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

Course Title: SENSORS MEASUREMENTS AND INSTRUMENTATION (GR20A3092)

The following documents are available in the 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 Timetable, 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 Papers and Scheme of Evaluation	√	
14	Best, Average and Weak Answer Scripts for Each Sessional Exam. (Photocopies)	√	
15	Assignment Questions and Solutions	√	
16	Previous Question Papers		√
17	Result Analysis	√	
18	Feedback From Students	√	
19	CO Attainment for All Mids.		√
20	Remedial Action.		√

Course Instructor / Course Coordinator **Course Instructor / Course Coordinator)**

Dr. P.Srividya Devi
Associate Professor
EEE Department

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 epicenter 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

1. To become an internationally leading department for higher learning.
2. To build upon the culture and values of universal science and contemporary education.
3. 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.
4. To develop partnerships with industrial, R&D and government agencies and actively participate in conferences, technical and community activities.

This Program is meant to prepare our students to professionally thrive and to lead. During their progression:

Graduates will be able to

PEO 1: Graduates will have a successful technical or professional career, including supportive and leadership roles on multidisciplinary teams.

PEO 2: Graduates will be able to acquire, use and develop skills as required for effective professional practices.

PEO 3: Graduates will be able to attain holistic education that is an essentialprerequisite for being a responsible member of society.

PEO 4: Graduates will be engaged in life-long learning, to remain abreast in their profession and be leaders in our technologically vibrant society.

Program Outcomes (B.Tech. – EEE)

At the end of the Program, a graduate will have the ability to

PO-1: Ability to apply knowledge of mathematics, science, and engineering.

PO-2: Ability to identify, formulate, analyze engineering problems using engineering sciences.

PO-3: Ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety.

PO-4: Ability to design and conduct experiments, as well as to analyze and interpret data with valid conclusions.

PO-5: Ability to utilize experimental, statistical, and computational methods and tools necessary for modelling engineering activities.

PO-6: Ability to apply reasoning informed by relative knowledge to evaluate societal, health, safety, legal and cultural issues, and tasks applicable to professional engineering practice.

PO-7: Ability to adapt broad education necessary to understand the impact of engineering solutions and obtain sustainability in a global, economic,environmental, and societal context.

PO-8: Ability to discover ethical principles and bind to professional and ethical responsibility.

PO-9: Ability to function as an individual and in multi-disciplinary teams.

PO-10: Ability to communicate effectively on complex activities in engineeringcommunity and society.

PO-11: Ability to develop Project management principles and apply them in variousdisciplinary environments.

PO-12: Recognition of the need for, and an ability to engage in life-long learning.

Program Specific Outcomes (PSOs):

PSO-1: Graduates will interpret data and be able to analyze digital and analog systemsrelated to electrical and programming them.

PSO-2: Graduates will be able to demonstrate, design and model electrical, electroniccircuits, power electronics, power systems and electrical machines.

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INSTITUTE OF ENGINEERING AND TECHNOLOGY
Department of Electrical & Electronics Engineering

GRIET/DAA/1H/G/22-23 19 July 2022

Academic Calendar
Academic Year 2022-23

IIIB.Tech.–First Semester

S. No.	EVENT	PERIOD	DURATION
1	Commencement of First Semester class work	08-08-2022	
2	I Spell of Instructions	08-08-2022 to 08-10-2022	9 Weeks
3	I Mid-term Examinations	10-10-2022 to 13-10-2022	3 Days
4	II Spell of Instructions	14-10-2022 to 12-12-2022	9 Weeks
5	II Mid-term Examinations	13-12-2022 to 15-12-2022	3 Days
6	Preparation	16-12-2022 to 22-12-2022	1 Week
7	End Semester Examinations (Theory/ Practical) Regular/ Supplementary	23-12-2022 to 13-01-2023	3 Weeks
8	Commencement of Second Semester, AY 2022-23	16-01-2023	

III B.Tech. – Second Semester

S. No.	EVENT	PERIOD	DURATION
1	Commencement of Second Semester class work	16-01-2023	
2	I Spell of Instructions	16-01-2023 to 16-03-2023	9 Weeks
3	I Mid-term Examinations	17-03-2023 to 20-03-2023	3 Days
4	II Spell of Instructions	21-03-2023 to 29-04-2023	6 Weeks
5	Summer Vacation	01-05-2023 to 20-05-2023	3 Weeks
6	II Spell of Instructions Contd	22-05-2023 to 12-06-2023	3 Weeks
7	II Mid-term Examinations	13-06-2023 to 15-06-2023	3 Days
8	Preparation	16-06-2023 to 22-06-2023	1 Week
9	End Semester Examinations (Theory/ Practical) Regular / Supplementary	23-06-2023 to 15-07-2023	3 Weeks
10	Commencement of IV B.Tech First Semester, AY 2023-24	17-07-2023	

J. Praveen

Gokaraju Rangaraju Institute of Engineering And Technology
Griet

Dean Academic Affairs

Copy to Principal, All HoDs, CoE

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

2022 -23 II sem Subject Allocation Sheet

II YEAR(GR20)	Section-A	
Probability and Statistics	Mr. S Bhagat Kumar	
AC Machines	Dr Phaneendra Babu B / G Sandhya Rani	
Control Systems	V Usha Rani	
Principles of Digital Electronics	Dr T Suresh Kumar	
Power Distribution and Protection	Dr V Vijaya Rama Raju	
Environmental Science	Dr K Kalpana	
Data Base for Engineers	G Satish	
Principles of Digital Electronics Lab	R Anil Kumar/ MNSandhya Rani	
AC Machines Lab	Dr V Vijaya Rama Raju / M Rekha	
Control Systems Lab	D Karuna Kumar /V Usha Rani	
III YEAR (GR20)	Section-A	
Programmab le Logic Controllers	P Prashanth Kumar	
Sensors Measuremen ts and Instrumentat ion	Dr P Srividyadevi	
Economics and Accounting for Engineers	K Sunil Kumar	
Modern Power Electronics (EEE) (PE-II)	Dr Pakkiraiah	
HVDC Transmission Systems (EEE) (PE-II)	Dr J Sridevi	
NPTEL (OE-II)	D Srinivasa Rao	
Power System Analysis Lab	GSR/MNSR	
Sensors Measuremen ts and Instrumentat ion Lab	Dr P Srividyadevi/ Dr DG Padhan /U Vijaya Lakshmi	
Mini Project with Seminar	Dr Phaneendra Babu B / D Srinvasa Rao	
IV YEAR (GR18)	Section-A	Section-B
Programmable Logic Controllers	Dr Pakkiraiah B	Dr Pakkiraiah B
Power Quality and FACTS (PE-V)	DKK	DKK
Electric Smart Grid (PE-VI)	Dr J Sridevi	Dr J Sridevi
Open Elective III	Complete	
Project work (Phase- II)	AVK/MNSR/GSR	AVK/MNSR/GSR
M.Tech (POWER ELECTRONICS) I-II SEM		
Electric Drives System	Dr A Vinay Kumar	
Modern and Digital Controlof Power Electronic and Drive Systems	Dr.D G Padhan	
Advanced Power Electronic Converters (PE-III)	Dr T Suresh Kumar	

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INSTITUTE OF ENGINEERING AND TECHNOLOGY

Department of Electrical & Electronics Engineering

AI and Machine LearningTechniques for Power Electronic Applications (PE-IV)	Dr B Phaneendra Babu
Electrical Drives Lab	Syed Sarfaraz Nawaz
DSP and MicrocontrollerLab	Dr A Vinay Kumar
Mini Project	G Sandhya Rani
(Audit Course II) Indian Constitution	Syed Sarfaraz Nawaz
M.Tech (POWER ELECTRONICS) II-II SEM	
Disseration Phase -II	Dr T Suresh Kumar

2022-23 I Year II sem BEE		
Staff Name	Theory	Labs
K Sudha	2	1
P Praveen Kumar	2	1
Dr D S N M Rao	2	1
P Prashanth Kumar	______	2
P Ravikanth	1	2
R Anil Kumar	1	______
M Rekha	______	3
U Vijaya Lakshmi	______	4
M Prashanth	______	3
Dr D G Padhan	1	______
V Usha Rani	______	1
CIVIL B.Tech II Year BEEE		
BEEE (CIVIL)	M Prashanth	

Dr Phaneendra Babu B
HOD,EEE

GOKARAJU RANGARAJU
INSTITUTE OF ENGINEERING AND TECHNOLOGY

Department of Electrical & Electronics Engineering

GRIET/PRIN/06/G/01/22-23 **Wef : 16th Jan 2023**

BTech - EEE - A **III Year - II Semester**

DAY/ HOUR	9:00 - 9:55	9:55- 10:50	10:50 - 11:45	11:45 -12:25	12:25-1:15	1:15 - 2:05	2:05 -2:55
MONDAY	EAE	SMI		BREAK	Mentoring	IoT	
TUESDAY	SMI		PLC	BREAK	SMI Lab (A1)/ PSA Lab (A2)		
WEDNESDAY	MPE/HVDCT		SMI	BREAK	SMI Lab (A2)/ PSA Lab (A1)		
THURSDAY	MPE/HVDCT	PLC		BREAK	Mentoring	EAE	
FRIDAY	MP Lab			BREAK	IoT	MPE/HVDCT	
SATURDAY	PLC		Library	BREAK	MP Lab/Mentoring/Student Techincal Activites		

ROOM NO	
Theory/Tutorial	**4402**
Lab	**PSA Lab (4504)** **SMI Lab (4507)** **MP Lab (4402)**
Class Incharge:	**G. Sandhya Rani**

Subject Code	Subject Name	Faculty Code	Faculty Name	Almanac	
G20A3081	Programmable Logic Controllers (PLC)	PK	P. Prasanth Kumar	1st Spell of Instructions	16-01-2023 to 16-03-2023
G20A3092	Sensors Measurements and Instrumentation(SMI)	Dr. PSVD	Dr. P. Srividya Devi	1st Mid-term Examinations	17-03-2023 to 20-03-2023
G20A2004	Economics and Accounting for Engineers (EAE)	KKSK	K. K. Sunil Kumar	2nd Spell of Instructions	21-03-2023 to 29-04-2023
G20A3093	Modern Power Electronics (MPE)	Dr. PB	Dr. B. Pakkiraiah	Summer Vacation	01-05-2023 to 20-05-2023
G20A3094	HVDC Transmission Systems (HVDCTS)	Dr.JS	Dr. J. Sridevi	2nd Spell of Instructions Contd.	22-05-2023 to 12-06-2023
G20A	Internet of Things (Open Elective - II)	DSR	D. Srinivasa Rao	2nd Mid-term Examinations	13-06-2023 to 15-06-2023
G20A3096	Power Systems Analysis Lab (PSA Lab)	GSR/MNSR	G. Sandhya Rani/ M. N. Sandhya Rani	Preparation	16-06-2023 to 22-06-2023
G20A3097	Sensors Measurements and InstrumentationLab (SMI Lab)	Dr PSVD/ Dr. DGP/ UVL	Dr. P. Srividya Devi/Dr. D. G. Padhan/ U. Vijaya Laxmi	End Semester Examinations (Theory/ Practicals) Regular / Supplementary	23-06-2023 to 15-07-2023
G20A3141	Mini Project With Seminar (MP Lab)	Dr. PBB/DSR	Dr. B. Phaneendra Babu/ D. Srinivasa Rao	Commencement ofIV B. Tech I Sem A.Y 2023-24	17/07/2023

Time Table Coordinator **HOD** **DAA**

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

Individual timetable

Day/Hour	9:00 - 9:55	9:55 - 10:50	10:50- 11:45	11:45 - 12:25	12:25- 1:15	1:15 - 2:05	2:05 -2:55
		SMI		BREAK			
TUESDAY	SMI						
WEDNESDAY			SMI				
THURSDAY							
FRIDAY							
SATURDAY							

Room No.4504	
Theory	4402
Lab	PSSLAB
Class Incharge :	G Sandhyarani

GOKARAJU RANGARAJU
INSTITUTE OF ENGINEERING AND TECHNOLOGY

Department of Electrical & Electronics Engineering

SENSORS MEASUREMENTS AND INSTRUMENTATION
(GR20A3092)

UNIT-I:
FUNDAMENTALS OF ELECTRICAL MEASUREMENTS
Ammeters & Voltmeters PMMC & Moving Iron Instruments C.T.s and PTs Ratio and Phase angle errors. Measurement of Power and power factor. Measurement of Active and Reactive power.

UNIT-II: MEASUREMENT OF ENERGY AND OTHER ELECTRICAL QUANTITIES Single phase & Three phase energy meters, Crompton's Potentiometer AC potentiometers. Measurement of resistance, Inductance and Capacitance by bridges: Wheatstone bridge, Meggar Kelvin Double Bridge, Maxwell's Bridge, Anderson's bridge, Schering Bridge

UNIT-III: OSCILLOSCOPE AND DIGITAL VOLTMETERS Cathode Ray Oscilloscope, Time base Horizontal & Vertical Amplifier, Measurement of phase and frequency. Sampling Oscilloscope, Digital storage Oscilloscope. Digital VoltmetersSuccessive Approximation, Ramp, Dual slope Integration.

UNIT-IV: SENSOR FUNDAMENTAL PRINCIPLES Sensors / Transducers, principles, classification, parameters, characterizations, Introduction to mechanical &Electromechanical Sensors: Resistive type, Inductive sensors, Capacitive Sensors, Force and displacement/ position sensor, LVDT.

UNIT V: SENSOR APPLICATIONS Working Principles: Flow - rate sensors, Pressure Sensors, Temperature Sensors, Ultrasonic sensor, Acceleration Sensors.

COURSE OBJECTIVES

Academic **Y**ear : 2022-23

Semester : II

Name of the Program: B.Tech Year: III

Course/Subject: Sensors Measurements and Instrumentation Course Code: **GR20A3092**

Name of the Faculty: Dr P Srividya Devi Dept.:EEE

On completion of this Subject/Course the student shall be able to:

S.No	**Objectives**
1	To Memorize, monitor, analyze and control any physical system.
2	Demonstration on construction and working of different types of meters.
3	Interpret the use of modern tools necessary for electrical projects.
4	Compose different techniques for precise measurement of electrical and non-electrical quantities
5	Design and create novel products and solutions for real life problems.

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INSTITUTE OF ENGINEERING AND TECHNOLOGY
Department of Electrical & Electronics Engineering

COURSE OUTCOMES

Academic **Y**ear : 2022-23

Semester : II

Name of the Program: B.Tech Year: III

Course/Subject: Sensors Measurements and Instrumentation Course Code: **GR20A3092**

Name of the Faculty: Dr P Srividya Devi Dept.:EEE

The expected outcomes of the Course/Subject are:

S.No	**Outcomes**
1	Outline the fundamentals and measurement of different electrical quantities.
2	Calculate unknown values in AC & DC Bridges.
3	Summarize Oscilloscopes and evaluate the usage of Digital voltmeters.
4	Identify working principles of various Sensors
5	Know how to design the various applications related to sensors and its applications

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GUIDELINES TO STUDY THE COURSE /SUBJECT

Academic **Y**ear : 2022-23

Semester : II

Name of the Program: B.Tech Year: III

Course/Subject: Sensors Measurements and Instrumentation Course Code: **GR20A3092**

Name of the Faculty: Dr P Srividya Devi Dept.:EEE

Guidelines to study the Course/ Subject: Sensors Measurements and Instrumentation

Course Design and Delivery System (CDD):

The Course syllabus is written into number of learning objectives and outcomes.

These learning objectives and outcomes will be achieved through lectures, assessments, assignments, experiments in the laboratory, projects, seminars, presentations, etc.

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

COURSE SCHEDULE

Academic **Y**ear : 2022-23

Semester : II

Name of the Program: B.Tech Year: III

Course/Subject: Sensors Measurements and Instrumentation Course Code: **GR20A3092**

Name of the Faculty: Dr P Srividya Devi Dept.:EEE

The Schedule for the whole Course / Subject is:

Sl.No	**Topics**	**No of periods**
1	FUNDAMENTALS OF ELECTRICAL MEASUREMENTS	15
2	MEASUREMENT OF ENERGY AND OTHER ELECTRICAL QUANTITIES	15
3	OSCILLOSCOPE AND DIGITAL VOLTMETERS	15
4	SENSOR FUNDAMENTAL PRINCIPLES	10
5	SENSOR APPLICATIONS	10

Total No. of Instructional periods available for the course: ……65……. Periods

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SCHEDULE OF INSRTUCTIONS COURSE PLAN

Academic **Y**ear : 2022-23

Semester : II

Name of the Program: B.Tech Year: III

Course/Subject: Sensors Measurements and Instrumentation Course Code: **GR20A3092**

Name of the Faculty: Dr P Srividya Devi Dept.:EEE

S.No.	No. of Periods	Topics / Sub-Topics	Objectives & Outcomes Nos.	References (Text Book, Journal…) Page Nos.: ___ _to
1	15	FUNDAMENTALS OF ELECTRICAL MEASUREMENTS	COBJ1, CO1	Electrical & Electronic Measurement & Instruments by A.K.Shawney Page Nos.: 1 to 8 , 123 to 139, 192-210
2	15	MEASUREMENT OF ENERGY AND OTHER ELECTRICAL QUANTITIES	COBJ2, CO2	Electrical & Electronic Measurement & Instruments by A.K.Shawney Page Nos.: 404 to 410 , 333 to 370, 424 to 454, 494 to 499
3	15	OSCILLOSCOPE AND DIGITAL VOLTMETERS	COBJ3, CO3	Electrical & Electronic Measurement & Instruments by A.K.Shawney Page Nos.: 655 to 697
4	10	SENSOR FUNDAMENTAL PRINCIPLES	COBJ4, CO4	Electrical & Electronic Measurement & Instruments by A.K.Shawney Page Nos.: 746 to 825
5	10	SENSOR APPLICATIONS	COBJ5, CO5	Electrical & Electronic Measurement & Instruments by A.K.Shawney Page Nos.: 962 to 1047

LESSON/ UNIT PLAN

Academic **Y**ear : 2022-23

Semester : II

Name of the Program: B.Tech Year: III

Course/Subject: Sensors Measurements and Instrumentation Course Code: **GR20A3092**

Name of the Faculty: Dr P Srividya Devi Dept.:EEE

UNIT No.	Lesson No.	No. of Periods	Lesson Title	Objectives	Outcomes	References (Text Book, Journal…) Page Nos.: ____to ____
1	1	2	Introduction to FUNDAMENTALS OF ELECTRICAL MEASUREMENTS	COBJ1	CO1	Electrical & Electronic Measurement & Instruments by A.K.Shawney Page Nos.: 1 to 8 , 123 to 139, 192-210
1	2	2	Ammeters & Voltmeters .	COBJ1	CO1	Electrical & Electronic Measurement & Instruments by A.K.Shawney Page Nos.: 1 to 8 , 123 to 139, 192-210
1	3	4	PMMC & Moving Iron Instruments	COBJ1	CO1	Electrical & Electronic Measurement & Instruments by A.K.Shawney Page Nos.: 1 to 8 , 123 to 139, 192-210
1	4	2	C.T.s and PTs Ratio and Phase angle errors.	COBJ1	CO1	Electrical & Electronic Measurement & Instruments by A.K.Shawney Page Nos.: 1 to 8 , 123 to 139, 192-210
1	5	2	Measurement of Power and power factor	COBJ1	CO1	Electrical & Electronic Measurement &

						Instruments by A.K.Shawney Page Nos.: 1 to 8 , 123 to 139, 192-210
1	6	2	Measurement of Active and Reactive power	COBJ1	CO1	Electrical & Electronic Measurement & Instruments by A.K.Shawney Page Nos.: 1 to 8 , 123 to 139, 192-210
1	7	1	Review of UNIT -I	COBJ1	CO1	Electrical & Electronic Measurement & Instruments by A.K.Shawney Page Nos.: 1 to 8 , 123 to 139, 192-210
2	8	2	Introduction to MEASUREMENT OF ENERGY AND OTHER ELECTRICAL QUANTITIES	COBJ2	CO2	Electrical & Electronic Measurement & Instruments by A.K.Shawney Page Nos.: 404 to 410 , 333 to 370, 424 to 454, 494 to 499
2	9	2	Single phase & Three phase energy meters	COBJ2	CO2	Electrical & Electronic Measurement & Instruments by A.K.Shawney Page Nos.: 404 to 410 , 333 to 370, 424 to 454, 494 to 499
2	10	3	Crompton's Potentiometer AC potentiometers.	COBJ2	CO2	Electrical & Electronic Measurement & Instruments by A.K.Shawney Page Nos.: 404 to 410 , 333 to 370, 424 to 454, 494 to 499
2	11	2	Introduction to Measurement of resistance, Inductance and Capacitance by bridges	COBJ2	CO2	Electrical & Electronic Measurement & Instruments by A.K.Shawney Page Nos.: 404 to 410 , 333 to 370, 424 to 454, 494 to 499

2	12	3	Wheatstone bridge, Meggar Kelvin Double Bridge, Maxwell's Bridge,	COBJ2	CO2	Electrical & Electronic Measurement & Instruments by A.K.Shawney Page Nos.: 404 to 410 , 333 to 370, 424 to 454, 494 to 499
2	13	2	Anderson's bridge, Schering Bridge	COBJ2	CO2	Electrical & Electronic Measurement & Instruments by A.K.Shawney Page Nos.: 404 to 410 , 333 to 370, 424 to 454, 494 to 499
2	14	1	Review of UNIT-II	COBJ2	CO2	Electrical & Electronic Measurement & Instruments by A.K.Shawney Page Nos.: 404 to 410 , 333 to 370, 424 to 454, 494 to 499
3	15	2	OSCILLOSCOPE AND DIGITAL VOLTMETERS	COBJ3	CO3	Electrical & Electronic Measurement & Instruments by A.K.Shawney Page Nos.: 655 to 697
33	16	2	Cathode Ray Oscilloscope	COBJ3	CO3	Electrical & Electronic Measurement & Instruments by A.K.Shawney Page Nos.: 655 to 697
3	17	3	Components of CRO: Time base Horizontal & Vertical Amplifier	COBJ3	CO3	Electrical & Electronic Measurement & Instruments by A.K.Shawney Page Nos.: 655 to 697
3	18	2	Measurement of phase and frequency. Sampling Oscilloscope	COBJ3	CO3	Electrical & Electronic Measurement & Instruments by A.K.Shawney Page Nos.: 655 to 697
3	19	3	Digital storage Oscilloscope. Digital Voltmeters Successive Approximation	COBJ3	CO3	Electrical & Electronic Measurement &

						Instruments by A.K.Shawney Page Nos.: 655 to 697
3	20	2	Ramp, Dual slope Integration	COBJ3	CO3	Electrical & Electronic Measurement & Instruments by A.K.Shawney Page Nos.: 655 to 697
3	21	1	Review of UNIT-III	COBJ3	CO3	Electrical & Electronic Measurement & Instruments by A.K.Shawney Page Nos.: 655 to 697
4	22	1	Introduction to SENSOR FUNDAMENTAL PRINCIPLES	COBJ4	CO4	Electrical & Electronic Measurement & Instruments by A.K.Shawney Page Nos.: 746 to 825
4	23	2	Sensors / Transducers, principles, classification, parameters.	COBJ4	CO4	Electrical & Electronic Measurement & Instruments by A.K.Shawney Page Nos.: 746 to 825
4	24	2	characterizations, Introduction to mechanical &Electromechanical Sensors	COBJ4	CO4	Electrical & Electronic Measurement & Instruments by A.K.Shawney Page Nos.: 746 to 825
4	25	2	Resistive type, Inductive sensors, Capacitive Sensors.	COBJ4	CO4	Electrical & Electronic Measurement & Instruments by A.K.Shawney Page Nos.: 746 to 825
4	26	2	Force and displacement/ position sensor, LVDT	COBJ4	CO4	Electrical & Electronic Measurement & Instruments by A.K.Shawney Page Nos.: 746 to 825
4	27	1	Review of UNIT-IV	COBJ4	CO4	Electrical & Electronic Measurement & Instruments by A.K.Shawney

						Page Nos.: 746 to 825
5	28	1	Introduction to SENSOR APPLICATIONS	COBJ5	CO5	Electrical & Electronic Measurement & Instruments by A.K.Shawney Page Nos.: 962 to 1047
5	29	2	Working Principles: Flow - rate sensors	COBJ5	CO5	Electrical & Electronic Measurement & Instruments by A.K.Shawney Page Nos.: 962 to 1047
5	30	1	Pressure Sensors	COBJ5	CO5	Electrical & Electronic Measurement & Instruments by A.K.Shawney Page Nos.: 962 to 1047
5	31	2	Temperature Sensors,	COBJ5	CO5	Electrical & Electronic Measurement & Instruments by A.K.Shawney Page Nos.: 962 to 1047
5	32	2	Ultrasonic sensor	COBJ5	CO5	Electrical & Electronic Measurement & Instruments by A.K.Shawney Page Nos.: 962 to 1047
5	33	2	Acceleration Sensors, Review of UNIT-V	COBJ5	CO5	Electrical & Electronic Measurement & Instruments by A.K.Shawney Page Nos.: 962 to 1047

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

	CO-PO Mapping

Assessment methods:

1. Quizzes
2. Internal examinations.
3. External examinations.
4. Assignments and Tutorials.

GR20A3092-SENSORS MEASUREMENTS AND INSTRUMENTATION														
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
1. Outline the fundamentals and measurement of different electrical quantities.	H	H	M			M	M	M		M	M	H	H	H
2. Calculate unknown values in AC & DC Bridges.	H	H	H	M	M					M	M	H	H	H
3. Summarize Oscilloscopes and evaluate the usage of Digital voltmeters.	H	H	H	M	M		M			M	M	H	H	H
4. Identify working principles of various Sensors	H	H	M						M	M	M	H	H	H
5. Know how to design the various applications related to sensors and its applications	H	H	H	H	M	M	M		M	M	M	H	H	H

	CO-Cognitive Level Mapping

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

Cognitive Learning Levels:

CLL1: Remembering
CLL2: Understanding
CLL3: Applying
CLL4: Analyzing
CLL5: Evaluating
CLL6: Creating

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

III B.Tech II Sem (EEE) Result Analysis

Academic Year: 2022-23 Total No. of Students Registered: 64

Course	**Total No. of Students appeared**	**Total No. of Students Passed**	**No. of Students Failed**	**Count of Students with Grade Point**					
				GP (10)	**GP (9)**	**GP (8)**	**GP (7)**	**GP (6)**	**GP (5)**
EAE	64	58	06	00	11	13	7	10	07
PLC	64	60	04	09	16	14	09	06	06
SMI	64	51	13	00	07	12	17	08	07
MPE	40	63	01	02	15	05	08	06	03
HVDCT	24	61	03	00	02	07	08	02	02
PSA Lab	64	58	06	02	14	16	11	11	04
SMI Lab	64	59	05	08	05	20	13	11	02
MINI Proj.	64	58	06	08	24	13	08	04	01
Cloud Computing (MOOCs)	64	52	12	00	10	23	16	13	00
DV	01	01	00	00	00	00	00	01	00
DV Lab	01	01	00	00	00	01	00	00	00

Arrears Position – III year / I Semester

No.of students	All Pass	One Arrear	Two Arrears	Three Arrears	More than three arrears	Over all % of pass
64	46	07	04	01	06	72%

Performance overall Class Three Toppers

ROLL NO.	NAME	SGPA
21245A0201	JAKINAPALLI CHANDHANA	9.48
20241A0257	SUSANI NEHA	9.30
20241A0223 20241A0233	M GAYATHRI PISINI SATHVIKA	9.18

GOKARAJU RANGARAJU
INSTITUTE OF ENGINEERING AND TECHNOLOGY

Department of Electrical & Electronics Engineering

III B.Tech - I Sem (EEE)

SECTION	Course s	EAE	PLC	SMI	MPE	HVDCT	PSA Lab	SMI Lab	MINI Proj.	CC	DV	DV Lab
	Course codes	GR20A2004	GR20A3091	GR20A3092	GR20A3093	GR20A3094	GR20A3096	GR20A3097	GR20A3141	GR20A6007	GR20A3065	GR20A3068
A	TOTAL	64	64	64	40	24	64	64	64	64	01	01
	PASS	58	60	51	39	21	58	59	58	52	01	01
	PASS(%)	90.62%	93.75%	79.68%	97.5%	87.5%	90.62%	92.18%	90.62%	81.25%	100	100
	FACULTY NAME	K Sunil Kumar	P Prashanth Kumar	Dr P Srividya devi	Dr Pakkiraiah	Dr J Sridevi	G Sandhya Rani/M N Sandhya Rani	Dr P Srividya Devi/ Dr DG Padhan/ U Vijaya Lakshmi	Dr Phaneendra Babu / D Srinivasa Rao	P Ravikanth	Dr V Srilakshmi	N Krishna Chaitanya
	FACULTY ID	176	1055	931	1593	516	888/882	931/1283/692	1563/1540	1178	923	1397

GOKARAJU RANGARAJU INSTITUTE OF ENGINEERING AND TECHNOLOGY

FEEDBACK OF FACULTY CONDUCTING BTECH CLASS WORK

FACULTY WISE

EEE- B.Tech- III Year SEMESTER - II ACADEMIC YEAR : 2022-2023 FEEDBACK NO:1 DATE: 21-02-2023

S.NO	FACULTY ID	FACULTY NAME	SUBJECT NAME	SECTION	DEPT	NO. OF SECTIONS	FEEDBACK 1 (4 POINTS) (AVG OF ALL SECTIONS)
1	1055	P. Prasanth Kumar	Programmable Logic Controllers (PLC)	A	EEE	1	3.04
2	931	Dr. P. Srividya Devi	Sensors Measurements and Instrumentation (SMI)	A	EEE	1	3.2
3	1604	K. K. Sunil Kumar	Economics and Accounting for Engineers (EAE)	A	EEE	1	3.08
4	1283	Dr D. G. Padhan	Modern Power Electronics (MPE)	A	EEE	1	3.24
5	516	Dr. J. Sridevi	HVDC Transmission Systems (HVDCTS)	A	EEE	1	2.8
6	1540	D. Srinivasa Rao	Internet of Things (Open Elective - II)	A	EEE	1	3.12
7	888	G. Sandhya Rani	Power Systems Analysis Lab (PSA Lab)	A	EEE	1	3.12
8	882	M. N. Sandhya Rani	Power Systems Analysis Lab (PSA Lab)	A	EEE	1	3.16
9	931	Dr. P. Srividya Devi	Sensors Measurements and Instrumentation Lab (SMI Lab)	A	EEE	1	3.16
10	1283	Dr. D. G. Padhan	Sensors Measurements and Instrumentation Lab (SMI Lab)	A	EEE	1	3.12
11	692	U. Vijaya Laxmi	Sensors Measurements and Instrumentation Lab (SMI Lab)	A	EEE	1	3.12
12	1563	Dr. B. Phaneendra Babu	Mini Project With Seminar (MP Lab)	A	EEE	1	3.12
13	1540	D. Srinivasa Rao	Mini Project With Seminar (MP Lab)	A	EEE	1	3.12

HOD Signature

FEEDBACK OF FACULTY CONDUCTING II BTECH CLASS WORK

Dept: EEE A.Y. 2022-23 Semester - 2 Feedback:2 Date: 22/03/2023

SECTION	SUBJECTS (THEORY)	FACULTY ID	FACULTY NAME	DEPT	FEEDBACK OF STUDENTES	RELATIVE FEEDBACK (AVG OF ALL SUBJECTS)
III	PLC	1055	P.Prasanth Kumar	EEE	2.86	3.02
	SMI	931	Dr.P.Srividya Devi		3.29	
	EAE	176	K.K.SunilKumar		3.07	
	MPE	1593	Dr.B.Pakkiraiah		2.82	
	HVDCTS	516	Dr.J.Sridevi		2.19	
	IOT	1540	D.SrinivasRao		3.02	
	PSA LAB	888	G.SandhyaRani		3.19	
	PSA LAB	882	M.N.SandhyaRani		3.20	
	SMI LAB	931	Dr.P.Srividya Devi		3.16	
	SMI LAB	1283	Dr.D.G.Padhan		3.21	
	SMI LAB	692	U.VijyaLaxmi		3.11	
	MP LAB	1563	Dr.PB.Phaneendra Babu		3.09	
	MP LAB	1540	D.SrinivasRao		3.01	

Signature of HOD

GOKARAJU RANGARAJU INSTITUTE OF ENGINEERING AND TECHNOLOGY
(Autonomous)
Department of Electrical Engineering

Academic Year: **2022-23** **Assignment – I**

Year: III **Sub: Sensors Measurements and Instrumentation** Duration: **03 days**

Semester: **II** Max Marks: **05**

Code: GR20A3092

S. No.	Question	Marks	CO	BL
1.	With a neat diagram explain attraction and repulsion type of MI instruments.	01	1	2
2.	List the advantages, disadvantages, and applications of MI instruments.	01	1	1
3.	Compare PMMI and PMMC instruments.	01	1	3
4.	Distinguish between moving iron instrument & moving coil instrument.	01	1	4
5.	Derive the calculations and formulas of ratio and phase angle errors of CT’s and PT’s, by representing its equivalent circuit & phasor diagram	01	1	6

GOKARAJU RANGARAJU INSTITUTE OF ENGINEERING AND TECHNOLOGY
(Autonomous)
Department of Civil Engineering

Academic Year: **2022-23** | **Assignment – II** | Duration: **03 days**

Year: **III** | **Sub: Sensors Measurements and Instrumentation** | Max Marks: **05**

Semester: **II**

Code: GR20A3092

S. No.	Question	Marks	CO	BL
1.	Explain working construction, operating principles, advantages & disadvantages with application for the following with neat sketch: (i) single-phase energy meter (ii) DC Crompton's potentiometer (iii) AC potentiometer	01	2	2
2.	Derive resultant induced EMF with neat equations of polar & coordinate AC potentiometer.	01	2	5
3.	Derive the formula with a neat diagram Kelvin double bridge for measurement of low measurement of low resistance and the experimentation in lab	01	2	6
4.	Summarize the purpose of the Wheatstone bridge & derive formula.	01	2	2
5.	With a neat phasor diagram representing the neat driving torque of a single-phase energy meter.	01	2	3

GOKARAJU RANGARAJU INSTITUTE OF ENGINEERING AND TECHNOLOGY
(Autonomous)
Department of Civil Engineering

Academic Year: **2022-23** | **Assignment – III** | Duration: **03 days**

Year: **III** | **Sub: Sensors Measurements and Instrumentation** | Max Marks: **05**

Semester: **II**

Code: GR20A3092

S. No.	Question	Marks	CO	BL
1.	List the advantages and disadvantages and application of Digital voltmeter (DVM).	01	3	1
2.	Describe the principle and operation with neat diagram along with advantages, disadvantages & applications for the following: (i) Ramp type- a) Linear Type b) Staircase Type	01	3	2
3.	Illustrate Dual Slope Integrating type.	01	3	2
4.	Draw the block diagram of inner components of CRO and explain them	01	3	4
5.	Go the Virtual labs and do the DRO experimentation	01	3	5

GOKARAJU RANGARAJU INSTITUTE OF ENGINEERING AND TECHNOLOGY
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Department of Civil Engineering

Academic Year: **2022-23** | **Assignment – IV** | Duration: **03 days**

Year: **III** | **Sub: Sensors Measurements and Instrumentation** | Max Marks: **05**

Semester: **II**

Code: GR20A3092

S. No.	Question	Marks	CO	BL
1.	Describe the construction of LVDT and explain its principle of operation with the aid of diagram	01	4	2
2.	Classify the Transducers and give suitable examples	01	4	3
3.	List the advantages, disadvantages, and applications of LVDT.	01	4	2
4.	Illustrate the principle involved in resistive type transducers	01	4	2
5.	List the application of capacitive type transducer	01	4	3

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Department of Civil Engineering

Academic Year: **2022-23** | **Assignment – V** | Duration: **03 days**

Year: **III** | **Sub: Sensors Measurements and Instrumentation** | Max Marks: **05**

Semester: **II**

Code: GR20A3092

S. No.	Question	Marks	CO	BL
1.	Describe the different transducers for measurement of displacement	01	5	3
2.	Explain the different types of transducers for measurement of flow	01	5	4
3.	Illustrate the different types of Acceleration Transducers.	01	5	3
4.	Describe the different types of linear velocity transducers	01	5	2
5.	Analyse the Flow in Ultrasonic sensor and interpret on it	01	5	3

Assignments Solutions from Students (Sample)

06/02/23

2A

- Instrument
  - Mechanical Instrument
  - Electrical instrument
    - Absolute indirect
      - Deflecting instrument
        - Indicating instrument
        - Integrating instrument
        - Recording instrument
      - Null Deflection
    - Secondary direct
  - Electronic instrument

Indicating: It indicate the magnitude of measurement of quantity ex: Voltmeter, Ammeter

Integrating: It indicates which measure the power supplied at a particular interval of time ex:- Energy record.

Recording: It measures circuit condition at a particular interval of time

Ex: ECG

3A Essential Requirements of an

- Deflecting torque
- Controlling torque
  → Spring control
  → Gravity control
- Damping torque — Air friction damping, Fluid " , Eddy "

Deflecting torque

It is produced by the utilizing the various effects (Magnetic, induction, thermal, hall effect) of the electric current or voltage & hence the causes the moving system & hence the pointer to move from zero position.

Controlling Torque: is produced by spring or gravity & opposes the deflecting torque. The pointer comes to the rest at a position, where these two opposing torque are equal.

Damping torque is provided by a friction or eddy currents, it ensures that the pointer comes to the final position without oscillation thus enabling accurate & quick reading to be taken.

Deflecting system

Most of the indicating instruments the mechanical for α to the ~~quantity~~ quantity to be measured is generated. The force or torque deflect the pointer.

The deflecting torque overcomes

→ The inertia of the moving system.

→ the controlling torque provided by controlling system

→ The ~~control~~ damping " " " damping system

Controlling system: The controlling torque opposes the deflecting torque & increases with the deflecting of the moving system. The pointer comes to the rest at a position where the two opposing torque are equal i.e., $T_d = T_C$.

Controlling torque performs two functions:

- Controlling torque increase with the deflection on the moving of th system so that the final position of the pointer on the scale will be according to the magnitude of the electrical quantity to be measured.
- control torque brings the pointer back to zero when the deflection torque is removed the pointer it is were not provided one deflected.

* Measurand is a physical parameter or variable to be a measure..
* Standard is defined as a quantity of the same kind chosen as a unit or basis for comparison of a quantitative value to be a measure.
* The direct measurement method categorized into 2 types < anolog / Digital
* Tangent galvanometer is an example for absolute instruments.; Rayleighs current bal

PMMC 4(*)

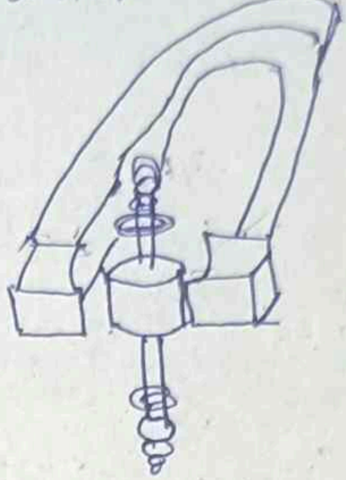
* Permanent Magnet Moving coil instrument
  → It is the most accurate measuring instrument used for measuring dc quantities
  → It's working principle is similar to a motor i.e., when a movable coil is placed in the magnetic field it experiences a torque moves
  → Here, permanent magnets are used to produce the magnetic field. &

Construction

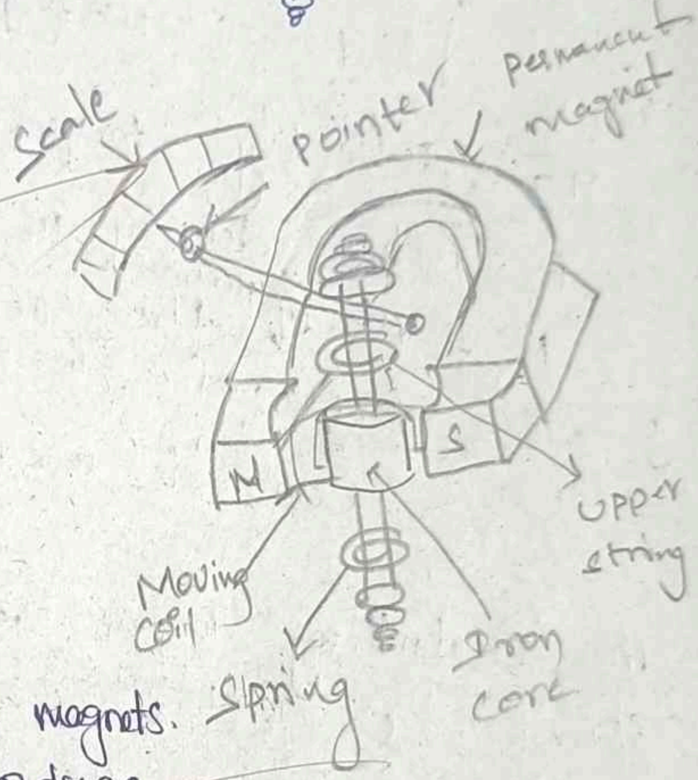
Moving coil

* It consist of a no. of turns which are made up of silk covered copper wire
* Whenever current flows through the moving wire & is kept in the magnetic field, a deflect

torque is produced & the coil moves due to which the pointer shows deflection.



Scale
pointer
Moving coil
Spring
Iron core
upper string
Permanent magnet.



Magnet system

- consist of Permanent magnets.
- The function is to produce a magnetic field.
- Available in different shapes & sizes
- Recent PMMC's, magnets are made up of materials like Alcomax & Alnico that have a high ability to withstand external magnetic fields without losing their magnetism.

Control system

- The function is to produce the necessary & sufficient controlling torque.
- The control torque produced is equal in magnitude

When the instrument is spring-controlled

$T_d = NBAI$ $\qquad \frac{I_1}{I_2} = \frac{\theta_1}{\theta_2}$

$T_c = K\theta$ $\qquad \Rightarrow NBAI = K\theta \qquad \frac{5}{2.5} = \frac{80°}{\theta_2}$

$T_d = T_c$

$\boxed{\theta_2 = 40°}$

* A moving iron type ammeter has far turns of thick wire so that resistance is less

* Merit of a Moving iron instrumen
* It can be used under severe over-load conditions

Power factor Meter

It measures the power factor of a transmission system. The power factor is the cosine of the angle b/w the voltage & current. The P.F.M determines the types of load using on the line, & it also calculates the losses occurs on it.

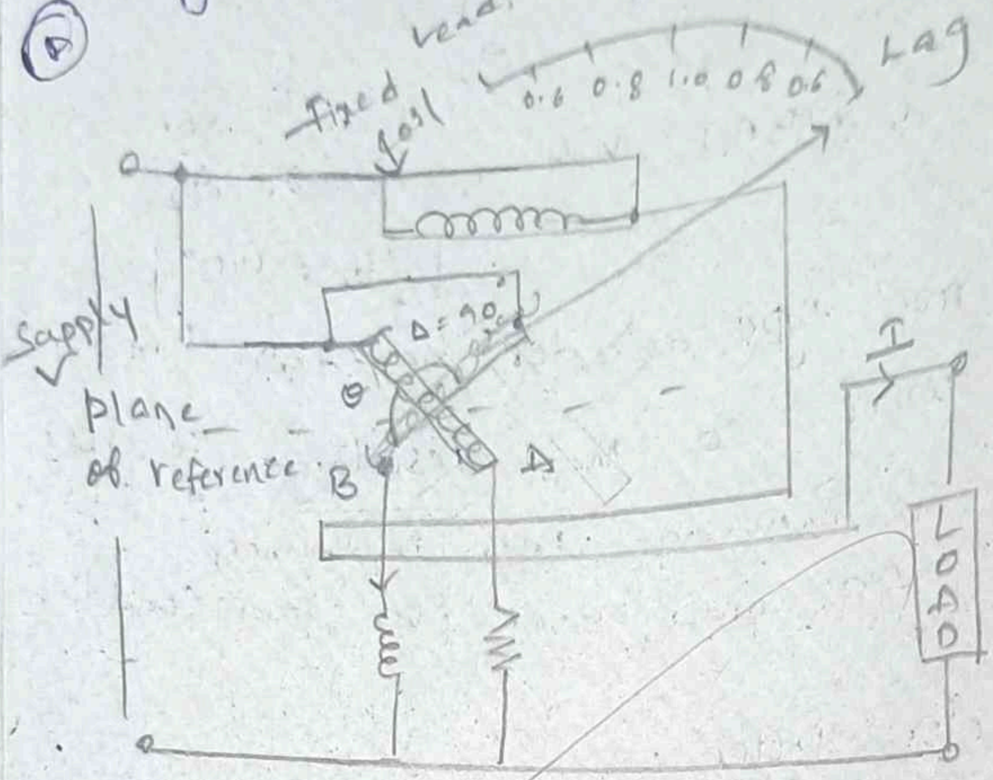
Types of Power factor Meter

(IA) 2 types

1. Electrodynamometer
   a) Single Phase b) three phase
2. Moving Iron type meter
   a) Rotating Iron Magnetic field
   b) No. of Alternating field

Single phase Electrodyn...

(b)



→ The meter has fixed coil which acts as a current coil.

→ This coil split into two parts & carry the current under test

→ The magnetic field of the coil is ∝ to the current flow through the coil

→ The meter has 2 identical pressure coils A & B.

→ Both the coils are pivoted on the spindle

→ The pressure coil A has no inductive resistance connected in series with the current & the coil B has high ind coil connected in series with the circuit.

→ The current in the coil A is in phase with the circuit while the current in the coil B lags by the voltage nearly equal to ~~8°~~ 90°.

→ The connection of the moving coil is made through silver ligaments which minimize the controlling torque of the moving system.

→ The meter has 2 deflecting torque one on coil A & another on coil B.

→ The windings are so arranged that they are opposite in direction.

→ The pointer is in equilibrium when the torques are equal.

→ Deflecting torque acting on coil A given by

$$T_A = KVIM \cos\theta \sin\theta$$

θ → Angular deflection from the plane of reference

M_{max} → Max. value of mutual inductance b/w the c

→ Deflecting torque acting on coil B is given

$$T_B \propto T_B = KVIM_{max} \cos(90° - \phi) \sin(90° + \theta)$$

$$T_B = KVIM_{max} \cos\phi \sin\theta$$

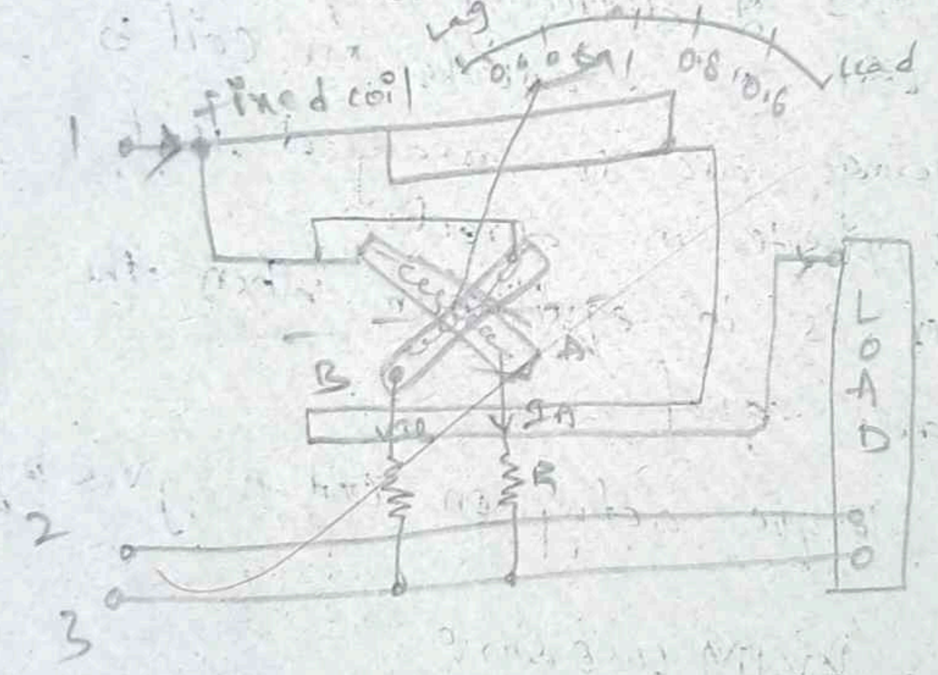
The deflecting torque is acting on the clockwise direction.

