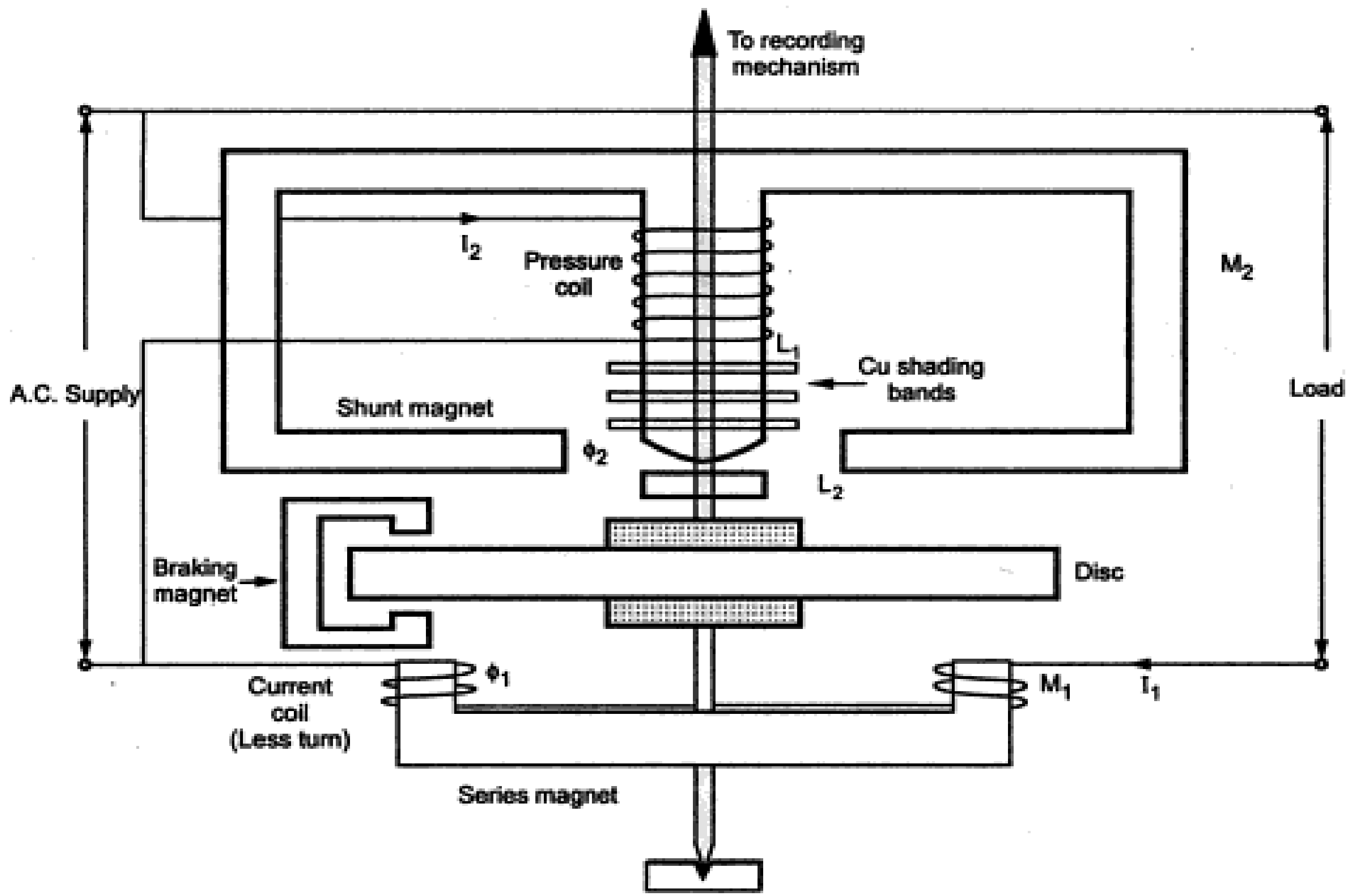
$$E = \int_0^t \text{power}(dt) = \int_0^t vi\,dt$$

where v = Voltage in volts and i = Current in amperes

The energy is measured in joules (J) or watt-sec (W-s). Thus energy of one joule means the power of 1 watt over a time interval of 1 second.

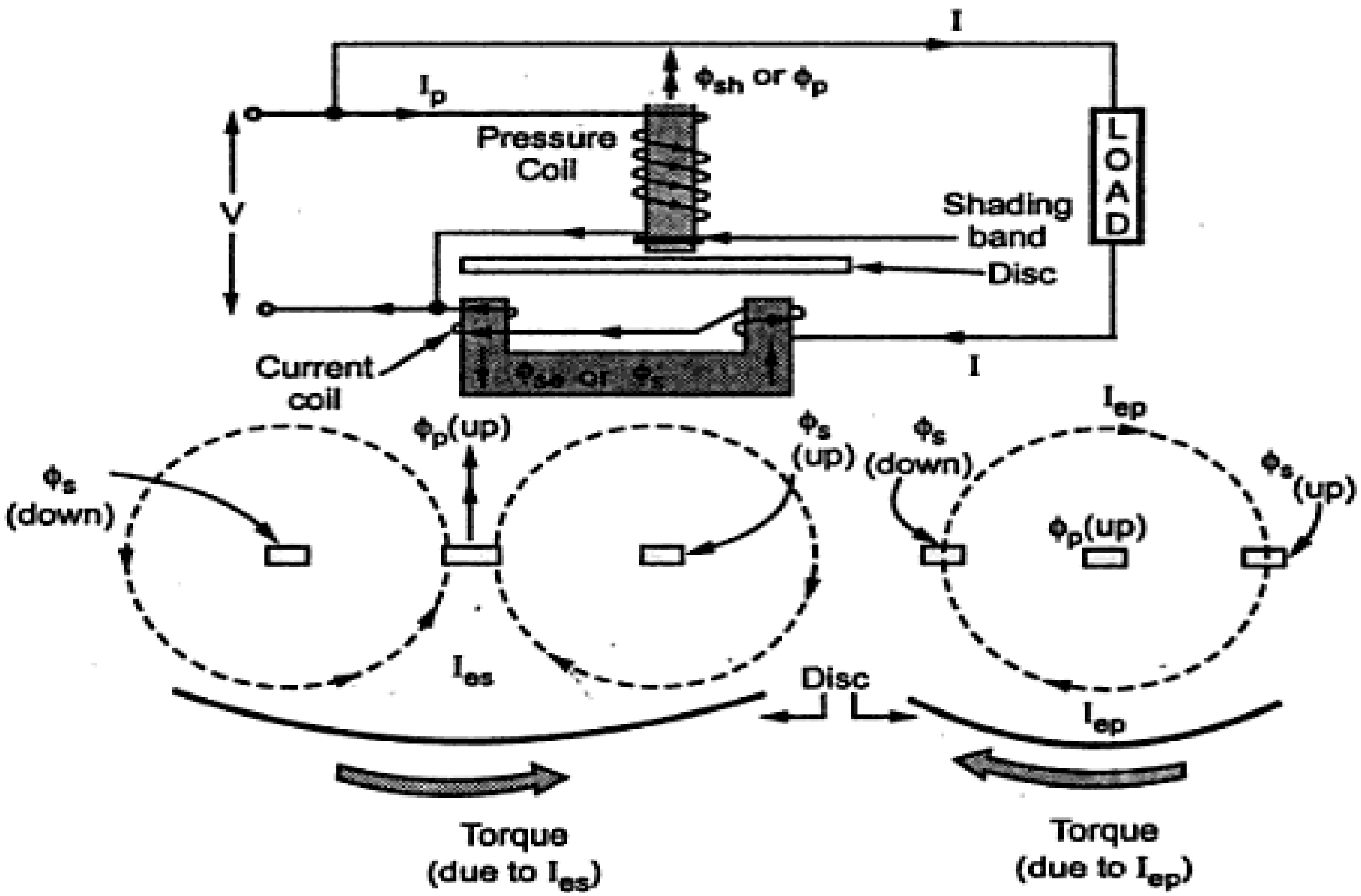
An electrical energy can also be expressed in the unit watt-hour (Wh) or kilowatt-hour (kWh). Thus one kilowatt-hour energy means the expenditure of 1 kW power over a time interval of 1 hour. The domestic electric energy expenditure is measured in kWh and 1 kWh is called 1 unit of energy.

Single Phase Energy Meter

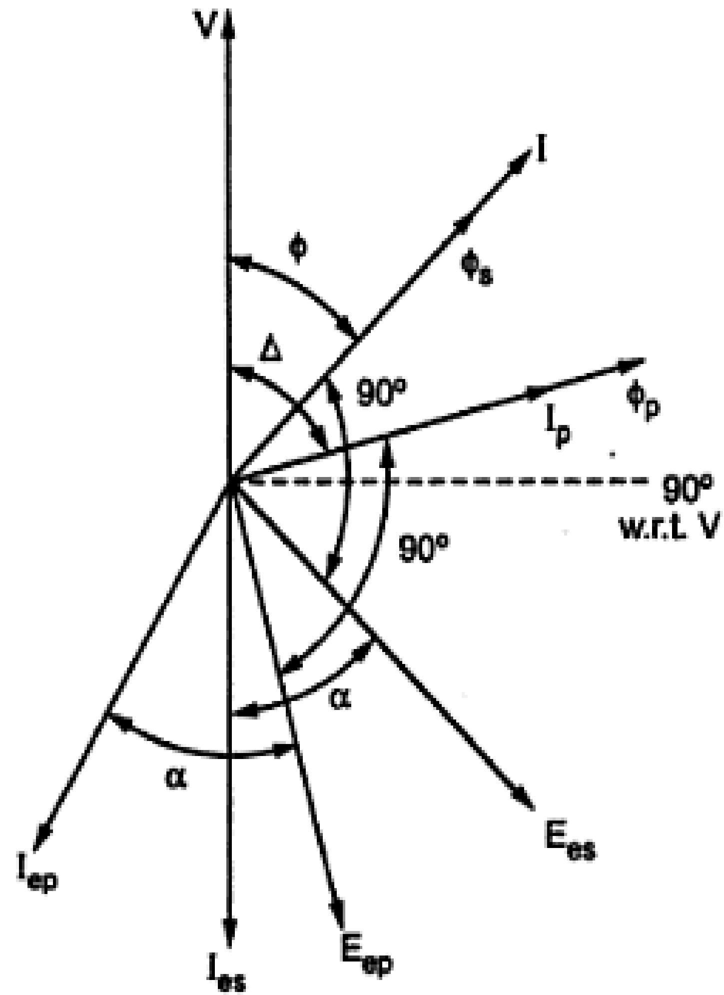


Induction type single phase energymeter

Working of Energy Meter

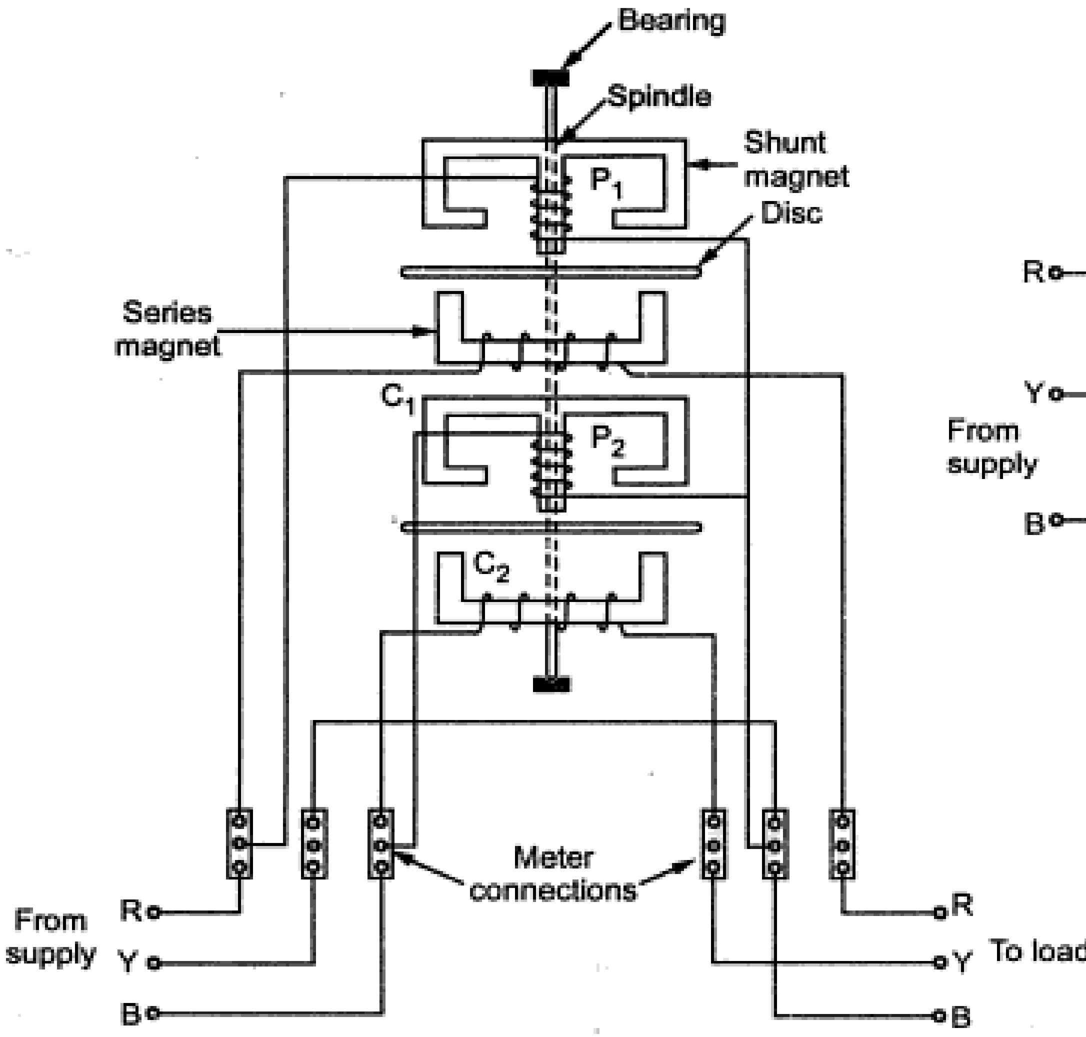


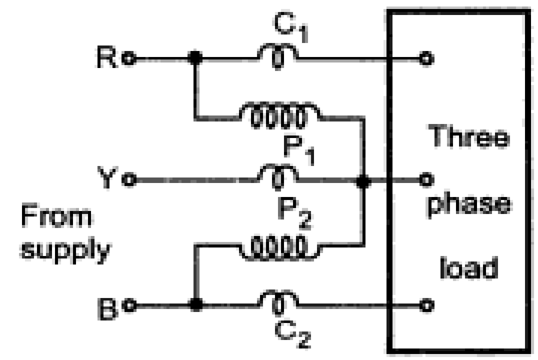
Functional diagram of induction type energymeter



Phasor diagram of single phase induction type energymeter

3 Phase Energy Meter





Two element energymeter

Potentiometers

A **potentiometer** *is an instrument used for measuring and comparing the e.m.fs of different cells and for calibrating and standardising voltmeters, ammeters, etc.*

Since a potentiometer measures voltage, it *can also be used to determine current* simply by measuring the voltage drop produced by the unknown current passing through a known standard resistance.

- Some *significant features/advantages* of potentiometers are :

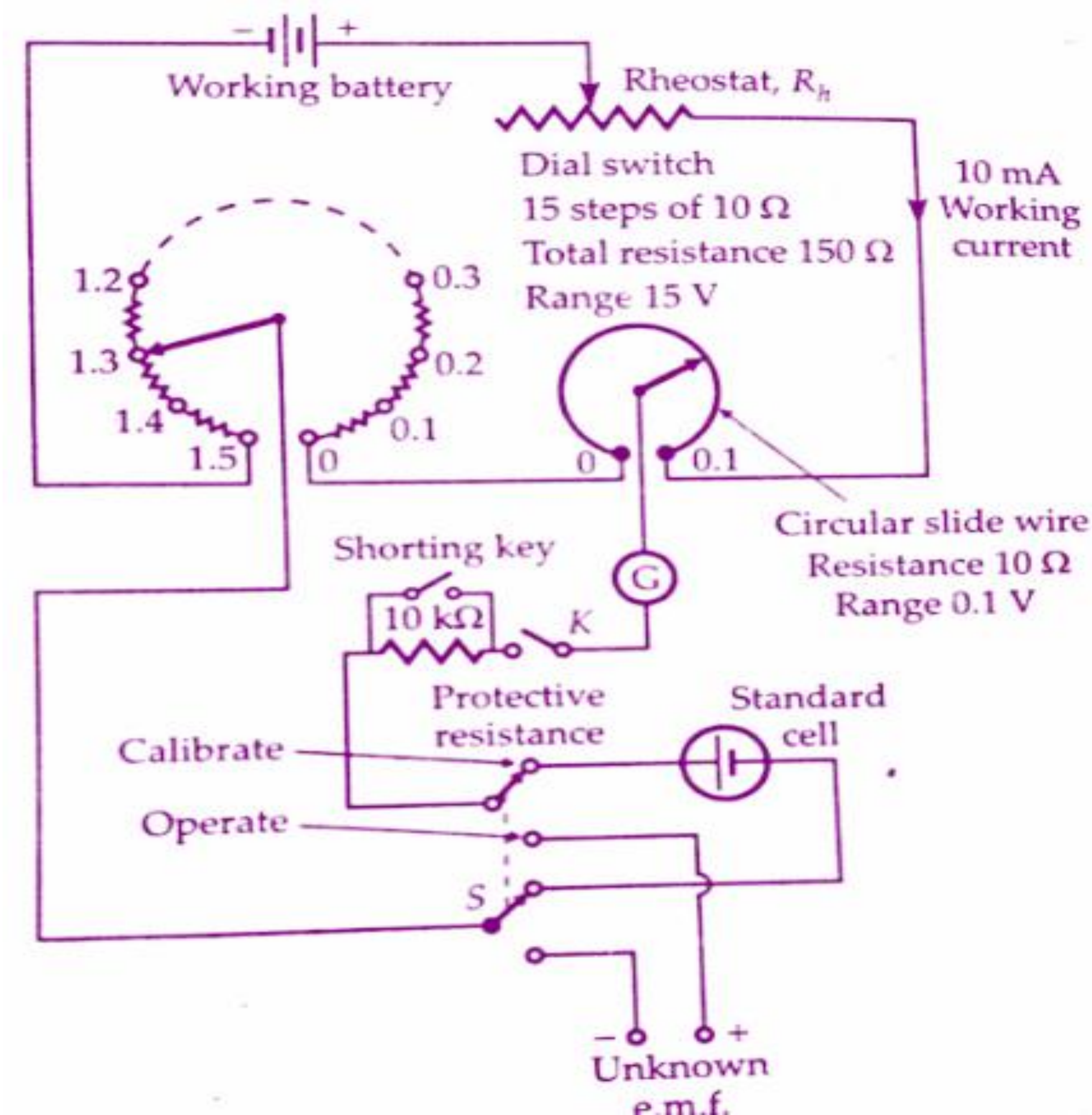
(*i*) Measurements using comparison methods are capable of *high degree of accuracy* because the result obtained does not depend on the actual deflection of a pointer, as is the case in deflection methods, but only upon the accuracy with which the voltage of the reference source is known.

(*ii*) A potentiometer makes use of a *balance or null condition, no current flows and hence no power is consumed* in the circuit containing the unknown e.m.f. when the instrument is balanced. Thus the determination of voltage by a potentiometer is quite *independent of the source resistance.*

Uses of potentiometer. The following are the *applications/uses of potentiometers* :

1. Measurement of small e.m.fs. (upto 2 volts).
2. Comparison of e.m.fs. of two cells.
3. Measurement of high e.m.fs. (say 250 volts).
4. Measurement of resistance.
5. Measurement of current.
6. Calibration of ammeter.
7. Calibration of voltmeter.

DC Crompton's Potentiometer



A.C. POTENTIOMETERS

The potentiometer method is an exceedingly useful one for the accurate measurement of alternating currents and voltages, since such measurements are not easily carried out by other methods.

- The principle of A.C. potentiometer is the *same* as that of D.C. potentiometer, the *most important difference in operation being that :*

"Whereas in the D.C. potentiometer *only the magnitudes* of the "unknown" e.m.f. and slide-wire voltage drop must be made equal to obtain balance, in the A.C. potentiometer the *phases of the two voltages, as well as their magnitudes, must be equal for balance to be obtained.*"

This condition obviously necessitates modification of the potentiometer as constructed for D.C. work, and means that the operation is somewhat more complicated.

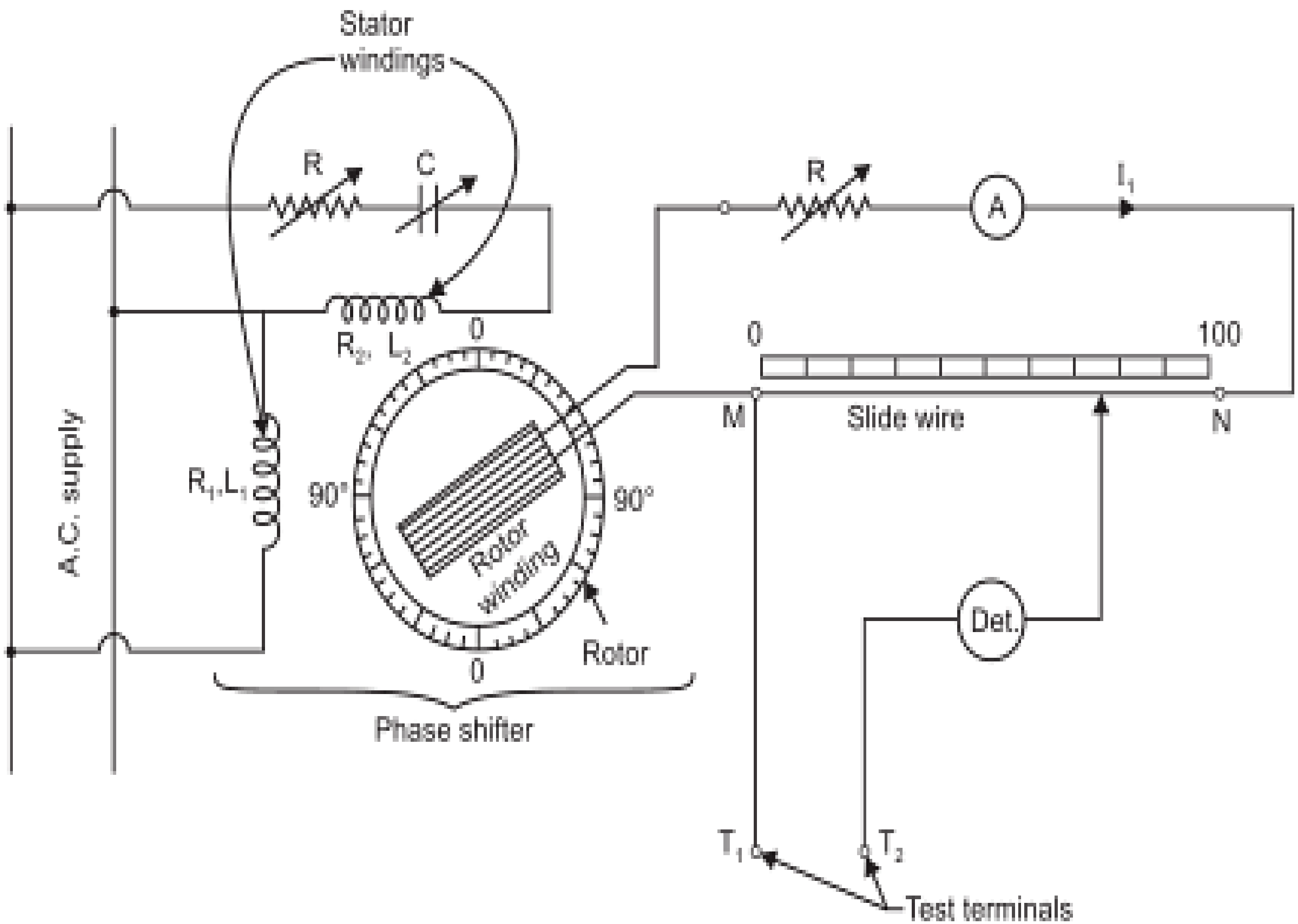
The following *factors* must be considered for the *operation of an A.C. potentiometer :*

(*i*) In all A.C. potentiometers, the potentiometer circuit must be supplied from the *same source as the voltage or current being measured.*

(*ii*) The sources of A.C. supply should be *free from harmonics* because in the presence of harmonic it may not be possible to achieve a balance. The supply source should be as *sinusoidal as possible.*

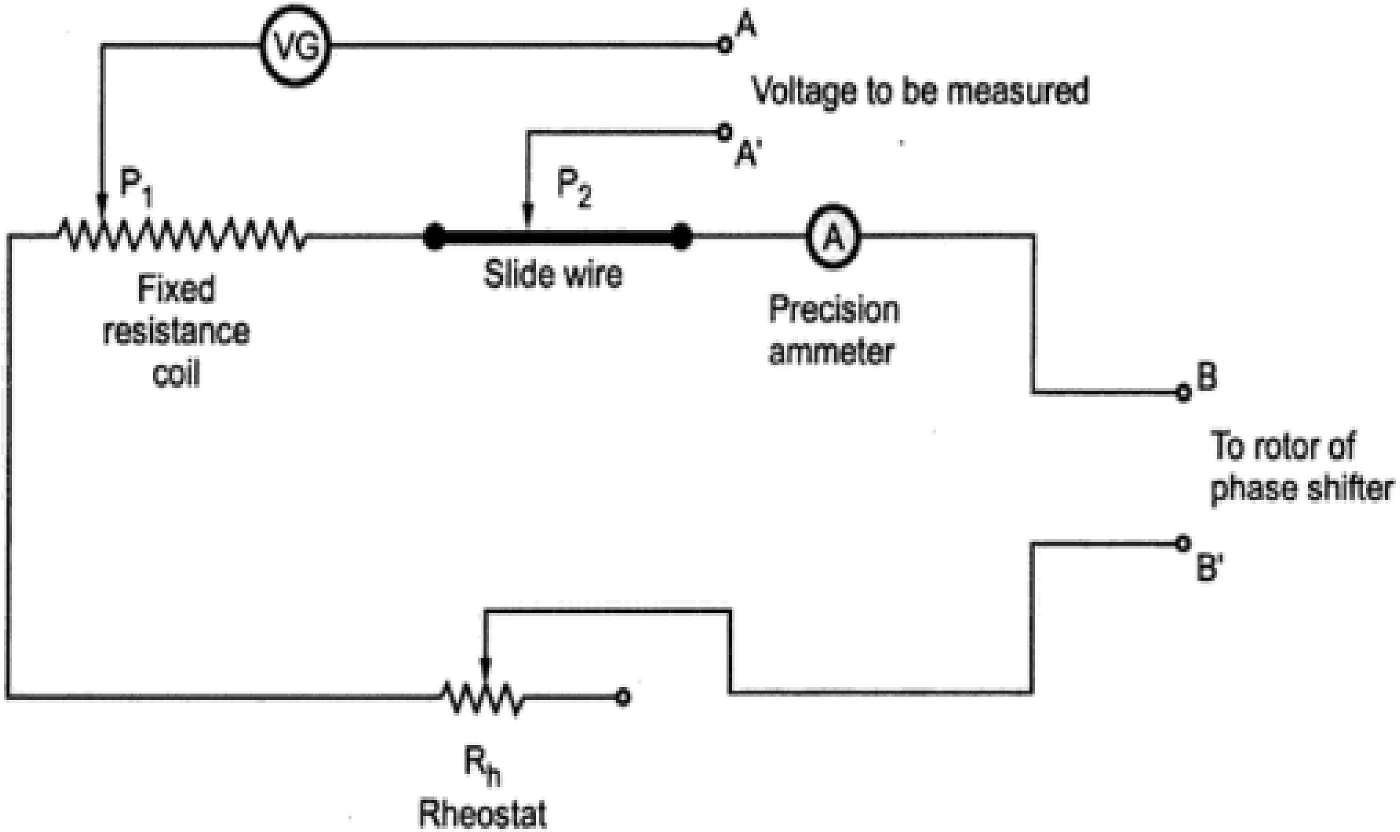
(*iii*) There being no reference source (the reference source in D.C. being a standard cell or a Zener source) the absolute accuracy with which an A.C. voltage can be measured in an A.C. potentiometer cannot be comparable with corresponding type of D.C. measurement.

Polar **Potentiometer**

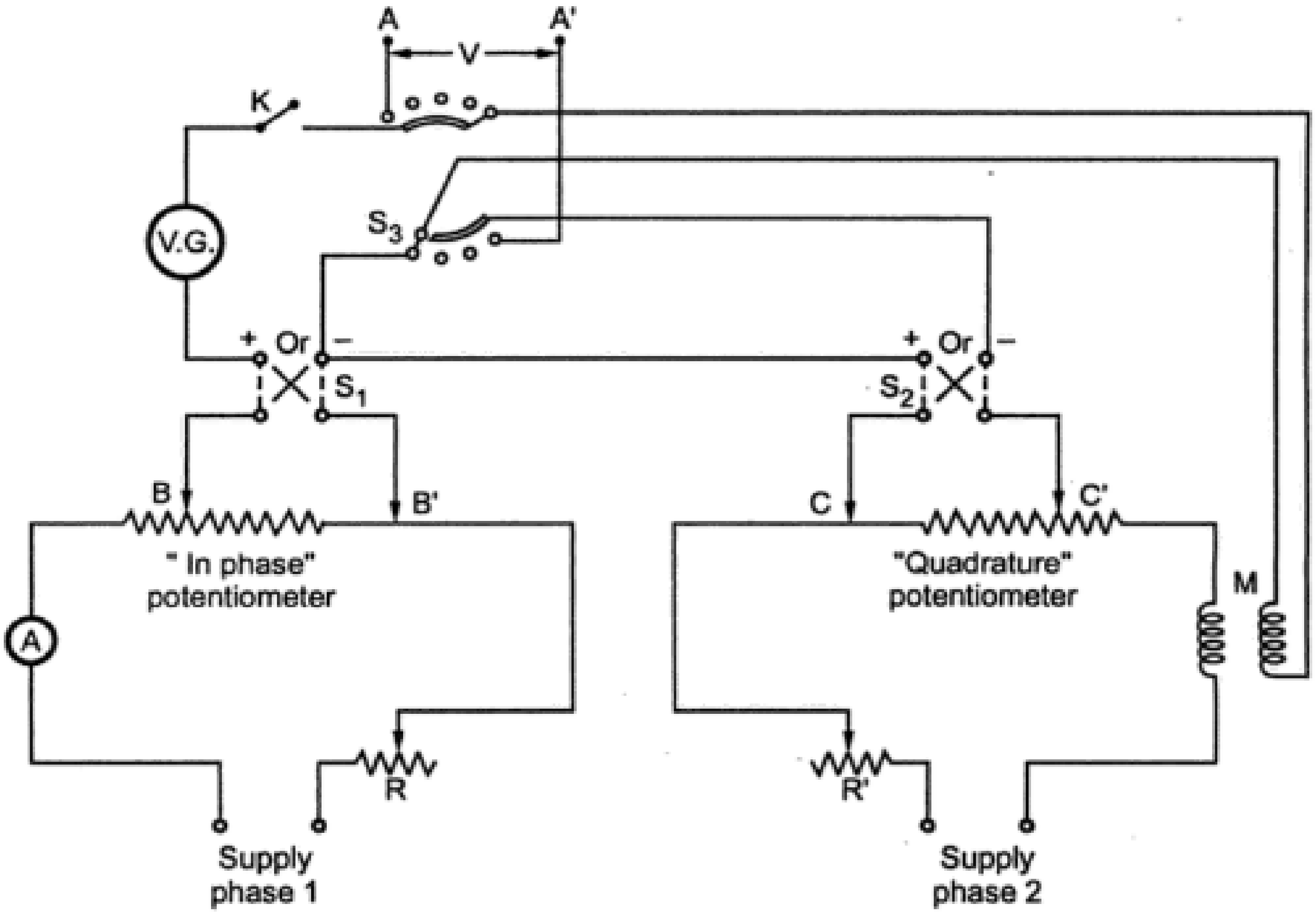


Drysdale polar potentiometer.

Standardization

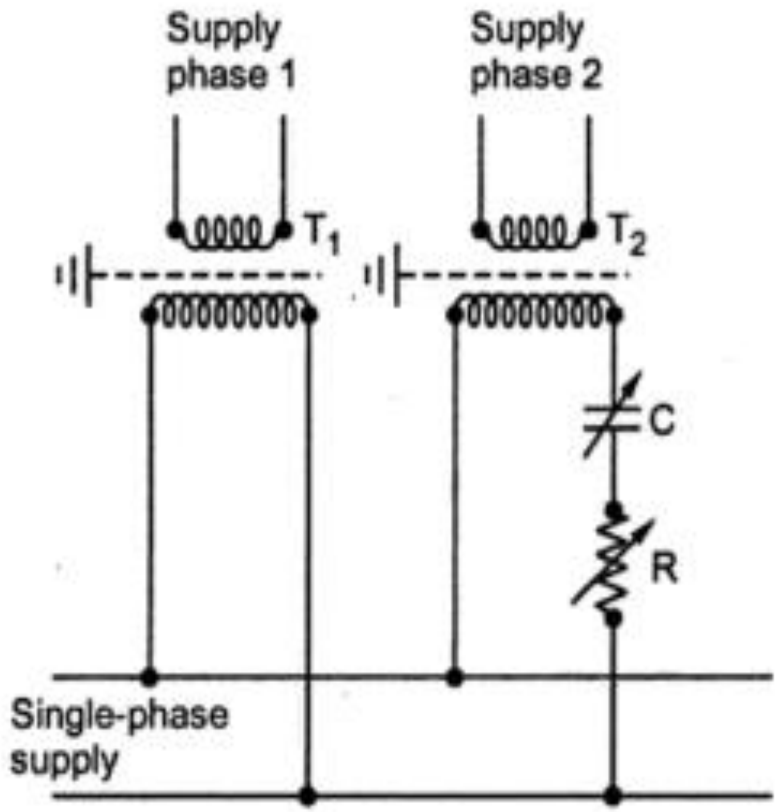


Gall-Tinsley Potentiometer



Connections of Gall-Tinsley potentiometers

Gall -Tinsley

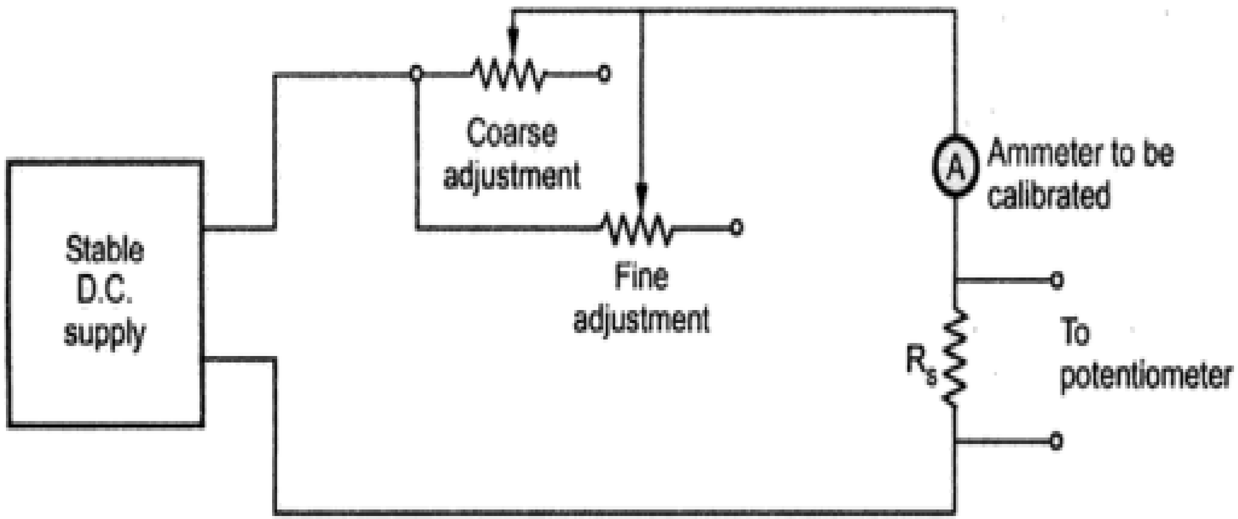


Phase splitting circuit

Applications of A.C. Potentiometers

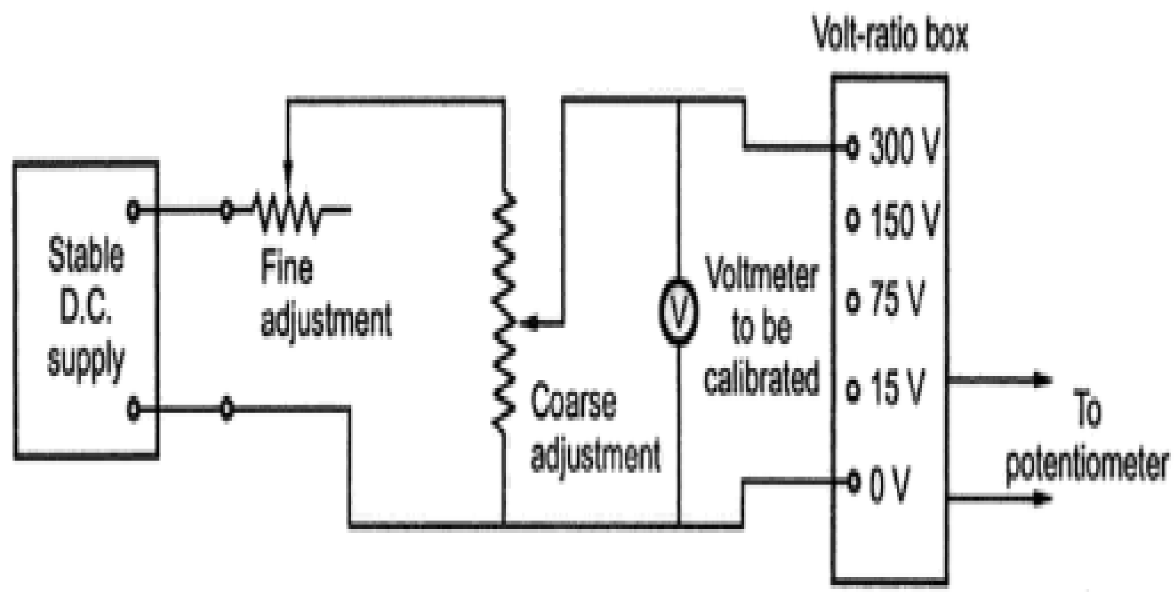
Out of the several applications, only the following important applications of A.C. potentiometers will be described here :

1. Measurement of self inductance.
2. Calibration of voltmeter.
3. Calibration of ammeter
4. Calibration of wattmeter.

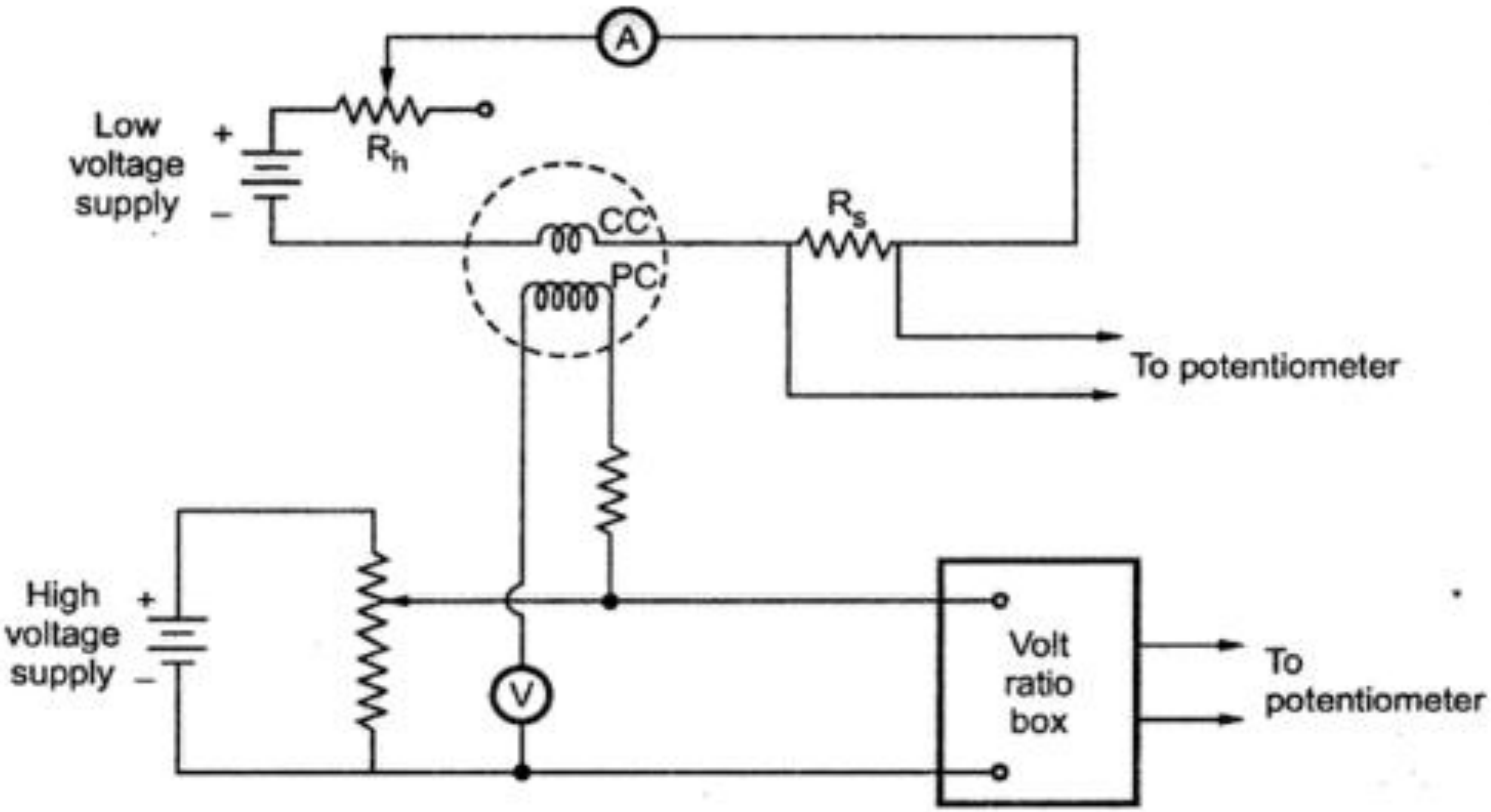


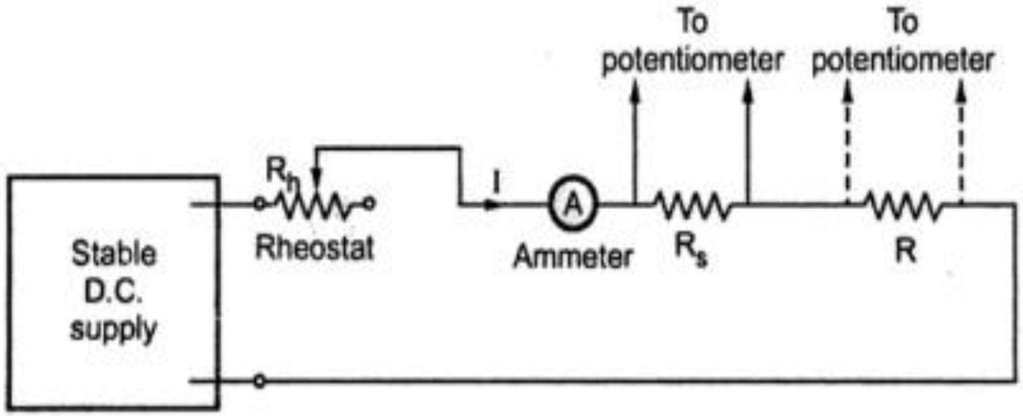
Calibration of Ammeter

Calibration of Voltmeter



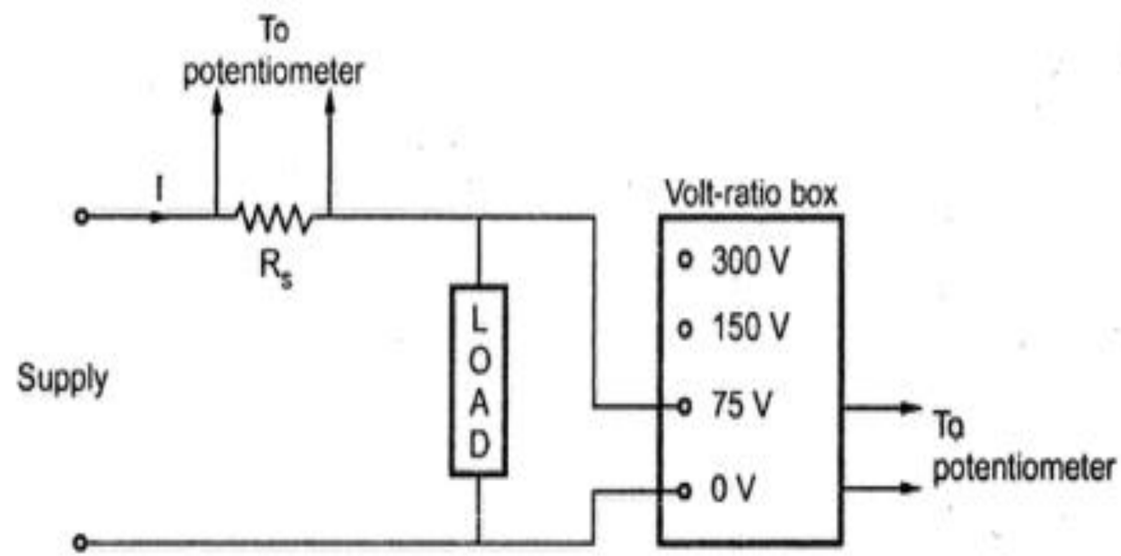
Calibration of Wattmeter





Measurement of Resistance

Measurement of Power



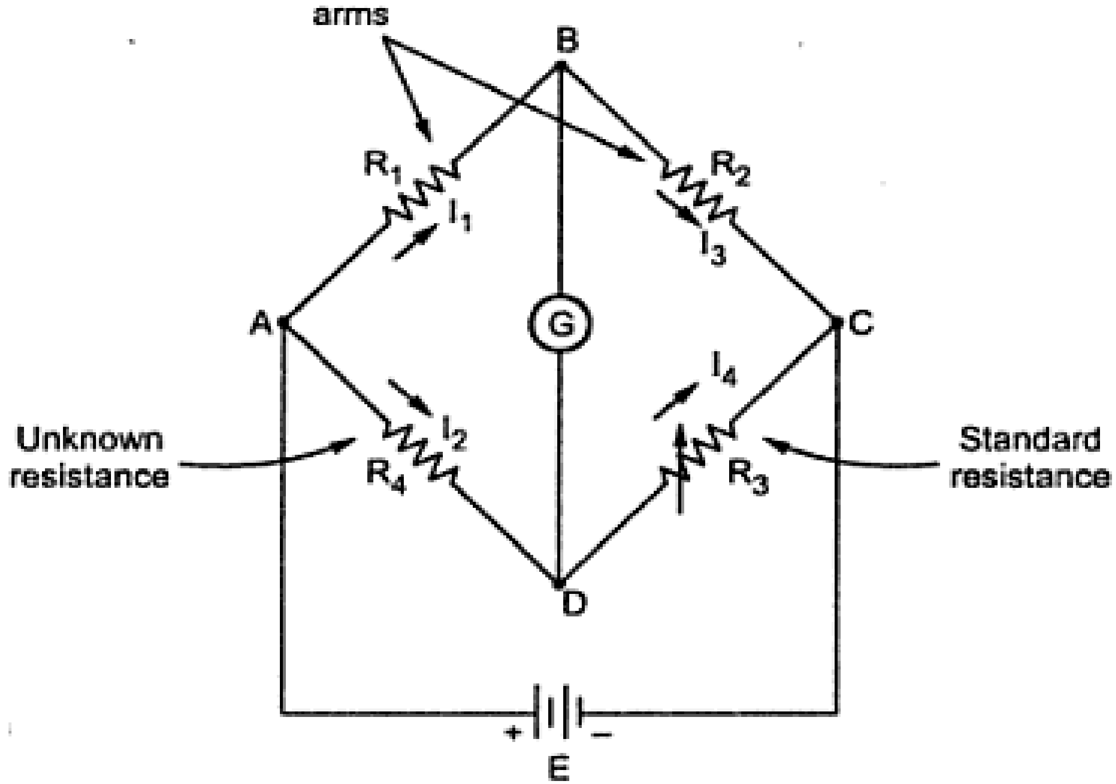
Measurement of Resistance

- Low Resistance
  - Ammeter –Voltmeter Method
  - Kelvin Double Bridge
  - Potentiometer Method
  - Ducter Method
- Medium Resistance
  - Ammeter-Voltmeter Method
  - Wheatstone Bridge
  - Carey Foster Bridge
  - Ohmmeter
  - Substitution Method

Measurement of Resistance

- High Resistance
  - Direct Deflection Method
  - Loss of Charge Method
  - Megohm Bridge
  - Meggar

DC Bridges



Wheatstone bridge

Limitations of Wheatstone Bridge

The effect of lead resistance and contact resistance is very much significant while measuring low resistances.

The bridge cannot be used for high resistance measurement i.e. measurement in high megaohm range. This is because while such measurement the resistance presented by the bridge becomes so large that the galvanometer becomes insensitive to show any imbalance.

Similarly heating effect due to large current also plays a major role. The excessive currents may generate heat which may cause the permanent change in the resistance.

The resistance used must be very precise having tolerance upto 1% or 0.1%, hence cost is high.

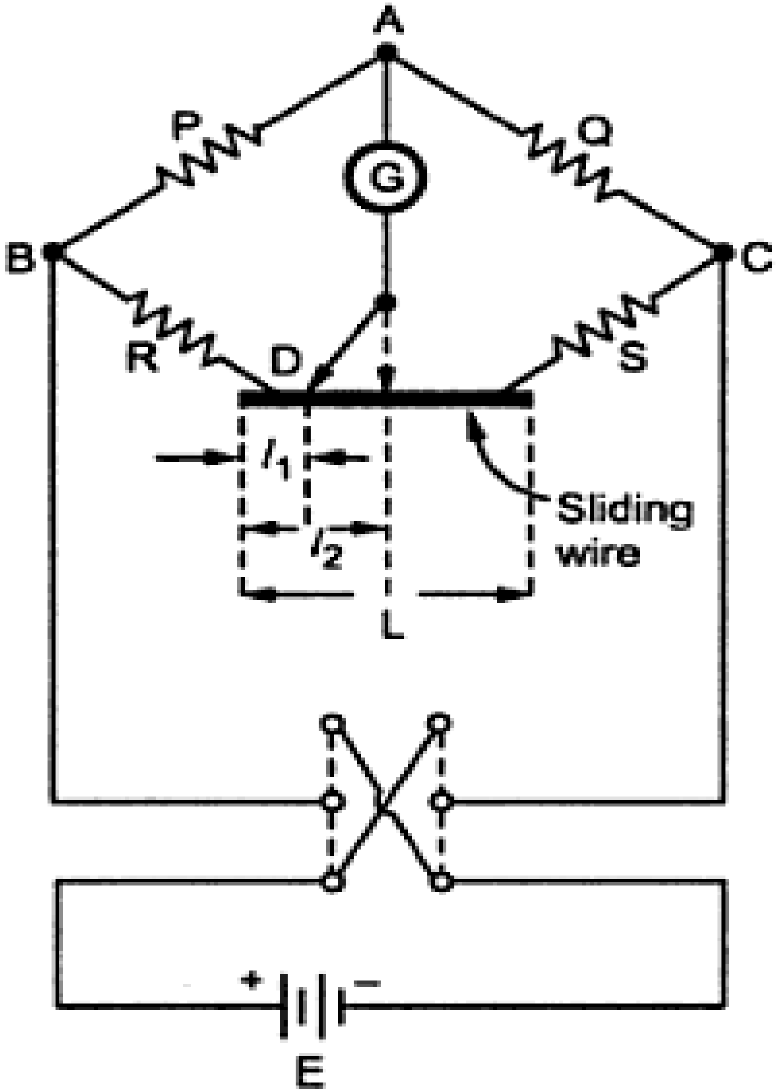
Applications of Wheatstone Bridge

The Wheatstone bridge is basically a d.c. bridge and used to measure the resistances in the range 1 Ω to low megaohm.

