GOKARAJU RANGARAJU
INSTITUTE OF ENGINEERING AND TECHNOLOGY

Department of Electrical & Electronics Engineering

Course Tittle: ______Switch Gear and Protection___________

Following documents are available in Course File.

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

Course Instructor / Course Coordinator (Name)

Course Instructor / Course Coordinator (Signature)

Department of Electrical & Electronics Engineering

Vision of the Institute

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

Mission of the Institute

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

Vision of the Department

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

Mission of the Department

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

Programme Educational Objectives (B.Tech. – EEE)

This programme is meant to prepare our students to professionally thrive and to lead.

During their progression:

Graduates will be able to

PEO 1: Have a successful technical or professional careers, including supportive and leadership roles on multidisciplinary teams.

PEO 2: Acquire, use and develop skills as required for effective professional practices.

PEO 3: Able to attain holistic education that is an essential prerequisite for being a responsible member of society.

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

Programme Outcomes (B.Tech. – EEE)

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

PO 1: Apply knowledge of mathematics, science, and engineering.

PO 2: Design and conduct experiments, as well as to analyze and interpret data.

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

PO 4: Function on multi-disciplinary teams.

PO 5: Identify, formulates, and solves engineering problems.

PO 6: Understanding of professional and ethical responsibility.

PO 7: Communicate effectively.

PO 8: Broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context.

PO 9: Recognition of the need for, and an ability to engage in life-long learning.

PO 10: Knowledge of contemporary issues.

PO 11: Utilize experimental, statistical and computational methods and tools necessary for engineering practice.

PO 12: Demonstrate an ability to design electrical and electronic circuits, power electronics, power systems; electrical machines analyze and interpret data and also an ability to design digital and analog systems and programming them.

PEOs & POs Mapping

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

* H: Strongly Correlating (3); M: Moderately Correlating (2)& L: Weakly Correlating (1)

GOKARAJU RANGARAJU
INSTITUTE OF ENGINEERING AND TECHNOLOGY

Department of Electrical & Electronics Engineering

GRIET/DAA/1H/G/18-19 05 May 2018

ACADEMIC CALENDAR
Academic Year 2018-19

III B.TECH – FIRST SEMESTER

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

III B.TECH – SECOND SEMESTER

S. No.	EVENT	PERIOD	DURATION
1	1st Spell of Instruction	10-12-2018 to 02-02-2019	8 Weeks
2	1st Mid-term Examinations	04-02-2019 to 06-02-2019	3 Days
3	2nd Spell of Instruction	07-02-2019 to 06-04-2019	**8 Weeks 3 Days**
4	2nd Mid-term Examinations	08-04-2019 to 10-04-2019	3 Days
5	Preparation	11-04-2019 to 17-04-2019	1 Week
6	**End Semester Examinations (Theory/ Practicals) Regular**	18-04-2019 to 08-05-2019	3 Weeks
7	**Supplementary and Summer Vacation**	**09-05-2019 to 22-06-2019**	**6 Weeks 3 Days**
8	Commencement of First Semester, A.Y 2019-20	24-06-2019	

Copy to Director, Principal, Vice Principal, DOA, DOE, Balaji Kumar, DCGC, All HODs

(Dr. K. Anuradha)
Dean of Academic Affairs

GOKARAJU RANGARAJU
INSTITUTE OF ENGINEERING AND TECHNOLOGY

Department of Electrical & Electronics Engineering

SUBJECT ALLOCATION SHEET

2018-19 II sem Subject Allocation sheet

GRIET/EEE/05B/G/18-19 **30.10.18**

II YEAR(GR17)	Section-A	Section-B
Managerial Economics and Financial Analysis		
Power Generation and Distrubution	SN	SN
AC Machines	VVSM	VVSM
Control Systems	Dr DGP	MS
Princeples of Digital Electronics	PRK	PRK
AC Machines Lab	PPK/DSR	PPK/DSR
Control Systems Lab	MS/PSVD	MS/PSVD
Analog and Digital Electronics Lab	RAK/DKK	RAK/DKK
Value Education and Ethics		
Gender Sensitization Lab	MS/PSVD	MS/PSVD
III YEAR (GR15)		
Computer Methods in Power systems	VVRR/MP	VVRR/MP
Switch Gear & Protection	PSVD	Dr JSD
Management Science		
Utilization of Electrical Energy	MRE	MRE
Non Conventional Sources of Energy		
Neural and Fuzzy Systems		
Sensors&Transducers	UVL	UVL
Power Systems Lab	GSR/YSV	GSR/YSV
Advanced English Communications Skills Lab		
Industry Oriented Mini Project Lab	PPK/AVK/Dr JP	MP/Dr JP
IV YEAR (GR15)		
Programmable Logic Controllers	PK	
Flexible AC Transmission Systems	Dr TSK	
EHV AC Transmission		
Power System Automation		
Modern Power Electronics	AVK	
DSP Based Electromechanical Systems		
Advaced Control Systems		
Programmable Logic Controllers-Lab	VVSM	PK
Main Projects	RAK/Dr SVJK	PK/VVRR

GOKARAJU RANGARAJU
INSTITUTE OF ENGINEERING AND TECHNOLOGY

Department of Electrical & Electronics Engineering

CLASS
TIME TABLE

GRIET/PRIN/06/G/01/18-19 **Wef : 10 Dec 2018**

BTech - EEE - B **III year - II Semester**

DAY/ HOUR	9:00 - 9:45	9:45 - 10:30	10:30 - 11:15	11:15- 12:00	12:00- 12:30	12:30 - 1:20	1:20 - 2:10	2:10 - 3:00
MONDAY	PS Lab(B1) /AECS Lab(B2)				BREAK	UEE	CMPS	
TUESDAY	PS Lab(B2) /IOMP Lab(B1)					CMPS	S&T	
WEDNESDAY	IOMP Lab(B2) / AECS Lab(B1)					SGP	CMPS	
THURSDAY	SGP		UEE			S&T	MS	
FRIDAY	UEE		CMPS			S&T	SGP	
SATURDAY	MS		SGP			UEE	S&T	

Room No	
Theory	4404
Lab	4504/4407/

Class Incharge:	M Rekha

Subject Code	Subject Name	Faculty Code	Faculty name	Almanac	
CMPS	Computer Methods in Power systems	VVRR/MP	V Vijaya Rama Raju/M Prashanth	1st Spell of Instructions	10-12-2018 to 06-02-2019
SGP	Switch Gear & Protection	DrJSD	Dr J Sridevi	1st Mid-term Examinations	07-02-2019 to 09-02-2019
MS	Management Science	Dr MSRS	Dr M S R Sesha giri	2nd Spell of Instructions	11-02-2019 to 03-04-2019
UEE	Utilization of Electrical Energy	MRE	M Rekha	2nd Mid-term Examinations	04-04-2019 to 06-04-2019
S&T	Sensors&Transducers	UVL	U Vijaya Lakshmi	Preparation	08-04-2019 to 17-04-2019
PS Lab	Power Systems Lab	GSR/YSV	G Sandhya Rani/Y Satyavani	End Semester Examinations (Theory/ Practicals) Regular	18-04-2019 to 08-05-2019
AECS Lab	Advanced English Communications Skills Lab	ES	E Sailaja		
IOMP Lab	Industry Oriented Mini Project Lab	MP/Dr JP	M Prashanth/ Dr J Praveen	Supplementary and Summer Vacation	09-05-2019-to 22-06-2019
				Commencement of Second Semester , AY	24/06/2019

GOKARAJU RANGARAJU
INSTITUTE OF ENGINEERING AND TECHNOLOGY

Department of Electrical & Electronics Engineering

Wef : 10 Dec 2018

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

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

DAY/ HOUR	9:00 - 9:45	9:45 - 10:30	10:30 - 11:15	11:15-12:00	12:00-12:30	12:30 - 1:20	1:20 - 2:10	2:10 - 3:00
MONDAY	SGP		CMPS		BREAK	S&T		UEE
TUESDAY	SGP		S&T			UEE		CMPS
WEDNESDAY	MS		UEE			SGP		S&T
THURSDAY	IOMP Lab(A1) / AECS Lab(A2)					CMPS		S&T
FRIDAY	PS Lab(A2) /AECS Lab(A1)					MS		UEE
SATURDAY	IOMP Lab(A2) / PS Lab (A1)					CMPS		SGP

Room No	
Theory	4501
Lab	4504/4407/

Class Incharge:	M Rekha

Subject Code	Subject Name	Faculty Code	Faculty name	Almanac	
CMPS	Computer Methods in Power systems	VVRR/MP	V Vijaya Rama Raju/M Prashanth	1st Spell of Instructions	10-12-2018 to 06-02-2019
SGP	Switch Gear & Protection	PSVD	P Srividya Devi	1st Mid-term Examinations	07-02-2019 to 09-02-2019
MS	Management Science	Dr MSRS	Dr M S R Sesha giri	2nd Spell of Instructions	11-02-2019 to 03-04-2019
UEE	Utilization of Electrical Energy	MRE	M Rekha	2nd Mid-term Examinations	04-04-2019 to 06-04-2019
S&T	Sensors&Transducers	UVL	U Vijaya Lakshmi	Preparation	08-04-2019 to 17-04-2019
PS Lab	Power Systems Lab	GSR/YSV	G Sandhya Rani/Y Satyavani	End Semester Examinations (Theory/ Practicals) Regular	18-04-2019 to 08-05-2019
AECS Lab	Advanced English Communications Skills Lab	ES	E Sailaja		
IOMP Lab	Industry Oriented Mini Project Lab	AVK/PPK/Dr JP	A Vinay Kumar/P Praveen Kumar/ Dr J Praveen	Supplementary and Summer Vacation	09-05-2019-to 22-06-2019
				Commencement of Second Semester , AY	24/06/2019

GOKARAJU RANGARAJU INSTITUTE OF ENGINEERING AND TECHNOLOGY

SWITCH GEAR AND PROTECTION

Course Code: GR15A3022	**L T P C**
III Year II Sem	3 1 0 4

UNIT I

INTRODUCTION TO CIRCUIT BREAKERS: Circuit Breakers: Elementary principles of arc interruption, Recovery, Restriking Voltage and Recovery voltages.- Restriking Phenomenon, Average and Max. RRRV, Numerical Problems- Current Chopping and Resistance Switching-CB ratings and Specifications.

Description and Operation of following types of circuit breakers: Minimum Oil Circuit breakers, Air Blast Circuit Breakers, Vacuum and SF6 circuit breakers.

UNIT II

ELECTRO MAGNETIC AND STATIC RELAYS:

Electromagnetic Relays: Principle of Operation and Construction of Attracted armature, Balanced Beam, induction Disc and Induction Cup relays. **Application of relays:** Over current, Under voltage relays, Directional relays, Differential Relays.

Universal torque equation, Distance relays: Impedance, Reactance and Mho and Off-Set Mho relays, Characteristics of Distance Relays and Comparison. Static Relays: Static Relays verses Electromagnetic Relays.

UNIT III

PROTECTION OF GENERATORS & TRANSFORMERS:

Protection of generators against Stator faults, Rotor faults, and Abnormal Conditions. Restricted Earth fault and Inter-turn fault Protection. Numerical Problems on Percentage Winding Unprotected.

Protection of transformers: Percentage Differential Protection, Numerical Problem on Design of CT s Ratio, Buchholtz relay Protection.

Protection of lines: Over Current, Carrier Current and Zonal Protection, Transley Relay.

Protection of Bus bars: Differential protection, Frame Leakage Protection.

UNIT IV

NEUTRAL GROUNDING: Grounded and Ungrounded Neutral Systems.-Effects of Ungrounded Neutral on system performance. Methods of Neutral Grounding: Solid, Resistance, Reactance-Arcing Grounds and Grounding Practices.

UNIT V

PROTECTION AGAINST OVER VOLTAGES: Generation of Over Voltages in Power Systems.-Protection against Lightning Over Voltages-Valve type and Zinc- Oxide Lightning Arresters-Insulation Coordination-BIL, Impulse Ratio, Standard Impulse Test Wave, Volt-Time Characteristics.

TEXT BOOKS:

1. Sunil S Rao, Switch gear and Protection–Khanna Publishers.

2. Badri Ram, D.N.Viswakarma, Power System Protection and Switch gear, TMH Publications.

REFERENCES

1. C.L.Wadhwa, Electrical Power Systems–New Age international (P) Limited, Publishers, 6th edition

2. B.L.Soni, Gupta, Bhatnagar, Chakrabarthy, A Text book on Power System Engineering, Dhanpat Rai & Co.

GOKARAJU RANGARAJU
INSTITUTE OF ENGINEERING AND TECHNOLOGY

Department of Electrical & Electronics Engineering

COURSE SCHEDULE

Academic **Y**ear : **2018-2019**

Semester : **II**

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

Course/Subject: …**Switch Gear and Protection**…Course Code: ..**GR15A3022..**

Name of the Faculty: …**Dr. J.Sridevi,P.Srividyadevi**……..…………..Dept.: …**EEE**………

Designation: PROFESSOR ,ASST.PROFESSOR

The Schedule for the whole Course / Subject is:

S. No.	Description	Total No. Of Periods
1.	Circuit Breakers-1	12
2.	Electromagnetic and Static Relays	8
3.	Protection of Power Systems Equipment	20
4.	Neutral Grounding	8
5.	Protection against Over Voltages	14

Total No. of Instructional periods available for the course:62 hrs

GOKARAJU RANGARAJU
INSTITUTE OF ENGINEERING AND TECHNOLOGY

Department of Electrical & Electronics Engineering

SCHEDULE OF INSTRUCTIONS
COURSE PLAN

Academic Year : **2018-2019**

Semester : **II**

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

Course/Subject: …**Switch Gear and Protection**…Course Code: ..**GR15A3022..**

Name of the Faculty: …**Dr. J.Sridevi,P.Srividyad**……………..…………..Dept.: …**EEE**………

Designation: PROFESSOR ,ASST.PROFESSOR

SUGGESTED BOOKS:

TEXT BOOKS:

T1: Sunil S Rao ***“Switchgear Protection & Power Systems”***,Khanna Publlishers

T2: Badari Ram & D.N Viswakarma ***“Power System Protection and Switchgear”***,TMH publications

REFERENCES BOOKS :

R1: Paithankar and S.R.Bhide, ***“Fundamentals of Power System Protection”***,PHI, 2003.