The value of max mutual inductance is same b/w both the deflecting equations :

$$\boxed{T_A = T_B}$$

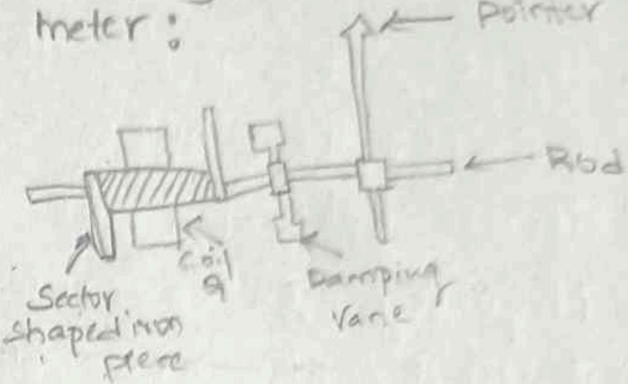
$$\boxed{KVIM\cos\phi\sin\theta = KVIM_{max}\cos\phi\sin\theta}$$

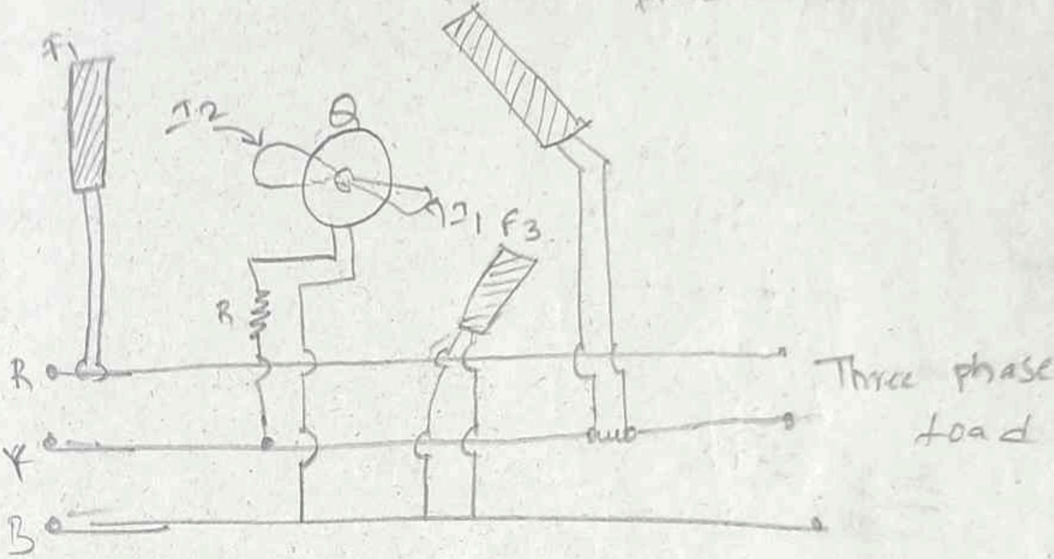
This torque acts on anti-clock dir



3-ϕ Electrodynamometer.

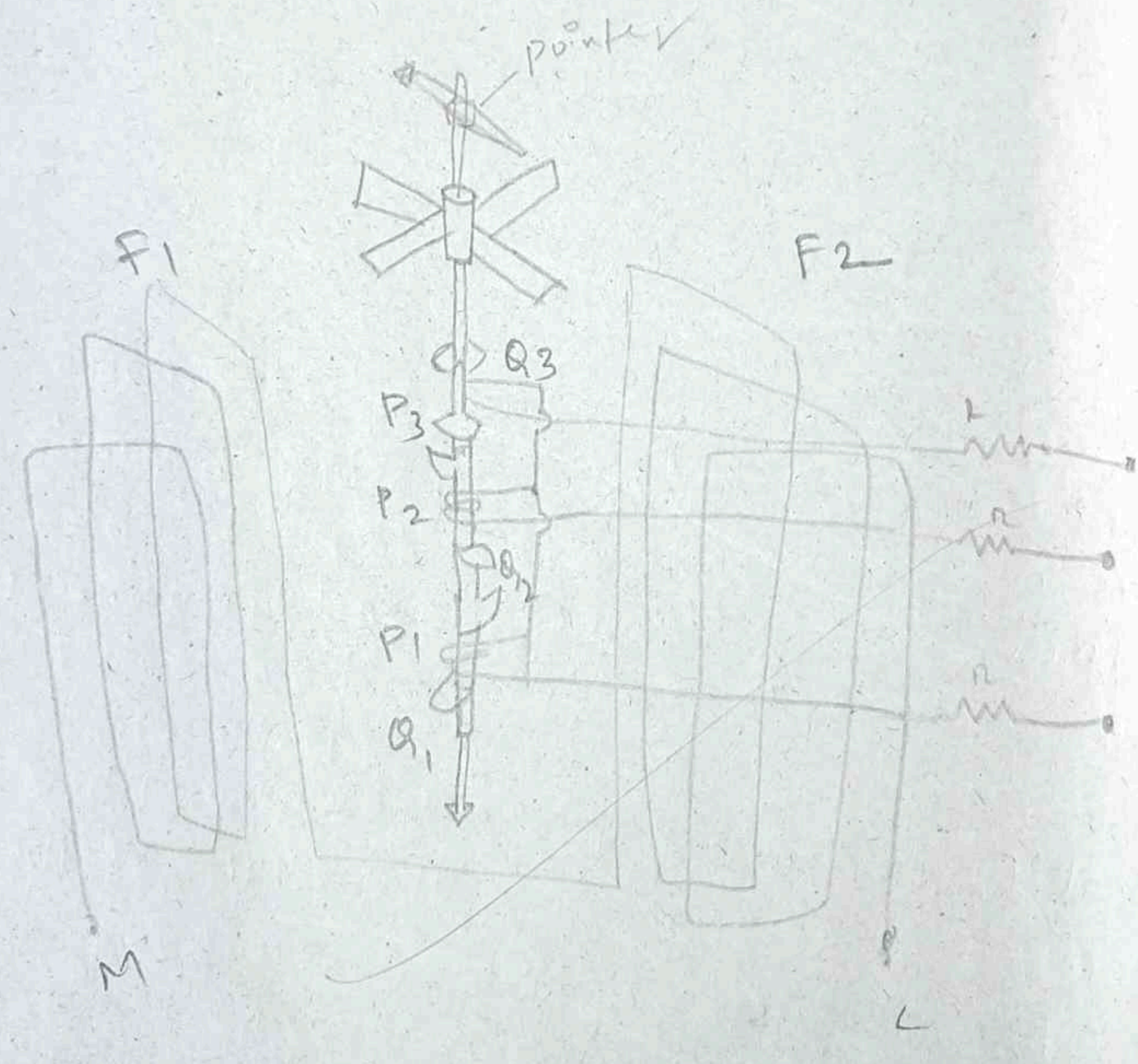
(Q) A
(b) Rotating Field type Moving Iron power factor meter:





- It consists of three fixed coils whose a... are displaced from each other by 120°.
- The coils are supplied from a three phase supply through current transformer (
- The coils F1, F2 & F3 are the fixed coils.
- The coil F1 is supplied from phase R, coil F2 from phase Y & coil F3 from phase
- The coil Q is placed at the centre of the 3 fixed coils & connected across any two lines of the supply through a series
- Inside coil Q, there is a short pivote... iron rod.
- The rod carries two sector shaped vanes I1 & I2, at its ends.
- The same rod carries damping vanes & a p...

The meter can be used for balanced loads, it is called westing house Powerfactor meter.
It is calibrated at the normal supply frequency & can cause serious errors if used at any other frequency,



— Alternating field type moving Iron Meter

This instrument consists of three moving irons & vanes, which are fixed to the common spindle. The spindle carries the damping vanes & the pointer.

The moving iron vanes are sector shaped similar to those used in the rotating field type meter.

The Area of these sectors have an angle of 120° w.r. to each other.

Each of the iron pieces is magnetized with a voltage coil connected to it from one of the 3 different phases of the system.

* An alternating field moving iron power factor meter can be suitably designed for measurement of power factor of an unbalanced 3 phase system

Assignment - 1

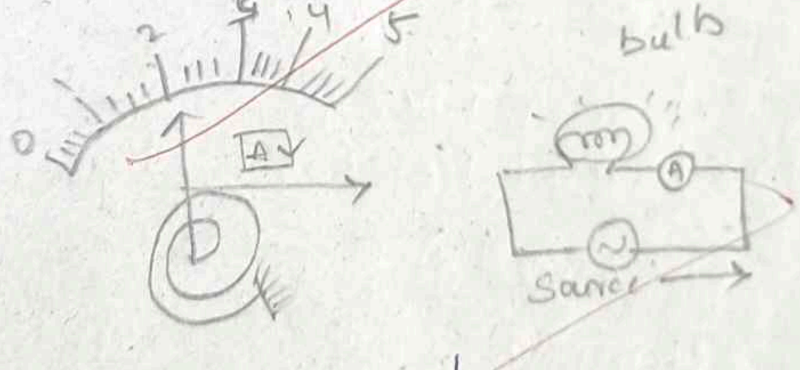
1 Q) What are the necessary requirement for any measuring instrument.

Requirement for any measuring instrument

- → Measuring instrument capability
- → Long term stability
- → unsuability → Cost efficiency
- → speed → flexibility
- → future - proof technology
- → Controlling & damping.

6Q) With neat circuit diagram explain the analysis of 1) PMMC as Ammeter
2) PMMC as Voltmeter

a) Ammeter (PMMC)



- → it measure current
- → Always connected in series
- → Resistance & Ammeter is vary less delay RA=0 Low (RA (Pract) = low) RB = ∞ current source
- → For Rang extension of Ammeter A wire is connected in parallel always

$V_{sh} = V_m$

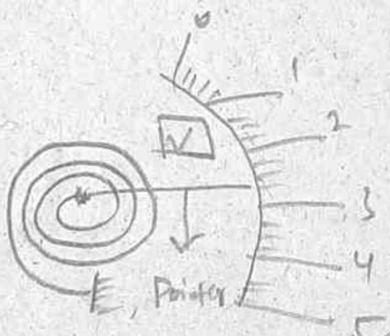
$I_{sh} R_{sh} = I_m R_m$

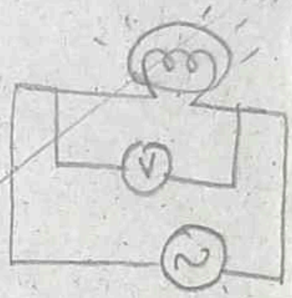
$(I - I_m) R_{sh} = I_m R_m$

$R_{sh} = \frac{I_m R_m}{(I - I_m)} \Rightarrow R_{sh} = \frac{R_m}{\frac{I}{I_m} - 1}$

$I = I_m \left(\frac{R_m}{R_{sh}} + 1 \right)$

b) PMMC as voltmeter





→ Measure voltage
→ Always connected in parallel
→ It is internal resistance is very high

$R_V = \infty$ (Ideally)

for Range extension

series with (Resistance) connected.

$I_m = I_{se}$

$\frac{V_m}{R_m} = \frac{V_{se}}{R_{se}}$

$R_{se} = R_m \left[\frac{V}{V_m} - 1 \right]$

Let $m = m_f = m_e = \frac{V}{V_m}$

$$R_{se} = R_m(m-1)$$

$$\frac{V}{V_m} - 1 = \frac{R_{se}}{R_m}$$

$$V = V_m\left[\frac{R_{se}}{R_m} + 1\right]$$

Q) Explain the constructiong & working principle of PMMI instrument

- The device where the moving iron is utilized for calculating either the current or voltage flow is termed as t[he] moving iron instrument.
- This device operates on the principle th[e] iron is placed in close to the magn[et] ~~that~~ ~~xxx~~ & it attracts this.
- This attractional force is based on [the] magnetic field strength
- And thas magnetic field is stimulat[ed] by the electromagnet where its ab[ility] is based on the current's magn[itude] that flows across it.

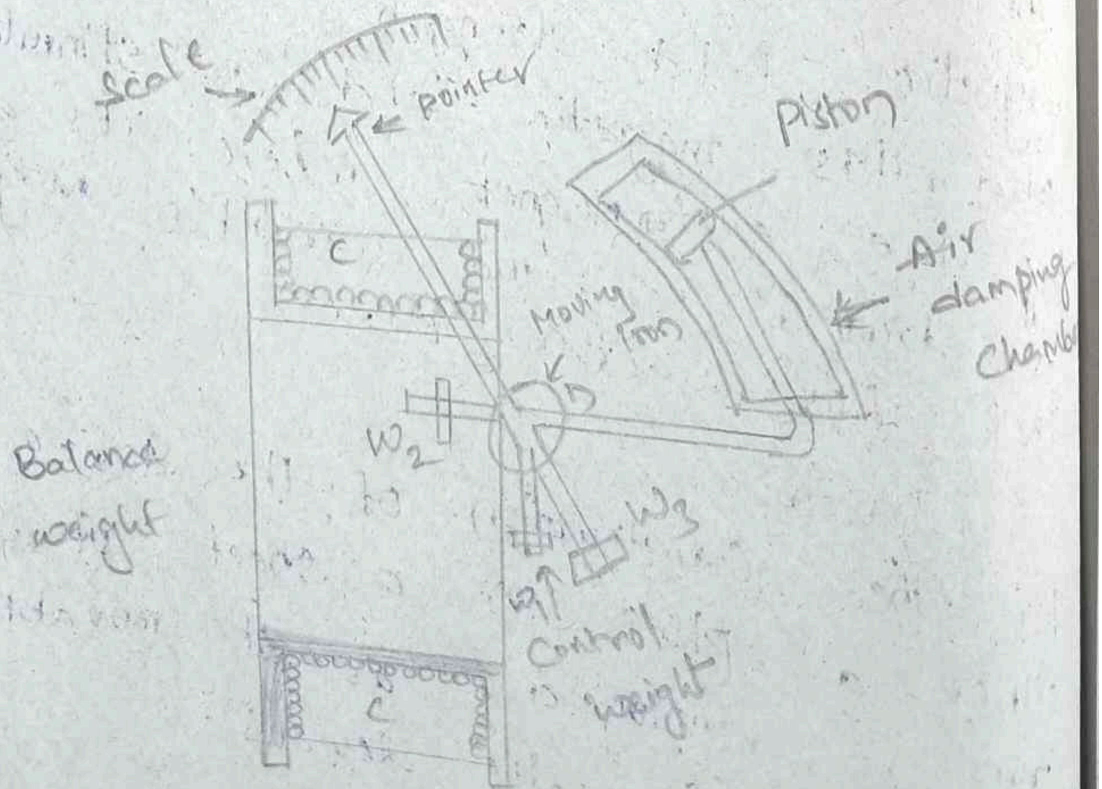
Construction

For the construction of the device either a plate or a sheet of s[oft] iron is employed as the movabl[e] component for the devices.

- The device makes use of the Stationary coil to function as an electromagnet.
- This electromagnet is only the transi[illegible] magnitude where its magnetic field ability either enhances or lessens along with the current's magnitude that flows across it.

Working principle

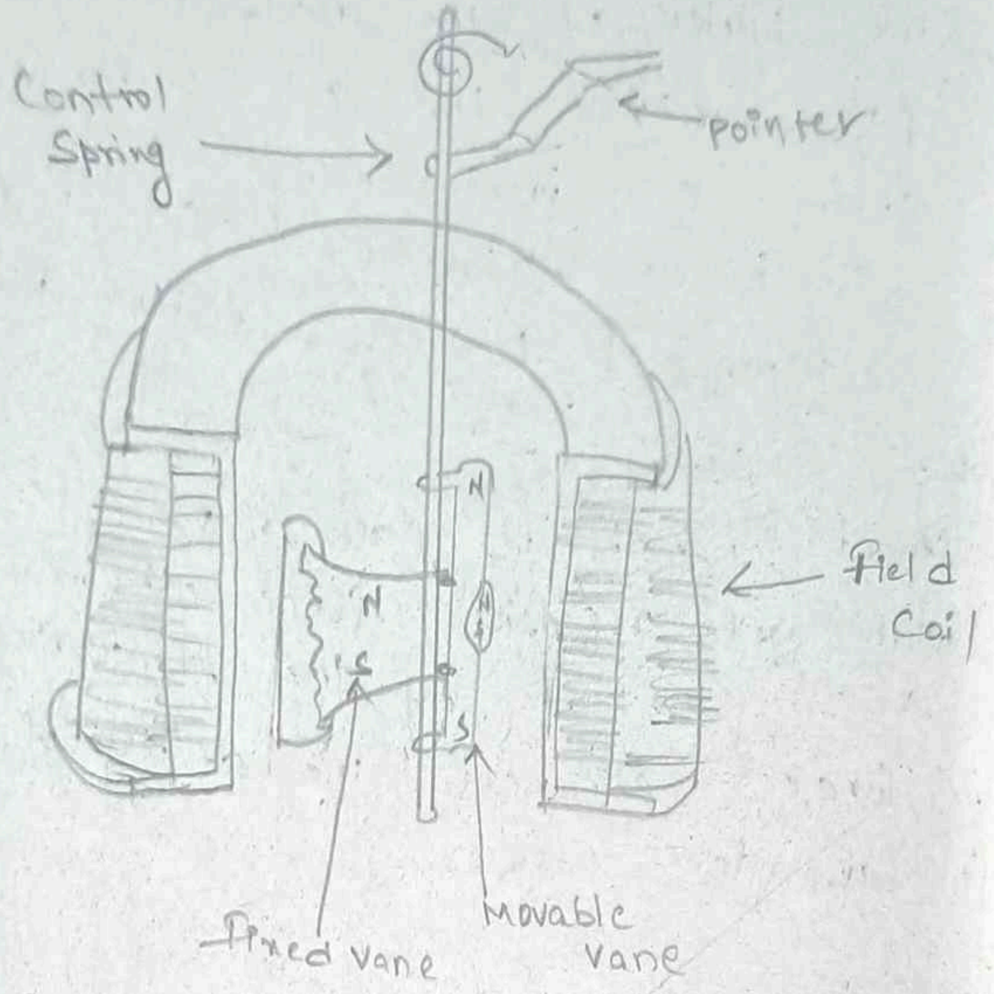
These devices make use of either aluminium constructed core or a static copper coil in order to function as a electromagnet when there is a current passage all through the instrument.



Either the plates of the iron sheets that pass across the coil enhance the static coil inductance.
There will be an attractional force for the electromagnet to attract the iron sheet.
The sheet which is passed via the coil will get repulsion force where this is created by the electromagnet.
• This force enhances the ability of the coil's inductance.

Ⓐ Types
There are 2 types
i) Attraction type 2) Repulsion type

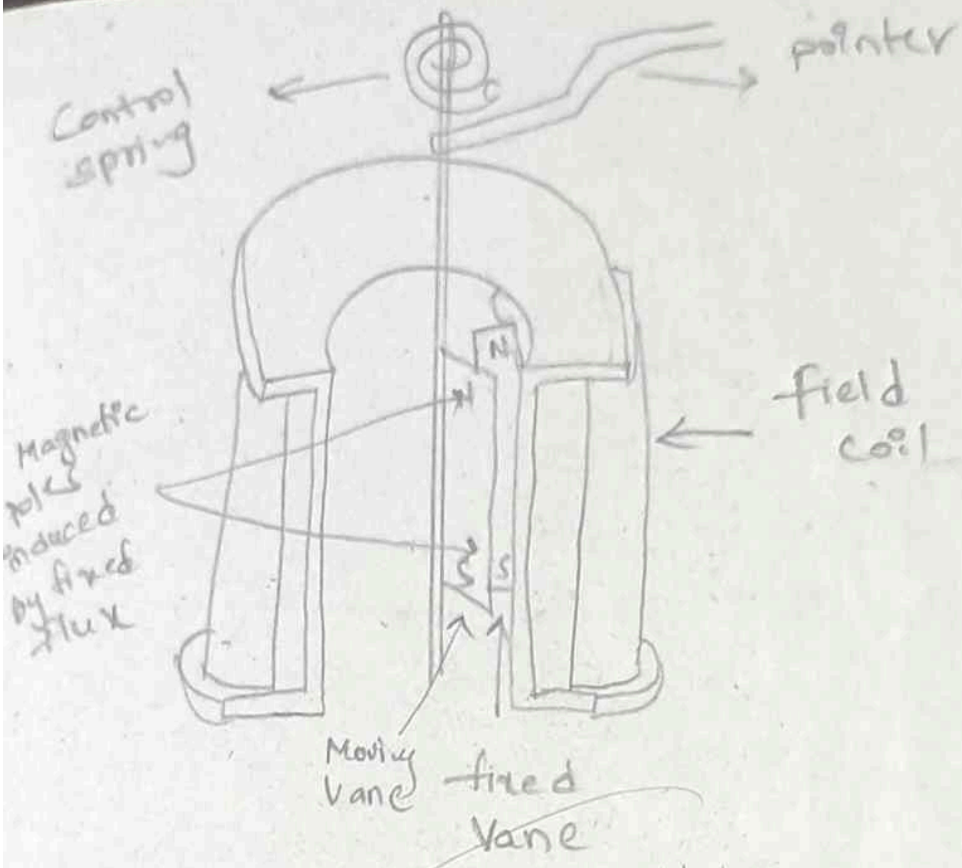
Attraction type
→ In this type, the iron plate is attracted towards the stronger field from the weaker field is termed as the attraction type of instrument
→ Here, the static coil in the device is in a flat shape & it has a small opening
→ The flow of current across the static coil generates the magnetic field & this has the attractional force to attract the coil.



Concentric Iron Vane (Repulsion type)

Repulsion type

- This device is constructed with two iron sheets where one is static & the other sheet is movable.
- These iron plates will be magnetized when there is current flow across the static coil & this created repulsion force in between the plates.



Radial vane repulsion

Torque equation

Applied voltage is given as

$$e = \frac{d}{dL}(LI)$$

On solving the energy equations, the deflecting torque is given as

$$T_d = \frac{1}{2} I^2 (dL/d\theta)$$

At the final equilibrium position, T_c becomes T_d and then

$$K\theta = \frac{1}{2} I^2 (dL/d\theta)$$

With this, the deflection is

$$\theta = \frac{1}{2}(I^2/K)\ (dL/d\theta)$$

9(b)

Advantages of Moving Iron Instrument

1) It is a universal instrument which can be used for the measurement of AC and DC quantities

2) These types of instruments have high value of torque to weight ratio. Due to this error because of friction is quite low

3) It is very cheap due to simple constructio

4) It is quite robust & simple

5) These instruments can withstand large loa & are not damaged even under sever overload conditions.

Disadvantages

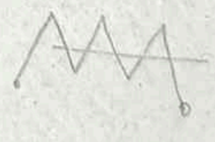
1) These instruments suffer from error due to hysteresis, frequency change & stray losse

2) The scale of moving iron instrutement is not uniform like PMMC instrument.

3) The calibration of these instruments should be done for both AC & DC.

4) Moving Iron Instruments are suitable for low frequency application.

5) the reading of the instrument is affected by temperature variable.

	Moving Coil instrument	Moving Iron instrument
Defination	A measuring instrument which involves the movement of a coil in a magnetic field of a P.M to measure the electric current or Voltage is called PMMC	The measuring instrument in which a core of soft iron moves in a magnetic field of an electromagnet to measure the electric I or V is called PMMI
Operation principle	Based on the fact that a current carrying coil experiences a force that tends to move it when placed in a magnetic field of a PM.	Based on the magnetism, i.e., magnetic field attracts a magnetic material such as iron etc.
Circuit symbol		
Reading Scale	uniform reading scale	Non-uniform which is cramped at starting
Measurement	Measure DC only	Both AC & DC
Accuracy	Comparatively more accurate	less accurate than MC
Magnet	permanent magnet	Electromagnet
Sensitivity	More Sensitive	less

(5) Instrument Transformer

In heavy currents & high voltages 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 I.T. These can be used, irrespective of the voltage & current ~~things~~ ratings of the a.c. circuits. These transformer not only extend the range of the low range instruments but also isolate them from high current & high voltag a.c. circuits. This makes their handli very safe. These are generally classified

(i) Current transformer (ii) potential transf

Current Transformer (CT)	potential transformer (PT)
1 Secondary must always be shorted	Secondary is nearly under open circuit condition
2 The winding carries full line current	The windings impressed with full line voltage
3 The primary current is independend of the secondary circuit condition	The primary current dependend on the secondary circuit conditions
4 It can be treated as series transformer under short circut condition	It can be treated as parallel under open circuit cond
5 Small voltage exists across its terminals as connected in series	full line voltage appears across terminals
6 The primary current & excitation varies over a wide range	The line voltage is almost constant hence exciting current and flux density varies over a limited range.

Applications

PT's

→ Used in metering and relay circuits

→ Uses in power line carrier communication network

→ Used for protecting feeders

→ Used as protection voltage transformers

→ Used in protection devices electrical

→ Used for the protection of impedance in different applications like the generator

CT's

Used to measure the current of another circuit.

Used to monitor high-voltage lines across national power grids.

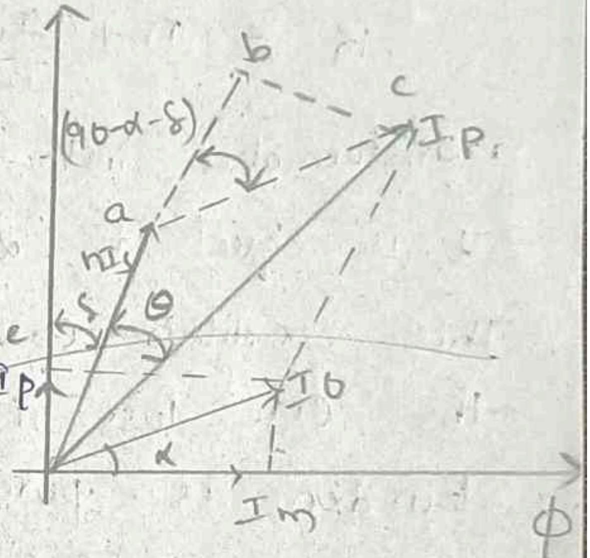
4 (a).

The current transformer has two types of errors

1) Ratio Error. 2) Phase angle Error

CT Ratio Error

We need to calculate primary current I_p as per defination & then divide it by secondary current I_s.



from the phasor, the primary current I_p is phasor sum of nI_s & I_0.

The CT primary current I_p can be calculated using vector addition formula

$$I_p = \sqrt{I_0^2 + (nI_s)^2 + 2I_0 nI_s \cos(90-\alpha-\delta)}$$

$$I_p = \sqrt{I_0^2 + (nI_s)^2 + 2I_0 nI_s \sin(\alpha+\delta)}$$

The CT ratio is equal to ratio of I_p / I_s

$$R = \frac{I_p}{I_s}$$

$$R = \frac{\sqrt{(nI_s)^2 + (I_0 \sin(\alpha+\delta))^2 + 2I_0 nI_s \sin(\alpha+\delta)}}{I_s}$$

The magnetizing current I_0 is very small compared to the primary current I_P.

$$R = \frac{\sqrt{[nI_s + (I_0 \sin(\alpha+\delta))]^2}}{I_s}$$

$$R = \frac{nI_s}{I_s} + \frac{I_0 \sin(\alpha+\delta)}{I_s}$$

$$R = n + \frac{I_0}{I_s} \sin(\alpha+\delta)$$

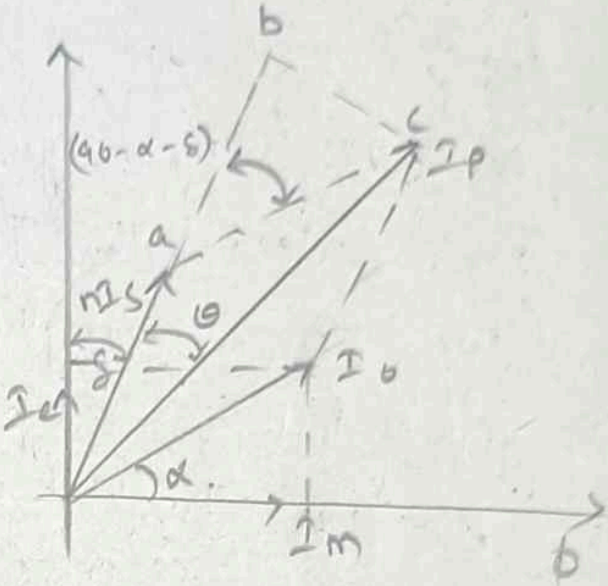
Transformation ratio is not equal to turn ratio. It is equal if $\alpha = 0$ & $\delta = 0$

This condition can be achieved if the core loss is equal to zero & the burden is purely resistive.

Phase Angle Error of CT

It is defined as the angle b/w the primary current I_P & secondary current I_S. θ is the phase angle

Consider right angle triangle obc in the phasor diagram.



$$\tan\theta = \frac{bc}{ob}$$

$$= \frac{I_0 \sin(90-\alpha-\delta)}{oa + ab}$$

$$= \frac{I_0 \cos(\alpha+\delta)}{[nI_s + I_0 \sin(\alpha+\delta)]}$$

Since θ is very small

$\tan\theta = \theta$

Also I_0 is very small

$I_0 \sin(\alpha+\delta) << nI_s$

Hence $I_0 \sin(\alpha+\delta)$ is neglected

$$\theta = \frac{I_0 \cos(\alpha+\delta)}{nI_s}$$

$$\theta = \frac{I_0(\cos\alpha\cos\delta - \sin\alpha\sin\delta)}{nI_s}$$

$$\theta = \frac{I_0\cos\alpha.\cos\delta - I_0\sin\alpha\sin\delta}{nI_s}$$

From phasor, $I_0\cos\alpha = I_m$ & $I_0 \sin\alpha = I_e$

$$\theta = \frac{I_m\cos\delta - I_e\sin\delta}{nI_s} \text{ Radians}$$

$$\theta = \frac{180}{\pi}\frac{(I_m\cos\delta - I_e\sin\delta)}{nI_s} \text{ Degree.}$$

The phase angle b/w primary & se...
of the CT must be 180 degree.
The deviation in the phase angle
of the primary & secondary current
is called the phase angle error

→ The phase angle error of CT is
given by

$$\theta = \frac{180}{\pi} \frac{I_m \cos\delta - I_e \sin\delta}{n I_s}$$

$$\theta = \frac{180}{\pi} \frac{I_m \cos 0 - I_e \sin 0}{n I_s}$$

$$\theta = \left(\frac{180}{\pi}\right) \frac{I_m}{n I_s} \text{ degree}$$

Since the burden of the CT is generally
resistivity the power factor of the
burden is unity & hence $\delta = 0$

Ratio Error of CT

It is defined as the per unit deviat...
in transformation ratio from its
nominal ratio.

Ratio error is expressed in percentage

Ratio error

$$= \frac{\text{Nominal ratio} - \text{Transformation ratio}}{\text{Transformation ratio}} \times 100$$

The power factor of the burden is unity & hence $\delta = 0$

$$R = n + \frac{I_0 \sin(\alpha + \delta)}{I_s}$$

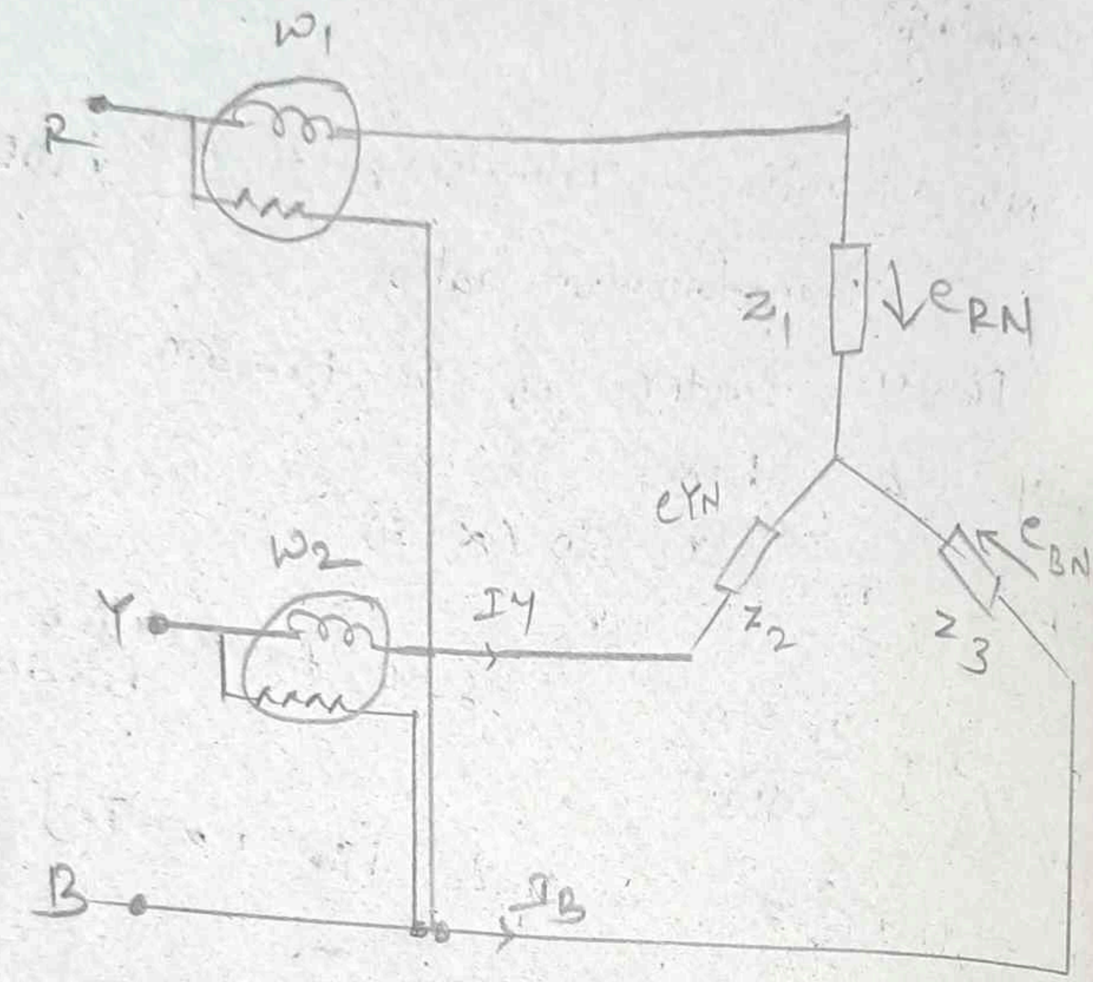
$$R = n + \frac{I_0 \sin\alpha}{I_s}$$ $\delta = 0$ for resistive burden

$$R = n + \frac{I_e}{I_s}$$ since $[I_0 \sin\alpha = I_e]$

3) Two Wattmeter Method of Power Measurement

It is used to measure 3 phase, 3 wire star or delta connected the balanced or unbalanced load.

In two wattmeter method, the current coil of the wattmeter are connected with any two lines, say R & Y & the potential coil of each wattmeter is joined on the same line, the third line i.e., B

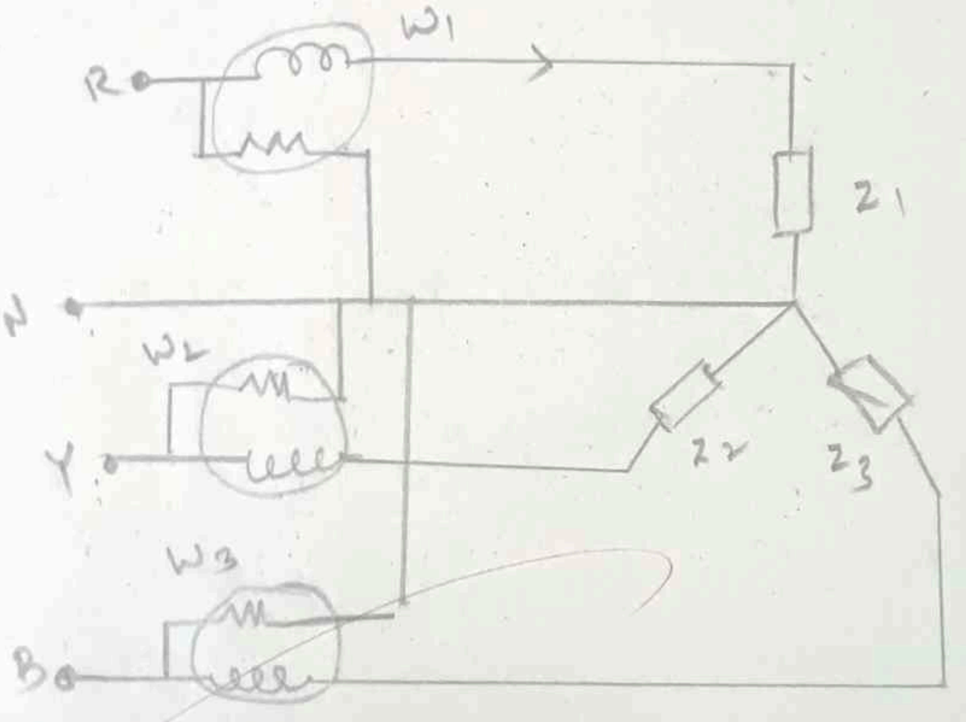


The total instantaneous power absorbed by the three loads Z_1, Z_2 & Z_3, is equal to the sum of the power measured by the two wattmeters, W1 & W2.

Three - Wattmeter Method.

It is used to measured po in a 3 phase, 4 wire system.
It is also employed in a 3 phase, 3 wire delta connected load, where power consumed by each load is required to be determined separately

The connections for star connected loads for measuring power by 3 Wattmeter method is shown below



The pressure coil of all the three wattmeters namely W1, W2 & W3 are connected to a common terminal known as the neutral point.

Reactive power

The power which exists in the circuit when the voltage & current are out of phase to each other, such type of power is known as the reactive power.

The formula measures the reactive power in the circuit

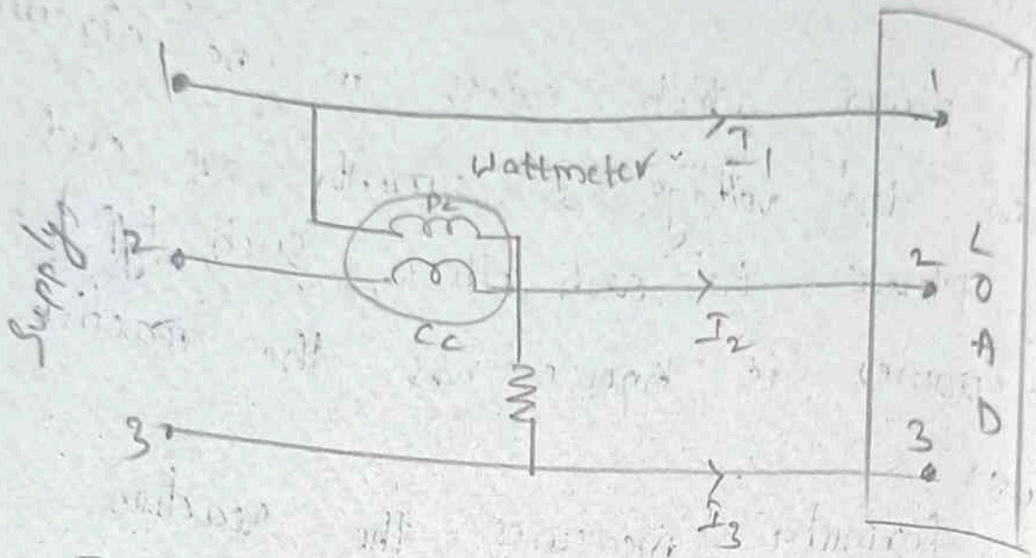
$$Q = VI \sin \phi$$

The measurement of reactive power is essential because the value of reactive power shows the total power loss in the circuit.

If the value of reactive power is low, the power factor of the load becomes poorer & more loss occurs in the system

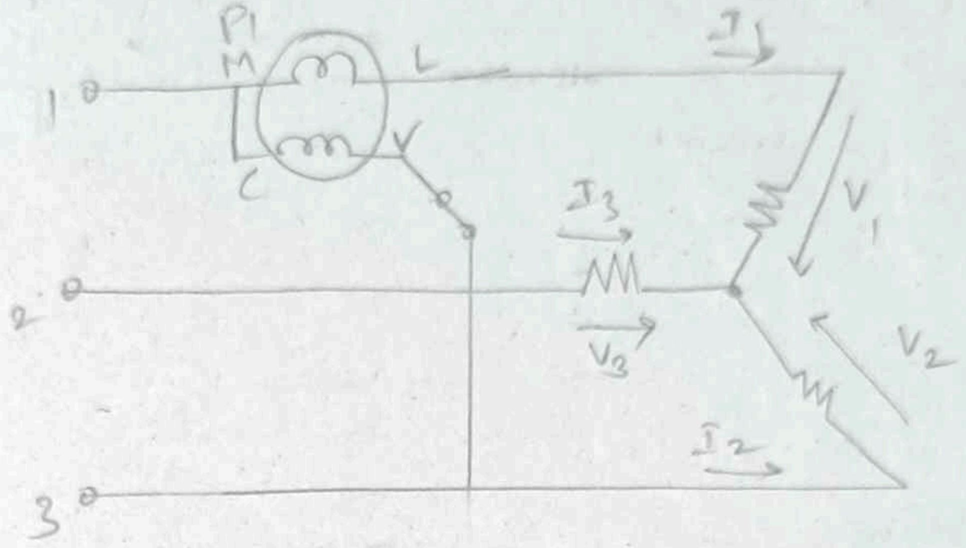
The electrical system is classified by the no. of phases used in the circuit, & according to these phases,

1) Single phase varmeter
2) polyphase Varmeter



Reactive power Measurement with one wattmeter

Reactive power is symbolized by letter Q & is measured in the unit of Volt-Amps-Reactive (VAR).



Single wattmeter Method

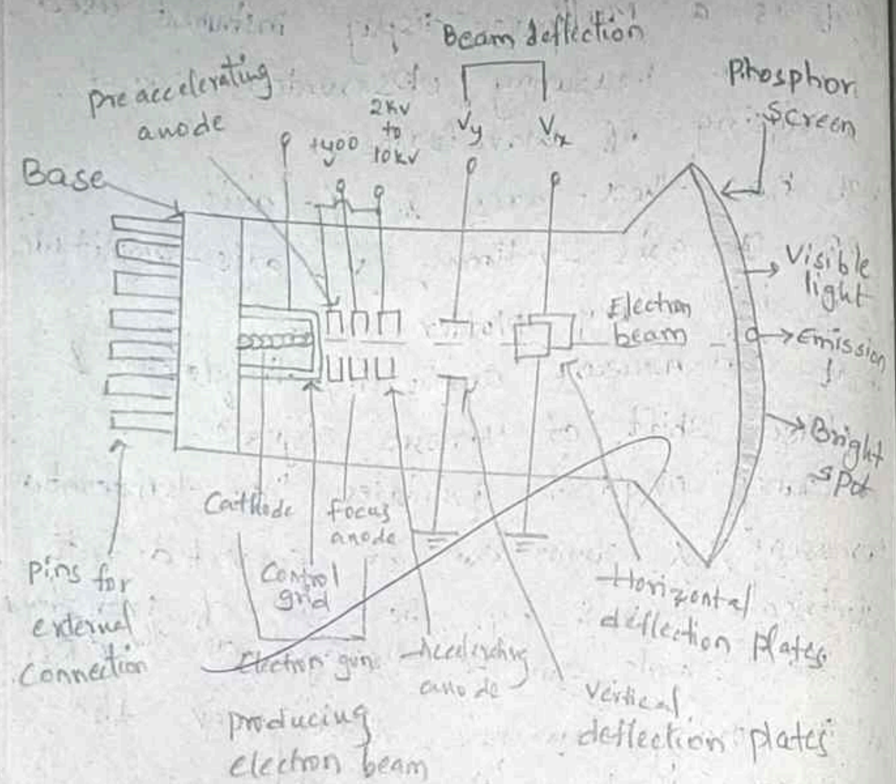
A single wattmeter method is used for measuring the power of the balanced three-phase circuit. The coil represented with less no. of turns b/w M & L is the current coil, which carries the current in the load & has very low impedance.
The coil with more no. of turns b/w the common terminal (C) & V is the pressure coil, which is connected across the load & has high impedance.

Unit - III **Oscilloscope and Digital Voltmeter**

04/04/2023
Tuesday

CRO

* It is a Multipurpose display instrument used for the measuring, observation and analysing of waveforms.
* It has the x - axis & y - axis
  on x - axis → time, Y - axis - amplitude
* It is a x-y plotter
* It can measure amplitude, frequencies & phase shift of various signals.
* Many physical quantities like temperature pressure, & strain can be converted into electrical signals by the use of transducer & the signals can be displayed on the CRO.
* A moving luminous spot over the screen displays the signal
* CROs are used to study waveforms & other time-varying phenomena from very low to very high frequencies.



components of CRO.

1) CRT (cathode Ray Tube)
2) Vertical amplifier
3) Delay line
4) Horizontal amplifier
5) power supply.
6) Time base generator
7) Triggering circuit

CRT
Three parts
Electron gun or electron emitter, deflecting system and flaorescent screen.

Electron gun

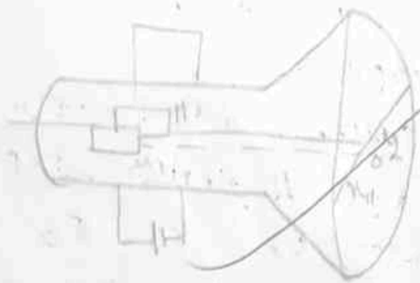
* In the electron gun of the CRT, electrons are emitted, converted into a sharp beam & focused upon the fluorescent screen
* The electron beam consists of an indirectly heated cathode, a control grid, an accelerating electrode & a focusing anode.
* The electrodes are connected to base pin
* cathode elect emitting the electrons is surrounded by a control grid with a fine hole at its centre
* the accelerated electron beam passes through the fine

Deflection system

Electrostatic deflection of an electron beam is used in a general purpose oscilloscope.
The deflecting system consist of a pair of horizontal & vertical D. plates.
→ let the two plates be P_1 & P_2
Center point O on the screen.

* The deflection is proportional to the deflecting voltage b/w the plates. If the polarity of the deflecting voltage is reversed, the spot appears at opp. point.

* The To deflect the beam horizontally, an alternating voltage is applied to the horizontal deflecting plates & the spot on the screen horizontally.



Horizontal

spot Beam Deflection sensitivity

It is defined as the distance of the spot-beam deflection on the screen per unit voltage

$$S = \frac{I_{total}}{V_d}$$

Electrostatic Deflection

S = Separation b/w D. plates

p = distance b/w the plate & screen S

l = length of each D.P

V_d = deflecting voltage applied across pla

m = mass of electron

e = charge of electron

v = velocity of entering electron

V_a = accelerating anode voltage

Thus K.E = P.E ; At equipotential both e

$$\frac{1}{2}mv^2 = eV_a$$

$$v^2 = \frac{2eV_a}{m}$$

Force exerted on the e^- towards the D.P i

$$F.S = eV_d \Rightarrow F = \frac{eV_d}{S}$$

(F

$$mf = \frac{eV_d}{S}$$

f = acc

Hence acceleration is $f = \frac{eV_d}{mS}$

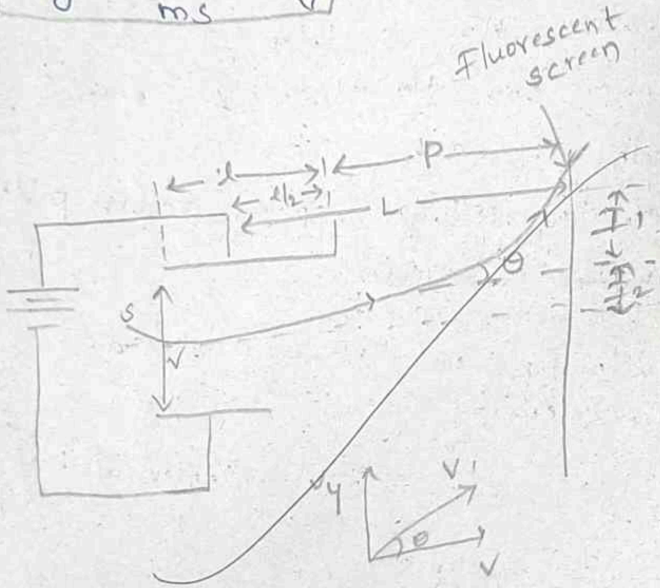
Time taken by the e^- to move through D

$$t = \frac{l}{v}$$

∴ Upward velocity acquired by the emerging e^- is

$v_y = ft \Rightarrow v_y = f\frac{l}{v}$

$$v_y = \frac{eV_d}{ms}\cdot\frac{l}{v}$$



D – distance

u – initial velocity   t – time

f – acceleration

At $u = 0$ $D = y_2$

$$y_2 = \frac{1}{2}ft^2 = \frac{1}{2}\cdot\frac{eV_d}{2sm}\left(\frac{l}{v}\right)^2$$

$$\tan\theta = \frac{v_y}{v} = \frac{y_1}{P}$$

$$y_{total} = y_1 + y_2 = \frac{eV_d}{smv^2}\underbrace{\left(\frac{l}{2}+P\right)}_{L}$$

$\because L = \frac{l}{2} + P$

$$y_{total} = \frac{lLV_d}{2sV_a} \quad (\text{sub } v^2 \text{ \& } L \text{ value})$$

The deflection sensitivity of CRT

$$S = \frac{y_{total}}{V_d} = \frac{lL}{2sV_a}\ \text{m/V}$$

deflection factor of CRT is

$$G = \frac{1}{S} = \frac{2sV_a}{lL}\ \text{V/m}$$

Fluorescent Screen

→ phosphor is used as screen material on the inner surface of a CRT

→ phosphor absorbs the energy of incident e^-

→ The bombarding e^- striking screen, release Secondary emission electrons.