It is used to measure the d.c. resistance of various types of wires for the purpose of quality control of wire.

It is used to measure the resistance of motor winding, relay coils etc.

It is used by the telephone companies to locate the cable faults. The faults may be of the type line to line short or line to ground short.



Carey-Foster slide wire bridge

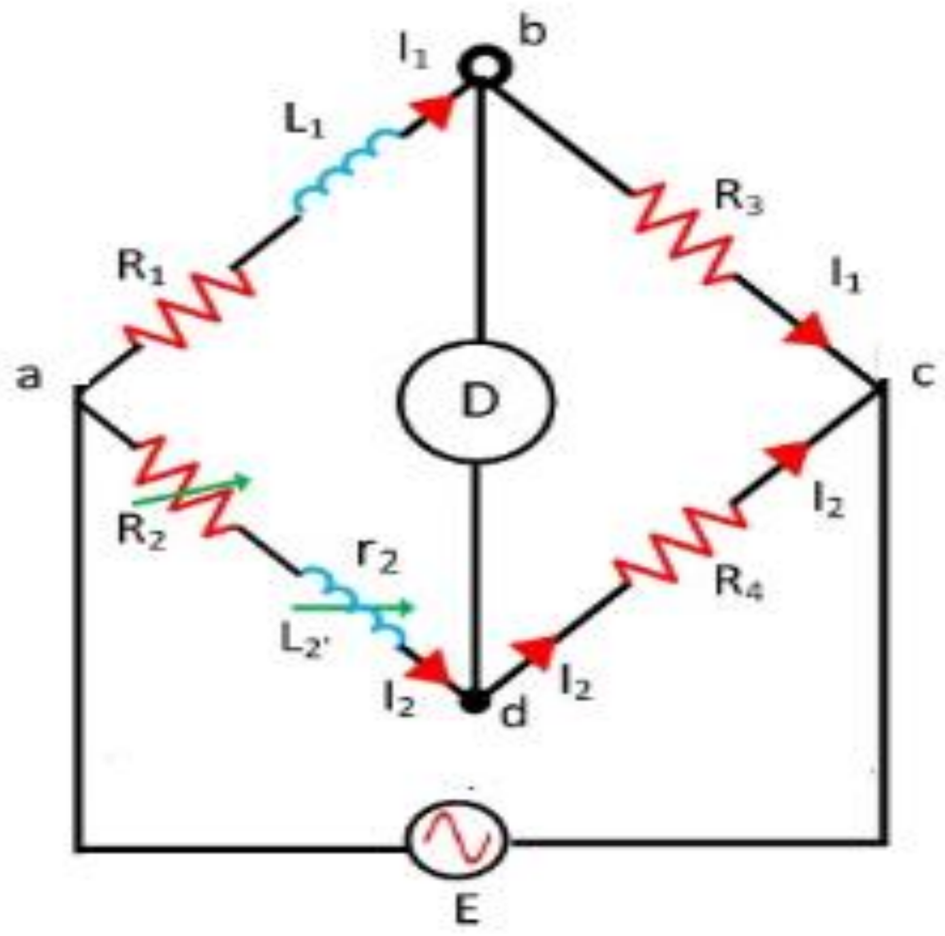
Measurement of Inductance

- Maxwell’s Inductance Bridge
- Maxwell’s Inductance & Capacitance Bridge
- Hay’s Bridge
- Anderson’s Bridge
- Owen’s Bridge

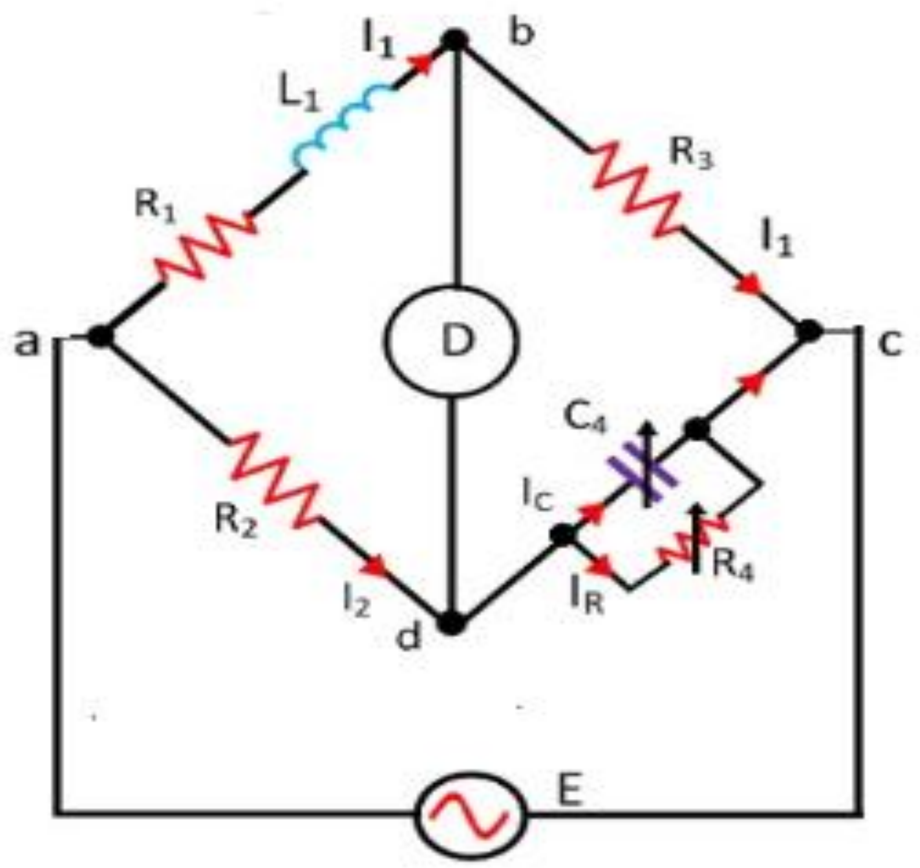
Measurement of Capacitance

- ❑Desauty's Bridge
- ❑Schering Bridge
- ❑Wein's Bridge

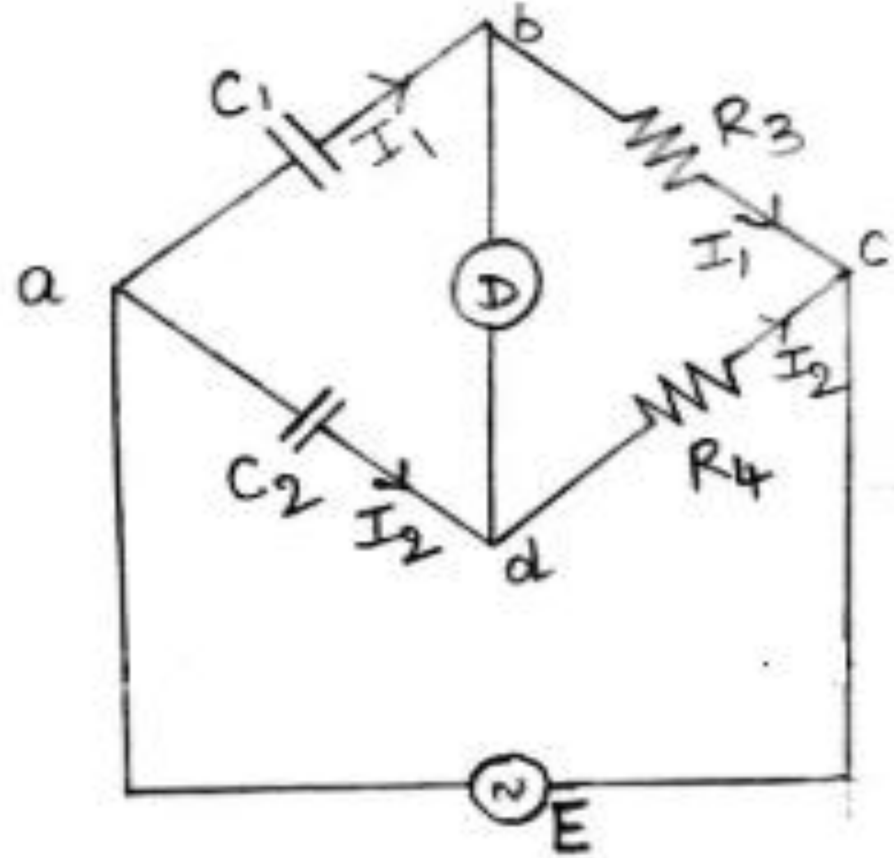
AC Bridges
Maxwell Inductance Bridge



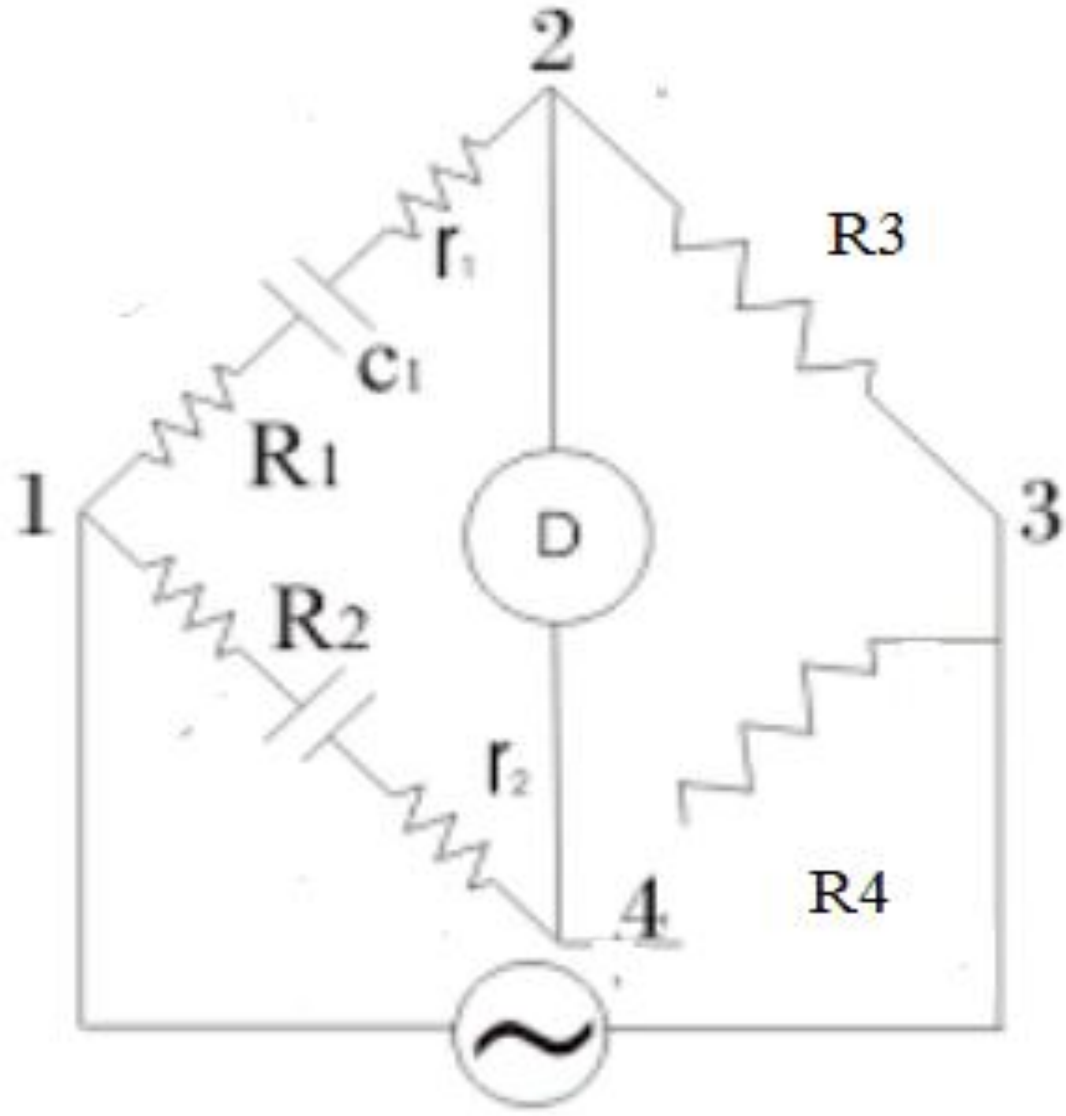
Maxwell Inductance & Capacitance Bridge



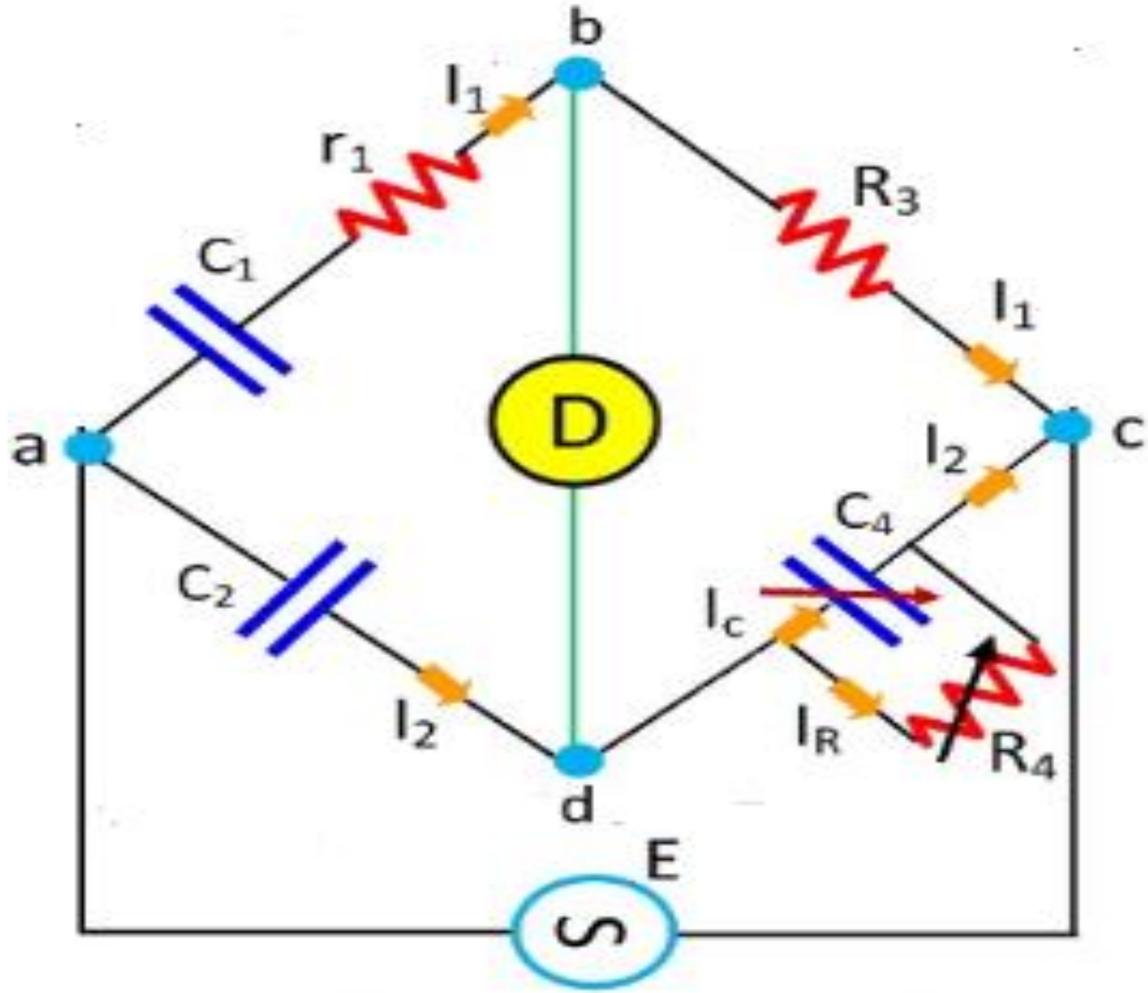
Desauty Bridge



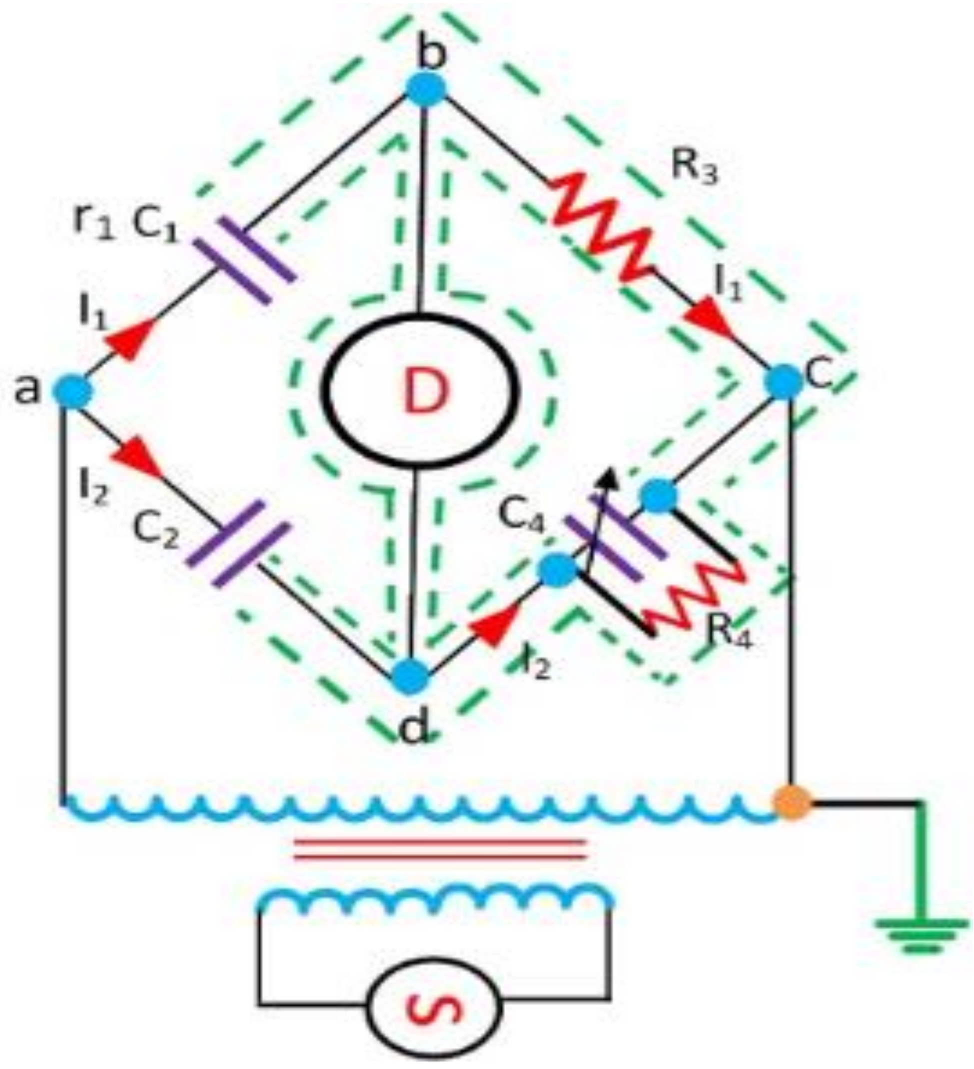
Modified Desauty Bridge



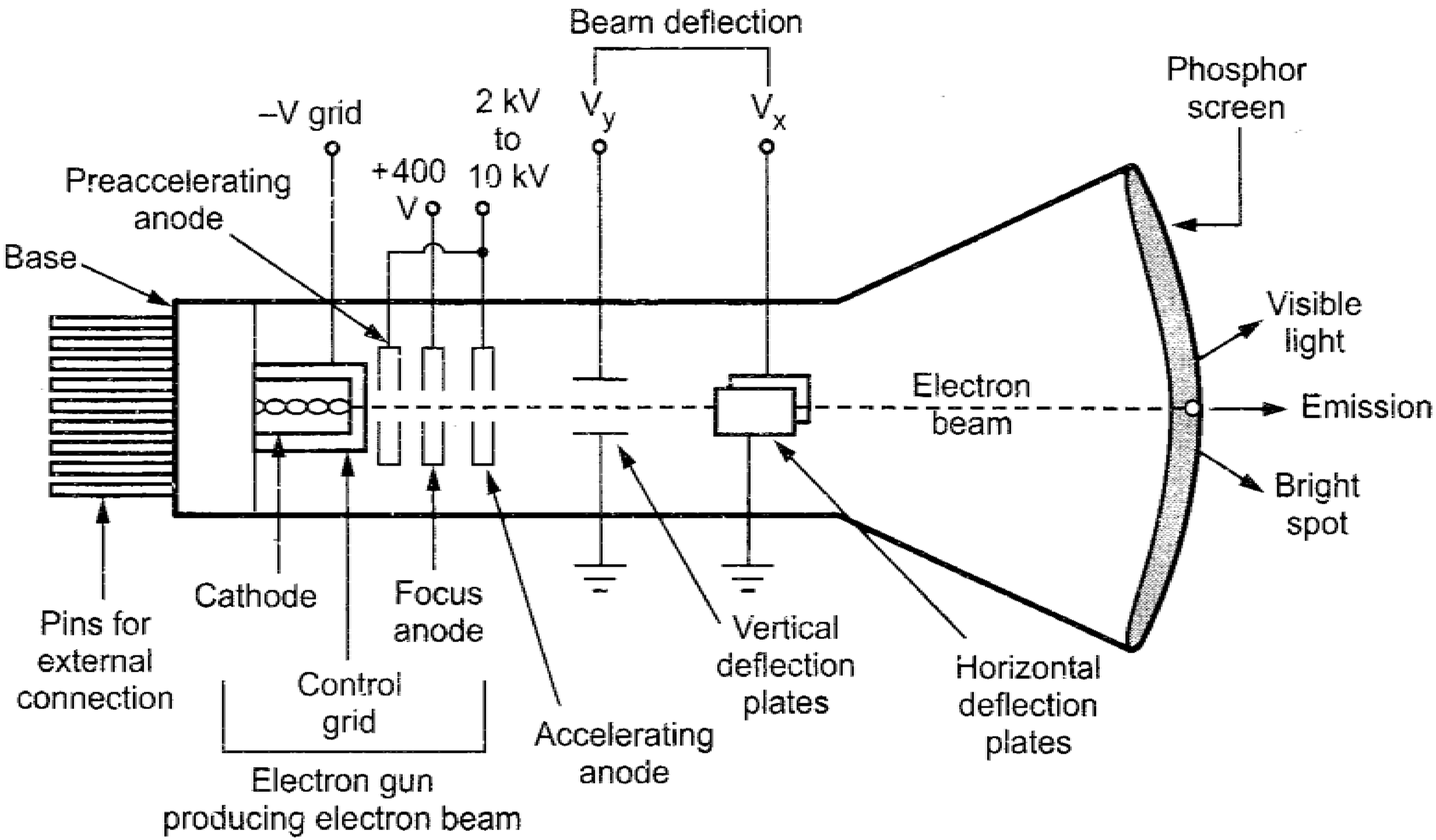
Low Voltage Schering Bridge



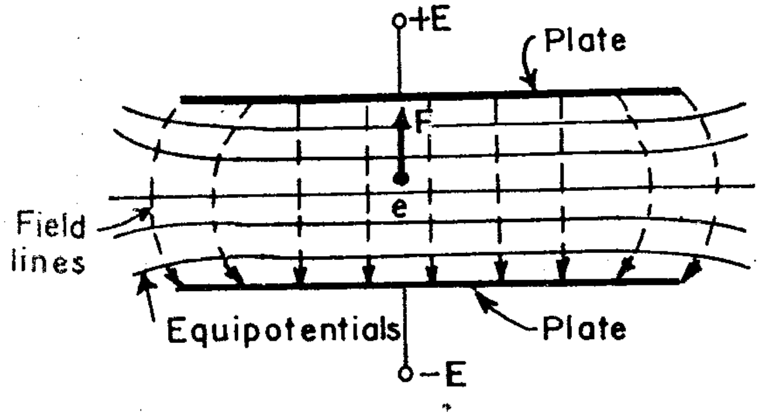
High Voltage Schering Bridge

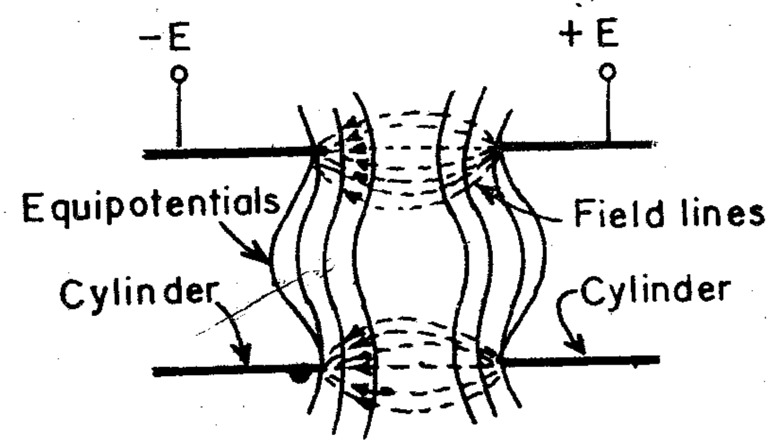


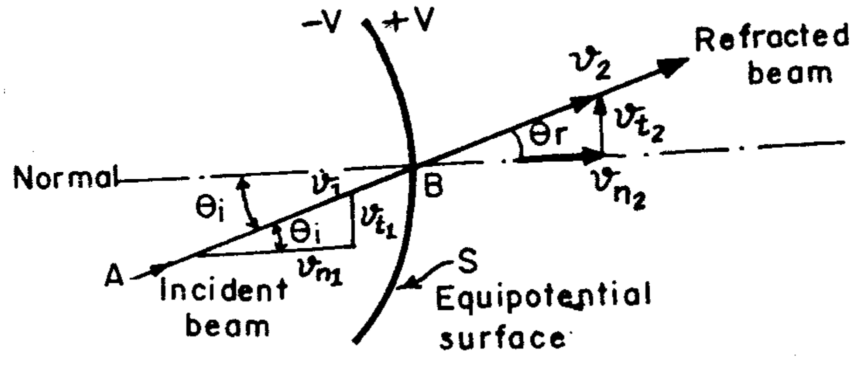
Cathode ray tube



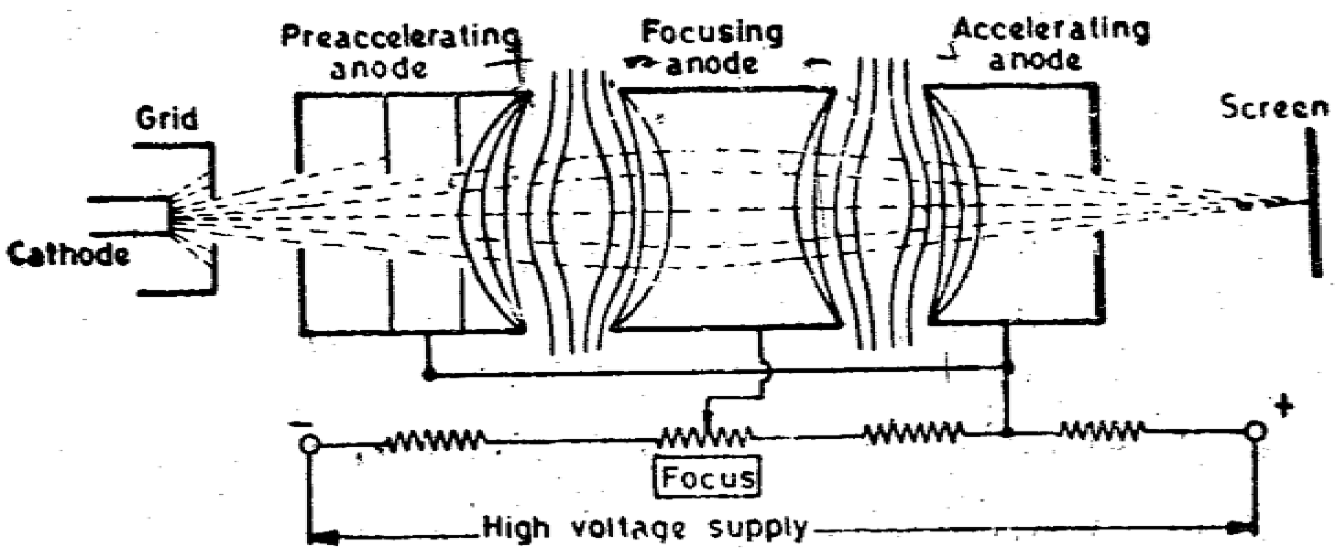
Electrostatic Focusing





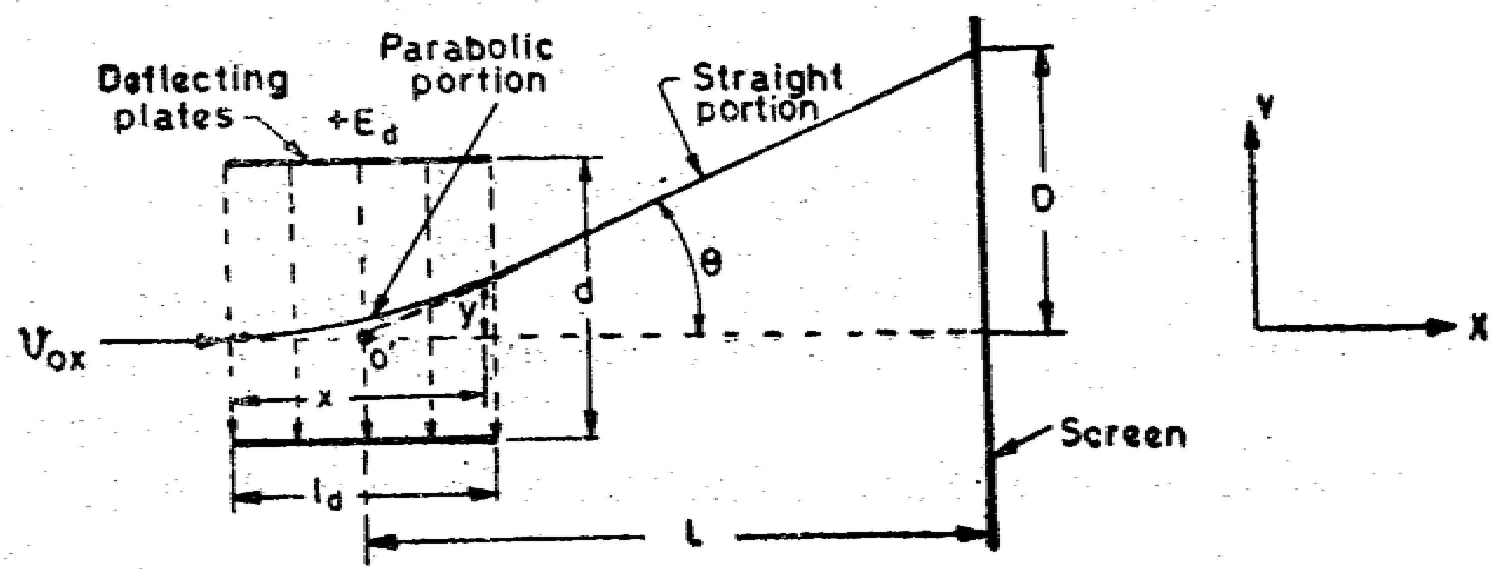


-V
+V
Refracted beam
Normal
B
A
Incident beam
S
Equipotential surface



Preaccelerating anode
Focusing anode
Accelerating anode
Grid
Screen
Cathode
Focus
High voltage supply

Electrostatic Deflection



The loss of potential energy (P E) when the electron moves from cathode to accelerating anode

$$P.E. = eE_a$$

The gain in kinetic energy (K B) by an electron

$$K.E. = (1/2)\, m v_{ox}^2$$

Equating the two energies, we have

$$v_{ox} = (2\ e\ E_d/m)^{1/2}$$

This is the velocity of the electron in the X direction when it entering the deflecting plates.

The velocity in the X direction remains the same throughout the passage of electrons through the deflecting plates as there is no force acting in this direction.

The electric field intensity in the Y direction

$$\varepsilon_y = E_d\ /d$$

Force acting on an electron in Y direction

$$F_y = e\varepsilon_y = eE_d/d$$

Suppose a_y is the acceleration of the electron in Y direction therefore

$$F_y = ma_y$$

$$a_y = e\varepsilon_y/m$$

As there is no initial velocity m the Y direction the displacement y at any instant t in the Y direction is

$$y = \frac{1}{2} a_y t^2 = \frac{1}{2} \frac{e\varepsilon_y}{m} t^2$$

As the velocity in X direction is constant, the displacement in X direction is given by

$$x = v_{ox} t$$

$$t = x / v_{ox}$$

Substituting the above value of t in Eqn. y, we have:

$$y = \frac{1}{2} \frac{e\varepsilon_y}{m\, v_{ox}^2} x^2$$

This is the equation of a parabola.

The slope at any point (x, y) is $\frac{dy}{dx} = \frac{e\varepsilon_y}{m v_{ox}^2} x$

Putting x = l_d in above equation, we get the value of tan θ.

$$\tan \theta = \frac{e\varepsilon_y}{m v_{ox}^2} l_d = \frac{e E_d l_d}{m d\, v_{ox}^2}$$

After leaving the deflection plates, the electrons travel in a straight line.
The straight line of travel of electrons is tangent to the parabola at $x = l_d$ and this tangent intersects the X-axis at point 0'.
The location is given by:

$$x = \frac{y}{\tan\theta} = \frac{e\varepsilon_y l_d^2}{2\,mv_{ox}^2} \Big/ \frac{e\varepsilon_y}{mv_{ox}^2}\,l_d = \frac{l_d}{2}.$$

The apparent origin is thus at the centre of deflection plates. The deflection D on the screen is given by:

$$D = L\tan\theta = \frac{L\,e\,E_d\,l_d}{m\,d\,v_{ox}^2}$$

Substituting the value $v_{ox}^2 = \frac{2e\,E_a}{m}$ in the above equation, we get

$$D = \frac{L\,e\,E_d\,l_d}{md} \cdot \frac{m}{2eE_a} = \frac{Ll_dE_d}{2dE_a}$$

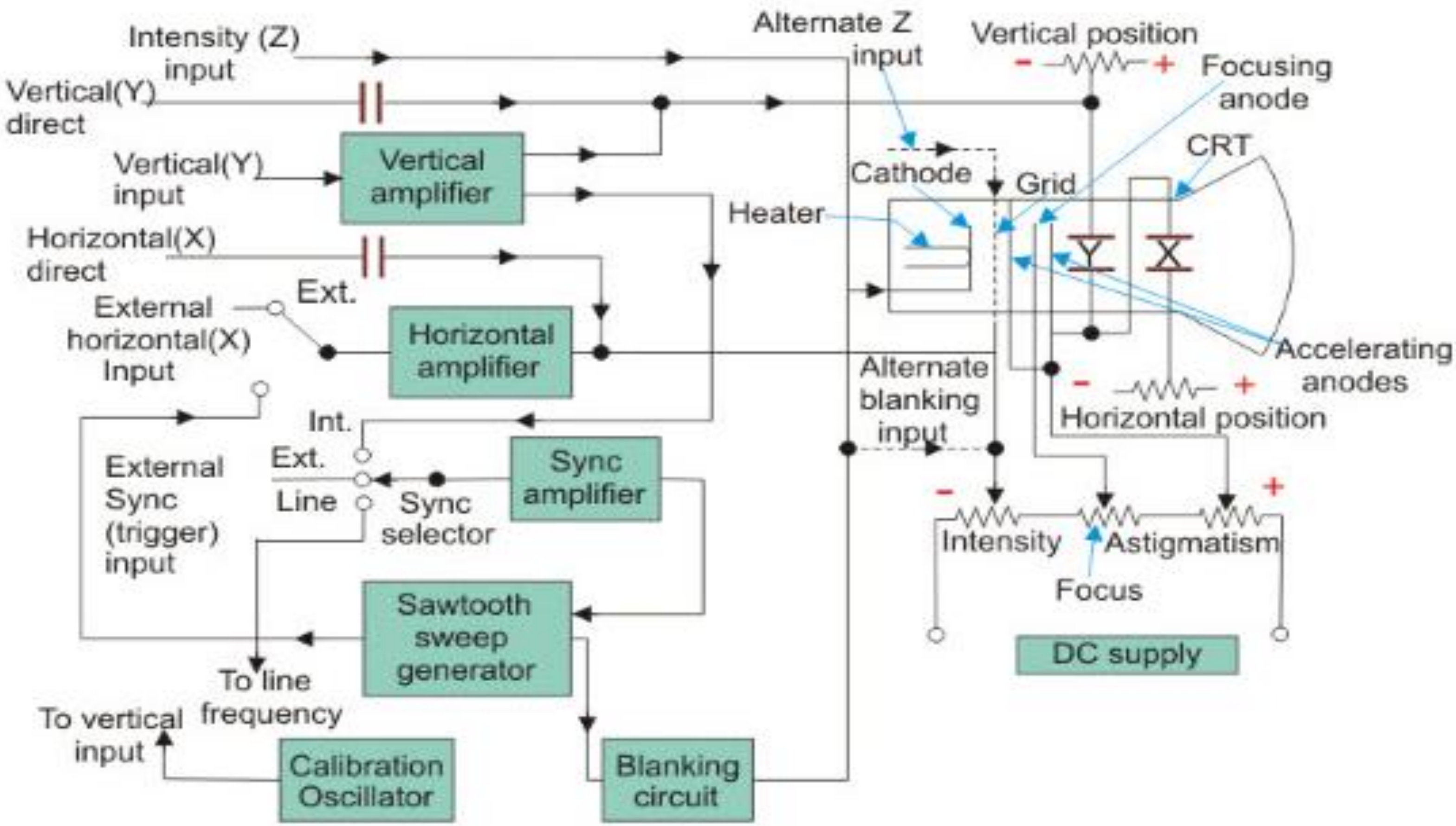
Deflection Sensitivity. The deflection sensitivity of a CRT is defined as the deflection of the screen per unit deflection voltage.

$$S = \frac{D}{E_d} = \frac{Ll_d}{2dE_a} \quad \text{m/V}$$

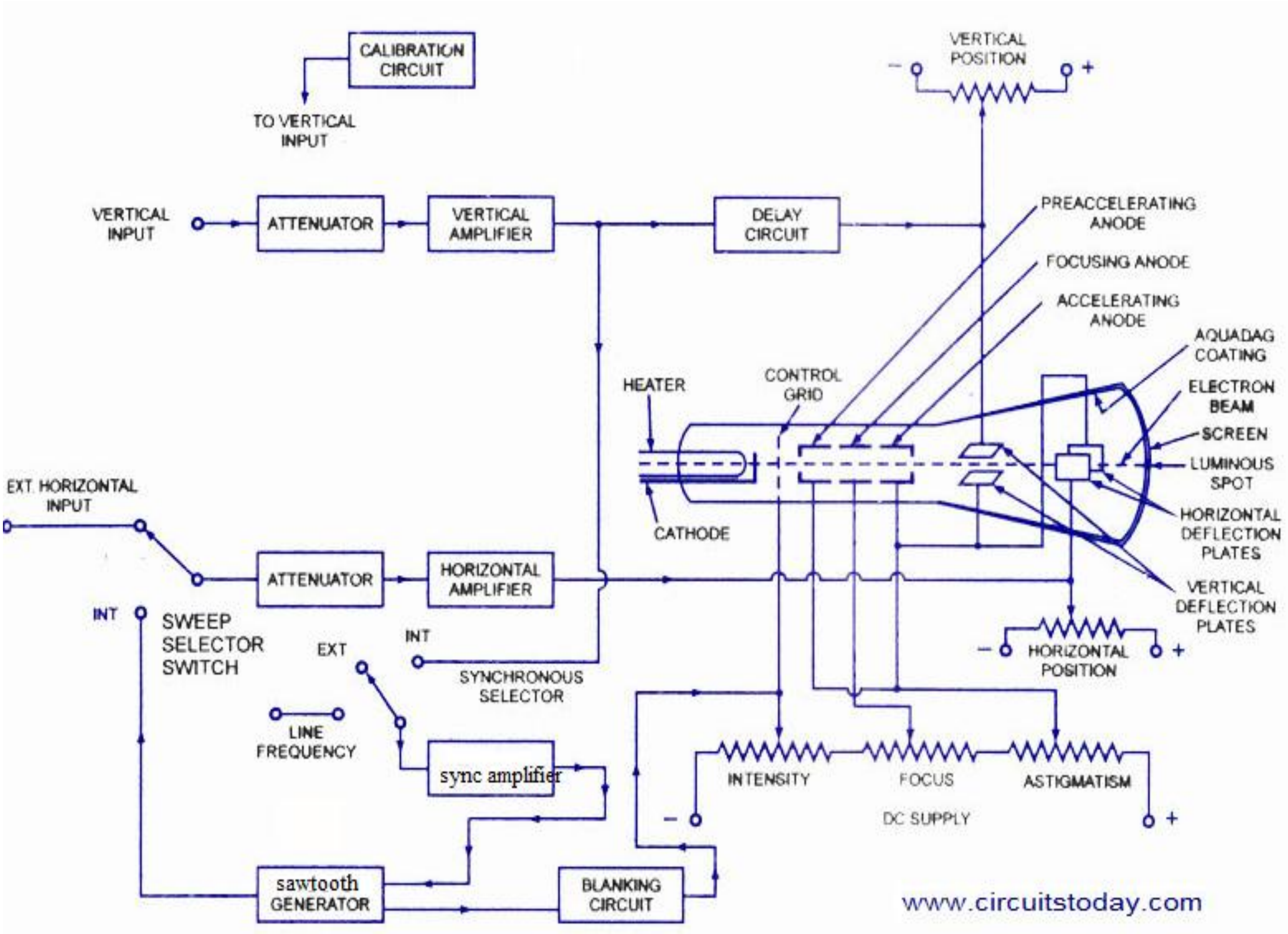
The **Deflection Factor** of a CRT is defined as the reciprocal of sensitivity.

$$G = \frac{1}{S} = \frac{2dE_a}{Ll_d} \quad \text{V/m}$$

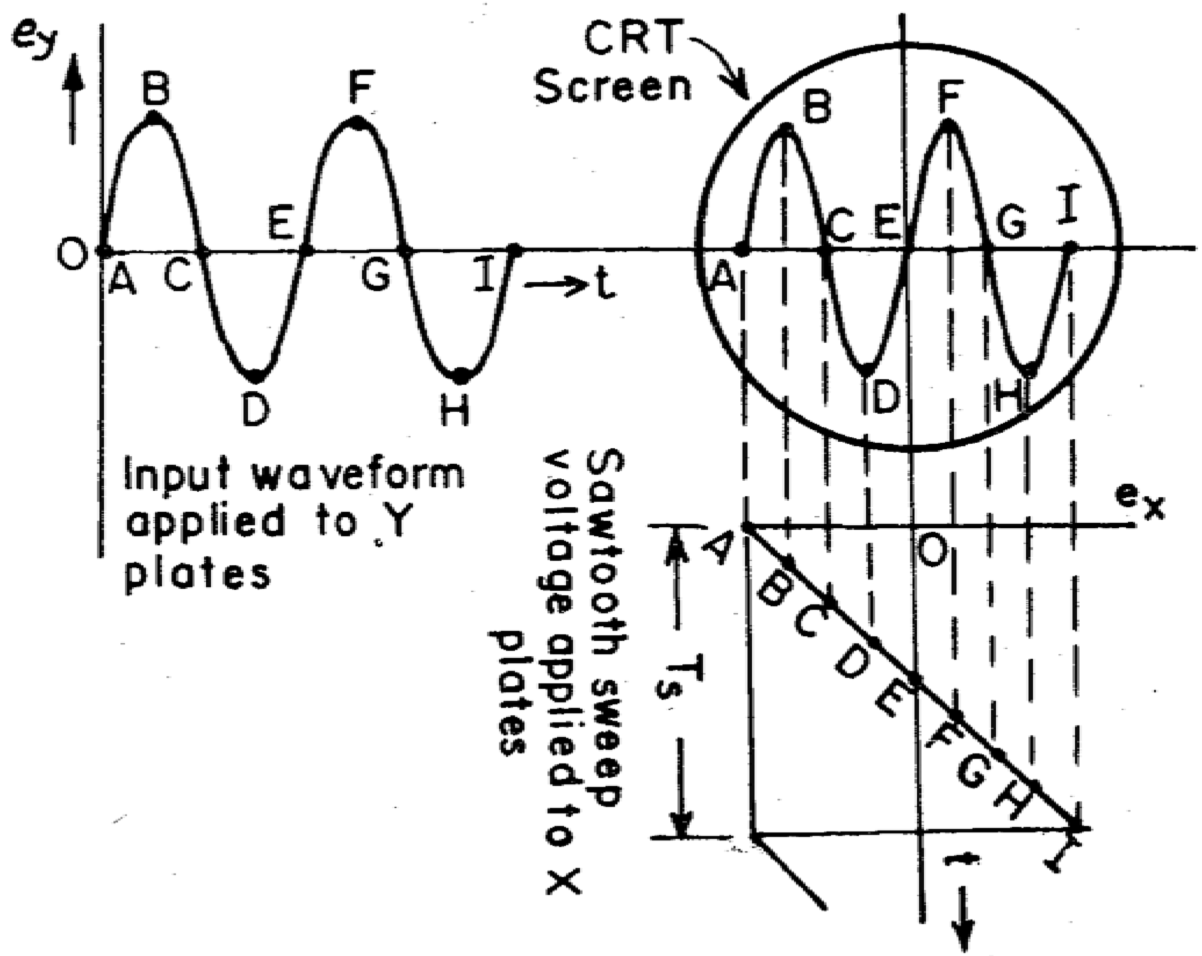
Basic Block Diagram of C.R.O



Working of CRO


CALIBRATION CIRCUIT
TO VERTICAL INPUT
VERTICAL POSITION
VERTICAL INPUT
ATTENUATOR
VERTICAL AMPLIFIER
DELAY CIRCUIT
PREACCELERATING ANODE
FOCUSING ANODE
ACCELERATING ANODE
AQUADAG COATING
HEATER
CONTROL GRID
ELECTRON BEAM
SCREEN
LUMINOUS SPOT
CATHODE
HORIZONTAL DEFLECTION PLATES
EXT HORIZONTAL INPUT
ATTENUATOR
HORIZONTAL AMPLIFIER
VERTICAL DEFLECTION PLATES
INT
SWEEP SELECTOR SWITCH
EXT
INT
HORIZONTAL POSITION
SYNCHRONOUS SELECTOR
LINE FREQUENCY
sync amplifier
INTENSITY
FOCUS
ASTIGMATISM
DC SUPPLY
sawtooth GENERATOR
BLANKING CIRCUIT
www.circuitstoday.com

Observation of waveform on CRO



Measurement of Phase & Frequency (Lissajous Patterns)

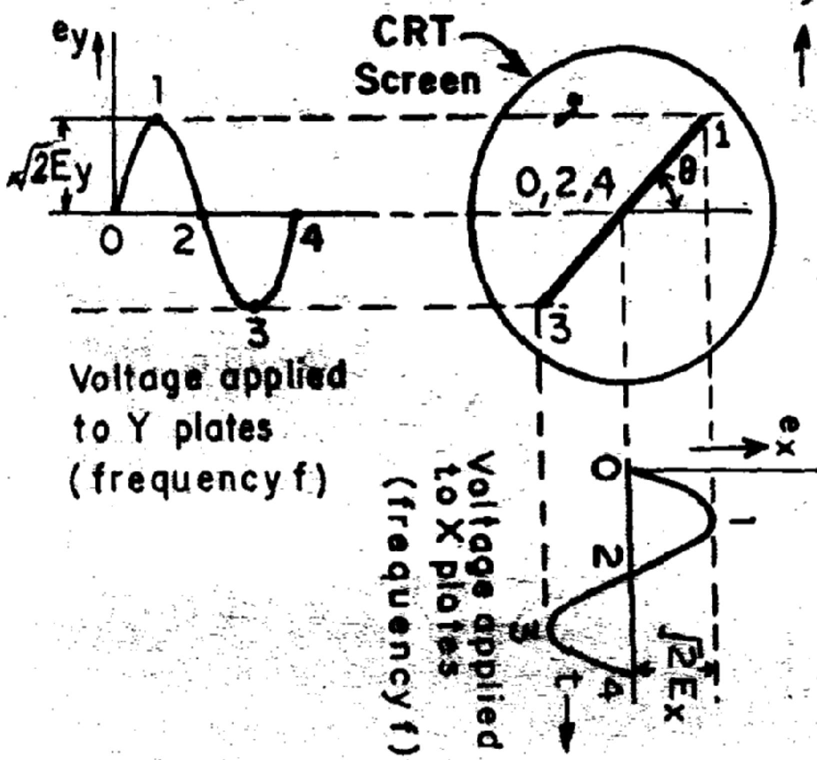


Fig. 21.30. Lissajous pattern with equal frequency voltages and zero phase shift.