R2: T S Madhav Rao, ***“Power System Protection : Static Relays”***,TataMcGraw-Hill, 2nd edition

R3: C R Mason, ***“Art & Science of Protective Relaying”***,Wiley Eastern Ltd.

R4: Cl Wadhwa, ***“Electrical Power Systems”***,New Age international (P) Limited, Publishers, 3rd editon

R5: ***“Hand Book of Switchgears by BHEL”***,TMH Publications.

Unit No.	Lesson No.	No. of Periods	Topics / Sub-Topics	Objectives & Outcomes Nos.	References **(Text Book, Journal…** Page Nos.: ____ to ____
I	1	2	Elementary principles of arc interruption Circuit Breakers Recovery, Restriking Voltage and Recovery voltages	1, 3 & 1,2,3	T1:3.7,4.8 T2:9.2, 9.3 R4:15.2 R6:13.6, 14.3
			Restriking Phenomenon,	2, 3 & 1,2,3,	T1:3.10,3.19

I	2	2	Average and Max. RRRV,		T2: 9.3 R4:15.2 R6:14.4, 14.5
I	3	2	Current chopping and Resistance switching, CB ratings and Specifications:	2, 3 & 1,2,3	T1:3.6,3.18,3.19 T2: 9.5,9.6,9.16 R4:15.3,15.9,15.11 R6:7.3,14.2,14.3 14.7
I	4	2	Description and Operation of Minimum Oil Circuit breakers, Description and Operation of Air Blast Circuit Breakers	2, 3 & 1,2,3	T1:6.2,8.3 T2: 9.7,9.8,9.9,9.10 R4:15.4,15.6 R6:15.3,15.5
I	5	2	Description and Operation of Vacuum circuit breakers, Description and Operation of SF6 circuit breakers	2, 3 & 1,2,3	T1:7.5,9.4 T2: 9.11,9.12,9.13,9.14,9.15 R4:15.7,15.8 R6:16.2,16.3
I	6	2	Problems		
II	1	2	Principle of Operation and Construction of Attracted armature relays, Principle of Operation and Construction of Balanced Beam relays	2, 3 & 1,2,3	T1:26.9,26.10 T2: 2.1 R2:1.1 R4:14.4 R6:3.2
II	2	2	Principle of Operation and Construction of induction Disc & cuprelays,	2, 3 & 1,2,3	T1: 26.10,26.12 T2: 2.1 R2:1.6 R4:14.4 R6:3.2
II	3	2	Direction relays, Differential Relays Impedance, Reactance	2, 3 & 1,2,3 4	T2: 3.10,3.11,4.1,4.2,4.5 to 4.20 T1: 27.10,28.1,29.6,29.8,29.9

			relays		R2:7.2,7.3 R4:14.8,14.12,14.7,14.10 R6:4.7,4.9,3.3
II	4	2	Mho and Off-Set Mho relays	2, 3 & 1,2,3 4	T2: 3.10,3.11,4.1,4.2,4.5 to 4.20
III	1	2	Protection of generators against Stator faults	2, 3 & 1,2,5	T2 : 6.1 T1 : 33.2,33.8 R2 : 16.3 R4 : 14.11 ,R6 ;6.3
III	2	2	Rotor faults.	2, 3 & 1,2,5	T2 : 6.1 T1 : 33.2,33.8 R2 : 16.3 R4 : 14.11 ,R6 ;6.3
III	3	2	Abnormal conditions	2, 3 & 1,2,5	T2 : 6.1 T1 : 33.2,33.8 R2 16.3 R4 : 14.11 ,R6 ;6.3
III	4	2	Problem on Stator faults	2, 3 & 1,2,5	T2 : 6.1 T1 : 33.2,33.8 R2 16.3
III	5	2	Problem on Stator faults	2, 3 & 1,2,5	T2 : 6.1 T1 : 33.2,33.8 R2 16.3
III	6	2	Protection of transformers: Percentage Differential Protection	2, 3 & 1,2,5	T2 : 6.2 T1 :32.5 R2- 7.8

III	7	2	Restricted Earth fault and Inter turn fault Protection	2, 3 & 1,2,5	T2 : 6.1 T1 : 33.12 R2-16.3 R4- 14.11 R6-6.3
III	8	2	Translay Relay.	2, 3 & 1,2,5	T2-6.3,6.4, T1- 30.9.1,30.18 R2-9.2,11.15,16.4 R4-14.10,14.13 R6-6.5,12.3
III	10	2	Protection of Bus bars – Differential protection	2, 3 & 1,2,5	T2-6.3,6.4, T1- 30.9.1,30.18 R2-9.2,11.15,16.4 R4-14.10,14.13 R6-6.5,12.3
III	11	2	Problems	2, 3 & 1,2,5	
IV	1	2	Grounded and Ungrounded Neutral Systems.- Effects of Ungrounded Neutral on system performance	2, 3 & 1,2,6	T1 18.15, 1.16,1 .17,1. 22 R4- 11.11, 11.2.1 1.5
IV	2	2	Methods of Neutral Grounding: Solid Resistance, Reactance	2, 3 & 1,2,6	T1 : 18.23 R4 : 11.4

IV	3	2	Arcing Grounds.	2, 3 & 1,2,6	T1 : 18.21,18.24
IV	4	2	Grounding Practices	2, 3 & 1,2,6	T1 : 18.21 ,18.2 4
V	1	2	Generation of Over Voltages in Power Systems.-Protection Against Lightning Over Voltage	2, 3 & 1,2,7	R4 : 16.2
V	2	2	Valve type and Zinc Oxide Lighting Arresters	2, 3 & 7,1,2	T2-11.4,11.6,11.7 R4-16.4

V	3	2	Insulation and Coordination -BIL, ,	2.3& 1,2,7	T2-11.10,11.11
V	4	2	Impulse Ratio Standard Impulse Test Wave,	2, 3 & 1,2,7	T2 : 11.11
V	5	2	Volt-Time Characteristics and Insulation Co-ordination	2, 3 & 1,2,7	T2 : 11.11
V	5	2	Problems	2, 3 & 1,2,7	T2 : 11.11
		2	revision		

GOKARAJU RANGARAJU
INSTITUTE OF ENGINEERING AND TECHNOLOGY

Department of Electrical & Electronics Engineering

SCHEDULE OF INSTRUCTIONS
UNIT PLAN-I

Academic Year : **2018-2019**

Semester : **II** UNIT NO.: ………**I**…………

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

Course/Subject: …**Switch Gear and Protection**…Course Code: ..**GR15A3022..**

Name of the Faculty: …**Dr. J.Sridevi,P.Srividyadevi**………..…………..Dept.: …**EEE**………

Designation: PROFESSOR ,ASST.PROFESSOR

Less on No	No. Of Periods	Topics / Sub - Topics	Obj &Out	References **(Text Book, Journal…)** Page Nos.: to
1	2	Elementary principles of arc interruption, Recovery, Restriking Voltage and Recoveryvoltages	1,3 & 1,2,3	T1:3.7,4.8 T2:9.2, 9.3 R4:15.2 R6:13.6, 14.3
2	2	.Restriking Phenomenon, Average and Max. RRRV,	2,3 & 1,2,3	T1:3.10,3.19 T2: 9.3 R4:15.2 R6:14.4, 14.5
3	2	Current Chopping and Resistance Switching. CB ratings and Specifications : Types	2,3 & 1,2,3	T1:3.6,3.18,3.19 T2: 9.5,9.6,9.16 R4:15.3,15.9,15.11 R6:7.3,14.2,14.3 14.7
4	2	Description and Operation of following types of circuit breakers: Minimum Oil Circuit breakers, Air Blast Circuit Breakers	2,3 & 1,2,3	T1:6.2,8.3 T2: 9.7,9.8,9.9,9.10 R4:15.4,15.6 R6:15.3,15.5
5	2	Description and Operation of following types of circuit breakers: Vacuum and SF6 circuit breakers.	2,3 & 1,2,3	T1:7.5,9.4 T2:9.11,9.12,9.13,9.1 4,9.15 R4:15.7,15.8 R6:16.2,16.3
5	2	problems		

GOKARAJU RANGARAJU
INSTITUTE OF ENGINEERING AND TECHNOLOGY

Department of Electrical & Electronics Engineering

SCHEDULE OF INSTRUCTIONS
UNIT PLAN-II

Academic Year : **2018-2019**

Semester : **II** UNIT NO.: ………**II**…………

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

Course/Subject: …**Switch Gear and Protection**…Course Code: ..**GR15A3022..**

Name of the Faculty: …**Dr. J.Sridevi,P.Srividyadevi**……………………..…………..Dept.: …**EEE**………

Designation: PROFESSOR ,ASST.PROFESSOR

Lesson No	No. Of Periods	Topics / Sub - Topics	Obj &Out	References **(Text Book, Journal…** Page Nos.: ____to ____
1	2	Principle of Operation and Construction of Attracted armature, Balanced Beam,	2, 3 & 1,2,3, 4	T1:26.9,26.10 T2: 2.1 R2:1.1 R4:14.4 R6:3.2
2	2	Principle of Operation and Construction of induction Disc and Induction Cup relays	2, 3 & 1,2,3, 4	T1: 26.10,26.12 T2: 2.1 R2:1.6 R4:14.4 R6:3.2
3	2	Direction relays, Differential Relays Impedance, Reactance	2, 3 & 1,2,3, 4	T2: 3.10,3.11,4.1,4.2,4.5 to 4.20 T1: 27.10,28.1,29.6,29.8,29.9 R2:7.2,7.3 R4:14.8,14.12,14.7,14.10 R6:4.7,4.9,3.3
4	2	Mho and Off-Set Mho relays	2, 3 & 1,2,3, 4	T2: 3.10,3.11,4.1,4.2,4.5 to 4.20 T1: 27.10,28.1,29.6,29.8,29.9 R2:7.2,7.3 R4:14.8,14.12,14.7,14.10 R6:4.7,4.9,3.3

GOKARAJU RANGARAJU
INSTITUTE OF ENGINEERING AND TECHNOLOGY

Department of Electrical & Electronics Engineering

SCHEDULE OF INSTRUCTIONS
UNIT PLAN-III

Academic Year : **2018-2019**

Semester : **II** UNIT NO.: ……III……….

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

Course/Subject: …**Switch Gear and Protection**…Course Code: ..**GR15A3022..**

Name of the Faculty: …**Dr. J.Sridevi,P.Srividyadevi**……..…………..Dept.: …**EEE**………

Designation: PROFESSOR ,ASST.PROFESSOR

Lesson No.	No. of Periods	Topics / Sub - Topics	Objectives & Outcomes Nos.	References **(Text Book, Journal…)** Page Nos.: ____to ____
1	2	Protection of generators against Stator faults	2, 3 & 1,2,5	T2 : 6.1 T1 : 33.2,33.8 R2 : 16.3 R4 : 14.11 R6 : 6.3
2	2	Protection of generators against Rotor faults.	2, 3 & 1,2,5	T2 : 6.1 T1 : 33.12 R2 : 16.3 R4 : 14.11 R6 : 6.3
3	2	Abnormal Conditions	2, 3 & 1,2,5	T2 : 6.1 T1 : 33.12 R2-16.3 R4-14.11 R6-6.3
4	2	Problems	2, 3 & 1,2,5	T2 : 6.1 T1 : 33.12 R2-16.3 R4-14.11 R6-6.3

5	2	Problems	2, 3 & 1,2,5	T2 : 6.1 T1 : 33.12 R2-16.3 R4-14.11 R6-6.3
6	2	Protection of transformers: Percentage Differential Protection	2, 3 & 1,2,5	T2 : 6.2 T1 :32.5 R2-7.8
7	2	Restricted Earth fault and Inter turn fault Protection	2, 3 & 1,2,5	T2 : 6.2 T1 :32.5 R2-7.8
8	2	Translay Relay.	2, 3 & 1,2,5	T2 : 6.2 T1 :32.5 R2-7.8
9	2	Protection of Bus bars – Differential protection	2, 3 & 1,2,5	T2 : 6.2 T1 :32.5 R2-7.8
10	2	Problems	2, 3 & 1,2,5	T2 : 6.2 T1 :32.5 R2-7.8

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Department of Electrical & Electronics Engineering

SCHEDULE OF INSTRUCTIONS
UNIT PLAN-IV

Academic Year : **2018-2019**

Semester : **II** UNIT NO.: ………**IV**……….
Name of the Program: **B.Tech** ……..…**Electrical**……..… Year: ……**III**………. Section: A&B

Course/Subject: …**Switch Gear and Protection**…Course Code: ..**GR15A3022..**

Name of the Faculty: …**Dr. J.Sridevi,P.Srividyadevi**………..…………..Dept.: …**EEE**………

Designation: PROFESSOR ,ASST.PROFESSOR

Lesson No.	No. of Periods	Topics / Sub - Topics	Objectives & Outcomes Nos.	References (**Text Book, Journal…**) Page Nos.: ____ to ____
1	2	Grounded and Ungrounded Neutral Systems.	2, 3 & 1,2,6	T1 18.15,1.16,1.17,1.22 R4-11.11,11.2.11.5
2	2	Methods of Neutral Grounding: Solid Resistance	2, 3 & 1,2,6	T1 : 18.23 R4- 11.4
3	2	Arcing Grounds	2, 3 & 1,2,6	T1 : 18.21,18.24 R4 : 11.6
4	2	Grounding Practices.	2, 3 & 1,2,6	T1 : 18.21,18.24

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Department of Electrical & Electronics Engineering

SCHEDULE OF INSTRUCTIONS
UNIT PLAN-V

Academic Year : **2018-2019**

Semester : **II** UNIT NO.: ……**V**……….
Name of the Program: **B.Tech** ……..…**Electrical**……..… Year: ……**III**………. Section: A&B

Course/Subject: …**Switch Gear and Protection**…Course Code: .**GR15A3022..**

Name of the Faculty: …**Dr. J.Sridevi,P.Srividyadevi**……………………..…………..Dept.: …**EEE**………