→ collection of S.E.e^- is necessary to keep the screen in a state of electrical equilibrium.

→ The type of phosphor used, determines the color of light spot.

11/04/2023
Tuesday :)

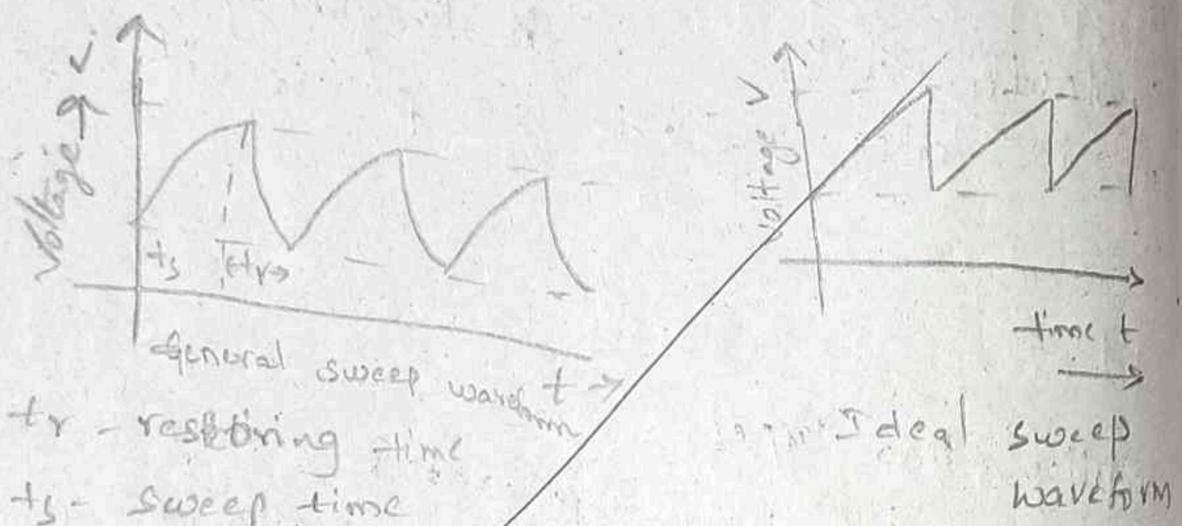
Time base generator

- The circuit that produces a linearly varing current or voltage is known as Time base generator.
- It is a function generator which produces Sawtooth with high frequency.
- It is also called sweep circuit

Basically two types
(i) Voltage time base generator
It generates a voltage that varies linearly according to time & finds its application in electrostatic deflection
(ii) Current
It generates linearly varing current w.r.to the time of o/p.

Time base Signal

* A CRO basically measures or display a quantity that varies according to the time.
* This needs CRT spot to move with a constant velocity that resultantly requires a linearly varing voltage to be applied at



Errors in time base generator

Slope or sweep speed error

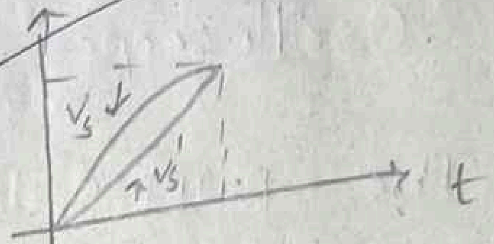
In a sweep generator, there is a need

$$e_s = \frac{\text{difference in slope at begining \& end of slope}}{\text{initial value of slope}}$$

Displacement error

It is the ratio of max. diff. b/w actual & linear sweep voltage to the peak value of voltage

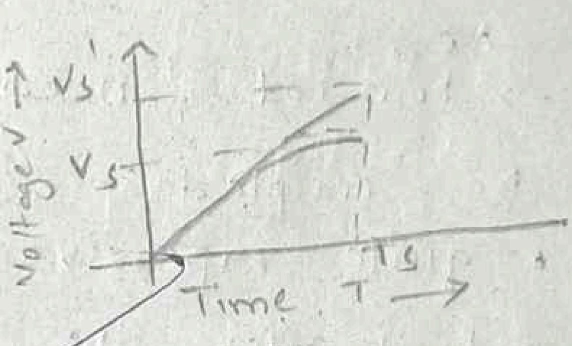
$$e_d = \frac{(V_s - V_s')_{max}}{V_s}$$



Transmission error

It is a result of passing sweep voltage through a high pass R-C network because the max. amplitude of o/p deviates from i/p

$$e_t = \frac{V_s' - V_s}{V_s'}$$



Applications

1) It is used in CRO for measuring & displaying ~~time~~ varing quantity
2) Used in radar system in order to target range
3) Used in computer display & television indicators

Oscilloscope Amplifier

The purpose of an oscilloscope is to produce a faithful representation of the signals applied to its input terminals.

2 types

1) Ac - coupled Amplifier (2) Dc - coupled

Ac

→ low cost, used in laboratory purpose

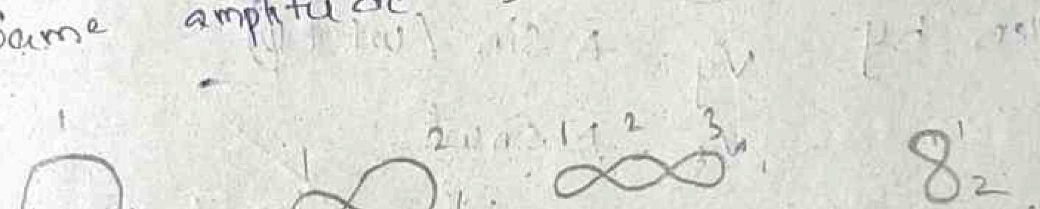
Dc - coupled

- quite expensive
- They offer the advantage of responding to dc voltages, so it is possible to measure dc voltages as pure signals & ac signals superimposed upon the dc signal
- they eliminate problems of low frequency

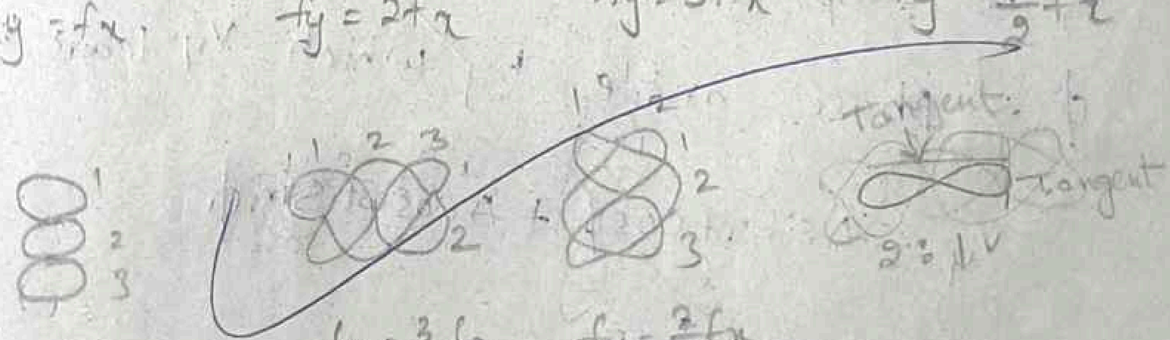
Lissajou's Figure

The defination of a Lissajous figure can be defined as one of an infinite no. of curves formed by combining two simple oscillations that are ⊥r to each other.
This is usually viewed by an oscilloscope & is used to study the frequency, amplitude, & phase relationships of harmonic variables.

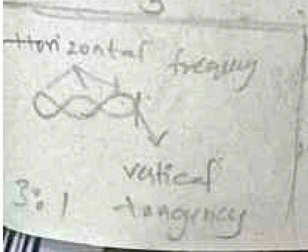
Same amplitude but different frequency

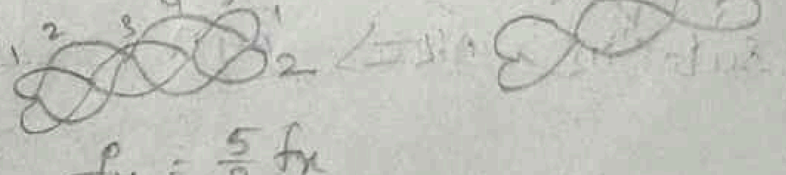


$f_y = f_x$ $f_y = 2f_x$ $f_y = 3f_x$ $f_y = \frac{1}{2}f_x$



$f_y = \frac{1}{3}f_x$ $f_y = \frac{3}{2}f_x$ $f_y = \frac{2}{3}f_x$





$f_y = \frac{5}{2}f_x$

$$\frac{f_y}{f_x} = \frac{\text{No. of times tangent touches top or bottom}}{\text{No. of times tangent touches either sides}}$$

$$= \frac{\text{No. of horizontal tangencies}}{\text{No. of vertical tangencies}}$$

where f_y = frequency of signal applied to Y plate

f_x = " " " x Plate

17th April '2023
Monday.

Measurement of phase
Using Lissajous

The values of the defination voltages are given by $V_y = A \sin(\omega t + \phi)$

$V_x = A \sin \omega t$

Here
A is amplitude, ω is angular frequency

$\phi \rightarrow$ phase angle by which V_y leads V_x.

$V_y = A \sin\omega t \cos\phi + A \cos\omega t \sin\phi$

$A \cos \omega t = \sqrt{A^2 - V_x^2}$

Sub in above eqn

$v_y = -A \sin\omega t \cos\phi + \sqrt{A^2 - v_x^2} \sin\phi$

$v_y = v_x \cos\phi + \sqrt{A^2 - v_x^2} \sin\phi$

$v_y - v_x \cos\phi = \sqrt{A^2 - v_x^2} \sin\phi$ (sq. b.s)

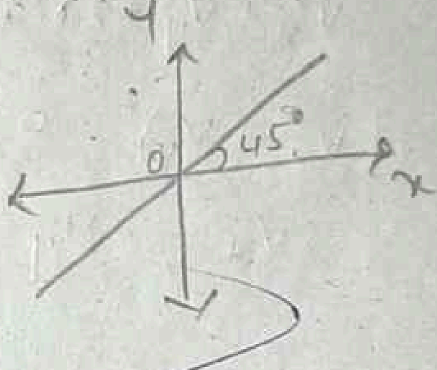
$(v_y - v_x \cos\phi)^2 = (A^2 - v_x^2) \sin^2\phi$

$v_y^2 - 2v_x v_y \cos\phi + v_x^2 \cos^2\phi + v_x^2 \sin^2\phi = A^2 \sin^2\phi$

$$v_y^2 - 2v_x v_y \cos\phi + v_x^2 = A^2 \sin^2\phi$$

when $\phi = 0°$, $\cos\phi = 1$, $\sin\phi = 0$

$v_y^2 + v_x^2 - 2v_x v_y \cos\phi = 0$ ⇒

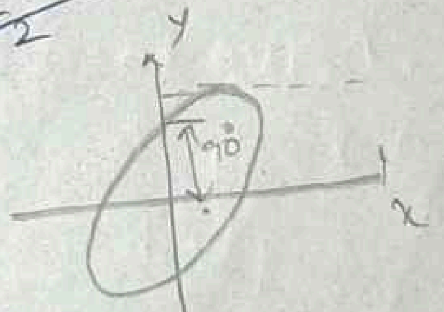


$(v_y - v_x)^2 = 0$

$v_y = v_x$

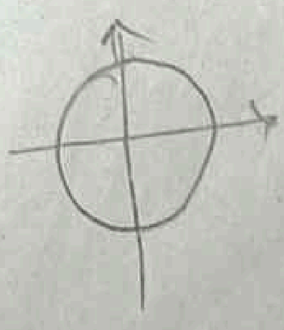
$\phi = 45°$ $\cos\phi = \frac{1}{\sqrt{2}}$, $\sin\phi = \frac{1}{\sqrt{2}}$

$0° < \phi < 90°$



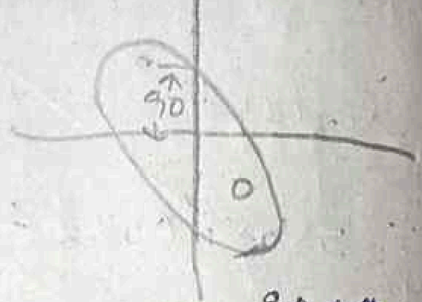
when $\phi = 90°$ $\cos\phi = 0$, $\sin\phi = 1$

$v_x^2 + v_y^2 = A^2$



Case -(iv)

$$V_x^2 + V_y^2 + \sqrt{2}\, V_x V_y = \frac{A^2}{2}$$



$90 < \phi < 180^\circ$

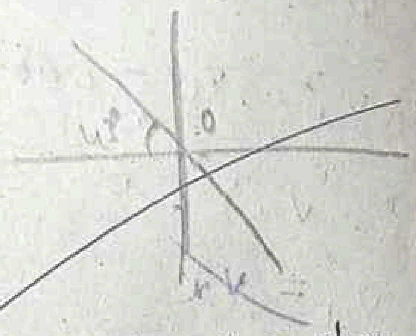
Case (v)

$\phi = 180^\circ \quad \cos\phi = -1, \quad \sin\phi = 0$

$$V_x^2 + V_y^2 + 2V_x V_y = 0$$

$$(V_x + V_y)^2 = 0$$

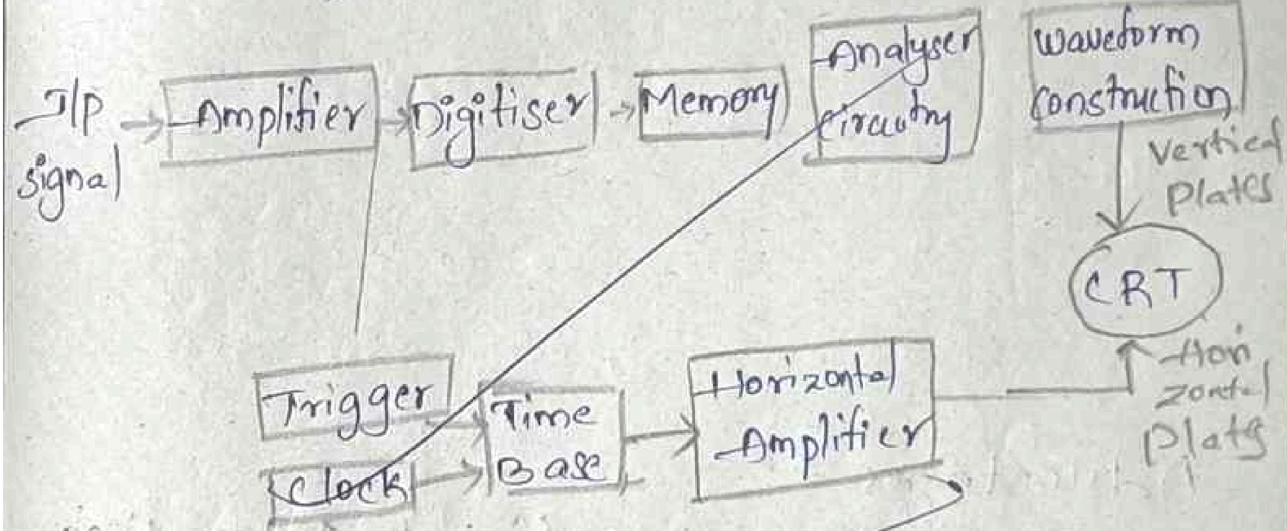
$$V_x = -V_y$$



Negative slope
$m = -1$

<u>DSO</u> Digital S Oscilloscope

* It is an electronic device which measures and records the electrical signals.
* It converts the analog format to digital format & stores in digital memory



Input analog signal is digitalized by digitiser into digital signal & stored in digital memory.
CRT is employed to display the stored signal or data in the memory.

The analog i/p signal is amplified by the amplifier & its o/p is digitized by the digitizer & stored in the memory. The analyzer circuit analyzes the digital o/p & it can be reconstructed to visualize the final waveform using interpolation technique.

The o/p is displayed on the CRT screen

Advantages

1) Easy to operate, efficient data display & high quality
2) Cost effective compared to analog os
3) It can trace & record temperature changes
4) It can analyze high frequency trancient response.
5) It can reconstruct the wave form
6) It can collect large sample of storage i/p data with the help of storage memory.

Types of Cathode Ray Oscilloscopes

① Analog CRO

In an analog CRO, the amplitude, Phase & frequency are measured from the displayed waveform, through direct Manual readings.

② Digital CRO

It offers digital read out of signal information, i.e., the time, Voltage or frequency along with signal display.

It consist of an electronic counter.

③ Storage CRO

It retains the display up to a substantial amount of time after the first trace has appeared on the screen.

Useful for the display of waveforms of low-frequency signal.

④ Dual-Beam CRO

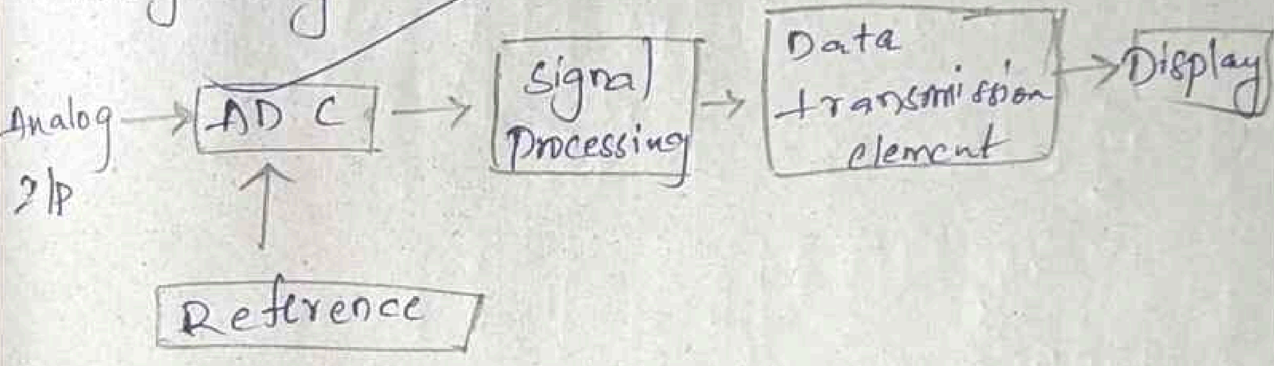
In this 2 e^- beams fall on a single CRT

The dual-gun CRT generates 2 different beams

Digital Voltmeter

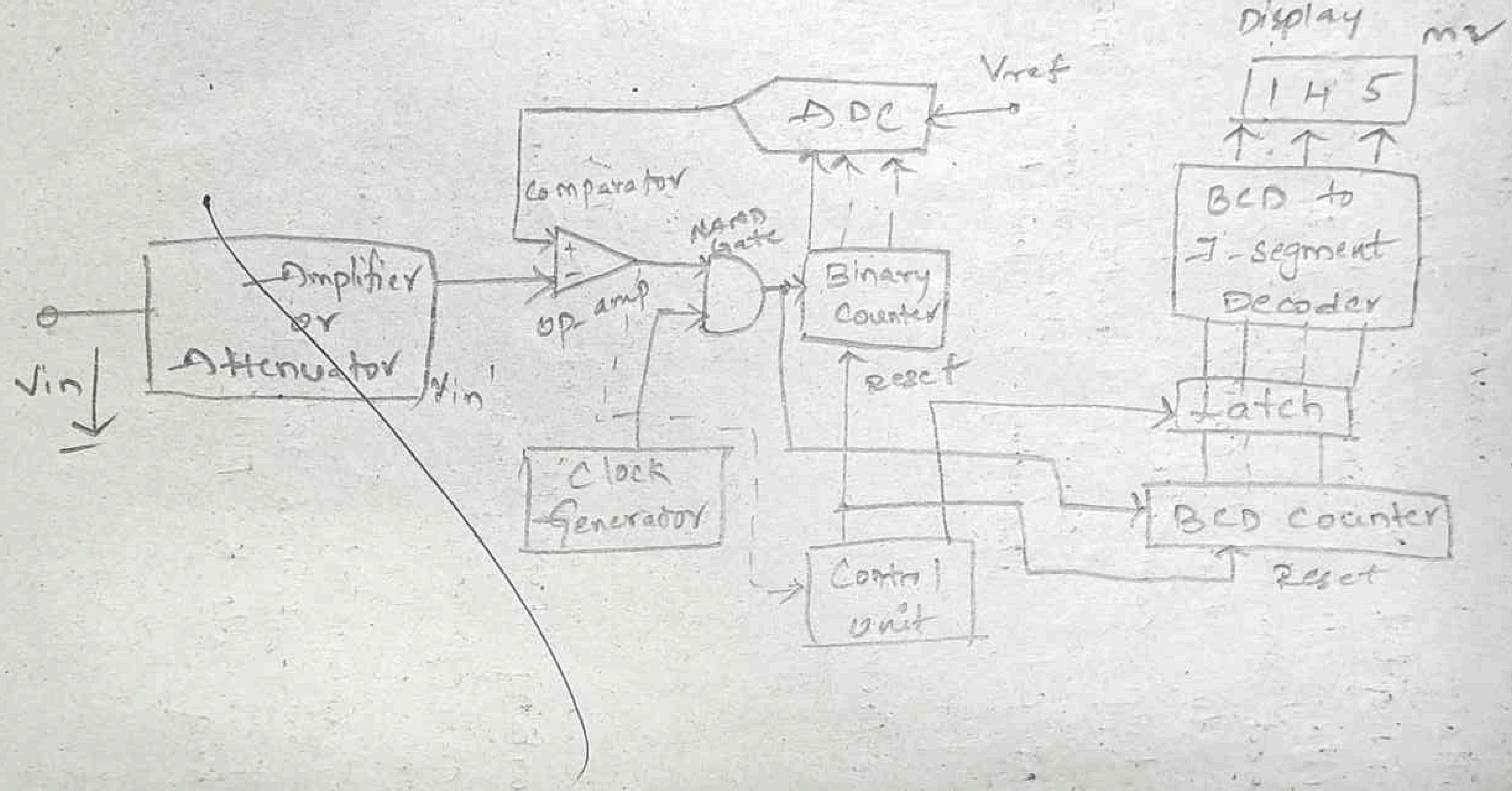
AD/ A DVM measures an unknown i/p voltage by converting the voltage to a digital value & then displays the voltage in numeric form.

→ Designed around a special type of analog- to digital Converter called an integrating converter.



The working principle of a DV can be categorized into 5 functional sections.

① pulse Generator
② Voltage Control & Gating clock pulse
③ Counting
④


Display
mv
1 4 5
BCD to
7-segment
Decoder
Latch
BCD counter
Reset
Vref
ADC
comparator
NAND Gate
op-amp
Binary Counter
Reset
Amplifier
or
Attenuator
Vin
Vin'
Clock Generator
Control unit

① Q

Advantages of Digital Voltmeter

* It eliminates human reading errors
* Readings are accurate & fast compared to analog meters
* Smaller in size & cost-effective
* DVM can measure both AC & DC voltages
* Have automatic range selection, high I/p impedance

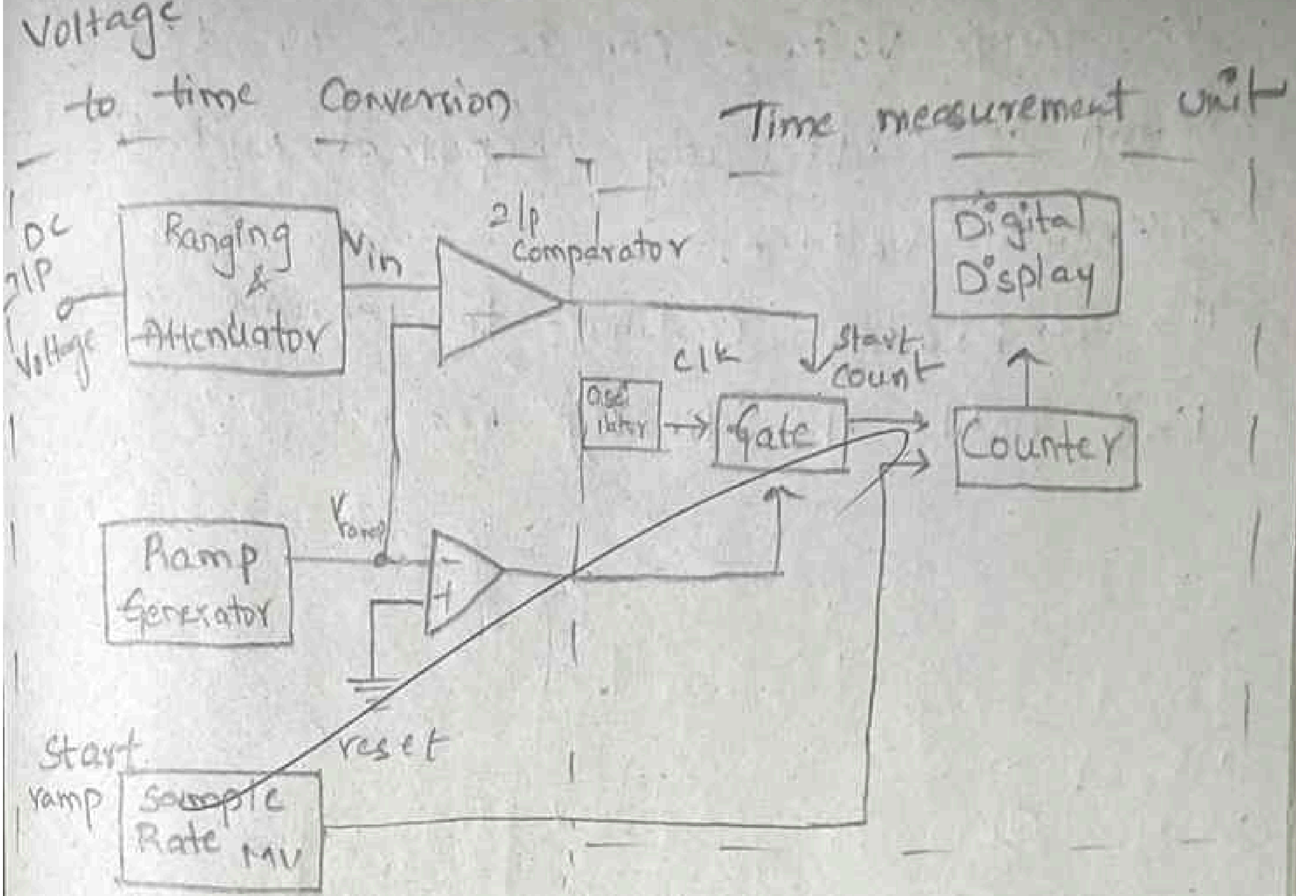
Disadvantages

1) DV's are prone to damage if the voltage is increased beyond the limit
2) The display depends on the external power source or battery.
3) While measuring the voltage, there are chances of the digital voltmeter getting heated up. This might cause o/p wrong readings
4) It is very hard to spot the transient voltage spikes

Applications

1) Used to know the actual voltage of different components
2) Used to check if there is power in the circuit, such as mains outlet.
3) Knowing the voltage across a circuit, current can be calculated.

Ramp type



The operating principle of the ramp type DVM is based on the measurement of the time taken by the DVM for a linear ramp voltage to rise from 0V to the level of the I/P voltage or to decrease from the level of the I/P voltage to zero.

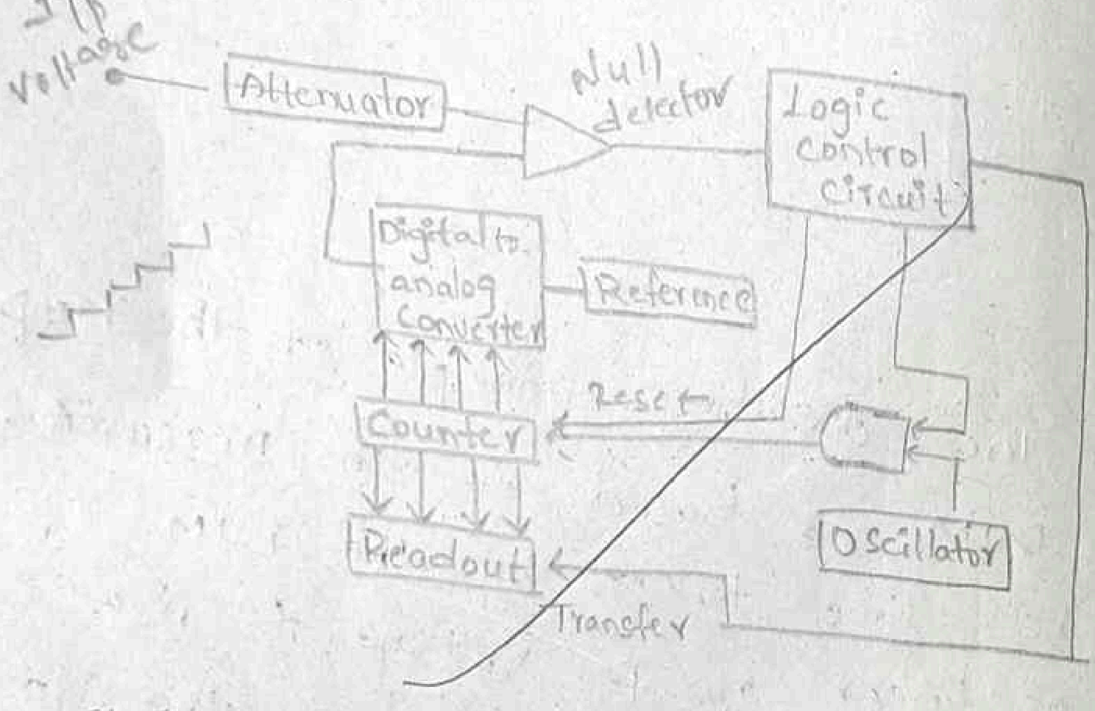
This time period is measured with an electronic time-interval counter & the count is displayed as a no. of digits on a digital display.

At the Start of measurement, a ramp voltage is initiated.

The ramp voltage can be -ve or +ve.

→ Ramp is continuously compared with the unknown i/p voltage.

→ The ramp voltage continues to decrease with time until it finally reaches 0V.



Stair case

→ The time b/w openning & closing of the gate is Δt.

→ An oscillator generates clock pulses that are allowed to pass through the gate to no. of counting units which totalize the no. of pulses passed through the gate.

Advantages

1) The circuit is easy to design & low in cost

2) o/p pulse can be transmitted over long distances.

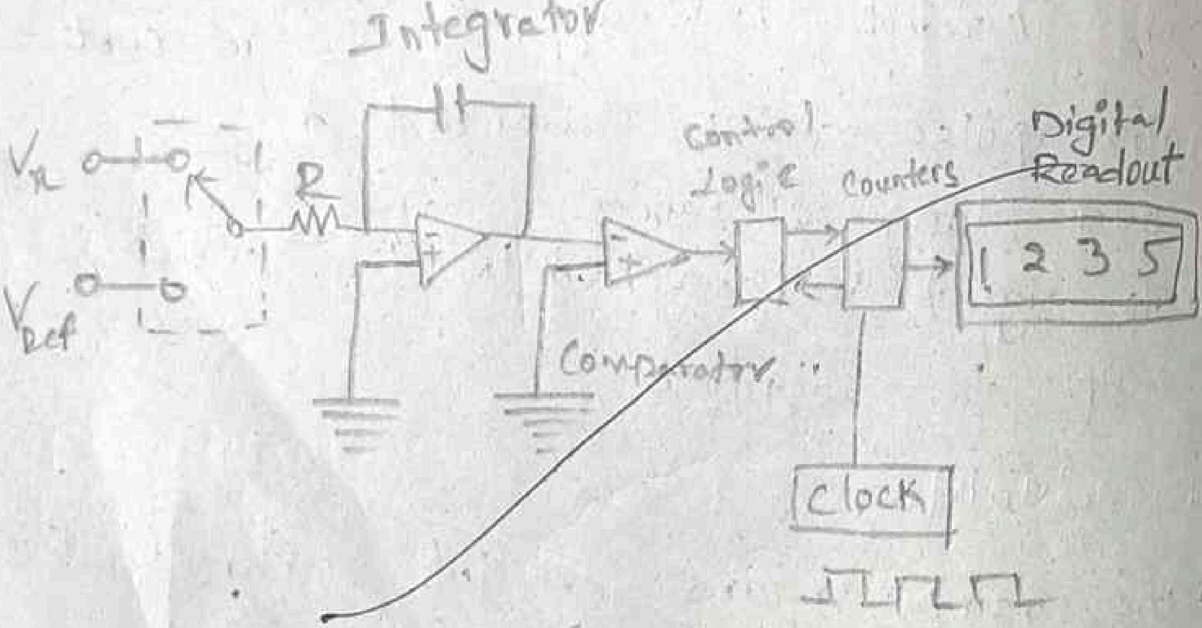
3) i/p signal is converted to time, which is easy to digitise

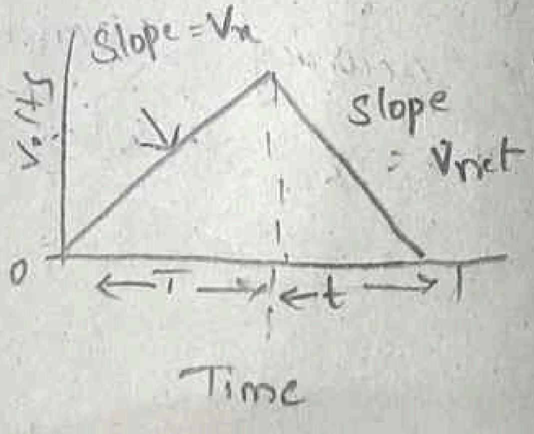
Disadvantages.

1) The ramp requires excellent characteristics regarding its linearity

2) The accuracy depends on slope of the ramp & stability of local oscillator.

Dual scope integrating





The dual slope analog - digital (A-D) converter consists of five basic blocks',

1) an OP - Amp used as an integrator,
2) A level comparator
3) A basic clock (for generating timing pulse)
4) A set of decimal counters
5) A block of logic circuitry.

<u>operation</u>

→ The unknown voltage V_x is applied through switch S to the integrator for a known period. (t)

→ This period is determined by counting the clock frequency in decimal counters.

→ During the period T_1 C is charged at a rate proportional to V_x.

→ At the end of time interval T_1 S is shifted to the reference voltage V_{ref}. of opposite polarity.

→ The capacitor charge begins to decrease with time.

→ The

Advantages

1) Excellent noise rejection as noise & superimposed ac are averaged out during the process of integration.

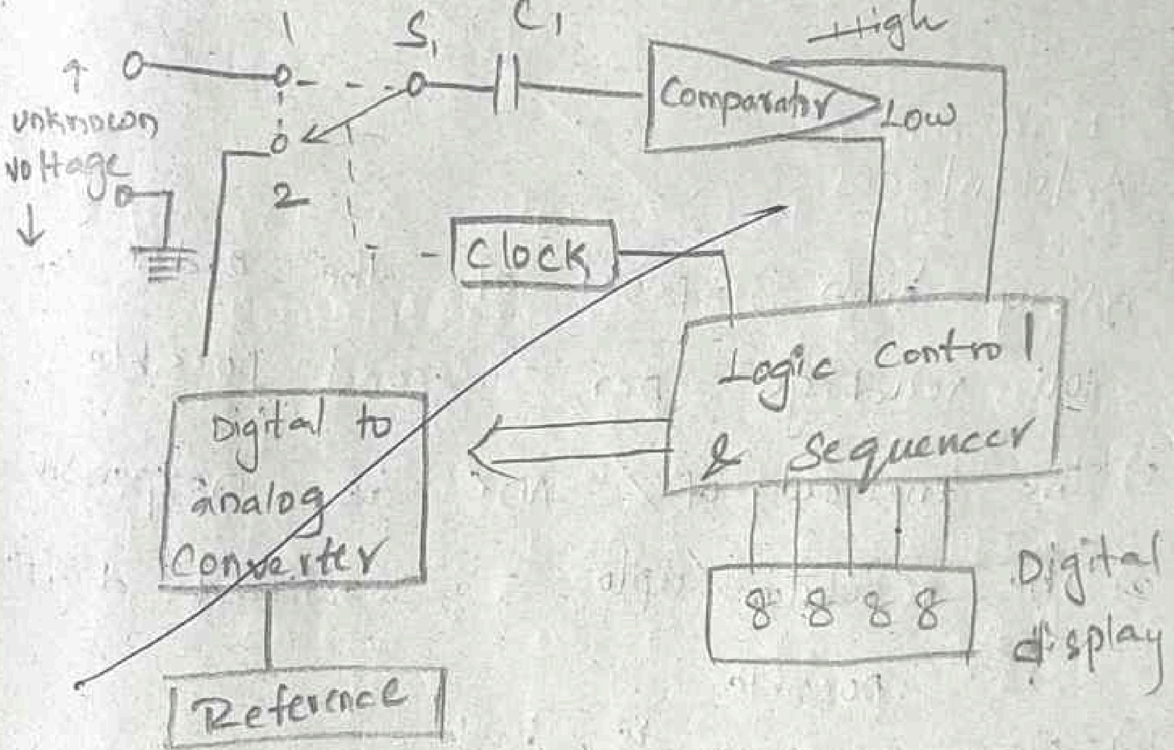
2) A sample & hold circuit is not necessary.

3) Accuracy is high & can be readily varied according to the specific requirement.

Disadvantages

The speed of DVM is very slow, as compared to other.

Successive Approximation



→ It is a special type of potentiometric DVM in which a digital divider is used in the place of linear divider

→ The servomotor replaced by electromagnetic logic.

→ The comparator compares the o/p of digital to analog converter with unknown voltage.

→ The comparator o/p is given to the sequencer & Logic controller.

→ The sequence of code is generated by the sequencer which is applied to the digital to analog converter.

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 i/p impedance is variable
4) The noise can cause error due to incorrect decisions made by comparator.

3. polar potentiometer :-

the induced emf in the rotor winding by stator winding 1 can be expressed as:

$E_1 = k I \sin\omega t \cos\phi$ ... (1)

Induced emf in the rotor winding by stator winding 2,

$E_2 = k I \sin(\omega t + 90°) \cos(\phi + 90°)$

$= -k I \cos\omega t \sin\phi$ - (2)

from (1) & (2), we get

$\therefore E = k I (\sin\omega t \cos\phi - \cos\omega t \sin\phi)$

- Resultant induced emf in the rotor winding due to 2 stator winding,

$E = k I \sin(\omega t - \phi)$, ϕ gives phase angle.

Co-ordinate potentiometer :-

→ In Co-ordinate AC potentiometer, two separate potentiometers are caged in one circuit.

→ The first one is named as the in-phase potentiometer which is used to measure the in-phase factor of an un-known emf & the other one is named as quadrature potentiometer which measures quadrature part of the unknown emf the sliding contact AA' in the in-phase potentiometer and BB' in quadrature potentiometer are used for obtaining the desired current in the ckt.

Unit - 3 Oscilloscope & Digital Voltmeter.

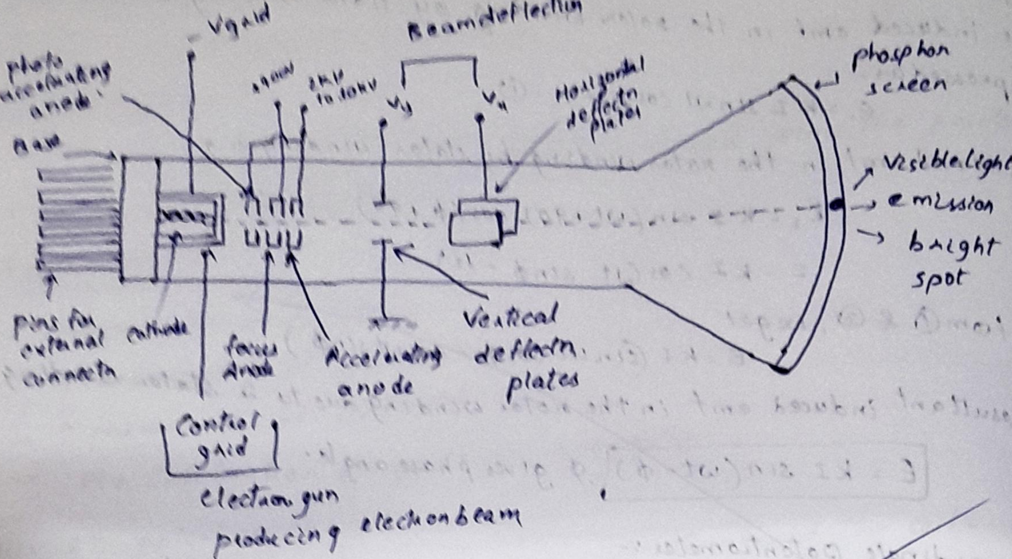
14/23

RO:- (The cat) →

→ CRO is a multipurpose instrument used ~~to measure~~ waveforms, in which it measures amplitude along Y-axis, and time along X-axis.

→ It has XY-plotters, used to measure many physical quantities like waveform; like amplitude, phase shift, time period, pressure, temperature etc by analysing

→ moving luminous spot displays the signal.



Components of the CRO :-

1) CRT
2) Vertical Amplifier
3) Delay ~~time~~ line
4) Triggering circuit
5) Horizontal Amplifier.
6) power Supply
7) Time - base generator.

CRT :-

↳ electron gun
↳ Deflecting system
↳ fluorescent screen

electron gun :-

→ electrons are emitted, converted into sharp beam and focused on fluorescent screen.

→ Electron beam consists of an indirectly heated cathode, a control grid, an accelerating electrode & focusing anode.

→ The electrodes ~~are~~ connected to the base pins. The cathode emitting the e^-s ~~are~~ is surrounded by a control grid with fine hole at its centre.

→ The accelerated e^-s passes through the fine hole.

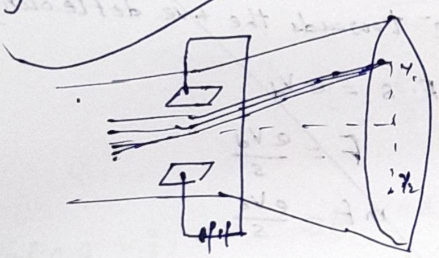
→ The negative voltage at the control grid controls the flow of e's, consequently brightness in the CRO is controlled.

Deflection system :- It consists of a pair of horizontal & vertical plates. It is an electron beam.

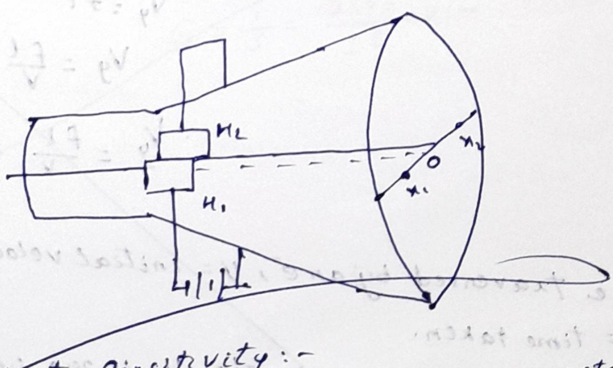
→ Let us consider 2 ~~Hel plats~~ vertical deflecting plates P_1 & P_2. The beam is focused at point O on the screen in absence of deflecting plate voltage.

→ If a +ve voltage is applied to plate 1 w.r.t plate 2, the -ve charged e's are attracted towards plate 1 & these e's will come & focus at 'Y₁' on the flourescent screen.

→ Deflection ∝ Deflecting voltage b/w plates. If polarity of the deflecting voltage is reversed, the spot appears at Y_2.



To deflect beam horizontally, an alternating voltage is applied to the horizontal



Spot beam Deflectn Sensitivity :-

→ Sensitivity is defined as the distance of the spot- beam deflectn on the screen per unit voltage.

$$S = \frac{I_{total}}{V_d}$$

Electrostatic Deflection

s = separation b/w deflecting plates

p = distance b/w the plates & screen S

l = length of each deflecting plate

V_d = deflecting voltage across plates

m = mass of e^-

e = charge of e^-

v = velocity at the entrance

V_a = accelerating anode voltage

Then, $\frac{1}{2} m v^2 = e V_a$ (K.E = P.E)

$$v^2 = \frac{2 e V_a}{m}$$

Force exerted on the e^- towards the +ve deflecting plate is

$$F \cdot s = e V_d$$

$$F = \frac{e V_d}{s}$$

$$mf = \frac{e V_d}{s}$$

$$\text{acceleration} = f = \frac{e V_d}{ms}$$

Time taken by the e^- to move through the deflecting plates is

$$t = \frac{l}{v}$$

∴ upward velocity acquired by the emerging e^- is

$$v_y = ft$$

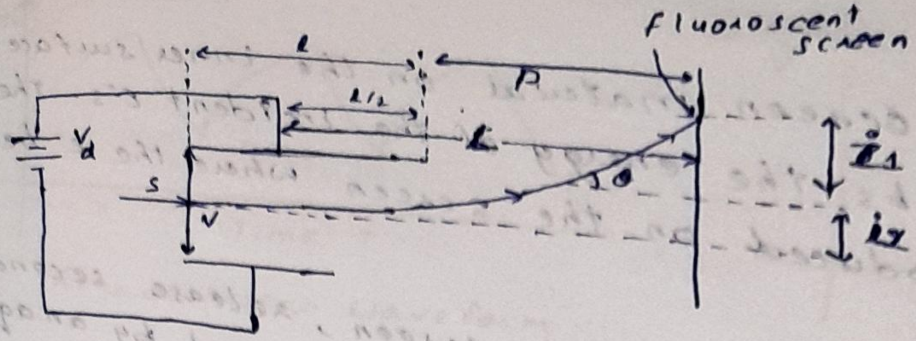
$$v_y = \frac{fl}{v}$$

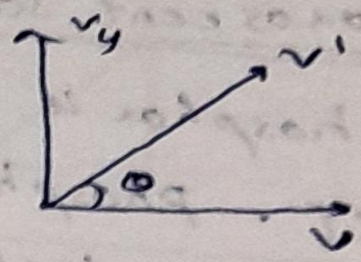
$$v_y = \frac{fl}{v} = \frac{e V_d}{ms}\left(\frac{l}{v}\right)$$

D = distance traversed by an e^-, u = initial velocity, f = acceleration of e^-, t = time taken.

As e^- is starting from rest, the u is zero i.e $u = 0$, the distance travelled by the electron $D = l$.

substituting this value of D in the expression for D from the formula of mechanics,





$I_2 = \frac{1}{2} f t^2$

substitute 't' in above eqn

$I_2 = \frac{1}{2} f \left(\frac{l}{v}\right)^2 = \frac{eV_d}{2Sm}\left(\frac{l}{v}\right)^2$

$\tan\theta = \frac{V_y}{V_1} = \frac{I_1}{P}$

$I_{total} = I_1 + I_2$

$\Rightarrow \frac{eV_d}{Smv^2}\left(\frac{l}{2} + P\right)$

$L = \frac{l}{2} + P$

substituting $v^2_{3\cdot3}$ & L, 3.11 in eq 3.10 we have

$I_{total} = \frac{lLV_d}{2V_a S}$

The deflection sensitivity of CRT is, $S = \frac{I_{total}}{V}$

Deflection factor of CRT's,

G

Fluorescent screen:-

- phosphor is used as screen material on the inner surface of a CRT. Phosphor absorbs the energy of the incident e's. The spot of light is produced on the screen where the e- beam hits.