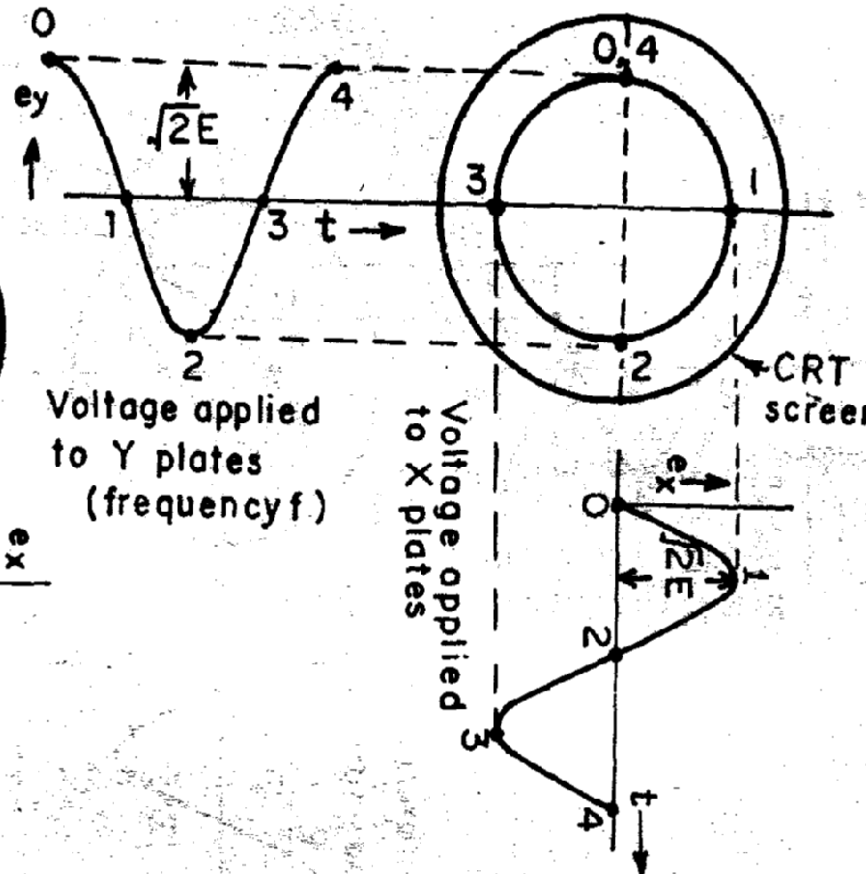
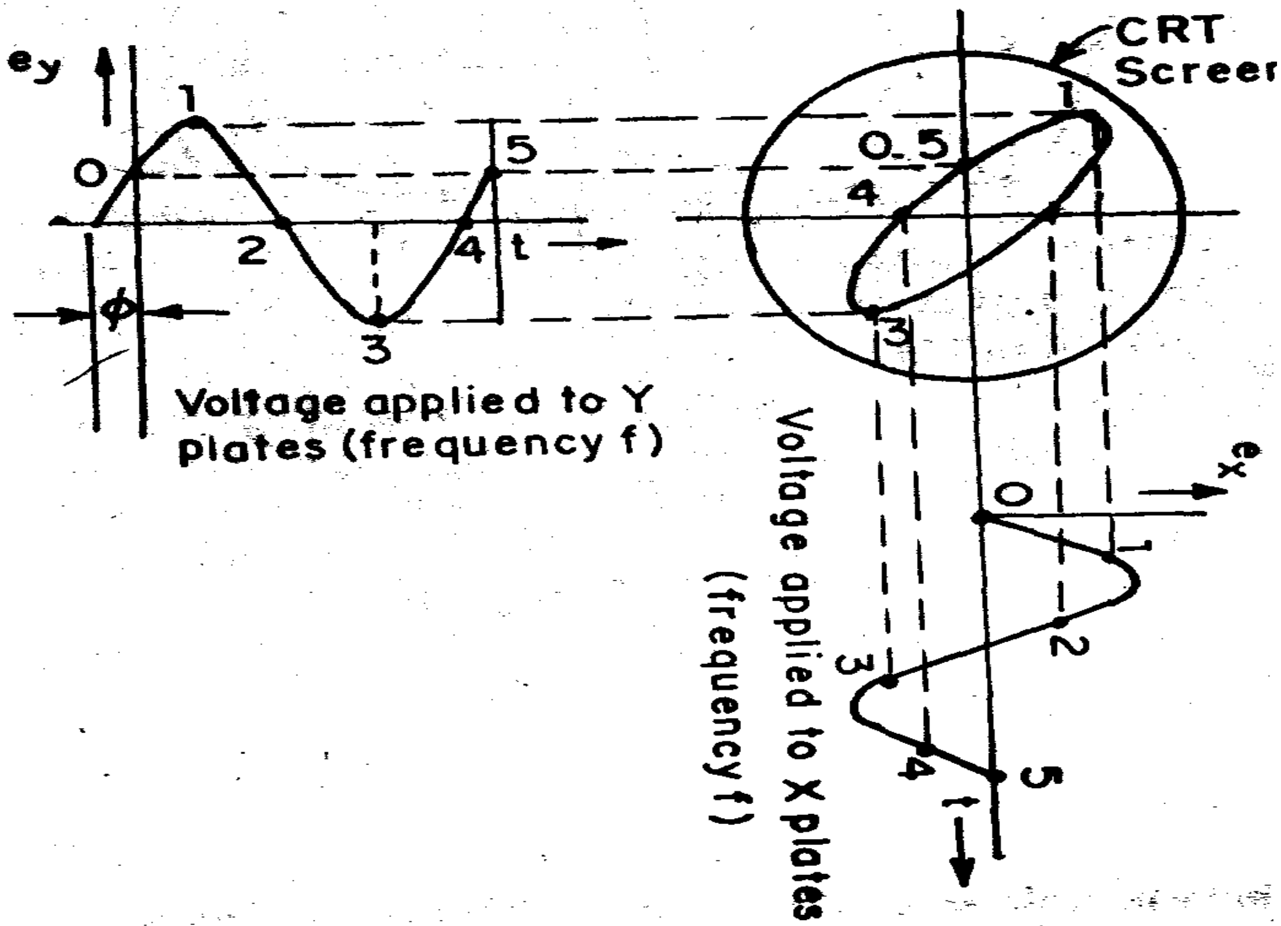
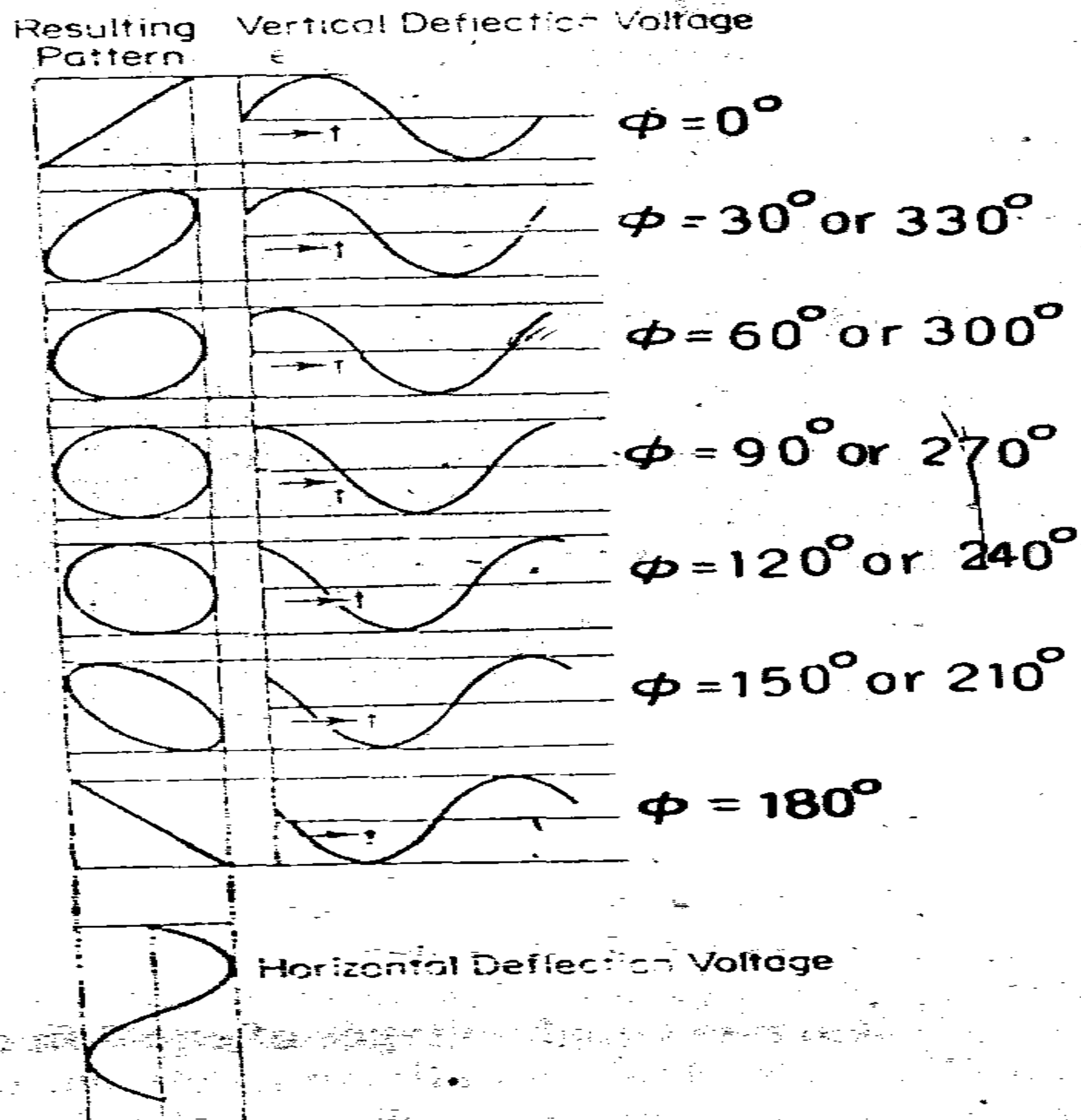


Fig. 21.31. Lissajous pattern with equal voltages of equal frequency and a phase shift of 90°.

Patterns with two equal voltages of same frequency & phase shift of Φ





Resulting Pattern
Vertical Deflection Voltage
$\phi = 0^\circ$
$\phi = 30^\circ$ or 330°
$\phi = 60^\circ$ or 300°
$\phi = 90^\circ$ or 270°
$\phi = 120^\circ$ or 240°
$\phi = 150^\circ$ or 210°
$\phi = 180^\circ$
Horizontal Deflection Voltage

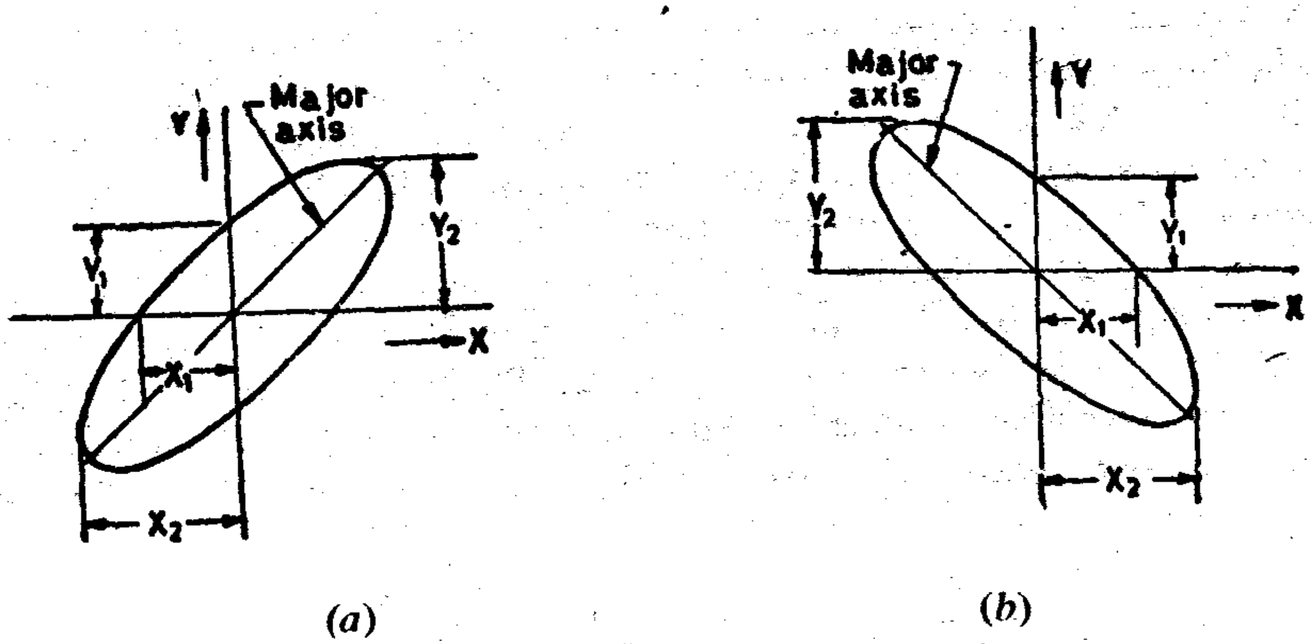
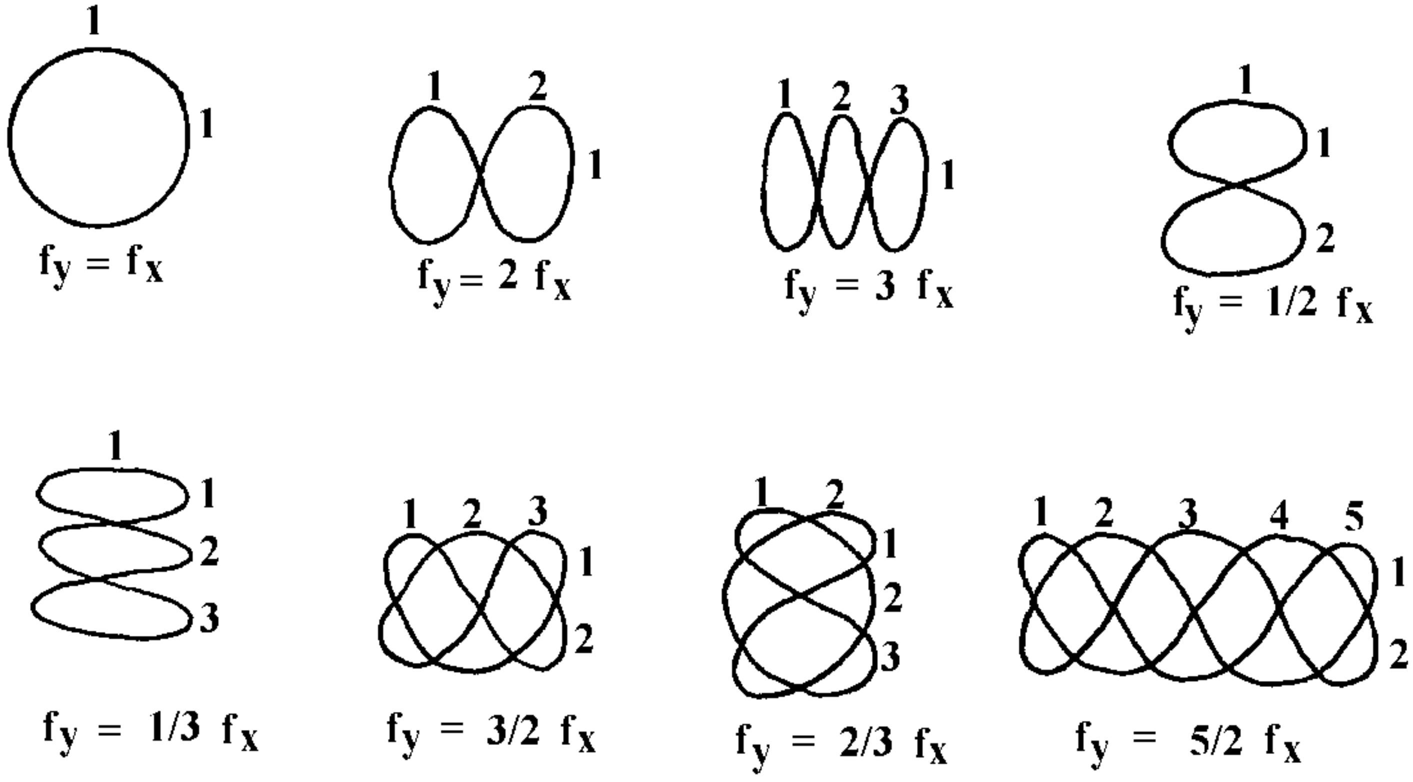


Fig. 21.34. Determination of angle of phase shift.

SinΦ= Y1/Y2 or X1/X2

Lissajous' Figures

Same amplitude but different frequencies



$$\frac{f_y}{f_x} = \frac{\text{number of times tangent touches top or bottom}}{\text{number of times tangent touches either side}}$$

$$= \frac{\text{number of horizontal tangencies}}{\text{number of vertical tangencies}}$$

where f_y = frequency of signal applied to Y plates,

and f_x = frequency of signal applied to X plates.

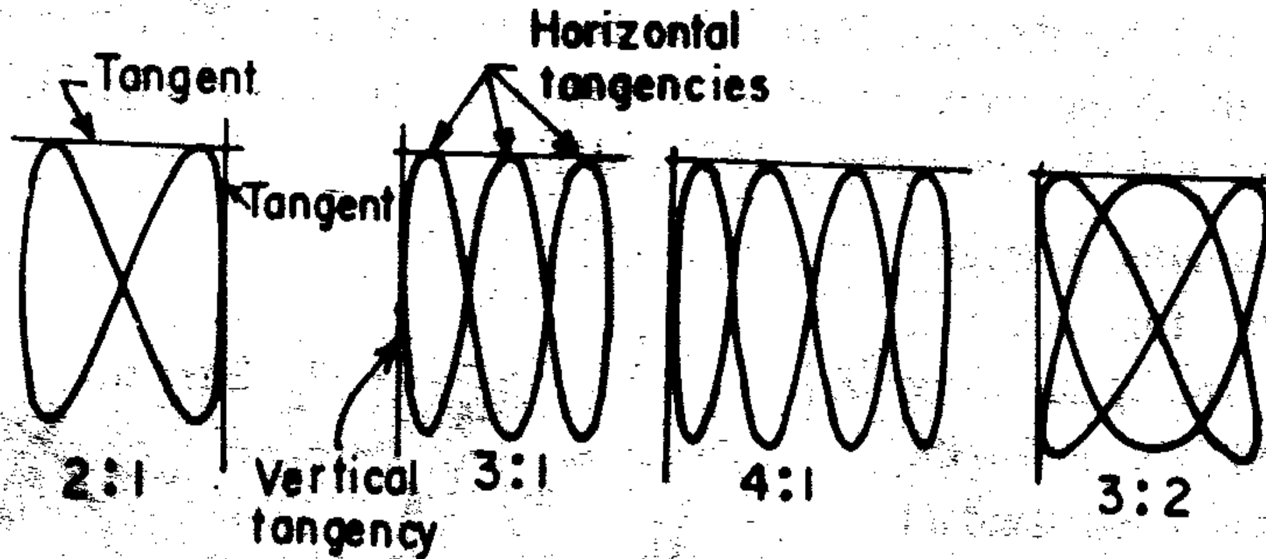
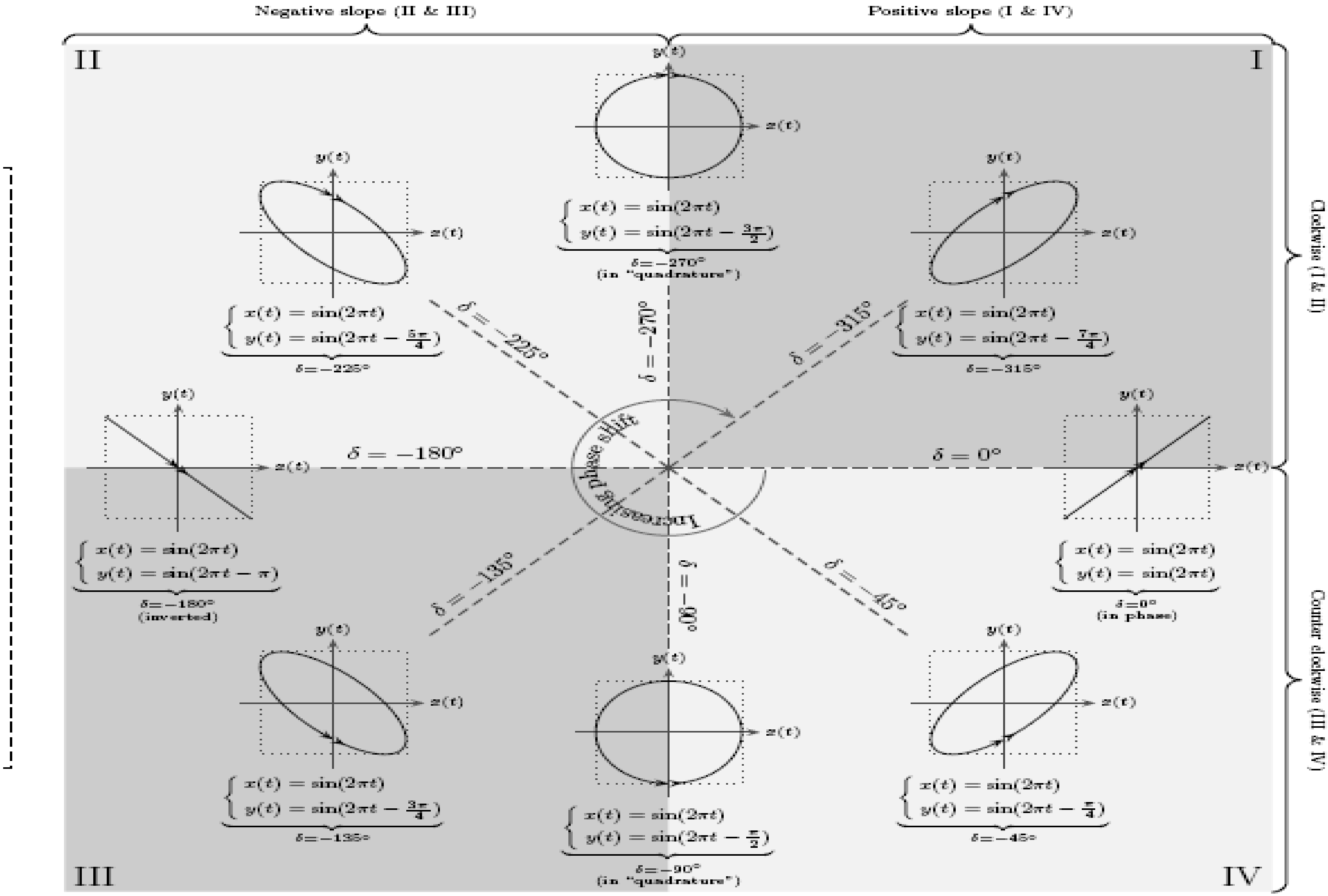
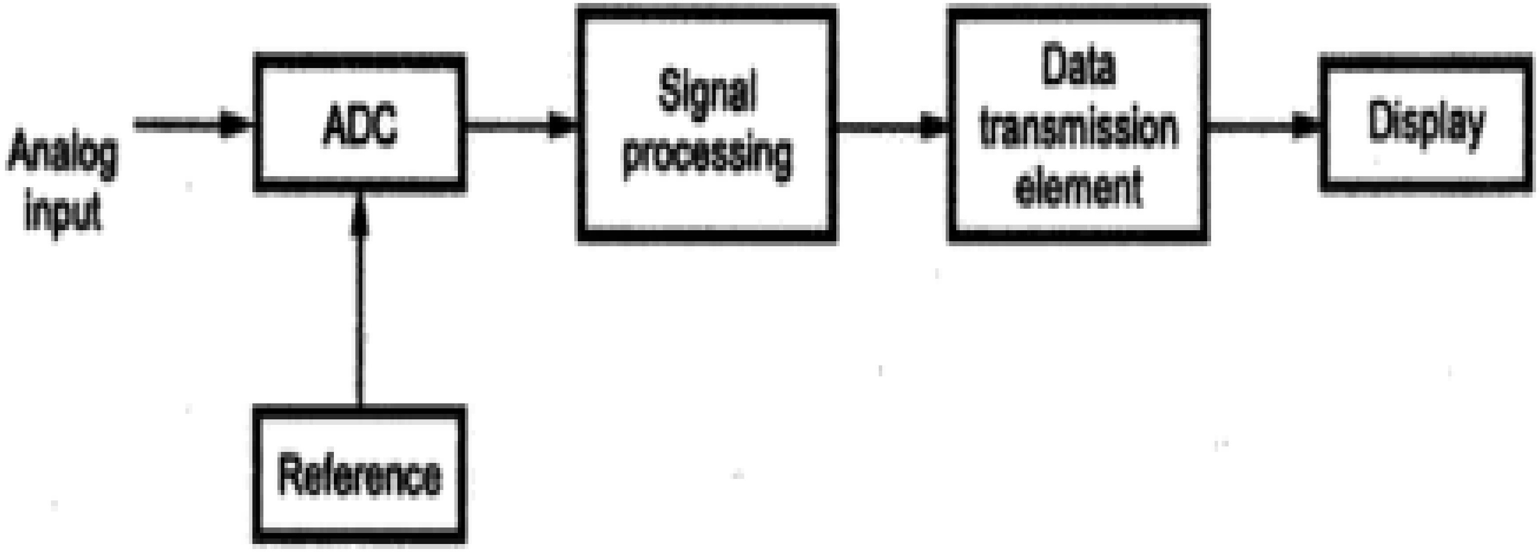


Fig. 21.36. Lissajous patterns with different frequency ratios.



Negative slope (II & III)
Positive slope (I & IV)
II
I
III
IV
Clockwise (I & II)
Counter clockwise (III & IV)
Increasing phase shift
$\delta = -180°$
$\delta = 0°$
$\delta = -225°$
$\delta = -270°$
$\delta = -315°$
$\delta = -135°$
$\delta = -90°$
$\delta = -45°$
$x(t) = \sin(2\pi t)$, $y(t) = \sin(2\pi t - \frac{3\pi}{2})$
$\delta = -270°$ (in "quadrature")
$x(t) = \sin(2\pi t)$, $y(t) = \sin(2\pi t - \frac{5\pi}{4})$
$\delta = -225°$
$x(t) = \sin(2\pi t)$, $y(t) = \sin(2\pi t - \frac{7\pi}{4})$
$\delta = -315°$
$x(t) = \sin(2\pi t)$, $y(t) = \sin(2\pi t - \pi)$
$\delta = -180°$ (inverted)
$x(t) = \sin(2\pi t)$, $y(t) = \sin(2\pi t)$
$\delta = 0°$ (in phase)
$x(t) = \sin(2\pi t)$, $y(t) = \sin(2\pi t - \frac{3\pi}{4})$
$\delta = -135°$
$x(t) = \sin(2\pi t)$, $y(t) = \sin(2\pi t - \frac{\pi}{2})$
$\delta = -90°$ (in "quadrature")
$x(t) = \sin(2\pi t)$, $y(t) = \sin(2\pi t - \frac{\pi}{4})$
$\delta = -45°$

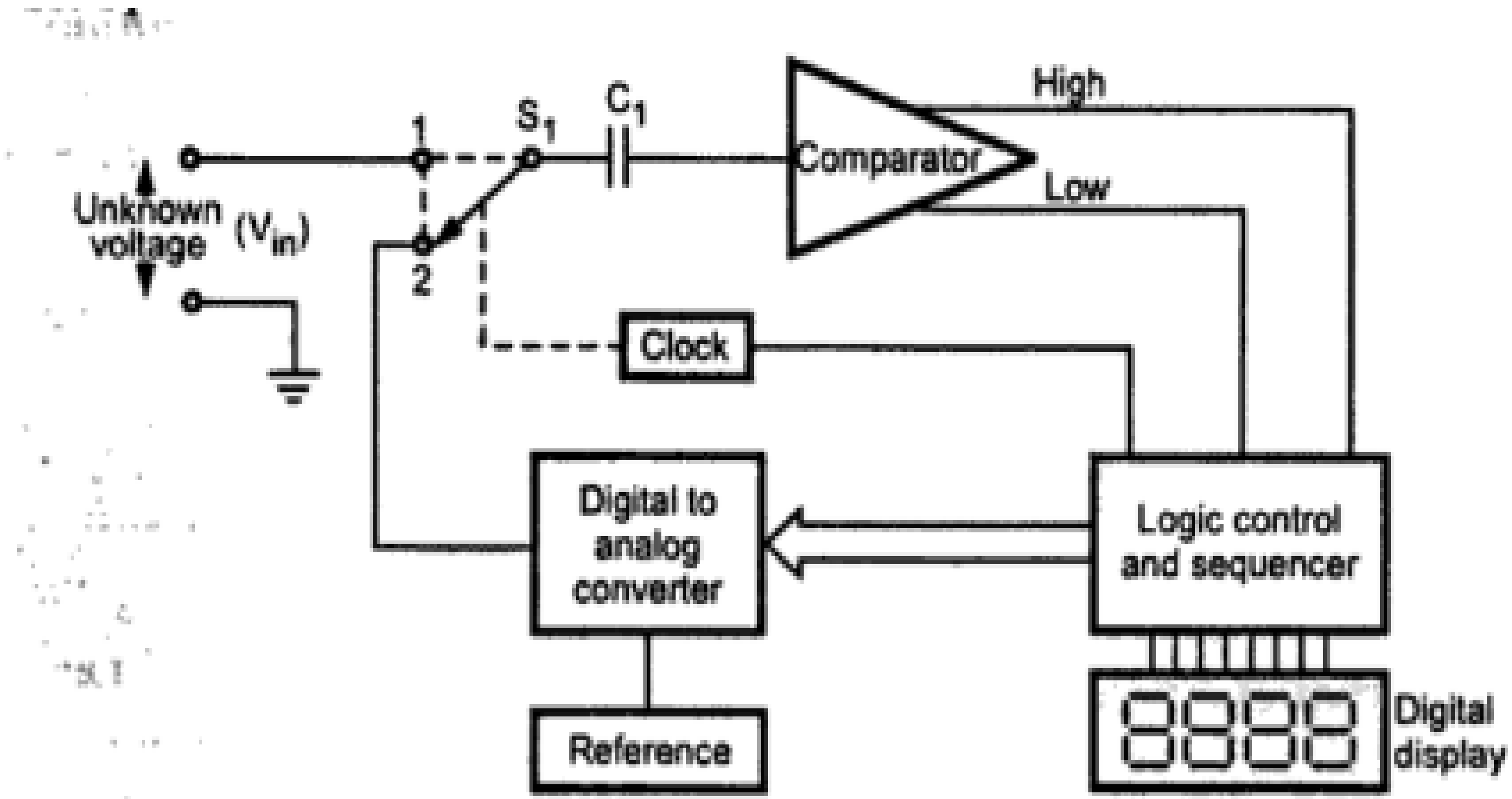
Digital Volt Meters



Classification of DVM's

- ❖ Non-Integrating Type
  - o Potentiometric Type
    - Servo Potentiometric Type
    - Successive Approximation Type
    - Null Balance Type
  - o Ramp Type
    - Linear Type
    - Staircase Type
- ❖ Integrating Type
  - Voltage to Frequency converter Type
  - Potentiometric Type
  - Dual Slope Integrating Type

Successive Approximation type DVM



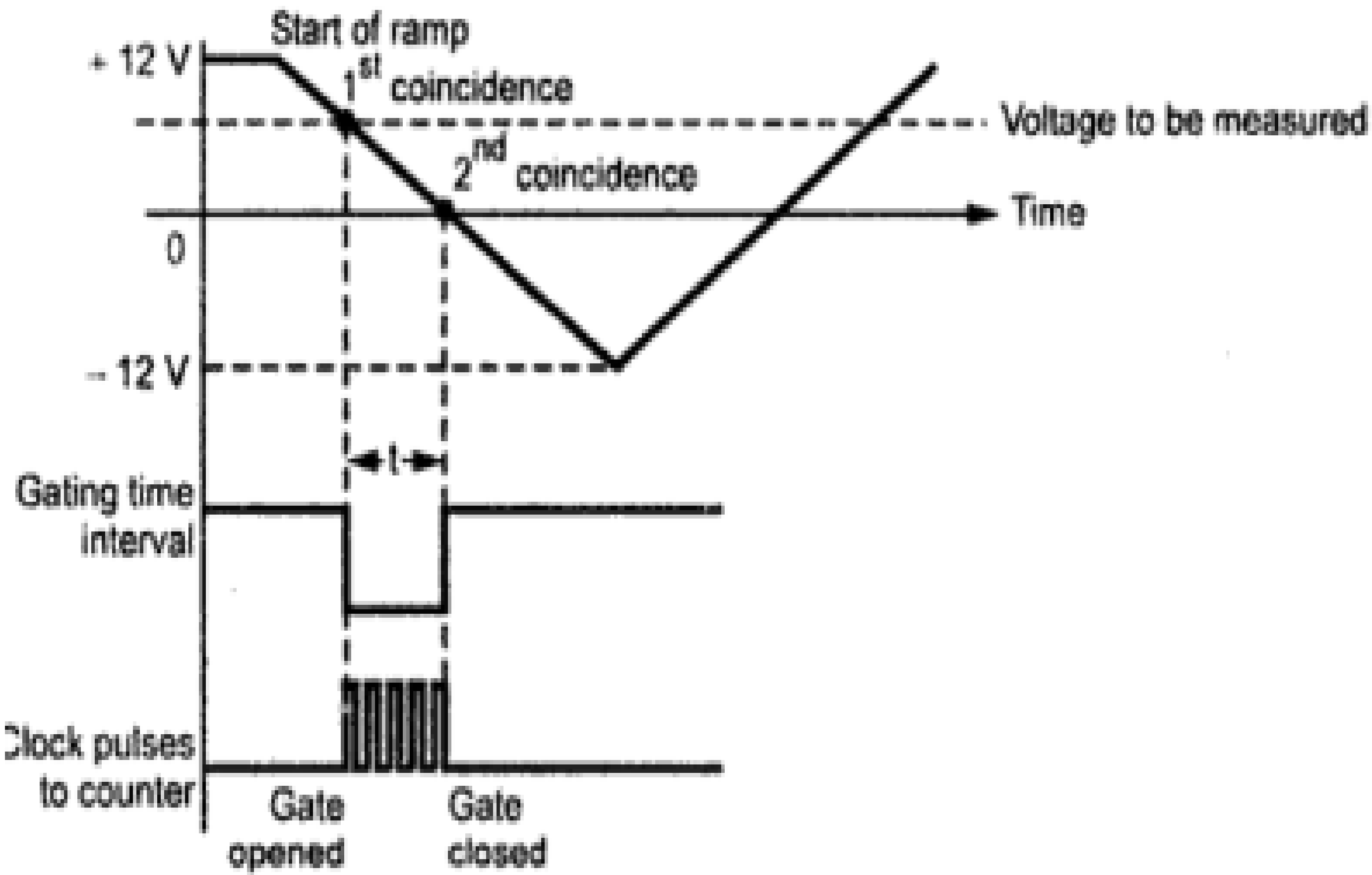
Advantages

1. Very high speed of the order of 100 readings per second possible.
2. The method of ADC is inexpensive.
3. The resolution upto 5 significant digits is possible.
4. The accuracy is high.

Disadvantages

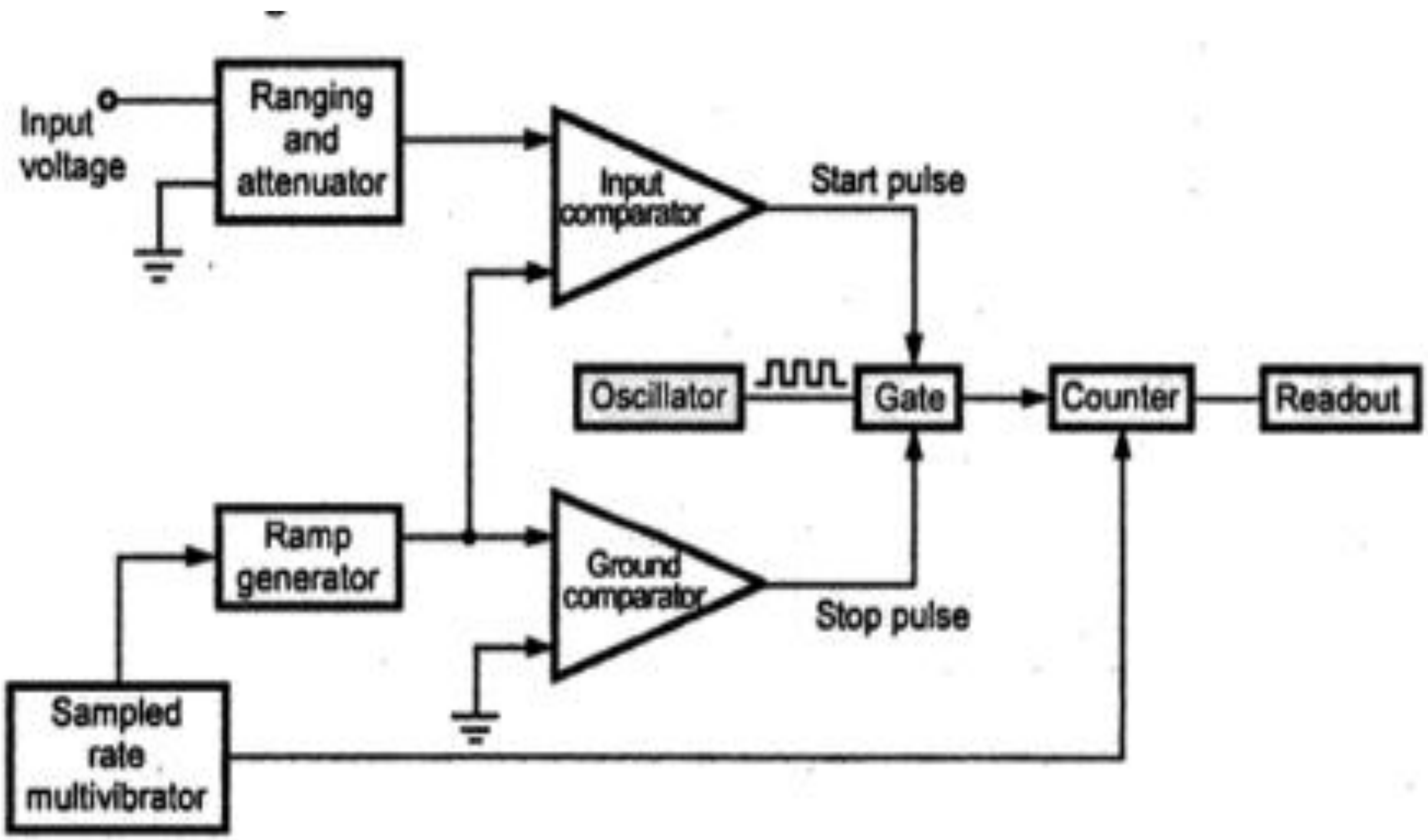
1. The circuit is complex.
2. The DAC is also required.
3. The input impedance is variable.
4. The noise can cause error due to incorrect decisions made by comparator.

Ramp type



Start of ramp
+12 V
1st coincidence
Voltage to be measured
2nd coincidence
Time
0
−12 V
t
Gating time interval
Clock pulses to counter
Gate opened
Gate closed

Block Diagram of Ramp type DVM



Advantages

i) The circuit is easy to design.

ii) The cost is low.

iii) The output pulse can be transferred over long feeder lines without loss of information.

iv) The input signal is converted to time, which is easy to digitise.

v) By adding external logic, the polarity of the input also can be displayed.

vi) The resolution of the readout is directly proportional to the frequency of the local oscillator. So adjusting the frequency of the local oscillator, better resolution can be obtained.

Disadvantages

i) The ramp requires excellent characteristics regarding its linearity.

ii) The accuracy depends on slope of the ramp and stability of the local oscillator.

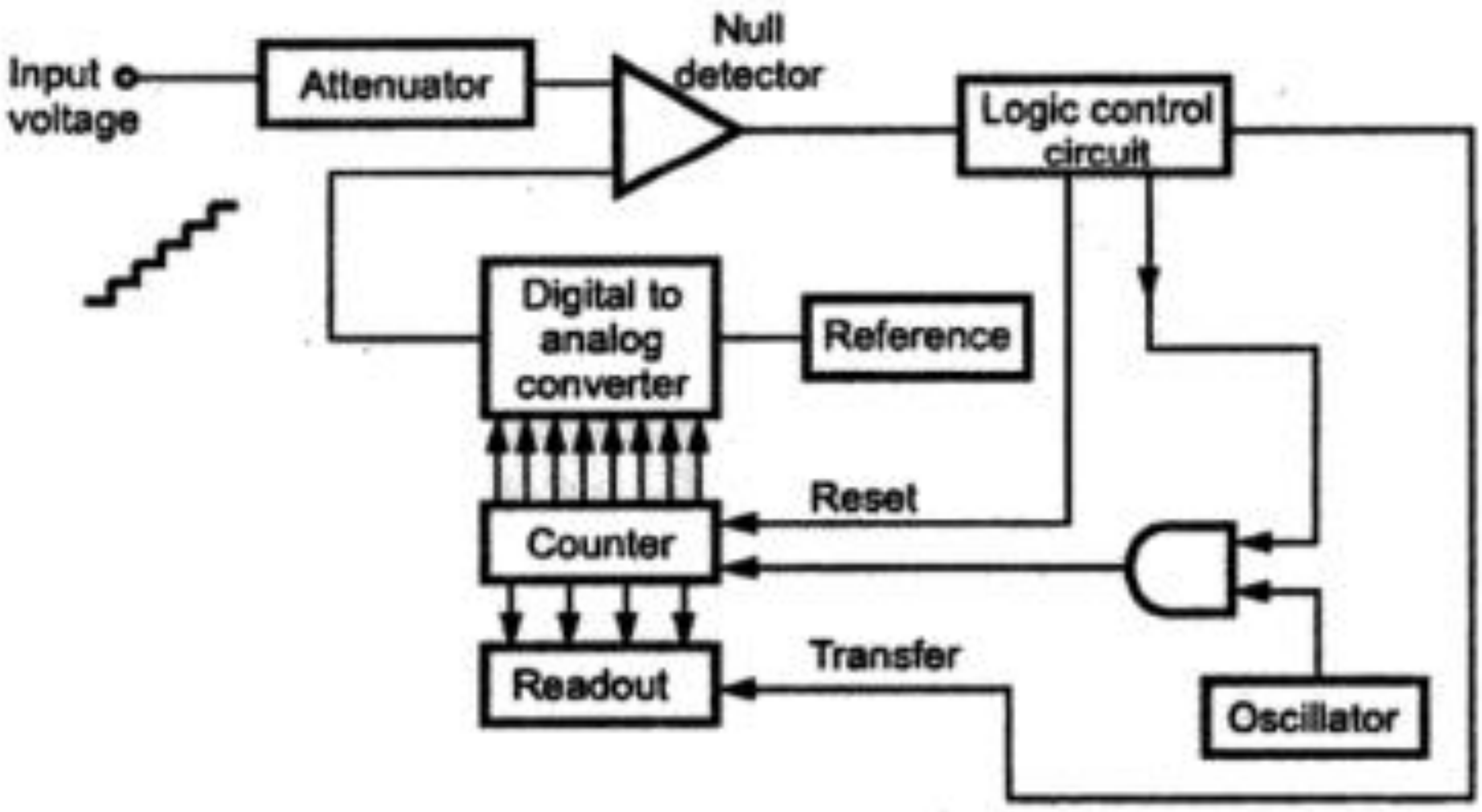
iii) Large errors are possible if noise is superimposed on the input signal.

iv) The offsets and drifts in the two comparators may cause errors.

v) The speed of measurement is low.

vi) The swing of the ramp is ± 12 V, this limits the base range of measurement to ± 10 V.

Stair case Ramp Type



Advantages

i) The greater accuracy is obtained than the linear ramp technique.

ii) The overall design is more simple hence economical.

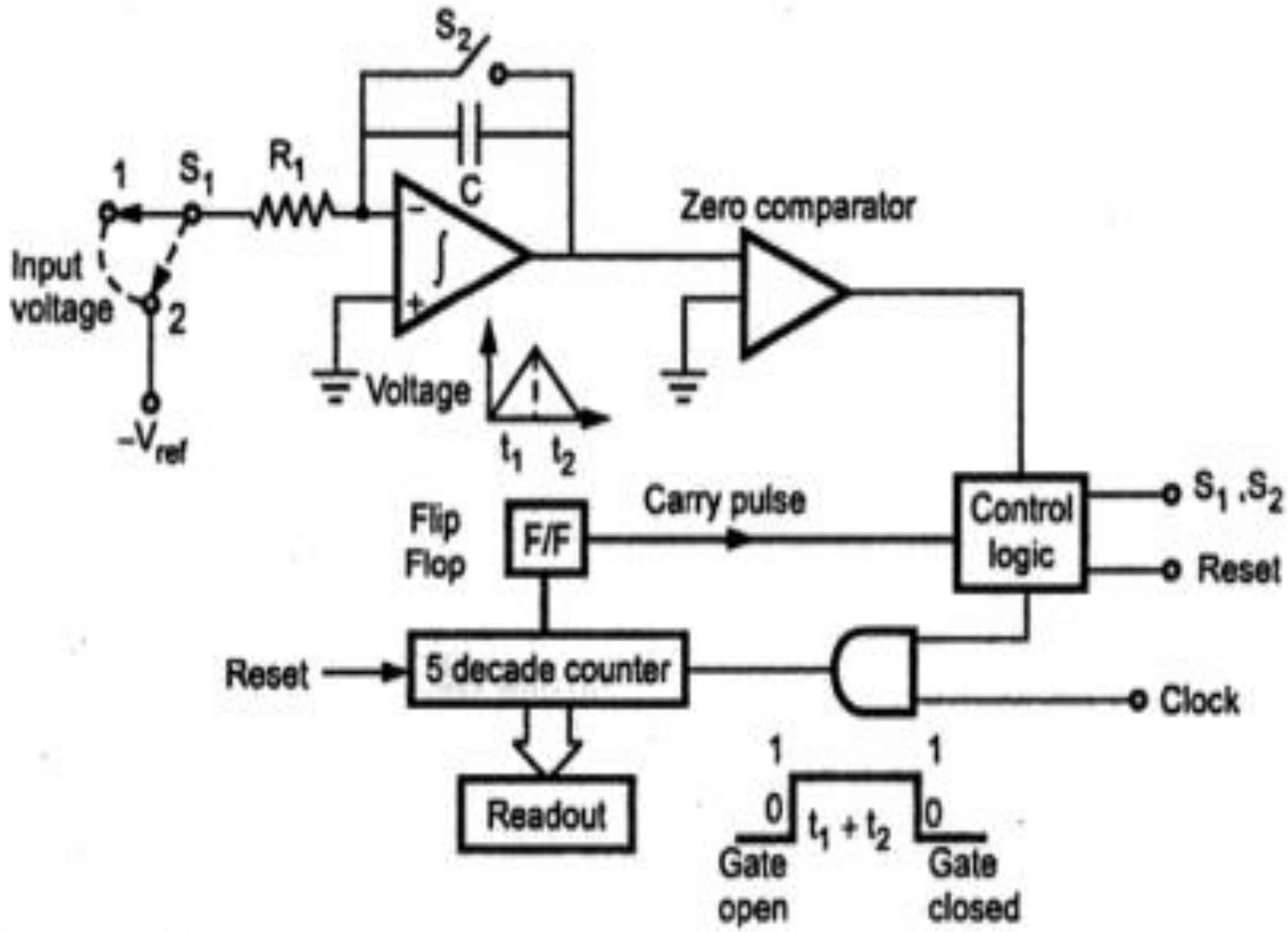
iii) The input impedance of the digital to analog converter is high when the compensation is reached.

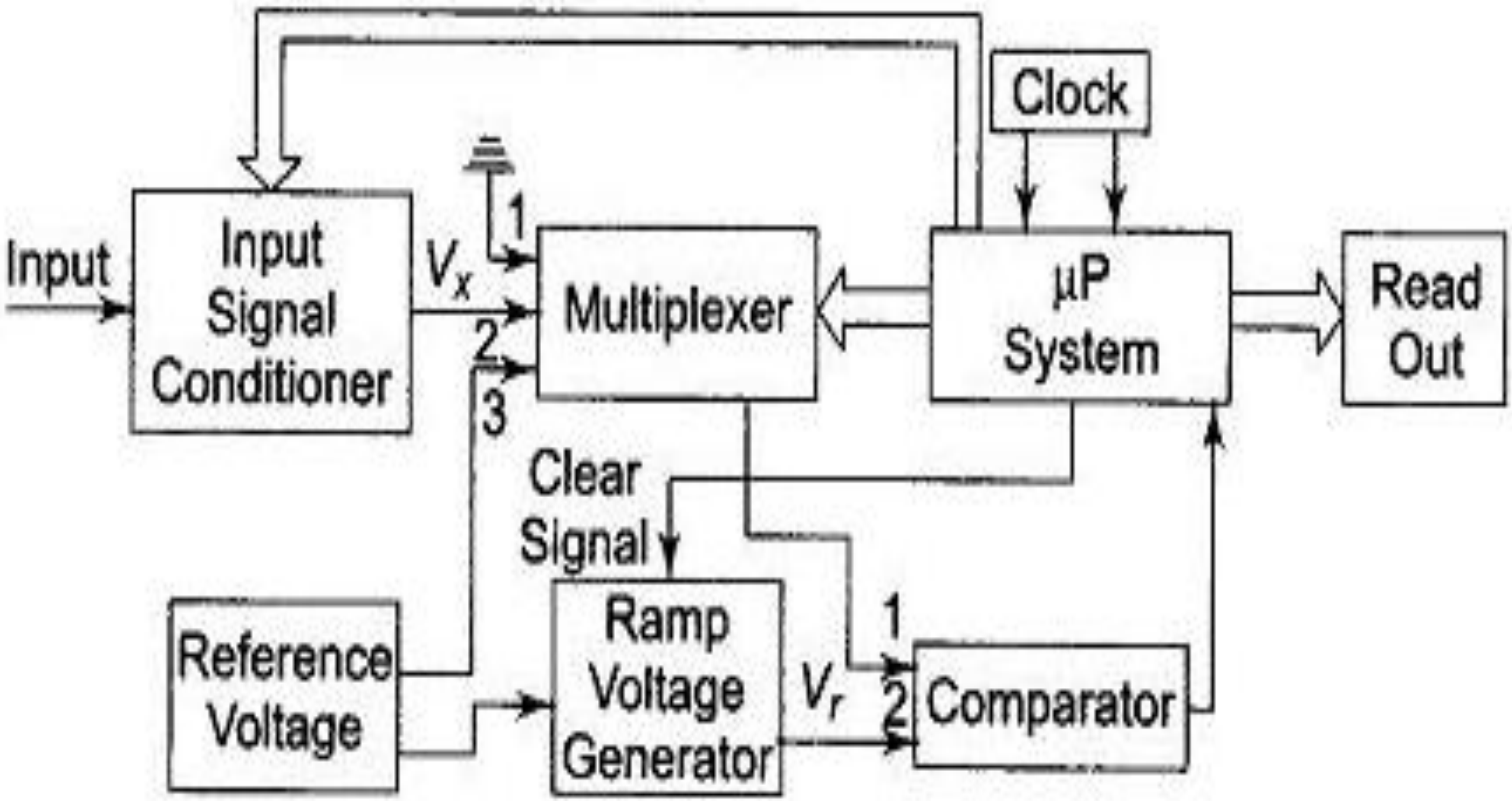
Disadvantages

i) Though accuracy is higher than linear ramp, it is dependent on the accuracy of digital to analog converter and its internal reference.