Designation: PROFESSOR ,ASST.PROFESSOR

Lesson No	No.of Period	Topics / Sub - Topics	Objectives & Outcomes No	References **(Text Book, Journal…)** Page Nos.: ____to ____
1	2	Generation of Over Voltages in Power Systems.-Protection Against Lightning Over Voltage	2.3,4& 1,2,7	T2-11.10,11.11
2	2	Valve type and Zinc Oxide Lighting Arresters	2.3,4& 1.2.7	T2-11.10,11.11
3	2	Insulation and Coordination -BIL,	2.3,4& 1,2.7	T2-11.10,11.11
4	2	Impulse Ratio Standard Impulse Test Wave,	2, 3,4 & 1,2.7	T2 : 11.11
5	2	Volt-Time Characteristics and Insulation Co-ordination	2, 3,4 & 1,2.7	T2 : 11.11
6	2	Problems	2, 3 ,4& 1,2,7	T2 : 11.11
7	2	revision		

Department of Electrical & Electronics Engineering

LESSON PLAN-1

Academic Year : **2018-2019**

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

Course/Subject: …**Switch Gear and Protection**…Course Code: ..**GR15A3022..**

Name of the Faculty: …**Dr. J.Sridevi,P.Srividyadevi**………..…………..Dept.: …**EEE**………

Designation: PROFESSOR ,ASST.PROFESSOR

Lesson No: 1 **Duration of Lesson:** 90 min

Lesson Title: Circuit Breakers - 1

INSTRUCTIONAL/LESSON OBJECTIVES:

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

1. Elementary principles of arc interruption Circuit Breakers, Recovery, Restriking Voltage and Recovery voltages

2. Current chopping and Resistance switching, CB ratings and Specifications: Types and Numerical

TEACHING AIDS : Power Point Presentation, White board, White board marker.
TEACHING POINTS :

In detail about arc interruption Circuit Breakers Restriking Phenomenon, Restriking Voltage and Recovery voltages Current chopping and Resistance switching

Assignment / Questions: Explain Current chopping and Resistance switching

Objectives and Outcomes Nos. 1, 3 &1,2,3

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LESSON PLAN-2

Academic Year : 2018-2019

Semester : II

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

Course/Subject: Switch Gear and Protection **Course Code:** GR15A3022

Name of the Faculty: Dr. J.Sridevi, P.Srividyadevi **Dept.:** EEE

Designation: PROFESSOR &ASSISTANTPROFESSOR

Lesson No: 2 **Duration of Lesson:** 90 min

Lesson Title: Circuit Breakers - 1

INSTRUCTIONAL/LESSON OBJECTIVES:

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

1. Elementary principles of Recovery, Restriking Voltage and Recovery voltages, Average and Max. RRRV, Average and Max. RRRV
2. Problem

TEACHING AIDS : Power Point Presentation, White board, White board marker.
TEACHING POINTS :

Restriking Phenomenon, Restriking Voltage and Recovery voltages Average and Max. RRRV, Average and Max. RRRV

Assignment / Questions:Derive Restriking Voltage

Objectives and Outcomes Nos. 2, 3 &1,2,3

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LESSON PLAN-3

Academic Year : 2018-2019

Semester : II

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

Course/Subject: Switch Gear and Protection **Course Code:** GR15A3022

Name of the Faculty: Dr. J.Sridevi,P.Srividyadevi **Dept.:** EEE

Designation: ASSISTANTPROFESSOR

Lesson No: III **Duration of Lesson:** 90 min

Lesson Title: Circuit Breakers - 1

INSTRUCTIONAL/LESSON OBJECTIVES:

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

1. Current chopping and Resistance switching, CB ratings and Specifications: Types and Numerical Problems. – Auto reclosures

TEACHING AIDS : Power Point Presentation, White board, White board marker.
TEACHING POINTS :

Current chopping and Resistance switching CB ratings and Specifications Auto reclosures

Assignment / Questions: What is Current Chopping
Objectives and Outcomes Nos. 2, 3 &1,2,3

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Department of Electrical & Electronics Engineering

LESSON PLAN-4

Academic Year : 2018-2019

Semester : II

Name of the Program: B.Tech EEE Year: III Section: A&B

Course/Subject: Switch Gear and Protection Course Code: GR15A3022

Name of the Faculty: Dr. J.Sridevi,P.Srividyadevi Dept.: EEE

Designation: ASST.PROFESSOR

Lesson No: IV Duration of Lesson: 90 min

Lesson Title: Circuit Breakers-1

INSTRUCTIONAL/LESSON OBJECTIVES:

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

1. Description and Operation of Minimum Oil Circuit breakers.
2. Description and Operation of Air Blast Circuit Breakers

TEACHING AIDS : Power Point Presentation, White board, White board marker.

TEACHING POINTS :

In detail about different types of Circuit Breakers and their description and operation

Assignment / Questions: Explain Operation of Min. Oil Circuit Breaker

Objectives and Outcomes Nos. 2, 3 & 1,2,3

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Department of Electrical & Electronics Engineering

LESSON PLAN-5

Academic Year : 2018-2019

Semester : **II**

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

Course/Subject: Switch Gear and Protection **Course Code:** GR15A3022

Name of the Faculty: Dr. J.Sridevi,P.Srividyadevi **Dept.**: EEE

Designation: ASST.PROFESSOR

Lesson No: 5 **Duration of Lesson:** 90 min

Lesson Title: Circuit Breakers-1

INSTRUCTIONAL/LESSON OBJECTIVES:

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

1. Description and Operation of Vacuum circuit breakers,
2. Description and Operation of SF6 circuit breakers

TEACHING AIDS : Power Point Presentation, White board, White board marker.

TEACHING POINTS :

In detail about different types of Circuit Breakers and their description and operation

Assignment / Questions:

Objectives and Outcomes Nos.
2, 3 & 1,2,3

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Department of Electrical & Electronics Engineering

LESSON PLAN-6

Academic Year : 2018-2019

Semester : **II**

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

Course/Subject: Switch Gear and Protection **Course Code:** GR15A3022

Name of the Faculty: Dr. J.Sridevi,P.Srividyadevi **Dept.**: EEE

Designation: PROFESSOR,ASST. PROFESSOR **Duration of Lesson:** 90 min

Lesson No: 6

INSTRUCTIONAL/LESSON OBJECTIVES:

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

1. Problems

TEACHING AIDS : Power Point Presentation, White board, White board marker.
TEACHING POINTS :

In detail about Relays and its operation and their classification. Different types of Relays and their applications.

Assignment / Questions: Problems

Objectives and Outcomes Nos. 2, 3 & 1,2,3

Department of Electrical & Electronics Engineering

LESSON PLAN-7

Academic Year : 2018-2019

Semester : **II**

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

Course/Subject: Switch Gear and Protection **Course Code:** GR15A3022

Name of the Faculty: Dr. J.Sridevi,P.Srividyadevi **Dept.**: EEE

Designation: PROFESSOR,ASST. PROFESSOR

Duration of Lesson: 90 min

Lesson No: 7
Lesson Title: Electromagnetic and Static Relays

INSTRUCTIONAL/LESSON OBJECTIVES:

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

2. Principle of Operation and Construction of Attracted armature relays, Principle of Operation and Construction of Balanced Beam relays

TEACHING AIDS : Power Point Presentation, White board, White board marker.
TEACHING POINTS :

In detail about Relays and its operation and their classification. Different types of Relays and their applications.

Assignment / Questions:Explain Balanced beam Relay

Objectives and Outcomes Nos. 2, 3 & 1,2,4

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Department of Electrical & Electronics Engineering

LESSON PLAN-8

Academic Year : 2018-2019

Semester : **II**

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

Course/Subject: Switch Gear and Protection **Course Code:** GR15A3022

Name of the Faculty: Dr. J.Sridevi,P.Srividyadevi **Dept.**: EEE

Designation: PROFESSOR,ASST. PROFESSOR

Lesson No: 8 **Duration of Lesson:** 90 min

Lesson Title: Electromagnetic and Static Relays

INSTRUCTIONAL/LESSON OBJECTIVES:

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

1.Principle of Operation and Construction of induction Disc relays, Principle of Operation and Construction of Induction Cup relays

TEACHING AIDS : Power Point Presentation, White board, White board marker.
TEACHING POINTS :

In detail about Relays and its operation and their classification. Different types of Relays and their applications.

Assignment / Questions: Write about Induction cup relay

Objectives and Outcomes Nos. 2, 3 & 1,2,4

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Department of Electrical & Electronics Engineering

LESSON PLAN-9

Academic Year : 2018-2019

Semester : II

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

Course/Subject: Switch Gear and Protection **Course Code:** GR15A3022

Name of the Faculty: Dr. J.Sridevi,P.Srividyadevi **Dept.**: EEE

Designation: PROFESSOR,ASST. PROFESSOR

Lesson No: 9 **Duration of Lesson: 90 min**

Lesson Title: Electromagnetic and Static Relays

INSTRUCTIONAL/LESSON OBJECTIVES:

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

1. Relays Classification: Instantaneous, DMT and IDMT types, Over current/ Under voltage relays
2. Direction relays, Differential Relays, Percentage Differential Relays, Impedance, Reactance relays, Mho and Off-Set Mho relays, Characteristics of Distance Relays and Comparison, Electromagnetic Relays.

TEACHING AIDS : Power Point Presentation, White board, White board marker.
TEACHING POINTS :

In detail about Relays and its operation and their classification.

Different types of Relays and their applications.

Assignment / Questions: Write about DMT relays

Objectives and Outcomes Nos. 2, 3 & 1,2,4

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Department of Electrical & Electronics Engineering

LESSON PLAN-10

Academic Year : 2018-2019

Semester : **II**

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

Course/Subject: Switch Gear and Protection **Course Code** : GR15A3022

Name of the Faculty: Dr. J.Sridevi,P.Srividyadevi **Dept.**: EEE

Designation: PROFESSOR,ASST. PROFESSOR

Lesson No: 10 **Duration of Lesson: 90 min**

Lesson Title: Electromagnetic and Static Relays

INSTRUCTIONAL/LESSON OBJECTIVES:

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

1. Explain Mho relays Relays
2. Write about characteristics of off set MHO Relay

TEACHING AIDS : Power Point Presentation, White board, White board marker.
TEACHING POINTS :

In detail about Relays and its operation and their classification.

Different types of Relays and their applications.

Assignment / Questions:Compare Characteristics of MHO and off set MHO relay

Objectives and Outcomes Nos. 2, 3 & 1,2,4

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Department of Electrical & Electronics Engineering

LESSON PLAN-11

Academic Year : 2018-2019

Semester : **II**

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

Course/Subject: Switch Gear and Protection **Course Code:** GR15A3022

Name of the Faculty: Dr. J.Sridevi,P.Srividyadevi **Dept.**: EEE

Designation: PROFESSOR,ASST. PROFESSOR

Lesson No: 11 **Duration of Lesson:** 90 min

Lesson Title: Protection of Power Systems Equipment

INSTRUCTIONAL/LESSON OBJECTIVES:

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

1. Protection of generators against Stator faults

TEACHING AIDS : Power Point Presentation, White board, White board marker.

TEACHING POINTS :

Protection of Generators against faults (i.e stator faults)

Assignment / Questions: Explain different types of Stator Faults

Objectives and Outcomes Nos2, 3 & 1,2,5

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LESSON PLAN-12

Academic Year : 2018-2019

Semester : **II**

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

Course/Subject: Switch Gear and Protection **Course Code:** GR15A3022

Name of the Faculty: Dr. J.Sridevi,P.Srividyadevi **Dept.**: EEE

Designation: PROFESSOR,ASST. PROFESSOR

Lesson No: 12 **Duration of Lesson:** 90 min

Lesson Title: Protection of Power Systems Equipment

INSTRUCTIONAL/LESSON OBJECTIVES:

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

1. Protection of generators against Rotor faults

TEACHING AIDS : Power Point Presentation, White board, White board marker.

TEACHING POINTS :

Protection of Generators against faults (i.e Rotor faults)

Assignment / Questions: Explain Different types of Rotor Faults

Objectives and Outcomes Nos 2, 3 & 1,2,5

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Department of Electrical & Electronics Engineering

LESSON PLAN-13

Academic Year : 2018-2019

Semester : **II**

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

Course/Subject: Switch Gear and Protection **Course Code:** GR15A3022

Name of the Faculty: Dr. J.Sridevi,P.Srividyadevi **Dept.**: EEE

Designation: PROFESSOR,ASST. PROFESSOR

Lesson No: 13 **Duration of Lesson:** 90 min
Lesson Title: Protection of Power Systems Equipment

INSTRUCTIONAL/LESSON OBJECTIVES:

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

1. Protection of generators against Abnormal Conditions

TEACHING AIDS : Power Point Presentation, White board, White board marker.
TEACHING POINTS :

Protection of Generators against faults

Assignment / Questions: Explain Different types of Abnormal Conditions

Objectives and Outcomes Nos 2, 3 & 1,2,5

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Department of Electrical & Electronics Engineering

LESSON PLAN-14 & 15

Academic Year : 2018-2019

Semester : **II**

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

Course/Subject: Switch Gear and Protection **Course Code:** GR15A3022

Name of the Faculty: Dr. J.Sridevi,P.Srividyadevi **Dept.**: EEE

Designation: PROFESSOR,ASST. PROFESSOR

Lesson No: 14,15 **Duration of Lesson:** 90 min

Lesson Title: Protection of Power Systems Equipment

INSTRUCTIONAL/LESSON OBJECTIVES:

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

1. Protection of generators against Stator faults , Problems

TEACHING AIDS : Power Point Presentation, White board, White board marker.