→ The bombarding e's striking the screen, release secondary emission e's. These e's are collected or trapped by an aqueous soln of graphite called 'Aquadag' which is connected to the second anode.

→ Collection of secondary e's is necessary to keep the screen in a state of electrical equilibrium.

→ The type of phosphor used, determines the color of light spot. The brightest available phosphor isotope, P_{31}, produces yellow-green light with relative luminance of 99.99%.

Time-Base generators:-

The ckts that produces linearly varying voltage or current w.r.t time is called time base generator. This are also known as sweep ckts which produce sweeptooth waveforms. These are called bcz it sweeps e- beam to the horizontal plate.

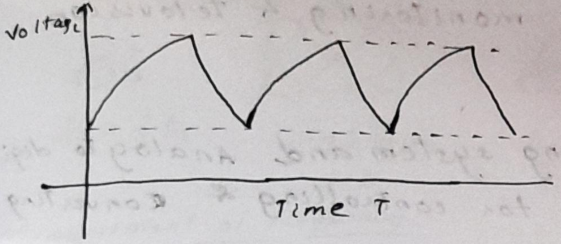
Types:-

→ Voltage time-base generator:- It generates a voltage that varies linearly according to time & find its application in electrostatic deflection.

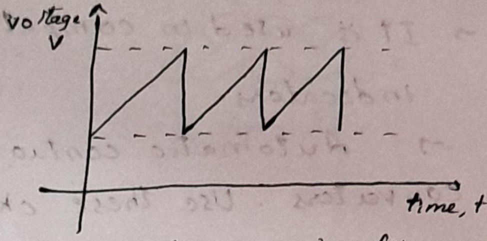
→ Current time-base generator:- It generates linearly varying current w.r.t time at the o/p.

Time-Base signal:-

→ A CRO basically measures or displays a quantity that varies according to time. This need CRT spot to move with a constant velocity that resultantly requires a linearly varying voltage to be applied at the set of deflection plates.



General sweep wave form



Ideal sweep waveform

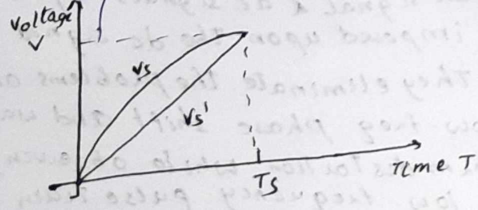
Errors of sweep waveform.

1) Slope or sweep speed error :- In a sweep gen, there is a need to keep sweep speed const with time. The variation in sweep results in non linearity of the slope of sweep voltage.

$$e_s = \frac{\text{difference in slope at beggining \& ending}}{\text{Initial slope}}$$

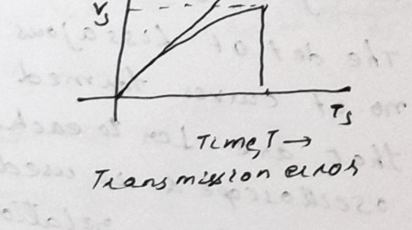
2) Displacement Error :- It is the ratio of max diff b/w actual & linear sweep voltage to the peak value of sweep voltage

$$e_d = \frac{(V_s - V_s')_{max}}{V_s}$$



3) Transmission error :- It is a result of passing sweep voltage through a high pass R-C n/w bcz the max amplitude of o/p deviates from i/p.

$$e_t = \frac{V_s' - V_s}{V_s'}$$



Transmission error

Applications of Time base gen :-

→ It is used for measuring & displaying time varying quantity.

→ It is used in radar systems to obtain target range

→ It is used in computer monitoring & television indicators.

→ Automatic controlling system and Analog to digital converters. Use these ckts for controlling & converting applications by time varying

→ Time measurement and time modulation techniques.

→ Oscilloscope Amplifiers:-

→ The purpose of an oscilloscope is to produce a faithful representation of the signals applied to its I/P terminals.

→ Considerable attention has to be paid to design this amplifier

→ These are divided into 2 types.

i) AC coupled Amp

ii) DC coupled Amp.

AC - coupled

→ Low cost

→ Laboratory experiments

DC - Coupled

→ expensive

→ Used to measure dc voltages as pure signal & ac signals super imposed upon the dc signal

→ They eliminate the problems of low-freq phase shift and wave form distortion while observing low-frequency pulse train

Amplifiers classified acc. to Bandwidth:-

i) Narrow Bandwidth Amp

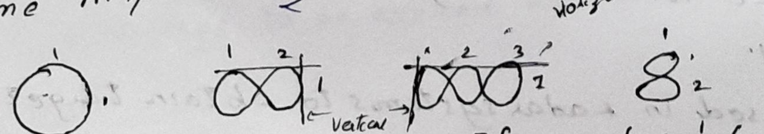
ii) Broad Bandwidth Amp

Lissajous Figures Def:-

The def of Lissajous fig can be defined as one of an infinite no. of curves formed by combining 2 simple oscillations that are ⊥r to each other. This is usually viewed by an oscilloscope & is used to study the frequency, amplitude and phase relationships of harmonic variables.

same Amplitude but diff frequencies:-

Horizontal tangency



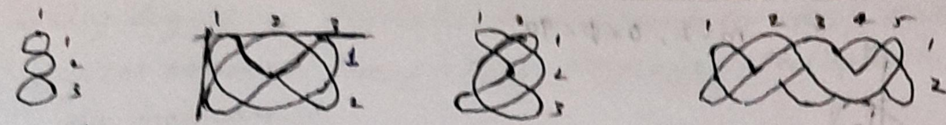
$f_y = f_x$

$f_y = 2f_x$ 2:1

Vertical tangency

$f_y = 3f_x$ 3:1

$f_y = \frac{1}{2} f_x$



$f_y = \frac{1}{3} f_x$ $\quad f_y = \frac{3}{2} f_x$ (3:2) $\quad f_y = \frac{2}{3} f_x$ $\quad f_y = \frac{5}{2} f_x$

Measurement of frequency :-

$$\frac{f_y}{f_x} = \frac{\text{no. of times tangent touches top or bottom}}{\text{no. of times Tangent touches either side}}$$

$$= \frac{\text{no. of horizontal tangencies}}{\text{no. of vertical tangencies}}$$

f_y = frequency of signal applied to x-axis

Measurement of phase using Lissajous figures :-

$V_y = A\sin(\omega t + \phi)$, $V_x = A\sin\omega t$ – values of deflection voltages,

Here A - amplitude, ϕ - phase angle by which V_y leads V_x.

$$V_y = A\sin\omega t\cos\phi + A\cos\omega t\sin\phi$$

$$A\cos\omega t = \sqrt{A^2 - V_x^2}$$

$$V_y = A\sin\omega t\cos\phi + \sqrt{A^2 - V_x^2}\sin\phi$$

$$V_y = V_x\cos\phi + \sqrt{A^2 - V_x^2}\sin\phi$$

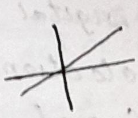
$$(V_y - V_x\cos\phi)^2 = (A^2 - V_x^2)\sin^2\phi$$

$$V_y^2 - 2V_yV_x\cos\phi + V_x^2\cos^2\phi = A^2\sin^2\phi$$
$$+ V_x^2\sin^2\phi$$

$$V_{xy}^2 - 2V_yV_x\cos\phi + V_x^2(1) = A^2\sin^2\phi$$

$$(V_{xy}^2 - 2V_yV_x\cos\phi + V_x^2) = A^2\sin^2\phi$$

case 1 :- when $\phi = 0$, $\cos\phi = 1$, $\sin\phi = 0$



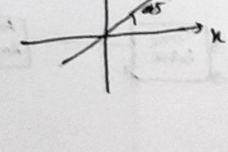
$$V_y^2 - 2V_yV_x + V_x^2 = 0$$

$$(V_y - V_x)^2 = 0$$

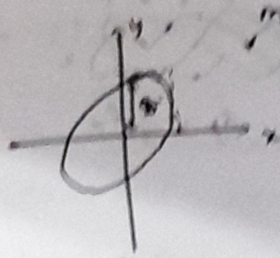
$$V_y = V_x$$ – st line with slope 45

case 2 :- when $0 < \phi < 90$, $\phi = 45$, $\cos\phi = \frac{1}{\sqrt{2}}$, $\sin\phi = \frac{1}{\sqrt{2}}$

$$V_y^2 + V_x^2 - \sqrt{2}V_xV_y = \frac{A^2}{2}$$



$m \neq 1, \; 0 < \phi < 90°$

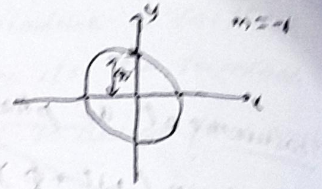


Case III when $\phi = 90$, $\cos\phi = 0$, $\sin\phi = 1$

$$V_x^2 + V_y^2 = A^2$$

Case IV when $90 < \phi < 180°$, say $135°$

$$V_x^2 + V_y^2 + \sqrt{2}\, V_x V_y = \frac{A^2}{2}$$

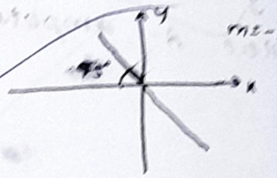


Case V – $\phi = 180$, $\cos\phi = -1$, $\sin\phi = 0$

$$V_x^2 + V_y^2 + 2V_x V_y = 0$$

$$(V_x + V_y)^2 = 0$$

$$V_x = -V_y$$



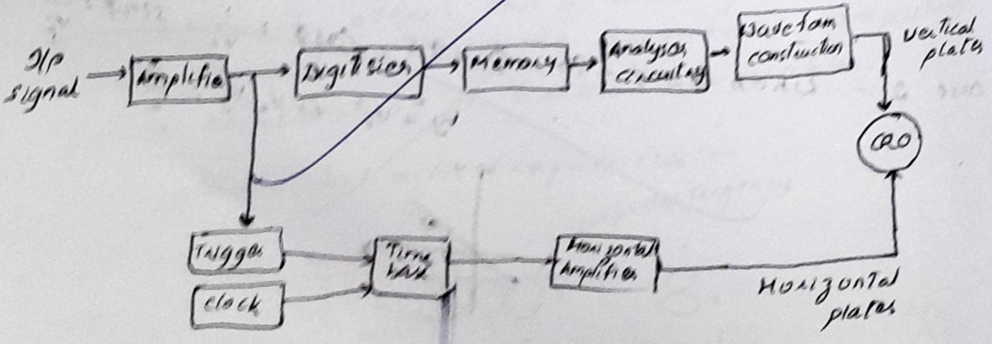
The max y-displacement A, and the vertical displacement, V_y at $t = 0$ can be measured from vertical scale of CRO.

$$V_{y_0} = A \sin\phi$$

DSO

- Digital storage oscilloscope is used to measure & record electronic signals. It converts analog signal to digital format and stores it in a digital memory for easy recall analysis.

Block Diagram of DSO



The analog ~~sig~~ signal is digitalised and (~~sent to CRO~~) stored in the digital memory. The CRT is employed to display the data from the memory.

Advantages:
- Cost effective when compared to analog.
- It can trace & record temp changes
→ It can analyse high frequency transient responses.
→ It can reconstruct the waveform.
→ It can collect large samples of i/p data with the help of storage memory.

Applications:
→ It is used in ckt debugging to test the voltage of the signal.
→ Used in testing during manufacturing.
→ Used in research and medical field.
→ Used in Radio Broadcasting to test the signals.
→ Used in video & audio recording equipments.
→ Used in to measure time period, frequency, inductance, capacitance (& ~~phase shift~~), voltage, I, & the ~~time~~ interval b/w the signals in both AC & DC ckts.
→ Used to compute V-I characteristics of diodes & transistors.

Disadvantages
→ Cost effective

Types of CRO's

i) Analog CRO :- Amp, frequency, phase are measured from displayed waveform through direct manual reading.

ii) Digital CRO :- offers digital read-out of signal information i.e t, volt along with signal display. Consists of counter along with body of CRO.

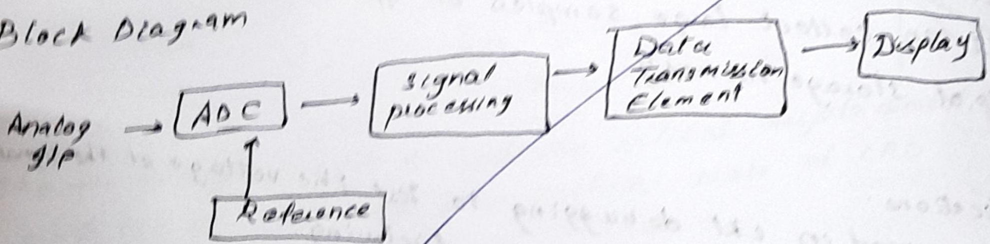
iii) Storage CRO :- retains the display upto a substantial amount of time after the 1st trace has appeared on the screen.

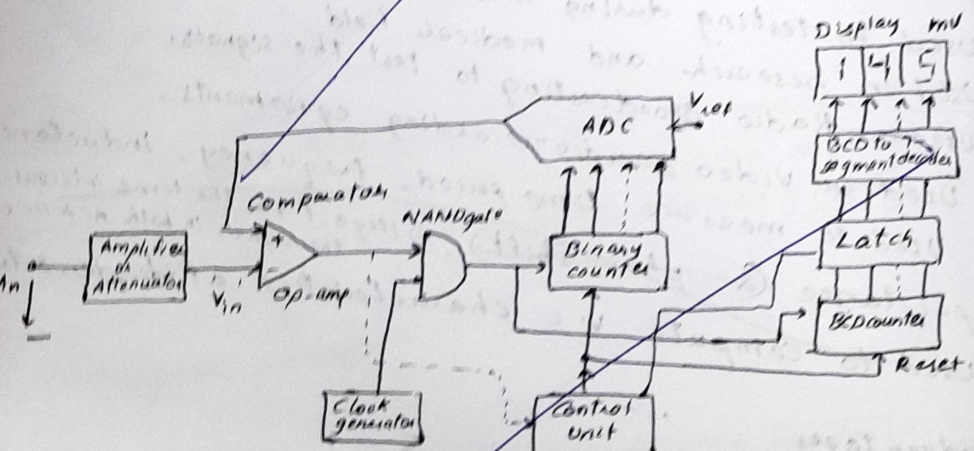
iv) Dual Beam CRO :- 2 e⁻ beam falls on a single CRT.

Digital Volt Meters :-

A DVM measures unknown voltage by converting the voltage to a digital value & then displays it in a numeric form. It uses special type of ADC known as Integrating converter.

Block Diagram





The working principle of DVM can be categorised into 5 sections:

i) pulse generator

ii) Voltage control & Gating

iii) Counting clock pulses

iv) ADC's

4) Latching & Display section.

Classification of DVMs :-

DVMs

→ Non-integrating Type

- potentiometric Type
  - i) Servo potentiometric Type
  - ii) Successive Approximation Type
  - iii) Null Balance type
- Ramp Type
  - i) Linear Type
  - ii) stair case Type

→ Integrating Type

- Voltage to frequency converter type
- Potentiometric Type
- Dual slope Integrating Type

1) Advantages, Disadvantages & Applications of DVMs.

2) Describe the principle & operation with a neat diagram along with advantages, disadvantages & applications for the following

i) Ramp-type (Linear & stair case)

ii) Dual slope

iii) Successive Approximation Type.

1) Advantages of DVM's :-

i) It can be programmed. so controlling by computer is achieved

ii) DVM's has automatic range selection.

iii) A digital voltmeter gives good stability.

iv) It provides better resolution. for ex can be read on 1V i/p range.

v) The internal calibration does not depend on the measuring circuit.

Disadvantages of DVM's :-

i) It gives some extra features which are expensive

ii) Speed of operation is limited due to digitizing circuit.

iii) It is usually very hard to spot transient voltage spikes.

Applications :-

→ Using a digital voltmeter, the actual voltage levels of various components can be known easily.

→ With the known voltage values from DVM, current levels can be found.

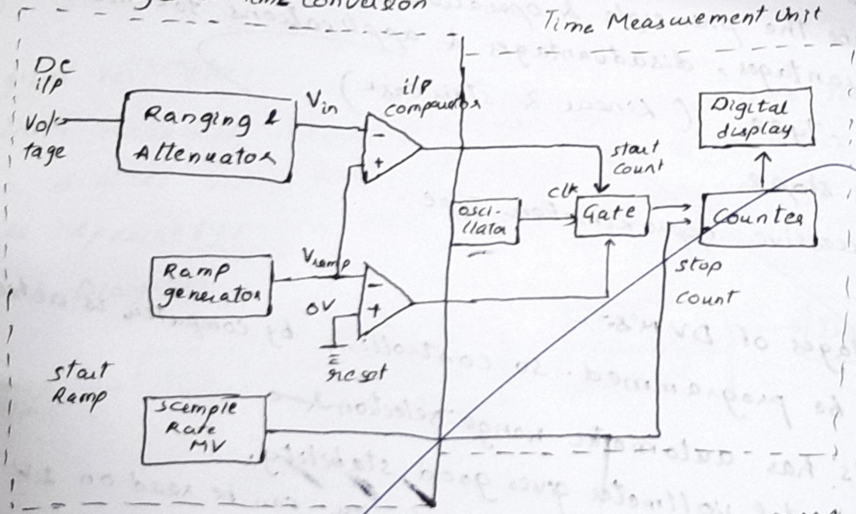
→ With a digital voltmeter, one can check whether there is power in the circuit (or) not.

→ Employing a DVM can be useful in knowing battery is drained or changed.

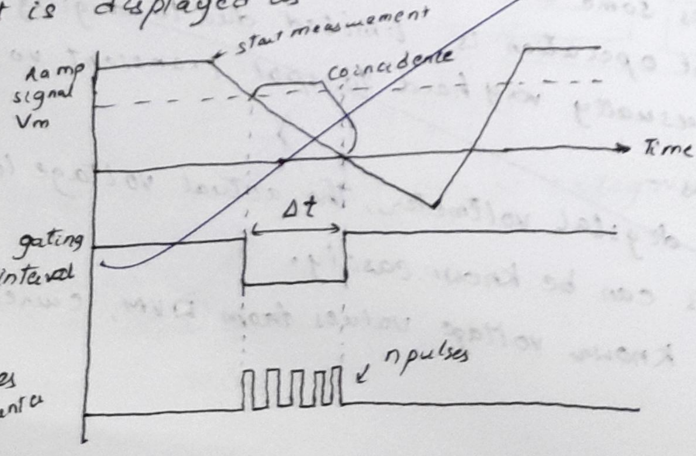
2)

(i) Linear Ramp-Type DVM:-

It consists of a voltage-to-time conversion unit and a time measurement unit



Operation: The operation principle of the ramp type DVM is based on the measurement of the time taken by the DVM for a linear ramp voltage to rise from 0V to the level of i/p voltage or decrease from the level of i/p voltage to zero. This time period is measured with electronic time-interval counter and the count is displayed as a no. of digits on a digital display.



Advantages :-

i) The circuit is easy to design and low in cost.

ii) O/P pulse can be transfered over long feeder lines without loss of information.

iii) The I/P signal is converted to time, which is easy to digitise.

v) By adding external logic, the polarity of the I/P also can be displayed.

Disadvantages :-

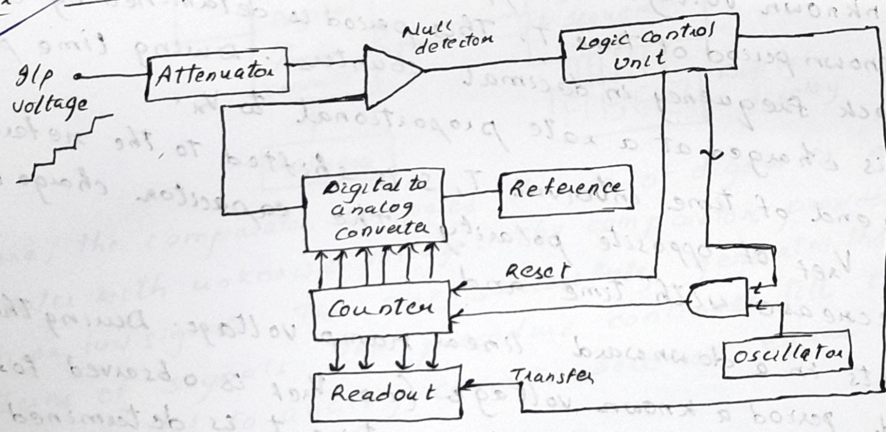
i) The ramp requires excellent characteristics regarding its linearity.

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

iii) Large errors are possible if noise is superimposed on the I/P signal.

iv) The speed of measurement is low.

ii) 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.

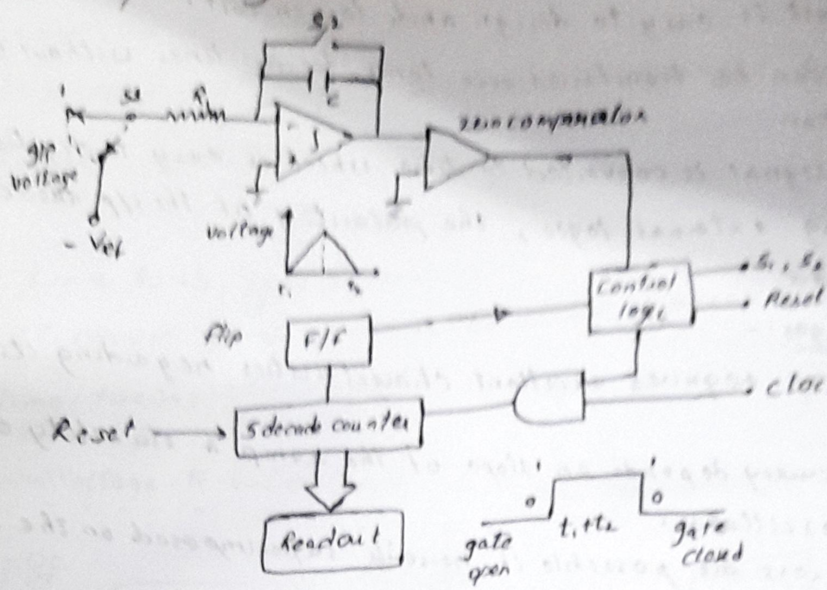
iii) The i/p impedance of the digital to analog converter is high when the compensation is reached.

Disadvantages :-

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

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

iii) Dual Slope Integration Type DVM:-



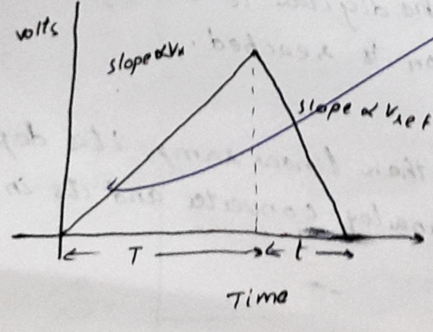
Operation:-

→ ~~The unknown (of the dual-slope integrating type digital voltmeter may be explained)~~

→ The unknown voltage V_x is applied through switch S to the integrator for a known period of time T. This period is determined by counting the clock frequency in decimal counters. During time period T, C is charged at a rate proportional to V_x.

→ At the end of time interval T, S is shifted to the reference voltage V_{ref} of opposite polarity. The capacitor charge begins to decrease with time and

→ Results in a downward linear ramp voltage. During the second period a known voltage (i.e V_{ref} is observed for an unknown time (t). This unknown time t is determined by counting time pulses from the clock until the voltage across the capacitor reaches its basic reference value.



Advantages :-

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

2) The RC time constant does not affect the i/p voltage measurement.

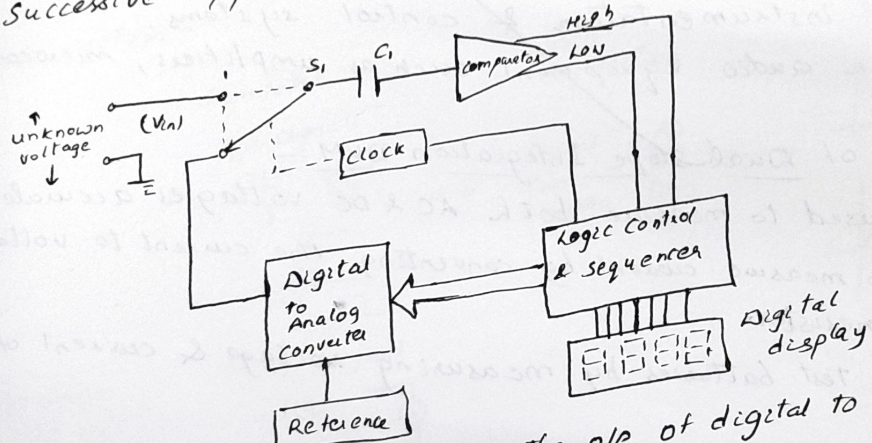
3) A sample & hold circuit is not necessary.

4) The accuracy is high & can be readily varied according to the specific requirements.

Disadvantages :-

The speed of DVM is very slow, as compared to other DVMs.

iv) Successive Approximation type DVM :-



- Here, the comparator compares the o/p of digital to analog converter with unknown voltage. The comparator provides logic high or low signals. The DAC successively generates the set patterns of signals. The procedure continues till the o/p of the digital to analog converter becomes equal to the unknown voltage

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 i/p impedance is variable.
4. The noise can cause error due to incorrect decisions made by comparator.

Applications:-

1. Used in highly sensitive and can measure low length signals range accurately.
2. Used in digital signal processing applications where they can be used to measure the amplitude, frequency of digital signals.
3. Used in instrumentation & control systems.
4. Used in audio equipment such as amplifiers, microcontrollers

Applications of Dual slope Integration DVM:-

1. Can be used to measure both AC & DC voltages accurately
2. Used to measure current by converting the current to voltage by shunt resistor.
3. Used to test batteries by measuring voltage & current of battery.

Applications of Linear Ramp type DVM:-

1. Suitable for measuring DC voltage in simple circuits.
2. Used to text batteries.
3. Used in calibration & testing of electronic device.

Applications of Stair Case Ramp type DVM:-

1. Used for high speed measurements when speed is essential.
2. Used in digital signal processing.
3. Used to test electronic components such as diodes, transistors & capacitor for their characteristics.

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I	II	MID TERM EXAMINATION

No. 529719

H.T. No.	2	0	2	4	1	A	0	2	0	1

Name of the Examination III rd BTECH II nd SEM MID-I EXAMINATION

Course SMI Branch EEE Date 21/03/2023

Signature of the Invigilator

Q.NO.	1		2		3		4		5		6		TOTAL
	a	b	a	b	a	b	a	b	a	b	a	b	
MARKS	2	3					2	2					9

START WRITING FROM HERE

(1)
(a) → Any instrument require these three torques i.e
(i) Deflecting Torque
(ii) controling Torque
(iii) Damping Torque.

(i) Deflecting Torque:
→ Deflecting torque moves the pointer from its initial (zero) position to further with the help of factors like current, voltage etc..,

(ii) Control torque:
→ after appling deflecting torque pointer goes till ∞. But the pointer in order to stop at the value we require we apply control torque.

(b) Deflecting Torque :-

*) In a PMMC instrument, the pointer fluctuates at a particular point. Deflecting torque makes the pointer to raise to the desired level by measuring.

*) The Deflecting torque is generated in the PMMC instrument, when the measurement is started.

*) The Deflecting torque sometimes of over intensity, so the controlling torque controls the pointer of PMMC instrument.

*) The Damping torque makes the fluctuating pointer steady.

*) The Deflecting torque can also be known as the moving force of the pointer in PMMC instrument.

*) The Deflecting torque varies on the amount of quantity that is being measured.

5. *) Measuring of a quantity using an instrument is called measurement.

*) The quantity that is measuring is either physical or other chemical quantity.

*) Measurement are classified based on the instruments we use for measuring.

*) Different types of measurement systems are
- → Indicating measurement system.
- → Absolute measurement system.
- → Integrating measurement system.
- → Recording measurement system.

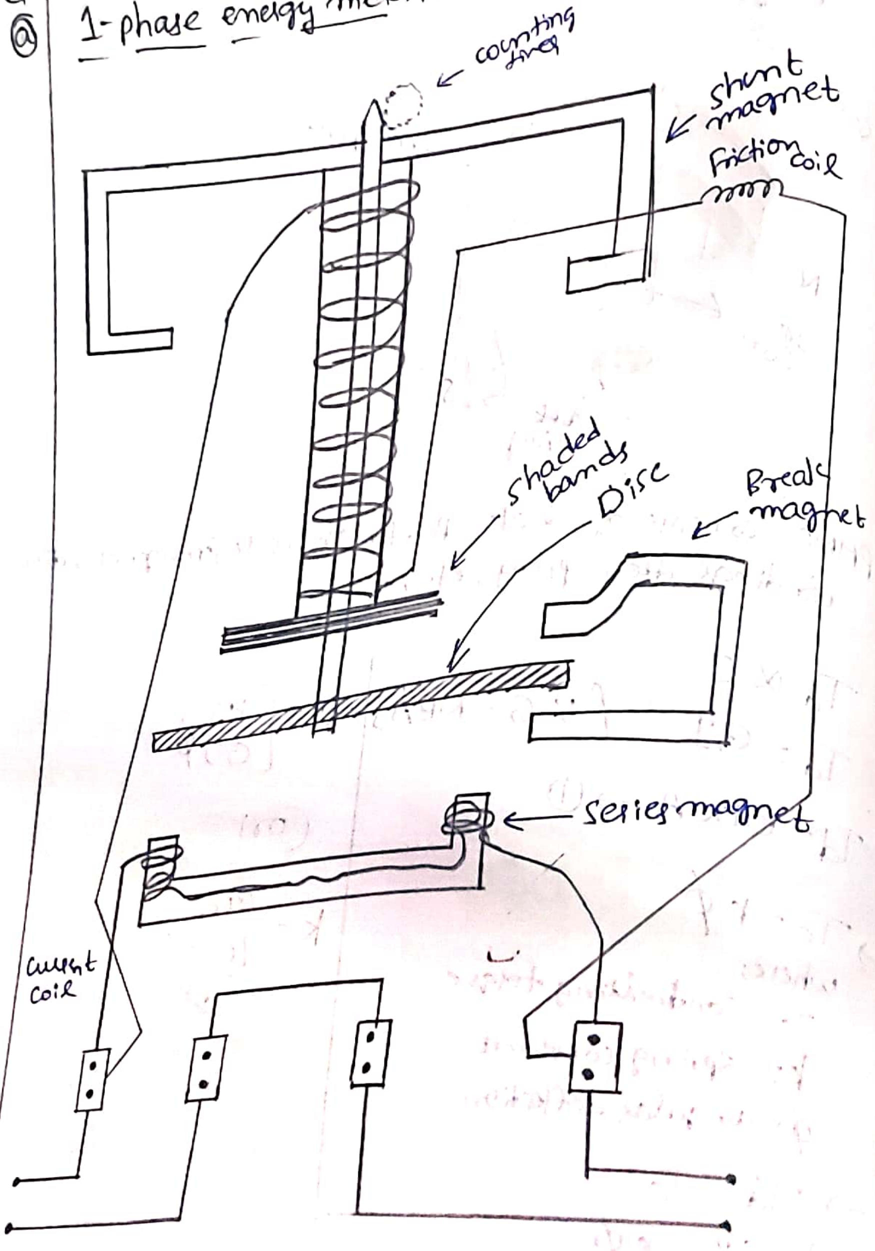
*) Indicating measurement system shows real time measuring values.

*) Absolute measurement system indicates all the measured values at a time.

*) Recording measurement system records the measured values.

*) Integrating measurement system indicates the difference between two measured values

④ ⓐ 1-phase energy meter:



→ Single phase energy meter is used to measure energy there is single phase energy meter and 3 phase energy meter

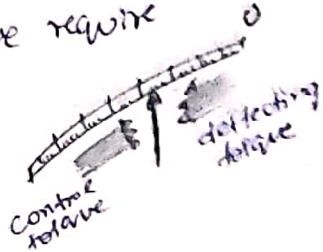
→ For lower applications we use single phase energy meter

→ Single phase energy meter as shown in the figure contains shunt magnet, series magnet, Friction control coil, shaded bands, Rotating disc, Break magnet

→ due to current produced in the coils the disc starts moving and the break magnet opposes its direction and later used to stop the disc from rotating

→ single phase energy meter thus stores energy and used wiedly in various industries and energy supply fields

→ Controlling torque opposes deflecting torque and hence the pointer stops at the value we require



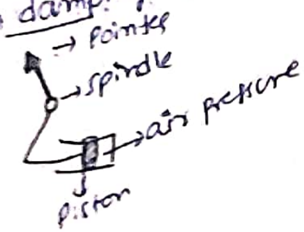
→ There are two types in controlling torque
(i) Spring control
(ii) Gravity control

(iii) Damping Torque:-

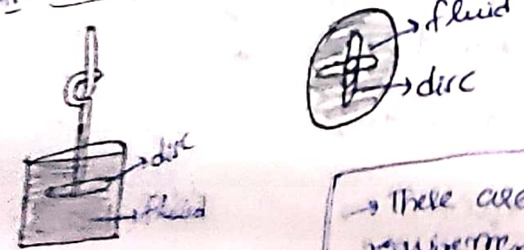
→ Damping torque makes the pointer more accurate and stops it at the correct and accurate value as we require

→ Damping torque has three types

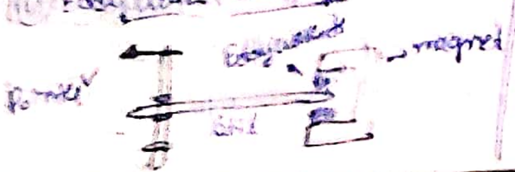
(i) Air friction damping:-



(ii) Fluid-friction damping:-

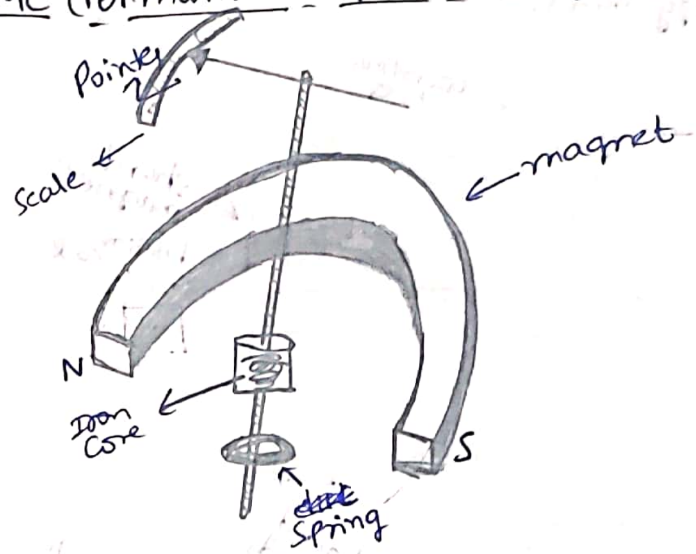


(iii) Eddy current damping:



→ These are the basic requirements of any instrument

PMMC (Permanent Magnet Moving Coil)



→ PMMC consists of scale, Pointer, iron core, magnet, disc windings, spring, etc.

→ $T_d \propto I$

$T_d = GI \quad [\because G = NBA]$

$T_d = BINA \rightarrow (1)$

→ $T_c = k\phi$

where;
T_c = Controlling torque
k = spring constant
ϕ = angular deflection

→ $T_d = T_c$

⇒ $GI = k\phi$

$I = \left[\frac{k}{G}\right]\phi$

(or)

$k = \left[\frac{I}{G}\right]\phi$

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| I | II | MID TERM EXAMINATION |

No. 529724

H.T. No.	2	0	2	4	1	A	0	2	1	0

Name of the Examination III B.Tech II Sem I Mid term Examination

Course SMI Branch EEE Date 21/03/2023

Signature of the Invigilator

Q.NO.	1		2		3		4		5		6		TOTAL
	a	b	a	b	a	b	a	b	a	b	a	b	
MARKS	1	1							2				4

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** For an instrument, the essential requirements are

→ An instrument need to caluculate atleast one quantity.

→ An instrument may be analog or digital.

→ An instrument have to show no errors while measuring.

→ An instrument should not be effected by other external factors like temperature etc.

→ An instrument should not react with the quantity that is being measured.

*) In a PMMC instrument, the pointer fluctuates at a particular point. Deflecting torque makes the pointer to raise to the desired level by measuring.

*) The Deflecting torque is generated in the PMMC instrument, when the measurement is started.

*) The Deflecting torque sometimes of over intensity, so the controlling torque controls the pointer of PMMC instrument.

*) The Damping torque makes the fluctuating pointer steady.

*) The Deflecting torque can also be known as the moving force of the pointer in PMMC instrument.

*) The Deflecting torque varies on the amount of quantity that is being measured.

5.

*) Measuring of a quantity using an instrument is called measurement.

*) The quantity that is measuring is either physical or other chemical quantity.

*) Measurement are classified based on the instruments we use for measuring.

*) Different types of measurement systems are

- → Indicating measurement system.
- → Absolute measurement system.
- → Integrating measurement system.
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*) Indicating measurement system shows real time measuring values.

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*) Integrating measurement system indicates the difference between two measured values.

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I	II

MID TERM EXAMINATION

No. 529708

H.T. No.	2	0	2	4	1	A	0	2	5	4

Name of the Examination: III yr II 2nd semester mid exam

Course: SMI Branch: EEE Date: 21/3/23

Signature of the Invigilator: [signature] 21/3/23

Q.NO.	1		2		3		4		5		6		TOTAL
	a	b	a	b	a	b	a	b	a	b	a	b	
MARKS	2	3					3	2		4	3		14

START WRITING FROM HERE

Essential requirements of an instruments is various kinds of torques like:

ii) Deflecting torque: The torque produced by the various types of effects is called deflecti torque.

The various effects are:

- Magnetic effect
- Induction effect
- Thermal effect
- Hall effect etc.

1b) Ans

PMMC - Permanent magnet moving coil.

Expression of deflecting torque.

deflecting torque is given by = T_d

Controlling torque is given by = T_c

for a stable instrument,

$$T_d = T_c \longrightarrow (1)$$

We know that,

$$T_d \propto I \Longrightarrow T_d = G\, I$$

(G → proportionality constant)

G is given by $G = NBA$

$$\therefore \quad T_d = G I = NBAI \longrightarrow (2)$$

where,

$N \rightarrow$ No. of turms

$B \rightarrow$ flux density

$A \rightarrow$ Area

Also,

$$T_c = K\phi \longrightarrow (3)$$

where

$K \rightarrow$ spring constant

$\phi \rightarrow$ deflecting angle.

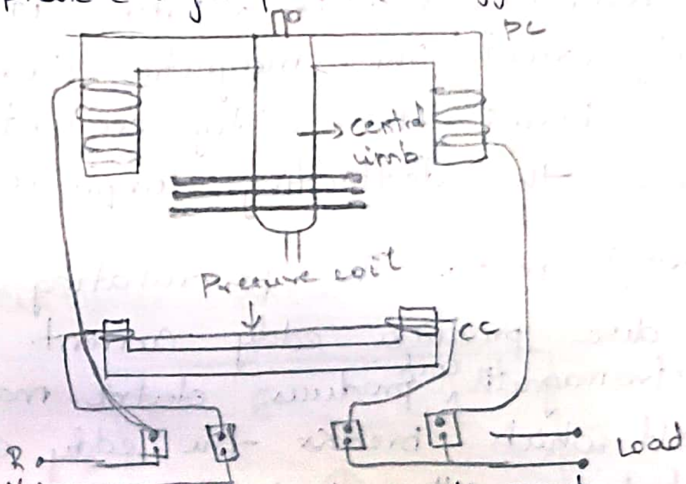
Substituting (2) & (3) in (1) we get

$$NBAI = K\phi$$

$$\phi = \frac{NBAI}{K} = \frac{GI}{K}$$

$\therefore$ deflecting angle is given by $\boxed{\phi = \frac{GI}{K}}$.

4a) 1-phase (single phase) energy ~~e~~ meter



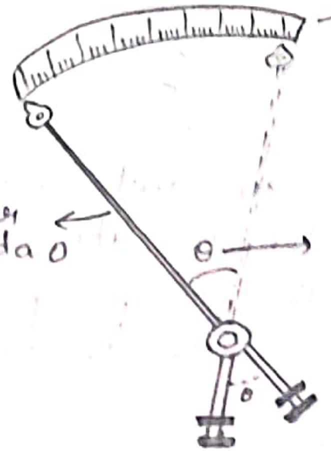
The energy meter has 4 parts

- Braking part
- Driving part
- Moving part
- Registrating part.

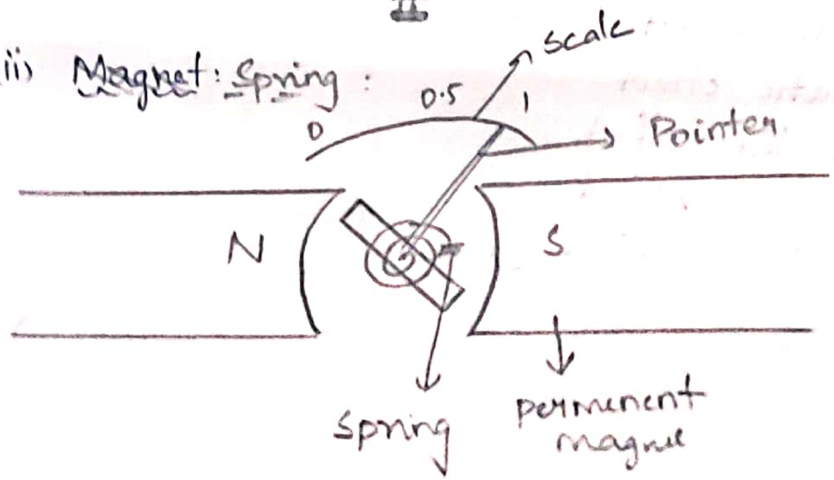
(i) Driving part - The part is of electromagnet, ~~T~~ which are enameled ~~co~~ or ~~Sh~~ silk coted copper materials. There are 2 electromagnets. One is shunt electromagnet which is connected to the

(ii) Controlling torque: It is the opposing torque of deflecting torque. A Instrum, would be precise when the controlling torque is equal to deflecting torque. ($T_d = T_c$). It opposes either by spring or by permenent magnet method

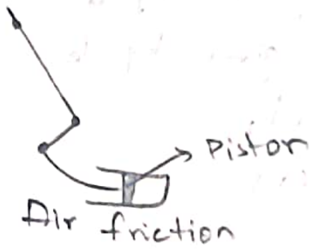
(i) Spring . Magnet

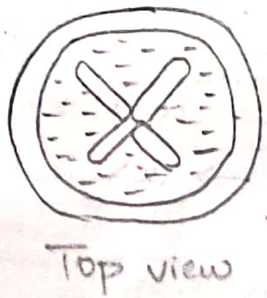


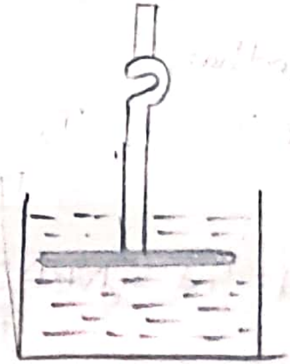
(ii) Magnet : Spring :



(iii) Damping torque: It is of 3 types:
- Air friction damping
- Fluid friction damping
- Eddy current damping







fluid friction

Supply and other one is series electromagnet connect to the load and products current by induction. The coil wounded is called pressure coil.

Moving part: The moving part is an aluminium disc. On rotating, it produces eddy currents. The magnetic flux is will break the eddy current and hence the deflecting torque is formed.

Braking part :- The rotating aluminium disc produces eddy current. The electromagnetic coil produces magnetic field which breaks the eddy current and hence the braking torque is formed.

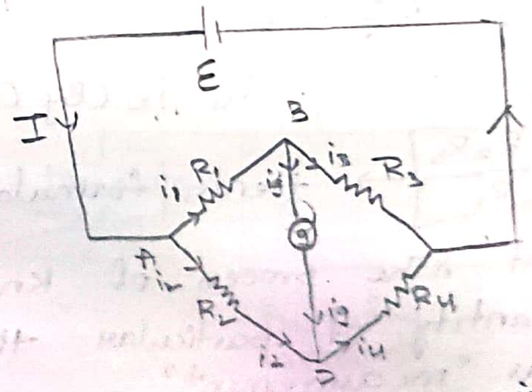
Registrations: The device part which counts the number of deflection because it is directly equal to the power generated by the device.

4b) Ans Wheatstone bridge: • It is used for the measurement of resistance

• But it is also used as Transducer for measuring physical quantities like temperature, pressure etc

• It can measure resistance from few ohm to few kilo ohm

• It is the most popular and simplest method to find precise resistance measurement.



cosider B point B & point D

$\therefore i_1 = i_g + i_3 \rightarrow (1)$

$i_2 + i_g = i_4 \rightarrow (2)$

(sum of incoming currents is equal to sum of outgoing currents)

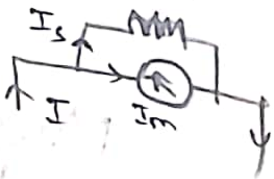
~~Indicating~~: Which indicates the quantity

~~Into~~ Recording: Which records the quantities over a period of time.

Integrating: Which indicates the quantity present over a period of time.

6) PMMC as ammeter:

- To extend PMMC as ammeter a resistor i.e, "shunt" is kept in parallel
- ~~The~~ The current passing through



2) $I_m R_m = I_s R_s$

B

PMMC as voltmeter:

- To extend PMMC as voltmeter a resistor called 'Voltage multiplier' is kept in series with PMMC.
- It has few functions, one of them is:
  - It doesn't let the PMMC to be on full deflection as it may damage system.

By kirchoff's law

~~$i_1R_1 = i_3R_3 + i_g$~~ $\quad i_1R_1 + i_g = i_2R_L \rightarrow (3)$

~~$I = \frac{V}{R}$~~ $\quad i_g + i_4R_4 = i_3R_3 \rightarrow (4)$

~~$i_2R_2 =$~~

But under stable conditions current passing through galvanometer $= 0 \Rightarrow i_g = 0$

$\therefore\ i_1 = i_3 \ (5)\ ;\ i_2 = i_4 \ (6)\ ;\ i_1R_1 = i_2R_2 \ (7)\ ;\ i_3R_3 = i_4R_4 \ (8)$

By calculating them, we get

$i_1 = i_2\frac{R_2}{R_1} \Rightarrow i_2\frac{R_2}{R_1} = i_3$

$\left(i_2\frac{R_2}{R_1}\right)R_3 = R_4 i_4 \quad \because i_4 = i_2$ (By (6))

$$\boxed{R_4 = \frac{R_2R_3}{R_1}}$$ → Hence, formula derived.

SAQ Measurement: i) The process of knowing the quantity of particular thing is called as "measurement"

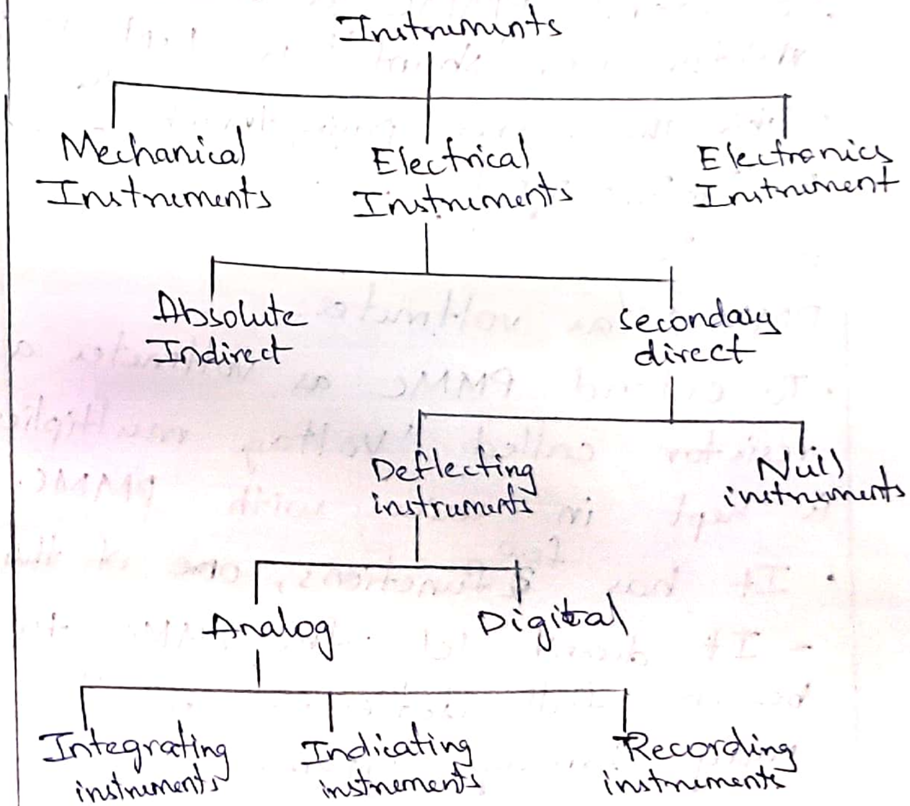
2) It is derived from latin word "Measurare".