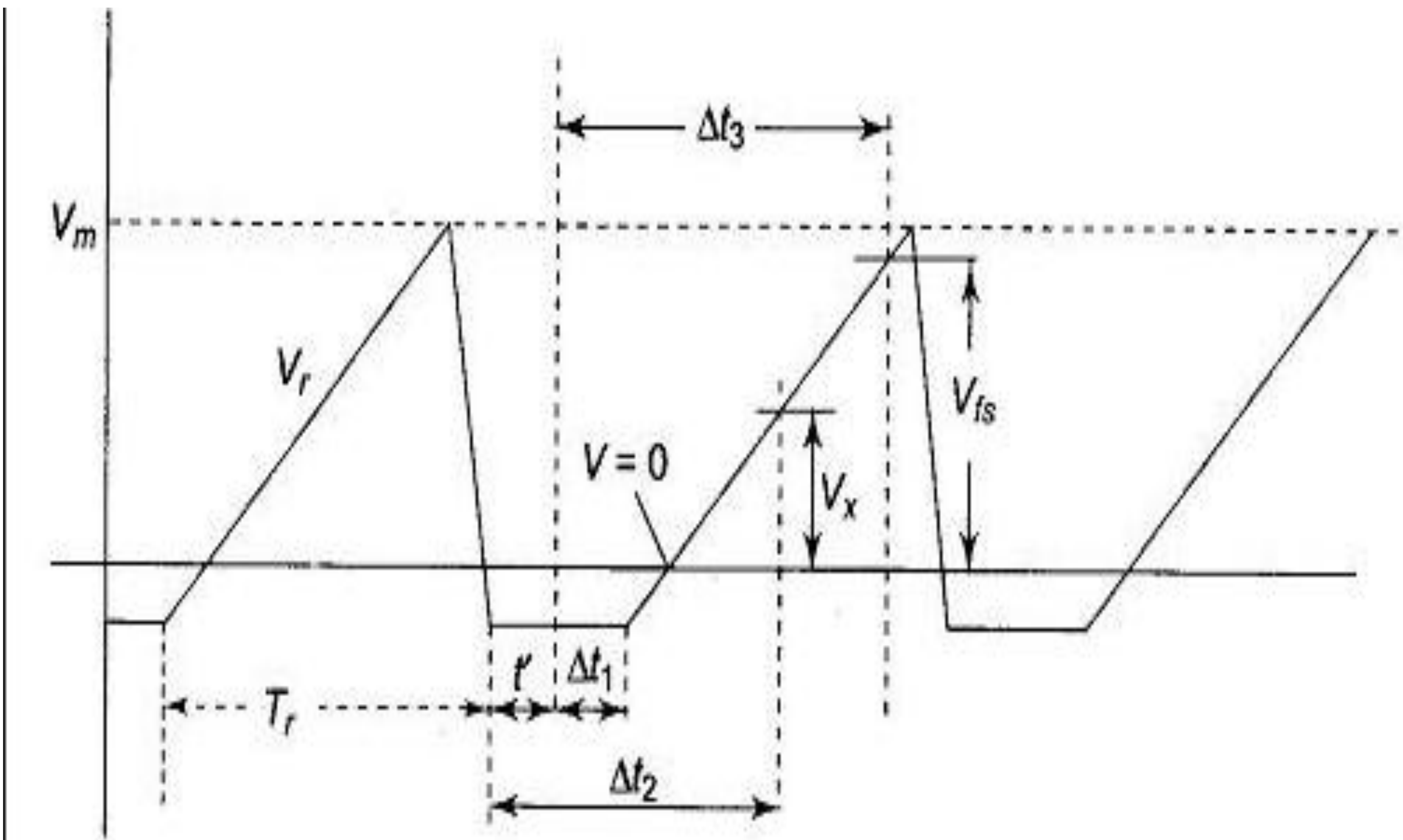
ii) The speed is limited upto 10 readings per second.

Dual Slope Integration Type DVM

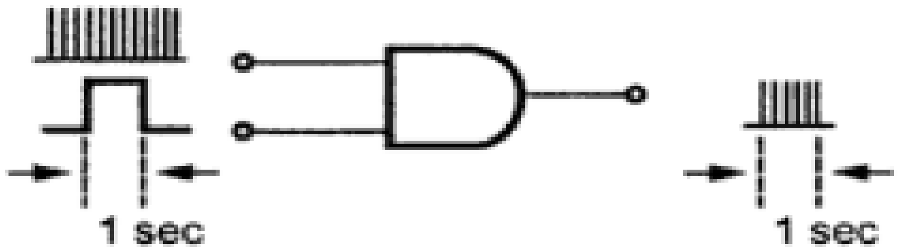




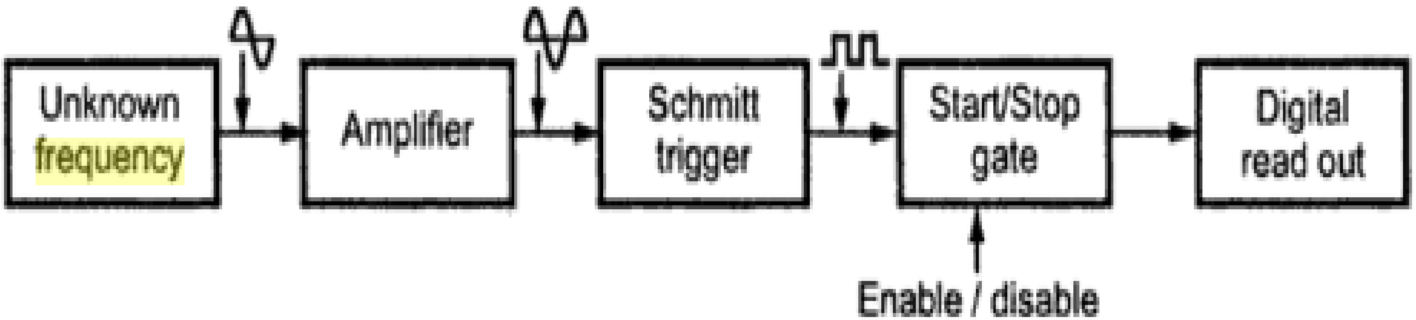
(a) Basic Block Diagram of a Microprocessor-based Ramp Type DVM



(b) Operating Waveform of a μp-based Ramp Type DVM

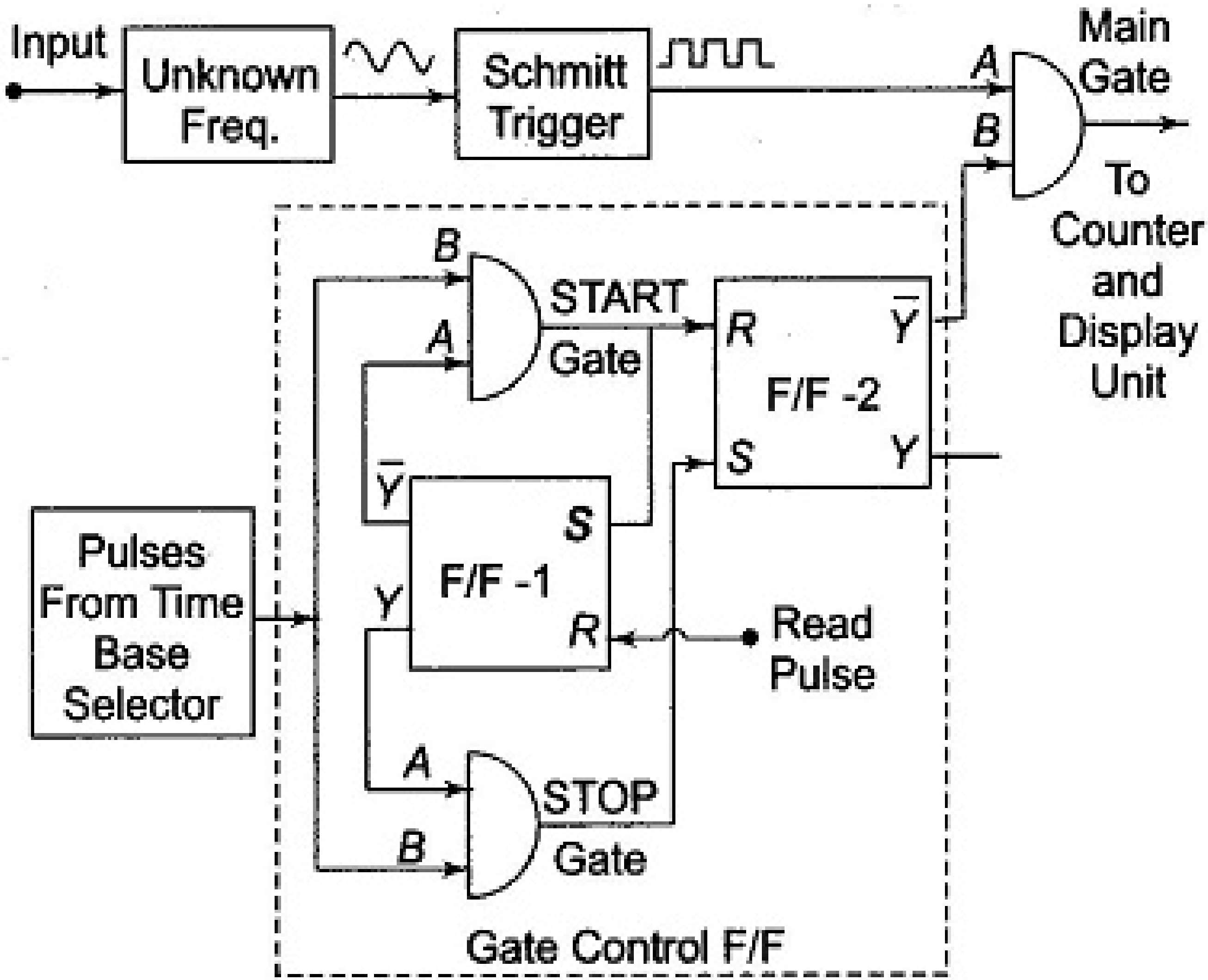


Principle of digital frequency measurement



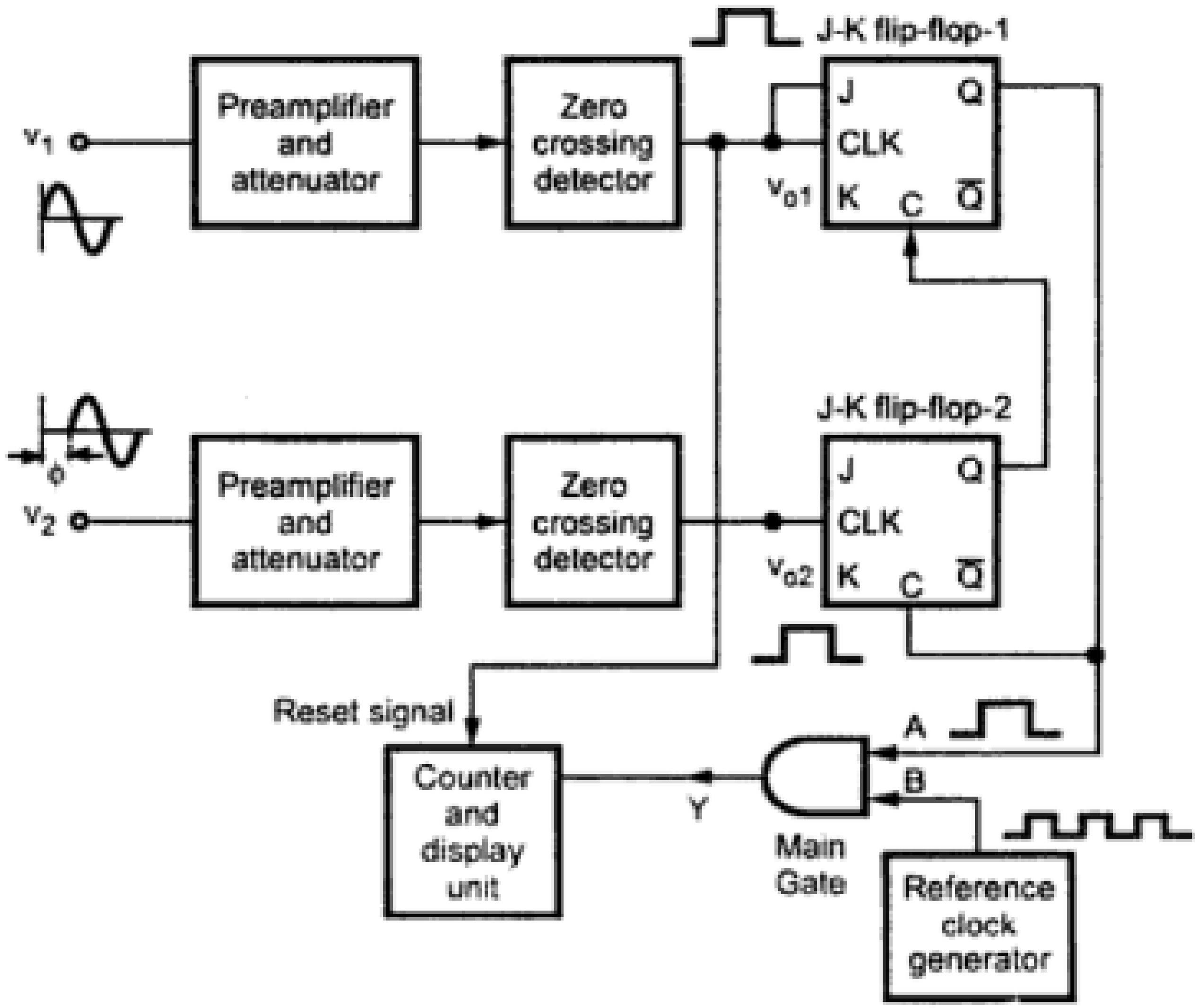
Block diagrm of digital frequency counter

Frequency Measurement



Basic Circuit for Measurement of Frequency Showing Gate Control F/F

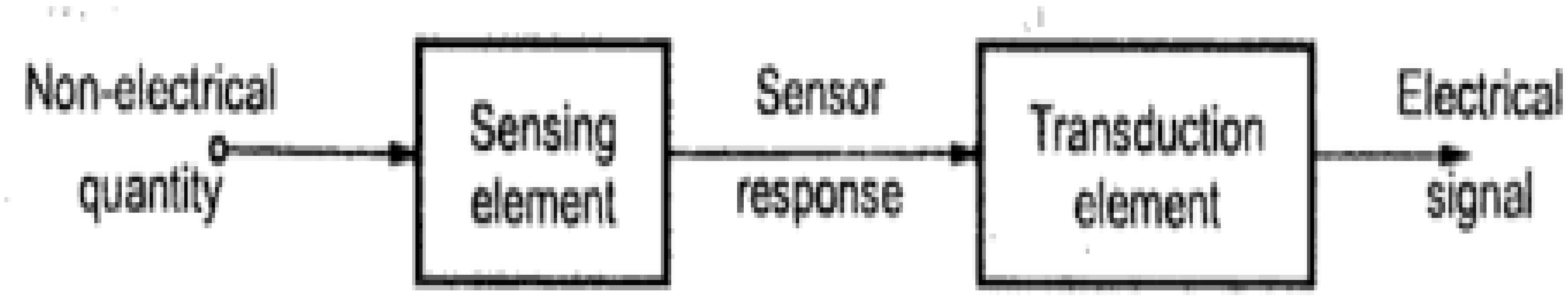
Phase Meter



Phase meter using flip-flops

Transducers

Block Diagram of Transducers



Transducer physical quantity → electrical Signal
Transduction Signal one form to another
Sensor produces a measurable response to a change in a physical condition

Classification

- Electrical

Active & Passive Transducers

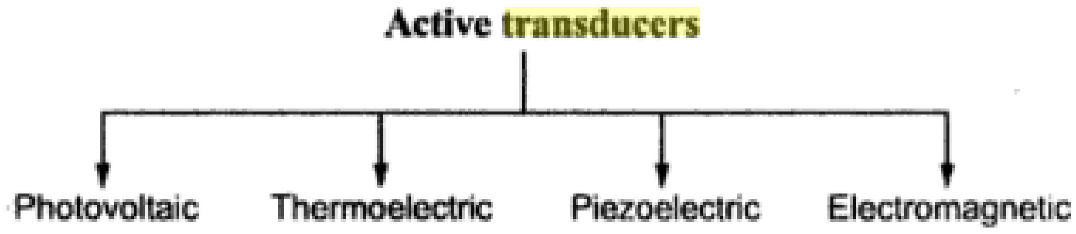
Analog & Digital Transducers

Primary & Secondary Transducers

Transducer & Inverse Transducers

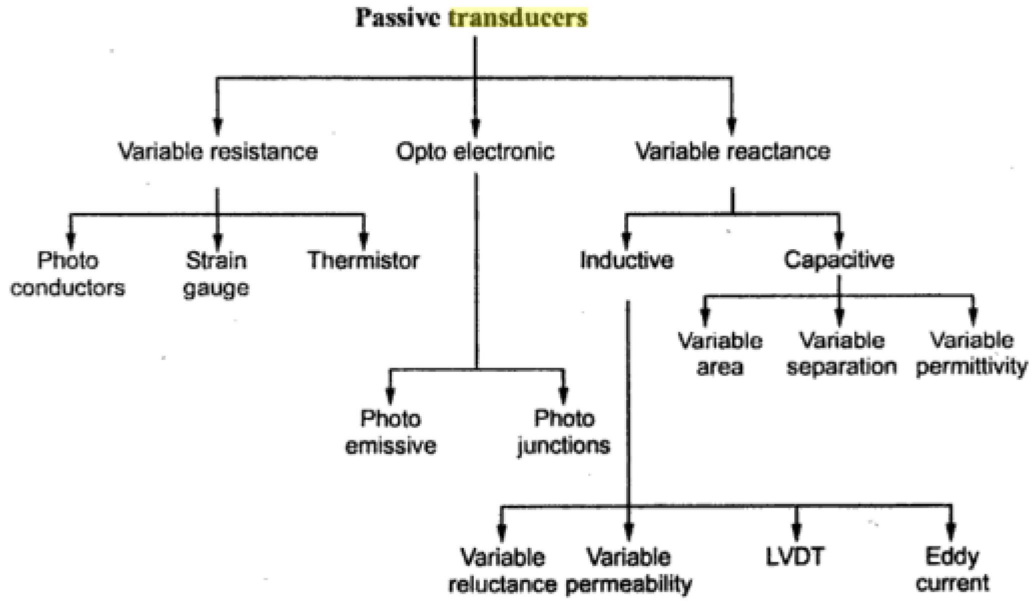
Based on Transduction Principle

- Mechanical



Active Transducers

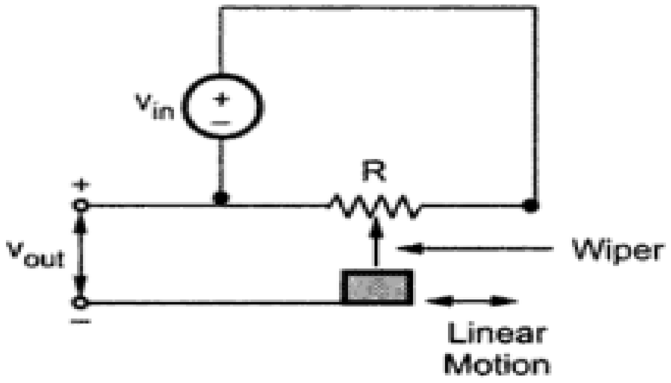
Passive Transducers



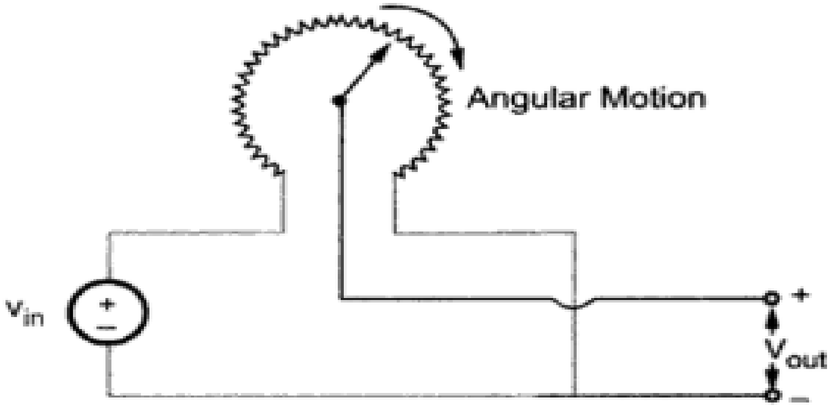
Based on Transduction Principle

- Capacitive Transduction
- Electromagnetic Transduction
- Inductive Transduction
- Piezoelectric Transduction
- Photovoltaic Transduction
- Photoconductive Transduction

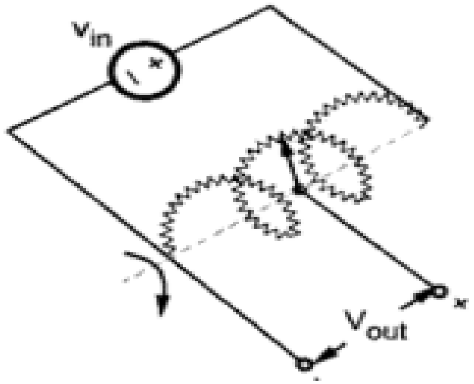
Resistive Transducers



(a) Linear vin



(b) Rotary



(c) Helipot

Inductive Transducers

- ❑Variation of Self inductance of coil
  - ▪ Change in no.of turns
  - ▪ Change in reluctance
  - ▪ Change in permeability
- ❑Variation of Mutual Inductance of coil
- ❑Production of eddy currents

Variation of Self inductance of coil

- Change in No.of turns
- Change in reluctance
- Change in permeability

$$L = \frac{N^2}{S}$$

where, N = Number of the coil

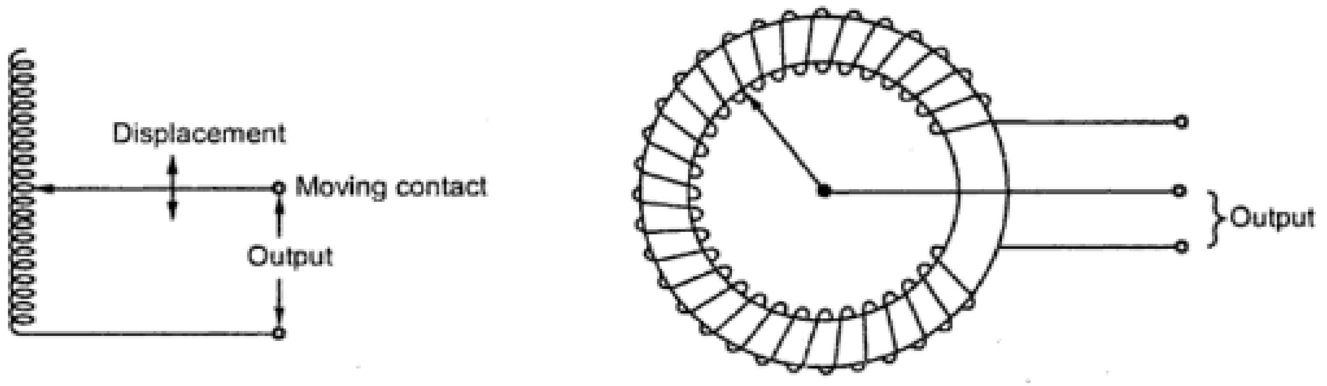
S = Reluctance of the coil (A/Wb)

But the reluctance S is given by

$$S = \frac{l}{\mu a}$$

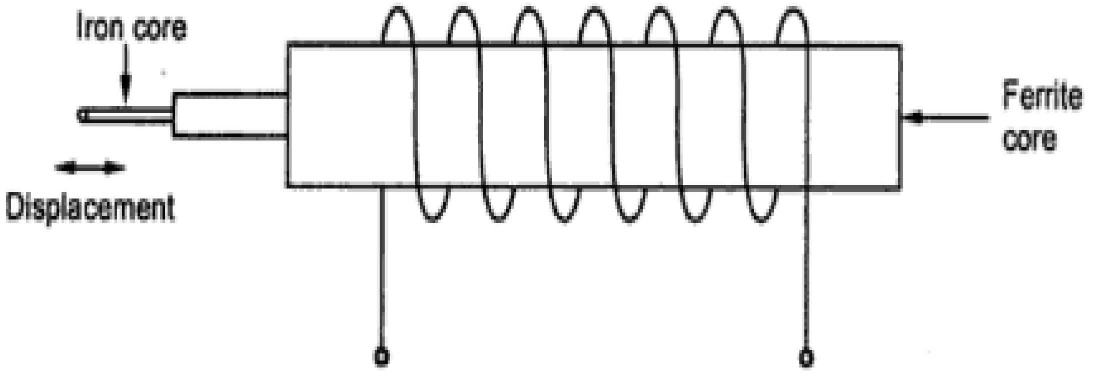
Hence self inductance L is given by,

$$L = \frac{N^2 \mu a}{l}$$

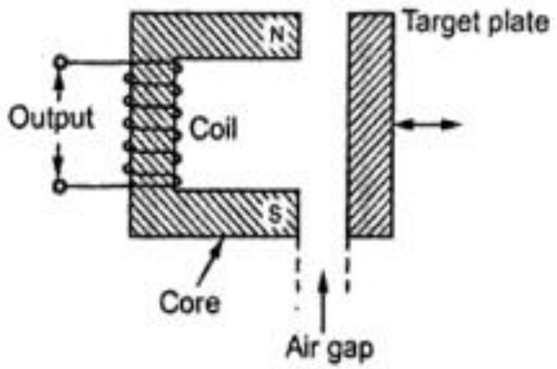


(a) Linear displacement (b) Angular displacement

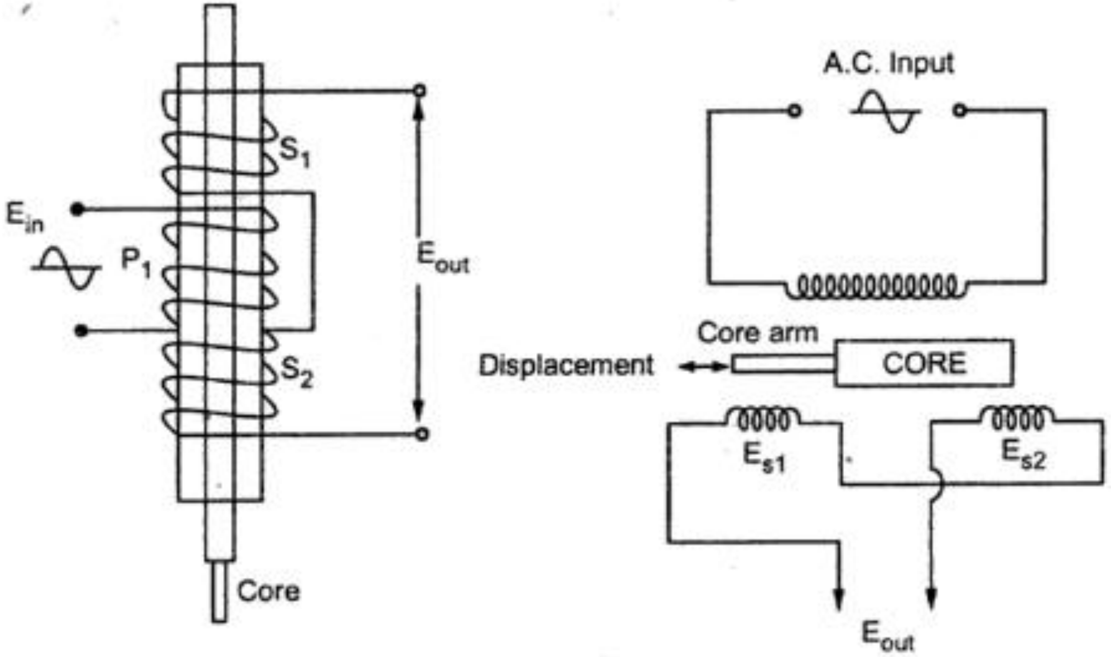
Inductive transducer based on change in self inductance



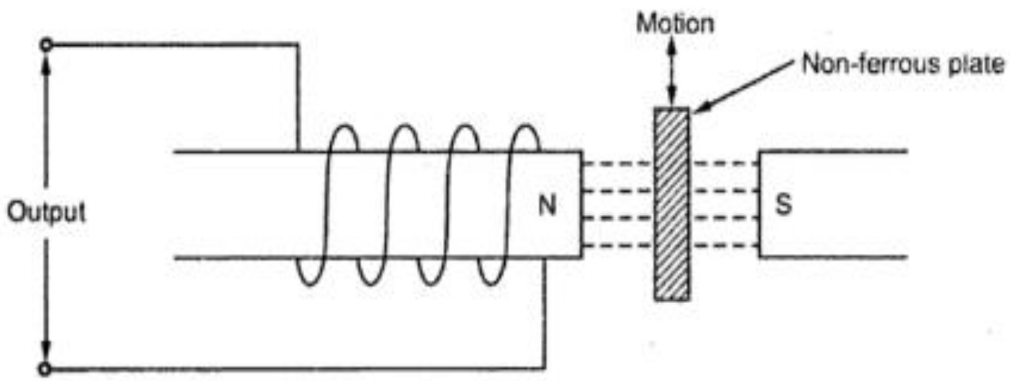
Variable permeability inductive transducer



Variable reluctance inductive transducer

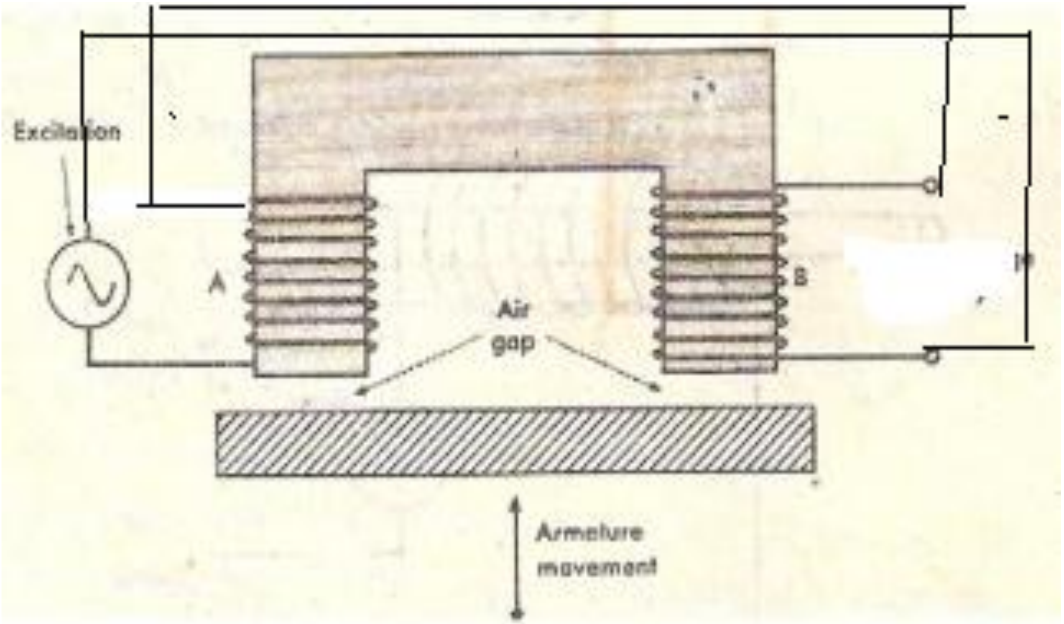


Linear variable differential transformer

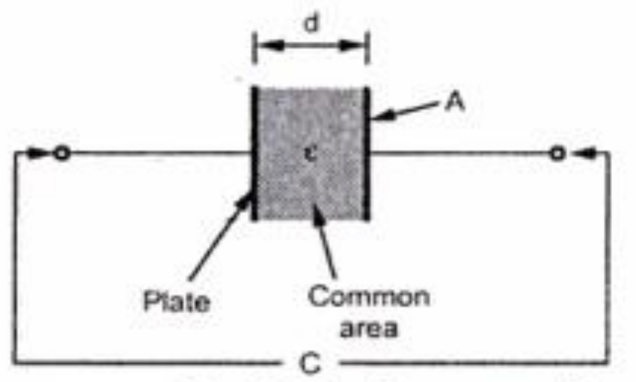


Eddy current type inductive transducer

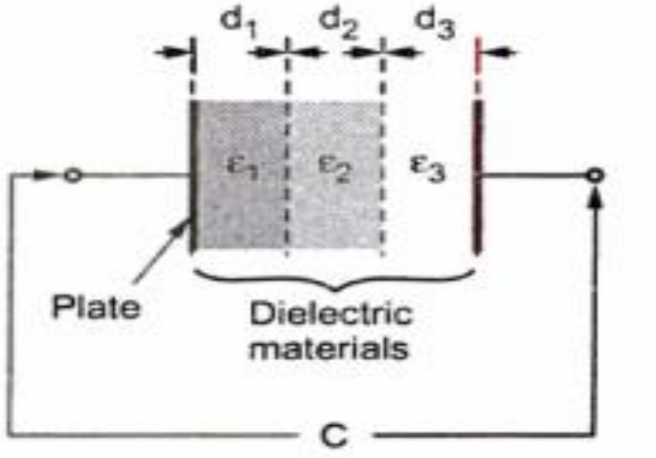
Transducer based on mutual inductance variation



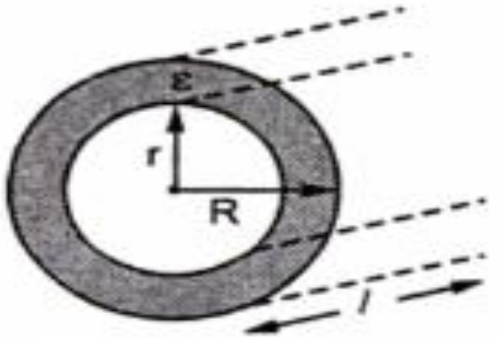
Capacitive Transducers



Parallel plate capacitor

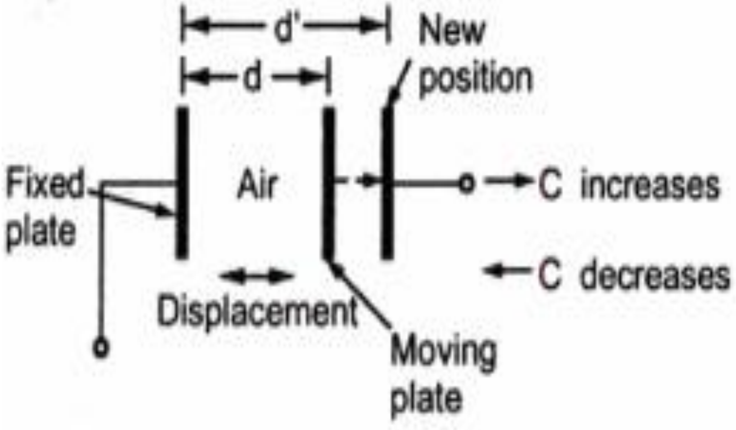


Composite capacitor

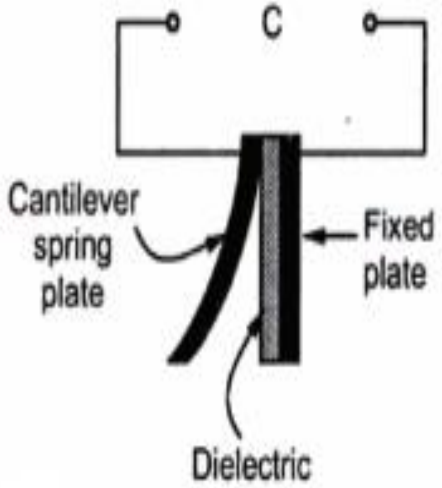


Cylindrical capacitance

Capacitive Transducers based on Change in Distance Between plates

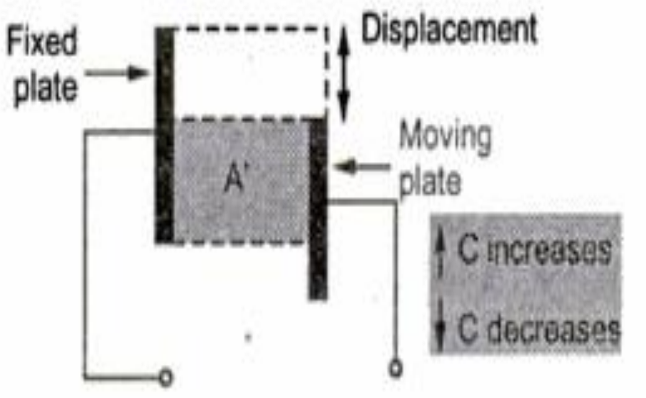


(a) Change in separation

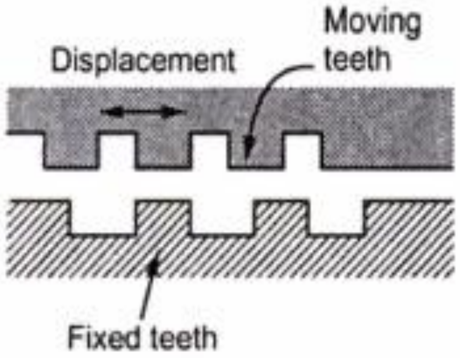


Use of cantilever spring plate

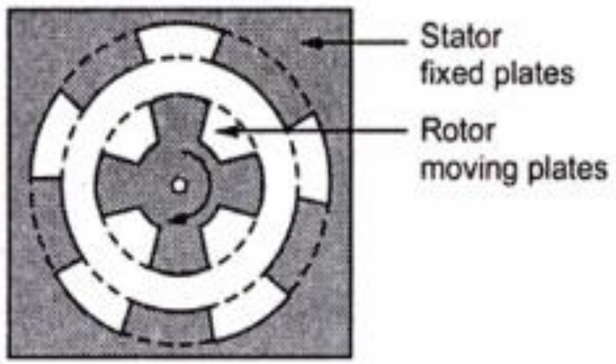
Capacitive Transducers based on Change in Area Between plates



Change in common plate area

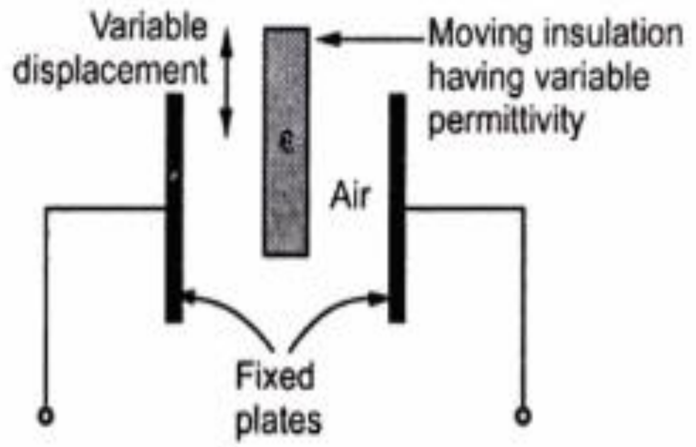


(a) Change in area



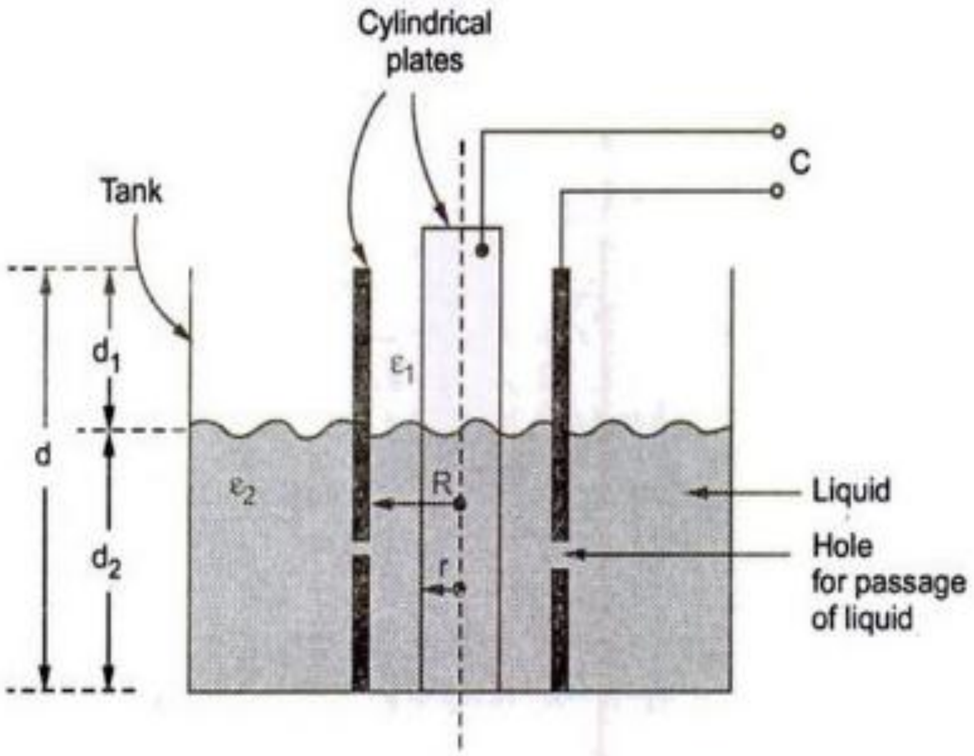
(b) Measurement of angular displacement

Capacitive Transducer based on change in dielectric



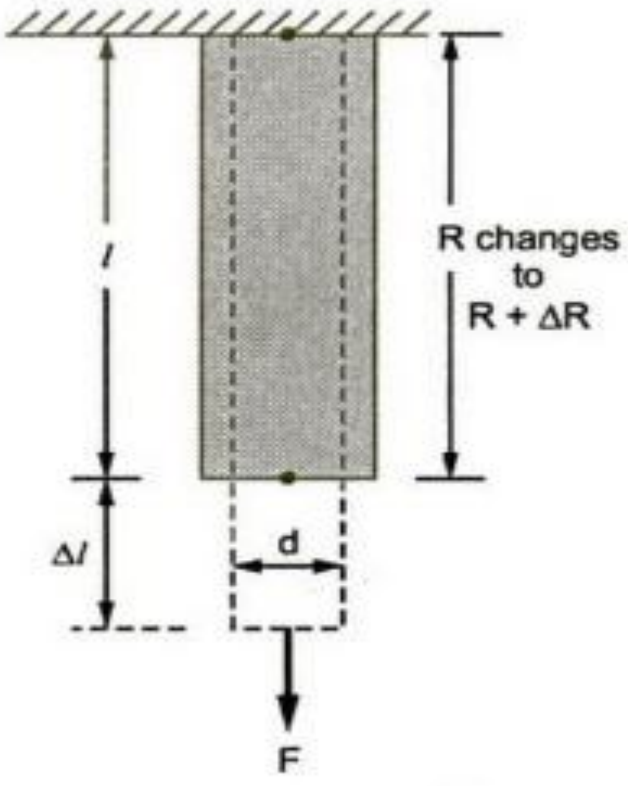
Change in dielectric

Capacitive Level Meter



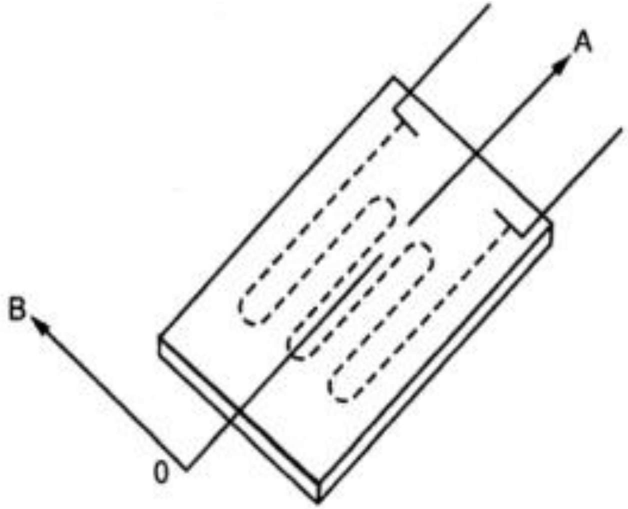
Capacitance type level meter

Strain Gauge-Gauge Factor

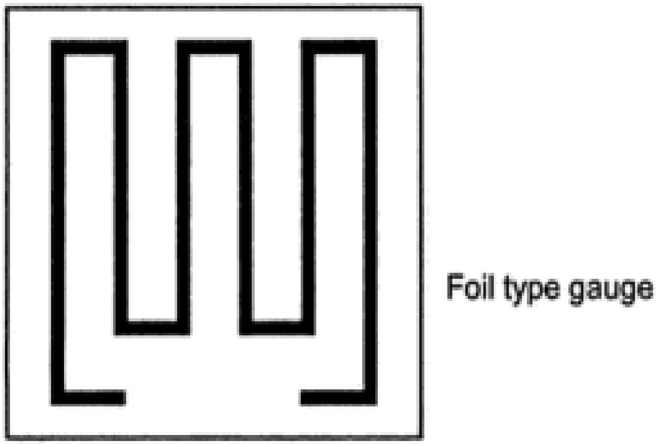


Deformed resistance wire

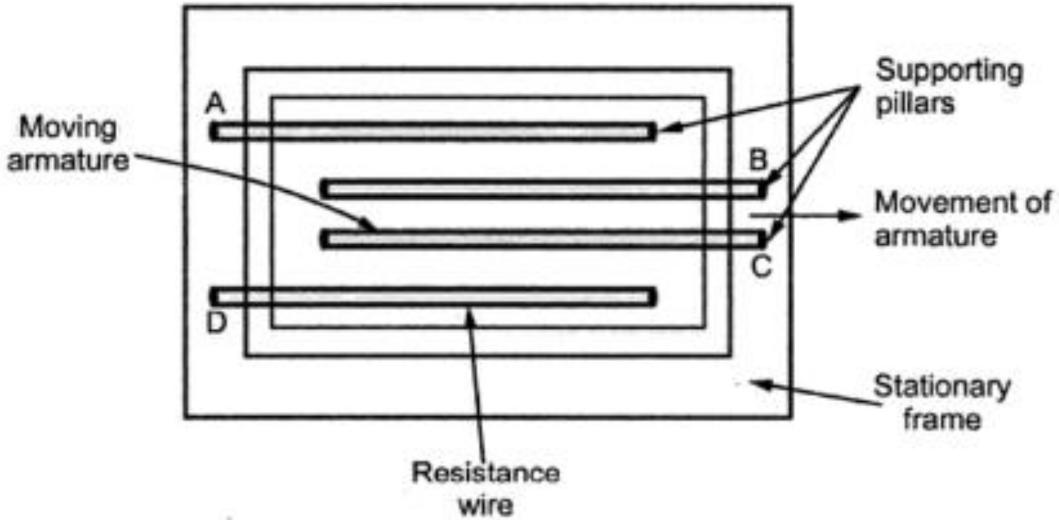
Resistance Wire Strain Gauges



Bonded type strain gauges



Foil strain gauge

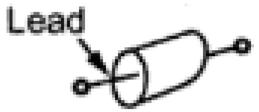


Unbonded strain gauge

Thermistors

(a) Disc

(b) Probe



(c) Bead type

(d) Rod

(e) Washer type

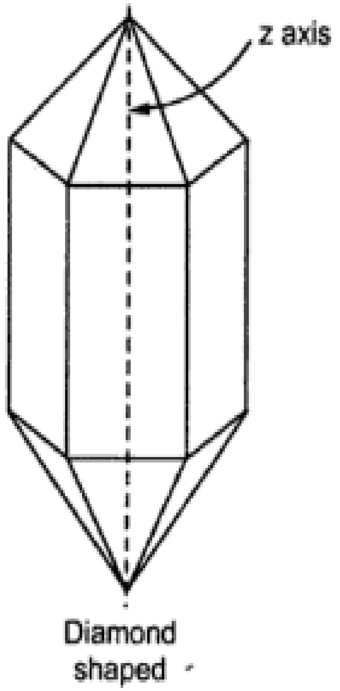
Thermocouple

Material used	Types of Thermocouple	Temperature range
Copper-constantan	T	– 250°C to 400°C
Iron-constantan	J	–200°C to 850°C
Chromel-Alumel	K	–200°C to 110°C
Chramel-constantan	E	–200°C to 850°C
Platinum-platinum-rhodium	S	0°C to 1400°C
Tungston-Molybdenum	–	0°C to 2700°C
Tungston-Rhenium	–	0°C to 2600°C

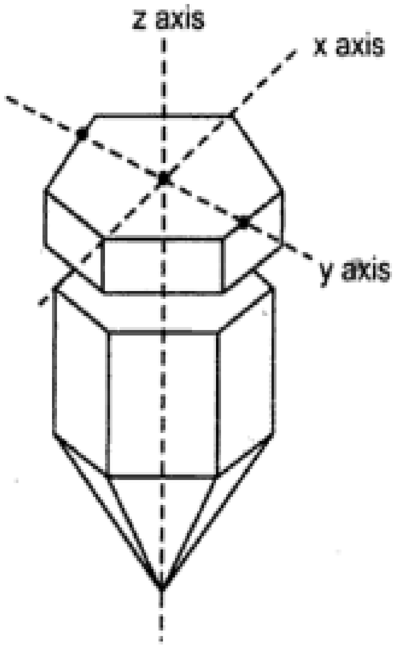
Thermocouples and temperature ranges

Insulating material	Temperature limit
Enamel and cotton	250°F
Asbestos	900°F
Glass	900°F
Ceramic Insulators	2600°F