TEACHING POINTS :

Protection of Generators against faults (Problems)

Assignment / Questions: Problems

Objectives and Outcomes Nos 2, 3 & 1,2,5

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Department of Electrical & Electronics Engineering

LESSON PLAN-16

Academic Year : 2018-2019

Semester : **II**

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

Course/Subject: Switch Gear and Protection **Course Code:** GR15A3022

Name of the Faculty: Dr. J.Sridevi,P.Srividyadevi **Dept.**: EEE

Designation: PROFESSOR,ASST. PROFESSOR

Lesson No: 16 **Duration of Lesson:** 90 min

Lesson Title: Protection of Power Systems Equipment

INSTRUCTIONAL/LESSON OBJECTIVES:

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

1. Protection of transformers: Percentage Differential Protection
2. Numerical Problem on Design of CT s Ratio

TEACHING AIDS
TEACHING POINTS

In detailabout transformer faults and how to overcome these faults. Protection system for Transformers and the devices used for protection

Assignment / Questions: Explain Percentage Differential Protection

Objectives and Outcomes Nos. 2, 3 & 1,2,5

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INSTITUTE OF ENGINEERING AND TECHNOLOGY

Department of Electrical & Electronics Engineering

LESSON PLAN-17

Academic Year : 2018-2019

Semester : **II**

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

Course/Subject: Switch Gear and Protection **Course Code:** GR15A3022

Name of the Faculty: Dr. J.Sridevi,P.Srividyadevi **Dept.**: EEE

Designation: PROFESSOR,ASST. PROFESSOR

Lesson No: 17 **Duration of Lesson:** 90 min

Lesson Title: Protection of Power Systems Equipment

INSTRUCTIONAL/LESSON OBJECTIVES:

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

1. Restricted Earth fault and Inter turn fault Protection

TEACHING AIDS : Power Point Presentation, White board, White board marker.

TEACHING POINTS :

1. In detail about Abnormal Conditions. Restricted Earth fault and Inter turn fault Protection

.

Assignment / Questions: Write about Restricted Earth fault and Inter turn fault Protection

Objectives and Outcomes Nos. 2, 3 & 1,5

LESSON PLAN-18

Academic Year : 2018-2019

Semester : II

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

Course/Subject: Switch Gear and Protection **Course Code:** GR15A3022

Name of the Faculty: Dr. J.Sridevi,P.Srividyadevi **Dept.:** EEE

Designation: PROFESSOR,ASST. PROFESSOR

Lesson No: 18 **Duration of Lesson:** 90min

Lesson Title: Protection of Power Systems Equipment

INSTRUCTIONAL/LESSON OBJECTIVES:

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

1. Translay Relay

TEACHING AIDS : Power Point Presentation, White board, White board marker.

TEACHING POINTS :

Translay Relay

Assignment / Questions: Explain Translay Relay

Objectives and Outcomes Nos. 2, 3 & 1,2,5

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Department of Electrical & Electronics Engineering

LESSON PLAN-19

Academic Year : 2018-2019

Semester : II

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

Course/Subject: Switch Gear and Protection **Course Code:** GR15A3022

Name of the Faculty: Dr. J.Sridevi,P.Srividyadevi **Dept.:** EEE

Designation: PROFESSOR,ASST. PROFESSOR

Lesson No: 19 **Duration of Lesson:** 90 min

Lesson Title: Protection of Power Systems Equipment

INSTRUCTIONAL/LESSON OBJECTIVES:

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

1. Protection of Bus bars – Differential protection, Numerical Problems

TEACHING AIDS : Power Point Presentation, White board, White board marker.

TEACHING POINTS :

Different methods of Bus bar protection and protection of lines.

Assignment / Questions: Explain types of Bus Bar Protection

Objectives and Outcomes Nos. 2, 3 & 1,2,5

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LESSON PLAN-20

Academic Year : 2018-2019

Semester : II

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

Course/Subject: Switch Gear and Protection **Course Code:** GR15A3022

Name of the Faculty: Dr. J.Sridevi,P.Srividyadevi **Dept.:** EEE

Designation: PROFESSOR,ASST. PROFESSOR

Lesson No: 20 **Duration of Lesson:** 90 min

Lesson Title: Protection of Power Systems Equipment

INSTRUCTIONAL/LESSON OBJECTIVES:

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

1. Protection of Bus bars – Differential protection, Numerical Problems

TEACHING AIDS : Power Point Presentation, White board, White board marker.
TEACHING POINTS :

Different methods of Bus bar protection and protection of lines.

2. Assignment / Questions: Protection of Bus bars – Differential protection, Numerical Problems

Objectives and Outcomes Nos. 2, 3 & 1,2,5

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LESSON PLAN-21

Academic Year : 2018-2019

Semester : **II**

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

Course/Subject: Switch Gear and Protection **Course Code:** GR15A3022

Name of the Faculty: Dr. J.Sridevi,P.Srividyadevi **Dept.**: EEE

Designation: PROFESSOR,ASST. PROFESSOR

Lesson No: 21 **Duration of Lesson:** 90 min

Lesson Title: Neutral Grounding

INSTRUCTIONAL/LESSON OBJECTIVES:

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

1. Grounded and Ungrounded Neutral Systems, Effects of Ungrounded Neutral on system performance

TEACHING AIDS : Power Point Presentation, White board, White board marker.

TEACHING POINTS :

In detail about grounding with examples Ungrounded and grounded system in detail with its advantages and disadvantages.

Assignment / Questions: Expalin what is Neutral Grounding

Objectives and Outcomes Nos. 2, 3 & 1,2,6

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Department of Electrical & Electronics Engineering

LESSON PLAN-22

Academic Year : 2018-2019

Semester : **II**

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

Course/Subject: Switch Gear and Protection **Course Code:** GR15A3022

Name of the Faculty: Dr. J.Sridevi,P.Srividyadevi **Dept.**: EEE

Designation: PROFESSOR,ASST. PROFESSOR

Lesson No: 22 **Duration of Lesson:** 90 min

Lesson Title: Neutral Grounding

INSTRUCTIONAL/LESSON OBJECTIVES:

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

1. Methods of Neutral Grounding: Solid, Resistance, Reactance

TEACHING AIDS : Power Point Presentation, White board, White board marker.
TEACHING POINTS :

Methods of neutral grounding

Assignment / Questions: Explain different methods of Neutral Grounding

Objectives and Outcomes Nos. 2, 3,5 & 1,2,

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LESSON PLAN-23

Academic Year : 2018-2019

Semester : II

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

Course/Subject: Switch Gear and Protection **Course Code:** GR15A3022

Name of the Faculty: Dr. J.Sridevi,P.Srividyadevi **Dept.**: EEE

Designation: PROFESSOR,ASST. PROFESSOR

Lesson No: 23 **Duration of Lesson:** 90min

Lesson Title: Neutral Grounding

INSTRUCTIONAL/LESSON OBJECTIVES:

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

1. Arcing Grounds

TEACHING AIDS : Power Point Presentation, White board, White board marker.

TEACHING POINTS :

Arcing Grounds

Assignment / Questions: Write about Arcing Grounds

Objectives and Outcomes Nos. 2, 3,5 & 1,2,6

GOKARAJU RANGARAJU
INSTITUTE OF ENGINEERING AND TECHNOLOGY

Department of Electrical & Electronics Engineering

LESSON PLAN-24

Academic Year : 2018-2019

Semester : **II**

Name of the Program: B.Tech EEE **Year:** III **Section: A/B**

Course/Subject: Switch Gear and Protection **Course Code:** GR15A3022

Name of the Faculty: Dr. J.Sridevi,P.Srividyadevi **Dept.**: EEE

Designation: PROFESSOR,ASST. PROFESSOR

Lesson No: 24 **Duration of Lesson:** 90min

Lesson Title: Neutral Grounding

INSTRUCTIONAL/LESSON OBJECTIVES:

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

1. Grounding Practices

TEACHING AIDS : Power Point Presentation, White board, White board marker.
TEACHING POINTS :

Grounding Practices

1. Assignment / Questions: Write about Grounding Practices

Objectives and Outcomes Nos. 2, 3 & 1,2,6

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Department of Electrical & Electronics Engineering

LESSON PLAN-25

Academic Year : 2018-2019

Semester : **II**

Name of the Program: B.Tech EEE **Year:** III **Section: A &B**
Course/Subject: Switch Gear and Protection **Course Code:** GR15A3022

Name of the Faculty: Dr. J.Sridevi,P.Srividyadevi **Dept.**: EEE

Designation: PROFESSOR,ASST. PROFESSOR

Lesson No: 25 **Duration of Lesson:** 90 min

Lesson Title: Protection against OverVoltages

INSTRUCTIONAL/LESSON OBJECTIVES:

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

1. Generation of Over Voltages in Power Systems, Protection against Lightning Over Voltages

TEACHING AIDS : Power Point Presentation, White board, White board marker.
TEACHING POINTS :

Generation of Over Voltages in power system and its causes.

Assignment / Questions: Explain Generation of Over Voltages in Power Systems

Objectives and Outcomes Nos. 2, 3 & 1,2,6

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Department of Electrical & Electronics Engineering

LESSON PLAN-26

Academic Year : 2018-2019

Semester : II

Name of the Program: B.Tech EEE **Year:** III **Section: A &B**
Course/Subject: Switch Gear and Protection **Course Code:** GR15A3022

Name of the Faculty: Dr. J.Sridevi,P.Srividyadevi **Dept.**: EEE

Designation: PROFESSOR,ASST. PROFESSOR

Lesson No: 26 **Duration of Lesson:** 90 min

Lesson Title: Protection against OverVoltages

INSTRUCTIONAL/LESSON OBJECTIVES:

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

1. Valve type and Zinc-Oxide Lighting Arresters

TEACHING AIDS : Power Point Presentation, White board, White board marker.
TEACHING POINTS :

Lightning and types of lightning strokes and its effects

Assignment / Questions: Write about Arresters

Objectives and Outcomes Nos. 2, 3 ,4,5& 1,2,7

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Department of Electrical & Electronics Engineering

LESSON PLAN-27

Academic Year : 2018-2019

Semester : **II**

Name of the Program: B.Tech EEE **Year:** III **Section: A &B**
Course/Subject: Switch Gear and Protection **Course Code:** GR15A3022

Name of the Faculty: Dr. J.Sridevi,P.Srividyadevi **Dept.**: EEE

Designation: PROFESSOR,ASST. PROFESSOR

Lesson No: 27 **Duration of Lesson:** 90 min

Lesson Title: Protection against OverVoltages

INSTRUCTIONAL/LESSON OBJECTIVES:

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

1. Insulation and Coordination-BIL,

TEACHING AIDS : Power Point Presentation, White board, White board marker.
TEACHING POINTS :

Insulation and Coordination-BIL

Assignment / Questions: what is BIL

Objectives and Outcomes Nos. 2, 3,5,4 & 1,2
,7

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Department of Electrical & Electronics Engineering

LESSON PLAN-28

Academic Year : 2018-2019

Semester : **II**

Name of the Program: B.Tech EEE **Year:** III **Section: A &B**
Course/Subject: Switch Gear and Protection **Course Code:** GR15A3022

Name of the Faculty: Dr. J.Sridevi,P.Srividyadevi **Dept.**: EEE

Designation: PROFESSOR,ASST. PROFESSOR

Lesson No: 28 **Duration of Lesson:** 90 min

Lesson Title: Protection against OverVoltages

INSTRUCTIONAL/LESSON OBJECTIVES:

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

1. Impulse Ratio and Standard Impulse Test Wave

TEACHING AIDS : Power Point Presentation, White board, White board marker.
TEACHING POINTS :

Impulse Ratio and Standard Impulse Test Wave

Assignment / Questions: Explain Impulse Ratio

Objectives and Outcomes Nos. 2, 3,4,5 & 1,2,7

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Department of Electrical & Electronics Engineering

LESSON PLAN-29

Academic Year : 2018-2019

Semester : **II**

Name of the Program: B.Tech EEE **Year:** III **Section: A &B**
Course/Subject: Switch Gear and Protection **Course Code:** GR15A3022

Name of the Faculty: Dr. J.Sridevi,P.Srividyadevi **Dept.**: EEE

Designation: PROFESSOR,ASST. PROFESSOR

Lesson No: 29 **Duration of Lesson:** 90 min

Lesson Title: Protection against OverVoltages

INSTRUCTIONAL/LESSON OBJECTIVES:

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

1. Volt-Time Characteristics and Insulation Co-ordination

TEACHING AIDS : Power Point Presentation, White board, White board marker.
TEACHING POINTS :

Volt-Time Characteristics and Insulation Co-ordination

Assignment / Questions: Explain Insulation Co-ordination

Objectives and Outcomes Nos. 2, 3,4,5 & 1,2,7

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Department of Electrical & Electronics Engineering

LESSON PLAN-30

Academic Year : 2018-2019

Semester : **II**

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

Course/Subject: Switch Gear and Protection **Course Code:** GR15A3022

Name of the Faculty: Dr. J.Sridevi,P.Srividyadevi **Dept.**: EEE

Designation: PROFESSOR,ASST. PROFESSOR

Lesson No: 30 **Duration of Lesson:** 90 min

Lesson Title: Protection against OverVoltages

INSTRUCTIONAL/LESSON OBJECTIVES:

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

1. Numerical Problems

TEACHING AIDS : Power Point Presentation, White board, White board marker.
TEACHING POINTS :

Numerical Problems

Assignment / Questions: Numerical Problems

Objectives and Outcomes Nos. 2, 3.5.4.1 & 1,2,7

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Department of Electrical & Electronics Engineering

ASSIGNMENT SHEET – 1

Academic **Y**ear : 2018-2019

Semester : I

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

Course/Subject: …**Switch Gear and Protection**…Course Code: ..**GR15A3022**.

Name of the Faculty: …… **: Dr. J.Sridevi,P.Srividyadevi** ………..Dept.: …**EEE**………

Designation: PROFESSOR ,ASST.PROFESSOR

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

1.What is arc quenching? Explain different arc quenching theories

2.Explain how the arc is initiated and sustained in a circuit breaker when the circuit breaker contacts separated

3.Discuss about the ratings of circuit breakers.
4. Explain Working Principle of Relay

5. Classify different types of Relays

6.Explain about Induction cup type relay

7.What are Characteristics of over current relay

8. Write a Short notes on Under Voltage relay

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

Outcome Nos.: ……………………1,2.3…………………………………………………….

Signature of HOD Signature of faculty

Date: Date:

GOKARAJU RANGARAJU
INSTITUTE OF ENGINEERING AND TECHNOLOGY

Department of Electrical & Electronics Engineering

ASSIGNMENT SHEET – 2

Academic **Y**ear : 2018-2019

Semester : I

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

Course/Subject: …**Switch Gear and Protection**…Course Code: ..**GR15A3022**.