3) The device which we use to measure a particular thing is called instrument.

4) The one which has to be measured is called "measurand".

5) Measurement system is very much important mainly in electrical concepts since we need calculate necessary calculations and generate electricity, power up devices etc.

6) Instruments are classified as follows



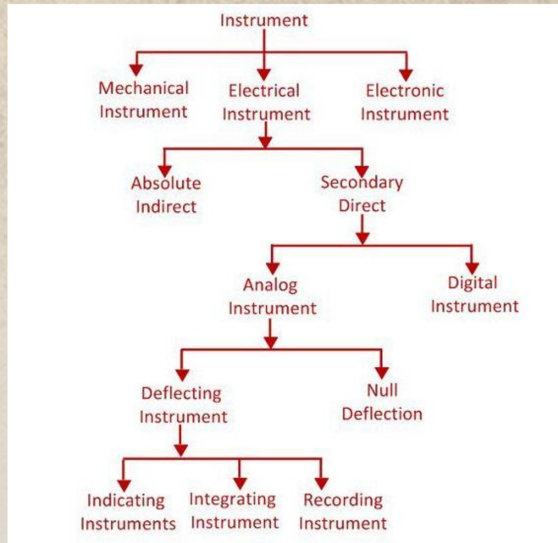
UNIT-I

Dr. P.SRIVIDYA DEVI

WHAT ARE THE NECESSARY REQUIREMENT'S FOR ANY MEASURING INSTRUMENT

CLASSIFICATION OF MEASURING INSTRUMENTS

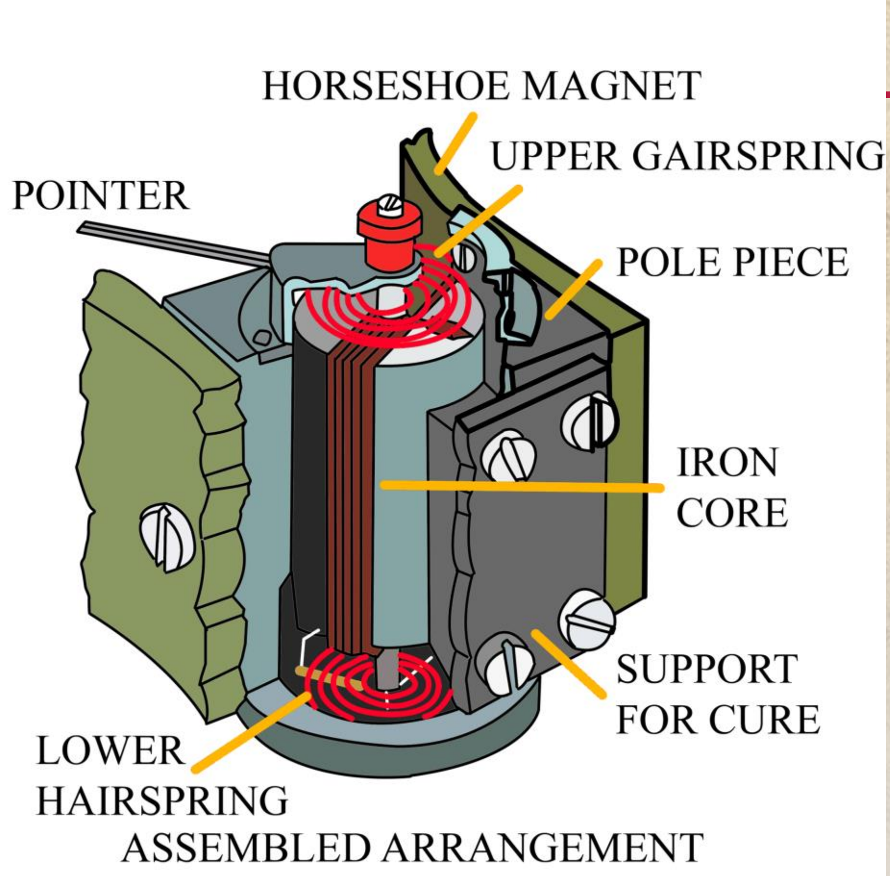
- INDICATING INSTRUMENTS
- RECORDING INSTRUEMENTS
- INTEGRATING INSTRUEMENTS

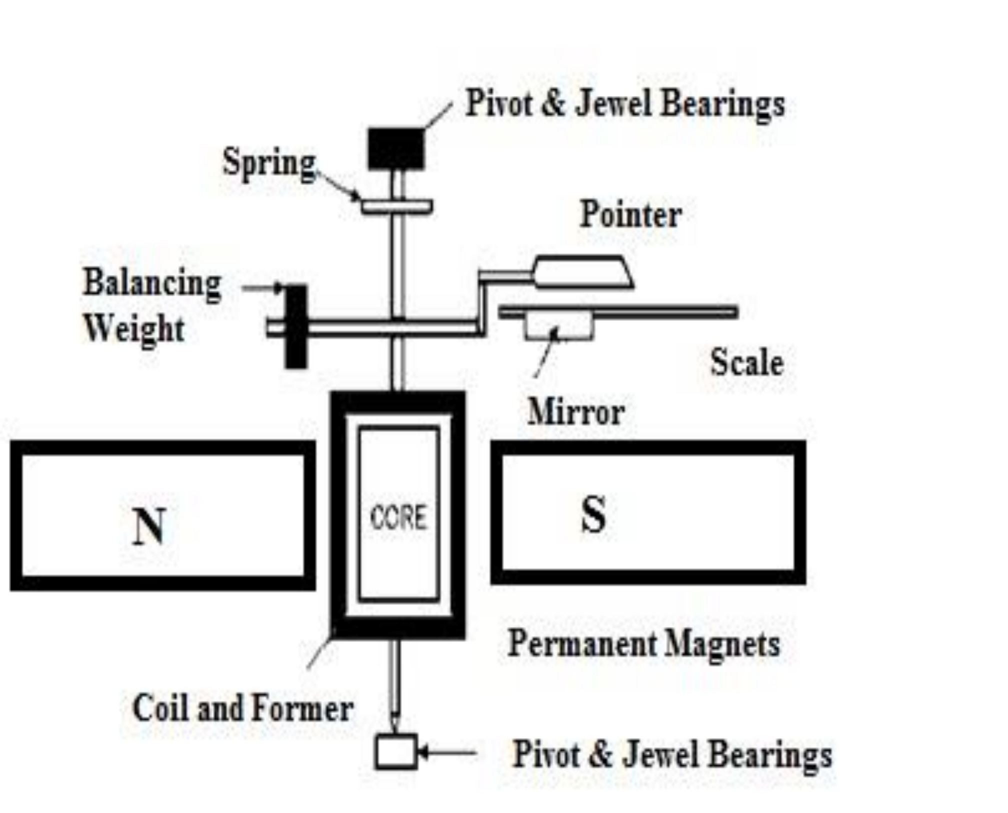


Indicating Instrument – The instrument which indicates the magnitude of the measured quantity is known as the indicating instrument.

Recording Instrument – The instrument records the circuit condition at a particular interval of time is known as the recording instrument.

Integrating Instrument – The instrument which measures the total energy supplied at a particular interval of time is known as the integrating instrument.


HORSESHOE MAGNET
UPPER GAIRSPRING
POINTER
POLE PIECE
IRON CORE
SUPPORT FOR CURE
LOWER HAIRSPRING
ASSEMBLED ARRANGEMENT


Pivot & Jewel Bearings
Spring
Pointer
Balancing Weight
Scale
Mirror
N
CORE
S
Permanent Magnets
Coil and Former
Pivot & Jewel Bearings

ESSENTIAL REQUIREMENTS OF AN INSTRUMENT

- Deflecting Torque
- Controlling Torque
  - Spring Control
  - Gravity Control
- Damping Torque
  - Air Friction Damping
  - Fluid Friction Damping
  - Eddy Current Damping

Deflecting torque:

- The ***deflecting torque*** is produced by utilizing the various effects (magnetic effect, induction effect, thermal effect, hall effect) of electric current or voltage, and causes the moving system and hence the pointer to move from zero position.

controlling torque:

- The ***controlling torque*** is produced by spring or gravity and opposes the deflecting torque. The pointer comes to rest at a position, where these two opposing torques are equal.

Damping torque:

- ***Damping torque*** is provided by air friction or eddy currents. It ensures that, the pointer comes to the final position, without oscillations, thus enabling accurate and quick readings to be taken.

Deflecting system:

- In most of the indicating instruments the mechanical force proportional to the quantity to be measured is generated. This force or torque deflects the pointer.

The deflecting torque overcomes,

1) The inertia of the moving system
2) The controlling torque provided by controlling system.
3) The damping torque provided by damping system.

The deflecting system uses on of the following effects produced by current or voltage, to produce deflecting torque.

a) Magnetic effect
b) Thermal effect
c) Electrostatic effect
d) Induction effect
e) Hall effect

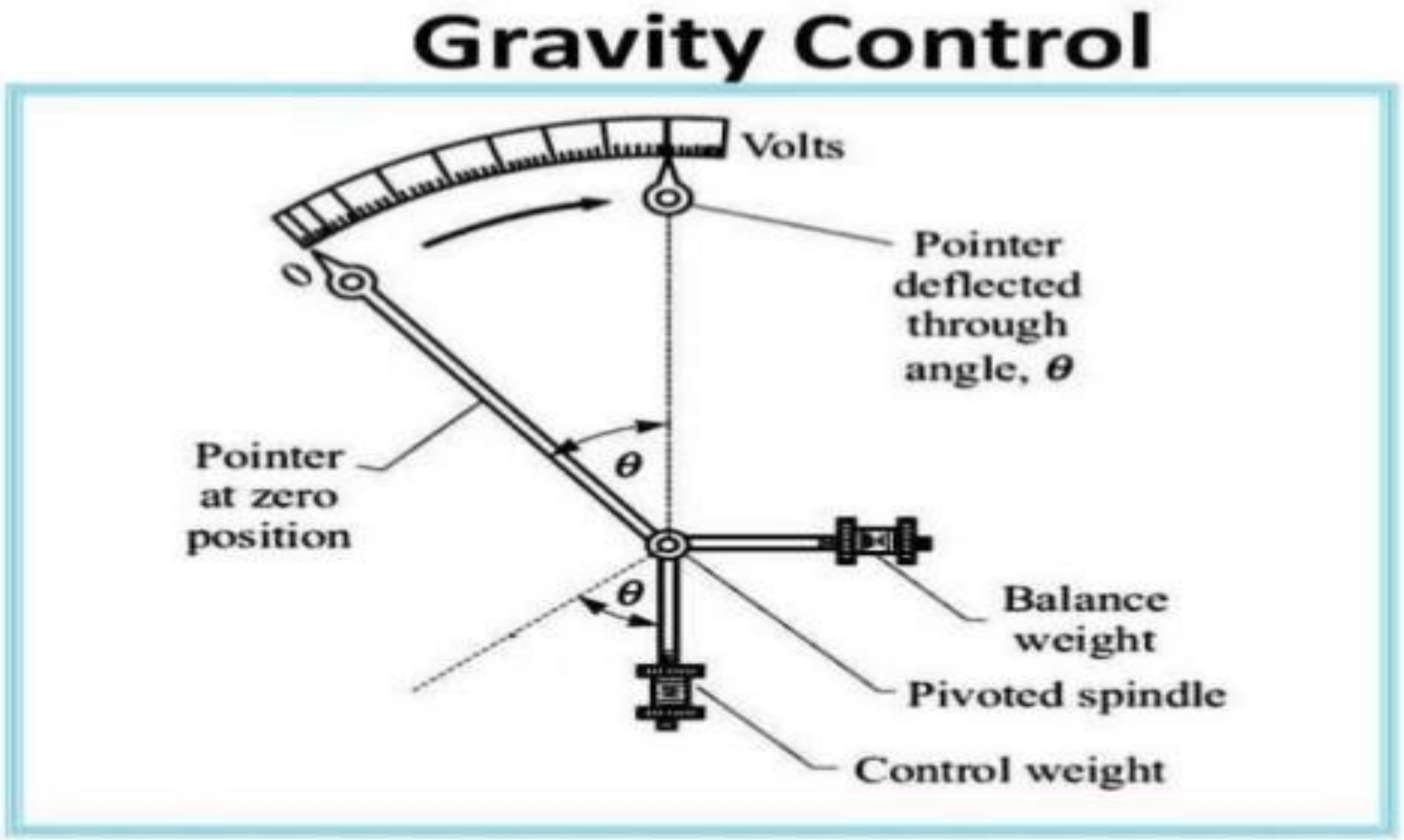
Controlling system:

- The controlling torque (T_c) opposes the deflecting torque and increases with the deflection of the moving system. The pointer comes to rest at a position where the two opposing torques are equal i.e. $T_d = T_c$.

The controlling torque performs two functions.

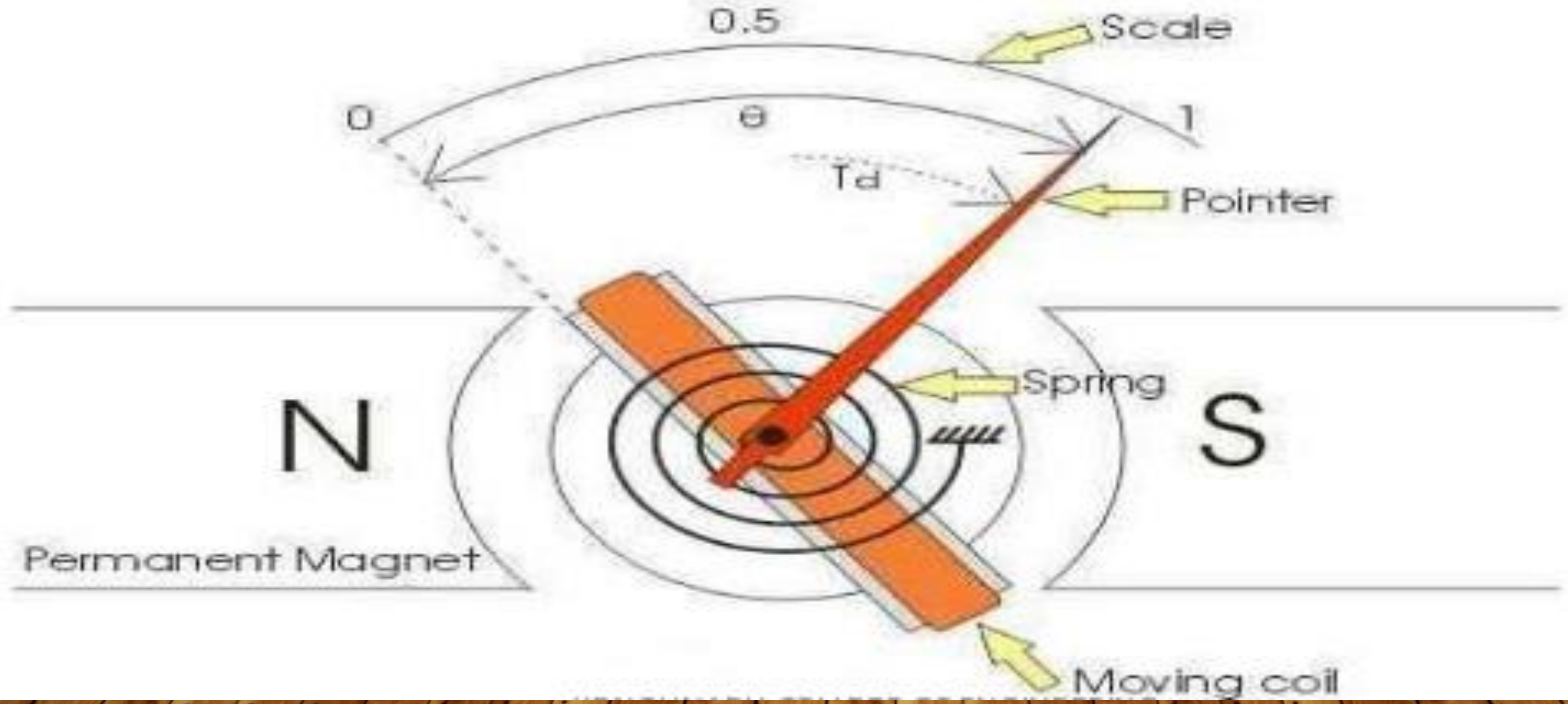
- Controlling torque increases with the deflection of the moving system so that the final position of the pointer on the scale will be according to the magnitude of an electrical quantity (i.e. current or voltage or power) to be measured.
- Controlling torque brings the pointer back to zero when the deflecting torque is removed. If it were not provided, the pointer once deflected would not return to zero position on removing the deflecting torque. The *controlling torque* in indicating instruments may be provided by one of the following two methods:
- (i) Spring control.
  (ii) Gravity control.

Gravity Control Method:

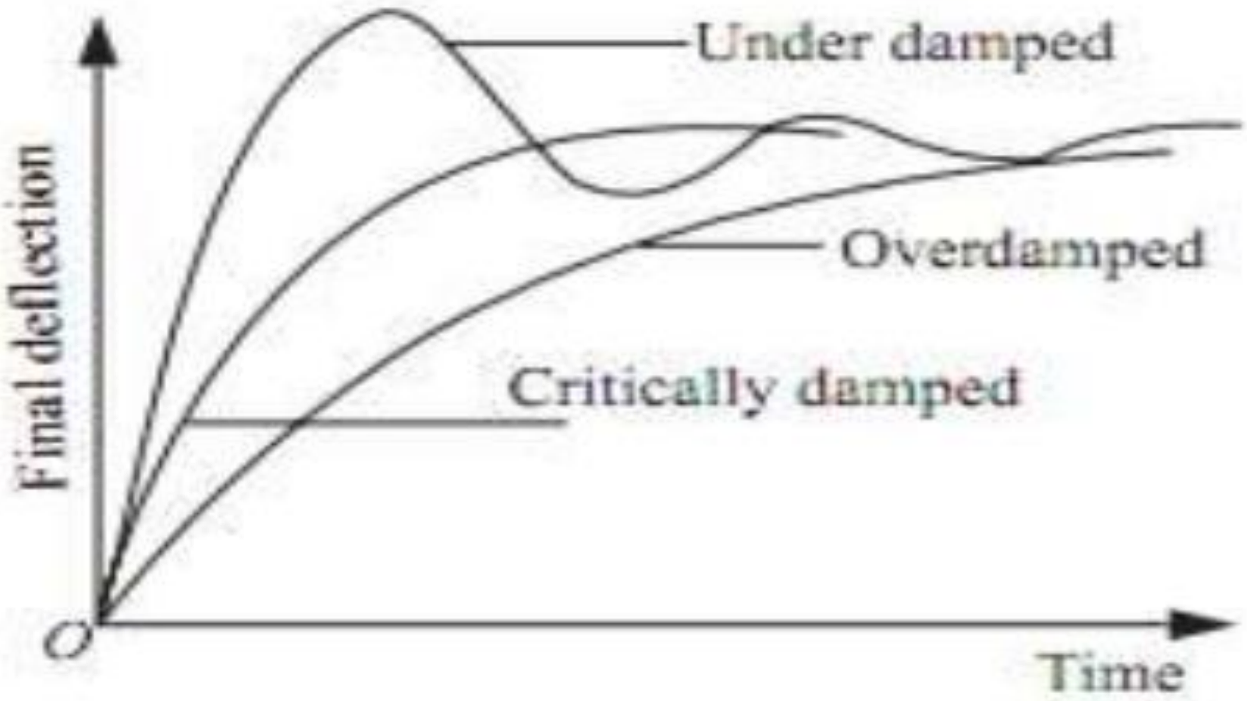


Spring Control Method

- This is the most common method of providing controlling torque, in electrical instruments. A spiral hairspring made of some non-magnetic material like phosphor bronze is attached to the moving system of the instrument as shown in the figure.



Damping System:

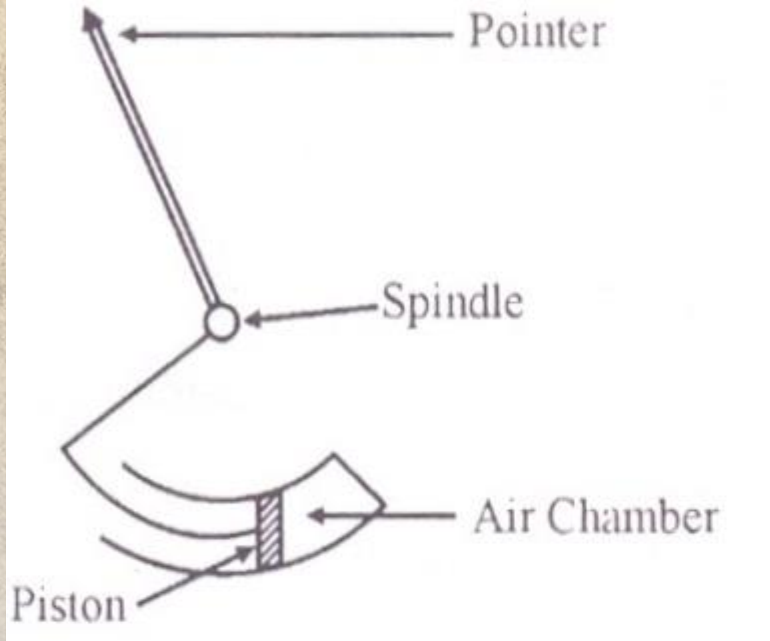


- *Dynamic response of a measuring instrument*

Damping Methods

1. Air Friction Damping
2. Fluid Friction damping
3. Eddy current Damping

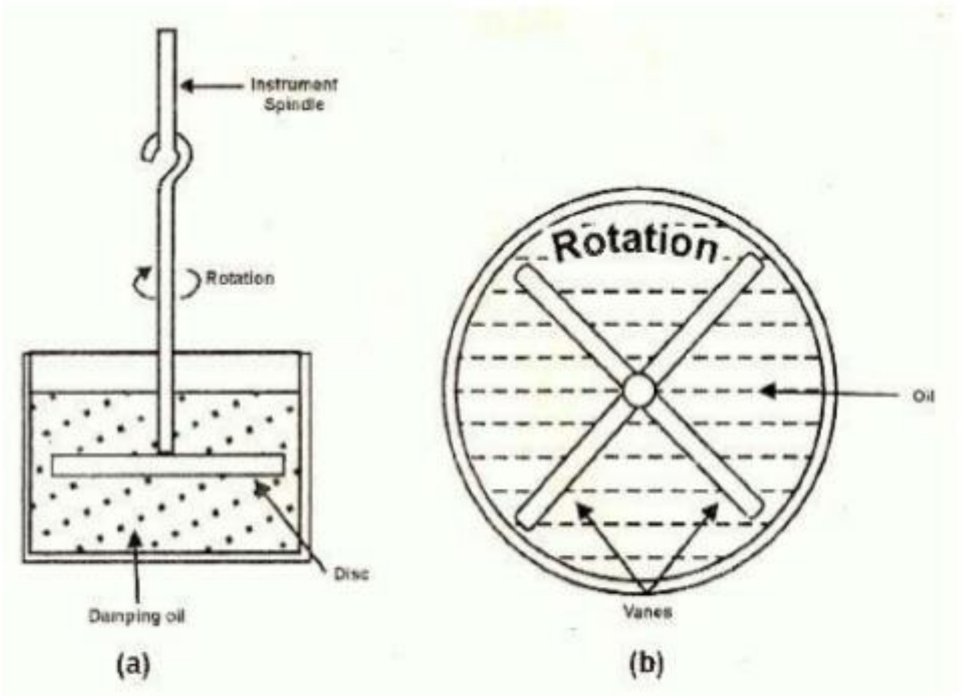
Air Friction damping



→A light aluminum frame is attached to the moving system.
→This piston moves in an air chamber (cylinder) closed at one end.
→At the time of oscillation of the moving system or pointer about its final steady state, if the piston is moving into the chamber, the trapped air gets compressed, and the pressure opposes the motion of the piston (and therefore the moving system or pointer).
→Similarly, if the piston is moving out of the chamber, the pressure in the closed chamber falls and becomes less than air pressure on the outer part of the piston.

Motion is thus again opposed. Oscillations are damped.

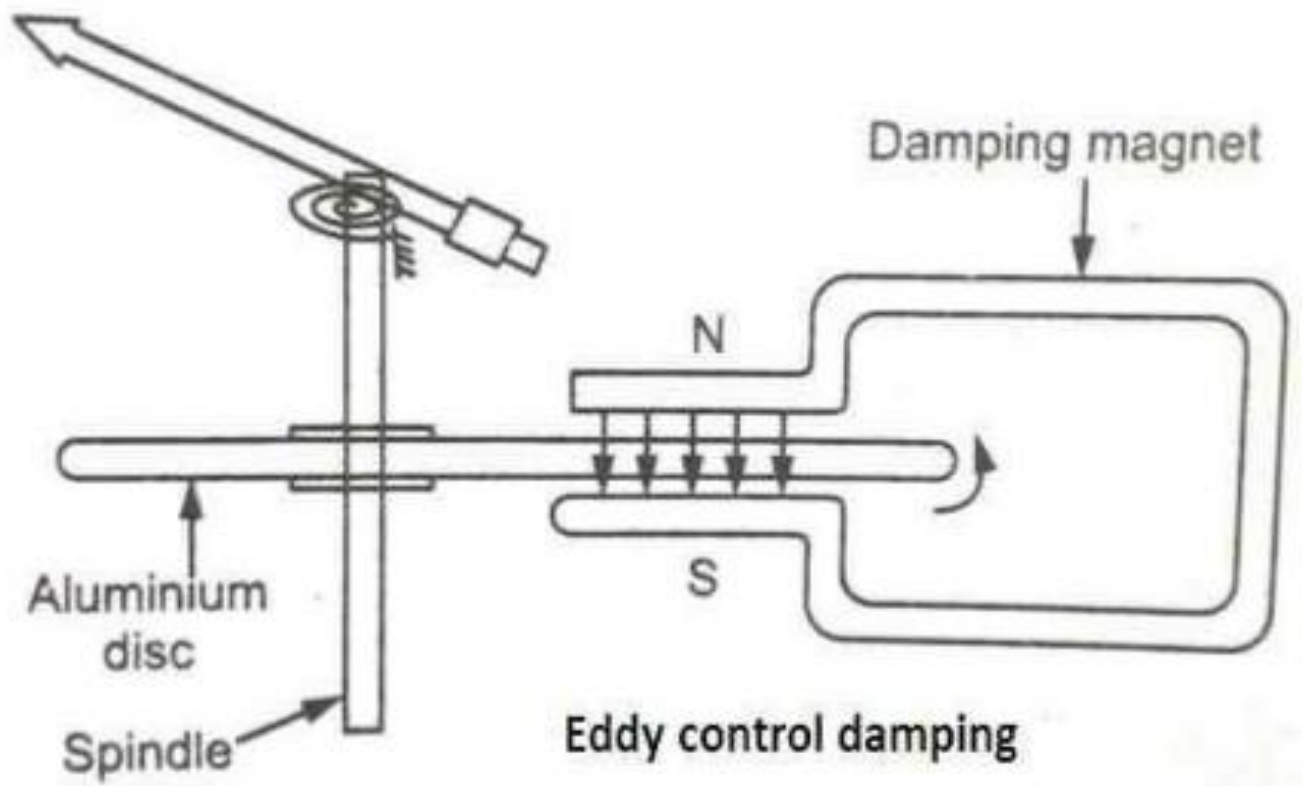
Fluid Friction Damping:



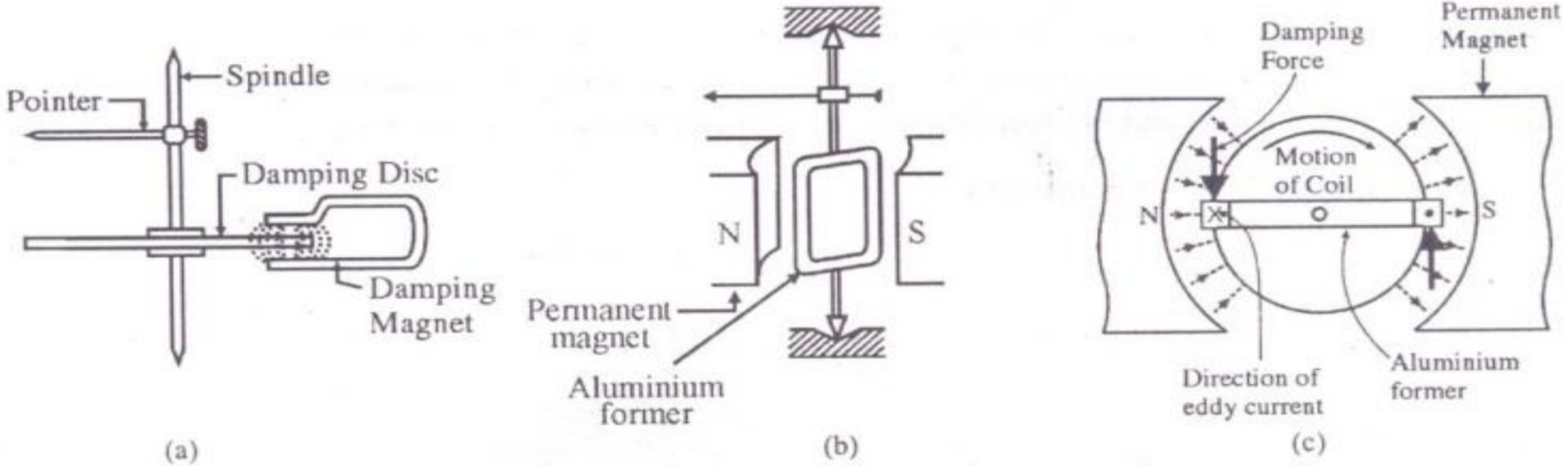
→ A light aluminum vane is attached to the moving system, which is placed inside the fluid container so that friction offered by the fluid can oppose the motion of the pointer.

→The friction offered by liquid is more compared to the friction offered by air.

Eddy Current Damping



Eddy control damping



An aluminum frame or damping disc is mounted on the spindle and free to rotate in the magnetic field provided by damping magnets.

Since damping disc is rotating with spindle, emf is induced in the disc according to faradays law of electromagnetic induction.

Since, disc is a closed circuit, eddy current in the form of concentric circles will be induced in the damping disc. Interaction between this eddy current and magnetic field develops a force on the damping disc which opposes the movement of sheet.

And thus, provides damping of the oscillations of the pointer.

1). ______________ is a physical parameter or variable to be a measure

2). ________ is defined as a quantity of the same kind chosen as a unit or basis for comparison of a quantitative value to be a measure

- Measurand
- Standard
- Both a and b
- None of the above

Ans. A, B

4). _______ are the measuring instruments

- ◯ Ruler
- ◯ Thermometer
- ◯ Stopwatch
- ◯ All of the above

6). In _________ measurement methods, the unknown quantity (measurand) is measured directly instead of comparing it with a standard

- ◯ Direct
- ◯ Indirect
- ◯ Both a and b
- ◯ None of the above

8). The direct measurement method categorized into __________

- One
- Two
- Three
- Four

11). ____________ is an example for absolute instruments

- Tangent galvanometer
- Rayleighs current balance
- Both a and b
- None of the above

Permanent Magnet Moving Coil Instrument (PMMC):

- The permanent magnet moving coil instrument is the most accurate type for **d.c. measurements. The working principle of these instruments is the same as that of the** d'Arsonval type of galvanometers, the difference being that a direct reading instrument is provided with a pointer and a scale.

Construction of PMMC Instruments

- The constructional features of this instrument are shown in Fig.
- The moving coil is wound with many turns of enameled or silk covered copper wire.
- The coil is mounted on a rectangular aluminum former which is pivoted on jewelled bearings.
- The coils move freely in the field of a permanent magnet.
- Most voltmeter coils are wound on metal frames to provide the required electro-magnetic damping.
- Most ammeter coils, however, are wound on non -magnetic formers, because coil turns are effectively shorted by the ammeter shunt.
- The coil itself, therefore, provides electro magnetic damping.

PMMC

Scale

Pointer

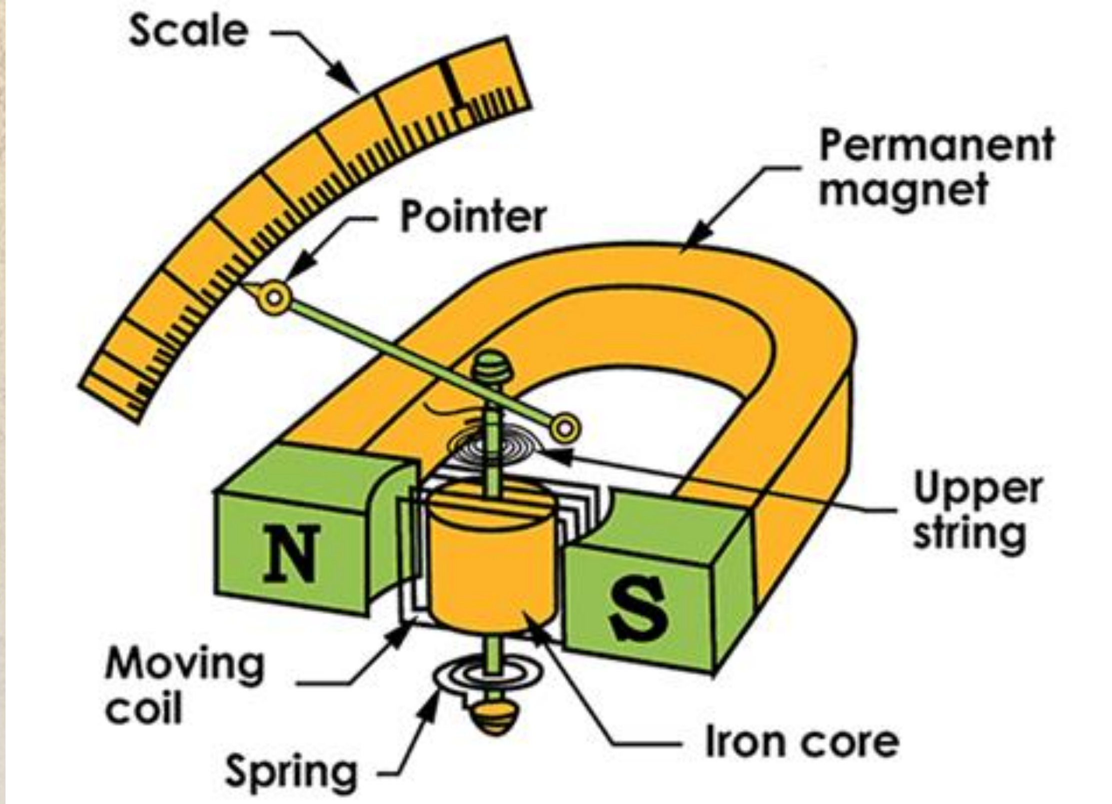
Moving coil

Spring

Iron core

Upper string

Permanent magnet



Magnet Systems

- Old style magnet system consisted of relatively long U shaped permanent magnets having soft iron pole pieces.
- Owing to development of materials like Alcona and Alnico, which have a high co-ercive force, it is possible to use smaller magnet lengths and high field intensities.
- The flux densities used in PMIMC instruments vary from 0.1 W b/m to 1Wb/m.

Control

- When the coil is supported between two jewel bearings the control torque is provided by two phosphor bronze hair springs.
- These springs also serve to lead current in and out of the coil. The control torque is provided by the ribbon suspension as shown.
- This method is comparatively new and is claimed to be advantageous as it eliminates bearing friction.

Damping

- Damping torque is produced by movement of the aluminum former moving in the magnetic field of the permanent magnet.

Pointer and Scale

- The pointer is carried by the spindle and moves over a graduated scale.
- The pointer is of light-weight construction and, apart from those used in some inexpensive instruments has the section over the scale twisted to form a fine blade.
- This helps to reduce parallax errors in the reading of the scale. When the coil is supported between two jewel bearings the control torque is provided by two phosphor bronze hair springs.
- These springs also serve to lead current in and out of the coil.

Torque Equation for PMMC

The equation for the developed torque of the PMMC can be obtained from the basic law of electromagnetic torque. The deflecting torque is given by,

$$Td = NBAI$$

Where,

Td = deflecting torque in N-m

B = flux density in air gap, Wb/m2

N = Number of turns of the coils

A = effective area of coil m2

I = current in the moving coil, amperes

Therefore, **Td = GI**

Where, G = NBA = constant

- The controlling torque is provided by the springs and is proportional to the angular deflection of the pointer.

$$Tc = KØ$$

Where,
Tc = Controlling Torque
K = Spring Constant Nm/rad or Nm/deg
Ø = angular deflection
For the final steady state position,

$$Td = Tc$$

Therefore **GI = KØ**

So, $Ø = (G/K)I$ or $I = (K/G)\,Ø$

Thus the deflection is directly proportional to the current passing through the coil. The pointer deflection can therefore be used to measure current.

Errors in PMMC Instruments

- The main sources of errors in moving coil instruments are due to Weakening of permanent magnets due to ageing at temperature effects.
- Weakening of springs due to ageing and temperature effects.
- Change of resistance of the moving coil with temperature.

Advantages and Disadvantages of PMMC Instruments

The main advantages of PMMC instruments are

- The scale is uniformly divided.
- The power consumption is very low
- The torque-weight ratio is high which gives a high accuracy. The accuracy is of the order of generally 2 percent of full scale deflection.
- A single instrument may be used for many different current and voltage ranges by using different values for shunts and multipliers.
- Self-shielding magnets make the core magnet mechanism particularly useful in aircraft and aerospace applications.

The disadvantages are

- These instruments are useful only for d.c. The torque reverses if the current reverses. If the instrument is connected to a.c., the pointer cannot follow the rapid reversals and the deflection corresponds to mean torque, which is zero. Hence these instruments cannot be used for a.c.
- The cost of these instruments is higher than that of moving iron instruments.

PMMC AS AMMETER

EXTENSION OF RANGE OF PMMC AMMETER

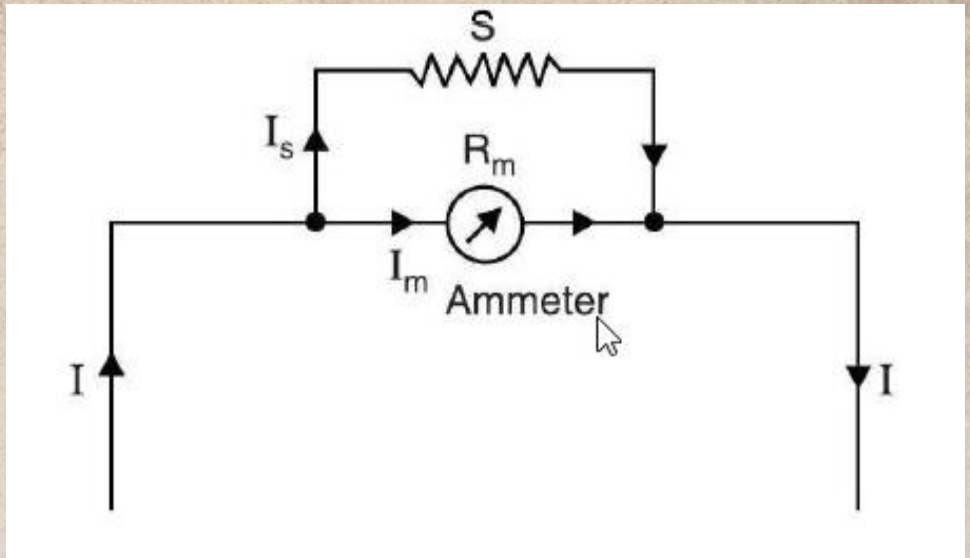
THE RANGE OF A PERMANENT-MAGNET MOVING COIL AMMETER CAN BE EXTENDED BY CONNECTING A LOW RESISTANCE, CALLED *SHUNT IN PARALLEL WITH THE MOVING COIL OF THE INSTRUMENT

$$(I - I_m)S = I_m R_m$$

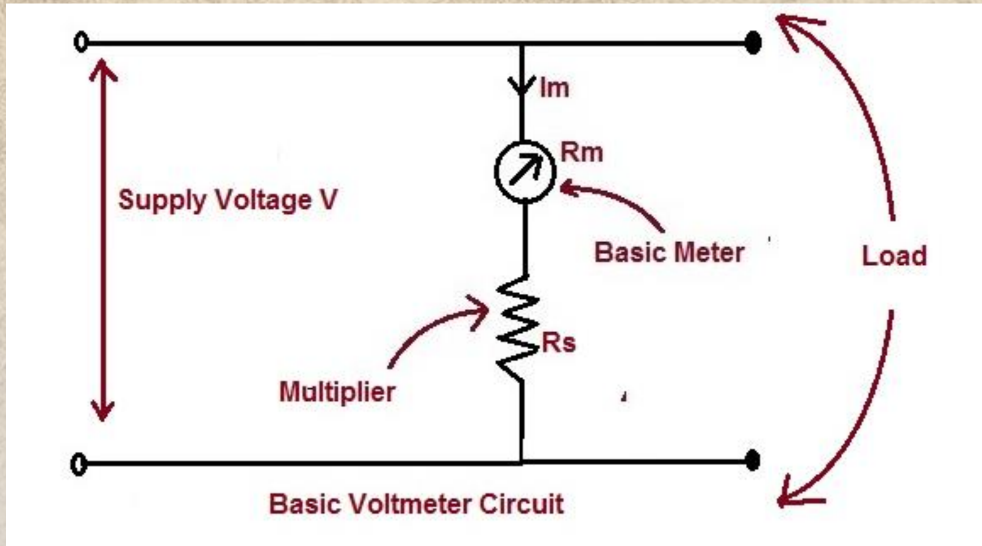
$$S = \frac{I_m R_m}{I - I_m}$$

$$\text{Multiplying power of shunt} = \frac{I}{I_m} = \frac{R_m + S}{S}$$

DIAGRAM



PMMC AS VOLTMETER



- A PMMC Instrument can be used as voltmeter by just connecting a series resistance with the moving coil. This series resistance is called Voltmeter Multiplier. This combination of moving coil and multiplier is connected across the point whose voltage is to be measured.

CALCULATION OF VOLTMETER MULTIPLIER:

- There are two main functions of voltmeter multiplier:

→ It limits the current through the PMMC moving coil to a value less than full scale deflection current and thus prevents moving coil from being damaged.

→ It minimizes the flow of current through the voltmeter and thus do not alter the circuit current whose voltage is to be measured. Ideally the resistance of voltmeter should be infinite.

- The value of multiplier required to extend the voltage range is calculated as below ,Let,
- I_m = Ifs = Full scale deflection current of meter
- R_m = Internal resistance of meter
- R_s = Multiplier resistance
- V_m = Voltage across the moving coil
- V = Full range voltage of meter
- From the simplified voltmeter circuit given below,

--CONTD.

- $V_m = I_m R_m$ ……………….(1)
- and $V = Im(R_m + R_s)$ ………….(2)
- Dividing equation (2) by (1) we get,
- $V/Vm = 1 + R_s/R_m$
- Thus,
- **m = Multiplying Factor = $1 + R_s/R_m$**
- The term V/V_m is called Multiplying Factor of Voltmeter.

Multiplying Factor is basically the value by which the range of voltmeter can be extended.

PERMANENT MAGNET MOVING IRON INSTRUMENTS

Moving-iron instruments are **generally used to measure alternating voltages and currents**. In moving-iron instruments the movable system consists of one or more pieces of specially-shaped soft iron, which are so pivoted as to be acted upon by the magnetic field produced by the current in coil.