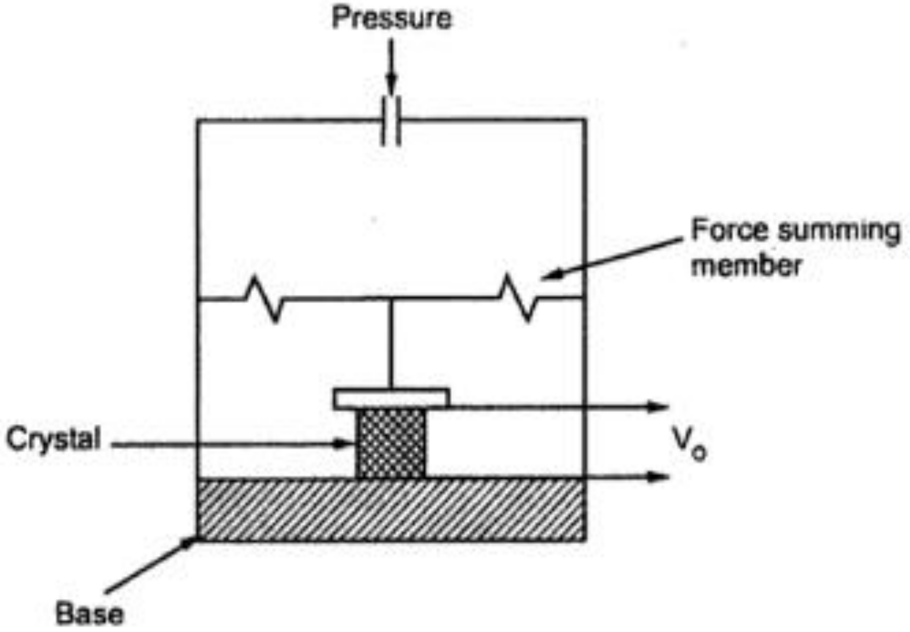
Piezo electric Transducers



(a) Quartz crystal

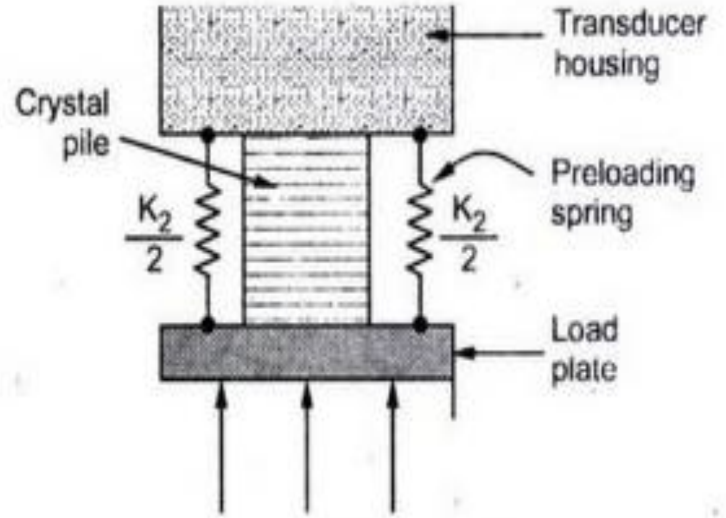


(b) Axes of crystal

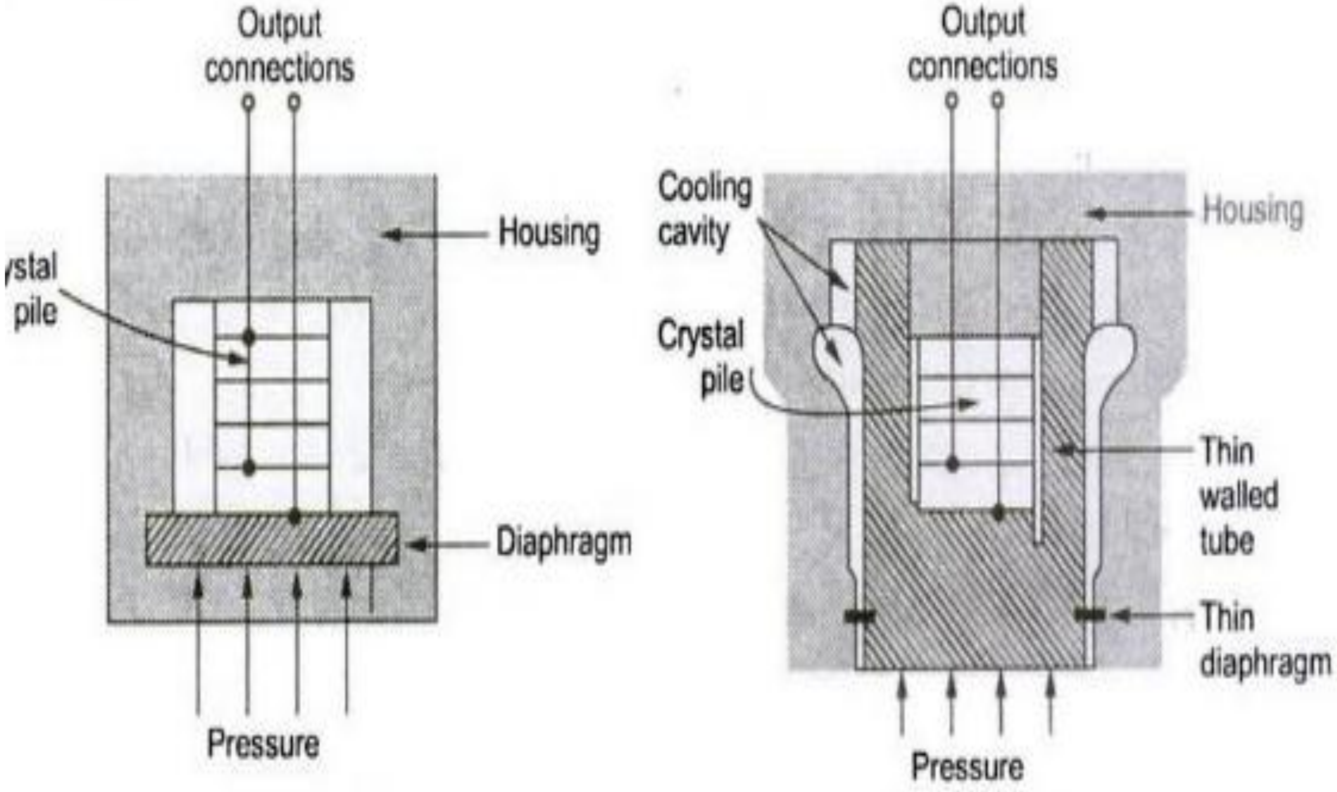


(a) Piezoelectric transducer

Piezo electric Transducers



(b) Crystal pile in a piezoelectric pressure transducer

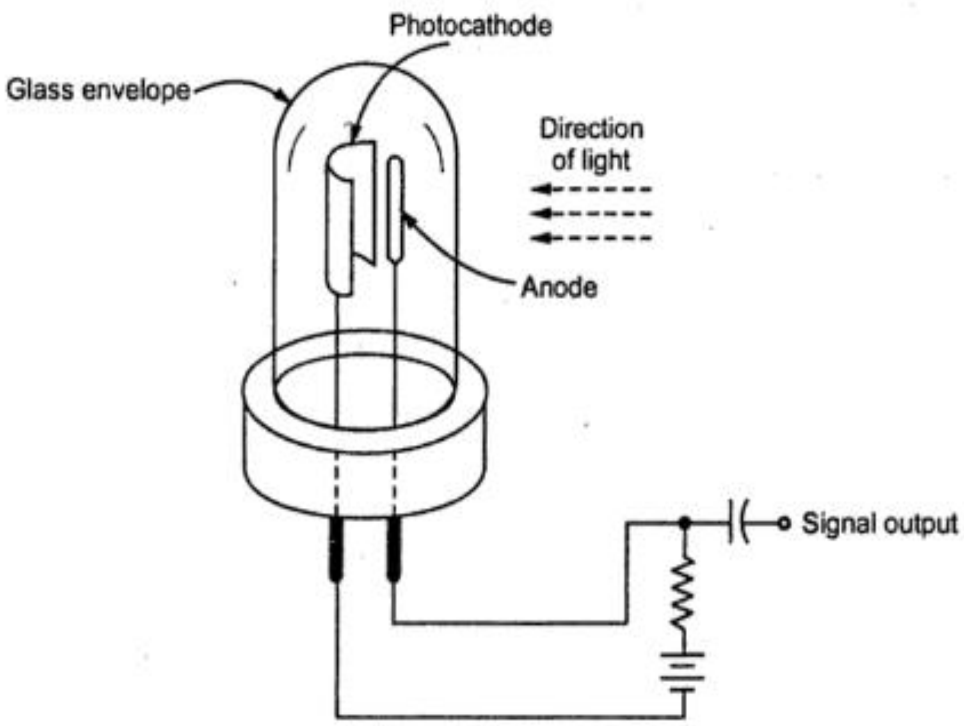


(a) Diaphragm loaded

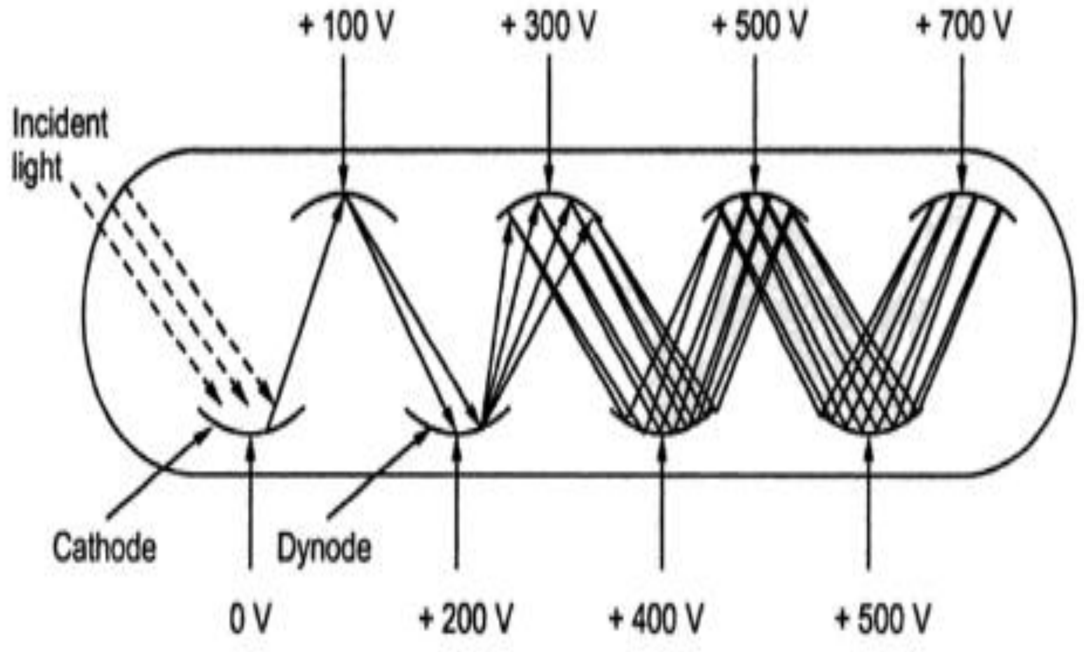
(b) Tube loaded

Piezoelectric pressure transducers

Photo Electric Transducers

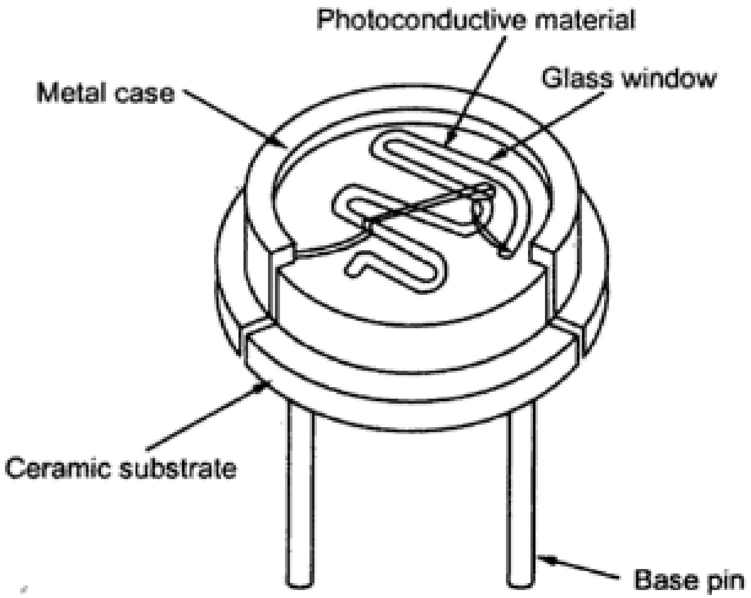


Vacuum phototube

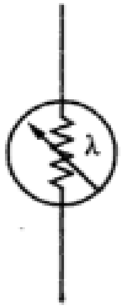


Photomultiplier tube

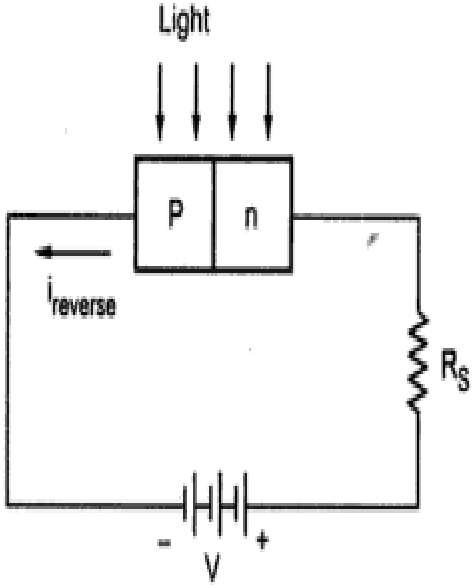
Photo Conductive Transducers



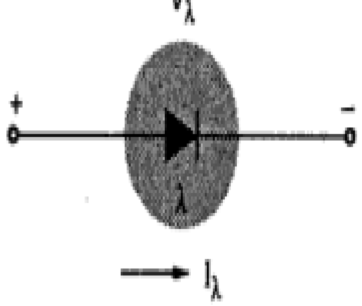
(a)



(b)

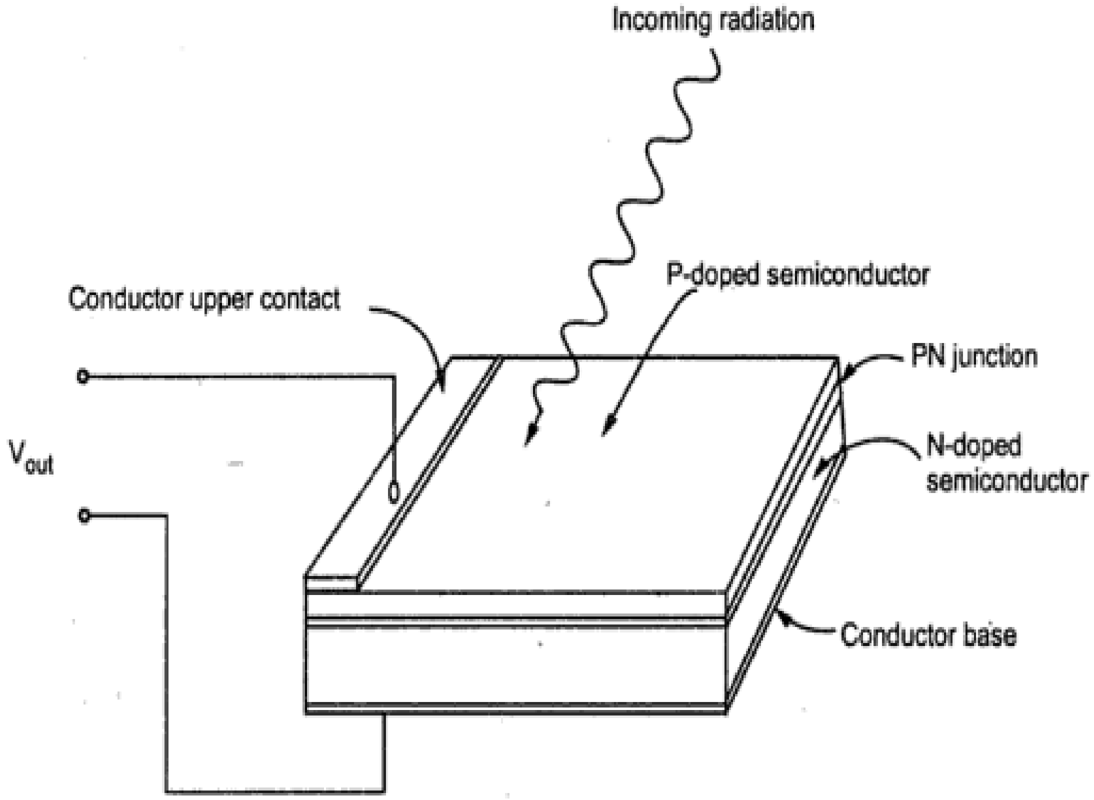


(a) Basic circuit arrangement

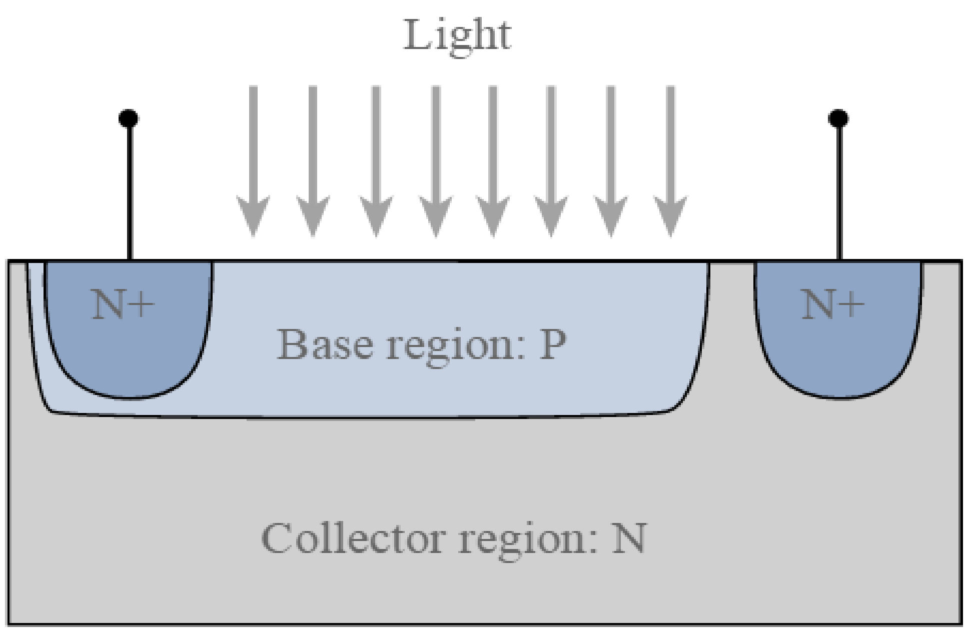


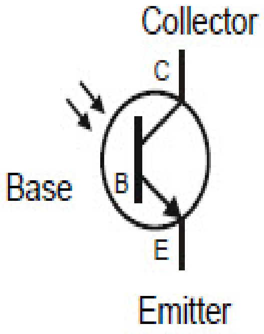
(b) Symbol

Photo Voltaic Transducers



Structure of photovoltaic cell





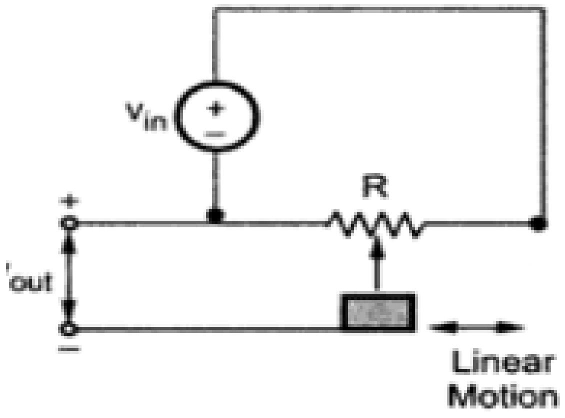
Measurement of Displacement

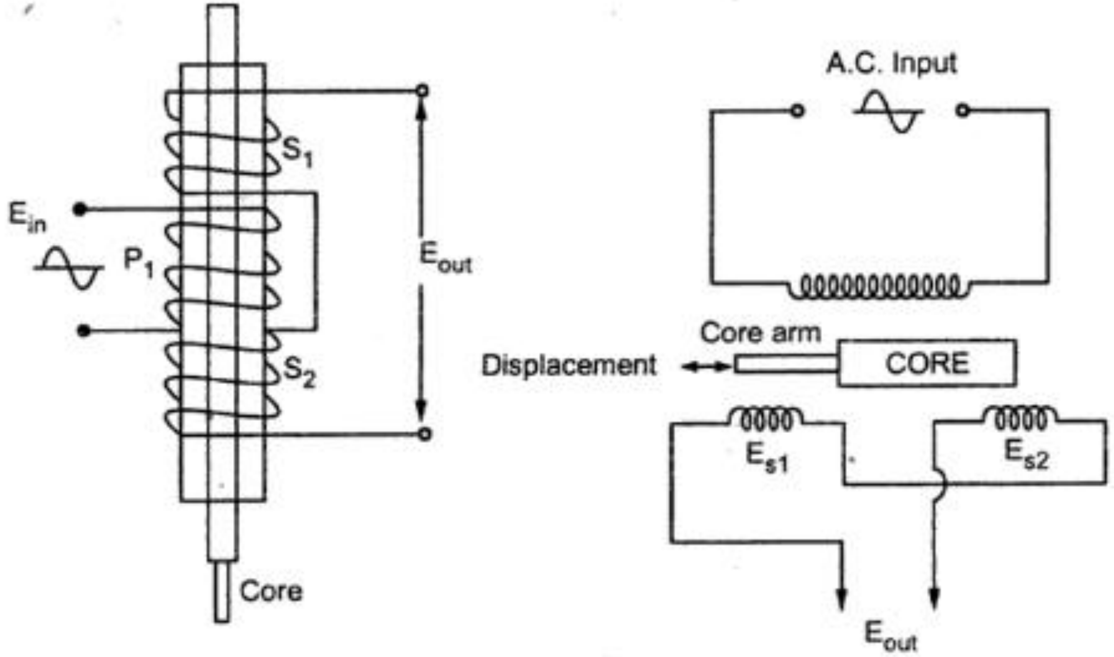
Translational Displacement

- Resistive Potentiometer Translational Displacement Transducer
- LVDT
- Variable Inductance Translational Displacement Transducers
- Variable Capacitance Displacement Transducers

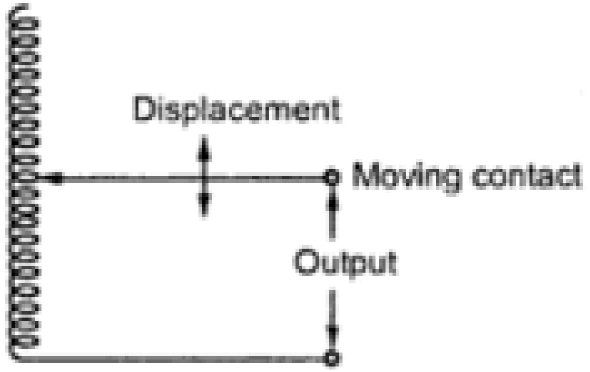
Rotational Displacement

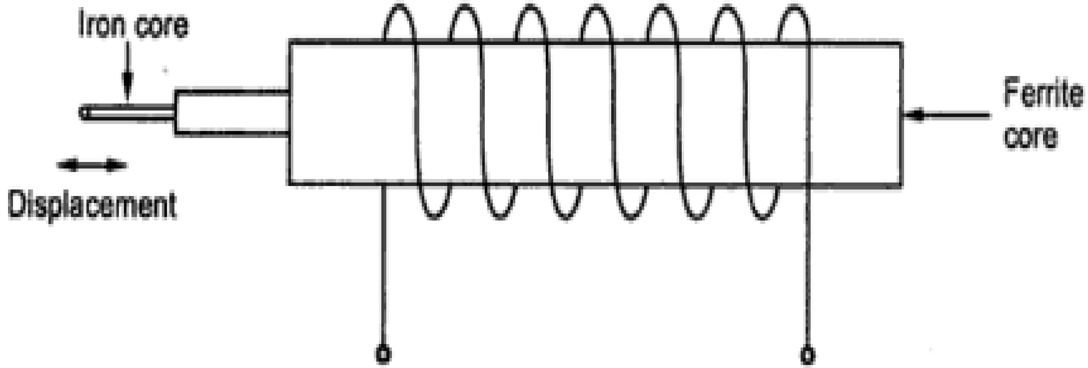
- Optical Encoders for Linear and Rotary Displacement



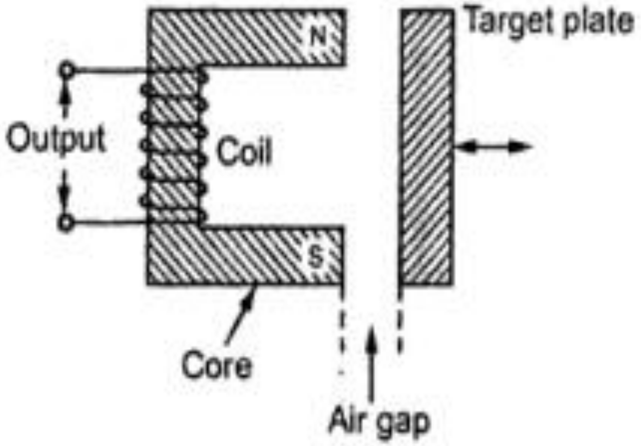


Linear variable differential transformer

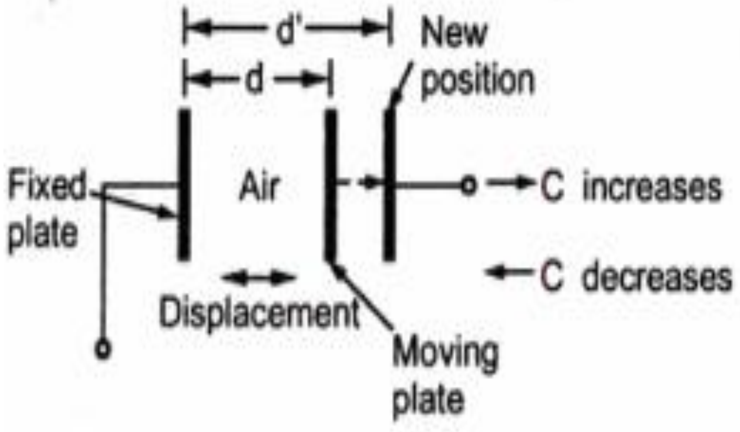




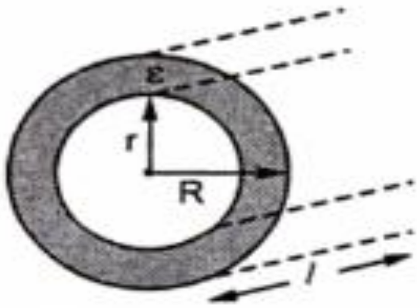
Variable permeability inductive transducer



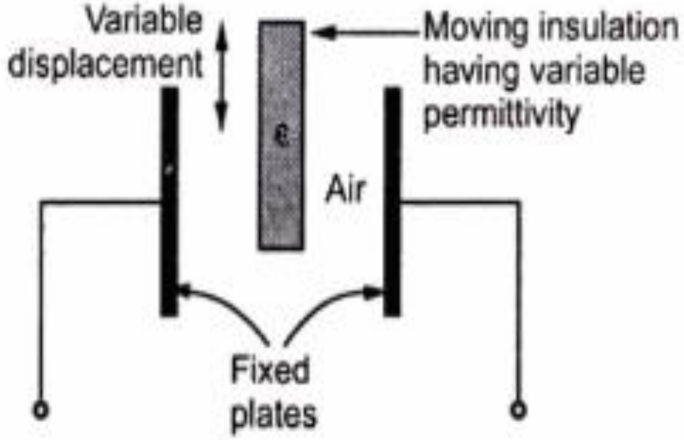
Variable reluctance inductive transducer



(a) Change in separation



Cylindrical capacitance



Change in dielectric

Velocity Transducers

- Linear Velocity Transducers

  Moving Coil Type Velocity Transducer

  Moving MGNET Type Velocity Transducer

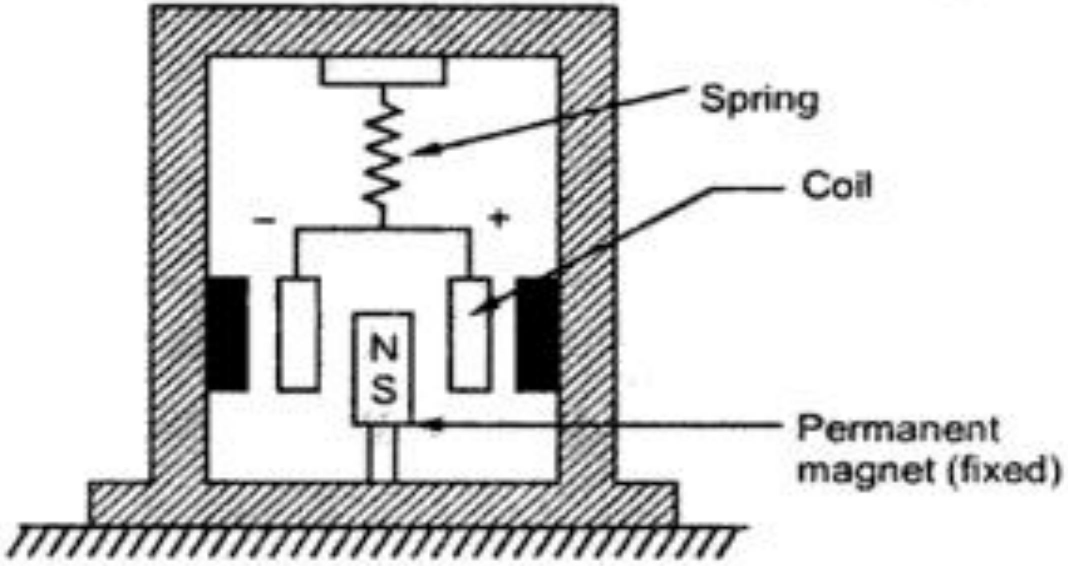
- Angular Velocity

  D.C Tachometer Generator or D.C Tachogenerator

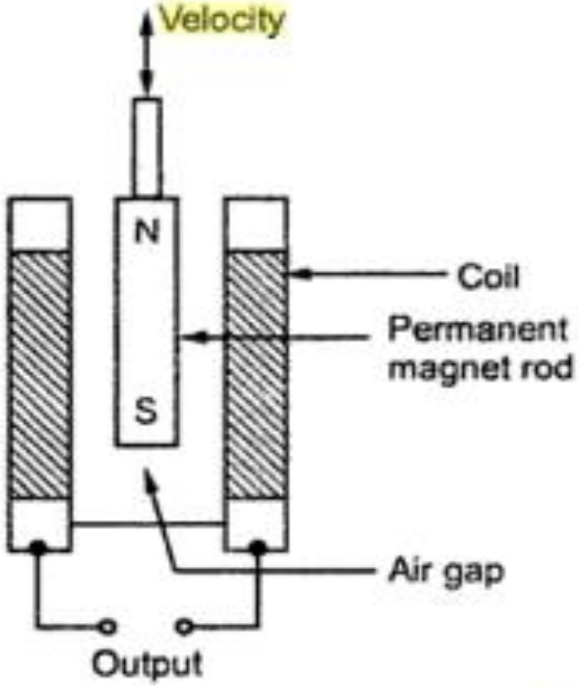
  A.C tachometer Generator or A.C Tachogenerator

  Eddy Current Tachometer

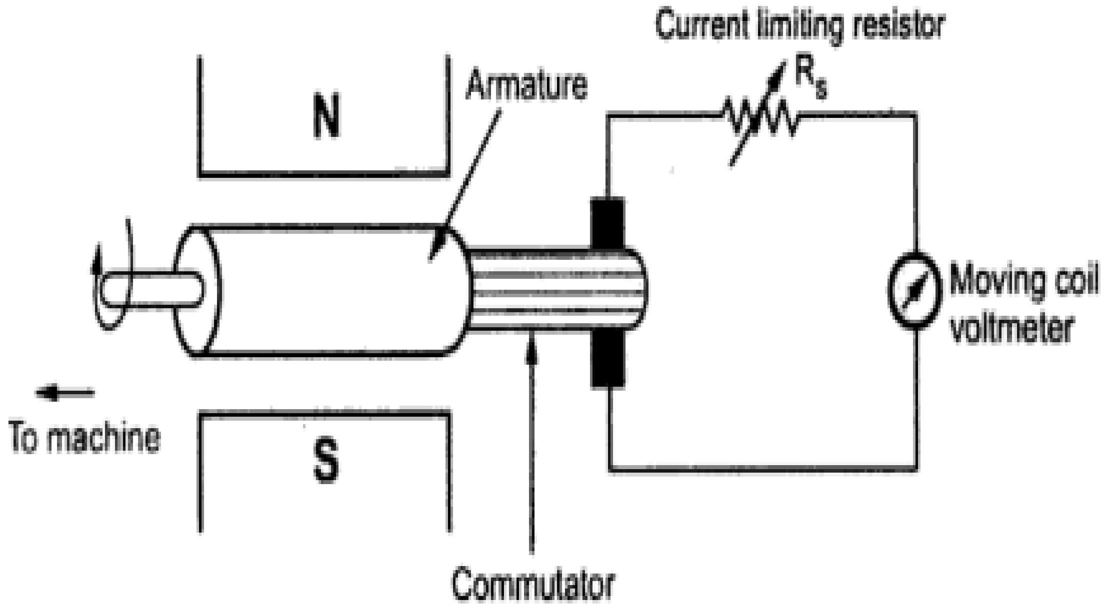
  Drag Cup Rotor A.C Tachometer Generator



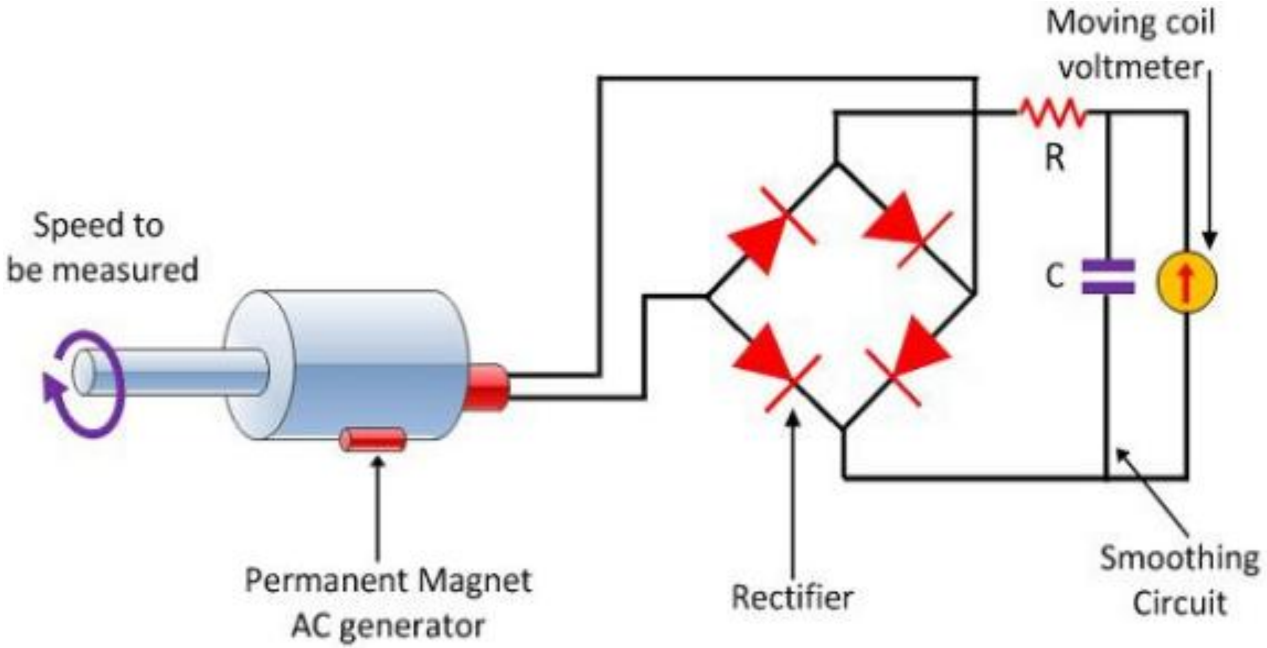
Moving coil type velocity transducer



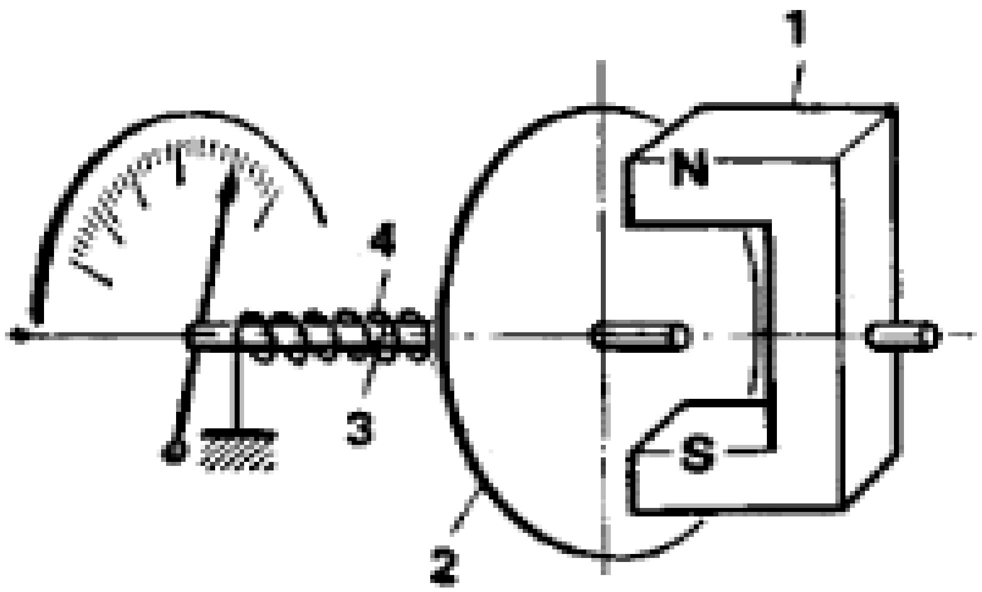
Moving magnet type velocity transducer

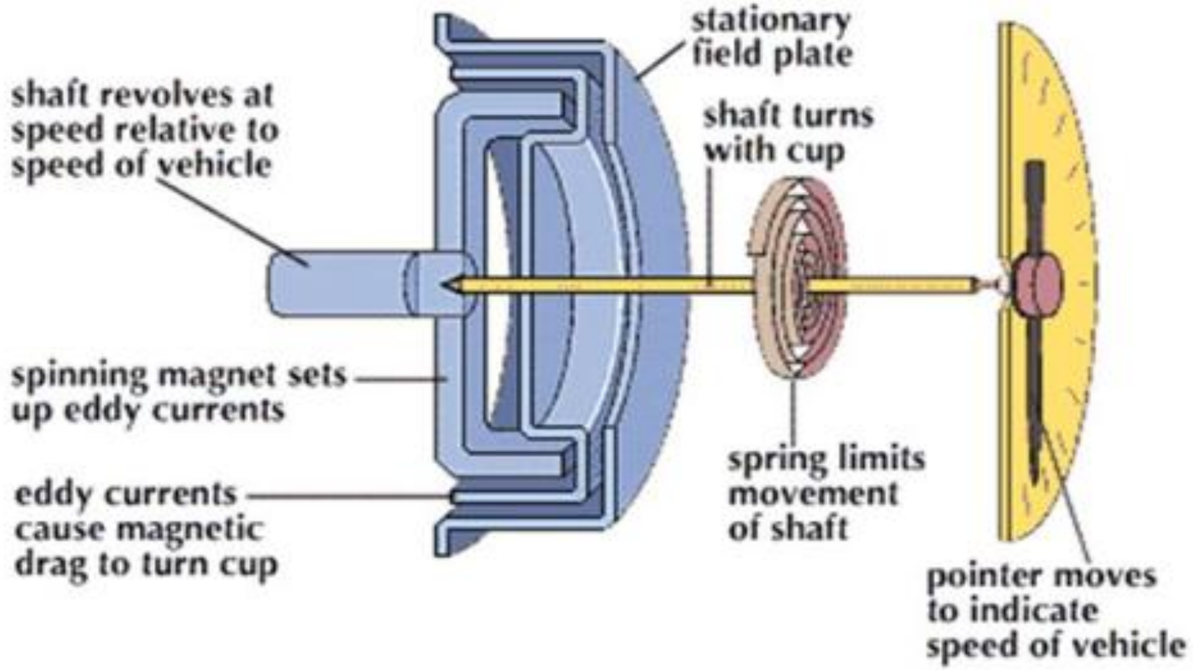


D.C. Tachogenerator



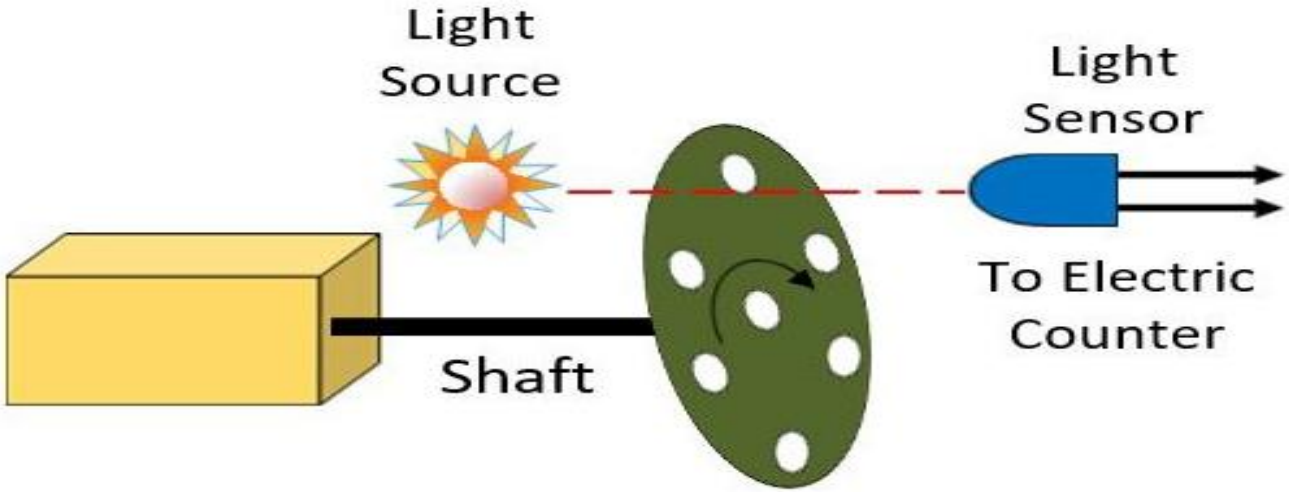
A.C Tachometer Generator


1
N
4
3
S
2

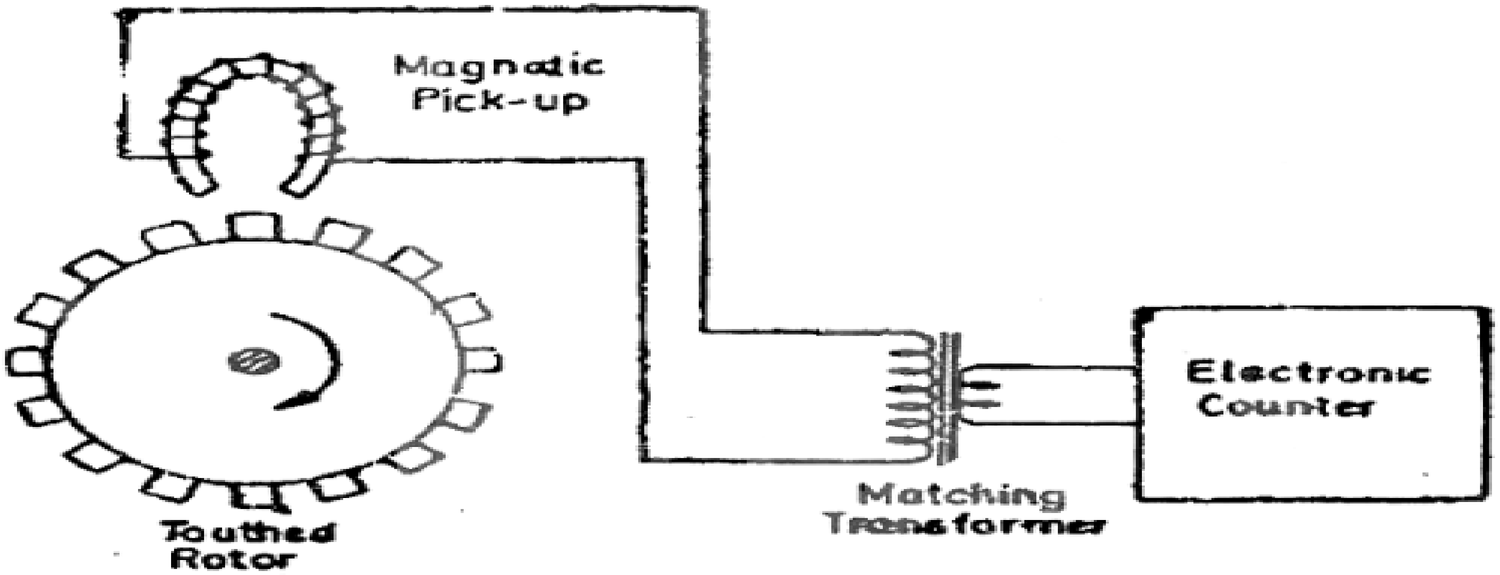

stationary
field plate
shaft revolves at
speed relative to
speed of vehicle
shaft turns
with cup
spinning magnet sets
up eddy currents
eddy currents
cause magnetic
drag to turn cup
spring limits
movement
of shaft
pointer moves
to indicate
speed of vehicle

Digital Methods for Measuremet of Angular Velocity

- Photo electric Tachometer
- Toothed rotor variable reluctance tachometer-inductive type tachometer



Photoeolectric Tachometer



Toothed Rotor Tachometer.

Academic Year: 2018-19 **Year: III** **Semester: I**	**MID Exam - I** **ELCTRICAL MEASUREMENTS & INSTRUMENTATION**	**Date:** **Duration:** **Max Marks: 15**

Note: Answer any three questions. All questions carry equal marks.

1	Calculate the Deflection angle for MI Instruments [CO1]
2	Summarize construction, working and Torque equation for Induction type Energy meter [CO3]
3	Conclude the working of Coordinate type AC Potentiometer[CO3]
4	a. Design a multi-range D.C milli ammeter using a basic movement with an internal resistance R_M= 50 ohms & a full scale deflection current I_M = 1mA. The range required are 0-10mA; 0-50mA; 0-100mA & 0-500mA [CO2] b. The arms of an A.C Maxwell bridge are arranged as follows : AB is an non inductive resistance of 1000 ohms in parallel with a capacitor of capacitance 0.5micro farad, BC is a non-inductive resistance of 600 ohms CD is an inductive impedance (unknown) and DA is a non inductive resistance of 400 ohms. If balance is obtained under these conditions, find the value of the resistance and the inductance of the branch CD [CO4]

GOKARAJU RANGARAJU INSTITUTE OF ENGINEERING AND TECHNOLOGY
(Autonomous)
Department of Electrical and Electronics Engineering

Academic Year: 2018-19 Year: III Semester: I	MID Exam – I (Objective) **Electrical Measurements & Instrumentation**	Date: Max Marks: 5

1. The following is not essential for the working of an indicating instrument

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

2. In a single-phase power factor meter, controlling torque is

(a) Provided by spring control (b) Provided by gravity control

(c) Provided by stiffness of suspension (d) Not required [ ]

3. The dielectric loss of a capacitor can be measured by which one of the following?

(a) Wien bridge (b) Owen bridge (c) Schering bridge (d) Maxwell bridge [ ]

4. Which of the following devices should be used for accurate measurement of low D.C. voltage?

(a) Small range moving coil voltmeter (b) D.C. potentiometer

(c) Small range thermocouple voltmeter (d) None of the above [ ]

5. How can a milli-ammeter be used as a voltmeter?

(a) By connecting a low resistance in parallel with the instrument

(b) By connecting a high resistance in parallel with the instrument

(c) By connecting a low resistance in series with the instrument

(d) By connecting a high resistance in series with the instrument [ ]

6. A moving coil ammeter has full scale deflection of 50 μA and coil of resistance 1000 Ω the value of shunt resistance to extend the range to 1 A is ________________ Ω.

7. An analog ammeter is an _____________________ instrument.

8. A ______________ device prevents the oscillation of the moving system and enables the later to reach its final position quickly.

9. Standardization of AC potentiometers is done by applying ________________ voltages.

10. Electro Dynamometer type PF meter has___________ fixed coils & ______moving coils.

GOKARAJU RANGARAJU INSTITUTE OF ENGINEERING & TECHNOLOGY

(Autonomous under JNTUH)

Dept. of EEE

ELECTRICAL MEASUREMENTS AND INSTRUMENTATION

III B.Tech- I Sem II Mid Examination

Time: 90 Min Date: Marks: 15

Answer any 3 Questions (All questions carry equal marks)

1)Articulate Ramp type & Stair case Ramp DVM's [CO6]

2)Generalize working of a CRT with a neat diagram. [CO5]

3) Summarize Photoelectric Transducers. [CO7]

4) Illustrate Flow Transducers.[CO7]

GOKARAJU RANGARAJU INSTITUTE OF ENGINEERING & TECHNOLOGY
(Autonomous under JNTUH)
Dept. of EEE
ELECTRICAL MEASUREMENTS AND INSTRUMENTATION
III B'Tech- I Sem II Mid Examination

Time: 20 Min   Date: Marks: 5   Roll No:

1. An inverse transducer is a device which converts ( )
   a) An electrical quantity into a non-electrical quantity
   b) Electrical quantity into mechanical quantity
   c) Electrical energy into thermal energy
   d) Electrical energy into light energy
2. A strain gauge is a passive transducer and is employed for converting ( )
   a) Mechanical displacement into a change of resistance
   b) Pressure into a change of resistance
   c) Force into a displacement
   d) Pressure into displacement
3. S1: Transducer is a device which converts physical into electrical quantity ( )
   S2: Transducer is also called as sensor.
   a) S1 is true & S2 is false
   b) S2 is true & S1 is false
   c) Both S1 & S2 are true
   d) Both S1 & S2 are false
4. The principle of operation of LVDT is based on the variation of ( )
   a) Self-inductance
   b) Mutual inductance
   c) Reluctance
   d) Permanence
5. Materials used for piezo-electric effect are ( )
   a) Quartz
   b) Rochelle Salts
   c) Tourmaline
   d) All
6. Thermistor is used for measurement of ____________________
7. Piezo-electric transducers are________________________ transducers.
8. _____________________________ and _______________________ are analog methods for Angular Velocity
9. The transducers that converts the input signal into the output signal, which is a continuous function of time is known as ___________ transducer
10. LVDT stands for________________________

Code No: NR310202 **NR**

III B.Tech I Semester Supplimentary Examinations, May/Jun 2009
ELECTRICAL MEASUREMENTS
(Electrical & Electronic Engineering)

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

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1. (a) Compare between spring and gravity control methods.
   (b) The deflecting torque of an ammeter varies as the square of the current passing through it. If a current of 5 amps produces a deflection of 90 degrees, what will be the deflection for a current of 10 amps when the instrument is
      i. Spring controlled
      ii. Gravity controlled

   [8+8]

2. (a) Draw and explain the equivalent circuit and phasor diagram of current transformer.
   (b) A 1000/5A current transformer, bar primary type, has the loss component of exciting current equal to 0.7% of the primary current. Find the ratio error
      i. when turn ratio is equal to nominal ratio
      ii. when the secondary turn is reduced by 0.5%. [8+8]

3. (a) With a neat figure, explain the construction and working principle of electrical resonance frequency meter.
   (b) Explain the working of single phase dynamometer type power factor meter.

   [8+8]

4. (a) What is energy meter testing? Explain phantom load testing.
   (b) A 220, 5A, d.c.energymeter is tested at its marked ratings. The resistance of the pressure circuit is 8800 ohm and that of current coil is 0.1 ohm. Calculate the power consumed when testing the meter with phantom loading with current circuit excited by a 6 volts battery. [8+8]

5. A current of 10A, at frequency of 50 Hz, was passed through the primary of a mutual inductor having a negligible phase defect, the voltage of primary and secondary terminals were measured on a co-ordinate potentiometer and are given below:
   With secondary open circuited; secondary voltage=-2.72+J1.57 volts,
   Primary voltage=-0.211+J0.352 volts.
   With secondary short-circuited: primary voltage=-0.051+J0.329 volts.
   The phase primary current relative to the potentiometer current was same in both the tests. Determine the resistances and self-inductances of the two windings. Find also the mutual inductance. [16]

6. (a) Describe any one method of measuring a very high value of resistance.
   (b) A lissajous pattern on the oscillascope is stationary and has 6 vertical maximum values and 5 horizontal maximum values. The frequency of horizontal Input is 1500Hz. Determine the frequency of vertical Input. [8+8]

7. Describe how an unknown capacitance can be measured with the help of D'sautys bridge. What are the limitations of the bridge and how are they overcome by using a modified form of D'stautys bridge. [16]

8. (a) Explain the Double bar method of measuring the flux density of iron specimen.
   (b) A solenoid is 60cm long and 2.5cm in diameter,it is uniformly wound with 600 turns of wire. Find the magnetic field strength at the centre of the solenoid when carrying a current of 2amp. If the secondary coil is wound round the central part of solenoid, calculate the flux passing through it . [8+8]

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Code No: OR211051 **OR**

II B.Tech I Semester Supplementary Examinations, May 2005
ELECTRICAL AND ELECTRONICS MEASUREMENTS
(Common to Electronics & Instrumentation Engineering and Electronics & Control Engineering)

Time: 3 hours **Max Marks: 70**

Answer any FIVE Questions
All Questions carry equal marks
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1. Derive the expression for Rh in shunt type ohm-meter. Also prove with an example its suitability for very low resistance measurement.