Name of the Faculty: ……**Dr. J.Sridevi,P.Srividyadevi** …………..Dept.: …**EEE**………

Designation: PROFESSOR ,ASST.PROFESSOR

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

1. Write a Short notes on Protection of Busbars
2.Illustrate the following on Protections of lines
   a. Carrier Current and Zonal Protection
   b. Transley relay
3. Describe the operation of Buchholz relay and list its advantages and disadvantages
4.Write a short notes on miscellaneous faults
5.A 11kV 3 phase alternator has a rated current of 200A ,reactance armature winding is 15%.The differential protection is said to operate on earth fault currents more than 200A . Find the neutral earthing resistance which gives earth fault protection to 90% of stator winding
6. Advantages and Disadvantages of ligtening arresters
7. Write about Neutral Grounding

.

Objective Nos.: …………………… 1,2,4,5……………………………………………………….

Outcome Nos.: ……………………1,2,5,6,7…………………………………………………….

Signature of HOD   Signature of faculty

Date: Date:

GOKARAJU RANGARAJU
INSTITUTE OF ENGINEERING AND TECHNOLOGY

Department of Electrical & Electronics Engineering

TUTORIAL SHEET – 1

Academic **Y**ear : 2018-2019

Semester : I

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

Course/Subject: …**Switch Gear and Protection**…Course Code: ..**GR15A3022**.

Name of the Faculty: ……**M. Rekha** ………………..……………...Dept.: …**EEE**………

Designation: PROFESSOR ,ASST.PROFESSOR

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

Q1. A 250V d.c. shunt motor drives a load whose torque remains constant. The motor takes a current of 22.5A from the supply and its speed is 400 rpm. If the speed is to be raised to 600 rpm, what additional resistance must be placed in the shunt field circuit? Shunt field resistance is 100 Ω and armature resistance is 0.5Ω.

.

Q2. A Motor Works on 2 mints load cycle constituted as follows:
0 to 15 sec. load rising from 0 to 1050 h.p., 15 to 85 sec. constant load of 600 h.p., 85 to 95 sec. Regenerative braking with the h.p returned falling uniformly from 200 to 0 h.p., 95 to 120 sec. Motor is at rest. Determine the continuous rating of the motor that would be suitable for the load Cycle. Assume the rating to depend upon the (i) r.m.s value of the loading (ii) average value of Loading.

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

Outcome Nos.: ……………………1,2,3……………………………………………………….

Signature of HOD Signature of faculty

Date: Date:

GOKARAJU RANGARAJU
INSTITUTE OF ENGINEERING AND TECHNOLOGY

Department of Electrical & Electronics Engineering

TUTORIAL SHEET – 2

Academic **Y**ear : 2018-2019

Semester : I

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

Course/Subject: …**Switch Gear and Protection**…Course Code: ..**GR15A3022**.

Name of the Faculty: ……**Dr. J.Sridevi,P.Srividyadevi** ………………….……………..Dept.: …**EEE**………

Designation: PROFESSOR ,ASST.PROFESSOR

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

Q1 Six resistances each of 40 ohms are used as heating elements in furnace. Find the power of the furnace for various connections to a three phase 230V supply.

Q2. A 20KW single phase 230V resistance oven employs a circular Nichrome wire for its heating element. If the wire temperature is not to exceed 1170^{0} C and temperature of charge to be 500^{0} C, calculate diameter and length of the wire. Take K=0.57, e=0.95 and ρ=1.09 micro ohm-m. What would be the temperature of the element when the charge is cold?

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

Outcome Nos.: ……………………1.2.4………………………………………………………….

Signature of HOD Signature of faculty

Date: Date:

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Department of Electrical & Electronics Engineering

TUTORIAL SHEET – 3

Academic **Y**ear : 2018-2019

Semester : I

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

Course/Subject: …**Switch Gear and Protection**…Course Code: ..**GR15A3022**.

Name of the Faculty: ……**Dr. J.Sridevi,P.Srividyadevi** ……………….……………….Dept.: …**EEE**………

Designation: PROFESSOR ,ASST.PROFESSOR

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

Q1. Determine the effective illumination of a room 12m x 15m, illuminated by 15 lamps of 200 watts each. The luminous efficiency of each lamp is given as 12 lumens /watt. Given coefficient of utilization as 0.4. Let D.F. =0.8 and waste light factor = 1.2.Q2. Write a short notes on Bunsen photometer head.

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

Outcome Nos.: ……………………1,2,5……………………………………………………….

Signature of HOD | Signature of faculty

Date: | Date:

TUTORIAL SHEET – 4

Academic **Y**ear : 2018-2019

Semester : I

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

Course/Subject: …**Switch Gear and Protection**…Course Code: ..**GR15A3022**.

Name of the Faculty: ……**Dr. J.Sridevi,P.Srividyadevi** ……………….……………..Dept.: …**EEE**………

Designation: PROFESSOR ,ASST.PROFESSOR

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

Q1 A train is to be run between two stations 5kms apart at an average speed of 50km/hr. If the maximum speed is to be limited to 70km/hr, acceleration to 2km/hr/sec, braking retardation to 4km/hr/sec and coasting retardation to 0.1km/hr/sec, determine the speed at the end of coasting, duration of coasting period and braking period.

Q2. A train runs with average speed of 40 kmph, Distance between stations is 2 Km, Values of acceleration and retardation are 1.5 Kmphps and 2.5 Kmphps respectively. Find the maximum speed of train assuming trapezoidal speed time curve.

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

Outcome Nos.: …………………1,2,6………………………………………………………….

Signature of HOD

Date:

Signature of faculty

Date:

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Department of Electrical & Electronics Engineering

TUTORIAL SHEET – 5

Academic **Y**ear : 2018-2019

Semester : I

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

Course/Subject: …**Switch Gear and Protection**…Course Code: ..**GR15A3022**.

Name of the Faculty: ……**Dr. J.Sridevi,P.Srividyadevi** ………………..Dept.: …**EEE**………

Designation: PROFESSOR ,ASST.PROFESSOR

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

Q1. Calculate the specific energy consumption if a maximum speed of 12.2 m/s and for a given run of 1,525 meters an acceleration of 0.366 m/s^2 are desired. Train resistance during acceleration is 52.6 Newtons/1000 kg and during coasting is 6.12 newtons/1000 kg, 10% being allowable for rotational inertia. The efficiency of the equipment during the acceleration period is 50%. Assume a quadrilateral speed- time curve.

Q2. An elective train has an average speed of 45kmph on a level track between stops 1800m apart. It is accelerated at 2 kmphps and braked at 3 kmphps. Draw the speed time curve for the run. Estimate the energy consumption at the axles of the train per tonne – km. Take train resistance constant at 45 N per tonne and allow 10 % for rotational inertia.

Objective Nos.: …………………… 1,2,5……………………………………………………….

Outcome Nos.: …………………1,2.7…………………………………………………….

Signature of HOD

Date:

Signature of faculty

Date:

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Department of Electrical & Electronics Engineering

COURSE OBJECTIVES

Academic **Y**ear :2018-19

Semester : **II**

Name of the Program: EEE……… Year:B.Tech III**………..**… Section:A/B

Course/Subject: ……Switch Gear and Protection…… CourseCode: **GR15A3022**

Name of the Faculty: Dr. J.Sridevi,P.Srividyadevi Dept.EEE:…………

Designation: PROFESSOR ,ASST.PROFESSOR

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

S.No **Objectives**

The objective of this course is to provide the student:

1. Introduction to power system protection and switchgear.
2. Description of main components used in power system such as protection for electric machines, transformers, bus bars, overhead and underground feeders.
3. Visualize construction, working and applications of Circuit breakers and Relays.
4. To develop an ability and skill to design the feasible protection systems needed for each main part of a power system in students.
5. Knowledge about protection against over voltages and effects of grounded and ungrounded systems.

Signature of HOD Signature of faculty

Date: Date:

Note: Please refer to Bloom's Taxonomy, to know objectives.

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Department of Electrical & Electronics Engineering

COURSE OUTCOMES

Academic **Y**ear :2018-19

Semester : **II**

Name of the Program:EEE**…**… Year:B.Tech III**………**.… Section: A/B

Course/Subject: Switch Gear and Protection CourseCode: **GR15A3022**

Name of the Faculty: Dr. J.Sridevi,P.Srividyadevi, Dept.: ……EEE…………

Designation: PROFESSOR ,ASST.PROFESSOR

The expected outcomes of the Course/Subject are:

Course Outcomes

At the end of the course, the student will be able to

1. Know different Protective Equipments in Power Systems
2. State the terms used for Switchgear and Protection.
3. Summarize different techniques for relays and circuit breakers in power systems
4. Analyze the types, characteristics and applications of Distance, OverCurrent and Differential relays.
5. Identify various protective schemes for Generators, Transformers, Transmission lines and Busbars.
6. Illustrate effects and types of Grounded and Ungrounded systems.
7. Generalize protection against over voltages for Power System equipment

Signature of HOD Signature of faculty

Date: Date:

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

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Department of Electrical & Electronics Engineering

CO-PO Mapping

Course Code	Course Title	Course Outcomes	Programme Outcomes											
			a	b	c	d	e	f	g	h	i	j	k	l
GR15A3022	SWITCH GEAR AND PROTECTION	Know different Protective Equipments in Power Systems	H	H	M	H	M	-	-	M	H	M	M	H
		State the terms used for Switchgear and Protection	M	M	M	H		-	-	M	M	H	M	H
		Summarize different techniques for relays and circuit breakers in power systems	H	H	M	H	M	M	-	M	M	H	M	H
		Analyze the types, characteristics and applications of Distance, OverCurrent and Differential relays.	H	H	M	H	M	-	-	M	M	M	M	H
		Identify various protective schemes for Generators, Transformers, Transmission lines and Busbars.	H	M	H	H	M	-	-	M	-	M	H	M
		Illustrate effects and types of Grounded and Ungrounded systems.	H	M	M	H	M	M	-	M	-	M	M	-
		Generalize protection against over voltages for Power System equipment	H	M	H	H	-	-	-	M	M	M	H	H

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Department of Electrical & Electronics Engineering

Academic Year: 2018-19 **Year: III** **Semester: II**	**MID Exam - I** **SWITCHGEAR AND PROTECTION**	**Date:4/2/19** **Duration:** **Max Marks: 15**

Note: Answer any three questions. All questions carry equal marks.

1	What is Restriking Voltage and Derive the expression for the RRRV with neat diagram [CO2]	
2	Classify circuit breakers and explain about SF6 Circuit breaker	[CO3]
3	Illustrate the Characteristics of Over current relay	[CO4]
4	Define the Following Terms a. Circuit Breaker b. Relay c. Fault clearing time d. Arcing time e. Current Chopping	[CO1]

Academic Year: 2018-19 **Year: III** **Semester: II**	**MID Exam – I (Objective)** **Switchgear and Protection**	**Date:4/2/19** **Max Marks: 5**

1. Time classification of relays includes [ ]
a) Instantaneous relays b) Definite time lag c) Inverse time lag d) All of these
2. Good relay should possess [ ]
a) Speed & reliability b) sensitivity c) Adequateness & selectivity d) All of these
3. In Resistance Switching, Resistance is connected to reduce [ ]
a) Restriking Voltage b) RRRV c) Transient Oscillations d) All
4. The function of protective relay in a circuit breaker is [ ]

a) to each any stray voltages

b) to close the contacts when the actuating quantity reaches a certain predetermined value

c) to limit arcing current during the operation of circuit breaker

d) to provide additional safety in the operation of circuit breaker.

5. Arc interruption is done by [ ]
a) High Resistance method b) Low current Method c) Both a and b d) none

Fill in the blanks:
6. RRRV stands for ______________________
7.________________ & ____________________ are types of Electromagnetic Relays.
8. Under voltage relays are used for___________________________
9. The fault clearing time of a circuit breaker is usually___________ (mins or sec or hours)
10. Air circuit breakers are used for voltages above _____________________________ kV

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Academic Year: 2018-19 **Year: III** **Semester: II**	**MID Exam - II** **SWITCHGEAR AND PROTECTION**	**Date:5/4/19** **Duration:** **Max Marks: 15**

Note: Answer any three questions. All questions carry equal marks.

1	What are the various types of differential relays write in brief	CO-4
2	Describe the operation of Buchholz relay and list its advantages and disadvantages	CO-5
3	Distinguish between neutral earthing and equipment earthing and Explain the necessity of Reactance grounding.	CO-6
4	Write short notes on a. Insulation coordination b. Basic Lightening impulse level(BIL)	CO-7

Academic Year: 2018-19 **Year: III** **Semester: II**	**MID Exam – II (Objective)** **Switchgear and Protection**	**Date:** **Max Marks: 5**

1.The lightning arrester acts as [ ]

a) Surge diverter b) Surge coil c) Surge absorber d) Surge reflector

2. Earth wire or ground wire is made of [ ]
   a) copper b) aluminium c) iron d) galvanized steel

3. Ground resistance should be designed such that: [ ]

   a) grounding resistance should be as low as possible b) grounding resistance should be as high as possible
   c) grounding resistance should be always zero d) none of the above
   a) Directional relays responds to [ ]
   Power b) voltage c) current d) reactance

4. The cheif cause of overspeed in an Alternator is [ ]

   a) Sudden loss of load b) overheating c) sudden increase in load d) None

5. Which of following are used to reduce short circuit fault currents [ ]

   a) reactors b) resistors c) capacitors d) Parallel combination of all these

6. Average resistance of human body is: [ ]

a) 500 ohms b) 1000 ohms c) 1500 ohms d) 2000 ohms

7. Generator internal fault protection is usually based the principle of [ ]

   a) differential protection b) cross-differential protection c) negative sequence protection d) All

8. Merz price circulating current principle is most suitable for _________than__________ [ ]

   a) Generators, Transformers b) Transformers, Generators
   c) Transmission lines, Transformers d) none

9. 10.Buchholz is ___________________type of relay [ ]

   a) Gas actuated b) Oil c) Liquid actuated d) None

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INSTITUTE OF ENGINEERING AND TECHNOLOGY

Department of Electrical & Electronics Engineering

GUIDELINES TO STUDY THE COURSE/SUBJECT

Academic **Y**ear :2018-19

Semester : II

Name of the Program: EEE…… Year: B. Tech III…… Section: A/B

Course/Subject: …Switch Gear and Protection Course Code: GR15A3022

Name of the Faculty: Dr. J.Sridevi,P.Srividyadevi Dept.: ……EEE…………

Designation: PROFESSOR ,ASST.PROFESSOR
Guidelines to study the Course/ Subject: Switch Gear and Protection

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

Signature of HOD Signature of faculty
Date: Date:

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INSTITUTE OF ENGINEERING AND TECHNOLOGY

Department of Electrical & Electronics Engineering

EVALUATION STRATEGY

Academic **Y**ear :2018-19

Semester : III

Name of the Program: EEE**…**… Year: B.Tech III**………**..… Section: A/B

Course/Subject:Switch Gear and Protection Course Code: GR14A3022

Name of the Faculty: Dr. J.Sridevi,P.Srividyadevi Dept.: ……EEE…………

Designation: PROFESSOR
,ASST.PROFESSOR

1. TARGET:

A) Percentage for pass:40%

b) Percentage of class:85%

2. COURSE PLAN& CONTENT DELIVERY
(Please write how you intend to cover the contents: i.e., coverage of Units/Lessons by lectures, design, exercises, solving numerical problems, demonstration of models, model preparation, experiments in the Lab., or by assignments,etc.)