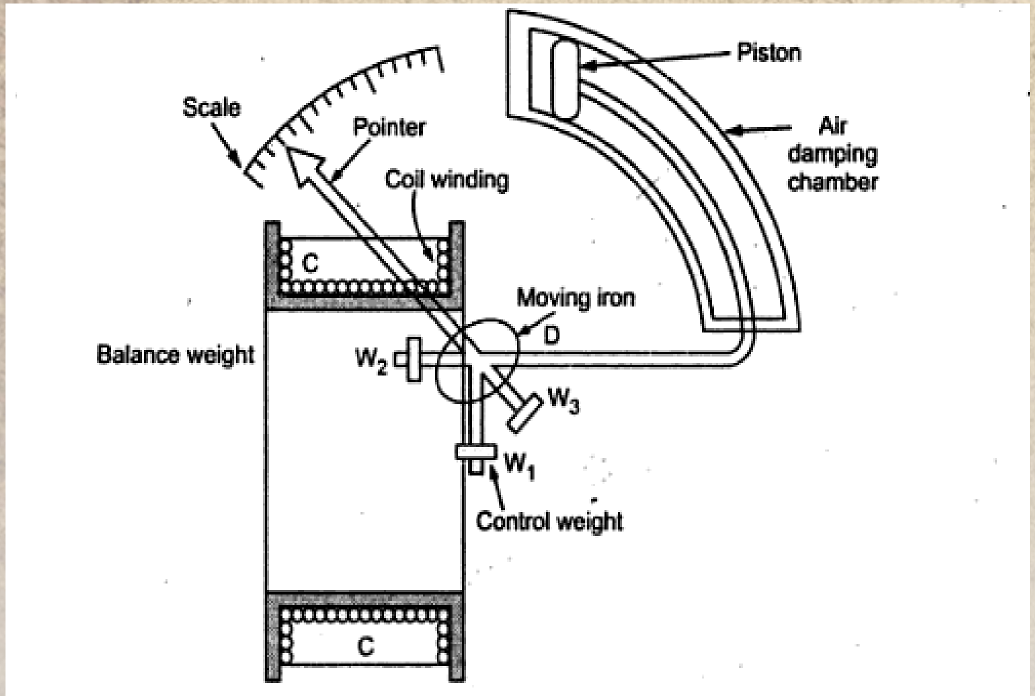
Moving Iron Instruments

Classification of Moving Iron Instruments

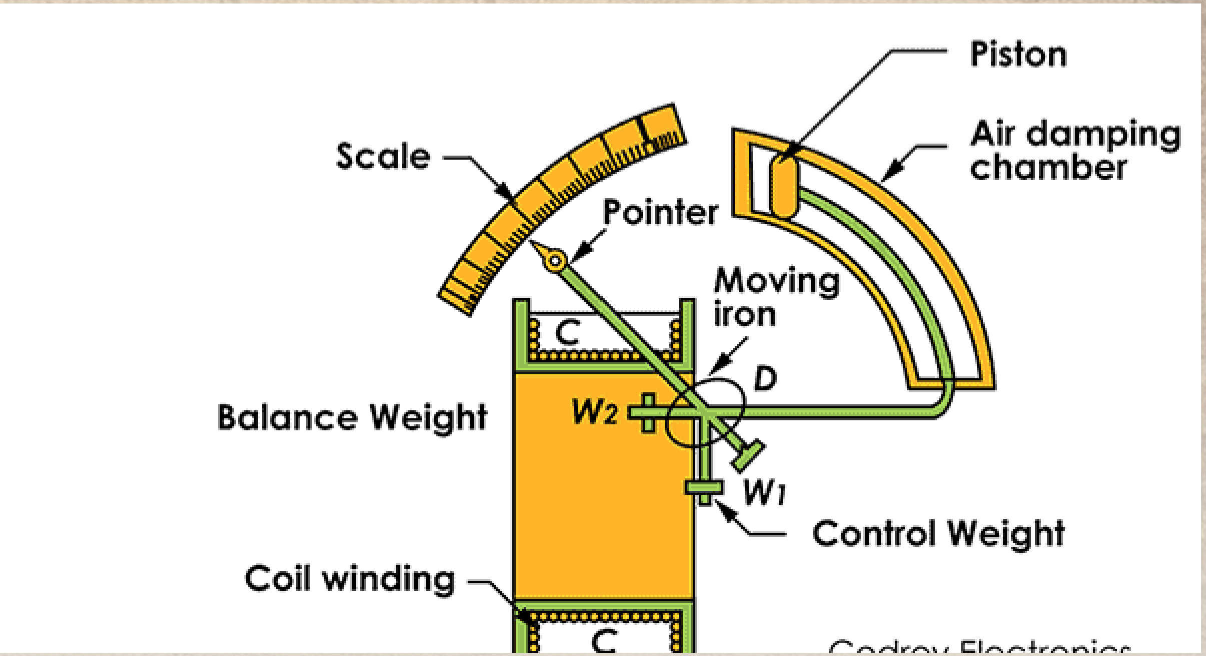
Moving iron instruments are of two types

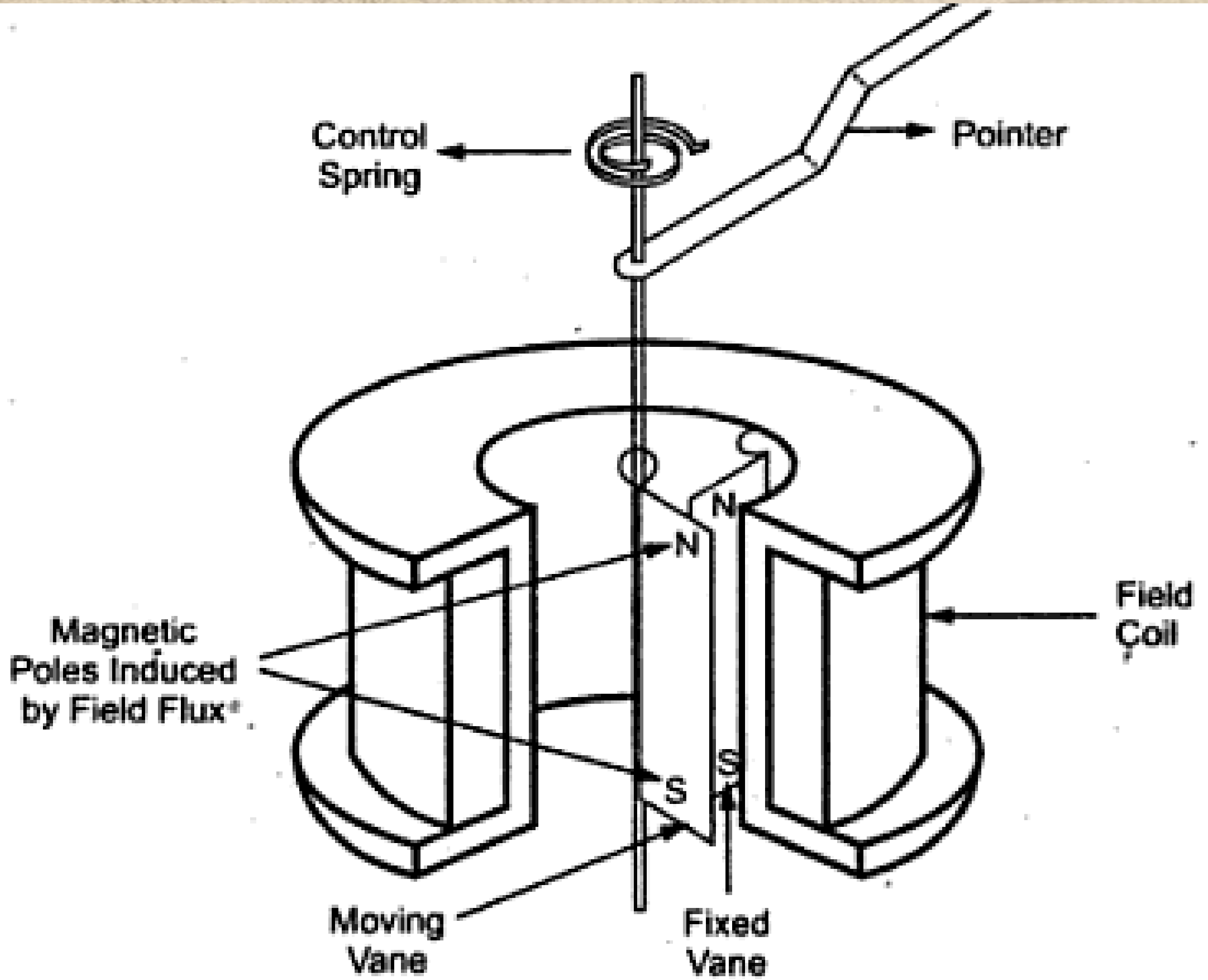
(i) Attraction type.

(ii) Repulsion type.

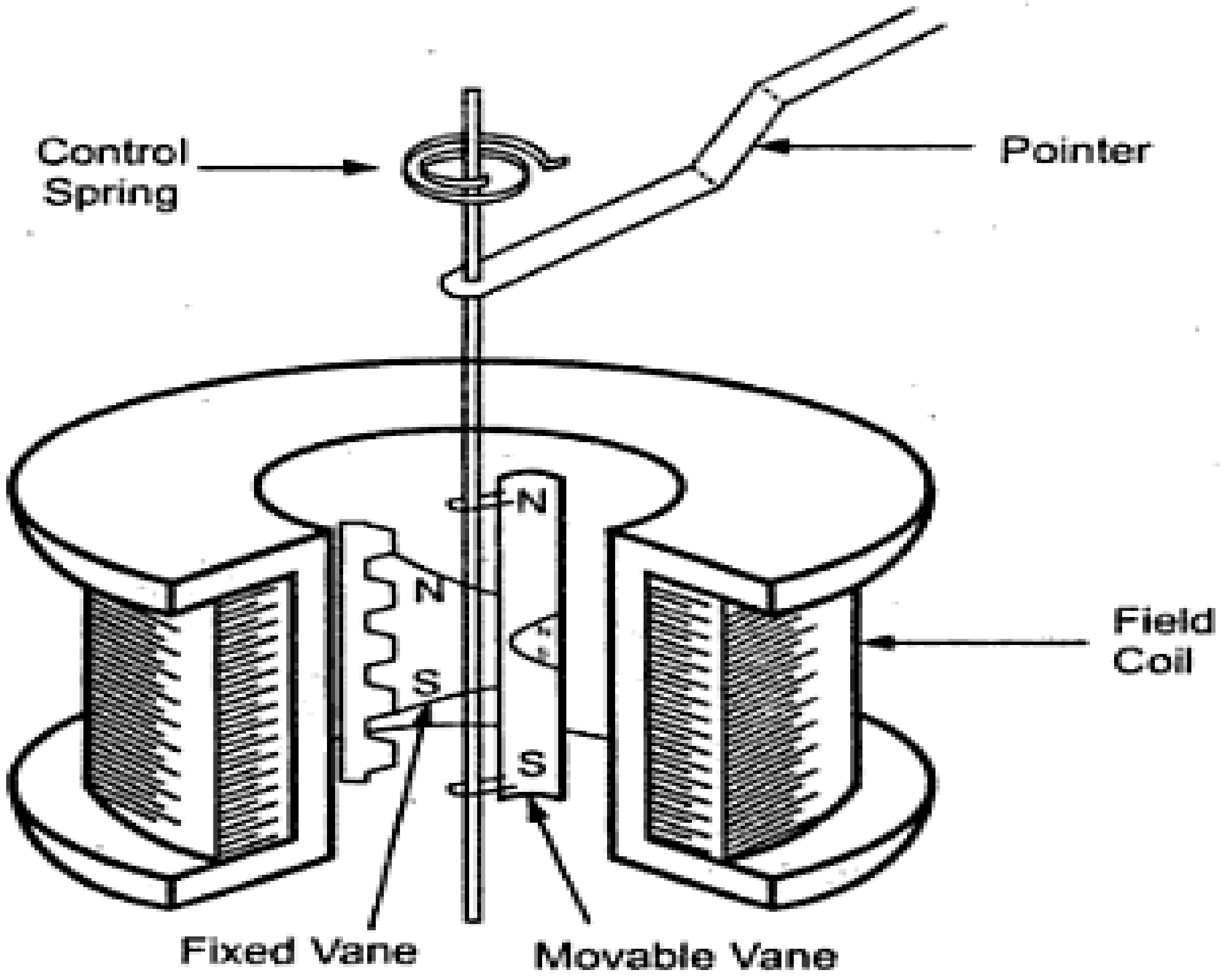


Moving iron attraction type instrument





Radial vane repulsion type instrument



Concentric vane repulsion type instrument

In a moving iron instrument, the deflecting torque is given as

$$T_d = (1/2)I^2(dL/d\theta)$$

The controlling torque in these instruments is provided through spring. So, controlling torque due to spring is

$$T_c = K\theta$$

Where,

'K' is the constant of spring.

'θ' is the deflection within the needle.

The deflecting & controlling torque in equilibrium condition is equivalent to the following.

Deflecting Torque = Controlling Torque

$$T_d = T_c$$

$$(1/2)I^2(dL/d\theta) = K\theta$$

From the above equation, 'θ' can be written as

$$\theta = (1/2)I^2/K(dL/d\theta)$$

Advantages

The **advantages of moving iron instruments** include the following.

- This instrument is applicable for both AC & DC.
- This device has very less friction error due to a high torque weight ratio
- These instruments are available at less cost because it has less number of coil turns as compared to other instruments like PMMC.
- This is robust due to its very simple construction.
- It can resist overload for a moment.
- Applicable for high power & low frequency-based circuits.
- It is capable of giving accuracy within limits of both accuracies as well as industrial grades

The **disadvantages of moving iron instruments** include the following.

- The scale is not uniform.
- The power utilization is high for a low range of voltage.
- The errors in this instrument can be caused because of the hysteresis within the iron & stray magnetic field.
- Change within frequency can cause very serious errors in AC measurements.
- The spring stiffness will decrease when the temperature increases.
- This instrument is nondirectional, so its accuracy is low.
- Power consumption is high

APPLICATIONS

The applications of moving iron instruments include the following.

- These instruments are mainly used as an ammeter, voltmeter & wattmeter which can work on both AC & DC.
- These are used for measuring alternating currents & voltages.
- These types of Instruments are used at power frequencies within laboratories.
- These MI instruments are extensively used in switchboards & labs.

MCQ'S

In a PMMC instrument, the torque weight ratio is

1. high
2. low
3. zero
4. infinity

Ans : I

In a permanent magnet moving coil instrument, the deflecting torque is

1. directly proportional to both number of turns and flux density.
2. directly proportional to the number of turns and inversely proportional to the flux density.
3. inversely proportional to the number of turns and directly proportional to the flux density.
4. inversely proportional to both number of turns and flux density.

Ans: I

A moving-coil ammeter has spring giving a control constant of 0.2×10^{-6} Nm/degree. If the deflecting torque on the instrument 24×10^{-6} Nm, find the angular deflection of the pointer.

1. 120°
2. 40°
3. 90°
4. 100°

Ans : I

A current of $-4 + 3\sqrt{2} \sin(\omega t + 30°)$ A is passed through a centre zero PMMC meter and moving-iron meter. The two meters will read respectively

1. -4 A and -5 A
2. 4 A and -5 A
3. -4 A and 5 A
4. 4 A and 5 A

In an ammeter, The deflecting torque is proportional to the current passing through it, and the instrument has full scale deflection of 80° for a current of 5 A. What deflection will occur for a current of 2.5 A when the instrument is spring-controlled?

1. 20°
2. 35°
3. 45°
4. 40°

A moving iron type ammeter has far turns of thick wire so that

A. Sensitivity is high
B. Damping is effective
C. Scale is large
D. Resistance is less

Which of the following is the merit of a moving iron instrument

A. It can be used under severe over-load conditions
B. It has linear scale
C. It can be used at high frequencies
D. Its current sensitivity is high

POWER FACTOR METER

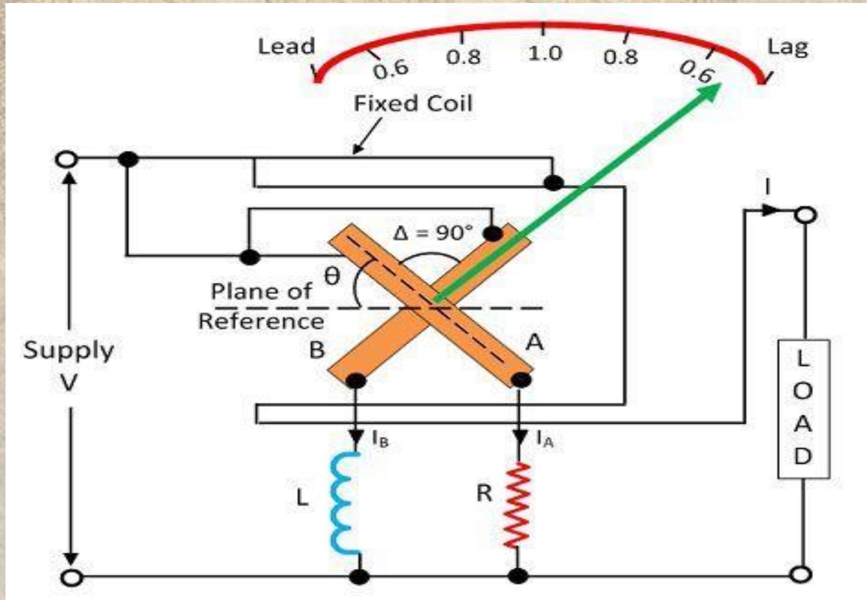
The power factor meter **measures** the **power factor** of a **transmission system**. The power factor is the cosine of the angle between the voltage and current. The power factor meter **determines the types of load** using on the line, and it also **calculates the losses** occur on it.

Types of Power Factor Meter

The power factor meter is of two types. They are

1. Electrodynamometer
   1. Single Phase Electrodynamometer
   2. Three Phases Electrodynamometer
2. Moving Iron Type Meter
   1. Rotating Iron Magnetic Field
   2. Number of Alternating Field

SINGLE PHASE ELECTRODYNAMOMETER



- The meter has fixed coil which acts as a current coil. This coil is split into two parts and carry the current under test. The magnetic field of the coil is directly proportional to the current flow through the coil.
- The meter has two identical pressure coils A and B. Both the coils are pivoted on the spindle. The pressure coil A has no inductive resistance connected in series with the circuit, and the coil B has highly inductive coil connected in series with the circuit.

The current in the coil A is in phase with the circuit while the current in the coil B lag by the voltage nearly equal to 90°. The connection of the moving coil is made through silver ligaments which minimize the controlling torque of the moving system.

The meter has two deflecting torque one acting on the coil A, and the other is on coil B. The windings are so arranged that they are opposite in directions. The pointer is in equilibrium when the torques are equal.

Deflecting torque acting on the coil A is given as

$$T_A = KVIMcos\emptyset sin\theta$$

θ – angular deflection from the plane of reference.

M_{max} – maximum value of mutual inductance between the coils.

The deflecting torque acting on coil B is expressed as

$$I_B = KVIM_{max}\,Cos(90^{\circ} - \emptyset)\,Sin(90^{\circ} + \emptyset) \qquad I_B = KVIM_{max}cos\emptyset sin\theta$$

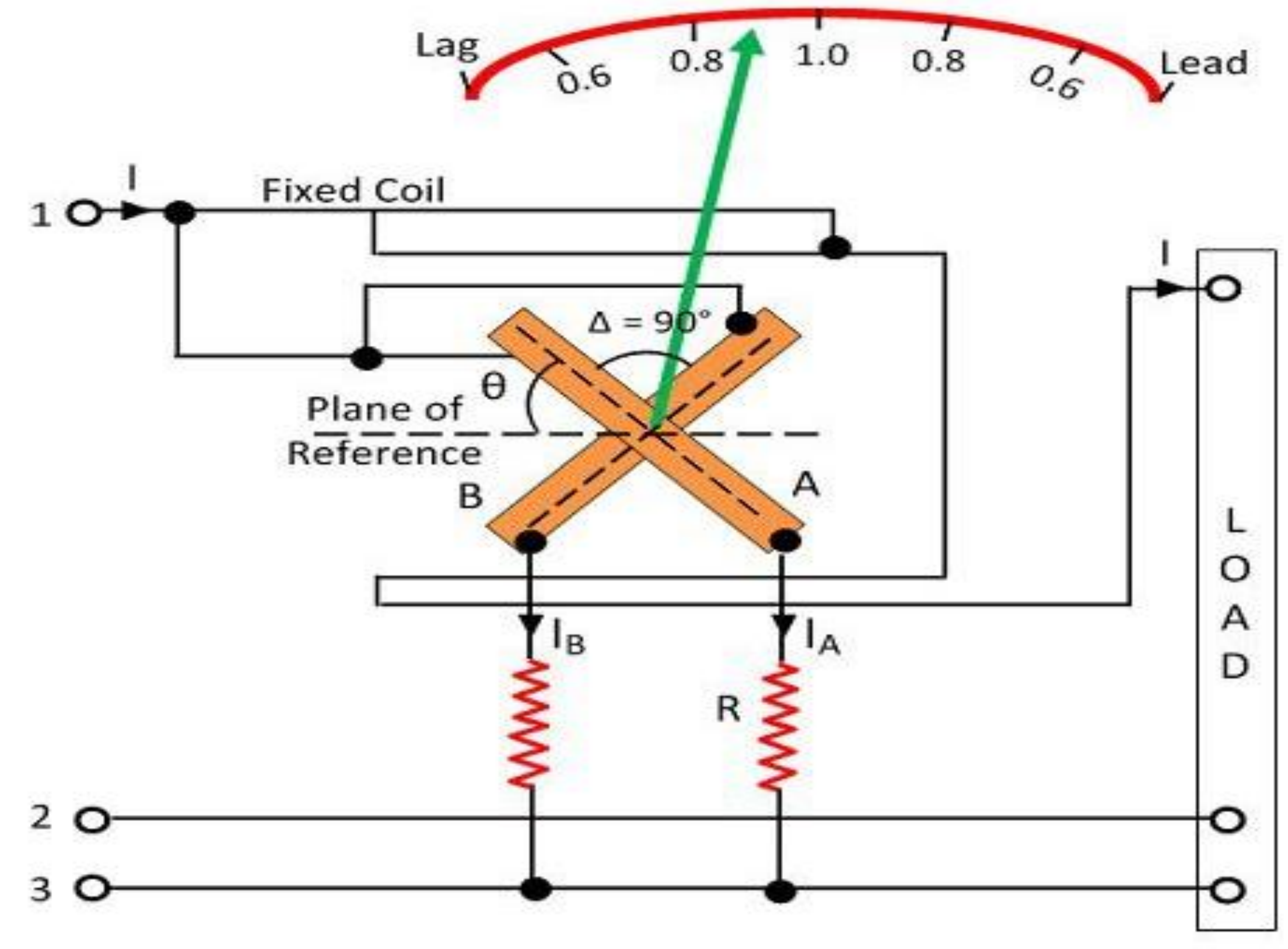
The deflecting torque is acting on the clockwise direction.

The value of maximum mutual inductance is same between both the deflecting equations.

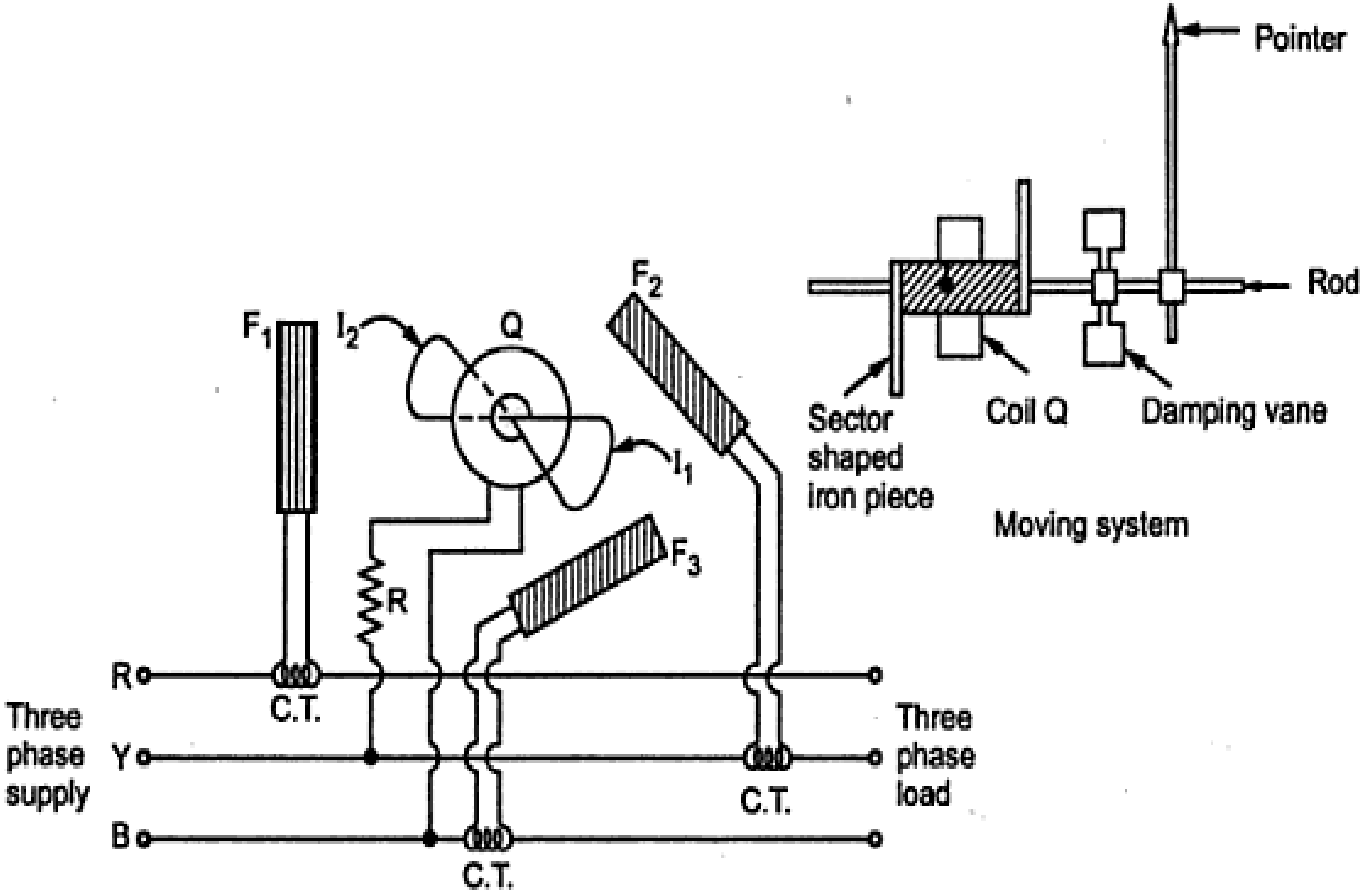
$$T_A = T_B$$

$$KVIMcos\emptyset sin\theta = KVIM_{max}cos\emptyset sin\theta$$

This torque acts on anti-clockwise direction.

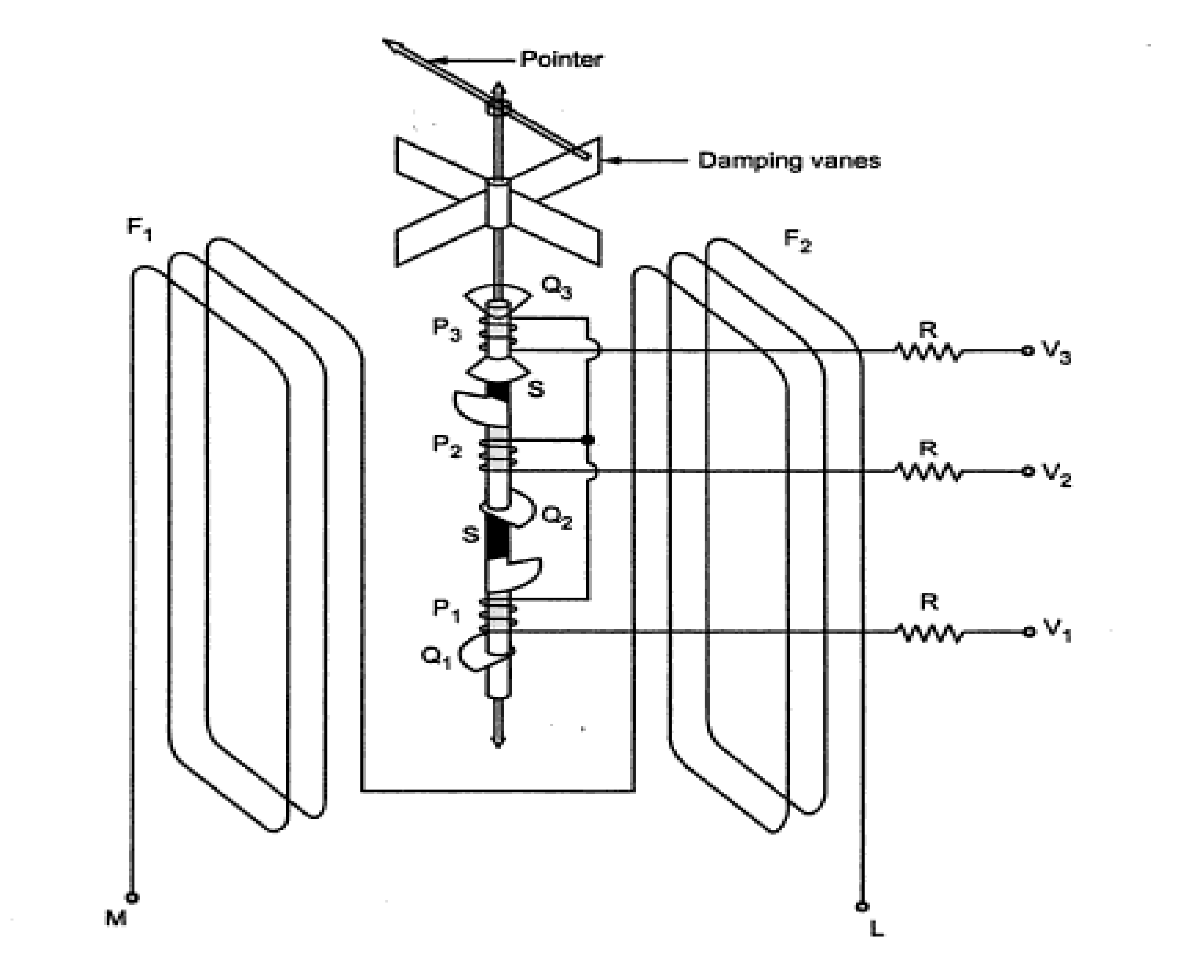


Three Phase Dynamo Type Factor Meter

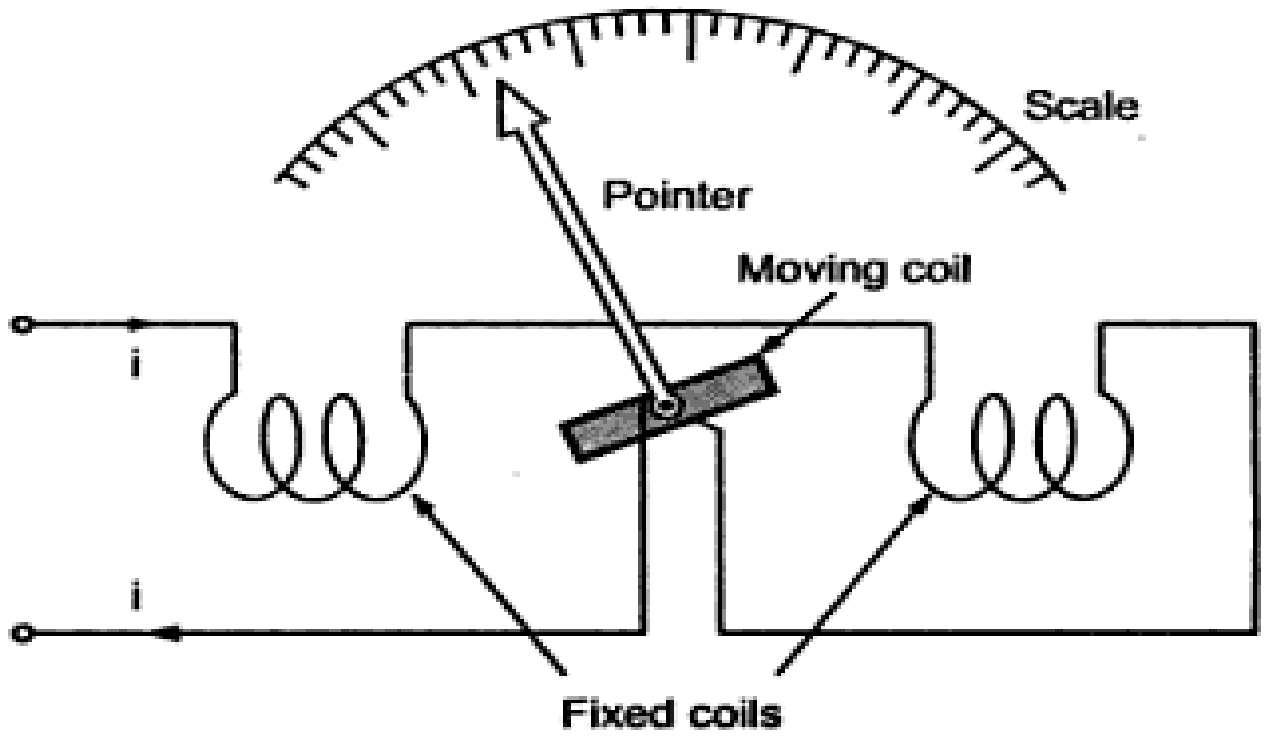


Rotating field type moving iron power factor meter

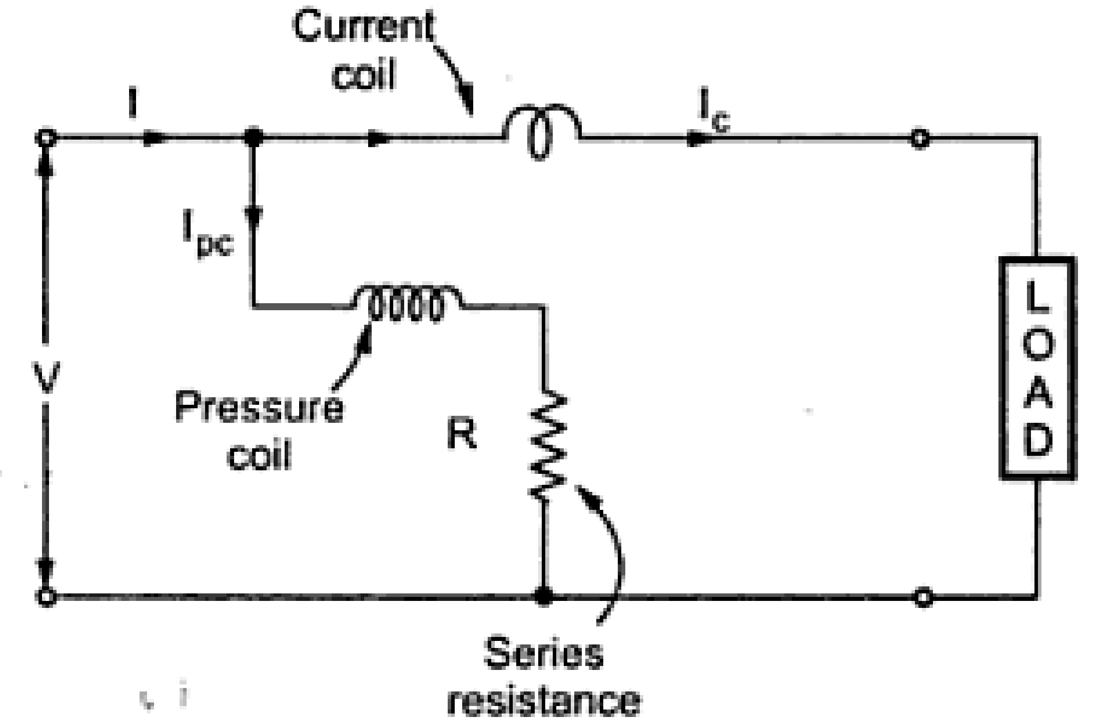
ALTERNATING FIELD TYPE MOVING IRON PF METER



MEASUREMENT OF POWER



Electrodynamometer type instrument



Electrodynamometer wattmeter

ADVANTAGES OF MOVING IRON POWER POWER FACTOR

1.The meter requires large working force as compared to the electrodynamometer type meter.
2.The coils of the moving iron instruments are fixed permanently.
3.The range of the scale extends up to 360°.
4.The construction of the meter is robust and simple.
5.The moving iron instrument is cheap as compared to electrodynamic meter.

DISADVANTAGES

1.The loss occurs in the iron part of the meter. The losses depend on the load and the frequency of the meter.
2.The meter has low accuracy.
3.The calibration of the meter is affected because of the variation in supply frequencies, voltage and waveforms etc.

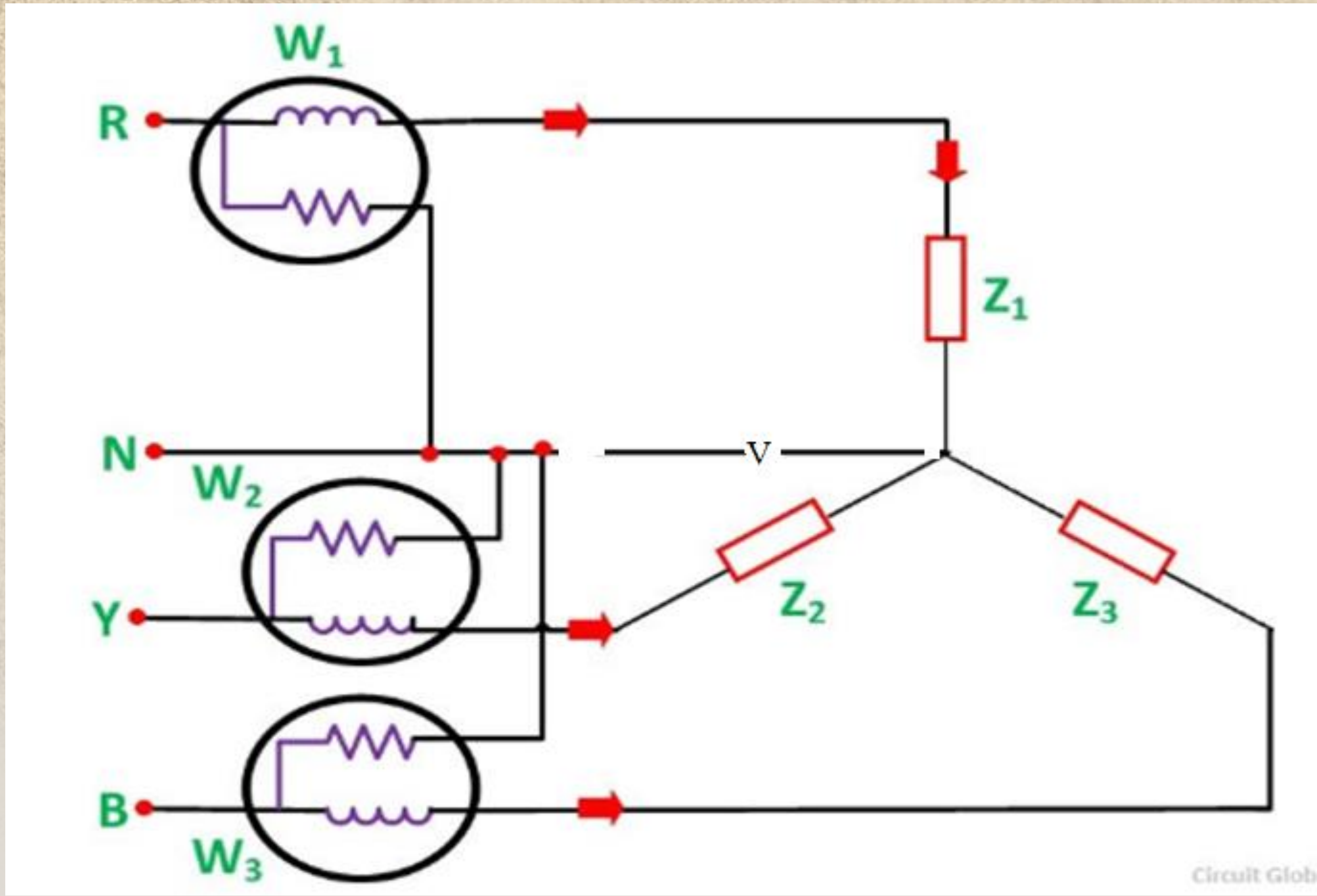
Low Power Factor Electrodynamic Type Wattmeter

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,

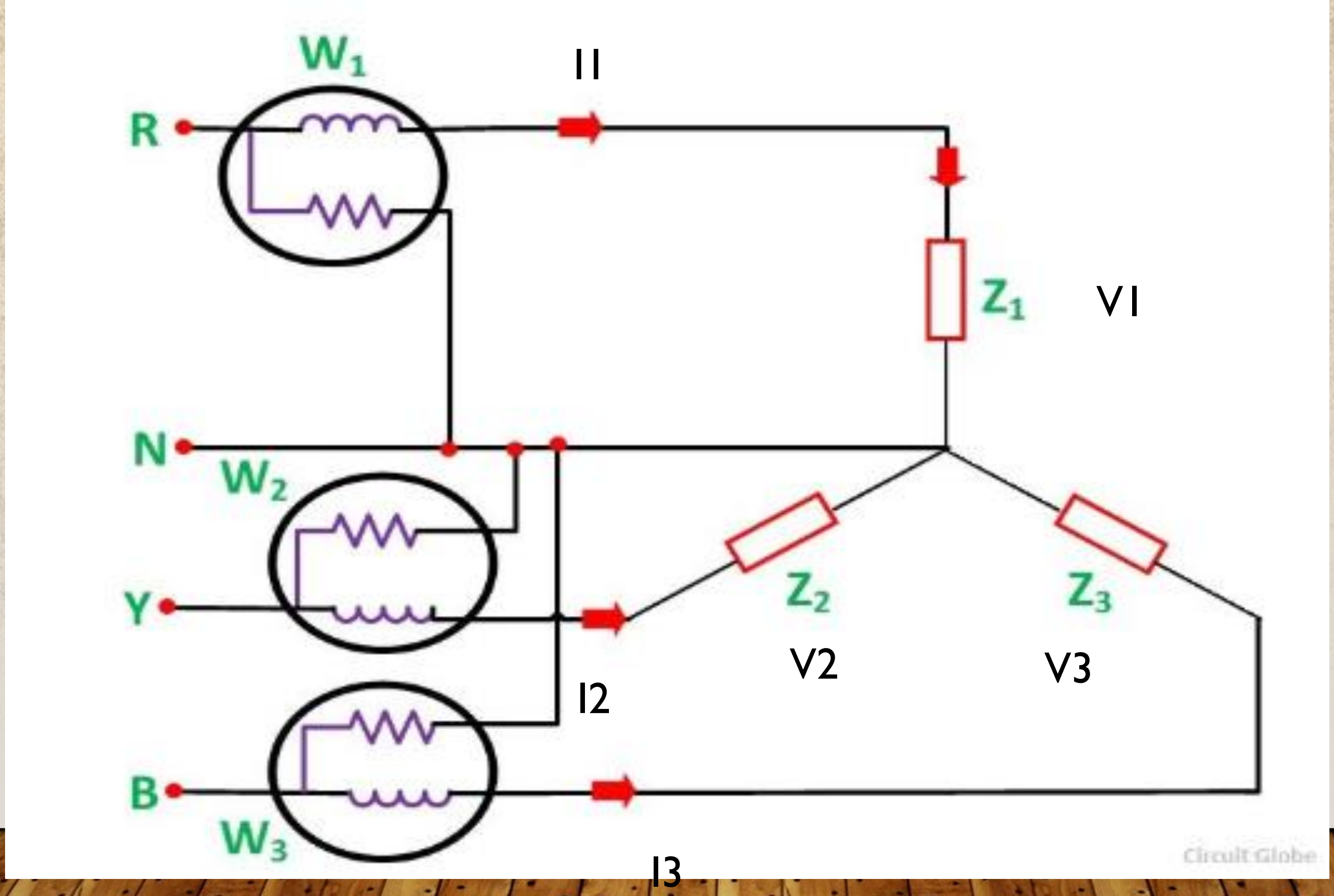
1. The deflecting torque on the moving system is small as the power factor is low even though the current and pressure coils are fully excited.
2. The inductance of pressure coil introduces considerable error at low power factors.

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.

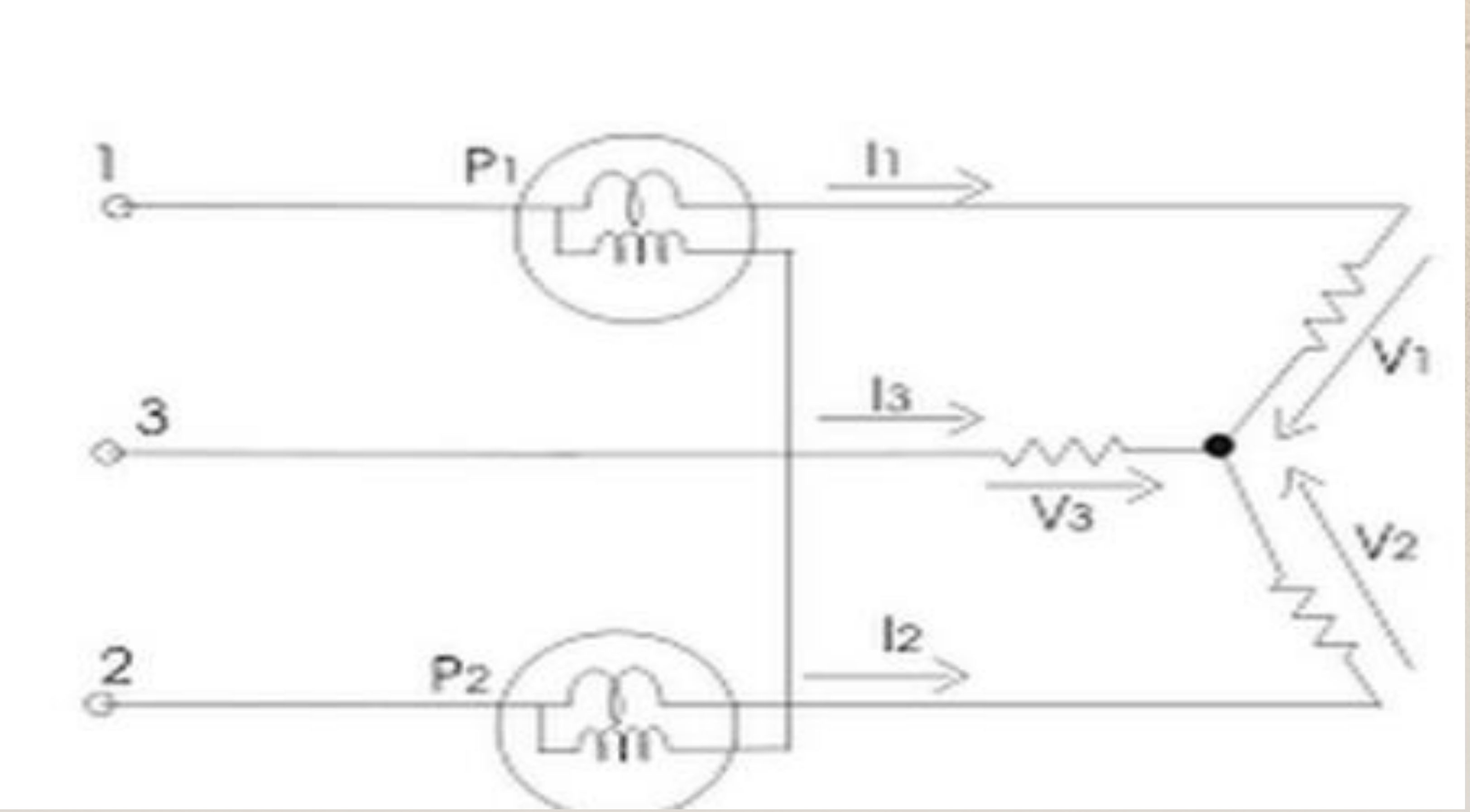
THREE-WATTMETER METHOD OF THREE PHASE POWER MEASUREMENT



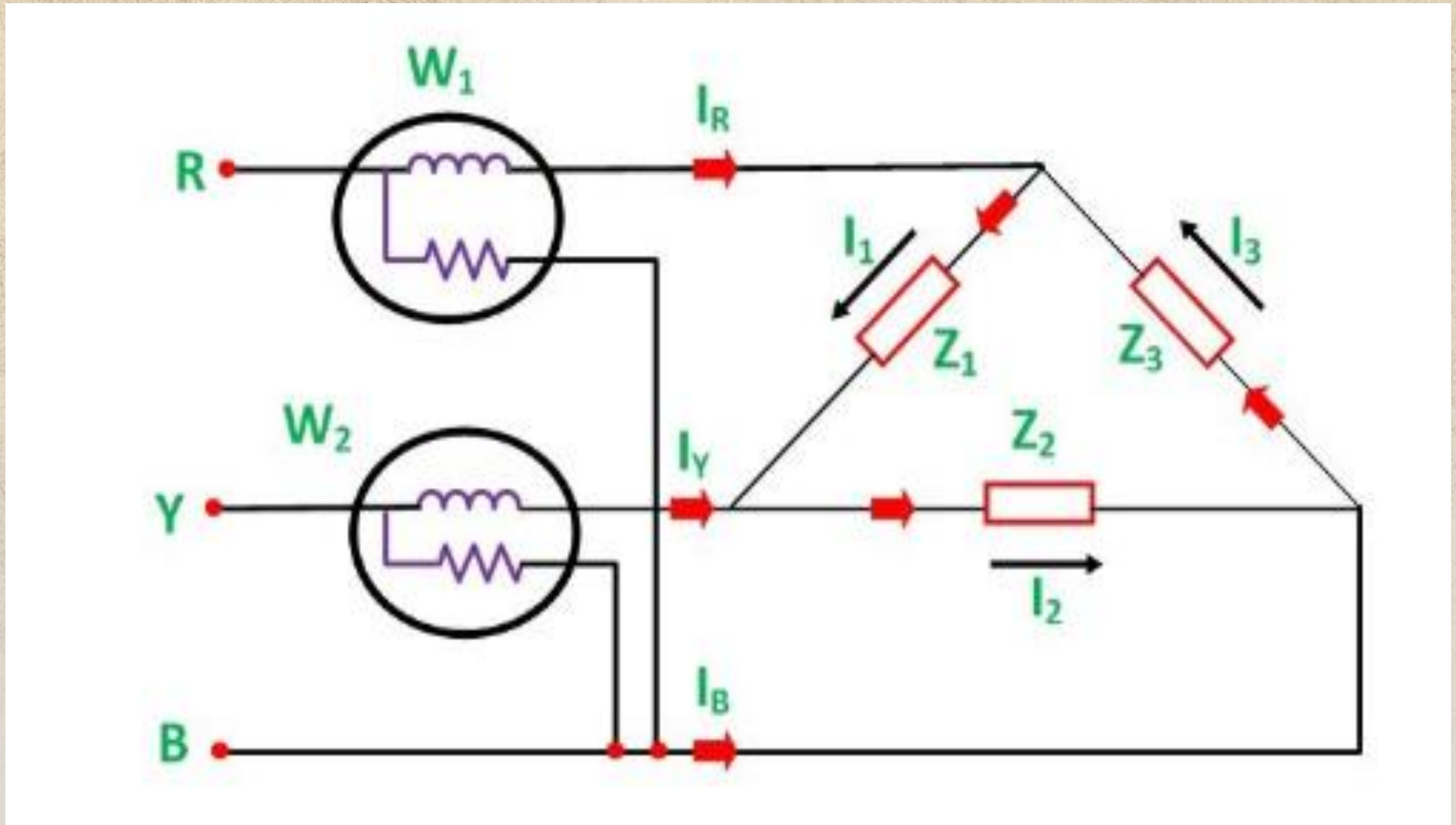
THREE-WATTMETER METHOD OF THREE PHASE POWER MEASUREMENT



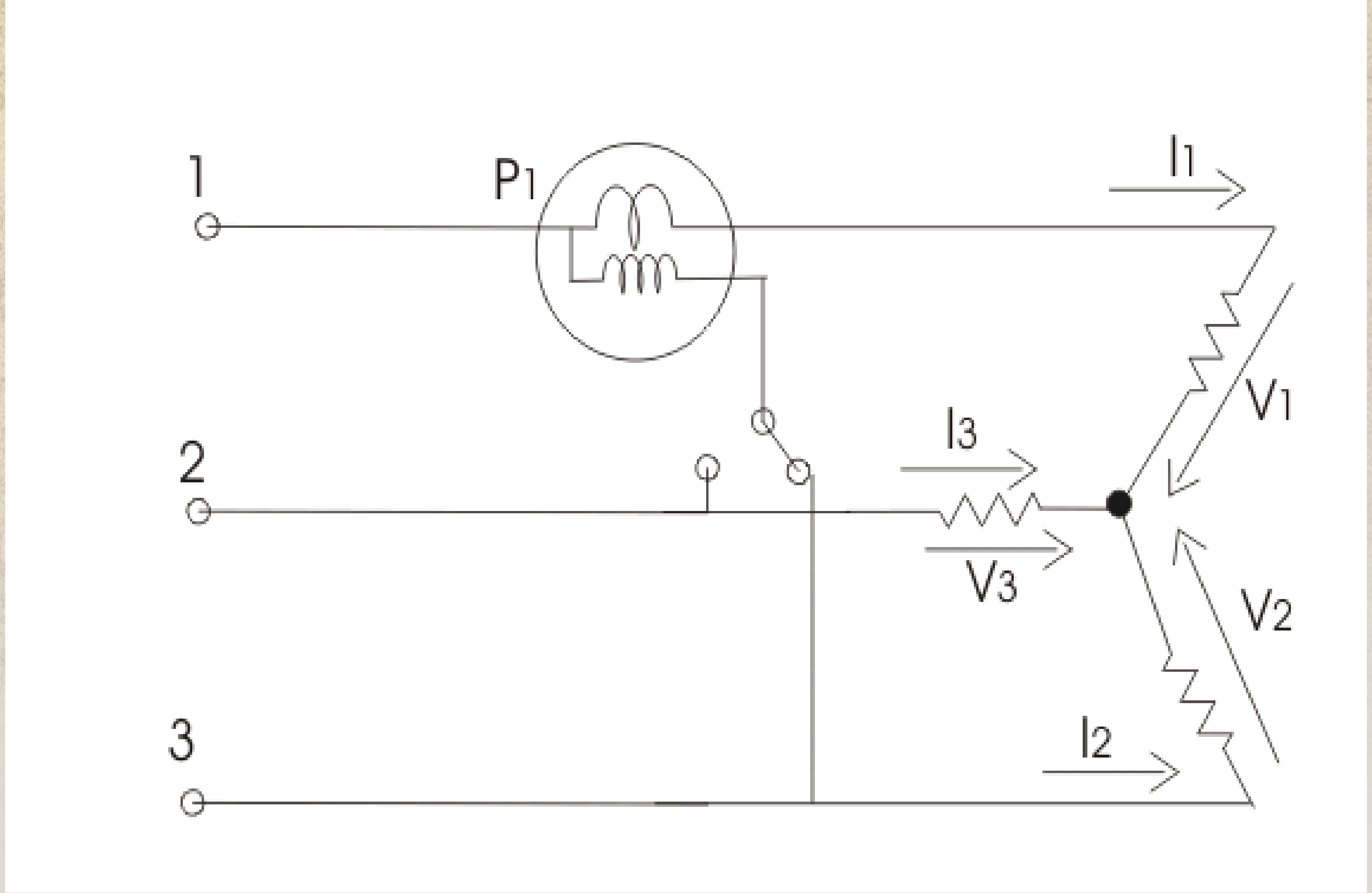
TWO WATTMETER METHOD OF POWER MEASUREMENT