2. With the help of a neat sketch and circuit connections for a single phase crossed coil, describe the working of polarized-vane power factor meter.

3. (a) Explain a ramp type digital volt meter using voltage to time conversion principle.
   (b) A dual slope integrating type of A/D converter has an integrating capacitor of
   0.1 μF and a resistance of 100 KΩ if the reference voltage is 2 volt and the output of the integrator is no to exceed 10 volts, what is the max time the reference voltage can be integrated.

4. (a) What are the constituent elements of a Digital Multimeter?
   (b) For measuring small values of capacitance, a 60 MHz source is to be used in a capacitance meter. What value of series resistance is required if the phase shift is to be kept below 5.7deg for full scale capacitance reading of 1,10, and 100 PF.

5. (a) Explain the working operation of differential deflection amplifier for an oscilloscope.
   (b) Give the specifications of CRO.

6. (a) Explain the working operation of a storage CRT with multiple targets and two electron guns with secondary emission curves.
   (b) With neat figure, explain schematic view of a bitable storage tube.

7. (a) Explain the term Capability of a 'phase lock' connected with function generator.
   (b) Explain briefly about various types of signal generators.
   (c) What is the necessity to have TTL output on a signal generator and a frequency counter?

8. (a) Explain with the help of a block diagram how the period can be measured?
   (b) What is meant by time base error and explain a calibration method to improve the accuracy of it.

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Code No: OR310255 **OR**

III B.Tech I Semester Supplementary Examinations, April/May 2005
ELECTRICAL MEASUREMENTS
(Electrical & Electronic Engineering)

Time: 3 hours **Max Marks: 70**

Answer any FIVE Questions
All Questions carry equal marks

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1. (a) How does errors due to magnetic field and frequency are compensated in moving iron instruments.
   (b) The coil of a 300 Volt of a moving iron voltmeter has a resistance of 500 ohm and an inductance of 0.8 H. The instrument reads correctly at 50 Hz AC supply and takes 100 milli amps at full-scale deflection. What is the percentage error in the instrument reading when it is connected to 200 Volt DC supply.

2. Explain the working of a 3 phase dynamometer wattmeter. Describe how mutual effects between the two elements of the wattmeter are eliminated.

3. (a) Describe with a diagram the construction and working of a ROTATING COIL TYPE SINGLE PHASE power factor meter ?
   (b) What is the need for the use of a Synchroscope in power station.? Explain with a diagram the construction and working of a Moving iron type synchroscope ?

4. (a) Explain the construction and working of a single phase energymeter.
   (b) What are the adjustments to be done in Single phase induction energymeter so that the meter reads correctly?

5. Explain in detail, the construction and working principle of a vibration galvanometer.

6. A Kelvin Double bridge has each of the ratio arms P = Q = p = q = 1000Ω. The emf of the battery is 100V and a resistance of 5Ω is included in the battery circuit. The galvanometer has a resistance of 500Ω and the resistance of the link connecting the unknown resistance to the standard resistance may be neglected. The bridge is balanced when the standard resistance S = 0.001Ω.
   (a) Determine the value of unknown resistance.
   (b) Determine the current (approximate value) through the unknown resistance R at balance.
   (c) Determine the deflection of the galvanometer when the unknown resistance, R, is changed by 0.1 percent from its value at balance. The galvanometer has a sensitivity of $200mm/\mu A$.

7. (a) Obtain the balanced condition of Andersons bridge in measurement of inductance.

(b) The four impedances of an a.c. bridge are $Z_1 = 400\angle 50\Omega,\ Z_2 = 200\angle 40\Omega,\ Z_3 = 800\angle - 50\Omega$ *and* $Z_4 = 400\angle 20\Omega$ one end of Z_1 is connected to one end of Z_2. Other end of Z_2 is connected to one end of Z_3, other end of Z_3 is connected one end of Z_4. Find under what conditions this bridge is balanced.

8. (a) Explain the Double bar method of measuring the flux density of iron specimen.

   (b) A solenoid is 60cm long and 2.5cm in diameter,it is uniformly wound with 600 turns of wire. Find the magnetic field strength at the centre of the solenoid when carrying a current of 2amp. If the secondary coil is wound round the central part of solenoid, calculate the flux passing through it .

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Code No: R05221301 **Set No. 1**

II B.Tech Supplimentary Examinations, Aug/Sep 2008
ELECTRICAL AND ELECTRONIC MEASUREMENTS
(Electronics & Control Engineering)

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

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1. (a) How is the current range of a PMMC instrument extended with the help of shunts?
   (b) Explain a method of reducing errors due to temperature changes in the shunt connected instruments with a suitable example. [8+8]
2. (a) Explain how an electrodynamometer type of instrument is able to measure the true r.m.s value of a voltage (or) current irrespective of its wave form.
   (b) What are the advantages and dis-advantages of electrodynamometer type of instruments? [8+8]
3. (a) Explain the principle of operation of 1-ϕ induction type energy meter with a neat circuit diagram.
   (b) The meter constant of a 230V, 10A watt hour meter is 1800 revolutions per Kwh. The meter is tested at half load and rated voltage and unity power factor. The meter is found to make 80 revolutions in 138 sec. Determine the meter error at half load? [10+6]
4. (a) Explain the importance of thermocouples in the construction of true RMS type of Voltmeter.
   (b) What is the necessity of electronic voltmeter? Explain.
   (c) What is multimeter? What are the parameters that can be measured with multimeter? [6+6+4]
5. (a) What is phase meter? Mention its type. Discuss the merits and demerits of it.
   (b) With a neat sketch explain the operation of digital phase meter. [8+8]
6. (a) What is probe? What are the advantages of an active voltage probe?
   (b) Why an attenuator probe is used in oscilloscope .
   (c) What is delayed sweep? when it used? [8+4+4]
7. (a) Explain how sine wave is generated from signal generator? Draw the circuit and explain its working.
   (b) Explain how square and triangular wave is generated from signal generator? Draw the circuit and explain its working. [8+8]
8. (a) List the different measurement errors and discuss in brief.

(b) Draw the block diagram of a frequency counter and explain its operation using appropriate wave forms. [8+8]

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Code No: R05221301 **Set No. 2**

II B.Tech Supplimentary Examinations, Aug/Sep 2008
ELECTRICAL AND ELECTRONIC MEASUREMENTS
(Electronics & Control Engineering)

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

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1. (a) Give the general requirements for the construction of shunts?
   (b) Explain the working of a universal shunt used for multirange Ammeters. Derive expressions for resistances of different sections of a universal shunt used for a 3 range ammeter. [6+10]

2. Explain the construction and working of a shunt type ohmmeter. Write down its design equations. Why are series type ohmmeters preferred over shunt type ohmmeters? [16]

3. (a) Define the following terms as used for instrument transformers.
      i. Transformation ratio
      ii. Nominal ratio
      iii. Turns ratio
      iv. Ratio correction factor and
      v. Burden.
   (b) State the advantages and dis-advantages of instrument-transformers. [10+6]

4. (a) Explain how Successive approximation DVM performance is better than other DVM's.
   (b) Compare the performance characteristics of different types of DVMs. [8+8]

5. Draw the basic blocks of RF vector impedance meter. Explain the functions of each block. Also give the specifications of the above meter. [16]

6. (a) What is probe? What are the advantages of an active voltage probe?
   (b) Why an attenuator probe is used in oscilloscope .
   (c) What is delayed sweep? when it used? [8+4+4]

7. Describe the circuits and working principle of wave analyzer used for radio frequency and also in Megahertz's ranges. Give the specification and mention the advantages and disadvantages of it. [16]

8. (a) List the different measurement errors and discuss in brief.
   (b) Draw the block diagram of a frequency counter and explain its operation using appropriate wave forms. [8+8]

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Code No: R05221301 **Set No. 3**

II B.Tech Supplimentary Examinations, Aug/Sep 2008
ELECTRICAL AND ELECTRONIC MEASUREMENTS
(Electronics & Control Engineering)

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

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1. (a) Explain the constructional details of PMMC instruments with a neat sketch.
   (b) Explain different errors of PMMC instruments. [10+6]

2. A series type of ohmmeter uses a 50Ω basic movement requiring a full scale current of 1mA. The internal battery voltage is 3V. The desired scale marking for half scale deflection is 2,000Ω. Calculate
   (a) the values of R_1 and R_2.
   (b) the maximum value of R_2 to compensate for a 10% drop in battery voltage.
   (c) the scale error at the half scale mark (2,000Ω) when R2 is set as in (ii). [16]

3. (a) Explain the following in an 1-ϕ induction type energy meter?
      i. Driving system
      ii. Moving system.
      iii. Braking system and
      iv. Registering mechanism.
   (b) A 50A, 230V meter on full load test makes 61 revolution in 37 sec. If the normal disc speed is 520 revolution per Kwh, find the percentage error?[12+4]

4. (a) Explain the importance of thermocouples in the construction of true RMS type of Voltmeter.
   (b) What is the necessity of electronic voltmeter? Explain.
   (c) What is multimeter? What are the parameters that can be measured with multimeter? [6+6+4]

5. (a) What is phase meter? Mention its type. Discuss the merits and demerits of it.
   (b) With a neat sketch explain the operation of digital phase meter. [8+8]

6. (a) What are the precautions to be taken while using a sampling oscilloscope.
   (b) What is the velocity of the electrons that have been accelerated through a potential of 100V.
   (c) Mention the applications of CRO. [6+5+5]

7. (a) Discuss in detail about Audio frequency wave generator.

(b) What are the precautionary measures to be considered in a signal generator? Explain how they can be achieved. [9+7]

8. (a) Justify what minimum gate is required for a frequency counter capable of measuring an unknown frequency, to within 10Hz by measuring frequency rather than period?

   (b) What is meant by time base error and explain a calibration method to improve the accuracy of it? [16]

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Code No: R05221301 **Set No. 4**

II B.Tech Supplimentary Examinations, Aug/Sep 2008
ELECTRICAL AND ELECTRONIC MEASUREMENTS
(Electronics & Control Engineering)

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

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1. (a) State the causes of change of accuracy in PMMC instruments?
   (b) The resistance of a moving coil voltmeter is 12,000 Ω. The moving coil has 100 turns and 4 cm long and 3 cm wide. The fluxdensity in the air gap is 6×10^{-2} wb/m^2. find the deflection produced by 300 V if the spring control gives a deflection of one degree for a torque of 25×10^{-7} N-m. [8+8]

2. (a) Explain the principle of operation of thermoelectric instruments?
   (b) Give the constructional details of thermoelectric instruments. [8+8]

3. Explain the construction and working of a 3-phase electrodynamometer type of power factor meter. [16]

4. (a) Explain the importance of thermocouples in the construction of true RMS type of Voltmeter.
   (b) What is the necessity of electronic voltmeter? Explain.
   (c) What is multimeter? What are the parameters that can be measured with multimeter? [6+6+4]

5. (a) Compute the Self capacitance of a coil when the following measurements are made at f_1=2MHz the tuning capacitor is set at 450pF. When the frequency is increased to 5MHz, the tuning capacitor is tuned to 60pF.
   (b) What are the advantages of Q-meter over other meters. [10+6]

6. (a) What is probe? What are the advantages of an active voltage probe?
   (b) Why an attenuator probe is used in oscilloscope .
   (c) What is delayed sweep? when it used? [8+4+4]

7. (a) What is distortion factor? Derive formula for the same.
   (b) Draw the block diagram of Spectrum analyzer of the swept receiver design and explain it. [8+8]

8. (a) List the different measurement errors and discuss in brief.
   (b) Draw the block diagram of a frequency counter and explain its operation using appropriate wave forms. [8+8]

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Code No: R05310202 **Set No. 1**

III B.Tech I Semester Regular Examinations, November 2008
ELECTRICAL MEASUREMENTS
(Electrical & Electronic Engineering)

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

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1. (a) Give the classification of electrical measuring Instruments.
   (b) Explain the working principle of PMMC instrument with a neat sketch.
   (c) State the advantages and dis-advantages of PMMC instrument. [5+6+5]

2. Draw the equivalent circuit and phasor diagram of a potential transformer. Derive the expressions for its ratio error. State the assumptions made for derivation of this error. [16]

3. (a) Give the constructional details of electrodynamometer type wattmeter with a neat sketch.
   (b) Prove that the true power= $\frac{COS\phi}{COS\phi.COS(\phi-\beta)}\times$ Actual wattmeter reading for electrodynamometer type of wattmeters, where cosϕ =p.f of the circuit, $\beta = \tan^{-1}\left(\frac{wL}{R}\right)$ where L and R are the inductance and resistance of the pressure coil of the circuit. [8+8]

4. Derive the expression for deflecting torque in single phase induction type Energy water. Show that deflection is maximum when the phase angle between two fluxes is 90^0 and when the disc is purely non-inductive. [16]

5. (a) How a co-ordinate type A.C. potentiometer is standardized? Explain how an unknown voltage can be measured by using this potentiometer?
   (b) What are the sources of errors in the above potentiometer? [10+6]

6. (a) What are the different difficulties encountered in the measurement of high resistances? Explain how these difficulties are overcome?
   (b) A highly sensitive galvanometer can detect a current as low 0.1 nano-Amperes. This galvanometer is used in a wheat-stone bridge as a detector. The resistance of galvanometer is negligible. Each arm of the bridge has a resistance of 1KΩ. The input voltage applied to the bridge is 20V. Calculate the smallest change in resistance, which can be detected. The resistance of the galvanometer can be neglected as compared with the internal resistance of bridge. [10+6]

7. (a) State the advantages and disadvantages of Anderson's bridge.
   (b) Draw the phasor diagram for Anderson's bridge under balance conditions.
   (c) A bridge consists of the following:
   Arm ab - a choke coil having a resistance R_1 and inductance L_1
   Arm bc - a non-inductive resistance R_3.

Arm cd - a mica condenser C_4 in series with a non-inductive resistance R_4.
Arm da - non-inductive resistance R_2.
When this bridge is fed from a source of 500 Hz, balance is obtained under following conditions.
R_2=2410Ω; R . 3=750Ω; C . 4=0.35 μF ; R_4 = 64.5Ω. The series resistance of capacitor is 0.4Ω. Calculate the resistance and inductance of the choke coil. The supply is connected between a and c and the detector is between b and d. [6+4+6]

8. Explain the construction and working principle of a ballistic galvanometer with a neat sketch. [16]

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Code No: R05310202 **Set No. 2**

III B.Tech I Semester Regular Examinations, November 2008
ELECTRICAL MEASUREMENTS
(Electrical & Electronic Engineering)

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

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1. (a) Explain the constructional details of PMMC instrument with neat sketch.
   (b) Explain why PMMC instruments are the most widely used instruments? Explain their advantages and disadvantages. [8+8]

2. (a) Explain the constructional details of different types of current transformers.
   (b) A 100/5A, 50 Hz current transformer has a bar primary and a rated secondary burden of 12.5VA. The secondary winding has 196 turns and a leakage inductance of 0.96mH. With a purely resistive burden at rated full load, the magnetizing mmf is 16AT and the loss excitation required 12A. Find ratio and phase angle errors. [8+8]

3. (a) Explain the working of a 3-phase wattmeter. Draw a neat sketch of the wattmerter and also its connections. Also, explain how the mutual effects between the two elements of the wattmeter are eliminated.
   (b) A voltage: 100 sinwt+40cos(3wt-30^o)+50sin(5wt+50^o)V is applied to the pressure circuit of a wattmeter and through the current coil is passes a current of 8 sin wt+6 cos (5wt-120^o)A. What will be the reading of the wattmeter? [10+6]

4. Explain the functions of the following in a single phase induction type Energymeter.
   (a) Shunt and series magnets
   (b) Moving disc
   (c) Permanentmagnet
   (d) Shading bands and holes in disc. [4+4+4+4]

5. Explain the following in A.C. potentiometer:
   (a) Drysdale phase shifting Transformer.
   (b) Transfer instrument. [8+8]

6. Explain the following:
   (a) Why is Kelvin's double bridge superior to the wheat-stone bridge for the purpose of low resistance measurement?
   (b) How the difficulties associated with the measurement of a very high resistance are over come?

(c) How the effects of contact resistance and resistance of the connecting leads are eliminated in the measurement of resistance by Kelvin's double bridge?

(d) Why is the Voltmeter-Ammeter method unsuitable for the precise measurement of the low resistance? [4+4+4+4]

7. (a) Draw the circuit diagram and phasor diagram of Owen's bridge under balance conditions. Derive the equations under balance conditions.

   (b) An owen's bridge is used to measure the properties of a sample of sheet steel at 2KHz. At balance, arm ab is test specimen; arm bc is R_3 =100Ω; arm cd is C_4 = 0.1 μF. Calculate the effective impedance of the specimen under test conditions. [10+6]

8. (a) What is ballistic galvanometer? What are its special features?

   (b) Explain the theory and working principle of ballistic galvanometer? [6+10]

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Code No: R05310202 **Set No. 3**

III B.Tech I Semester Regular Examinations, November 2008
ELECTRICAL MEASUREMENTS
(Electrical & Electronic Engineering)

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

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1. (a) What are the different effects used in producing deflecting torque in an analog instruments. State the examples, in which these effects are used?
   (b) Define the terms "indicating instruments", "recording instruments" and "integrating instruments". Give examples of each case.
   (c) Derive the equation for deflection if the instrument is PMMC spring controlled. [5+5+6]

2. Explain the constructional details and working of a single phase electrodynamometer type of powerfactor meter. Prove that the special displacement of moving system is equal to the phase angle of the system. [16]

3. (a) Draw the possible methods of connection the pressure coil of a wattmeter and compare the errors. Explain the meaning of "Compensation winding" in a Wattmeter and show how they help to reduce the error.
   (b) A dynamometer type wattmeter has a field system which may be considered long compared with its moving coils. The flux density is 0.012T, the mean diameter of the moving coil is 3 cm and the moving coil turns are 500. The current through the moving coil is 0.05A and power factor of the circuit of which power is measured is 0.866. Calculate the torque when the axis of the field and moving coils are [8+8]
      i. 30^o
      ii. 90^o.

4. Explain the constructional details of a single phase induction type energy meter. Explain, why the phase of shunt flux is made exactly in quadrature with that of applied voltage so as to produce a deflecting torque exactly proportional to power. [16]

5. (a) Draw the circuit of d.c. potentiometer. Explain how you can calibrate the same against a standard cell. Discuss the effect of room temperature on this calibration.
   (b) Explain how the potentiometer may be used for precise measurement of voltage (240V d.c.). [10+6]

6. (a) Explain how insulation resistance of a cable can be measured with a help of loss of charge method?

(b) The following results were obtained by loss of charge method of testing cable: discharged immediately after charging the deflection = 200 divisions; discharged 30 seconds after charging the deflection = 125 divisions; discharged 30 seconds after charging, when in parallel with a resistance of 10 MΩ, the deflection = 100 divisions. Calculate the insulation resistance of the cable. [8+8]

7. (a) Explain the working of Hay's bridge for measurement of inductance with a circuit diagram. Derive the equations for balance and draw the phasor diagram under balanced conditions.

   (b) The four arms of a Hay's bridge are arranged as follows: AB is a coil of unknown impedance; BC is a non-reactive resistor of 100 Ω; CD is a non-reactive resistor of 833 Ω in series with a standard capacitor of 0.38μF; DA is non-reactive resistor of 16800 Ω. If the supply frequency is 50 Hz, determine the inductance and the resistance at the balanced conditions. [10+6]

8. Explain the construction and working principle of flux meter with a neat diagram. [16]

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Code No: R05310202 **Set No. 4**

III B.Tech I Semester Regular Examinations, November 2008
ELECTRICAL MEASUREMENTS
(Electrical & Electronic Engineering)

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

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1. (a) Explain the construction and working of an attracted disc type kelvin absolute electrometer.
   (b) What are the advantages and disadvantages of the above instrument?
   (c) Can it be used for measurement of low voltages such as 100 V? Give the reason. [6+6+4]

2. Derive the expressions for ratio and phase angle error of a potential transformer. State the assumptions made for derivation of these errors. [16]

3. (a) Draw the necessary circuit diagram for measurement of three phase power by two wattmeter method. Make necessary derivations. In case of balanced, discuss the effects of the following load power factors on the two wattmeter readings.
      i. zero
      ii. unity
   (b) The power to a 3-phase induction motor was measured by this method, and the readings were 3,400 and ?1,200 watts respectively. Calculate the total power and power factor. [10+6]

4. (a) Explain the different sources of errors in single phase induction type energymeter.
   (b) A 50 A, 230 V meter on full load test makes 61 revolutions in 37 seconds. If the normal disc speed is 520 revolutions per Kwh, find the percentage error. [10+6]

5. (a) Describe the steps when D.C. crompton's potentiometer is used to measure an unknown resistance?
   (b) A basic slide wire potentiometer has a working battery voltage of 3 volts with negligible internal resistance. The resistance of slide wire is 400 Ω and its length is 200 cm. A 200 cm scale is placed along the slide wire. The slide wire has 1 mm scale divisions and it is possible to read upto of a division. The instrument is standardized with 1.018 V standard cell with sliding contact at the 101.8 cm mark on scale. Calculate:
      i. Working current
      ii. The resistance of series rheostat
      iii. The measurement range and

iv. The resolution of the instrument. [10+6]

6. (a) Draw the circuit diagram of a Wheatstone bridge and derive the conditions for balance.
   (b) The four arms of a Wheat shone bridge are as follows: AB = 100 Ω; BC = 10 Ω; CD = 4 Ω; DA = 50 Ω. The galvanometer has a resistance of 20 Ω and is connected across BD. A source of 10V d.c. is connected across AC. Find the current through the galvanometer. What should be the resistance in the arm DA for no current through the galvanometer? [8+8]

7. (a) What is the difference between L.V. schering bridge and H.V. schering bridge?
   (b) Draw the circuit diagram of H.V. schering bridge.
   (c) A capacitor bushing forms arm ab of a schering bridge and a standard capacitor of 500 pF capacitance and negligible loss, forms arm ad. Arm bc consists of a noninductive resistance of 300 Ω. When the bridge is balanced arm cd has a resistance of 72.6 Ω in parallel with a capacitance of 0.148 μF. The supply frequency is 50 Hz. Calculate the capacitance and dielectric loss angle of capacitor. Derive the equations for balance and draw the phasor diagram under conditions of balance. [4+3+9]

8. (a) Explain the theory of flux meter with a neat sketch.
   (b) A flux density =0.05 W/m^2; turns on moving coil=40; area of moving coil=750 mm^2 If the flux linking with a 10 turn search coil of 20 mm^2 area connected to the flux meter is reversed in a uniform field of 0.5 W/m^2, calculate the deflection of the flux meter. [10+6]

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Code No: R05320204 **Set No. 1**

III B.Tech II Semester Regular Examinations, Apr/May 2009

INSTRUMENTATION

(Electrical & Electronic Engineering)

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions

All Questions carry equal marks

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1. (a) In how many stages, can any measuring process can be divided? Draw the block diagram and bring out the uniqueness of each stage, in terms of its functions.
   (b) Distinguish between 'error? and 'correction' and show how they are usually expressed for an instrument. [8+8]
2. What is the process of modulation? Describe the techniques usually adopted. [16]
3. What is Synchronization? What are the different methods by which it can be accomplished? [16]
4. Explain with neat circuit diagram the working of the linear ramp type DVM. [16]
5. (a) Explain the principle and working of peak reading voltmeter with a block diagram.
   (b) Explain the two modes of operation of a vector impedance meter. [8+8]
6. (a) what do you understanding by an analog Transducer and a Digital Transducer? Give examples.
   (b) What are the errors in a Transducer? [8+8]
7. (a) Explain about magneto-strictive torque transducers.
   (b) A shaft is to transmit power up to 44kW at a constant speed of 25rps an it is proposed that the torque be sensed by a pair of torque strain gauges bonded to specially machine potion of the shaft. The gauges are to be connected pushpull in an equiarmed voltage sensitive bridge, the output of which is to be calibrated in power units. If the maximum strain value of the gauges is 0.0015, their resistance is 120 Ω and gauge factor is 2.1, calculate
      i. the diameter of the steel shaft to which they are to be bonded, if its modulus of elasticity is $200\times10^9 N/m^2$.
      ii. the output voltage at full power if the excitation of the bridge is 6V.
      iii. the sensitivity of the bridge in V/kW. [6+10]
8. (a) Describe the working of Pirani gauge with a neat sketch.
   (b) A thermopile arrangement of a copper constantan thermocouple consists of free junction parts and has the reference junction at 2000 ^{0}C. If the output voltage is 3.3mv, determine the temperature of the detecting junction. The

calibration chart of the thermocouple is [8+8]

Temp(^{0}C)	100	200	250
Voltage(mV)	4.22	9.23	11.95

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Code No: R05320204 **Set No. 2**

III B.Tech II Semester Regular Examinations, Apr/May 2009

INSTRUMENTATION

(Electrical & Electronic Engineering)

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions

All Questions carry equal marks

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1. Define Systematic error and explain the types of systematic errors? [16]

2. What is the process of modulation? Describe the techniques usually adopted. [16]

3. (a) Why is an attenuator probe used?
   (b) In a cathode ray tube the distance between the deflecting plates is 1.5cm, the length of the deflecting plates is 4.5cm and the distance of the screen from the centre of the deflecting plates is 33cm. If the accelerating voltage supply is 300volt, calculate deflecting sensitivity of the tube. [8+8]

4. (a) Explain the Phase Meter principles employed in measuring equipment?
   (b) Draw and explain Digital phase meter? [8+8]

5. (a) What is the spectrum of a signal? Explain with various examples.
   (b) A coil of unknown impedance is connected in series with a capacitor of 224μF and an ammeter of negligible impedance is connected to a variable frequency of constant voltage and negligible impedance. The frequency was adjusted both above and below the resonance frequency till the reading of the ammeter was reduced to70.7% of its value at resonance. This occurred at the frequencies of 876 and 892 kHz. Determine effective resistance, inductance and Q of the coil.
   (c) What is a vector impedance meter? What are its salient features? [6+6+4]

6. (a) What is a self generating Transducers?
   (b) What is a thermocouple? [8+8]

7. (a) Discuss in detail about strain gauge Rosettes.
   (b) The strain gauge having a gauge factor of 2 is connected in a bridge circuit having an excitation voltage 8V. The resistances are equal.It is subjected to a strain of 0.006. If this output is to represent $2/3^{rd}$ of full scale deflection of a recorder, **what should be the gain of the amplifier**. The full scale input voltage of the recorder is 1V. [10+6]

8. (a) Mention various types of instruments used for temperature measurement.
   (b) Describe the temperature measurement with resistance thermometers. [4+12]

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Code No: R05320204 **Set No. 3**

III B.Tech II Semester Regular Examinations, Apr/May 2009

INSTRUMENTATION

(Electrical & Electronic Engineering)

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions

All Questions carry equal marks

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1. (a) Define 'Drift', 'Threshold Value' and 'Dead-band' of a measuring system, with suitable example for each.
   (b) Distinguish between 'Range' and 'Span' of an instrument. [8+8]

2. (a) Define bandwidth of a signal and explain the ways in which signals are classified according to bandwidth.
   (b) Determine which of the following signals is periodic. If a signal is periodic determine its fundamental period.
   i)$x(t) = [\sin(t-\Pi/6)]^2$
   ii)$x(t) = e^{j(nt-1)}$ [8+8]

3. Define deflection sensitivity and deflection factor of a cathode ray tube. [16]

4. What are the different types of Digital voltmeters? Explain them briefly with neat sketches. [16]

5. (a) What is a Q-Factor? Explain hoe Q-Factor is measmed?Give the working principle of the meter.
   (b) Tests using a Q meter on a radio tuning coil to find its self capacitance gave the following results.
      i. With the radio coil connected normally, the resonance was obtained at 1 MHz with tuning capacitor set at 80 pF.
      ii. With the standard inductor connected in place of the radio coil, the resonance was obtained at 3 MHz. and this condition was not altered when the radio coil was connected in parallel with the standard inductor.Calculate the self-capacitance of the radio coil. [6+10]

6. Explain about the following:
   (a) bonded wire strain gauges
   (b) bonded metal foil strain gauges. [10+6]

7. (a) Explain the operation of DC Tachometer generators. What are it's advantages and disadvantages.
   (b) Explain Strobotran with a neat sketch. [8+8]

8. Discuss in detail about

(a) total radiation pyrometers

(b) optical pyrometers. [8+8]

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Code No: R05320204 **Set No. 4**

III B.Tech II Semester Regular Examinations, Apr/May 2009

INSTRUMENTATION

(Electrical & Electronic Engineering)

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions

All Questions carry equal marks

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1. (a) How are the performance characteristics of an instrument, classified?
   (b) Explain clearly the difference between Accuracy and Precision? [8+8]

2. Derive from fundamentals the expressions representing
   (a) A rectangular pulse train
   (b) a saw tooth wave. [8+8]

3. Draw the block diagram of a general purpose CRO and explain the functions of the following controls:
   (a) Intensity
   (b) Focus
   (c) Horizontal and Vertical positioning. [4+3×4=16]

4. Draw and explain the circuit of a digital frequency meter. What are the different methods used for high frequency determination? [16]

5. Explain the principle and operation of vector impedance meter with a neat block diagram. [16]

6. (a) Discuss the characteristics ofmaterials used for potentiometers.
   (b) A voltage dividing potentiometer is used to measure an angular displacement of 60^0 and the total angle travel of the potentiometer is 355^0. Calculate the voltage output on open circuit if the potentiometer is excited by a 60V source. Calculate the actual value of the output voltage at this setting if a voltmeter of 1MΩ resistance is connected across the output.The resistance of the potentiometer is 1KΩ. Calculate the % error. [6+10]

7. (a) Explain shaft speed measurements using Stroboscope with a neat sketches.
   (b) What are the advantages and disadvantages of moving magnet type linear velocity transducer. [12+4]

8. (a) Discuss in detail about turbine meters including their advantages and limitations.
   (b) Describe pressure measurement Piezoelectric transducers with neat sketches. [10+6]

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Code No: RR212202

Set No. 1

II B.Tech I Semester Supplimentary Examinations, November 2008
ELECTRICAL AND ELECTRONICS MEASUREMENTS
(Instrumentation & Control Engineering)

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

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1. (a) Derive the value of Torque and Deflection of the galvanometer with its dynamic behavior.
   (b) What value of shunt resistance is required for using 50μA meter movement with an internal resistance of 250Ω for measuring 0-500mA. [10+6]
2. With the help of a neat sketch and circuit connections for a single phase crossed coil, describe the working of polarized-vane power factor meter. [4+4+8]
3. (a) Give a circuit of an AC coupled amplifier to amplify DC signals when the input and out put are chopped.
   (b) Explain the operation of an all-electrical chopper circuit using FET's. [8+8]
4. Explain the working of a vector voltmeter in detail. Draw the schematic. Mention its applications. [5+5+6]
5. Explain in detail with figure
   (a) Electrostatic focusing system of a CRT
   (b) Refraction of an electron ray at an equipotential surface. [8+8]
6. (a) Explain the working functions of each block of a sampling oscilloscope in full detail.
   (b) Compare the merits and demerits of sampling oscilloscope. [10+6]
7. (a) What are the precautionary measures to be considered in a signal generator. And how can they be achieved?
   (b) Discuss in detail about RF signal generators. [6+10]
8. (a) Explain an automated frequency counter using block diagram.
   (b) If the internal time base of a frequency counter is 15MHz, what frequency range is best measured by a period measurement and why. [10+6]

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Code No: RR212202

Set No. 2

II B.Tech I Semester Supplimentary Examinations, November 2008
ELECTRICAL AND ELECTRONICS MEASUREMENTS
(Instrumentation & Control Engineering)

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

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1. Explain the voltmeter sensitivity and measuring method with loading effect. [2+7+7]

2. (a) How the elements of a single phase watthour meter are connected? Explain with the help of a sketch.
   (b) Describe the principle of measurement and working of a domestic watthour meter. [8+8]

3. Draw the block diagram of a dual-slope digital volt meter and explain how it is advantageous to use dual slope A/D converter in DUM? [4+8+4]

4. Draw the basic block diagram of a vector impedance meter. Explain the functions of each block. Also give the specifications of the above meter. [6+6+4]

5. (a) With neat block diagram explain the working function of each block of general purpose oscilloscope.
   (b) Mention the advantages of general purpose oscilloscope. [10+6]

6. (a) How much voltage is required across two deflection plates separated by 2 cms to deflect an electron beam 1.5^0 if the effective length of deflection plates is 2 cms and the accelerating potential is 900 volts?
   (b) What is an oscilloscope Probe compensation? How is this adjusted? What effects are noted when the compensation is not correctly adjusted? [8+8]

7. (a) What principle is employed in the operation of a function generator?
   (b) What are the ways in which isolation can be accomplished between signal generator output and oscillator in a simple signal generator? [8+8]

8. (a) Explain an automated frequency counter using block diagram.
   (b) If the internal time base of a frequency counter is 15MHz, what frequency range is best measured by a period measurement and why. [10+6]

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Code No: RR212202 **Set No. 3**

II B.Tech I Semester Supplimentary Examinations, November 2008
ELECTRICAL AND ELECTRONICS MEASUREMENTS
(Instrumentation & Control Engineering)

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

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1. (a) Explain Tant-band suspension. [6]
   (b) Draw the schematic, including values for an Ayrton shunt for a meter movement having full- scale deflection of 1mA and an internal resistance of 500Ω to cover the current ranges of 10, 50, 100 and 500mA. [5+5]
2. (a) Draw the block diagram of a true RMS measuring instrument and explain its working.
   (b) A symmetrical square wave voltage of maximum value E_M and time period T is applied to an average responding AC voltmeter with a scale calibrated in terms of the RMS value of a sine wave. Calculate the error in meter indication. [8+8]
3. (a) How can one select Digital volt meter? What are the outstanding qualities to make the selection? [3+3]
   (b) Classify the Digital voltmeters. Explain the operating principle of one of the above Digital Voltmeters. [2+8]
4. Write a notes on sources of error encountered in capacitance measuring meter. Explain parasitic inductance, resistance and capacitance. [4+4+4+4]
5. (a) Explain the working operation of differential deflection amplifier for an oscilloscope.
   (b) Give the specifications of CRO. [8+8]
6. (a) Explain the working function of each blocks of a digital storage oscilloscope.
   (b) How does the digital storage oscilloscope differ from the conventional storage oscilloscope using a storage CRT? What are the advantages of each? [8+8]
7. (a) With the help of a block diagram explain an audio-range wave analyzer.
   (b) Explain the applications of spectrum analyzer. [8+8]
8. (a) Draw and explain the logic diagram of a time base used for a frequency counter.
   (b) Draw and explain the input signal processing circuit for the frequency counter.
   (c) Define gating error. [8+6+2]

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Code No: RR212202 **Set No. 4**

II B.Tech I Semester Supplimentary Examinations, November 2008
ELECTRICAL AND ELECTRONICS MEASUREMENTS
(Instrumentation & Control Engineering)

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

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1. Explain in detail the Permanent magnet moving coil mechanism with construction and temperature compensation. [8+4+4]

2. (a) With neat diagram explain the principle and working of AC voltmeter.
   (b) An AC voltmeter calibrated for sine wave is used to measure a ramp voltage waveform rising to a peak value of 6 V in 3 m.sec. Determine the percentage error. [8+8]

3. Explain in detail the working of stair case Ramp DVM, giving the block diagram. Compare its performance with other types of DVMs. [8+4+4]

4. (a) Compute the value of self-capacitance of a coil when the following measurements are made; at f_1 = 2MHz, the tuning capacitor is set at 450 pf. When the frequency is increased to 5 MHz, the tuning capacitor is tuned to 60 pf.
   (b) Draw the block diagram of the RF milli voltmeter. Explain its working. [6+10]

5. (a) With neat block diagram explain the working function of each block of general purpose oscilloscope.
   (b) Mention the advantages of general purpose oscilloscope. [10+6]

6. (a) Explain the working functions of each block of a sampling oscilloscope in full detail.
   (b) Compare the merits and demerits of sampling oscilloscope. [10+6]

7. (a) With a block diagram explain AF sine -square wave oscillator.
   (b) Explain the different front panel controls of a signal generator. Give the specifications with typical values. [10+6]

8. (a) Draw and explain the temperature compensated crystal oscillator circuit.
   (b) List the suggestions to be followed to attain maximum accuracy in a frequency counter.
   (c) Explain the basic principle behind the extension of frequency range of counter.

   [6+4+6]

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Code No: RR221001

Set No. 1

II B.Tech Supplimentary Examinations, Aug/Sep 2008
ELECTRICAL AND ELECTRONICS MEASUREMENTS
(Common to Electronics & Instrumentation Engineering and Electronics & Control Engineering)

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

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1. (a) Derive the value of Torque and Deflection of the galvanometer with its dynamic behavior.
   (b) What value of shunt resistance is required for using 50μA meter movement with an internal resistance of 250Ω for measuring 0-500mA. [10+6]
2. (a) Explain the thermo instrument for measuring both AC and DC.
   (b) Write short notes on crossed-coil PF meter. [8+8]
3. (a) Give the schematic diagram of a balanced bridge DC amplifier used in electronic analog voltmeters and explain its working.
   (b) What would true RMS reading meter indicate if a pulse wave from of 5 volts peak and a 25% duty cycle applied? What would the meter indicate if a 5volt DC input were applied (assume the meter has DC capability). [8+8]
4. (a) What do you understand by Q of an inductor, explain with reference to series resonant circuit?
   (b) Give one method of measurement of Q of a coil. [8+8]
5. (a) With neat circuit diagram, explain the function of associated circuits that are used for CRT operation.
   (b) Explain how the light is emitted on the screen of a CRO. [10+6]
6. (a) With a neat block diagram explain working operation of storage oscilloscope.
   (b) Compare storage oscilloscope with ordinary oscilloscope. [10+6]
7. (a) What is the difference between a wave analyzer and harmonic distortion analyzer?
   (b) Explain with the help of block diagram the working of a harmonic distortion analyzer? [8+8]
8. (a) Explain the basic principle and working of an electronic frequency counter. Also explain how period can be measured.
   (b) List the detailed specifications of electronic frequency counters. [10+6]

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Code No: RR221001 **Set No. 2**

II B.Tech Supplimentary Examinations, Aug/Sep 2008
ELECTRICAL AND ELECTRONICS MEASUREMENTS
(Common to Electronics & Instrumentation Engineering and Electronics & Control Engineering)

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

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1. (a) With the help of a neat sketch explain the principle and working of permanet-magnet moving coil(PMMC)deflection mechanism. Derive the expression for torque developed. [2+2+4+4]
   (b) Explain about Ayrton shunt used in ammeters. [4]
2. Explain in detail the principle, working, and constructional details of current transformer and potential transformer. [8+8]
3. Draw the block diagram of a dual-slope digital volt meter and explain how it is advantageous to use dual slope A/D converter in DUM? [4+8+4]
4. (a) What do you understand by Q of an inductor, explain with reference to series resonant circuit?
   (b) Give one method of measurement of Q of a coil. [8+8]
5. (a) With neat circuit diagram, explain the function of associated circuits that are used for CRT operation.
   (b) Explain how the light is emitted on the screen of a CRO. [10+6]
6. (a) What are the major components of a CRT and explain the working function of each?
   (b) Why are operating voltages of CRT arranged so that the deflection plates are nearly at ground potential? [10+6]
7. (a) Explain the term Capability of a 'phase lock' connected with function generator.
   (b) Explain briefly about various types of signal generators.
   (c) What is the necessity to have TTL output on a signal generator and a frequency counter? [4+8+4]
8. (a) Explain the basic principle and working of an electronic frequency counter. Also explain how period can be measured.
   (b) List the detailed specifications of electronic frequency counters. [10+6]

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Code No: RR221001 **Set No. 3**

II B.Tech Supplimentary Examinations, Aug/Sep 2008
ELECTRICAL AND ELECTRONICS MEASUREMENTS
(Common to Electronics & Instrumentation Engineering and Electronics & Control Engineering)

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

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1. (a) Derive the value of Torque and Deflection of the galvanometer with its dynamic behavior.
   (b) What value of shunt resistance is required for using 50μA meter movement with an internal resistance of 250Ω for measuring 0-500mA. [10+6]
2. Explain with suitable diagram a three-phase measurement application using an Instrument Transformer. [6+10]
3. (a) Give the schematic diagram of a balanced bridge DC amplifier used in electronic analog voltmeters and explain its working.
   (b) What would true RMS reading meter indicate if a pulse wave from of 5 volts peak and a 25% duty cycle applied? What would the meter indicate if a 5volt DC input were applied (assume the meter has DC capability). [8+8]
4. (a) What do you understand by Q of an inductor, explain with reference to series resonant circuit?
   (b) Give one method of measurement of Q of a coil. [8+8]
5. (a) With neat circuit diagram, explain the function of associated circuits that are used for CRT operation.
   (b) Explain how the light is emitted on the screen of a CRO. [10+6]
6. (a) Explain the working functions of each block of a sampling oscilloscope in full detail.
   (b) Compare the merits and demerits of sampling oscilloscope. [10+6]
7. (a) Explain the term Capability of a 'phase lock' connected with function generator.
   (b) Explain briefly about various types of signal generators.
   (c) What is the necessity to have TTL output on a signal generator and a frequency counter? [4+8+4]
8. (a) Explain the basic principle and working of an electronic frequency counter. Also explain how period can be measured.
   (b) List the detailed specifications of electronic frequency counters. [10+6]

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Code No: RR221001 **Set No. 4**

II B.Tech Supplimentary Examinations, Aug/Sep 2008
ELECTRICAL AND ELECTRONICS MEASUREMENTS
(Common to Electronics & Instrumentation Engineering and Electronics & Control Engineering)

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

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1. (a) Explain Tant-band suspension. [6]
   (b) Draw the schematic, including values for an Ayrton shunt for a meter movement having full- scale deflection of 1mA and an internal resistance of 500Ω to cover the current ranges of 10, 50, 100 and 500mA. [5+5]
2. (a) Explain in detail the measurement of power using electrodynamometer.
   (b) Write short notes on watt-hour meter. [8+8]
3. Draw the block diagram of a dual-slope digital volt meter and explain how it is advantageous to use dual slope A/D converter in DUM? [4+8+4]
4. (a) What do you understand by Q of an inductor, explain with reference to series resonant circuit?
   (b) Give one method of measurement of Q of a coil. [8+8]
5. (a) With neat circuit diagram, explain the function of associated circuits that are used for CRT operation.
   (b) Explain how the light is emitted on the screen of a CRO. [10+6]
6. (a) What is a Probe? What are the advantages of using an active voltage probe?
   (b) What is delayed sweep? When it is used?
   (c) Why is an attenuator probe used? [6+4+6]
7. (a) What are the precautionary measures to be considered in a signal generator. And how can they be achieved?
   (b) Discuss in detail about RF signal generators. [6+10]
8. (a) Draw the block diagram of a general purpose frequency counter and explain it in detail.
   (b) What is the necessity of a time and frequency comparison instruments? Explain.
   (c) What are the reasons of the fluctuations in frequency standards and discuss its effect. [8+4+4]

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Code No: RR310202 **Set No. 1**

III B.Tech I Semester Supplimentary Examinations, November 2008
ELECTRICAL MEASUREMENTS
(Electrical & Electronic Engineering)

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

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1. (a) What are the errors that occur in moving iron instruments with alternating current only? Discuss how can we eliminate those errors.
   (b) The law of deflection of a moving iron ammeter is given by $I = 40^n$ amperes where θ is the deflection in radian and n is a constant. The self-inductance when the meter current is zero is 10mH. The spring constant is 0.16 Nm/rad.
      i. Determine an expression for self-inductance of the meter as a function of θ and n.
      ii. With n=0.75 calculate the meter current and the deflection that corresponds to a self inductance of 60mH. [8+8]

2. (a) Why electro static instruments cannot be used for measurement of low voltages while electromagnetic instruments can be? Illustrate your answer with some specific example comparing the energy densities produced in electrostatic instruments and electromagnetic instruments.
   (b) The movable range of a quadrant electrometer turns through 40 scale divisions when it is idiostatically connected to a potential of 100V. When it is used heterostatically with the quadrants connected to a small voltage "e"? and the needle to a 100v supply, the deflection is 15 scale divisions. Determine the voltage "e". [8+8]

3. (a) Explain how the power in a 3 phase system is measured by the use of
      i. only one wattmeter
      ii. two wattmeters. Indicate how the power factor is determined.
   (b) A non inductive resistance is connected in series with a coil across a 230V, 50Hz supply. The current is 1.8A and the potential difference across the resistance and the coil is 80 & 171 volts respectively. Calculate
      i. resistance & inductive reactance of the coil
      ii. the supply power & pf [8+8]

4. (a) Draw a neat circuit diagram of a single phase watt hour meter and explain its working. What are the various sources of errors and how they are compensated?
   (b) A large consumer has a KVA demand R a KVAh tariff measured by "Sine" R "cosine" watthour type meters each equipped with a Merz price demand indicator. The tariff is Rs.40 per month per KVA of demand plus 30 paise per KVAh. Determine the monthly bill for 30 days based upon the following

readings: 'Sine' meter advances by 90,000 reactive KVAR demand indicator 150 KVAR, 'cosine' meter advances by 120,000 kwh & demand indicator by 200kw. What is the average monthly pf and the total cost per unit? [8+8]

5. With a neat sketch explain the working and construction of electro resonance type power factor meters. Draw the phasor diagrams under different power factor conditions. [16]

6. Describe the construction and working of a polar type potentiometer. How is it standardized? What are the functions of the transfer instrument and the phase shifting transformer? [16]

7. (a) Explain why Maxwell's inductance - capacitance bridge is useful for measurement of coils having storage factor between 1 and 10.

   (b) An ac bridge circuit is working at 1000Hz. Arm ab is 0.2μF pure capacitance, arm bc is a 500Ω pure resistance, arm cd contains an unknown impedance and arm da has a 300Ω resistance in parallel with a 0.1μF capacitor. Find the R and C (or) L constants of arm cd considering it as a series circuit. [8+8]

8. Describe a method of experimental determination of flux density in a specimen of magnetic material using a ballistic glavanometer [16]

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Code No: RR310202 **Set No. 2**

III B.Tech I Semester Supplimentary Examinations, November 2008
ELECTRICAL MEASUREMENTS
(Electrical & Electronic Engineering)

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

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1. (a) How would you extend the range of dc ammeters and voltmeters? Explain with suitable diagrams.
   (b) Show that for a.c. operation, the time constant of the shunt and the ammeter must be equal for an accurate reading at all frequencies. [8+8]

2. (a) Discuss with neat diagrams, the theory and working of an electro static voltmeter of the quadrant type. Draw the connections for
      i. heterostatically connected
      ii. ideostatically connected instruments.
   (b) Derive an expression for the force of attraction between the plates in a parallel plate electrostatic voltmeter. [10+6]

3. (a) Explain the errors caused due to pressure coil inductance and pressure coil capacitance in electro dynamometer wattmeter.
   (b) Discuss the shape of scale of electro dynamometer wattmeters with the help of a neat sketch. [8+8]

4. (a) Draw a neat sketch showing the construction of a single phase induction type energy meter. Give the theory & operation of the instrument
   (b) An energy meter is designed to make 100 revolutions of the disc for one unit of energy. Calculate the no. of revolutions made by it when connected to a load carrying 20A at 230volts at 0.8 pf for an hour. If it actually makes 360 revolutions, find the percentage error. [8+8]

5. With a neat sketch explain the working and construction of electro resonance type power factor meters. Draw the phasor diagrams under different power factor conditions. [16]

6. Describe the construction and working of a polar type potentiometer. How is it standardized? What are the functions of the transfer instrument and the phase shifting transformer? [16]

7. (a) Discuss advantages and disadvantages of D'Sauty Bridge
   (b) Describe the working of a low voltage schering bridge. Derive the equations for capacitance and dissipation Factor. Draw the phasor diagram of the bridge under balanced conditions. [8+8]

8. (a) Give advantages of Burrow's permeameter with respect to others.

(b) A ring having a mean diameter of 0.3m and a cross-sectional area $400mm^2$ has a primary winding of 80 turns wound uniformly. The secondary winding of 30 turns is connected to a fluxmeter having a constant of $0.12x10^{-3}$ weber turn per division. A deflection of 46 divisions is observed when a current of 2A is reversed in the primary winding. Calculate the relative permeability of iron. [8+8]

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Code No: RR310202

Set No. 3

III B.Tech I Semester Supplimentary Examinations, November 2008
ELECTRICAL MEASUREMENTS
(Electrical & Electronic Engineering)

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

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1. (a) What are the different types of instruments that are used as ammeters and voltmeters? What are the errors that occur in ammeters and voltmeters?
   (b) Describe how can we obtain different voltage ranges by using a multirange dc voltmeter. Discuss about sensitivity and loading effects of PMMC voltmeters. [8+8]

2. (a) Explain the construction and working of an attracted disc type Kelvin absolute electrometer. What are its advantages and disadvantages? Can it be used for measurement of low voltages such as 100V? If not why?
   (b) The plates of an absolute electrometer, which are 250mm in diameter and 20mm apart are charged to a potential difference of 10KV, calculate the force of attraction between the plates and the charge on each. [10+6]

3. Explain the following errors for electro dynamometer wattmeters.
   (a) Mutual inductance effects
   (b) Errors due to connections
   (c) Eddy currents
   (d) Stray Magnetic fields
   (e) Vibration of Moving system
   (f) Tempetature errors [16]

4. (a) Explain how KVAh & KVA measurements can be done with the help of a trivector meter
   (b) Explain the method of testing a.c. meters by phantom loading [8+8]

5. (a) Find the working current of the slide wire and the rheostat setting
   (b) If the slide wire has divisions marked in mm and each division can be interpolated to one fifth, calculate the resolution of the instrument.
   (c) What is standardization and explain with an example, how it is obtained. [6+4+6]

6. (a) Mention some of the difficulties in measuring of high resistance.
   (b) Derive an expression for insulation resistance of a single core cable. The conductor of a cable has a diameter of 5 mm and the over all diameter of the cable is 35cm. If the insulation resistance of the cable is 16,000Ω/km, calculate the specific resistance of insulating matrial. [6+10]

7. (a) Describe how an Inductance can be measured in terms of capacitance, by using owen‘s bridge. Draw the phasor diagram and explain
   (b) Give the advantages and disadvantages of owen‘s bridge. [12+4]

8. Describe a method of experimental determination of flux density in a specimen of magnetic material using a ballistic glavanometer [16]

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Code No: RR310202 **Set No. 4**

III B.Tech I Semester Supplimentary Examinations, November 2008
ELECTRICAL MEASUREMENTS
(Electrical & Electronic Engineering)

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

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1. (a) How would you extend the range of dc ammeters and voltmeters? Explain with suitable diagrams.
   (b) Show that for a.c. operation, the time constant of the shunt and the ammeter must be equal for an accurate reading at all frequencies. [8+8]

2. (a) Discuss with neat diagrams, the theory and working of an electro static voltmeter of the quadrant type. Draw the connections for
      i. heterostatically connected
      ii. ideostatically connected instruments.
   (b) Derive an expression for the force of attraction between the plates in a parallel plate electrostatic voltmeter. [10+6]

3. (a) Explain how the power in a 3 phase system is measured by the use of
      i. only one wattmeter
      ii. two wattmeters. Indicate how the power factor is determined.
   (b) A non inductive resistance is connected in series with a coil across a 230V, 50Hz supply. The current is 1.8A and the potential difference across the resistance and the coil is 80 & 171 volts respectively. Calculate
      i. resistance & inductive reactance of the coil
      ii. the supply power & pf [8+8]

4. (a) Draw a neat sketch showing the construction of a single phase induction type energy meter. Give the theory & operation of the instrument
   (b) An energy meter is designed to make 100 revolutions of the disc for one unit of energy. Calculate the no. of revolutions made by it when connected to a load carrying 20A at 230volts at 0.8 pf for an hour. If it actually makes 360 revolutions, find the percentage error. [8+8]

5. (a) Write short notes about dial type synchroscope. Electro dynameter power factor meter.
   (b) Write explanatory notes on the frequency meters with illustrative sketches wherever necessary. [8+8]

6. (a) Describe a method by which the insulation resistance to earth of each of a pair of live mains can be measured by a voltmeter of known resistance. Discuss the limitations of the method

(b) The following readings were taken with a 250V, 1000Ω per volt, voltmeter
Between two mains ⇒ 218 volts
Positive main to earth ⇒ 188 volts
Negative main to earth ⇒ 10 volts
Calculate the insulation resistance of each main. [8+8]

7. (a) In Maxwell's Inductance-capacitance bridge the dial of variable capacitor can be made to read the value of unknown inductance directly? How is it done?