3. METHOD OF EVALUATION

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

3.2 ☐ Assignments/Seminars

3.3 ☐ Quiz

3.4 ☐ Semester/End Examination

4. List out any new topic(s) or any innovation you would like to introduce in teaching the subjects in this
Semester.

……………………………………………………………………………………………..

Signature of HOD Signature of faculty

Date: Date:

Cognitive Level Mapping

COs	Cognitive Learning Levels					
	1	2	3	4	5	6
1		√				
2				√		
3			√			
4		√				
5		√				
6					√	
7						√

Cognitive Learning Levels

CLL 1: Remembering
CLL 2: Understanding
CLL 3: Applying
CLL 4: Analyzing
CLL 5: Evaluating
CLL 6: Creating

GOKARAJU RANGARAJU
INSTITUTE OF ENGINEERING AND TECHNOLOGY

Department of Electrical & Electronics Engineering

Sub:SGP Dept: EEE Academic Year: 2018-19

	Course Outcome	CO1	CO2	CO3	CO4	CO4	CO5	CO6	CO7
S.No	Total marks								
1	16241A0201				3	3			
2	16241A0202		5	5	5	5		5	5
3	16241A0203	5		5	5	5	5		5
5	16241A0205	5		1	5		5	5	5
6	16241A0206	3	1		5	5	5	5	
7	16241A0207	3	4			5	5	5	
8	16241A0208	2	2			AB	AB	AB	AB
9	16241A0209	4	5	3		5	5	5	
10	16241A0210	3	2		2		3		
11	16241A0211	2		1	5	5			5
12	16241A0212	3	4	3			5	4	3
13	16241A0213	2	4	3	5	4	4	3	
14	16241A0214	5				4		1	
16	16241A0216	AB	AB	AB	AB	0		4	
17	16241A0217	5	2	2	5	5	5	5	
18	16241A0218	5	2	1		4			2
19	16241A0219	5	2	5		5	5	5	
20	16241A0220	2	1	3		2	3	1	
21	16241A0221	4		3		4		4	
22	16241A0222		4		1	AB	AB	AB	AB
23	16241A0223	5	5		5	5	5		5
24	16241A0224	2			4	4			4
25	16241A0225	4	4		3	4	4	4	
26	16241A0226	5			5	5	4		
27	16241A0227	5	2		5		3	5	5
28	16241A0228	2	1	4	1	4		2	1
29	16241A0229	4		1		3	4		
30	16241A0230	5		5		4	4	3	
31	16241A0231	5			5	5	5	3	
32	16241A0232	AB	AB	AB	AB	4	4		
33	16241A0233	5		1		2	2		
34	16241A0234	3		1	2	5		4	4
35	16241A0235	5	1	4	5	5	4	3	
36	16241A0236	5	2	5		5		5	3
37	16241A0237	3				5	2		
38	16241A0238	4	2	2		2	5		
39	16241A0239	4		4		5	4		5
41	16241A0240	5	5	5		5	5	5	
42	16241A0241	5	2	5	1	AB	AB	AB	AB
43	16241A0242	5	2		5	5	5		5

44	16241A0243	4		2	5	5	5	5	
45	16241A0244	5		5	2	4		4	
46	16241A0245	5		5		5	5		3
47	16241A0246	4		3	3	5	4	3	
48	16241A0247	4		2	4	4	4		4
49	16241A0248	5		3	5	5	4		5
50	16241A0249	5			5	4	4	2	
51	16241A0250	5	5		5	5	5		5
52	16241A0251	5	1					5	
53	16241A0252	5		5	5		5	5	5
54	16241A0253	3		5	3	4	3		
55	16241A0254	5			5		5	4	
56	16241A0255	5			2	5		5	5
57	16241A0256	4		2	5	5	5	5	
58	16241A0257	5		4	5	5	5	5	
59	16241A0258	5			3	4		3	
60	16241A0259	5		5	5	5	5	5	
61	16241A0260	4	1	3		4		4	
62	17245A0201	3		5	5	5	5		5
63	17245A0202	4		3	3	5	5		
64	17245A0203	4		4	4	4	5	3	
65	17245A0204	3		1	4	4	4	4	
66	17245A0205	4		5	5	5	5		5
67	17245A0206	5		2	3	3	5	4	
68	17245A0207	4			4	4	4		2
69	17245A0208	AB	AB	AB	AB	5	4		
70	17245A0209	5			5	5	5	5	
71	17245A0210	5	5	2		5	5		5
72	17245A0211		2	3	5	4	4	4	
73	17245A0212	5		5	5	5	5		5
74	15241A0243	3		3				3	
	No.of students attempted	62	27	42	44	58	49	39	24
	Total marks	259	76	138	187	261	225	161	106
	%Attempted	87.32394	38.02817	59.15493	83.01887	109.434	92.45283	73.58491	45.28302
	Average marks Coi	4.177419	2.814815	3.285714	4.25	4.5	4.591837	4.128205	4.416667
	Evaluation of course outcome attainment %	83.54839	56.2963	65.71429	85	90	91.83673	82.5641	88.33333

	%
Co1	83.54839
Co2	56.2963
Co3	65.71429
Co4	87.5
Co5	91.83673
Co6	82.5641
Co7	88.33333

Co attainment : Section –B

	Course Outcome	CO1	CO2	CO3	CO4	CO5	CO6	CO7
S.No	Total marks							
1	16241A0261	5	4		5	5		5
2	16241A0262				5	5	5	
3	16241A0263	5		4	5		5	5
4	16241A0264	3						5
5	16241A0265		5	3		5	5	5
6	16241A0266	5	3			5		5
7	16241A0267	5	3	3	5		5	5
8	16241A0268	3	5	3	5		5	5
9	16241A0269	5	5	4	5	5		5
10	16241A0270	5		5	5		5	5
11	16241A0271	5	4	2	5		5	5
12	16241A0272	5	5	4	5	5		5
13	16241A0273	2	3		5	3		5
14	16241A0274	5	5	3	5	5	5	
15	16241A0275	5		2	5	5	5	
16	16241A0276	5	4		5	5	5	
17	16241A0277	4	2		5	5	3	
18	16241A0278	2	5	5	5	3	5	
19	16241A0279		5	4	5		5	
20	16241A0280	5	3	3	5	5	5	
21	16241A0281	3	4	5	5	5	5	
22	16241A0282	5	5		5	5	5	
23	16241A0283	2	2		3	5		
24	16241A0284	5	5		5	5	5	
25	16241A0285	4	5	5	5	5	5	
26	16241A0286	4	5	5	5	5	5	
27	16241A0287	3	2		5	5		
28	16241A0288	5		2	2	3		
29	16241A0289	5	5	5		5	5	5
30	16241A0290	5	4	3		5	5	5
31	16241A0291	4	5	3	1		5	5
32	16241A0292	5	5		3	5	5	
33	16241A0293		5	5		5	5	
34	16241A0294	3	3		5	2	5	
35	16241A0295		4	3	5		3	5
36	16241A0296	5		4	2	5	5	
37	16241A0297	5	5		5		5	5
38	16241A0298	2			5	3		

39	16241A0299	4	4			2	5	5
40	16241A02A0	5		4		5	2	
41	16241A02A2	5	4	3	5		5	5
42	16241A02A3	5		2		5	5	5
43	16241A02A4	5	5	5	5	5	5	
44	16241A02A5	5	3	3	5	5		5
45	16241A02A6	3	5		5			
46	16241A02A7	3	5	5		5	5	5
47	16241A02A8	5	5	3		5	5	5
48	16241A02A9	5		2	2		5	
49	16241A02B0	5	4			5	5	2
50	16241A02B1	5	5	5		5	5	5
51	16241A02B2	5	3		5	2	5	
52	16241A02B3	3		3	5	5		
53	16241A02B4	5	3	3	5		5	
54	16241A02B5		5	5	5	2		
55	16241A02B6	5	5		3		5	5
56	16241A02B7	5	5	3	5	5		3
57	16241A02B8	5	3	4		2	5	
58	16241A02B9	2		3	4	2		
59	17245A0213		3		5			2
60	17245A0214	5	5	5		5	5	5
61	17245A0215		5	5	5	5		
62	17245A0216	5	4	2	5	5	5	
63	17245A0217	4	4		5	2	5	
64	17245A0218	5		5	5	5		5
65	17245A0219	5	4			5	2	5
66	17245A0220	4	3	4	5	5	5	
67	17245A0221	5	5	5	5	5	5	
68	17245A0222	5	2		5	5	5	
69	17245A0223	2	5		5	1	5	
70	17245A0224	4	4		3	5	5	
	No.of students attempted	62	56	44	54	54	51	31
	Total marks	268	233	164	248	237	245	147
	%Attempted	83.78378	75.67568	59.45946	72.97297	72.97297	68.91892	41.89189
	Average marks Coi	4.322581	4.160714	3.727273	4.592593	4.388889	4.803922	4.741935
	Evaluation of course outcome attainment %	86.45	83.21	74.55	91.85	87.78	96.07	94.84

	%
Co1	86.45
Co2	83.21
Co3	74.55
Co4	91.85
Co5	87.78
Co6	96.07
Co7	94.84

SGP -Result Analysis

Year	Total No. Of Students appeared	Total No. of Students Passed	No. of Students Failed	GRADE =10	GRADE= 9	GRADE=8	GRADE= 7	GRADE= 6	GRADE= 5	GRADE= 4	PASS PERCENTAGE(%)
2017-18	140	129	11	58	28	19	09	06	04	05	92.14
2016-17	124	112	12			29 (>70%)	30 (60-70 %)	53 (<60 %)			90.3
2015-16	140	119	21			60 (>70%)	34 (60-70 %)	25 (<60 %)			85

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

Feedback

Summation of Teacher Appraisal by Student
Academic Year 2018-19

Name of the Instructor	P Sri Vidya Devi
Faculty ID	931
Branch	EEE
Class and Semester/Section	III / II / A
Academic Year	2018-19
Subject Title	Switch Gear & Protection
Total No. of Responses/class strength	11/71

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

S. No	Questions of Feedback	Average
1	How do the teacher explain the subject?	3.1
2	The teacher pays attention to	3.3
3	The Language and communication skills of the teacher is	3.2
4	Is the session Interactive?	3.1
5	Rate your teacher's explanation in clearing the doubts	3.1
6	Rate your teacher's commitment in completing the syllabus	3.3
7	Rate your teacher's punctuality	3.2
8	Rate your teachers use of teaching aids	3.3
9	Rate your teacher's guidance in other activities like NPTEL, Moodle, Swayam, Projects.	3.3
10	What is your overall opinion about the teacher?	3

Net Feedback on a scale of 1 to 4: 3.19

GOKARAJU RANGARAJU
INSTITUTE OF ENGINEERING AND TECHNOLOGY

Department of Electrical & Electronics Engineering

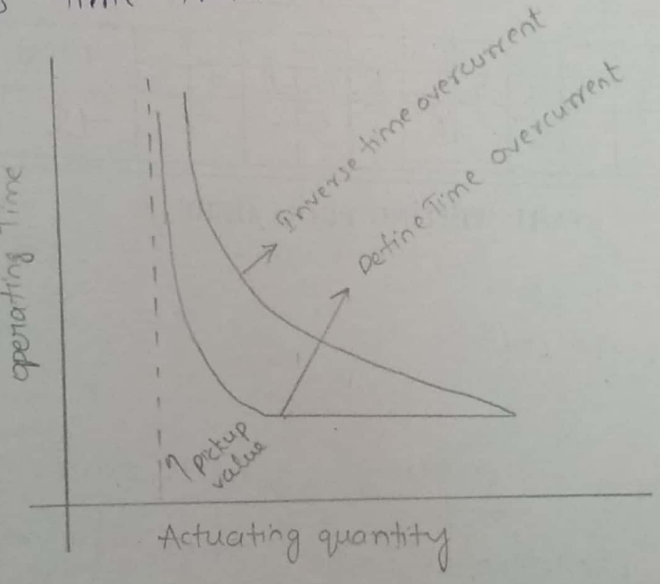
LECTURE NOTES

3. Time Current Characteristics:

1. Definite time Overcurrent Relay: Definite time overcurrent relay operates after a predetermine time when the current increase above its pick up value. Figure shows the characteristics of ~~ove~~ definite time overcurrent relay. The operating time is constant irrespective of the magnitude of the current. The desired operating time can be set by intentional time delay mechonism in relaying unit.