TWO WATTMETER METHOD IN DELTA CONNECTION



ONE WATTMETER METHOD



VAR METERS

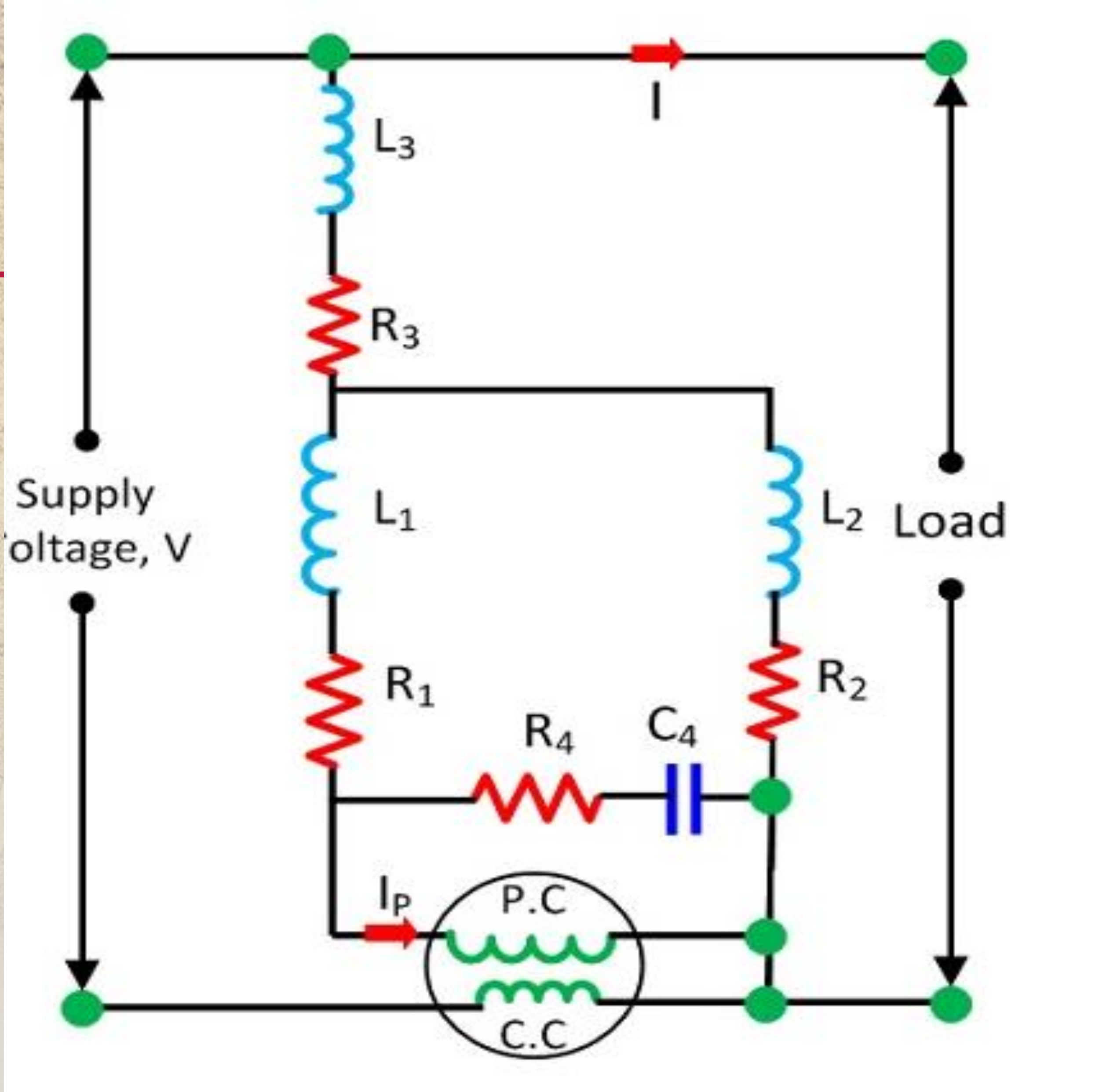
Measurement of volt-ampere hours reactive (VARh)

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*.

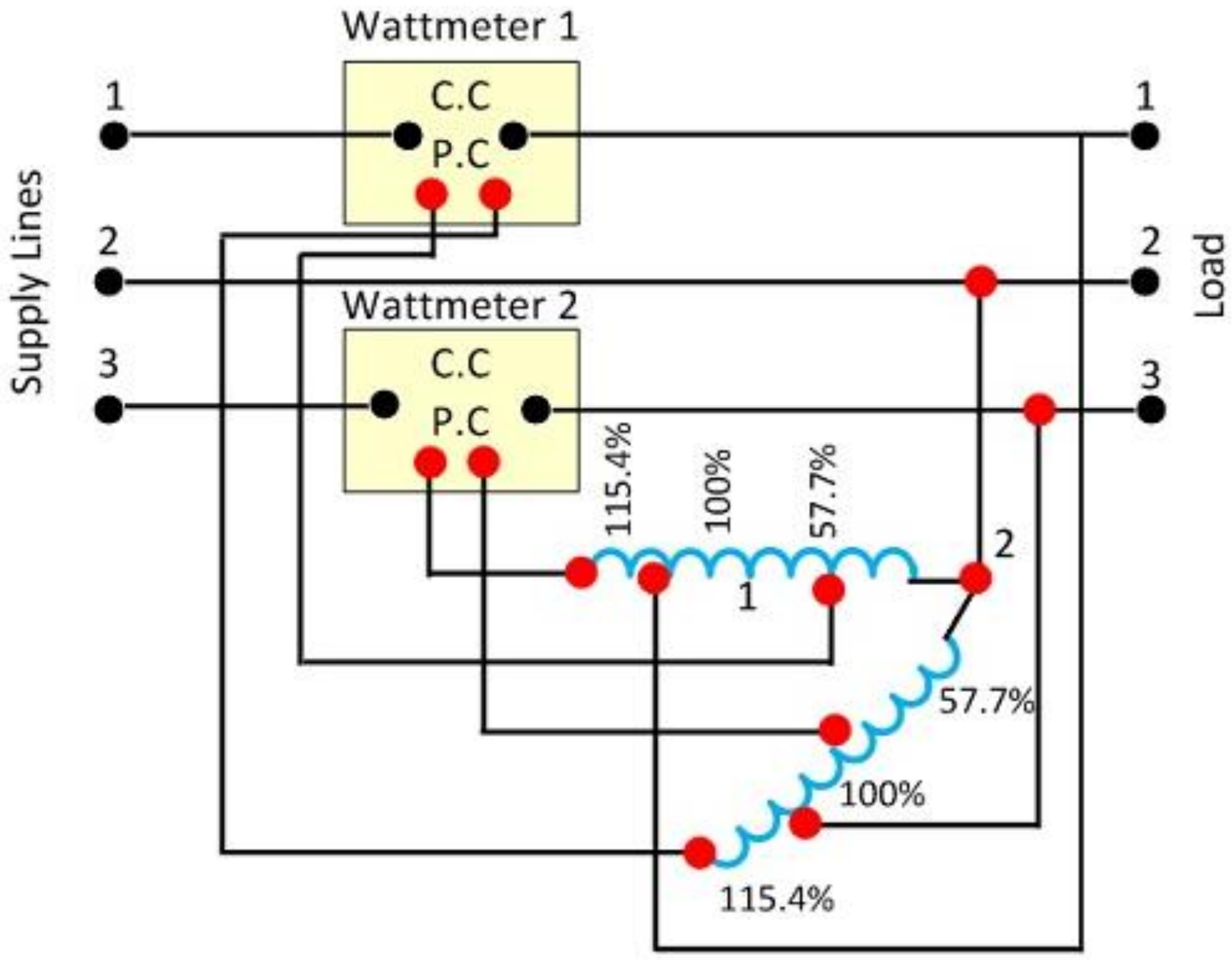
- In order to measure VARh in single-phase circuits, use of specially compensated watt-hour meter is made. *Phase compensation is accomplished by suitable combination of resistance, capacitance and inductance.*

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 :

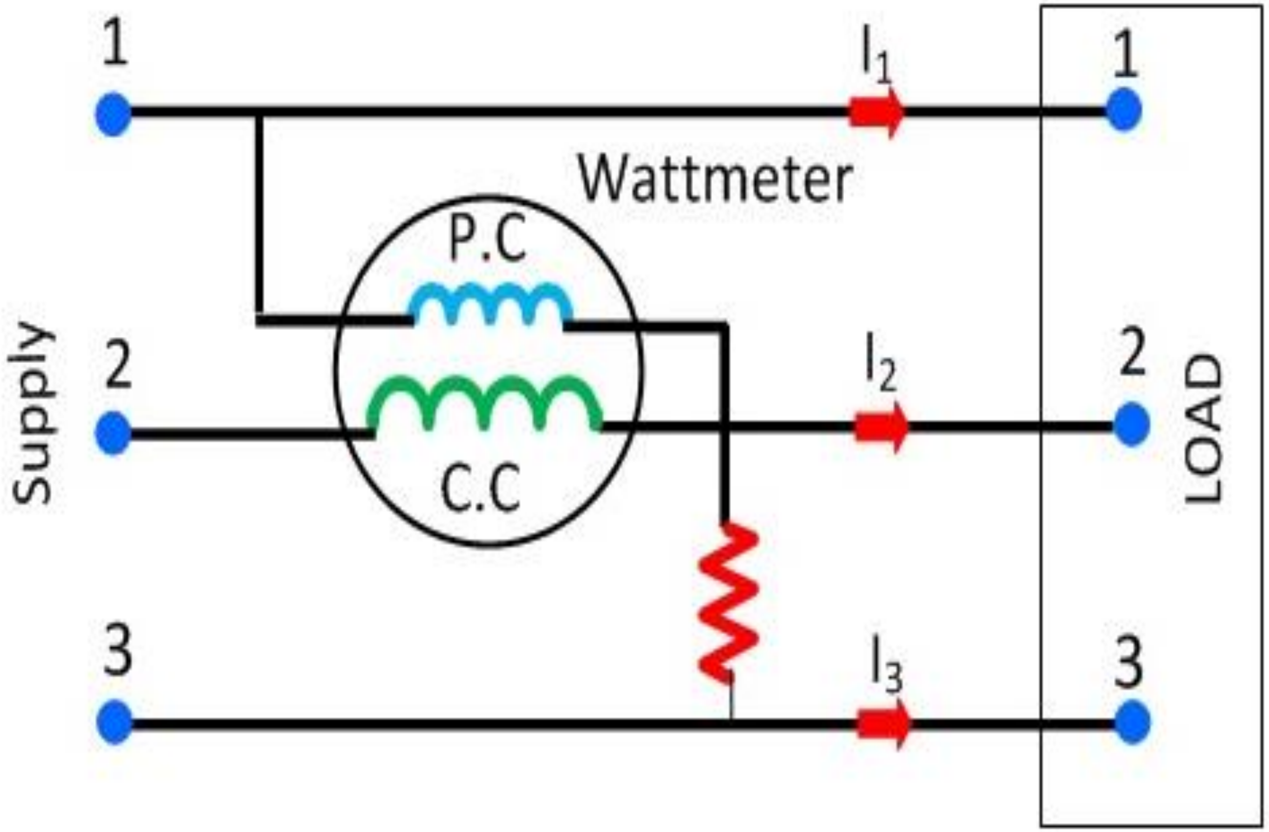
1. Single element method.
2. Crossed phase method.
3. Auto-transformer method.



Single phase Varmeter



Reactive Power Measurement with Two Auto-Transformer



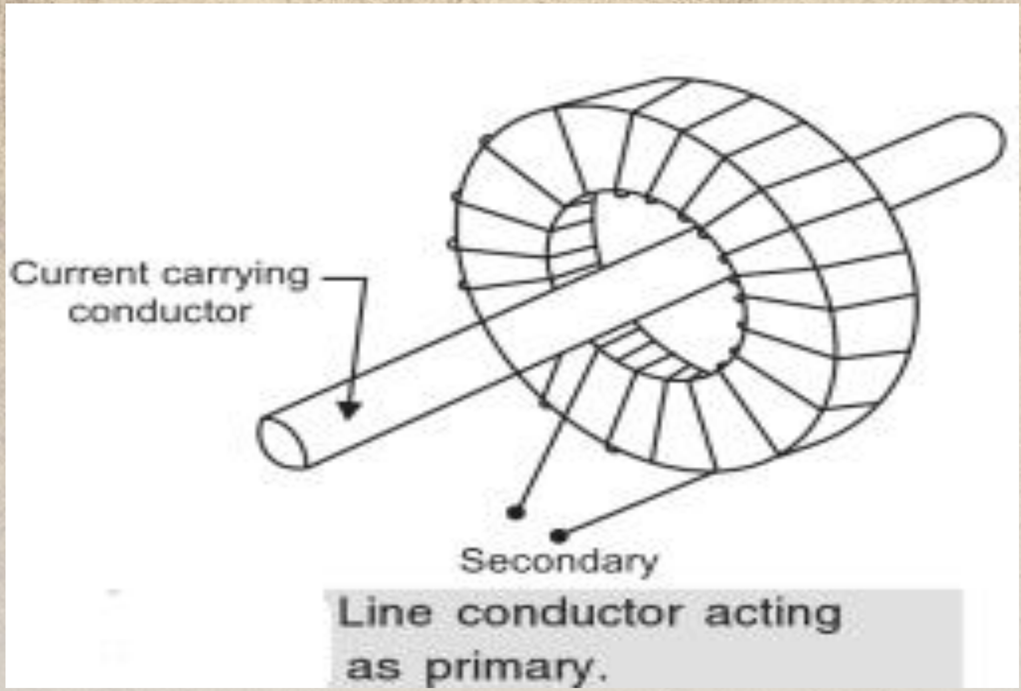
Reactive Power Measurement with One Wattmeter

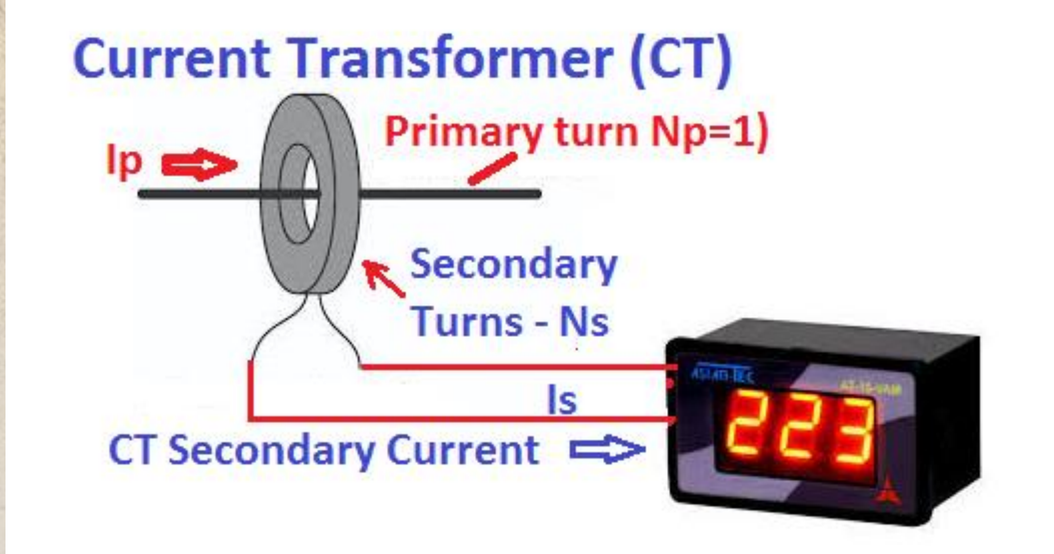
INSTRUMENT TRANSFORMER

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

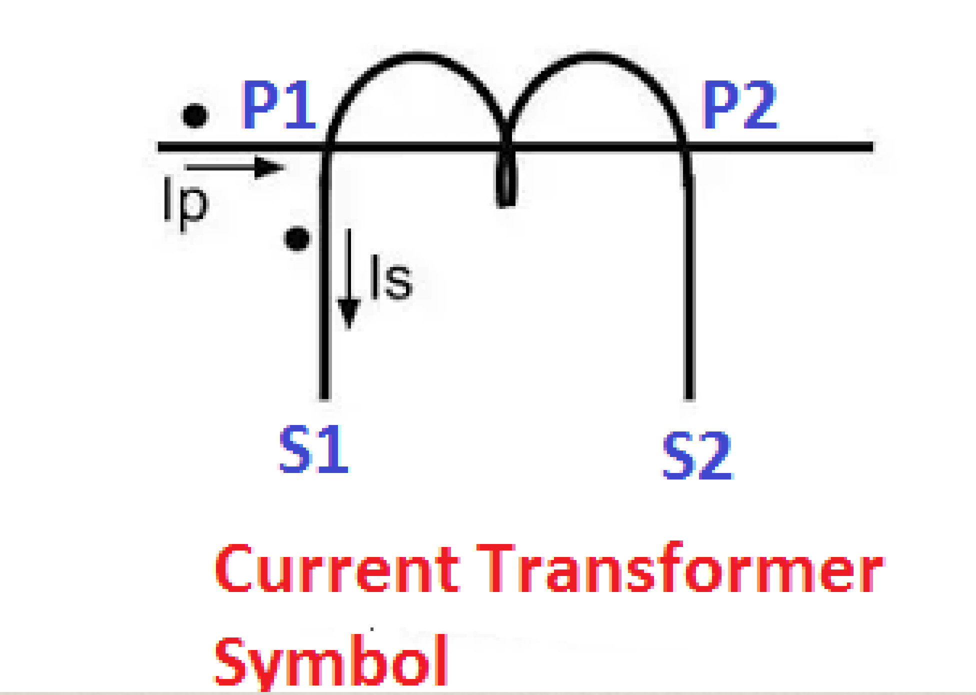
(i) current transformers and (ii) potential transformers.

CURRENT TRANSFORMER





CT



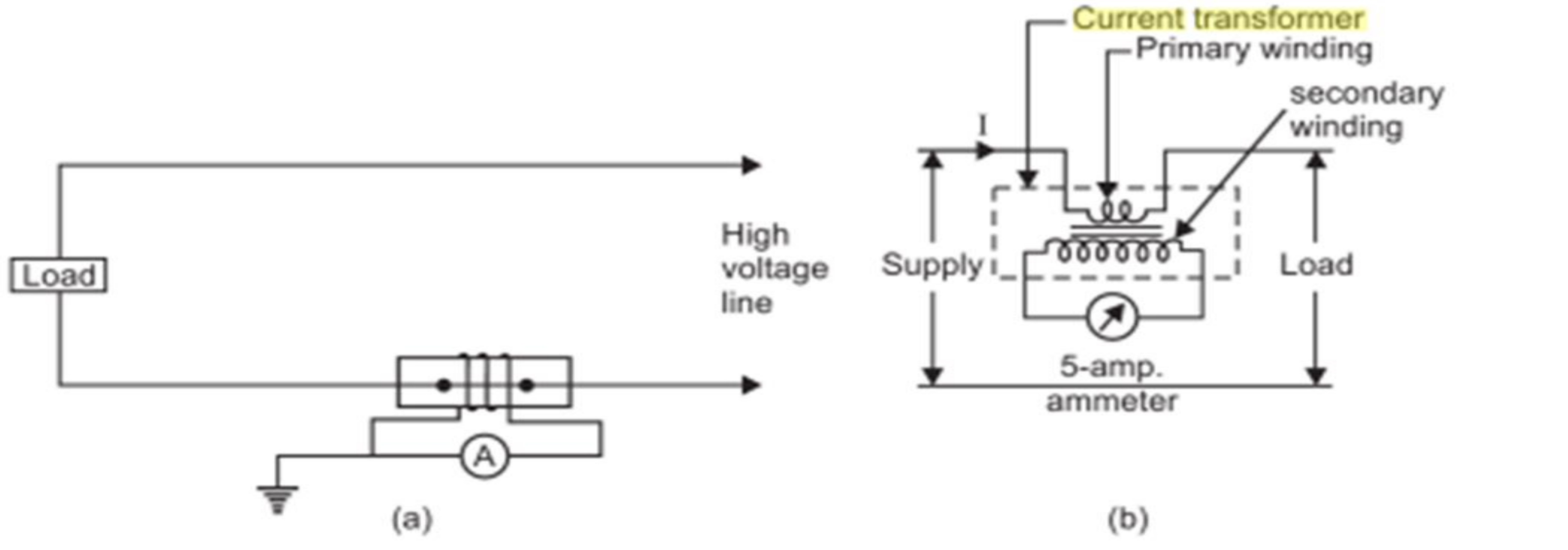
- The secondary winding has more number of turns compared to the primary winding and it is connected with ampere meter, energy meter, watt meter,transducer and protection relay. The secondary winding of the CT must be connected with low impedance meter to keep the magnetic flux in the core up to its rated flux capacity.

Based on the construction, there are two types of current transformer-

- Live Tank CT
- Dead Tank CT.

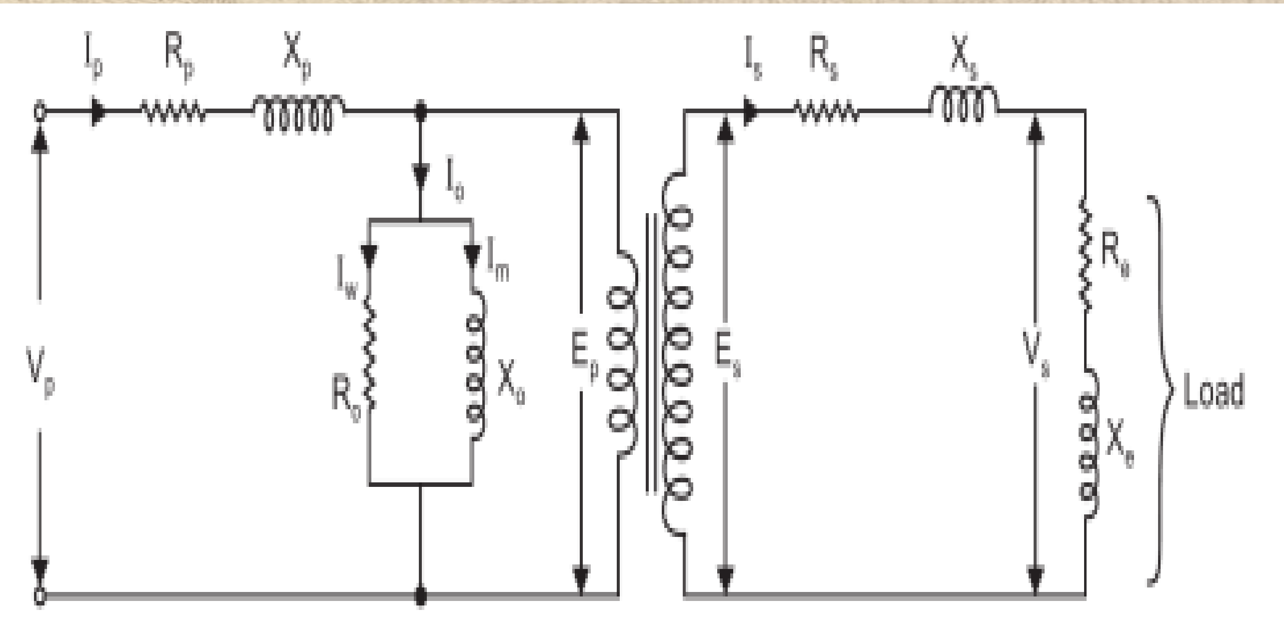
In both types of CTs, the core and winding are enclosed in a porcelain structure and this structure is filled with mineral insulated oil which acts as cooling media, and it also provide required electrical insulation.

The terminal P_1 and P_2 shows the primary winding of the CT and terminal S1 and S2 shows secondary winding of the CT. The CT ratio 2000/1 means the secondary current will be 1 ampere if primary current through the CT is 2000 amperes.



Current transformer connections.

CURRENT TRANSFORMER

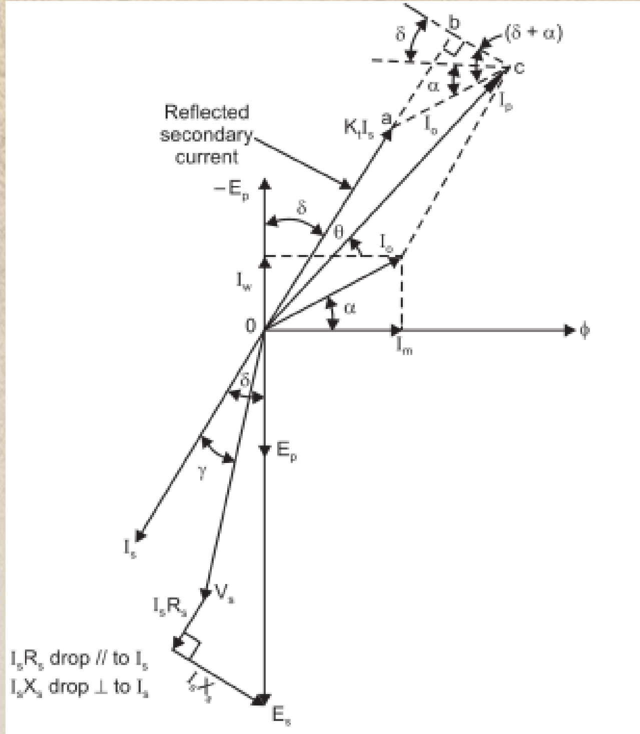


(a) Equivalent circuit

CURRENT TRANSFORMER

The equivalent circuit of the current transformer is similar to that of power transformer and induction motor. **The current transformer has two types of errors.**

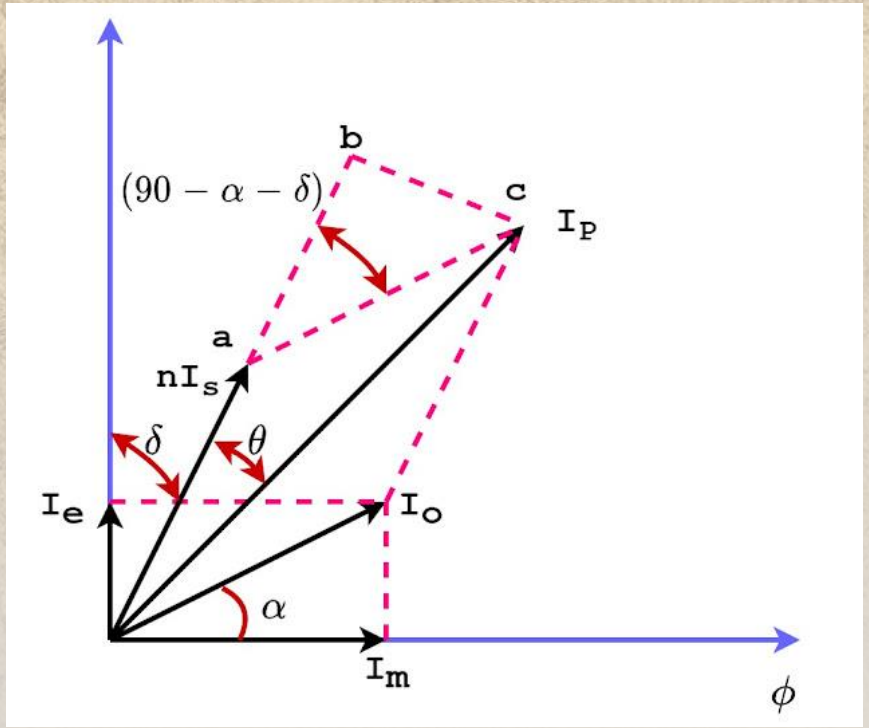
- **Ratio Error**
- **Phase Angle Error**



(b) Phase diagram (Not to scale)

Current transformer (CT).

CT TRANSFORMATION RATIO



- CT transformation ratio is calculated as follows. For finding transformation ratio we need to calculate primary current I_p as per definition and then divide it by secondary current Is.
- CT Ratio Error Formula Derivation

Let us consider the part of phasor of our importance for calculating I_p as shown below.

..CONTD

- From the above phasor, the primary current Ip is phasor sum of nI_s and I_o. The CT primary current Ip can be calculated using vector addition formula.

$$I_p = \sqrt{I_0^2 + (nI_s)^2 + 2\, I_o\, nI_s\, Cos(90 - \alpha - \delta)}$$

$$I_p = \sqrt{I_0^2 + (nI_s)^2 + 2\, I_o\, nI_s\, Sin(\alpha + \delta)}$$

The CT Ratio is equal to ratio of I_p / Is

$$R = \frac{I_p}{Is}$$

$$R = \frac{\sqrt{I_0^2 + (nI_s)^2 + 2\, I_o\, nI_s\, Sin(\alpha + \delta)}}{I_s}$$

The magnetizing current Io is very small compared to the primary current I_p. Therefore, the above expression can be simplified as follows.

$$R = \frac{\sqrt{I_0^2 + (nI_s)^2 + 2\, I_o\, nI_s\, Sin(\alpha + \delta)}}{I_s}$$

$$R = \frac{\sqrt{[(nI_s)^2 + \left(I_0 Sin(\alpha + \delta)\right)^2 + (2\, I_o\, nI_s\, Sin(\alpha + \delta)]}}{I_s}$$

$$R = \frac{\sqrt{\left[nI_s + \left(I_0 Sin(\alpha + \delta)\right)\right]^2}}{I_s}$$

$$R = \frac{nI_s + I_0 Sin(\alpha + \delta)}{I_s}$$

$$R = n + \frac{I_o Sin(\alpha + \delta)}{I_s}$$

$$\boldsymbol{R = n + \frac{I_o}{I_s} Sin(\alpha + \delta)}$$

From above expression, it is clear that transformation ratio is not equal to turn ratio. The transformation ratio and turn ratio will be equal if α=0 and δ=0.This condition can be achieved **if the core loss is equal to zero and the burden is purely resistive.** This is **an ideal condition**, however this condition is practically impossible.

RATIO ERROR OF CURRENT TRANSFORMER

Since the burden of the CT is generally resistive. Therefore, the power factor of the burden is unity and hence δ=0

$$R = n + \frac{I_o Sin(\alpha + \delta)}{I_s}$$

$$\delta = 0 \; for \; resitive \; burden$$

$$R = n + \frac{I_o Sin\alpha}{I_s}$$

$$R = n + \frac{I_e}{I_s} \qquad Since \; [\, I_o Sin\alpha = I_e]$$

The CT ratio Error is defined as the per unit deviation in transformation ratio from its nominal ratio. Ratio error is expressed in percentage.

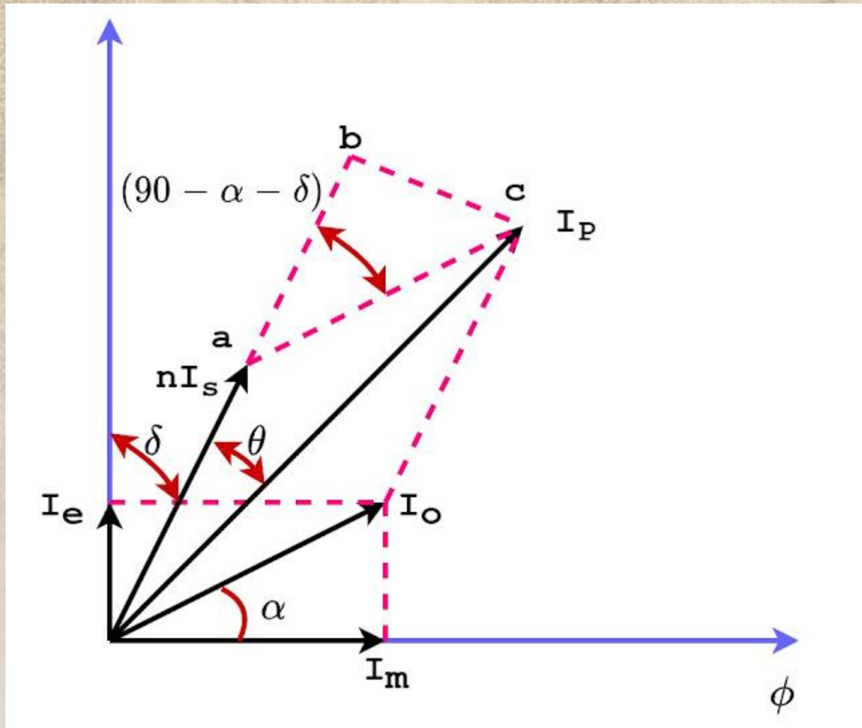
$$Ratio \; error = \frac{Nominal \; ratio - Transformation \; ratio}{Transformation \; ratio} \; X \; 100$$

$$\% \; \begin{matrix} Ratio \\ Error \end{matrix} = \frac{\begin{matrix} Nominal \\ ratio \end{matrix} - \begin{matrix} Actual \\ ratio \end{matrix}}{Actual \; ratio} \times 100$$

$$= \frac{K_n - R}{R} \times 100$$

PHASE ANGLE ERROR OF CURRENT TRANSFORMER

- Phase angle of current transformer is defined as the angle between the primary current Ip and secondary current I_s. In above phasor diagram, θ is the phase angle.



$$\tan\theta = \frac{bc}{ob}$$

$$= \frac{I_0 Sin(90-\alpha-\delta)}{oa+ab}$$

$$= \frac{I_0 Cos(\alpha+\delta)}{[nI_s + I_0 Sin(\alpha+\delta)]}$$

Since θ is very small, so $\tan\theta = \theta$

$$\theta = \frac{I_0 Cos(\alpha+\delta)}{[nI_s + I_0 Sin(\alpha+\delta)]}$$

Also I_o *is very small and,* $I_0 Sin(\alpha+\delta) \lll nI_s$

hence $I_0 Sin(\alpha+\delta)$ *can be neglected*

$$\theta = \frac{I_0 Cos(\alpha+\delta)}{nI_s}$$

$$\theta = \frac{I_0 (Cos\alpha\ Cos\delta - Sin\alpha\ Sin\delta)}{nI_s}$$

$$\theta = \frac{I_0\ Cos\alpha\ Cos\delta - I_o Sin\alpha\ Sin\delta}{nI_s}$$

From Phasor, $I_0 Cos\alpha = I_m$ *and* $I_o Sin\alpha = I_e$

$$\theta = \frac{I_m\ Cos\delta - I_e\ Sin\delta}{nI_s}\ \textbf{Radians}$$

$$\theta = 180/\pi \frac{(I_m\ Cos\delta - I_e\ Sin\delta)}{nI_s}\ \textbf{Degree}$$

Since the burden of the CT is generally resistive. Therefore, the power factor of the burden is unity and hence δ=0. The phase angle error of CT is given by following expression.

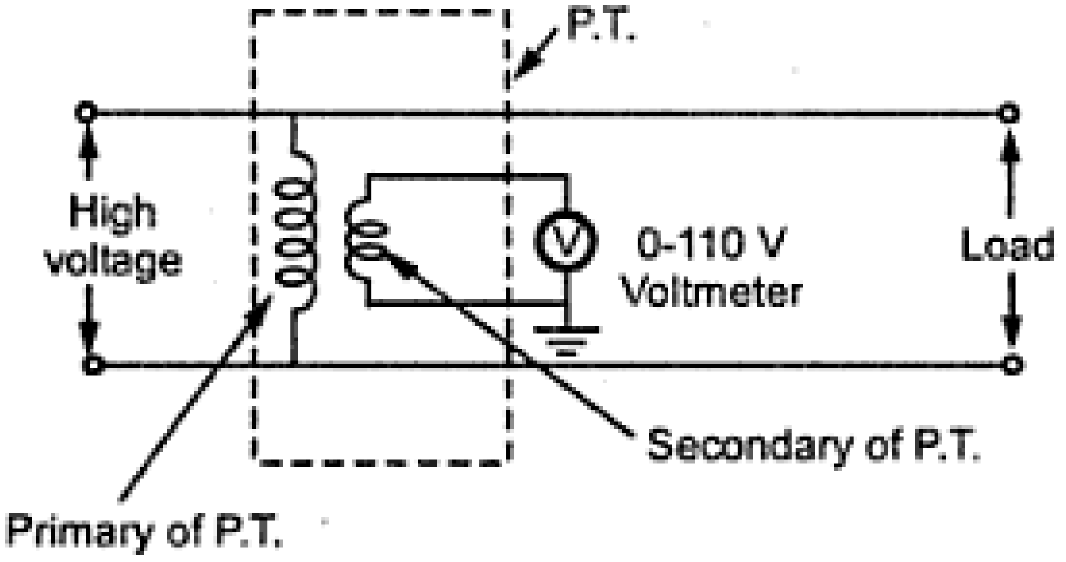
$$\theta = 180/\pi \frac{(I_m \, Cos\delta - I_e \, Sin\delta)}{nI_s}$$

$$\theta = 180/\pi \frac{(I_m \, Cos0 - I_e \, Sin0)}{nI_s}$$

$$\theta = (\frac{180}{\pi}) \frac{I_m}{nI_s} \; Degree$$

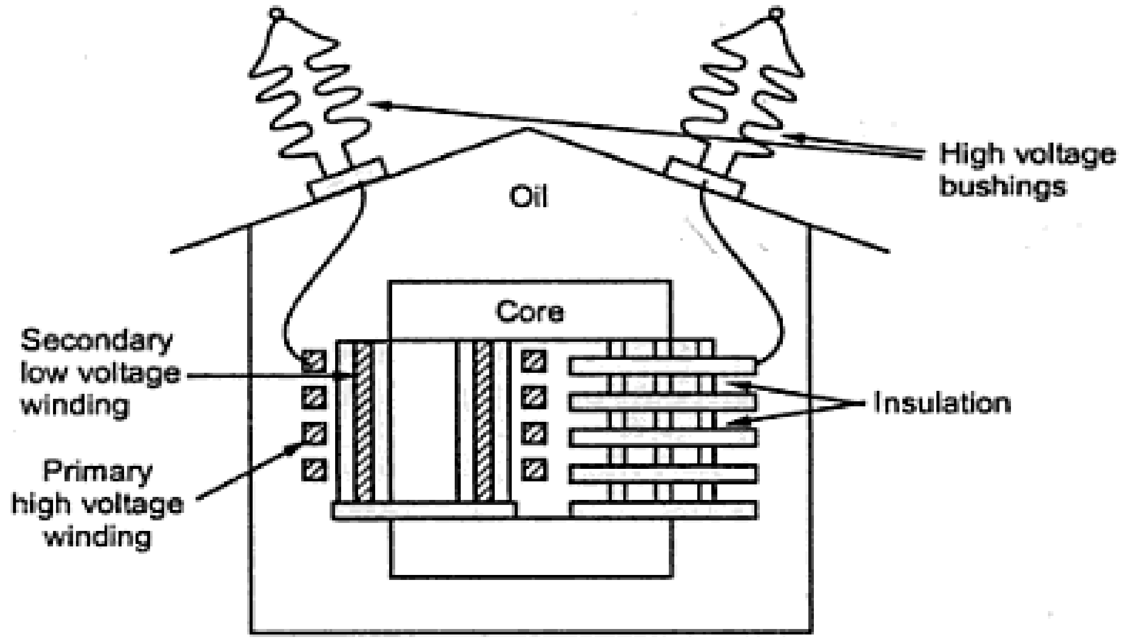
Since the burden of the CT is generally resistivity the power factor of the burden is unity and hence δ=0.

POTENTIAL TRANSFORMER



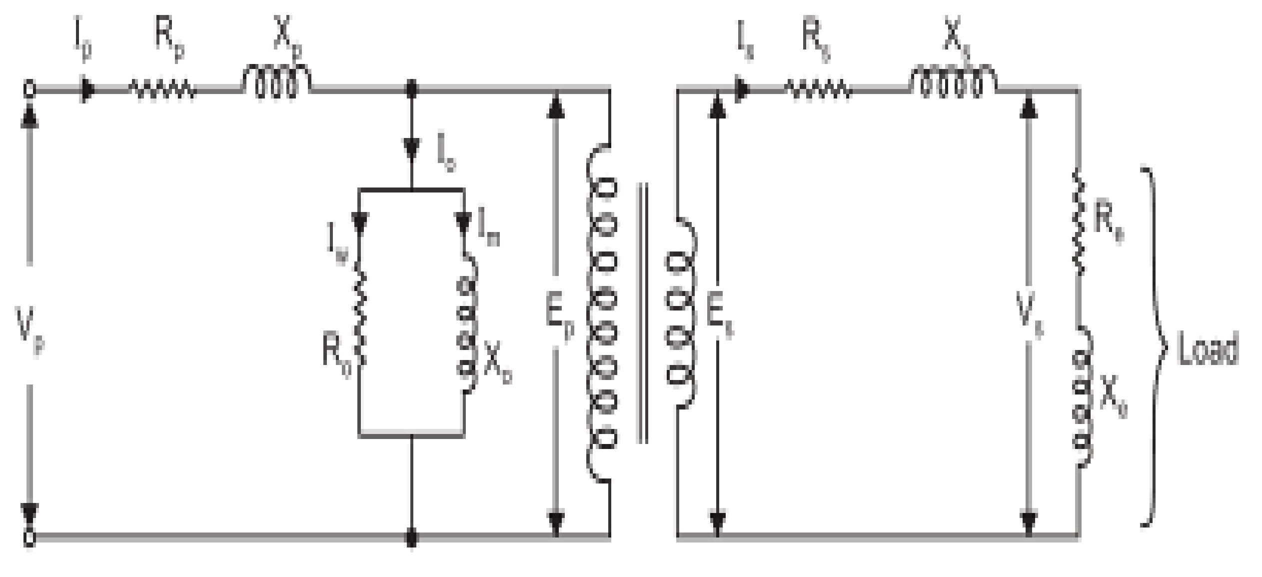
Potential transformer

POTENTIAL TRANSFORMER



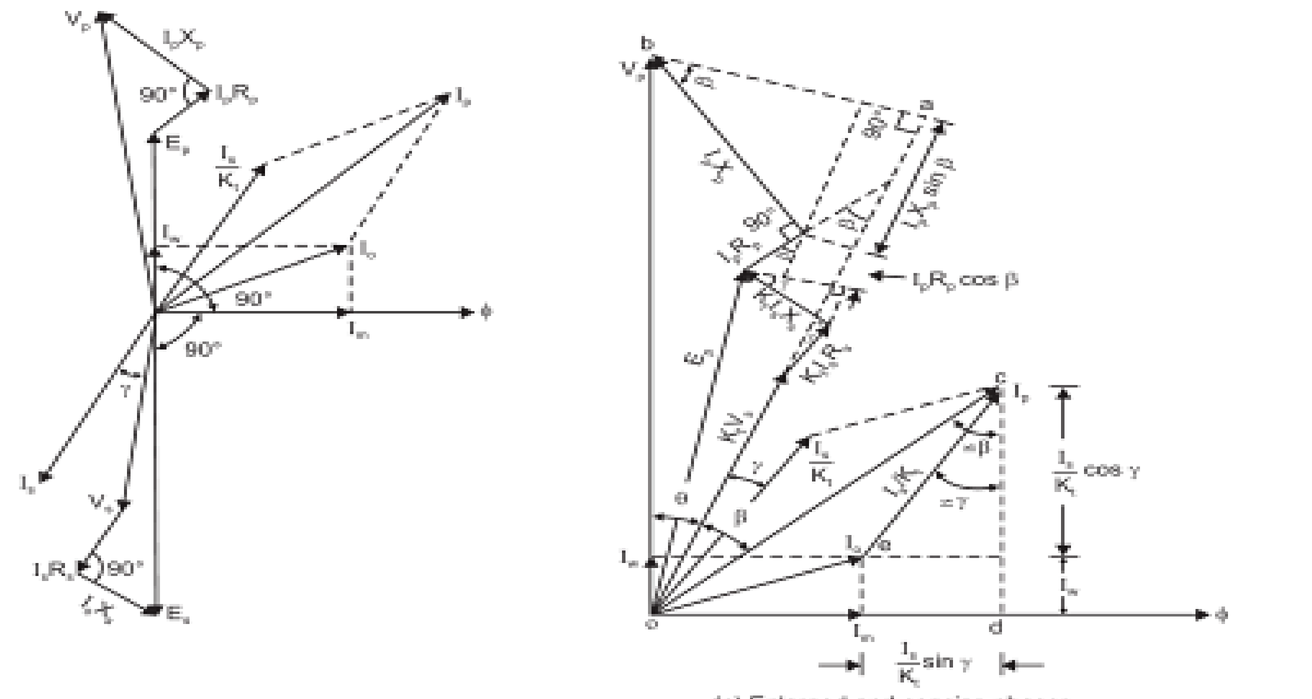
Single phase potential transformer

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).

COMPARISON

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.