   (b) A Maxwell's inductance capacitance bridge is used to measure an unknown inductance in comparison with capacitance.
   The various values at balance : are
   R_2 of arm ad =400Ω
   R_3 of arm bc = 600Ω
   R_4 and C_4 of arm Cd = 1000Ω, 0.5 μ
   Calculate the values of R_1 and L_1 arm ab calculate also the value of storage (Φ) factor of coil if requency is 1000Hz. [8+8]

8. (a) Give advantages of Burrow's permeameter with respect to others.

   (b) A ring having a mean diameter of 0.3m and a cross-sectional area $400mm^2$ has a primary winding of 80 turns wound uniformly. The secondary winding of 30 turns is connected to a fluxmeter having a constant of $0.12x10^{-3}$ weber turn per division. A deflection of 46 divisions is observed when a current of 2A is reversed in the primary winding. Calculate the relative permeability of iron. [8+8]

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Code No: RR320204 **RR** **Set No. 2**

III B.Tech II Semester Supplementary Examinations,May 2010
INSTRUMENTATION
Electrical And Electronics Engineering

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

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1. What are side bands of a modulated signal and explain their presence in the AM and FM signals. [16]

2. (a) Why is a delay line used in the vertical section of the oscilloscopes.
   (b) What are the advantages of dual trace over dual beam for multiple-trace oscilloscopes. [8+8]

3. (a) With the help at a circuit diagram, explain the measurement of low pressure using ionization type gauge.
   (b) Explain the measurement of pressure using resistive transducer. [8+8]

4. (a) What is a torsion bar and how is it used for torque measurement.
   (b) Explain how torque can be measured using an inductive transducer. Give the sketch for arrangement of inductive transducers with respect to shaft. [8+8]

5. Draw the block diagram of the measuring system and explain the each stage with their functions. [16]

6. Explain in detail about piezo electric transducer [16]

7. (a) Discuss the principle of operation of strain gauge. What is gauge factor. Compare some of the important characteristics of metallic and semiconductor type strain gauges.
   (b) A resistive strain gauge with a gauge factor of 2 is fastened to a member which is subjected to a strain of $1x10^{-6}$. If the original value of gauges is 130 ohms, calculate change in resistance. [8+8]

8. Write short notes on:
   (a) Digital phase angle meter
   (b) Vector impedance voltmeter. [8+8]

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III B.Tech II Semester Supplementary Examinations,May 2010
INSTRUMENTATION
Electrical And Electronics Engineering

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

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1. Explain in detail about piezo electric transducer [16]

2. Draw the block diagram of the measuring system and explain the each stage with their functions. [16]

3. (a) What is a torsion bar and how is it used for torque measurement.
   (b) Explain how torque can be measured using an inductive transducer. Give the sketch for arrangement of inductive transducers with respect to shaft. [8+8]

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   (b) A resistive strain gauge with a gauge factor of 2 is fastened to a member which is subjected to a strain of $1x10^{-6}$. If the original value of gauges is 130 ohms, calculate change in resistance. [8+8]

5. What are side bands of a modulated signal and explain their presence in the AM and FM signals. [16]

6. Write short notes on:
   (a) Digital phase angle meter
   (b) Vector impedance voltmeter. [8+8]

7. (a) With the help at a circuit diagram, explain the measurement of low pressure using ionization type gauge.
   (b) Explain the measurement of pressure using resistive transducer. [8+8]

8. (a) Why is a delay line used in the vertical section of the oscilloscopes.
   (b) What are the advantages of dual trace over dual beam for multiple-trace oscilloscopes. [8+8]

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Code No: RR320204 **RR** **Set No. 1**

III B.Tech II Semester Supplementary Examinations,May 2010
INSTRUMENTATION
Electrical And Electronics Engineering

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

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1. What are side bands of a modulated signal and explain their presence in the AM and FM signals. [16]

2. Draw the block diagram of the measuring system and explain the each stage with their functions. [16]

3. Write short notes on:
   (a) Digital phase angle meter
   (b) Vector impedance voltmeter. [8+8]

4. (a) With the help at a circuit diagram, explain the measurement of low pressure using ionization type gauge.
   (b) Explain the measurement of pressure using resistive transducer. [8+8]

5. Explain in detail about piezo electric transducer [16]

6. (a) Why is a delay line used in the vertical section of the oscilloscopes.
   (b) What are the advantages of dual trace over dual beam for multiple-trace oscilloscopes. [8+8]

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   (b) Explain how torque can be measured using an inductive transducer. Give the sketch for arrangement of inductive transducers with respect to shaft. [8+8]

8. (a) Discuss the principle of operation of strain gauge. What is gauge factor. Compare some of the important characteristics of metallic and semiconductor type strain gauges.
   (b) A resistive strain gauge with a gauge factor of 2 is fastened to a member which is subjected to a strain of $1x10^{-6}$. If the original value of gauges is 130 ohms, calculate change in resistance. [8+8]

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Code No: RR320204 **RR** **Set No. 3**

III B.Tech II Semester Supplementary Examinations,May 2010
INSTRUMENTATION
Electrical And Electronics Engineering

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

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1. (a) Discuss the principle of operation of strain gauge. What is gauge factor. Compare some of the important characteristics of metallic and semiconductor type strain gauges.
   (b) A resistive strain gauge with a gauge factor of 2 is fastened to a member which is subjected to a strain of $1x10^{-6}$. If the original value of gauges is 130 ohms, calculate change in resistance. [8+8]
2. Draw the block diagram of the measuring system and explain the each stage with their functions. [16]
3. What are side bands of a modulated signal and explain their presence in the AM and FM signals. [16]
4. Write short notes on:
   (a) Digital phase angle meter
   (b) Vector impedance voltmeter. [8+8]
5. (a) Why is a delay line used in the vertical section of the oscilloscopes.
   (b) What are the advantages of dual trace over dual beam for multiple-trace oscilloscopes. [8+8]
6. Explain in detail about piezo electric transducer [16]
7. (a) What is a torsion bar and how is it used for torque measurement.
   (b) Explain how torque can be measured using an inductive transducer. Give the sketch for arrangement of inductive transducers with respect to shaft. [8+8]
8. (a) With the help at a circuit diagram, explain the measurement of low pressure using ionization type gauge.
   (b) Explain the measurement of pressure using resistive transducer. [8+8]

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Code No: 07A41301 **R07** **Set No. 2**

II B.TECH II SEM–REGULAR/SUPPLEMENTARY EXAMINATIONS MAY - 2010
ELECTRICAL AND ELECTRONICS MEASUREMENTS
Electronics And Control Engineering

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

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1. Explain the following:
   (a) On what principle does D'Arsonval galvanometer operate?
   (b) How an Ammeter can be changed into a voltmeter?
   (c) Why PMMC instruments cannot be used for a.c. measurements?
   (d) What is Ayrton shunt? [4+4+4+4]

2. (a) What are the different applications of Spectrum analyzer?
   (b) Compare the merits and demerits of different types of Spectrum analyzer.
   (c) What are the different types of Distortion analyzer and wave analyzers.[6+6+4]

3. (a) There are two types of connections which can be used for an electrodynamometer type wattmeter, one where the current coil is on load side and second where the pressure coil is on the load side. Explain the errors caused on account of the two connections. Also, explain under what conditions each of the two types of connection should be used?
   (b) A wattmeter has a current coil of 0.03Ω resistance and a pressure coil of 6000Ω resistance. Calculate the percentage error if the wattmeter is so connected that:
      i. the current coil is on the load side,
      ii. the pressure coil is on the load side, if the load takes 20 A at a voltage of 220 V and 0.8p.f. in each case. [10+6]

4. (a) With a neat sketch explain the method of period measurement.
   (b) What are the reasons of fluctuations in frequency standards and discuss its effects. [8+8]

5. With a neat sketch explain the circuit which is capable of measuring DC & AC voltages as well as Current and Resistances in the solid state electronic multimeter. [16]

6. Define Q of a series and parallel resonant circuit. Derive the Q-factors for any one. [16]

7. (a) Write the differences between the Dual trace and Dual beam CRO.
   (b) With a neat sketch explain the operation of 3-bit flash converter in a digital storage oscilloscope . [8+8]

8. A series type ohmmeter designed to operate with a 6V battery. The meter movement has an internal resistance of 2,000Ω and requires a current a 100μA for full scale deflection. The value of R_1 is 49 KΩ.

   (a) Assume the battery voltage has fallen to 5.9V, calculate the value of R_2 required to zero the meter.

   (b) Under the conditions mentioned in part (A), an unknown resistor is connected to the meter causing a 60 percent meter deflection. Calculate the value of the unknown resistance. [16]

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Code No: 07A41301 **R07** **Set No. 4**

II B.TECH II SEM–REGULAR/SUPPLEMENTARY EXAMINATIONS MAY - 2010

ELECTRICAL AND ELECTRONICS MEASUREMENTS

Electronics And Control Engineering

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions

All Questions carry equal marks

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1. Explain the constructional details and working of an electrodynamometer type instrument. [16]

2. (a) Explain the constructional details of PMMC instruments with a neat sketch.
   (b) Explain different errors of PMMC instruments. [10+6]

3. Explain the construction and working of a 3-phase electrodynamometer type of power factor meter. [16]

4. What are the different types of attenuators used in sine wave generators? Discuss in detail. [16]

5. With a neat sketch explain the standard time base generator and give its applications. [16]

6. (a) Name the measurement for which a Vector Voltmeter is used.
   (b) Draw the block diagram of Vector Voltmeter and explain briefly. [8+8]

7. (a) Write short notes on sampling circuit used in Vector Voltmeter and illustrate the process.
   (b) What are the advantages and disadvantages of RF Power and Voltage measurement. [8+8]

8. (a) In the oscilloscope a certain amount of time delay is occurred in transmission of signal voltage to the deflection plates. Why?
   (b) Explain the operation of delay of the vertical signal allows horizontal sweep to start prior to vertical deflection. [8+8]

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Code No: 07A41301 **R07** **Set No. 1**

II B.TECH II SEM–REGULAR/SUPPLEMENTARY EXAMINATIONS MAY - 2010

ELECTRICAL AND ELECTRONICS MEASUREMENTS

Electronics And Control Engineering

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions

All Questions carry equal marks

⋆ ⋆ ⋆ ⋆ ⋆

1. (a) What is probe? What are the advantages of an active voltage probe?
   (b) Why an attenuator probe is used in oscilloscope .
   (c) What is delayed sweep? when it used? [8+4+4]
2. (a) Derive the expression for deflection for a PMMC instrument if it is
      i. spring controlled
      ii. gravity controlled.
      Comment upon the shape of scale in both cases.
   (b) Enlist the advantages and dis-advantages of PMMC meters. [10+6]
3. (a) Derive the expression for ratio error in case of current transformer with a neat phasor diagram.
   (b) Explain the effect of opening the secondary circuit of a current transformer when the primary winding is energized. [10+6]
4. (a) Explain the importance of thermocouples in the construction of true RMS type of Voltmeter.
   (b) What is the necessity of electronic voltmeter? Explain.
   (c) What is multimeter? What are the parameters that can be measured with multimeter? [6+6+4]
5. Draw the circuit diagram of series type ohmmeter. Explain its working principle? What is significance of half scale value? How are the adjustments done in case the battery runs down? How are the zero adjustments made? [16]
6. (a) Discuss about the measurement errors of an electronic counter.
   (b) Write a short notes on
      i. time base generator
      ii. Frequency counter. [8+8]
7. (a) What is phase meter? Mention its type. Discuss the merits and demerits of it.
   (b) With a neat sketch explain the operation of digital phase meter. [8+8]
8. What are the different types of Audio frequency Sine wave oscillator's? Explain any one of them. Discuss the merits and demerits of the same. [16]

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Code No: 07A41301 **R07** **Set No. 3**

II B.TECH II SEM–REGULAR/SUPPLEMENTARY EXAMINATIONS MAY - 2010

ELECTRICAL AND ELECTRONICS MEASUREMENTS

Electronics And Control Engineering

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions

All Questions carry equal marks

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1. (a) Show that the displacement of moving system is equal to the phase angle of the system in case of single phase electrodynamometer type of power factor meter.
   (b) Explain the advantages and dis-advantages of moving iron power factor meters. [8+8]
2. (a) Discuss the merits and demerits of RF generator.
   (b) Discuss the merits and demerits of AF generator. [8+8]
3. Explain the construction and working of PMMC instrument with a neat sketch. [16]
4. Name the different types of oscilloscopes. Compare their merits and demerits along with their applications. [16]
5. (a) With a neat sketch explain a circuit which is capable of measuring RF power.
   (b) With a neat sketch explain a circuit which is capable of measuring voltage. [8+8]
6. (a) List the application of frequency synthesizer. Discuss in brief.
   (b) Explain the standard time base generator with a neat sketch. [8+8]
7. Explain why electrodynamometer type of instruments can be used on a a.c and d.c? Why are these instruments used as transfer instruments? State the advantages and dis-advantages of the above instrument. [16]
8. (a) Explain how Successive approximation DVM performance is better than other DVM's.
   (b) Compare the performance characteristics of different types of DVMs. [8+8]

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Code No: 07A41301 **Set No. 1**

II B.Tech II Semester Regular Examinations, Apr/May 2009
ELECTRICAL AND ELECTRONICS MEASUREMENTS
(Electronics & Control Engineering)

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

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1. Explain the construction and working of PMMC instrument with a neat sketch. [16]

2. Explain the working of a rectifier type of voltmeter. Explain sensitivity of these instruments in measuring a.c. quantities? How does the a.c. sensitivity of rectifier type of instruments compare with their d.c. Sensitivity. [16]

3. Explain the constructional details and principle of operation of an electrodynamometer type wattmeter. [8+8]

4. (a) Explain the importance of thermocouples in the construction of true RMS type of Voltmeter.
   (b) What is the necessity of electronic voltmeter? Explain.
   (c) What is multimeter? What are the parameters that can be measured with multimeter? [6+6+4]

5. Draw the basic blocks of vector impedance meter. Explain the functions of each block. Also give the specifications of the above meter. [16]

6. With a neat sketch explain the digital storage oscilloscope using an analog delay line and give the merits and demerits. [16]

7. (a) What are the different applications of Spectrum analyzer?
   (b) Compare the merits and demerits of different types of Spectrum analyzer.
   (c) What are the different types of Distortion analyzer and wave analyzers. [6+6+4]

8. (a) Explain the extension of the frequency range of frequency counter by automatic heterodyning unit.
   (b) Write a short notes on
      i. time base generator
      ii. Frequency synthesizer. [8+8]

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Code No: 07A41301 **Set No. 2**

II B.Tech II Semester Regular Examinations, Apr/May 2009
ELECTRICAL AND ELECTRONICS MEASUREMENTS
(Electronics & Control Engineering)

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

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1. Derive the equation for deflection if the instrument is spring controlled in permanent magnet moving coil instrument. Also, explain the method of damping used in these instruments. [16]

2. Explain the constructional details and working of an electrodynamometer type instrument. [16]

3. (a) Derive the expression for ratio error in case of current transformer with a neat phasor diagram.
   (b) Explain the effect of opening the secondary circuit of a current transformer when the primary winding is energized. [10+6]

4. A dual slope integrating type A/D Converter has an integrating capacitance of 0.1 microfarads and resistor of 100kohms. If the reference voltage is 5V and the output of the voltage is not exceeding 15V.What is the maximum time the reference voltage can be integrated. Derive the formula used. [16]

5. (a) The self capacitance of a coil is to be measure by Q meter. The first measurement result is $f_1 = 1.5$MHz and C1=550 pF. The second measurement result is $f_2 = 3$ MHz and new value of tuning capacitor is 110 pF. Find the distributed capacitance and the inductance.
   (b) What are the alternate methods used to measure R, L & C in measurement? Name them? [10+6]

6. (a) What is probe? What are the advantages of an active voltage probe?
   (b) Why an attenuator probe is used in oscilloscope .
   (c) What is delayed sweep? when it used? [8+4+4]

7. (a) Discuss in detail about Audio frequency wave generator.
   (b) What are the precautionary measures to be considered in a signal generator? Explain how they can be achieved. [9+7]

8. (a) Give the importance of time base in a digital frequency counter.
   (b) Why frequency synthesizer is required? Discuss the alternate methods for frequency synthesizing. [6+10]

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Code No: 07A41301 **Set No. 3**

II B.Tech II Semester Regular Examinations, Apr/May 2009
ELECTRICAL AND ELECTRONICS MEASUREMENTS
(Electronics & Control Engineering)

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

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1. Derive the equation for deflection if the instrument is spring controlled in permanent magnet moving coil instrument. Also, explain the method of damping used in these instruments. [16]

2. (a) Explain the principle of operation of thermoelectric instruments?
   (b) Give the constructional details of thermoelectric instruments. [8+8]

3. (a) There are two types of connections which can be used for an electrodynamometer type wattmeter, one where the current coil is on load side and second where the pressure coil is on the load side. Explain the errors caused on account of the two connections. Also, explain under what conditions each of the two types of connection should be used?
   (b) A wattmeter has a current coil of 0.03Ω resistance and a pressure coil of 6000Ω resistance. Calculate the percentage error if the wattmeter is so connected that:
      i. the current coil is on the load side,
      ii. the pressure coil is on the load side, if the load takes 20 A at a voltage of 220 V and 0.8p.f. in each case. [10+6]

4. (a) Explain the importance of thermocouples in the construction of true RMS type of Voltmeter.
   (b) What is the necessity of electronic voltmeter? Explain.
   (c) What is multimeter? What are the parameters that can be measured with multimeter? [6+6+4]

5. (a) Write a short notes on source of error encountered in capacitance measuring meter.
   (b) Give one method of measurement of Q of a coil . [8+8]

6. (a) What is probe? What are the advantages of an active voltage probe?
   (b) Why an attenuator probe is used in oscilloscope .
   (c) What is delayed sweep? when it used? [8+4+4]

7. With a neat sketch explain the operation of RF generator and compare the performance with Audio Frequency generator. [16]

8. (a) What is long term crystal stability? Explain the reason for it.

(b) If the internal time base of a frequency counter is 10MHz, What frequency range is best that is measured by a conventional frequency measurement and why?

(c) Define trigger level error. [6+6+4]

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Code No: 07A41301 **Set No. 4**

II B.Tech II Semester Regular Examinations, Apr/May 2009
ELECTRICAL AND ELECTRONICS MEASUREMENTS
(Electronics & Control Engineering)

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

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1. Explain the constructional details and principle of operation of a d'Arsonval galvanometer with a neat figure. [16]

2. Explain the construction and working of a shunt type ohmmeter. Write down its design equations. Why are series type ohmmeters preferred over shunt type ohmmeters? [16]

3. Explain the constructional details and principle of operation of an electrodynamometer type wattmeter. [8+8]

4. (a) Explain the importance of thermocouples in the construction of true RMS type of Voltmeter.
   (b) What is the necessity of electronic voltmeter? Explain.
   (c) What is multimeter? What are the parameters that can be measured with multimeter? [6+6+4]

5. Define Q of a series and parallel resonant circuit. Derive the Q-factors for any one. [16]

6. (a) What is probe? What are the advantages of an active voltage probe?
   (b) Why an attenuator probe is used in oscilloscope .
   (c) What is delayed sweep? when it used? [8+4+4]

7. (a) With a neat sketch explain the Digital FFT Spectrum analyzer .
   (b) Discuss the different applications of spectrum analyzer. [8+8]

8. (a) Why period measurement is preferred in low frequencies?
   (b) Explain a method to measure the ratio of two frequencies using suitable block diagram. [6+10]

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Code No: NR221001 **NR**

II B.Tech II Semester Supplementary Examinations,
November/December 2005
ELECTRICAL AND ELECTRONICS MEASUREMENTS
(Common to Electronics & Instrumentation Engineering and Electronics & Control Engineering)

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

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1. (a) How do you extend the range of a given voltmeter? Draw the circuit and derive the expressions for the component values to be used. [4+4+4]
   (b) Explain about Ayrton shunt used in ammeters. [4]
2. (a) With a neat sketch explain the principle and works of thermocouple meter. Mention advantages. [8]
   (b) The multimeter movement has an internal resistance of 150n and requires 1.5mA for full-scale deflection. Two diodes $D_1$and D_2 have an average forward resistance of 500Ωeach. An R_{sh} is placed across the meter with 150Ω. The diode offer infinite resistance when reverse biased. For a 15V a.c range calculate
      i. The multiplier value R_s.
      ii. The Sensitivity of voltmeter on the a.c range.

   [5+3]
3. Explain in detail the working of stair case Ramp DVM, giving the block diagram. Compare its performance with other types of DVMs. [8+4+4]
4. (a) What are the constituent elements of a Digital Multimeter?
   (b) For measuring small values of capacitance, a 60 MHz source is to be used in a capacitance meter. What value of series resistance is required if the phase shift is to be kept below 5.7deg for full scale capacitance reading of 1,10, and 100 PF. [8+8]
5. (a) With neat block diagram explain the working function of each block of general purpose oscilloscope.
   (b) Mention the advantages of general purpose oscilloscope. [10+6]
6. (a) How does the sampling oscilloscope increase the apparent frequency response of an oscilloscope?
   (b) What precautions must be taken when using a sampling oscilloscope? [10+6]
7. (a) Explain the term Capability of a 'phase lock' connected with function generator.
   (b) Explain briefly about various types of signal generators.

(c) What is the necessity to have TTL output on a signal generator and a frequency counter? [4+8+4]

8. (a) Explain an automated frequency counter using block diagram.

   (b) If the internal time base of a frequency counter is 15MHz, what frequency range is best measured by a period measurement and why. [10+6]

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Code No: NR221001 **NR**

II B.Tech II Semester Supplimentary Examinations, Apr/May 2009
ELECTRICAL AND ELECTRONICS MEASUREMENTS
(Common to Electronics & Instrumentation Engineering and Electronics & Control Engineering)

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

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1. (a) With the help of a neat sketch explain the principle and working of permanet-magnet moving coil(PMMC)deflection mechanism. Derive the expression for torque developed. [2+2+4+4]
   (b) Explain about Ayrton shunt used in ammeters. [4]
2. (a) Explain principle and working of power factor meter. [10]
   (b) Calculate the value of series resistance required to extend the 0-150V range of a 22,000Ω/V meter to 0-1000V? Also find the power rating. [4+2]
3. (a) How can one select Digital volt meter? What are the outstanding qualities to make the selection? [3+3]
   (b) Classify the Digital voltmeters. Explain the operating principle of one of the above Digital Voltmeters. [2+8]
4. Write a notes on sources of error encountered in capacitance measuring meter. Explain parasitic inductance, resistance and capacitance. [4+4+4+4]
5. (a) With neat block diagram explain the working function of each block of general purpose oscilloscope.
   (b) Mention the advantages of general purpose oscilloscope. [10+6]
6. (a) Explain the working functions of each block of a sampling oscilloscope in full detail.
   (b) Compare the merits and demerits of sampling oscilloscope. [10+6]
7. (a) With a block diagram explain AF sine -square wave oscillator.
   (b) Explain the different front panel controls of a signal generator. Give the specifications with typical values. [10+6]
8. (a) Draw and explain the block diagram of a multiple period measuring system for measuring oscillator deviations.
   (b) Derive the expression for the deviation in measurement the above system. [10+6]

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Code No: NR310202 **NR**

III B.Tech I Semester Supplementary Examinations, April/May 2005
ELECTRICAL MEASUREMENTS
(Electrical & Electronic Engineering)

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks
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1. (a) Discuss why indicating instruments with gravity control have a non-uniform scale and with spring control have a uniform scale? Explain.
   (b) Compare air-friction damping, fluid friction damping, eddy-current damping which have been used for producing damping torque in an indicating instrument.
2. Draw the equivalent circuit and phasor diagram of a current transformer.Derive the expressions for ratio and phase angle errors.
3. (a) With suitable diagram explain the working of electrodynamometer type frequency meter.
   (b) Write short notes on Synchroscope.
4. (a) Why trivector meter is used? Explain its working.
   (b) An energy meter is designed to make 100 revolutions of disc for one unit of energy. Calculate the number of revolutions made by it when connected to load carrying 40 amps at 230 volts and 0.4 power factor for an hour. If it actually makes 360 revolutions, find the percentage error.
5. (a) With a neat sketch explain the operation of a potentiometer what is standardization ? How is it achieved?
   (b) A simple slide wire is used for measurement of current in a circuit. The voltage drop across a standard resistor of 0.1Ω is balanced at 75cm . Find the magnitude of the current if the standard cell emf of 1.45 V is balanced at 50cm.
6. (a) An electrically deflected CRT has a final anode voltage of 2000v and parallel deflecting plates of 1.5cm long and 5mm apart. If the screen in 50 cm from the centre of deflecting plates find
      i. beam speed
      ii. the deflection sensitivity of the tube
      iii. the deflection factor of the tube.
   (b) A lissajous pattern on an oscilloscope is stationary and has 5 horizontal tangencies and 2 vertical tangencies. The frequency of horizontal input is 1000Hz. Determine the frequency of vertical input.
7. (a) With neat sketches, explain the measurement of capacitance using low voltage schering bridge.

(b) Explain the special features of high voltage schering bridge and show how capacitance value can be measured.

8. (a) Describe the Epstein square method for finding the iron losses in the square specimen.

   (b) The Hysteresis loop for an iron specimen is drawn to a scale of 1cm : 200Amp/metre and 1cm : 0.1T. The area of the loop is 50 Sq.cm. Assuming the density of the specimen to be 7.5 gm/cc. Calculate the hysteresis loss in watts/kg at 50 HZ supply.

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1.a With a neat sketch explain PMMC instrument. Derive expression for deflecting torque.Write advantages & dis advantages

Permanent Magnet Moving Coil Instruments (PMMC)

The permanent magnet moving coil instruments are most accurate type for d.c.measurements.The action of these instruments is based on the motoring principle. When a current carrying coil is placed in the magnetic field produced by permanent magnet, the coil experiences a force and moves.As the coil is moving and the magnet is permanent, the instrument is called permanent magnet moving coil instrument. This basic principle is called **D'Arsonval principle.** The amount of force experienced by the coil is proportional to the current passing through the coil.

The PMMC instrument is shown in the Fig.

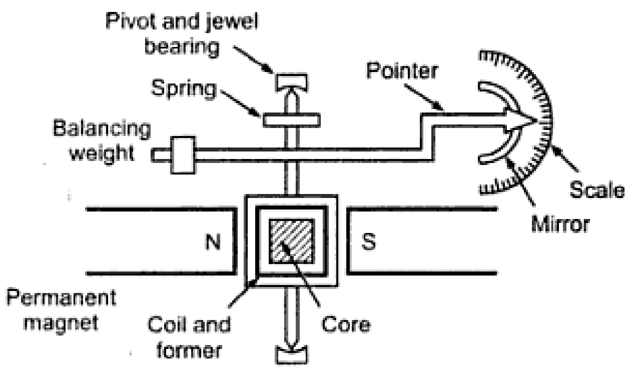


Fig. Construction of PMMC instrument

The moving coil is either rectangular or circular in shape. It has number of turns of fine wire. The coil is suspended so that it is free to turn about its vertical axis. The coil is placed in uniform, horizontal and radial magnetic field of a permanent magnet in the shape of a horse-shoe. The iron core is spherical if coil is circular and is cylindrical if the coil is rectangular. Due to iron core, the deflecting torque increases, increasing the sensitivity of the instrument.

The controlling torque is provided by two phosphor bronze hair springs.

The damping torque is provided by eddy current damping. It is obtained by movement of the aluminium former, moving in the magnetic field of the permanent magnet.

The pointer is carried by the spindle and it moves over a graduated scale. The pointer has light weight so that it can deflect rapidly. The mirror is placed below the pointer to get the accurate reading by removing the parallax. The weight of the instrument is normally counter balanced by the weights situated diametrically opposite and rigidly connected to it. The scale markings of the basic d.c. PMMC instruments are usually linearly spaced as the deflecting torque and hence the pointer deflection are directly proportional to the current passing through the coil.

In a practical PMMC instrument, a Y shaped member is attached to the fixed end of the front control spring. An eccentric pin through the instrument case engages the Y shaped member so that the zero position of the pointer can be adjusted from outside.

Torque Equation

The equation for the developed torque can be obtained from the basic law of the electromagnetic torque. The deflecting toque is given by,

$$\boxed{T_d = NBAI}$$

where T_d = deflecting torque in N-m

B = flux density in air gap, Wb/m^2

N = number of turns of the coil

A = effective coil area m^2

I = Current in the moving coil, amperes

$\therefore \quad T_d = GI$

where $G = NBA$ = constant

The controlling torque is provided by the springs and is proportional to the angular deflection of the pointer.

$$T_c = K\theta$$

where T_c = controlling torque

K = spring constant, Nm/rad or Nm/deg

θ = angular deflection

For the final steady state position,

$$T_d = T_c$$

$$\therefore \quad GI = K\theta$$

$$\therefore \quad \theta = \left(\frac{G}{K}\right)I$$

or

$$\boxed{I = \left(\frac{K}{G}\right)\theta}$$

Key Point : *Thus the deflection is directly proportional to the current passing through the coil.*

The pointer deflection can therefore be used to measure current.

As the direction of the current through the coil changes, the direction of the deflection of the pointer also changes. Hence such instruments are well suited for the d.c. measurements.

Advantages

The various advantages of PMMC instruments are,

1) It has uniform scale.
2) With a powerful magnet, its torque to weight ratio is very high. So operating current is small.
3) The sensitivity is high.
4) The eddy currents induced in the metallic former over which coil is wound, provide effective damping.
5) It consumes low power, of the order of 25 W to 200 μW.
6) It has high accuracy.
7) Instrument is free from hysteresis error.
8) Extension of instrument range is possible.
9) Not affected by external magnetic fields called stray magnetic fields.

Disadvantages

The various disadvantages of PMMC instruments are,

1) Suitable for d.c. measurements only.
2) Ageing of permanent magnet and the control springs introduces the errors.
3) The cost is high due to delicate construction and accurate machining.
4) The friction due to jewel-pivot suspension.

1.b Explain different methods for the production of Damping Torque

Damping System

The deflecting torque provides some deflection and controlling torque acts in the opposite direction to that of deflecting torque. So before coming to the rest, pointer always oscillates due to inertia, about the equilibrium position.Unless pointer rests, final reading can not be obtained. So to bring the pointer to rest within short time, damping system is required. The system should provide a damping torque only when the moving system is in motion. Damping torque is proportional to velocity of the moving system but it does not depend on operating current. It must not affect controlling torque or increase the friction.

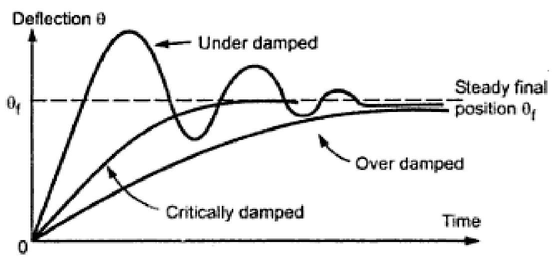


Fig.

The quickness with which the moving system settles to the final steady position depends on relative damping. If the moving system reaches to its final position rapidly but smoothly without oscillations, **the instrument is said to be critically damped.** If the instrument is **under damped,** the moving system will oscillate about the final steady position with a decreasing amplitude and will take sometime to come to rest. While the instrument is said to be **over damped** if the moving system moves slowly to its final steady position. In over damped case the response of the system is very slow and sluggish. In practice slightly damped case the response of the system is very slow and sluggish. In practice slightly under damped systems are preferred. The time response of damping system for various types of damping conditions is shown in the Fig.

The following methods are used to produce damping torque.

1) Air friction damping 2) Fluid friction damping 3) Eddy current damping.

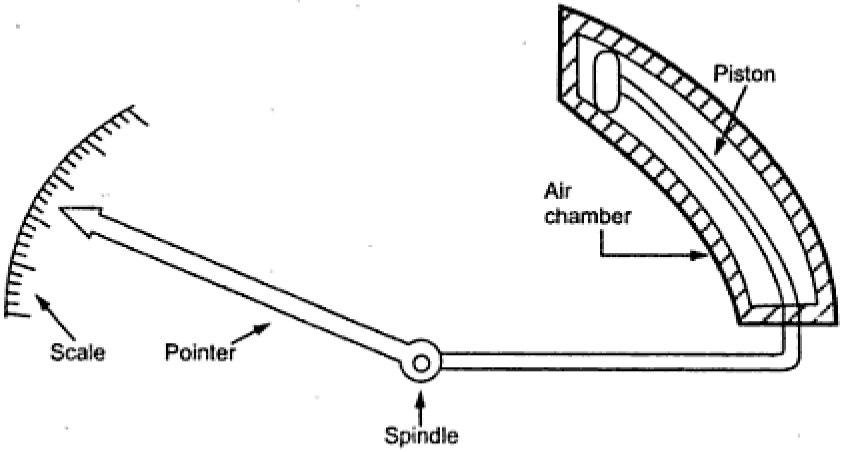


Fig. Air friction damping

This arrangement consists of a light aluminium piston which is attached to the moving system, as shown in the Fig.

Eddy Current Damping

This is the most effective way of providing damping. It is based on the **Faraday's law** and **Lenz's law**. When a conductor moves in a magnetic field cutting the flux, e.m.f. gets induced in it. And direction of this e.m.f. is so as to oppose the cause producing it.

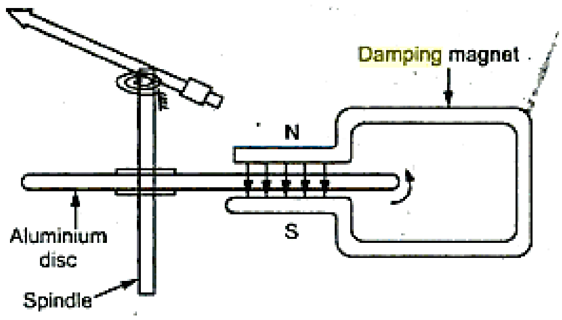


Fig. Eddy current damping

In this method, an aluminium disc is connected to the spindle. The arrangement of disc is such that when it rotates, it cuts the magnetic flux lines of a permanent magnet. The arrangement is shown in the Fig.

When the pointer oscillates, aluminium disc rotates under the influence of magnetic field of damping magnet. So disc cuts the flux which causes an induced e.m.f. in the disc. The disc is a closed path hence induced e.m.f.circulates current through the disc called **eddy current**. The direction of such eddy current is so as oppose the cause producing it. The cause is relative motion between disc and field. Thus it produces an opposing torque so as to reduce the oscillations of pointer. This brings pointer to rest quickly. This is most effective and efficient method of damping.

The piston moves in a fixed air chamber. It is close to one end. The clearance between piston and wall chambers is uniform and small. The piston reciprocates in the chamber when there are oscillations. When piston moves into the chamber, air inside is compressed and pressure of air developed due to friction opposes the motion of pointer. There is also opposition to motion of moving system when piston moves out of the chamber. Thus the oscillations and the overshoot gets reduced due to to and fro motion of the piston in the chamber, providing necessary damping torque. This helps in settling down the pointer to its final steady position very quickly.

Fluid Friction Damping

Fluid friction damping may be used in some instruments. The method is similar to air friction damping, only air is replaced by working fluid. The friction between the disc and fluid is used for opposing motion. Damping force due to fluid is greater than that of air due to more viscosity. The disc is also called vane.

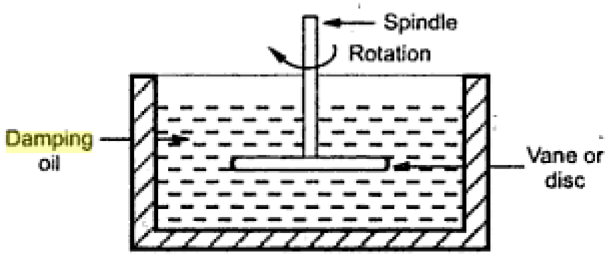


Fig. Fluid friction damping

The arrangement is shown in the Fig. 1.6. It consists of a vane attached to the spindle which is completely dipped in the oil. The frictional force between oil and the vane is used to produce the damping torque, which opposes the oscillating behaviour of the pointer.

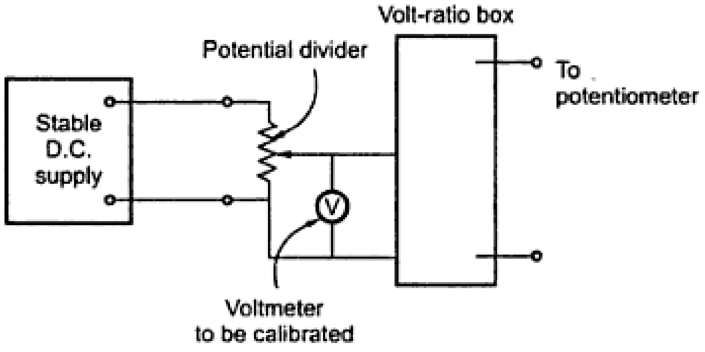
2.a What are the different applications of DC Potentiometers? Explain

Applications of D.C. Potentiometers

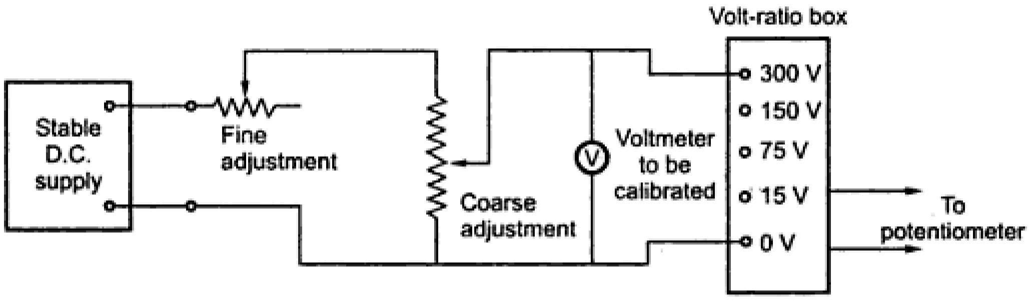
The main application of d.c. potentiometer is measurement of voltage. But it may be also used for measurement of resistance, current and power. The d.c. potentiometer is also useful in the calibration of voltmeters, ammeters, wattmeters etc. Let us take a review of few applications of d.c. potentiometers.

Calibration of Voltmeter

The practical set up for calibration of voltmeter is as shown in the Fig. (a) & (b).



(a)



(b)

Fig. Calibration of voltmeter

In both the circuits the concept used is of potential divider. The main important requirement of these circuits is the use of very stabilized D.C. supply. The only difference is that in the second circuit two rheostats used which are useful in coarse and fine adjustment. With these adjustments it is possible to adjust a voltage such that the pointer of voltmeter exactly coincides the major division. The voltage across voltmeter is stepped down using volt-ratio box. For high accuracy it is advisable to measure voltages near the maximum range of potentiometer.

Calibration of Wattmeter

By using d.c. potentiometer it is possible to calibrate wattmeter too. The practical setup is as shown in the Fig. 5.15.

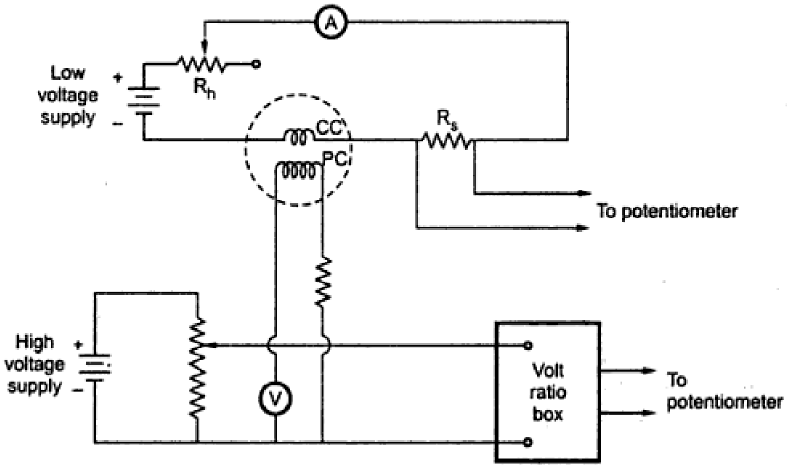


Fig. Calibration of wattmeter

A low voltage supply supplies a current to current coil (CC) of wattmeter. This current is adjusted by using a rheostat R_h in series with low voltage supply. The potential divider circuit is supplied by a high voltage supply. The voltage is stepped down by volt-ratio box and the tappings are adjusted accordingly. A voltmeter measures voltage V and ammeter measures current I which gives true power as,

$$W_{ind} = V\,I$$

This value can be compared with a value indicated by wattmeter. If two values are not matching, a positive or negative error is indicated which is given by,

$$\%\ \text{error} = \frac{W_{ind} - W_{act}}{W_{ind}} \times 100$$

Measurement of Resistance

The set up for measurement of resistance is as shown in the Fig. 4.14.

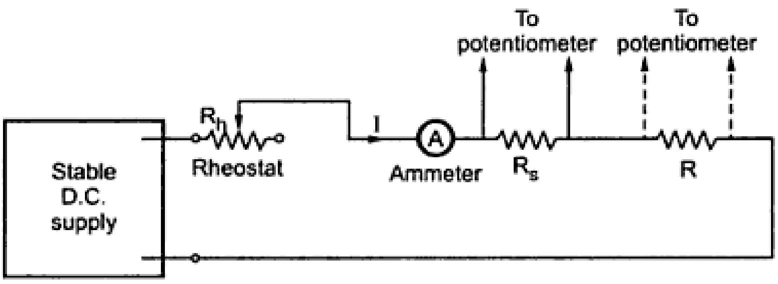


Fig. Measurement of unknown resistance

A resistor whose resistance is to be measured is connected in series with a standard resistor of resistance R_s. The current through the circuit is supplied by a stable D.C. supply and it is controlled by a rheostat R_h. The current is adjusted such that the drop across each resistors is of the order of 1V. Due to the current I, voltages are developed across R_s and R. Both are then measured by using a dc potentiometer.

Let the voltage across standard resistance be V_{RS}. Then, we can write,

$$V_{RS} = I\,R_s \qquad \text{... (1)}$$

Let the voltage across unknown resistance be V_R. Then, we can write, Let the voltage across unknown resistance be V_R. Then, we can write,

$$V_R = I R \quad \text{... (2)}$$

Dividing (2) by (1),

$$\frac{V_R}{V_{RS}} = \frac{R}{R_s}$$

Hence the unknown resistance is given by,

$$R_s = R\left(\frac{V_R}{V_{RS}}\right) \quad \text{... (3)}$$

The basic requirement of above measurement method is that the current flowing through the circuit should remain same during measurement of voltages across R and R_s. This need can be fulfilled by using a stabilized D.C. supply at the input.

Measurement of Power

The circuit diagram for measurement of power is as shown in the Fig.

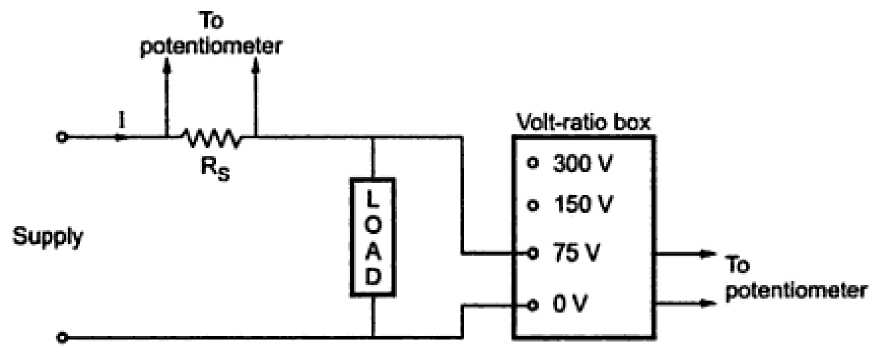


Fig. Measurement of power

The power across load can be calculated as,

$$P = I V$$

In above circuit, voltage across standard resistance R_s is measured using potentiometer. Let it be V_{RS}. Then current flowing through it is given by,

$$I = \frac{V_{RS}}{R_s} \quad \text{... (4)}$$

For the measurement of voltage V across load, volt ratio box is connected across load. The output of volt-ratio box is then connected to potentiometer. Let it be V. Then the voltage across load is given by

$$V = k\,V_R \quad \text{... (5)}$$

where k is the multiplying factor of volt ratio box and V_R is actual reading of potentiometer when it is connected across volt-ratio box. Thus from equation (4) and (5), the power is given by,

$$P = V\,I = (k\,V_R)\left(\frac{V_{RS}}{R_s}\right)$$

$$P = k\left(\frac{V_R\,V_{RS}}{R_s}\right) \quad \text{... (6)}$$

2.b.

Example : *Design a volt-ratio box with a resistance of 20 Ω/V and ranges 3 V, 10 V, 30 V, 100 V. The volt-ratio box is to be used with a potentiometer having a measuring range of 1.6 V.*

Solution : Let the output voltage of potentiometer be 1.5 V. The resistance of volt-ratio box per volt is 20 Ω/V.

∴ Total output resistance R = (20) (1.5) = 30 Ω

For volt-ratio box,

$$\text{Actual voltage measured } (V_A) = \begin{bmatrix}\text{Measured voltage} \\ \text{on potentiometer}(V_m)\end{bmatrix}\left[\frac{\text{Resistance of tapping}}{\text{Output resistance of potentiometer}}\right]$$

From above relationship, for given range of voltages we can calculate the resistance of tapping as follows,

$$\text{Resistance of tapping} = R = \left[\frac{\text{Actual voltage measured } (V_A)}{\text{Measured voltage on potentiometer } (V_m)}\right]\begin{bmatrix}\text{Output resistance} \\ \text{of potentiometer}\end{bmatrix}$$

For 3 V,

$$R = \left[\frac{3}{1.5}\right][30] = 60\ \Omega$$

For 10 V,

$$R = \left[\frac{10}{1.5}\right][30] = 200\ \Omega$$

For 30 V,

$$R = \left[\frac{30}{1.5}\right][30] = 600\ \Omega$$

For 100 V,

$$R = \left[\frac{100}{1.5}\right][30] = 2000\ \Omega$$

The volt-ratio box can be drawn as shown in the Fig. .

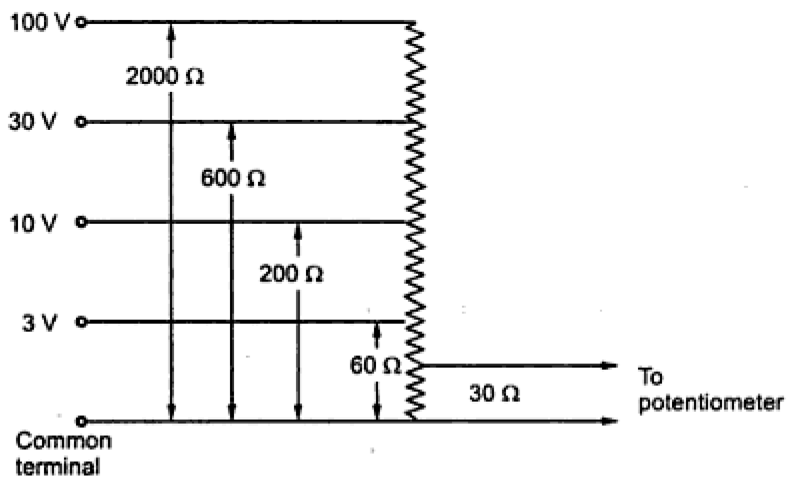


Fig.

3.a Explain different methods of focusing an electron beam in CRO

Electrostatic Deflection and Sensitivity

In a device like cathode ray tube, number of electrons are projected by the gun, in the form of an electron beam towards the screen. But due to variations in energy, the electrons diverge and cannot produce dominant spot on the screen. Hence the focusing of an electron beam is must. One of the methods of focusing an electron beam is electrostatic focusing.

The electrostatic focusing uses two parallel plates called **deflecting plates.** These are spaced at a distance d from each other. The plates are subjected to a potential difference V_d due to which an electric field E exists between the two plates. While electrons are emitted by the hot cathode K, which are accelerated towards the anode by the potential V_a. Those electrons which are not collected by anode pass through small hole at the anode. This is shown in the Fig. 3.28. These electrons are then focused with the help of vertical deflecting plates on the screen coated with fluorescent material. Properly focused electrons strike the screen and positions where the electrons strike become visible to an eye. This is called **electrostatic deflection** of the electrons.

The electrons are emitted by cathode and emerge from anode hole with a velocity determined by voltage V_a given by,

$$v_{ox} = \sqrt{\frac{2 q V_a}{m}} \quad \text{... (1)}$$

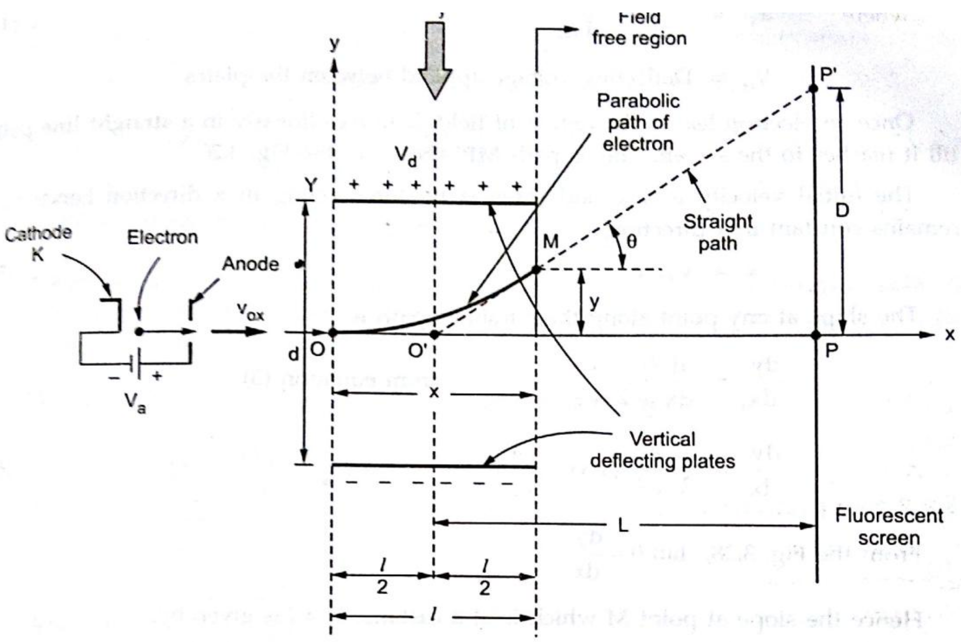


Fig. 3.28 Electrostatic deflection

This is initial velocity with which an electron enters into an electric field E_y given by,

$$E_y = \frac{V_d}{d} \quad \text{... (2)}$$

The field E_y is in the y-direction, towards negative y axis while velocity v_{ox} of an electron is directed towards positive x-axis. This is **two dimensional** motion. Hence electron moves along the **parabolic path** between the plates from point O to M as shown in the Fig. 3.28.