2. Instanteneous Overcurrent Relay: Instanteneous overcurrent relay operates in a definite time when the current

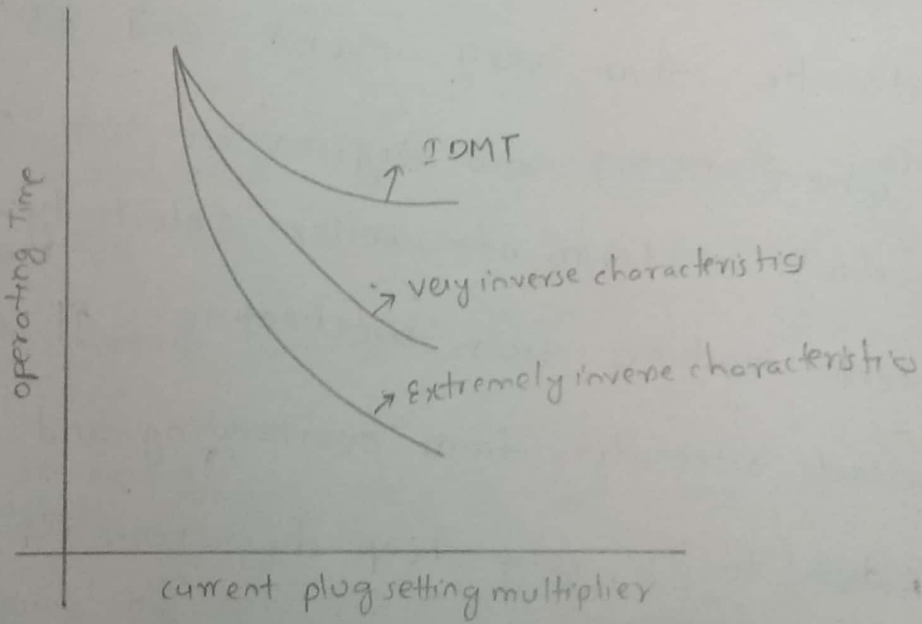
increases above its pick up value. Figure shows the characteristics of instanteneous overcurrent relay. The operating time is constant irrespective of the magnitude, of the current. The operating time is 0.1 sec. Sometimes the term "high set" and "high speed" are used to fast relays operating at a less time than 0.1sec



Inverse time overcurrent relay: Inverse time overcurrent relay operates when the current increases above its pickup value. Figure shows the characteristics of inverse time overcurrent relay. The operating time depends on the magnitude of current. The operating time decreases as the magnitude of current increases.

Inverse Definite Minimum Time (IDMT) Overcurrent relay:

In this relay, it will exhibit, inverse time-current charac-eristics for low values of fault current and definite time current characteristics for high values of fault current. Inverse time-current characteristics are obtainted for plug setting multiplier value less than 10. If the psm value is between 10 to 20 definite characteris-tics are obtained. It is used for protecting the distribution lines.



Very inverse time overcurrent relay: It has more inverse characteristics than. IDMT. Its characteristics lie between IDMT and extremely inverse time current characteristics. It has better selectivity than IDMT. The general expression for time current characteristics for overcurrent relay is

$$t = \frac{K}{I^n - 1}$$

where n value is lies between 1.02 and 2. It is recommend-ed where there is decrease in fault current with incre-ase in distance from power supply. It is also effectiv-e for earthing faults.

Extremely inverse time overcurrent relay: It has more inverse characteristics than very inverse and IDMT. It is used where IDMT and very inverse time overcurrent relay fail in terms of better selectivity. It is used to protect machines from overheating. It is also used to protect alternators from overloading and internal faults, due to its very steep characteristics. It is also used to distinguish the fault current from inrush current when circuit breaker is reclosed after long outages.

4. a. Circuit Breaker: A circuit breaker is a device which can be operated manually or automatically, senses the trip signal and opens its contacts thereby disconnecting the load from the supply under faulty conditions.

b. Relay: A relay is an automatic device which senses the fault in the system and closes its contacts to energise the trip coil of the circuit breaker.

c. Fault clearing time: Fault clearing time is the time taken from the arc initiation to the time till the arc is interrupted completely.

d. Arcing time: Arcing time is the time taken from the opening of the contacts to the formation of the arc between the contacts of the circuit breaker.

e. Current chopping: Current chopping is done for extinguishing the arc before the current zero point. It is done by interrupting the current forcefully by introducing dielectric material in be

-een the gaps of the contacts.

2A. → Circuit breakers can be classified into four types depending on the type of dielectric medium used for extinguishing the arc.

→ The working of the circuits breakers is same, the only difference is the dielectric material used in betw-een the contacts of the circuit breaker.

The four types of circuit breakers are:

1. Air break circuit breakers
2. Oil break circuit breakers.
3. Vaccum break circuit breakers
4. SF6 circuit breakers.

<u>SF_6 circuit breaker:</u> In SF_6 circuit breaker, sulphur hexafluoride is used as a dielectric medium to extinguish the arc formed. When the contacts of the circuit breaker open due to fault, the voltage driving the current appears across the contacts of the circuit breaker. If the contacts open at high voltage, an arc is formed across the contacts. When an arc is formed, sulphur hexafluoride gas is sent to deionize the gap between the contacts. It is more effective than air blast circuit breakers because the density of SF_6 gas is five times the density of the air. Hence, the ions and electrons are removed or swept away by the SF_6 gas thereby the arc is extingui-shed. The SF_6 gas is sent at a certain pressure.

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

Academic Year: 2018-19 Year: III Semester: II	MID Exam – I (Objective) Switchgear and Protection	Date: 04/02/19 Max Marks: 5

1. Time classification of relays includes [D]

a) Instantaneous relays b) Definite time lag c) Inverse time lag d) All of these

2. Good relay should possess [D]

a) Speed & reliability b) sensitivity c) Adequateness & selectivity d) All of these

3. In Resistance Switching, Resistance is connected to reduce [D]

a) Restriking Voltage b) RRRV c) Transient Oscillations d) All

4. The function of protective relay in a circuit breaker is [B]

a) to each any stray voltages

b) to close the contacts when the actuating quantity reaches a certain predetermined value

c) to limit arcing current during the operation of circuit breaker

d) to provide additional safety in the operation of circuit breaker.

5. Arc interruption is done by [C]

a) High Resistance method b) Low current Method c) Both a and b d) none

6. RRRV stands for Rate of Reetriking Voltage

7. Armature Attracted Induction disct cup are types of Electromagnetic Relays.

8. Under voltage relays are used for Transmission lines, Motors etc

9. The fault clearing time of a circuit breaker is usually few sec (mins or sec or hours)

10. Air circuit breakers are used for voltages above 12 kV

(Autonomous)
Department of Electrical and Electronics Engineering

Academic Year: 2018-19 Year: III Semester: II	MID Exam – II (Objective) Switchgear and Protection	Date:5/4/19 Max Marks: 5

1.The lightning arrester acts as [a]

a) Surge diverter b) Surge coil c) Surge absorber d) Surge reflector

2. Earth wire or ground wire is made of [d]

a) copper b) aluminium c) iron d) galvanized steel

3. Ground resistance should be designed such that: [a]

a) grounding resistance should be as low as possible b) grounding resistance should be as high as possible

c) grounding resistance should be always zero d) none of the above

4. Directional relays responds to [a]

a) Power b) voltage c) current d) reactance

5. The cheif cause of overspeed in an Alternator is [a]

a) Sudden loss of load b) overheating c) sudden increase in load d) None

6. Which of following are used to reduce short circuit fault currents [d/a]

a) reactors b) resistors c) capacitors d) Parallel combination of all these

7. Average resistance of human body is: [b]

a) 500 ohms b) 1000 ohms c) 1500 ohms d) 2000 ohms

8. Generator internal fault protection is usually based the principle of [a]

a) differential protection b) cross-differential protection c) negative sequence protection d) All

9. Merz price circulating current principle is most suitable for ________than__________ [a]

a) Generators, Transformers b) Transformers, Generators
c) Transmission lines, Transformers d) none

10. 10.Buchholz is ________________type of relay [a]

a) Gas actuated b) Oil c) Liquid actuated d) None

(12 Pages)

Gokaraju Rangaraju Institute of Engineering & Technology

(Autonomous)

Bachupally, Kukatpally, Hyderabad - 500090

No. 290710 ROLL NO.: 1 6 2 4 1 A 0 2 5 9

CLASS & BRANCH EEE - A

NAME V. Sowmya SUBJECT SGP.

SIGNATURE OF THE INVIGILATOR [signature] DATE: 05/04/19

SEMESTER	I	~~II~~

I	~~II~~	MID TERM EXAMINATION

Q.NO.	1		2		3		4		5		TOTAL
	a	b	a	b	a	b	a	b	a	b	
MARKS	5		5		5		5				15

START WRITING FROM HERE

1. Differential Relay:

1. A differential relay is a relay that operates when phasor difference of two or more than two currents exceeds a predetermined value.

2. It is a method of protection in which the internal faults are identified by comparing currents on either side of the protected equipment.

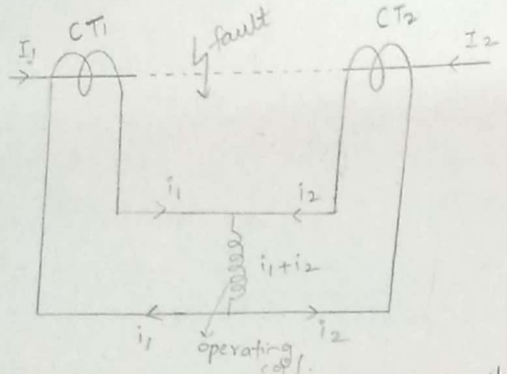
3. It is based on the fact that the equipment with internal fault, the entering current and leaving current are not same.

4. The differential protection is applicable to all power system equipments such as transformer, generator, motor, busbar.

1. Simple differential relay:

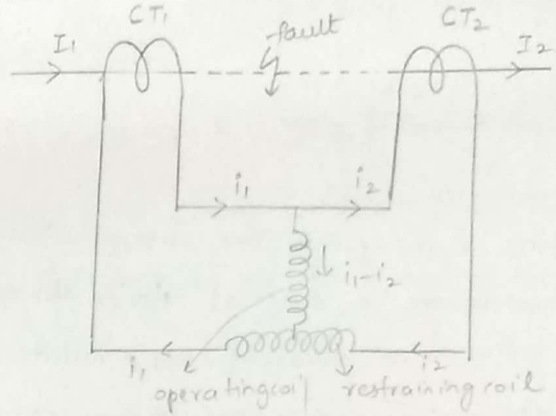
The dotted line shows the protected section of equipment. The current transformers are placed on either side of the protected zone. The secondaries of the C.Ts are connected in

series with a pilot wire. Hence the induced currents in the
CT's flow in the same direction. The relay is placed across
the secondaries of the C.T's



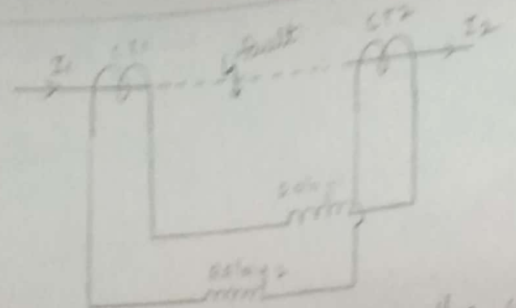
When under normal condition, the currents in the secondaries of
CT's are equal. Hence no current flows through the operating
coil. Under fault conditions the magnitude of currents flowing
through secondaries of CT's are not same hence the relay operates.

2. <u>Percentage Biased Differential relay:</u>
It is the most commonly used type of relay. It is same as
the current differential relay. The only difference is there is
an additional coil called restraining coil. in the pilot wires.
The operating coil is placed in the centre of the restraining
coil. Under normal operating conditions, the restraining torque
is greater than the operating torque and the relay will
not operate. Under fault conditions, the operating
torque will be greater than the restraining torque
and the relay will operate. The bias force can be
changed by changing the number of turns of the restrain-
-ing coil.



3. <u>Voltage Balance Differential Relay:</u> The current differential
relay is not used for the protection of feeders.
The voltage balance differential relay is used for the
protection of feeders. In voltage balance differential
relay the two current transformers which are similar
to each other are placed on the either side of the
protected zone through the pilot wires.

The relay is connected in series with
the secondaries of the current transformer. The relay is
placed such that it wont operate under normal conditions.
In voltage differential relay the C.T's used are air cored
C.T's such that the voltage induced in them is accordi-
-ng to the current flowing through them.



When a fault occurs in the system the current flowing throu-gh the current transformers is different. Hence the voltage induced in the CTs is also different. As a result the relays will operate sending commands to the circuit brea-ker to trip.

Buchholz relay:

Buchholz relay is a gas actuated relay which is used to identify the incipient faults which are minor faults in the beginning but turns into major faults with time. Buchholz relay is used to supplement the biased differen-tial rel. protection of transformer. Buchholz relay will sound an alarm when sufficient amount of gas is collected. The type of gas will be used to determine the type of fault. If the gas formed containing

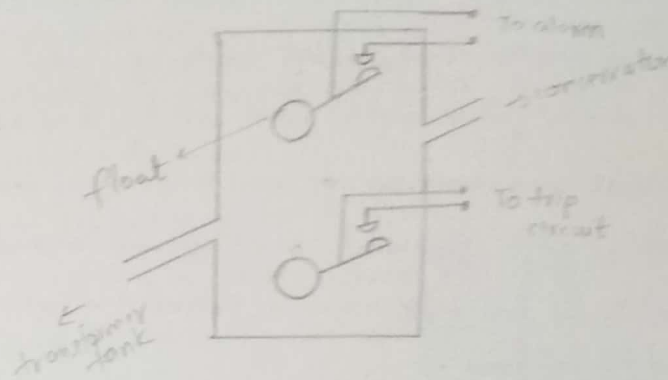
(i) C_2H_2 and H_2 it indicates the arcing in oil between parts.

(ii) C_2H_2, CH_4 and H_2 indicates arcing with deterioration

(iii) CH_4, C_2H_4 and H_2 indicates hot spot formation in the joints of core

(iv) C_2H_4, C_3H_6 and H_2, CO_2 indicates hot spot in the winding

There is a chamber allocated for the Buchholz relay between the transformer tank and conservator. When gas is formed the oil level falls and the buchholz relay sounds an alarm. There is a mercury switch with float. The type of gas formed will determine the type of fault. If a severe fault occurs, large volume of gas will be formed and finally the circuit breaker will be tripped. The minimum operating time is 0.1 s and the average operating time is 0.2 sec.