THANK - ‘U’

MEASUREMENT OF ENERGY AND OTHER ELECTRICAL QUANTITIES
PART-II

Dr. P.Srividya Devi

- Generally, the resistance measurement is divided into three types:
  - Low Resistance Measurement
  - Medium Resistance Measurement
  - High Resistance Measurement

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

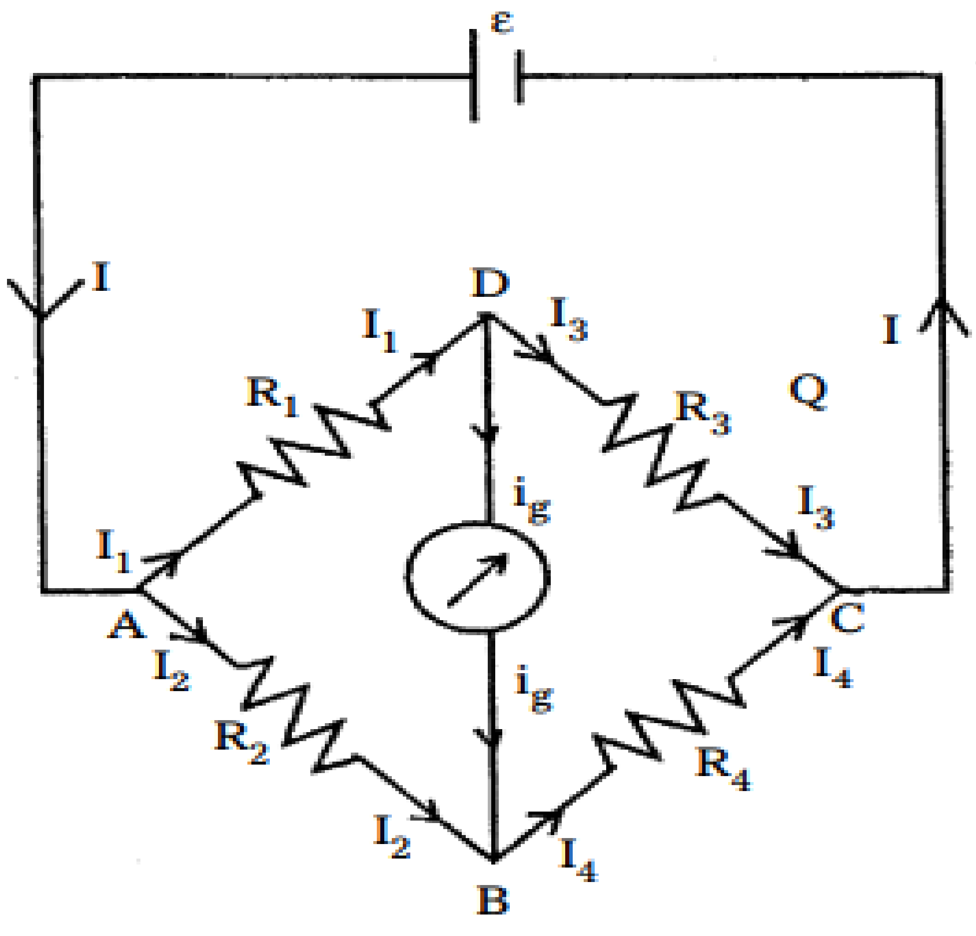
MEASUREMENT OF RESISTANCE

- High Resistance
  - Direct Deflection Method
  - Loss of Charge Method
  - Megohm Bridge
  - Megger

WHEAT STONE BRIDGE

- The Wheatstone Bridge is one of the most common and simplest bridge network / circuit, which can be used to measure resistance very precisely. But often the Wheatstone Bridge is used with Transducers to measure physical quantities like Temperature, Pressure, Strain etc.
- Wheatstone Bridge is used in applications where small changes in resistance are to be measured in sensors. This is used to convert a change in resistance to a change in voltage of a transducer. The combination of this bridge with operational amplifier is used extensively in industries for various transducers and sensors.
- Wheatstone is used for the measurement of a medium value range of resistance from 1 Ω to a few M Ω.

WHEATSTONE BRIDGE



Wheatstone's bridge circuit consists of four resistances R1, R2, R3 and R4 are connected to form a closed path.
A cell of emf ε is connected between the point A and C and a galvanometer is connected between the points B and D as shown in fig.
The current through the various branches are indicated in the figure. The current through the galvanometer is Ig and the resistance of the galvanometer is G.

Applying Kirchhoff's first law

at the junction D, $I_1 - I_3 - I_g = 0$ ..... (1)

at the junction B, $I_2 + I_g - I_4 = 0$ ..... (2)

⇒ Applying Kirchhoff's second law to the closed path ADBA

$-I_1R_1 - I_gG + I_2R_2 = 0$ or

⇒ $I_1R_1 + I_gG = I_2R_2$ ..... (3)

⇒ to the closed path DCBD

$-I_3R_3 + I_4R_4 + I_gG = 0$

$\Rightarrow I_3R_3 - I_gG = I_4R_4$ ......(4)

⇒ When the galvanometer shows zero deflection the points D and B are at the same potential so $I_g = 0$.

Substituting this value in (1), (2), (3) and (4).

$I_1 = I_3$ – (5)

$I_2 = I_4$ – (6)

$I_1R_1 = I_2R_2$ – (7)

$I_3R_3 = I_4R_4$ – (8)

⇒ **Dividing (7) by (8)** $\frac{I_1R_1}{I_3R_3} = \frac{I_2R_2}{I_4R_4}$

$$\Rightarrow \frac{R_1}{R_3} = \frac{R_2}{R_1} \left[\because I_1 = I_3 \;\&\; I_2 = I_4\right]$$

∴ **Wheatstone's Bridge principle :**

$$R_4 = R_3 \times \frac{R_2}{R_1}$$

APPLICATIONS OF WHEATSTONE BRIDGE

- Maxwell bridge and Wein bridge are modifications of the original Wheatstone bridge which is used for calculations with reactive measurements and not just resistors
- Carey foster bridge is another type of Wheatstone bridge and can measure very small resistances.
- Kelvin Bridge is also a type of Wheatstone bridge which is modified such that four-terminal resistance can be measured instead of the conventional two port resistors.
- Wheatstone Bridge in Light Detector
- Wheatstone Bridge in Load Cells

LIMITATIONS OF WHEATSTONE BRIDGE

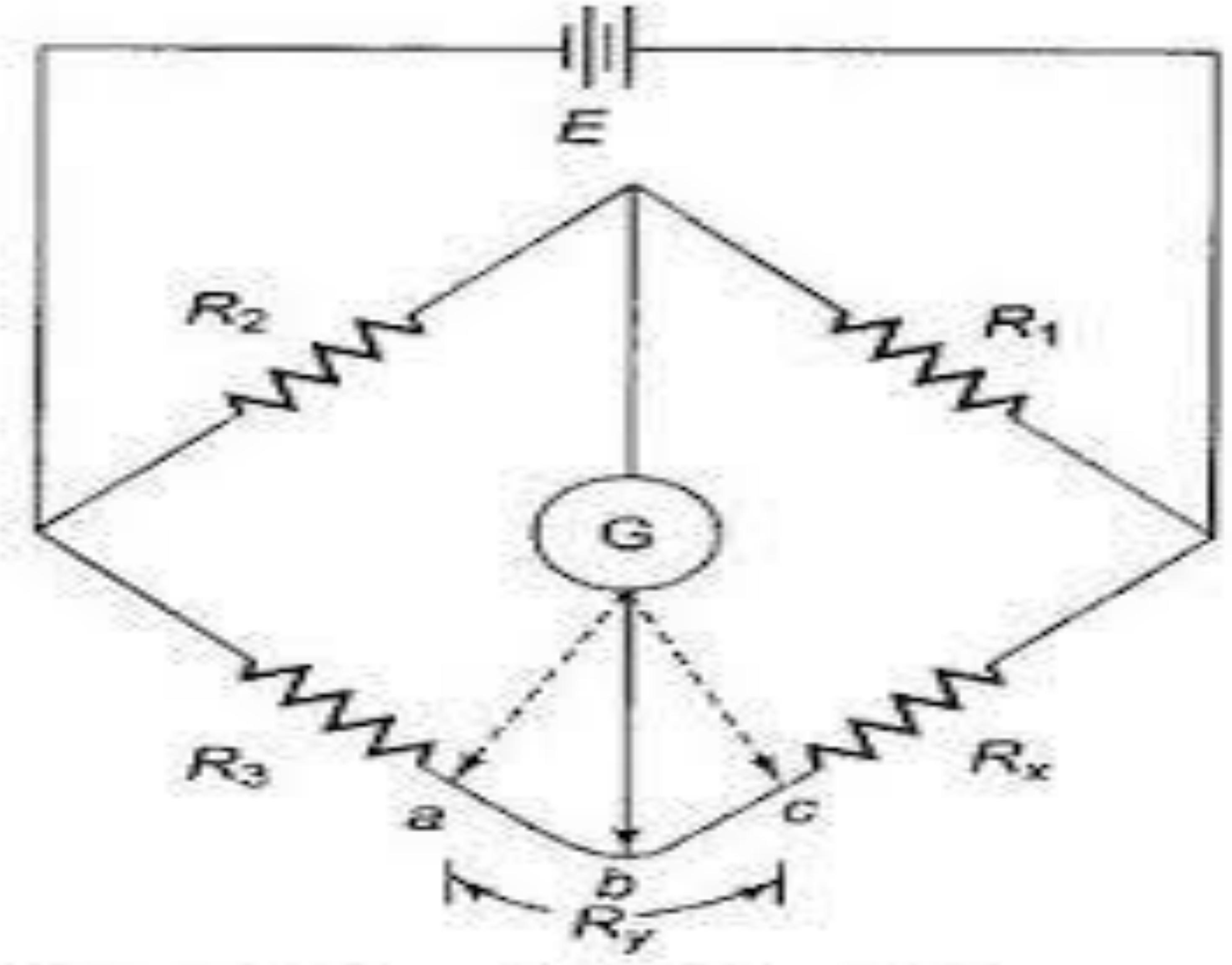
- Wheatstone bridge is a very sensitive device. The measurements may not be precise in an off-balance condition.
- Wheatstone bridge is generally used for measuring resistances ranging from a few ohms to a few kilo-ohms.
- The sensitivity of the circuit reduces if the four resistances are not comparable.

KELVIN DOUBLE BRIDGE

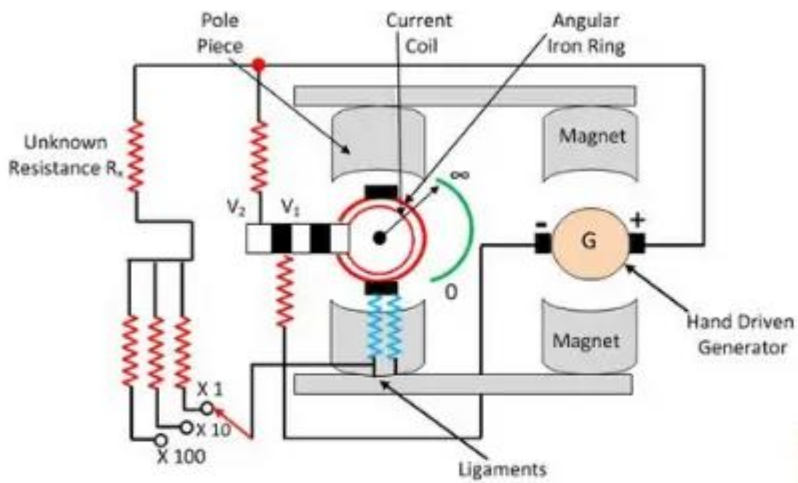
- One of the major drawback of the Wheatstone bridge is that it can measure the resistance from few ohm to several mega ohm but to measure low resistance it gives significant error.

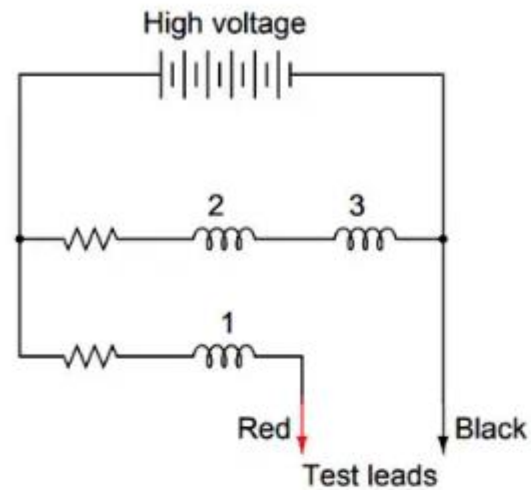
- So, we need some modification in Wheatstone bridge itself, and the modified bridge so obtained is Kelvin bridge, which is not only suitable for measuring low value of resistance but has wide range of applications in the industrial world.

- The kelvin's bridge may be regarded as a modified of the Wheatstone bridge to secure increased accuracy in the measurement of low resistance. It is used to measure resistance from few micro-ohm to 1.0 ohm.


E
R2
R1
G
R3
Rx
a
c
b
Ry

MEGGER





Insulation resistance IR quality of an electrical system degrades with time, environment condition, i.e., temperature, humidity, moisture and dust particles. It also gets impacted negatively due to the presence of electrical and mechanical stress, so it's become very necessary to check the IR (Insulation resistance) of equipment at a constant regular interval to avoid any measure fatal or electrical shock.

TYPES OF MEGGER

This can be separated into mainly two categories:-

Electronic Type (Battery Operated)
Manual Type (Hand Operated)
But there is another types of megger which is motor operated type which does not use battery to produce voltage it requires external source to rotate a electrical motor which in turn rotates the generator of the megger.

https://www.electrical4u.com/megger-working-principle-types-history-uses-of-megger/

MEASUREMENT OF INDUCTANCE

- Maxwell's Inductance Bridge
- Maxwell's Inductance & Capacitance Bridge
- Hay's Bridge
- Anderson's Bridge
- Owen's Bridge

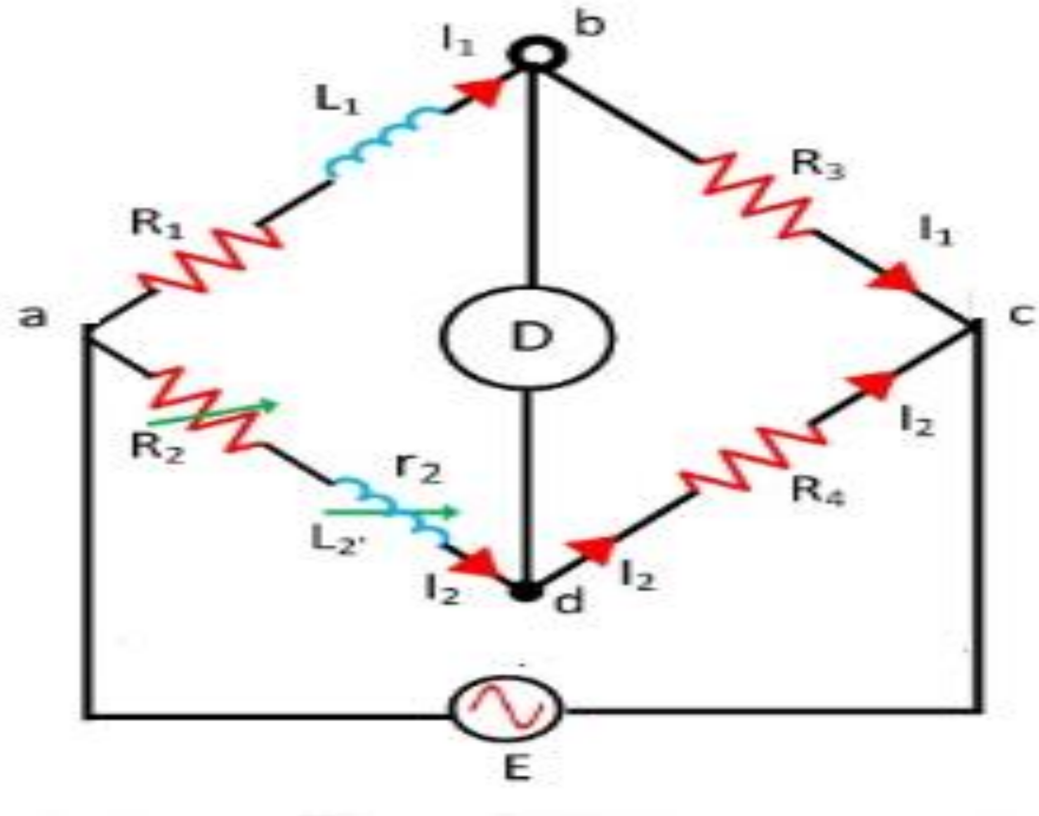
MAXWELL BRIDGE

- The bridge used for the measurement of self-inductance of the circuit is known as the Maxwell bridge. It is the advanced form of the Wheatstone bridge. The Maxwell bridge works on the principle of the comparison, i.e., the value of unknown inductance is determined by comparing it with the known value or standard value.

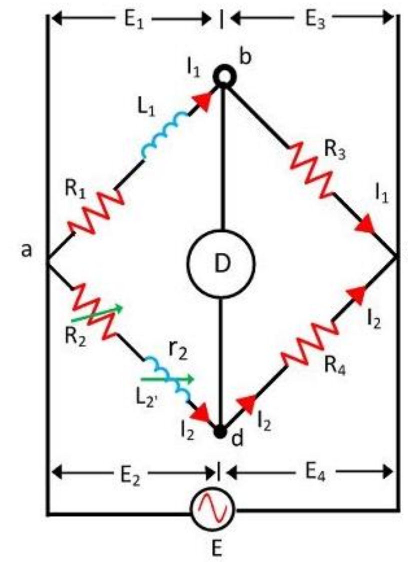
Two methods are used for determining the self-inductance of the circuit. They are

Maxwell's Inductance Bridge
Maxwell's inductance Capacitance Bridge

AC BRIDGES
MAXWELL INDUCTANCE BRIDGE



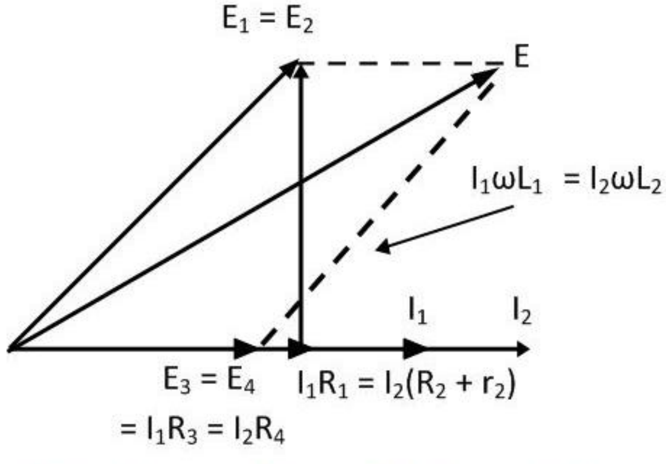
Let, L1 – unknown inductance of resistance R1.
L2 – Variable inductance of fixed resistance r1.
R2 – variable resistance connected in series with inductor L2.
R3, R4 – known non-inductance resistance



At balance,

$$L_1 = \frac{R_3}{R_4} L_2 \qquad R_1 = \frac{R_3}{R_4}(R_2 + r_2)$$

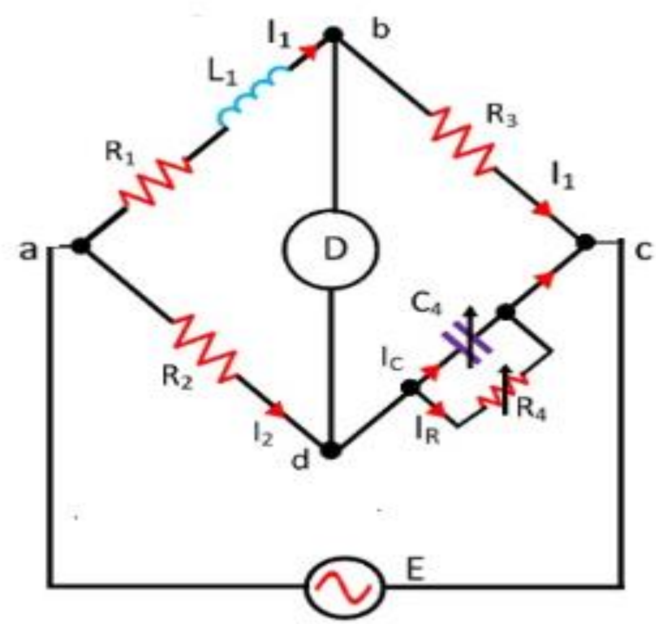
The value of the R3 and the R4 resistance varies from 10 to 1000 ohms with the help of the resistance box. Sometimes for balancing the bridge, the additional resistance is also inserted into the circuit.



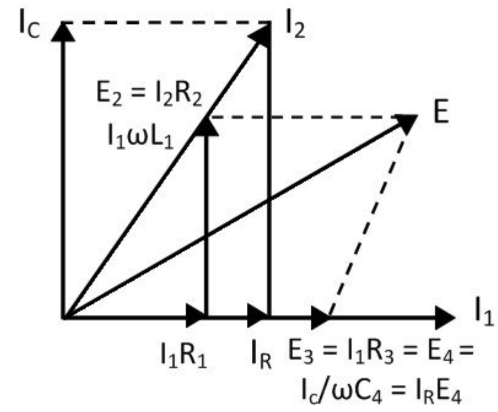
Phasor Diagram of Maxewell Inductance Bridge

MAXWELL INDUCTANCE & CAPACITANCE BRIDGE

In this type of bridges, the unknown resistance is measured with the help of the standard variable capacitance. The connection diagram of the Maxwell Bridge is shown in the figure below.



Let, L1 – unknown inductance of resistance R1.
R1 – Variable inductance of fixed resistance r1.
R2, R3, R4 – variable resistance connected in series with inductor L2.
C4 – known non-inductance resistance



For balance condition,

$$(R_1 + j\omega L_1)\left(\frac{R_4}{1 + j\omega C_4 R_4}\right) = R_2 R_3$$

$$R_1 R_4 = j\omega L_1 R_4 = R_2 R_3 + j\omega C_4 R_4 R_2 R_3$$

By separating the real and imaginary equation we get,

$$R_1 = \frac{R_2 R_3}{R_4}$$

$$L_1 = R_2 R_3 C_4$$

The above equation shows that the bridges have two variables R4 and C4 which appear in one of the two equations and hence both the equations are independent. The circuit quality factor is expressed as

$$Q = \frac{\omega L_1}{R_1} = \omega C_4 R_4$$

ADVANTAGES OF THE MAXWELL'S BRIDGES

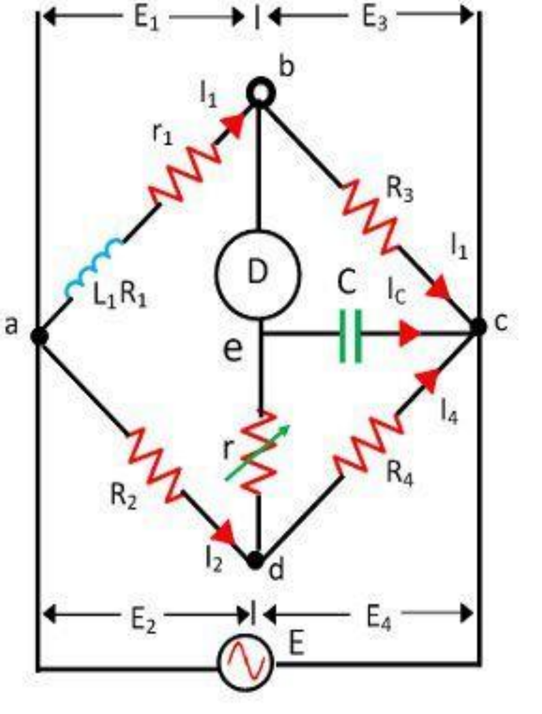
- The balance equation of the circuit is free from frequency.
- Both the balance equations are independent of each other.
- The Maxwell's inductor capacitance bridge is used for the measurement of the high range inductance.

DISADVANTAGES OF THE MAXWELL'S BRIDGE

- The Maxwell inductor capacitance bridge requires a variable capacitor which is very expensive. Thus, sometimes the standard variable capacitor is used in the bridges.
- The bridge is only used for the measurement of medium quality coils.

ANDERSON'S BRIDGE

- The Anderson's bridge gives the accurate measurement of self-inductance of the circuit.
- The bridge is the advanced form of Maxwell's inductance capacitance bridge.
- In Anderson bridge, the unknown inductance is compared with the standard fixed capacitance which is connected between the two arms of the bridge.

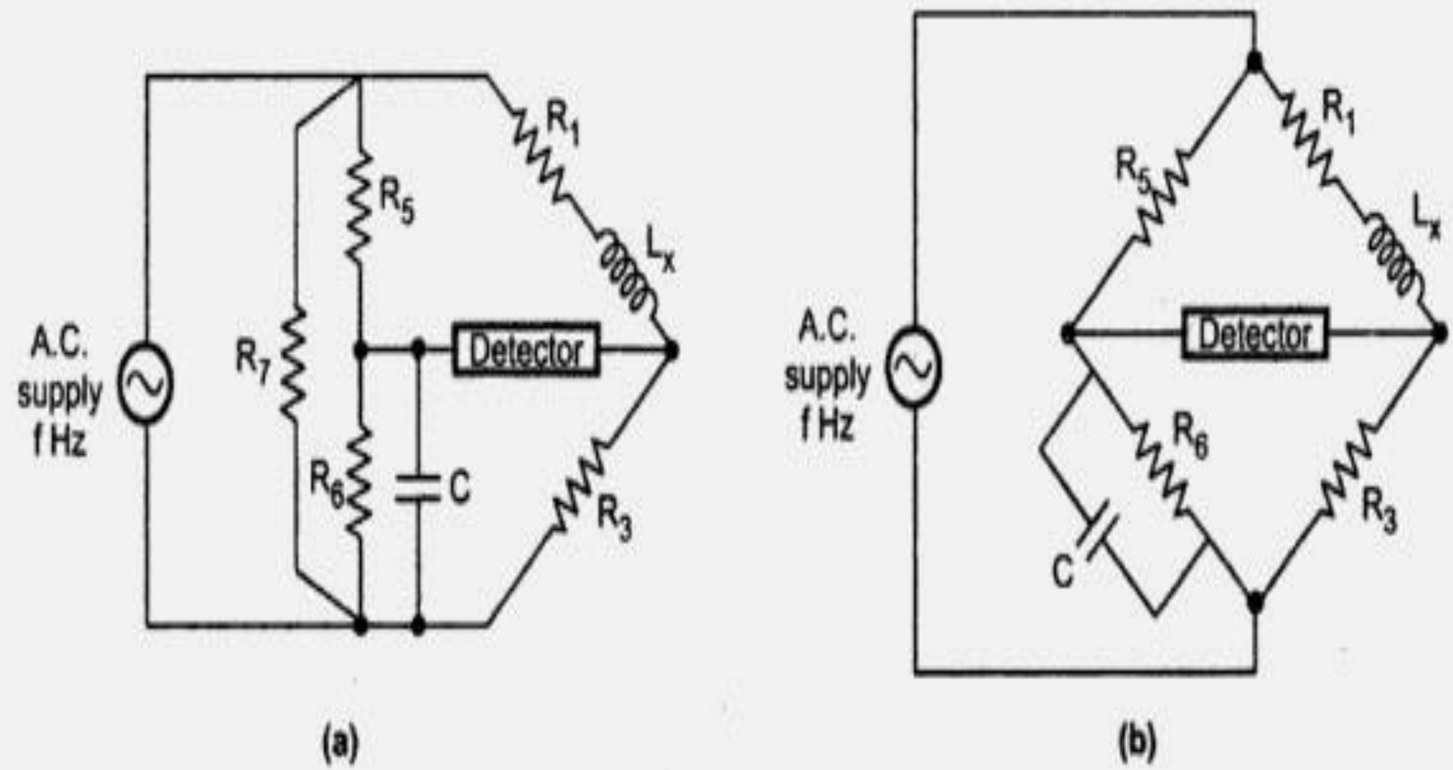


Anderson's Bridge

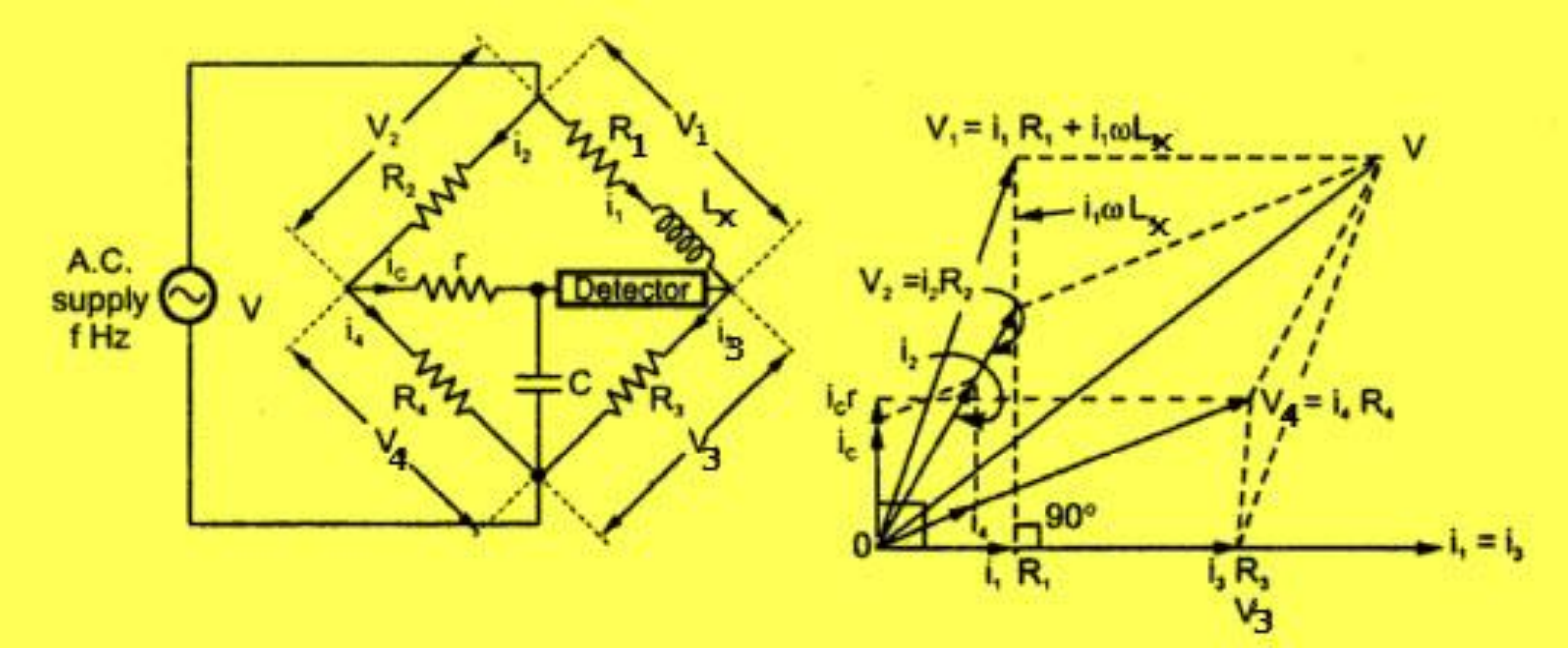
CONSTRUCTIONS OF ANDERSON'S BRIDGE

- The bridge has fours arms ab, bc, cd, and ad.
- The arm ab consists unknown inductance along with the resistance.
- And the other three arms consist the purely resistive arms connected in series with the circuit.
- The static capacitor and the variable resistor are connected in series and placed in parallel with the cd arm.
- The voltage source is applied to the terminal a and c.

ANDERSON BRIDGE



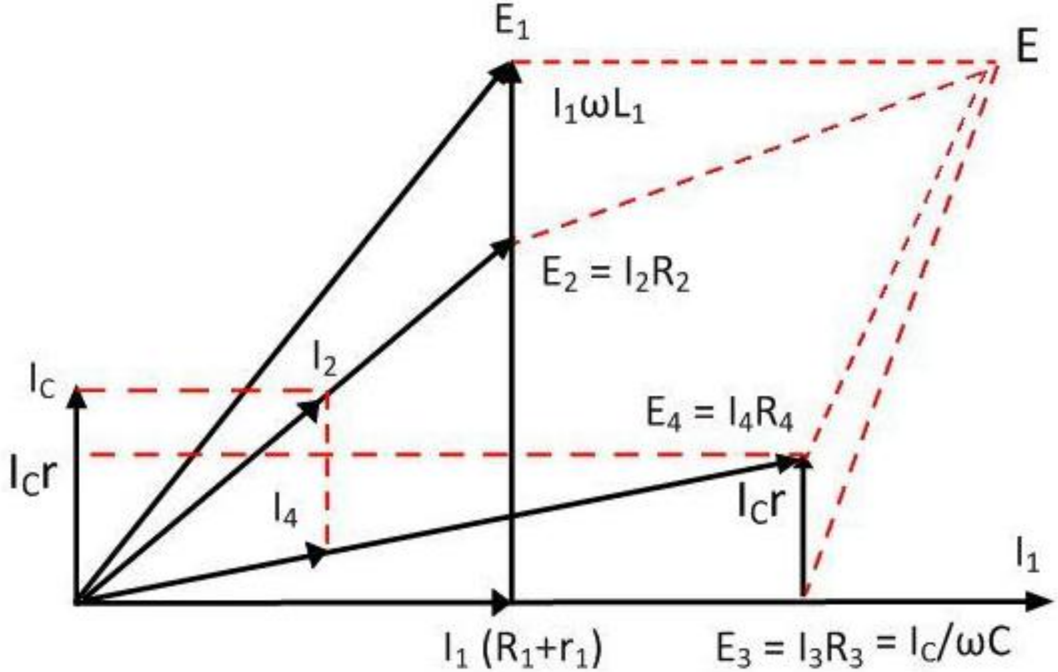
Transformed Anderson bridge



A.C.
supply
f Hz
V
V2
R2
i2
R1
V1
i1
Lx
ic
r
Detector
i4
i3
R4
C
R3
V4
V3
V1 = i1 R1 + i1ωLx
V
i1ωLx
V2 =i2R2
i2
icr
ic
V4 = i4 R4
i4
90°
0
i1 R1
i3 R3
V3
i1 = i3

...CONT

PHASOR DIAGRAM OF ANDERSON'S BRIDGE



Let,
C = Standard capacitor of fixed known value
R2, R3, R4 = Standard non-inductive resistances of known values
L1 = Self-inductance to be measured
r1 = Resistance of the unknown inductor.
Under balanced condition, we have,

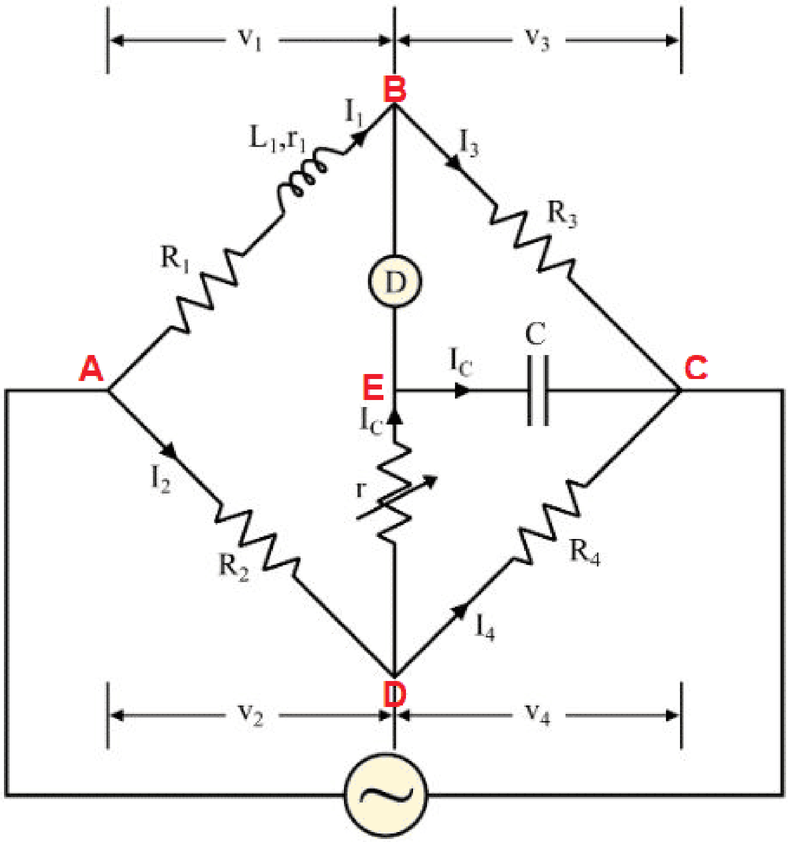
$$I_1 = I_3 \dots (1)$$

$$I_2 = I_4 + I_c \dots (2)$$

$$V_3 = V_c \dots (3)$$

$$V_1 = V_2 + V_r \;\; and \dots (4)$$

$$V_4 = V_r + V_c \dots (5)$$



From equation 3, we have,

$$V_3 = V_c$$

$$I_3\, R_3 = I_c \times \frac{1}{j\omega C}$$

$$I_c = I_3(j\omega C R_3)$$

$$= I_1(j\omega C R_3) \;\; (\because from\; equation\; 1)$$

From equation 4, we have,

$$V_1 = V_2 + V_r$$

$$I_1(r_1 + R_1 + j\omega L_1) = I_2\, R_2 + I_c\, r$$

$$I_1(r_1 + R_1 + j\omega L_1) = I_2\, R_2 + I_1(j\omega C R_3)r$$

$$I_1(r_1 + R_1 + j\omega L_1 - j\omega C R_3 r) = I_2\, R_2$$

$$I_2 = \frac{I_1}{R_2}(r_1 + R_1 + j\omega L_1 - j\omega C R_3 r) \ldots (6)$$

From equation 5, we have,

$$I_4R_4 = I_cr + I_c \times \frac{1}{j\omega C}$$

$$(I_2 - I_c)R_4 = I_c\left(r + \frac{1}{j\omega C}\right)$$

$$I_2R_4 = I_c\left(r + R_4 + \frac{1}{j\omega C}\right)$$

$$I_2R_4 = I_1(j\omega CR_3)\left(r + R_4 + \frac{1}{j\omega C}\right)$$

$$I_2 = I_1\left(\frac{j\omega CR_3r}{R_4} + j\omega CR_3 + \frac{R_3}{R_4}\right) \ldots (7)$$

From equations 6 and 7, we have

$$\frac{I_1}{R_2}(r_1 + R_1 + j\omega L_1 - j\omega CR_3r) = I_1\left(\frac{R_3}{R_4} + \frac{j\omega CR_3r}{R_4} + j\omega CR_3\right)$$

$$r_1 + R_1 + j\omega(L_1 - CR_3r) = \frac{R_2R_3}{R_4} + j\omega\left(\frac{CR_2R_3r}{R_4} + CR_2R_3\right)$$

Equating real and imaginary parts on both sides, we get,

$$R_1 = \frac{R_2 R_3}{R_4} - r_1 \ \ and$$

$$L_1 - CR_3 r = CR_2 R_3 + \frac{CR_2 R_3 r}{R_4}$$

$$L_1 = CR_3 \left[R_2 + r + \frac{R_2 r}{R_4}\right]$$

$$L_1 = \frac{CR_3}{R_4}[R_2 R_4 + r R_4 + R_2 r]$$

$$L_1 = \frac{CR_3}{R_4}[R_2 R_4 + r(R_4 + R_2)]$$

Therefore, the unknown value of self-inductance is, $L_1 = \frac{CR_3}{R_4}[R_2 R_4 + r(R_2 + R_4)]$

The unknown value of resistance of the self inductor is, $R_1 = \frac{R_2 R_3}{R_4} - r_1$

ADVANTAGES OF ANDERSON'S BRIDGE :

- The problem of sliding balance condition normally faced with low Q coils is overcome in Anderson's bridge. This is because both the variable resistances to be adjusted are independent of each other. Hence, the balance can be obtained easily.
- Instead of a variable capacitor, a fixed capacitor can be used. This makes the bridge cheaper than Maxwell's bridge.
- Determination of unknown capacitance in terms of known inductance is also possible.
- The expression for self-inductance of the coil does not change even with the use of an imperfect capacitor (i.e., the capacitor with dielectric loss). Instead, only the value of coil resistance is affected.
- For more precise measurements, a second balance is obtained by short-circuiting the coil, and the inductance of coil leads is calculated. Finally, the actual self-inductance of the coil is obtained by subtracting the values of inductances obtained in both the measurement cases.

DISADVANTAGES OF ANDERSON'S BRIDGE

- The Anderson's bridge (which is a modified form of Maxwell's bridge) is more complex in terms of circuit connections and computations when compared to Maxwell's bridge due to the increase in the number of components used in the circuit.
- The balance equation calculations are also complicated than Maxwell's bridge calculations.
- Shielding of the bridge circuit is difficult as an additional junction point is introduced in the circuit.

MEASUREMENT OF CAPACITANCE

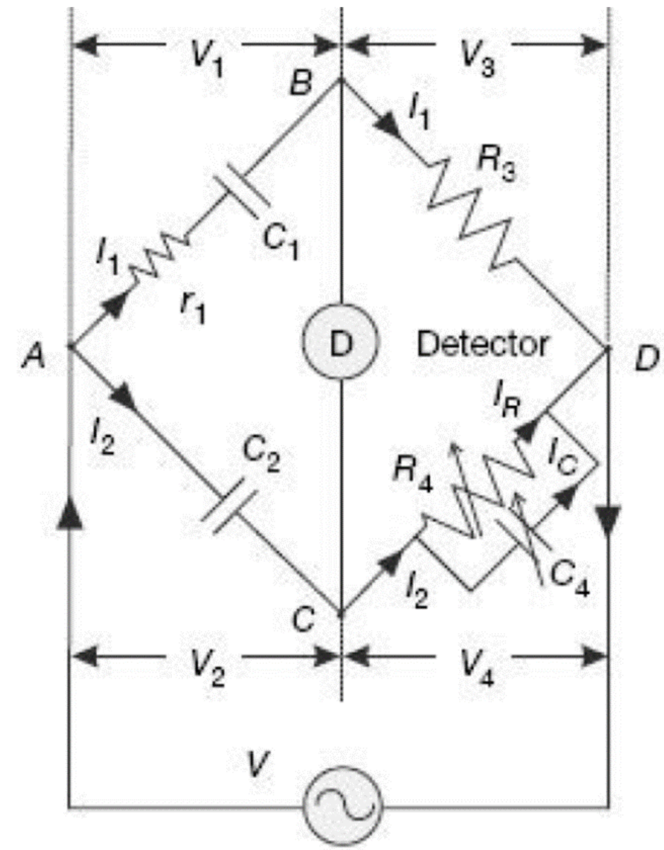
- Desauty's Bridge
- Schering Bridge
- Wein's Bridge

SCHERING BRIDGE

This bridge is used to measure to the capacitance of the capacitor, dissipation factor and measurement of relative permittivity.

$$R_1 = \frac{R_3 C_4}{C_2}$$

$$C_1 = \frac{C_2 R_4}{R_3}$$



DISSIPATION FACTOR

The dissipation factor of a capacitor is the ratio of its resistance to its capacitive reactance.

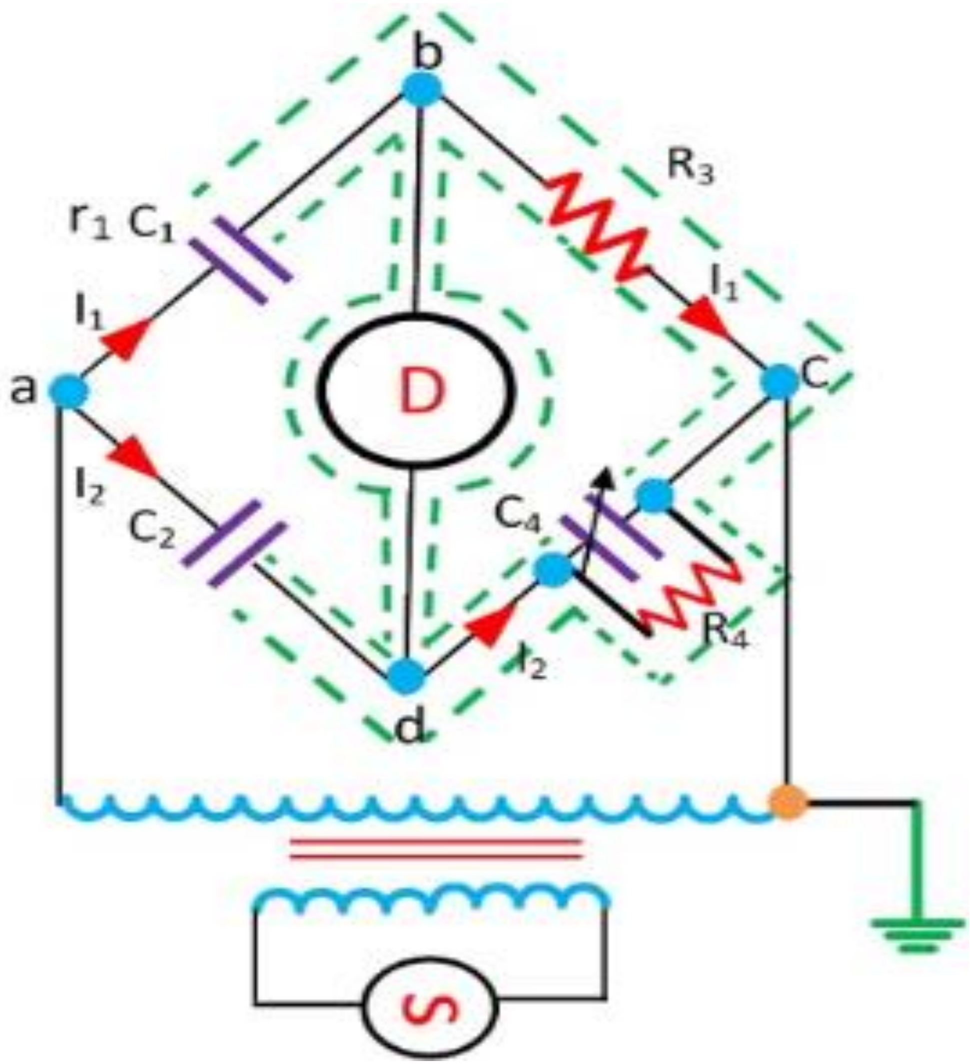
$$D = \frac{R_1}{\frac{1}{\omega C_1}}$$

$$D = \omega C_1 R_1$$

$$D = \omega \frac{C_2 R_4}{R_3} \frac{R_3 C_4}{C_2}$$

$$D = \omega C_4 R_4$$

HIGH VOLTAGE SCHERING BRIDGE



ADVANTAGES

- 1. The balanced equation obtained is independent of frequency terms.
- 2. By using fixed values of C_2, R_4, the dial of R_3 may be calibrated to read the capacitance (C_1) directly.
- 3. In case of fixed frequency, the dial of capacitor C_4 can be calibrated to read dissipation factor directly as $D = \omega C_4 R_4$.

DISADVANTAGES

The LV Schering bridge suffers from the following disadvantages,

- The calibration for the dissipation factor is useful only for one value of frequency. ...
- The detector used is not so sensitive.
- It is quite difficult to obtain a balanced condition.

Type of Bridge	Name of the Bridge	Used to measure
DC Bridges	Wheat Stone Bridge	Medium R
	Corey fosters bridge	Medium R
	Kelvin double bridge	Very low R
	Loss of charge method	High R
	Megger	High insulation R

Type of Bridge	Name of Bridge	Used to measure	Important
	Maxwell's inductance bridge	Inductance	Not suitable to measure Q
	Maxwell's inductance capacitance bridge	**Inductance**	**Suitable for medium Q coil (1 < Q < 10)**
	Hay's bridge	**Inductance**	**Suitable for high Q coil (Q > 10), slowest bridge**
	Anderson's bridge	Inductance	5-point bridge, accurate and fastest bridge (Q < 1)
	Owen's bridge	**Inductance**	**Used for measuring low Q coils**
AC Bridges	Heaviside mutual inductance bridge	Mutual inductance	-

	Campbell's modification of the Heaviside bridge	Mutual inductance	-
	De-Sauty's bridge	Capacitance	Suitable for perfect capacitor
	Schering bridge	Capacitance	Used to measure relative permittivity
	Wein's bridge	Capacitance and frequency	Harmonic distortion analyzer, used as a notch filter, used in audio and high-frequency applications

THANK-U