The equation of parabola is given by,

$$y = \frac{1}{2} a_y t^2 \quad \text{where } a_y \text{ is accelertion}$$

Now $$t = \frac{\text{Distance}}{\text{Velocity}} = \frac{x}{v_{ox}}$$

$$\therefore \quad y = \frac{1}{2} a_y \left(\frac{x}{v_{ox}}\right)^2 = \frac{1}{2} \frac{a_y}{(v_{ox})^2} x^2 \quad \text{...(3)}$$

where $\quad a_y = \frac{E_y q}{m} = \frac{q V_d}{d m}$ ... (4)

V_d = Deflecting voltage applied between the plates

Once an electron leaves the region of field, it moves linearly in a **straight line path** till it reaches to the screen. This is path **MP'** shown in the Fig. 3.29.

The initial velocity is v_{ox} and there is no force acting in x direction hence v_{ox} remains constant in x direction.

$$\therefore \quad x = v_{ox}\, t \qquad \text{... (5)}$$

The slope at any point along the parabolic path is,

$$\frac{dy}{dx} = \frac{d}{dx}\left[\left(\frac{1}{2}\frac{a_y}{v_{ox}^2}\right)x^2\right] \quad \text{... from equation (3)}$$

$$\therefore \quad \frac{dy}{dx} = \frac{1}{2}\frac{a_y}{v_{ox}^2}(2x) = \frac{x\, a_y}{v_{ox}^2} \qquad \text{... (6)}$$

From the Fig. 3.28, $\tan\theta = \frac{dy}{dx}$

Hence the slope at point M which is at a distance $x = l$ is given by,

$$\tan\theta = \left.\frac{dy}{dx}\right|_{x=l} = \frac{l\, a_y}{v_{ox}^2} \qquad \text{... (7)}$$

From point M onwards electron moves along the straight line which is tangent to the parabola at $x = l$ and intersects x axis at O'. This is called **apparent origin.**

The equation of the straight line MP' is,

$$y = m x + C \text{ where } m = \text{slope} = \left.\frac{dy}{dx}\right|_{x=l}$$

$$\therefore \quad y = \frac{l\, a_y}{v_{ox}^2}\, x + C \qquad \text{... (8)}$$

At $x = l$, $\quad y = \frac{1}{2}\frac{a_y}{v_{ox}^2} l^2 \quad$ from equation (3)

$$\therefore \quad \frac{1}{2}\frac{a_y}{v_{ox}^2} l^2 = \frac{l^2 a_y}{v_{ox}^2} + C$$

$$\therefore \quad C = -\frac{a_y}{v_{ox}^2}\frac{l^2}{2}$$

So the equation of straight line,

$$y = \frac{l a_y}{v_{ox}^2} x - \frac{a_y}{v_{ox}^2} \frac{l^2}{2}$$

$$\therefore \quad y = \frac{l a_y}{v_{ox}^2}\left[x - \frac{l}{2}\right] \quad \text{... (9)}$$

At O′, y = 0 hence $x = \frac{l}{2}$ from equation (9).

Key Point: *Thus point O′ is at the centre of the plates and is called* ***virtual cathode*** *as electron appears to emerge from O′ regardless of V_a and V_d following the straight line path O′MP′.*

Now at point P′, y = D and $x = L + \frac{l}{2}$ hence from equation (9),

$$D = \frac{l a_y}{v_{ox}^2}\left[L + \frac{l}{2} - \frac{l}{2}\right]$$

$$\therefore \quad \boxed{D = \frac{l L a_y}{v_{ox}^2}} \quad \text{... (10)}$$

From equations (4) and (1) we have,

$$v_{ox}^2 = \frac{2 q V_a}{m}$$

$$a_y = \frac{q V_d}{d m}$$

$$\therefore \quad D = l L\left(\frac{q V_d}{d m}\right) \times \frac{1}{\left(\frac{2 q V_a}{m}\right)}$$

$$\therefore \quad \boxed{D = \frac{l L V_d}{2 d V_a}} \quad \text{... Required deflection in metres (11)}$$

3.b Explain the working of Successive approximation type DVM with a neat diagram.

Successive Approximation Type DVM

The potentiometer used in the servo balancing type DVM is a linear divider but in successive approximation type a digital divider is used. The digital divider is nothing but a digital to analog (D/A) converter. The servomotor is replaced by an electronic logic.

The basic principle of measurement by this method is similar to the simple example of determination of weight of the object. The object is placed on one side of the balance and the approximate weight is placed on other side. If weight placed is more, the weight is removed and smaller weight is placed. If this weight is smaller than the object, another small weight is added, to the weight present. If now the total weight is higher than the object, the added weight is removed and smaller weight is added. Thus by such successive procedure of adding and removing, the weight of the object is determined. The successive approximation type DVM works exactly on the same principle.

In successive approximation type DVM, the comparator compares the output of digital to analog converter with the unknown voltage. Accordingly, the comparator provides logic high or low signals. The digital to analog converter successively generates the set pattern of signals. The procedure continues till the output of the digital to analog converter becomes equal to the unknown voltage.

The Fig. shows the block diagram of successive approximation type DVM.

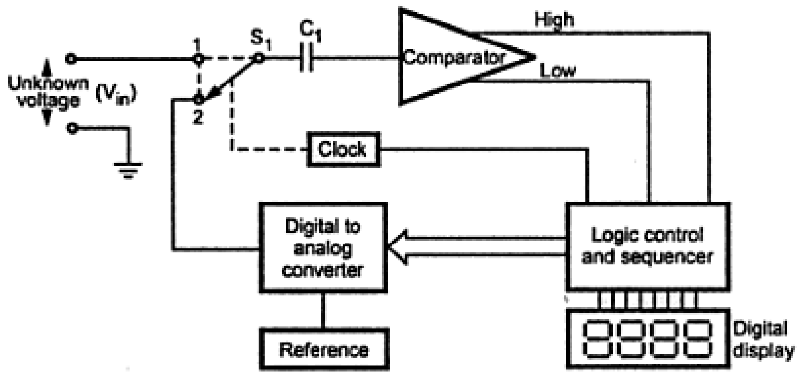


Fig. Successive approximation type DVM

The capacitor is connected at the input of the comparator. The output of the digital to analog converter is compared with the unknown voltage, by the comparator. The output of the comparator is given to the logic control and sequencer. This unit generates the sequence of code which is applied to digital to analog converter. The position 2 of the switch S_1 receives the output from digital to analog converter. The unknown voltage is available at the position 1 of the switch S_1. The logic control also drives the clock which is used to alternate the switch S_1 between the positions 1 and 2, as per the requirement.

Consider the voltage to be measured is 3.7924 V. The set pattern of digital to analog converter is say 8-4-2-1. At the start, the converter generates 8 V and switch is at the position 2. The capacitor C_1 charges to 8 V. The clock is used to change the switch position. So during next time interval, switch position is 1 and unknown input is applied to the capacitor. As capacitor is charged to 8 V which is more than the input voltage 3.7924 V, the comparator sends HIGH signal to the logic control and sequencer circuit. This HIGH signal resets the digital to analog converter which generates its next step of 4 V. This again generates HIGH signal. This again resets the converter to generate the next step of 2 V.

Now 2 V is less than the input voltage. The comparator generates LOW signal and sends it to logic control and sequence circuit. During the generation of LOW signal, the generated signal by the converter is retained. Thus the 2 V step gets stored in the converter. In addition to this, next step of 1 V is generated. Thus the total voltage level becomes, stored 2 + generated 1 i.e. 3 V. This is again less than the input and generates LOW signal. Due to low signal, this gets stored. After this 0.8 V step is generated for the second digit approximation.

Thus the process of successive approximation continues till the converter generates 3.7924 V. This voltage is then displayed on the digital display.

At each low signal, there is an incremental change in the output of the digital to analog converter. This output voltage approaches the value of the unknown voltage. The limit to how close this output can approach to the unknown voltage, depends on the level of noise at the input of comparator and the stability of the input switch. To reduce the noise, filters may be used but it reduces the speed of measurement. These limiting factors usually determine the number of digits of resolution of an instrument. The general range of digits is 3 to 5. The speed depends upon the type of switches used in digital to analog converter and comparator circuitry. If solid state switches are used, the high speed can be obtained. For electromechanical switches, the speed is few readings per second. The accuracy depends on the internal reference supply associated with the digital to analog converter and the accuracy of the converter itself.

4.a State and explain the desirable characteristics of resistance wire strain gauge.

Basic Forms of Resistance Wire Strain Gauges

The resistance wire strain gauges of metallic type are available in two basic forms; bonded and unbonded type. The bonded metallic strain gauges are further classified as flat grid, helical grid and thin foil type strain gauges.

A. Bonded Resistance Wire Strain Gauge

In bonded resistance wire strain gauge resistive element is cemented to the base which may be a thin sheet of paper, a thin sheet of bakelite or a sheet of teflon. The resistive element may be in the form of wire, foil or film of the material. The most common types of bonded strain gauges are as shown in the Fig.

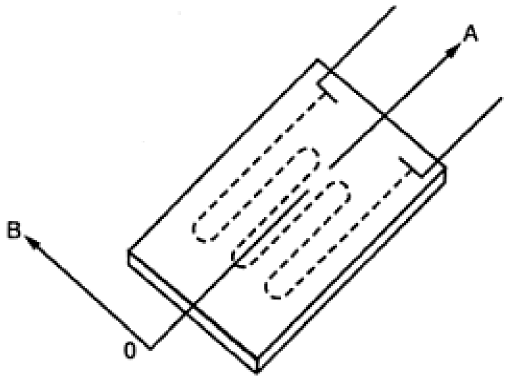


Fig. Bonded type strain gauges

In metallic bonded strain gauge a fine wire element about 25 μm or less in diameter is looped back and forth on a base (carrier) or mounting plate. The base is cemented to the member subjected to stress. The grid of fine wire is cemented on a carrier which may be a thinsheet of paper, bakelite or teflon.

A *tensile stress* tends to elongate the wire and thereby increase its length and decreases its cross-sectional area. The combined effect is an increase in resistance.

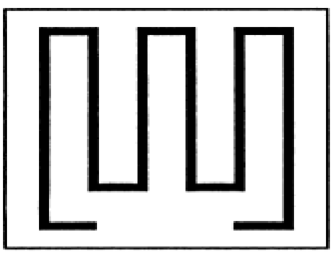
Foil Strain Gauges

In this gauge, the strain is detected using a metal foil. The metals and alloys used for the foil and wire are nichrome, constantan, isoelastic (Ni + Cr + Mo), nickel and platinum.

On account of their larger surface area, foil gauges have a much greater dissipation capacity. Therefore they can be used at a higher operating temperature range. The characteristics of foil type strain gauges and wire type strain gauges are similar, including almost the same gauge factor.

The advantage of foil type strain gauge is that they can be fabricated on a large scale and in any shape. The foil can be etched on the base.

The Fig. shows the foil type strain gauge.



Foil type gauge

Fig. Foil strain gauge

The etched foil strain gauges can be made thinner than comparable wire units. Also they are more flexible. Because of these properties, the etched foil can be mounted in remote and restricted places and especially on curved surfaces.

The resistance film formed is typically 0.2 mm thick. The resistance value of commercial foil gauges is between 50 and 1000 Ω.

B. Unbonded Resistance Wire Strain Gauge

In general, the basic usage of the unbonded strain gauge is as displacement transducer. It can be constructed in variety of configuration. The unbonded strain gauge consists of a stationary frame with an armature supported at the centre of the frame as shown in the Fig.

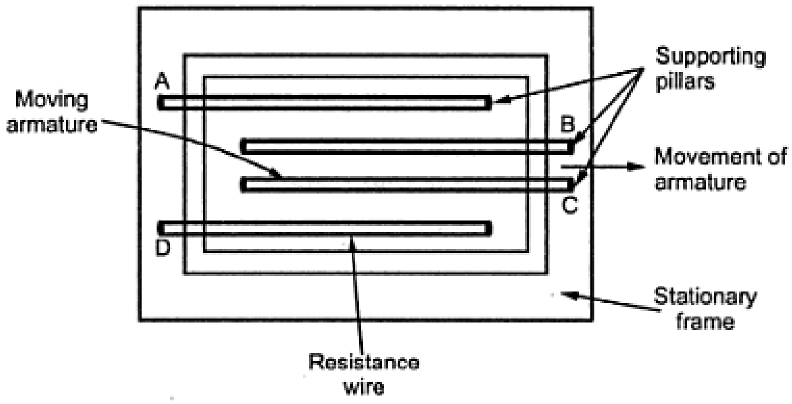


Fig. Unbonded strain gauge

The strain gauge is constructed such that an armature can move only in one direction. Its travel in that direction is limited by four filaments of strain sensitive wires. These wires are wound on the rigid insulators. These insulators are mounted on the frame and on the armature.

4.b Explain construction and working of LVDT. State advantages and disadvantages

Linear Variable Differential Transformer

The **linear variable differential transformer** is also called **linear variable displacement transducer (LVDT).** It consists of a transformer with single primary winding and two secondary windings. The secondary windings are connected in series opposition as shown in the Fig. 7.2.

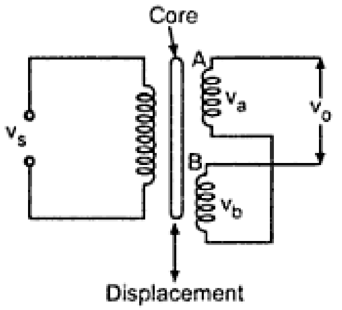


Fig. LVDT

The object whose translational displacement is to be measured is physically attached to the central core which is usually an iron core. The core moves linearly, when the translational displacement is attached to it. When the core moves forward or backward, then depending on that output voltage changes. When the core is at central position, the e.m.f. induced in both the secondaries is of same amplitude and phase hence both cancel out and output becomes zero. This is called **null position.** The null position is important in case of the measurement of displacement on both the sides of the null position. The displacement can be found out by measuring amplitude and phase of the output voltage. The magnitude of the output voltage indicates how much displacement takes place, while the phase of output voltage indicates the direction of the displacement.

This type of transducer is most widely used to measure linear displacements because the only moving part of the transducer i.e. iron core moves in the air gap between winding without any friction or wear during operation. Alongwith this, as compared with other translational displacement transducer, LVDT has high accuracy and almost infinite resolution. The major advantage of this transducer is its insensetivity to mechanical shocks and vibrations. The drawback of LVDT is that its accuracy gets affected due to the hormonics in the supply voltage and the stray capacitances.

Advantages of LVDT

1. **Linearity :** The output voltage of LVDT is almost linear for displacement upto 5 mm.
2. **Infinite Resolution :** The change in output voltage is continuous, stepless. The effective resolution depends more on the equipment used for the measurement rather than on the LVDT.
3. **High Output :** LVDT gives reasonably high output, and hence requires less amplification afterwards.
4. **High Sensitivity :** LVDT has high sensitivity of about 300 mV/mm; i.e., 1 mm displacement of the core produces a output voltage of 300 mV.
5. **Ruggedness :** LVDT is mechanically rugged and can withstand mechanical shock and vibrations.
6. **Less Friction :** Since there are no sliding contacts, the friction is very less.
7. **Low Hysteresis :** LVDT has a low hysteresis, hence its repeatability is extremely good under all conditions.
8. **Low Power Consumption :** Most LVDTs consume less than 1 W of power.
9. The LVDT transducers are small, simple, and light in weight. They are stable and easy to align and maintain.

Disadvantages of LVDT :

1. Comparatively large displacements are necessary for appreciable differential output.
2. They are sensitive to stray magnetic fields. However, this interference can be reduced by shielding.
3. The dynamic response is limited by the mass of the core.
4. Temperature affects the transducer.

5.a. Explain how angular velocity is measured by AC Tacho meter generator. What are the limitations?

A.C. Tachogenerator

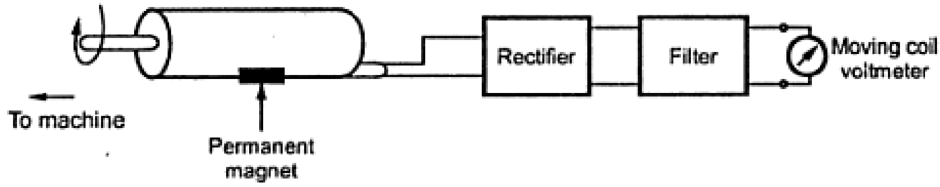


Fig. A.C. tachogenerator

The coil is wound on stator itself. In this tachogenerator, the magnetic field is rotating. The magnetic field can be obtained by using electromagnet or permanent magnet. Due to rotation of magnet, an e.m.f. induces in the stator coil which has amplitude and frequency directly proportional to the speed of rotation. Thus the speed of rotation can be calibrated in terms of either amplitude of frequency of the induced voltage.

In the circuit shown in the Fig. 3.37, the amplitude of the induced voltage is used to measure speed. A rectifier and filter are used to get constant d.c. voltage which can be measured with the help of the moving coil voltmeter.

Advantages :

The advantages of a.c. tachogenerator are as follows.

i) The output can be calibrated in terms of two parameters namely amplitude and frequency of induced voltage.

ii) Commutator and brush contact resistance problems are eliminated as the coil is wound on stator.

Disadvantages :

The disadvantages of a.c. tachogenerator are as follows

i) For very low speed rotation, the frequency of the induced voltage is also very low, thus the ripple in the output increases. To overcome this the number of poles of stator are increased, so that the frequency of the induced voltage increases even at low speeds of rotation.

ii) At high speeds, the frequency of the induced voltage is also very high. Thus the coil impedance increases. This effects linearity of the output. To maintain the good linearity, the display device used should have input impedance greater than that of the coil.

5.b. Describe different electrical methods for the measurement of liquid level.

Electrical Methods

Using electrical methods for level measurement directly a liquid level is converted to an electrical signal. First the liquid level is converted to either the float displacement in a liquid or to displacement of spring loaded plate placed at bottom of surface in a vessel. Then by using appropriate secondary transducer, the displacement is converted to the electrical signal which is proportional to the level of the liquid. According to electric transducer used, the electric methods of level measurement are classified as follows.

Resistive Method

The resistive method uses mercury column as conductor which is operated by a liquid column. It is the simplest electric method. It is also called **contact point method.** The arrangement for resistive type level measurement is as shown in the Fig.

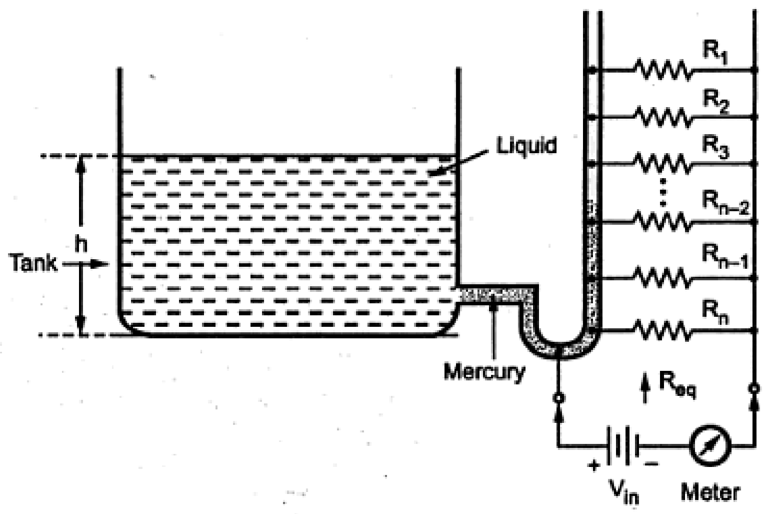


Fig. Resistive method for level measurement

Various resistances of suitable values are connected at different levels of the liquid. When the level of liquid in the tank rises, the liquid operates level of mercury to rise its level also. According to level, corresponding successive resistances are short circuited. Hence overall equivalent resistance R_{eq} looking from input side decreases and thus overall current in electric circuit increases. Note that the resistances R_1, R_2 through R_n are selected such as 1/R is a linear function of liquid level. Here we get stepwise measurements of the liquid levels. One can modify same arrangement for continuous measurement of liquid levels.

6.a What is standardization of AC Potentiometer? Explain clearly the measurement of unknown AC

Standardisation of Drysdale-Tinsley A.C. Potentiometer

In standardisation of a.c. potentiometer, both d.c. as well as a.c. standardisations are done. The d.c. standardisation is done first by replacing vibration galvanometer by D'Arsonval galvanometer. A standard cell such as Weston cell is used for d.c. standardisation. Then by adjusting sliding contacts null deflection in galvanometer is achieved. The reading of a precision ammeter included in battery supply is noted. During a.c. standardisation again vibration galvanometer is used. The ammeter is still included in the supply circuit but now this circuit is without standard cell. By properly adjusting resistance in the circuit, the r.m.s. value of current in slide wire is made same as that of d.c. current noted in d.c. standardisation.

voltage using Drysdale Tinsley Potentiometer

Drysdale-Tinsley Polar Type A.C. Potentiometer

Being a polar type, Drysdale-Tinsley a.c. potentiometer measures unknown e.m.f. interms of its magnitude and phase angle. It consists of basic d.c. potentiometer alongwith some auxillary components such as, Drysdale phase shifter and electrodynamometer type ammeter. Let us study Drysdale phase shifter construction first.

Drysdale phase shifter is also called **phase shifting transformer**. It consists of a ring shaped laminated steel stator. This sector is wound with either a two phase or three phase winding. Inside it there is a laminated rotor keeping some air gap between it and stator. The rotor consists of a winding provided in the slot which supplies voltage to slide wire circuit of potentiometer. The connection of Drysdale phase shifter with the circuit is as shown in the Fig.

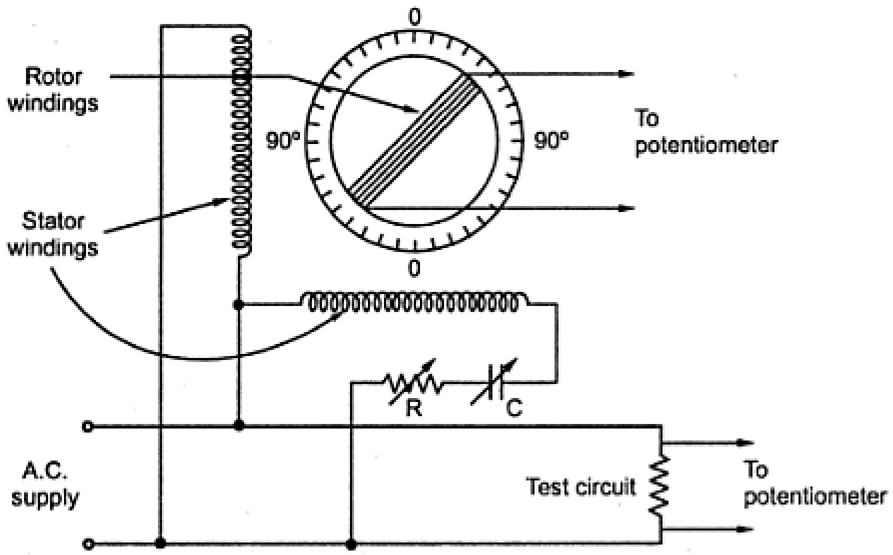


Fig. Drysdale phase shifter connection diagram

When current flows through stator winding, a rotating field is produced inducing e.m.f. in the rotor. The phase of rotor current can be changed through any angle relative to stator supply voltage by rotating rotor. Thus the change in the phase of secondary e.m.f. is equal to the angle through which rotor is moved from its original zero position. It is very important to arrange windings such that eventhough the magnitude of e.m.f. induced in rotor is changed, phase remains unchanged. Thus we can directly read the phase angle with the help of scale fixed on top of the instrument.

The variable capacitor and resistor shown in the circuit diagram are so adjusted that exact quadrature component between the two stator winding currents is obtained.

An electrodynamometer type ammeter is used to measure a.c. as well as d.c. currents during the standardisation of an a.c. potentiometer.

6.b. State the principles of Ramp type and Dual slope Integrating type DVM's. Briefly explain the operation of Digital Frequency meter.

Ramp Type DVM

It uses a linear ramp technique or staircase ramp technique. The staircase ramp technique is simpler than the linear ramp technique. Let us discuss both the techniques.

Linear Ramp Technique

The basic principle of such measurement is based on the measurement of the time taken by a linear ramp to rise from 0 V to the level of the input voltage or to decrease from the level of the input voltage to zero. This time is measured with the help of electronic time interval counter and the count is displayed in the numeric form with the help of a digital display.

Basically it consists of a linear ramp which is positive going or negative going. The range of the ramp is ± 12 V while the base range is ± 10 V. The conversion from a voltage to a time interval is shown in the Fig.

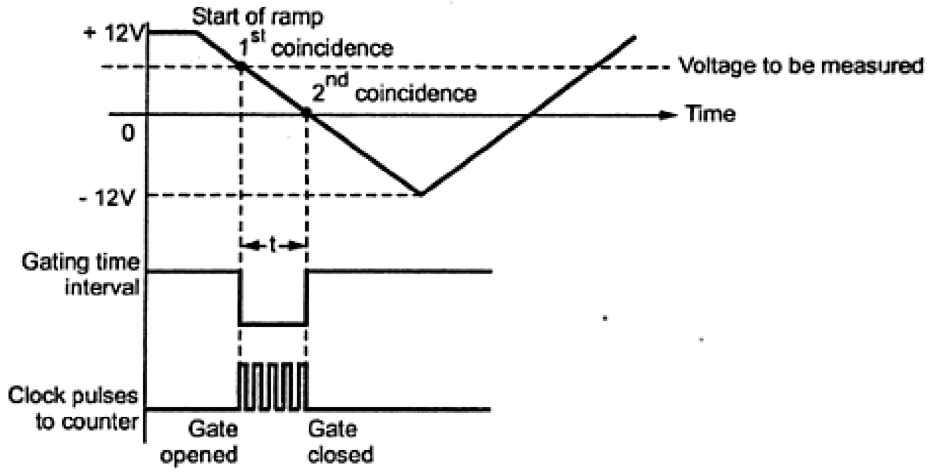


Fig. Voltage to time conversion

At the start of measurement, a ramp voltage is initiated which is continuously compared with the input voltage. When these two voltages are same, the comparator generates a pulse which opens a gate i.e. the input comparator generates a start pulse. The ramp continues to decrease and finally reaches to 0 V or ground potential. This is sensed by the second comparator or ground comparator. At exactly 0 V, this comparator produces a stop pulse which closes the gate. The number of clock pulses are measured by the counter. Thus the time duration for which the gate is opened, is proportional to the input voltage. In the time interval between start and stop pulses, the gate remains open and the oscillator circuit drives the counter. The magnitude of the count indicates the magnitude of the input voltage, which is displayed by the display. The block diagram of linear ramp DVM is shown in the Fig.

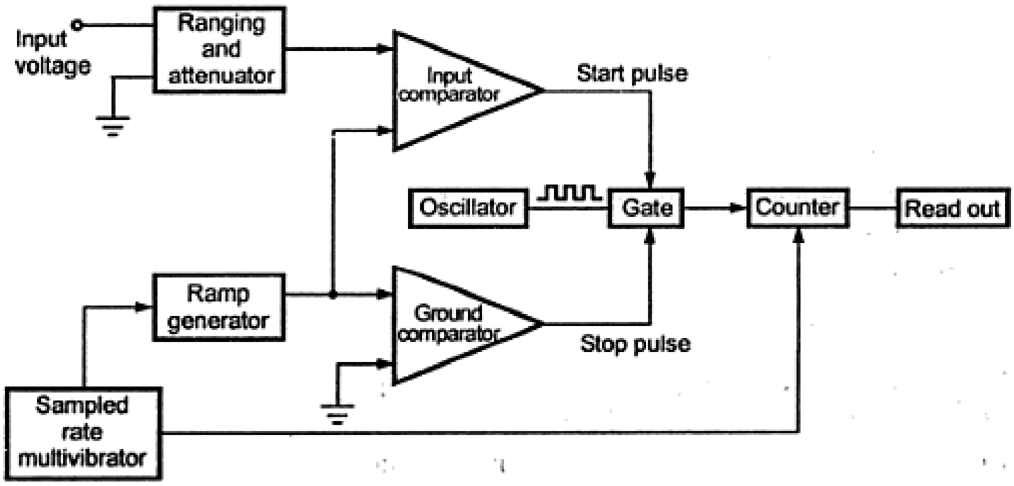


Fig. Linear ramp type DVM

Properly attenuated input signal is applied as one input to the input comparator. The ramp generator generates the proper linear ramp signal which is applied to both the comparators. Initially the logic circuit sends a reset signal to the counter and the readout. The comparators are designed in such a way that when both the input signals of comparator are equal then only the comparator changes its state. The input comparator is used to send the start pulse while the ground comparator is used to send the stop pulse.

When the input and ramp are applied to the input comparator and at the point when negative going ramp becomes equal to input voltages the comparator sends start pulse, due to which gate opens. The oscillator drives the counter. The counter starts counting the pulses received from the oscillator. Now the same ramp is applied to the ground comparator and it is decreasing. Thus when ramp becomes zero, both the inputs of ground comparator becomes zero (grounded) i.e. equal and it sends a stop pulse to the gate due to which gate gets closed. Thus the counter stops receiving the pulses from the local oscillator. A definite number of pulses will be counted by the counter, during the start and stop pulses which is measure of the input voltage. This is displayed by the digital readout.

The sample rate multivibrator determines the rate at which the measurement cycles are initiated. The oscillation of this multivibrator is usually adjusted by a front panel control named **rate**, from few cycles per second to as high as 1000 or more cycles per second. The typical value is 5 measuring cycles/second with an accuracy of ± 0.005 % of the reading. The sample rate provides an initiating pulse to the ramp generator to start its next ramp voltage. At the same time, a reset pulse is also generated which resets the counter to the zero state.

Staircase Ramp Technique

In this type of DVM, instead of linear ramp, the staircase ramp is used. The staircase ramp is generated by the digital to analog converter. The block diagam of staircase ramp type DVM is shown in the Fig.

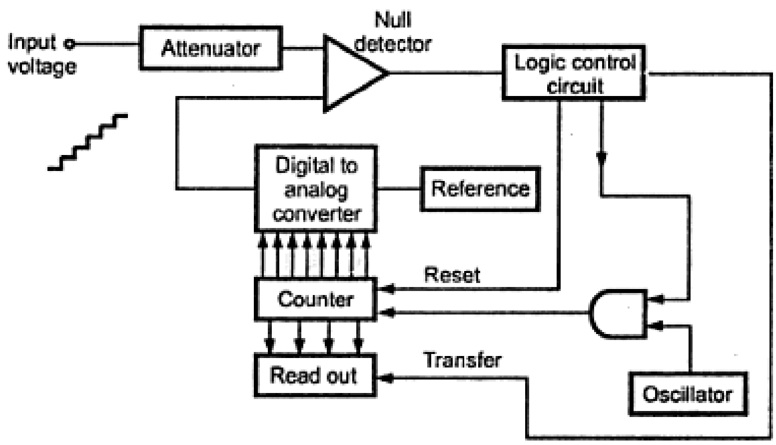


Fig. Staircase ramp type DVM

The technique of using staircase ramp is also called **null balance technique.** The input voltage is properly attenuated and is applied to a null detector. The another input to null detector is the staircase ramp generated by digital to analog converter. The ramp is continuously compared with the input signal.

Initially the logical control circuit sends a reset signal. This signal resets the counter. The digital to analog converter is also resetted by same signal.

At the start of the measurement, the logic control circuit sends a starting pulse which opens the gate. The counter starts counting the pulses generated by the local oscillator.

The output of counter is given to the digital to analog converter which generates the ramp signal. At every count there is an incremental change in the ramp generated. Thus the staircase ramp is generated at the output of the digital to analog converter. This is given as the second input of the null detector. The increase in ramp continues till it achieves the voltage equal to input voltage.

When the two voltages are equal, the null detector generates a signal which in turn initiates the logic control circuit. Thus logic control circuit sends a stop pulse, which closes the gate and the counter stops counting.

At the same time, the logic control circuit generates a transfer signal due to which the counter information is transferred to the readout. The readout shows the digital result of the count.

Dual Slope Integrating Type DVM

This is the most popular method of analog to digital conversion. In the ramp techniques, the noise can cause large errors but in dual slope method the noise is averaged out by the positive and negative ramps using the process of integration. The basic principle of this method is that the input signal is integrated for a fixed interval of time. And then the same integrator is used to integrate the reference voltage with reverse slope. Hence the name given to the technique is **dual slope integration technique.**

The block diagram of dual slope integrating type DVM is shown in the Fig. . It consists of five blocks, an op-amp used as an integrator, a zero comparator, clock pulse generator, a set of decimal counters and a block of control logic.

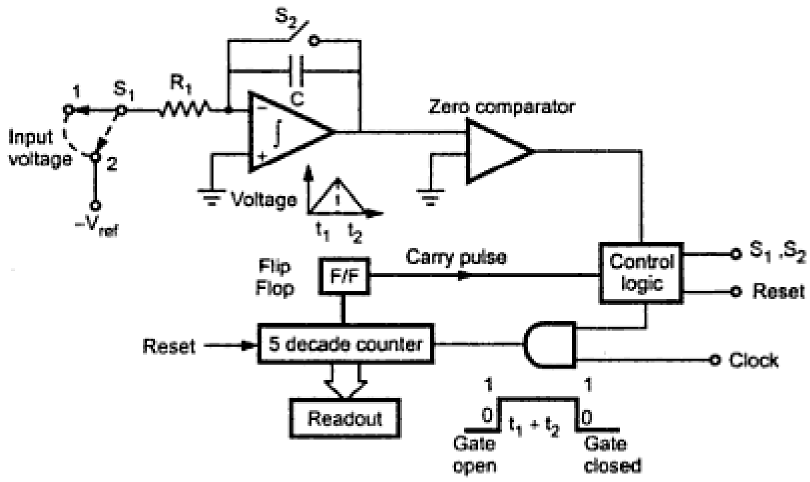


Fig. Dual slope integrating type DVM

When the switch S_1 is in position 1, the capacitor C starts charging from zero level. The rate of charging is proportional to the input voltage level. The output of the op-amp is given by,

$$V_{out} = -\frac{1}{R_1 C}\int_0^{t_1} V_{in}\, dt$$

$$\therefore \quad \boxed{V_{out} = -\frac{V_{in}\, t_1}{R_1\, C}} \quad \ldots (1)$$

where t_1 = Time for which capacitor is charged

V_{in} = Input voltage

R_1 = Series resistance

C = Capacitor in feedback path

After the interval t_1, the input voltage is disconnected and a negative voltage $-V_{ref}$ is connected by throwing the switch S_1 in position 2. In this position, the output of the op-amp is given by,

$$V_{out} = \frac{1}{R_1 C}\int_0^{t_2} -V_{ref}\, dt$$

$$\therefore \quad \boxed{V_{out} = -\frac{V_{ref}\, t_2}{R_1\, C}} \quad \ldots (2)$$

Subtracting (1) from (2),

$$V_{out} - V_{out} = 0 = \frac{-V_{ref}\, t_2}{R_1\, C} - \left(\frac{-V_{in}\, t_1}{R_1\, C}\right)$$

$$\therefore \quad \frac{V_{ref}\ t_2}{R_1\ C} = \frac{V_{in}\ t_1}{R_1\ C}$$

$$\therefore \quad V_{ref}\ t_2 = V_{in}\ t_1$$

$$\therefore \quad \boxed{V_{in} = V_{ref} \cdot \frac{t_2}{t_1}} \quad \text{... (3)}$$

Thus the input voltage is dependent on the time periods t_1 and t_2 and not on the values of R_1 and C.

This basic principle of this method is shown in the Fig. .

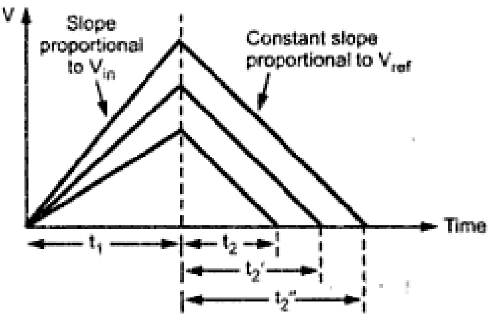


Fig. : Basic principle of dual slope method

At the start of the measurement, the counter is resetted to zero. The output of the flip-flop is also zero. This is given to the control logic. This control sends a signal so as to close an electronic switch to position 1 and integration of the input voltage starts. It continues till the time period t_1. As the output of the integrator changes from its zero value, the zero comparator output changes its state. This provides a signal to control logic which inturn opens the gate and the counting of the clock pulses starts.

The counter counts the pulses and when it reaches to 9999, it generates a carry pulse and all digits go to zero. The flip flop output gets activated to the logic level '1'. This activates the control logic. This sends a signal which changes the switch S_1 position from 1 to 2. Thus $-V_{ref}$ gets connected to op-amp. As V_{ref} polarity is opposite, the capacitor starts discharging. The integrator output will have constant negative slope as shown in the Fig. 2.51. The output decreases linearly and after the interval t_2, attains zero value, when the capacitor C gets fully discharged.

At this instant, the output of zero comparator changes its state. This inturn sends a signal to the control logic and the gate gets closed. Thus gate remains open for the period $t_1 + t_2$. The counting operation stops at this instant. The pulses counted by the counter thus have a direct relation with the input voltage. The counts are then transferred to the readout.

From equation (3) we can write,

$$V_{in} = V_{ref} \cdot \frac{t_2}{t_1}$$

Let time period of clock oscillator be T and digital counter has counted the counts n_1 and n_2 during the period t_1 and t_2 respectively.

$$\therefore \quad \boxed{V_{in} = V_{ref} \cdot \frac{n_2 T}{n_1 T} = V_{ref} \cdot \frac{n_2}{n_1}}$$

Thus the unknown voltage measurement is not dependent on the clock frequency, but dependent on the counts measured by the counter.

Basic Circuit of Digital Frequency Meter

The basic circuit of digital frequency meter used for the measurement of frequency consists two R-S flip flops. The basic circuit for measurement of frequency is as shown in the Fig.

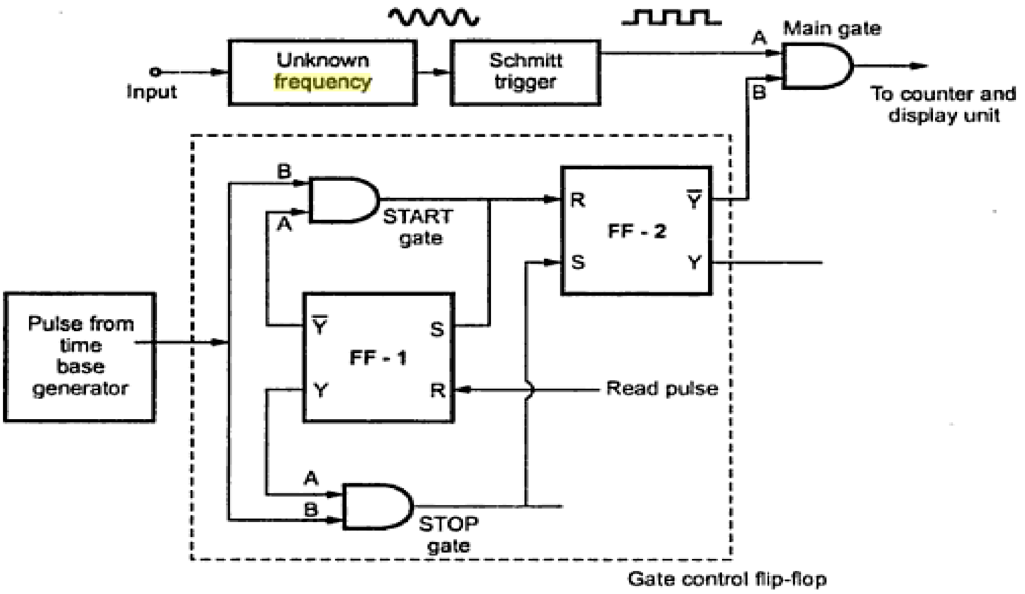


Fig. Basic circuit for frequency measurement

The output of unknown frequency is applied to the schmitt trigger which produces positive pulse at the output. These are **counted pulses** present at A of the main gate. The time base selector provides positive pulses at B of the START gate and STOP gate, both.

Initially FF - 1 is at LOGIC 1 state. The voltage from Y output is applied to A of the STOP gate which enables this gate. The LOGIC 0 state of the output $\overline{Y}$ is applied to input A of START gate which disables this gate.

When STOP gate enables, positive pulses from the time base pass through STOP gate to S input of FF - 2, setting FF - 2 to LOGIC 1 state.

The LOGIC 0 level of $\overline{Y}$ of **FF - 2** is connected to B of main gate, which confirms that pulses from unknown frequency source can't pass through the main gate.

By applying a positive pulse to R input of FF - 1, the operation is started. This changes states of the FF - 1 to $\overline{Y}$ = 1 and Y = 0. Due to this, STOP gate gets disabled, while START gate gets enabled. The same pulse is simultaneously applied to all decade counters to reset all of them, to start new counting.

With the next pulse from the time base passes through START gate reseting FF - 2 and it changes state from LOGIC 0 to LOGIC 1. As $\overline{Y}$ changes from 0 to 1, the gating signal is applied to input B of the main gate which enables the main gate.

Now the pulses from source can pass through the main gate to the counter. The counter counts pulses. The state of FF - 1 changes from 0 to 1 by applying same pulse from START gate to S input of FF - 1. Now the START gate gets disabled, while STOP gate gets enabled. It is important that the pulses of unknown frequency pass through the main gate to counter till the main gate is enabled.

The next pulse from the time base generator passes through STOP Gate to S input of FF - 2. This sets output back to 1 and $\overline{Y} = 0$. Now main gate gets disabled. The source supplying pulses of unknown frequency gets disconnected. In between this pulse and previous pulse from the time base selector, the number of pulses are counted by the counter. When the interval of time between two pulses is 1 second, then the count of pulses indicates the frequency of the unknown frequency source.

7.a. Explain in detail about characteristics & choice of transducers.

Transducer Selection Factors

Picking the right transducer for a given measurement application involves considering the transducer's characteristics, desired system performance and input requirements. Because there are so many kinds of transducers, proper selection requires careful consideration.

1. **Nature of measurement :** The selection of transducer will naturally depend upon the nature of quantity to be measured. For example, for temperature measurement, temperature sensors will be used; for measuring stress or strain, strain gauges will be utilized.
2. **Loading effect :** If the transducer in any way affects or changes the value of the parameter under measurement, errors may be introduced. The transducer is selected to have minimum loading effect to keep the errors to minimum.
3. **Environmental considerations :** A careful study be made of the conditions under which a transducer is expected to give satisfactory output. The troublesome aspects of the transducer location are the temperature changes, shock and vibration and electromagnetic interference.

To minimize the errors due to temperature changes, some transducers are temperature compensated. For operation of transducer beyond 300 °F, such temperature compensation becomes extremely difficult to design and special materials are used for the transducer internal construction and bonding.

It is often very difficult to eliminate completely the errors due to shock and vibration. To have these errors as minimum as possible, transducers should be selected with a minimum movable mass in the sensing mechanism. Proper **damping** may extend the range of a transducer's usefulness under high shock and vibration conditions.

Transducers are often required to operate in the presence of varying strong electromagnetic fields. Transducers with low output impedance, high output voltage and short cable length are less susceptible to such interferences.

Other considerations for transducer environments include :

i) Simplicity of mounting and cable installation,

ii) Convenient size, shape and weight,

iii) Resistance of corrosion,

iv) Accessibility of the transducer for later repairs.

4. **Measuring system compatibility :** The transducer selected and the electrical system used for measurement should be compatible. The output impedance of the transducer and the impedance imposed by the **measuring** system must be such that one does not adversely affect the other.

5. **Cost and availability :** General factors involved in selection are cost, availability, basic simplicity, reliability and low maintenance.

While selecting transducers of comparatively equal merits for a given application, the one that is most simple in operation and contains minimum number of moving parts would usually be selected.

Transducers are selected which do not require excessive repair or continuous calibration checking.

The selection of a transducer for a given application is normally a compromise between a number of factors discussed above.

Characteristics of Transducers

1. **Accuracy :** It is defined as the closeness with which the reading approaches an accepted standard value or ideal value or true value, of the variable being measured.

2. **Ruggedness :** The transducer should be mechanically rugged to withstand overloads. It should have overload protection.

3. **Linearity :** The output of the transducer should be linearily proportional to the input quantity under measurement. It should have linear input-output characteristic.

4. **Repeatability :** The output of the transducer must be exactly the same, under same environmental conditions, when the same quantity is applied at the input repeatedly.

5. **High output :** The transducer should give reasonably high output signal so that it can be easily processed and measured. The output must be much larger than noise. Now-a-days, digital output is preferred in many applications.

6. **High stability and reliability :** The output of the transducer should be highly stable and reliable so that there will be minimum error in measurement. The output must remain unaffected by environmental conditions such as change in temperature, pressure, etc.

7. **Sensitivity :** The sensitivity of the electrical transducer is defined as the electrical output obtained per unit change in the physical parameter of the input quantity. For example, for a transducer used for temperature measurement, sensitivity will be expressed in mV/℃. A high sensitivity is always desirable for a given transducer.

8. **Dynamic range :** For a transducer, the operating range should be wide, so that it can be used over a wide range of measurement conditions.

9. **Size :** The transducer should have smallest possible size and shape with minimal weight and volume. This will make the measurement system very compact.

10. **Speed of response :** It is the rapidity with which the transducer responds to changes in the measured quantity. The speed of response of the transducer should be as high as practicable.

7.b. Explain the measurement of pressure using Piezo electric transducers

Piezoelectric Transducers

In 1880, **J. Cuire** showed that when two opposite faces of a thin slice of certain crystals are subjected to a mechanical force, then opposite charges are developed on the two faces of the slice. The magnitude of the electric potential between the two faces is proportional to the deformation produced.

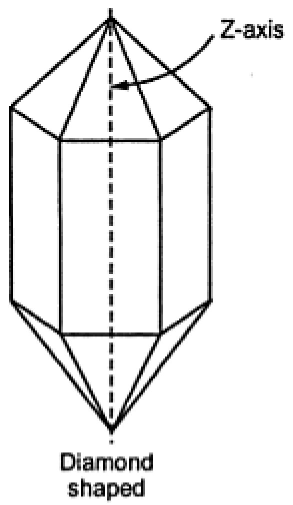
It is interesting to note that the polarity of the potential produced across the faces gets reversed if the direction of deformation is reversed.

Conversely if varying potential is applied to the axis of the crystal, the dimensions are changed and the crystal deforms.

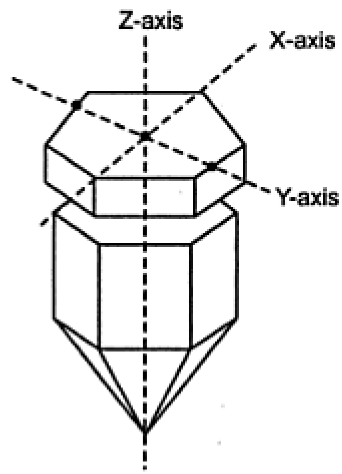
This phenomenon is called **piezoelectric effect** and the materials exhibiting this effect are called **piezoelectric materials.**

The main substances exhibiting piezoelectric effect are quartz, Rochelle salts and tourmaline. Rochelle salts show greatest piezoelectric activity. But mechanically they are weakest as they break easily. Tourmaline is the strongest of the three but it exhibits least piezoelectric activity. It is very expensive. Quartz is a compromise between the piezoelectric activity of Rochelle salts and the strength of tourmaline. It is readily available in nature and it is inexpensive. Rochelle salts are used to make microphones, headsets, loudspeakers and phonograph pickups. Quartz is used for RF oscillators and filters. The quartz and tourmaline are natural crystals while Rochelle salts are synthetic crystals. Other synthetic crystals are Barium Titanate, Dipotassium Tartarate, Lithium sulphate, ceramics A and B etc. The natural crystals have the advantage of very low leakage and allows measurements of slowly varying parameters. While the synthetic crystals have the advantages of higher output, high sensitivity and capability to withstand high mechanical stresses.

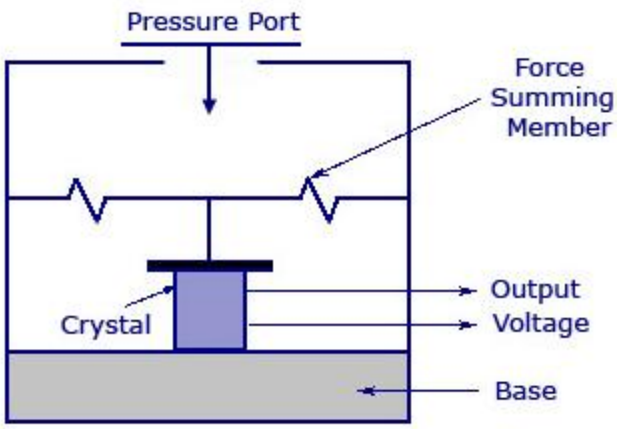
A piezoelectric quartz crystal is hexagonal prism shaped crystal, which has pyramids at both ends. This is shown in the Fig. (a). The marking of co-ordinate axes are fixed for such crystals. The axis passing through the end points of pyramids is called **optic axis** or Z-axis. The axis passing through corners is called **electrical axis** or X-axis while the axis passing through midpoints of opposite sides is called **mechanical axis** or Y-axis. The axes are shown in the Fig. (b).



(a) Quartz crystal



(b) Axes of crystal



Piezo-Electric Transducer

The main principle of a piezoelectric transducer is that a force, when applied on the quartz crystal, produces electric charges on the crystal surface. The charge thus produced can be called as piezoelectricity. Piezo electricity can be defined as the electrical polarization produced by mechanical strain on certain class of crystals. The rate of charge produced will be proportional to the rate of change of force applied as input. As the charge produced is very small, a charge amplifier is needed so as to produce an output voltage big enough to be measured. The device is also known to be mechanically stiff. For example, if a force of 15 kiloN is given to the transducer, it may only deflect to a maximum of 0.002mm. But the output response may be as high as 100KiloHz.This proves that the device is best applicable for dynamic measurement.

The figure shows a conventional piezoelectric transducer with a piezoelectric crystal inserted between a solid base and the force summing member. If a force is applied on the pressure port, the same force will fall on the force summing member. Thus a potential difference will be generated on the crystal due to its property. The voltage produced will be proportional to the magnitude of the applied force.