Buchholz relay

Advantages:

1. It is used to detect the internal faults due to overheating
2. Severity of the fault can be known even without transformers
3. If it is a major fault the transformer is isolated.

Disadvantages:

1. There is a possibility of false operation due to vibration or shock due to earthquake and mechanical shock
2. It can be rectified by improved mercury switches design.

3. Equipment earthing: Equipment earthing means connecting the dead part i.e the part of the equipment that doesnot carry current during normal operating conditions to the earth for example equipment frame, enclosure, support etc.

→ The main purpose of equipment earthing is to minimise the risk of shock when metal parts are touched during fault.

→ Under fault conditions, the non current carrying metal parts will attain high potential w.r.t ground and when a person touches it he experiences a potential difference causing the current to flow

→ To prevent this the equipment is connected to ground through a conductor of through which the fault current is diverted to ground.

→ It is acheived by ground rods or electrodes inserted deep inside the earth.

Neutral earthing:- Neutral earthing means connecting the live part i.e the part of the equipment that carries the current during normal operating conditions to the ground for example neutral of power transformer

→ It is done to protect the electrical equipment and to provide a return path from machine to power source.

→ Due to lightning, high voltage surges can be occurred in the distribution system.

→ Grounding will reduce the damage to the distribution system by providing an alternate path for the fault current

→ All the electrical network needs a reference potential called ground potential in order to make the current flow from the generator to load.

Necessity of reactance grounding:-

→ Reactance grounding will reduce the magnitude of the fault current thereby interference with the communication circuits is reduced.

→ The arcing voltages are also minimized.

→ It will improve the stability of the system.

4.

a) Insulation coordination:

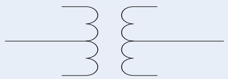
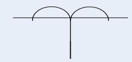
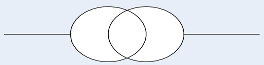
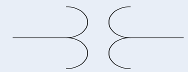
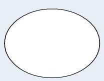
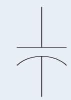
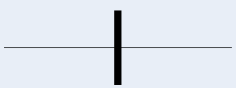
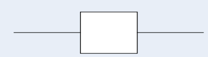
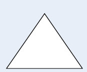
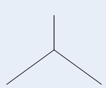
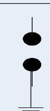
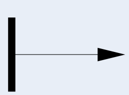
Insulation coordination is the process of coordinating the insulation levels of all the electrical equipment along with their surge diverters to withstand the expected overvoltages in the powersystem.

→ It is the process of selecting the insulation levels of the power system equipment.

Basic Lightening impulse (BIL): It is the electrical strength of the insulation expressed in terms of the crest value of the standard lightning impulse of the power system equipment.

Importance of protective schemes for electrical apparatus and power system

PROTECTION SYMBOL

	two-winding transformer		current transformer
	two-winding transformer		voltage transformer
	generator		capacitor
	bus		circuit breaker
	transmission line		circuit breaker
	delta connection		fuse
	wye connection		surge arrestor
	static load		disconnect

Primary Equipment & Components

- **Transformers** - to step up or step down voltage level
- **Breakers** - to energize equipment and interrupt fault current to isolate faulted equipment
- **Insulators** - to insulate equipment from ground and other phases
- **Isolators (switches)** - to create a visible and permanent isolation of primary equipment for maintenance purposes and route power flow over certain buses.
- **Bus** - to allow multiple connections (feeders) to the same source of power (transformer).

Primary Equipment & Components

- **Grounding** - to operate and maintain equipment safely
- **Arrester** - to protect primary equipment of sudden overvoltage (lightning strike).
- **Switchgear** – integrated components to switch, protect, meter and control power flow
- **Reactors** - to limit fault current (series) or compensate for charge current (shunt)
- **VT and CT** - to measure primary current and voltage and supply scaled down values to P&C, metering, SCADA, etc.
- **Regulators** - voltage, current, VAR, phase angle, etc.

Why A System Needs Protection?

- There is no '**fault free**' system.
- Ensure safety of personnel.
- Usually faults are caused by breakdown of insulation due to various reasons: system over current, over voltage, lighting, etc.

PROTECTION SYSTEM

A series of devices whose main purpose is to protect persons and primary electric power equipment from the effects of faults

BLACKOUTS

Characteristics

Loss of service in a large area or population region

Hazard to human life

May result in enormous economic losses

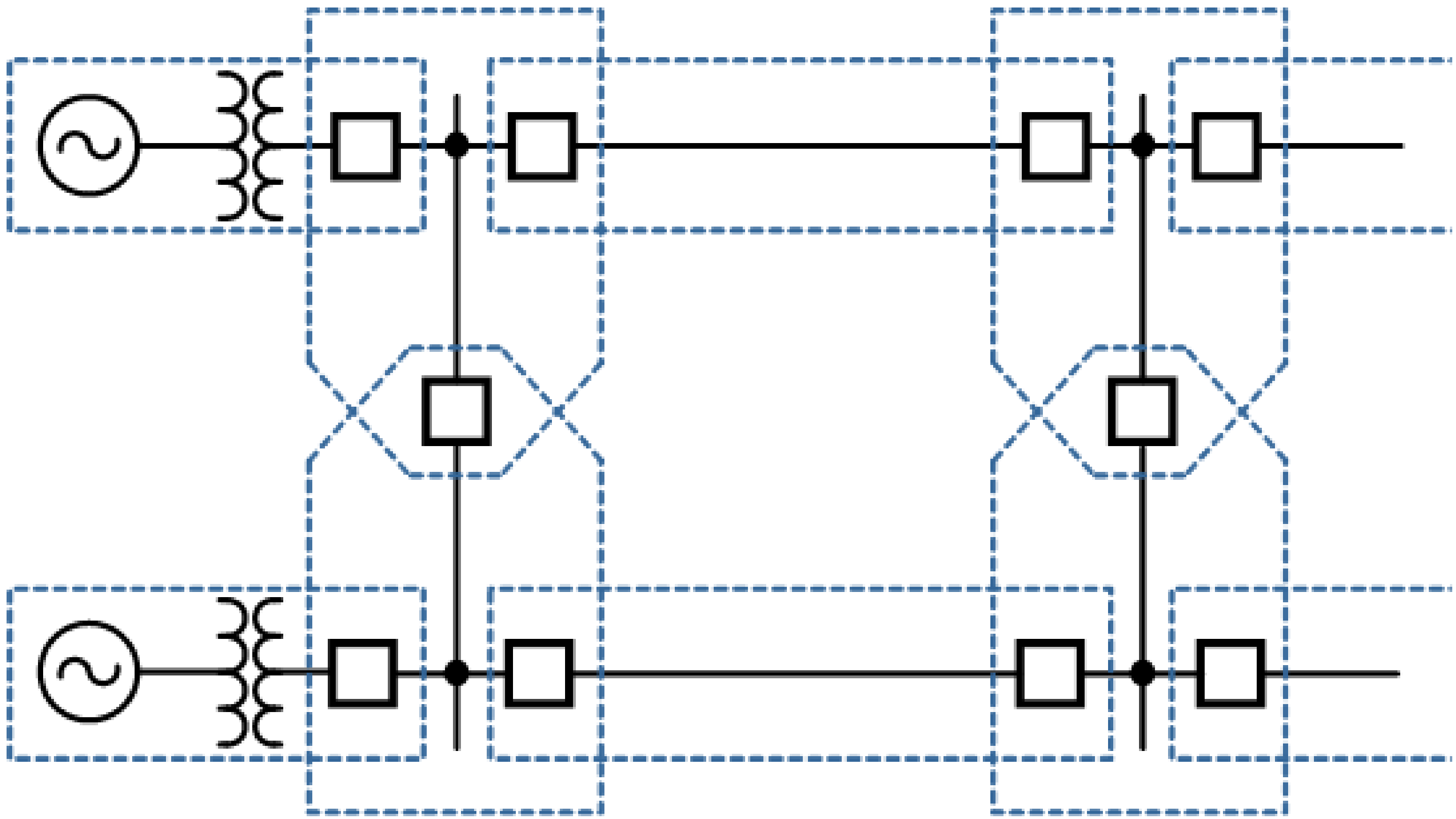
Main Causes

Overreaction of the protection system

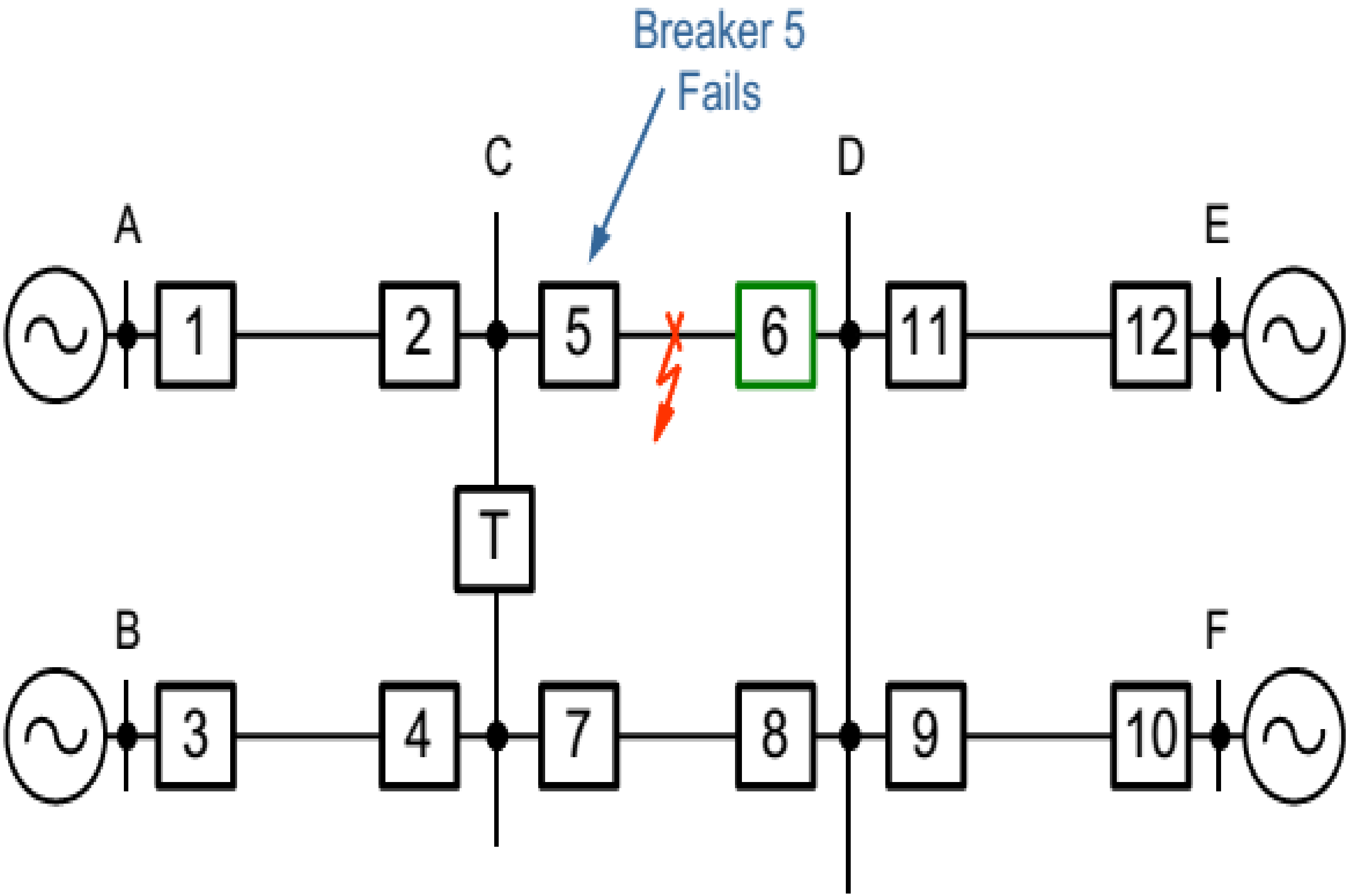
Bad design of the protection system

19

PRIMARY PROTECTION



BACKUP PROTECTION



POWER SYSTEM WITHOUT PROTECTION

- Short circuits and other abnormal conditions often occur on the power system. The heavy current associated with short circuits is likely to cause damage to the equipment

Element of protection system

(1)Current and Voltage Transformers

(2)Relays

(3)Circuit breakers

(4)Batteries

(5)Fuses

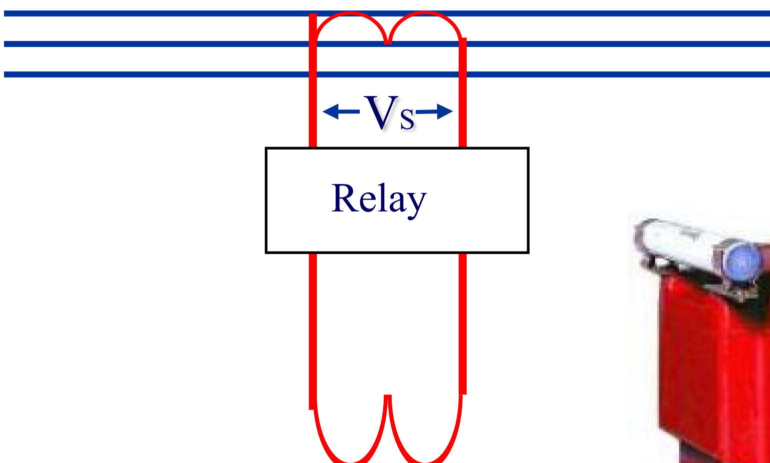
(6)Lighting Arresters

Current transformer

- Current transformer consists at least of two secondary windings.
- The first winding is usually designed for measuring, the second is used for protection.
- The secondary of current transformers are almost connected in star

Voltage transformer

- Voltage transformer is often consists of two windings.
- The first winding is connected in star, and the stare point must be earthed.
- The second winding is connected as open delta.



Relay Purpose

- Isolate controlling circuit from controlled circuit.
- Control high voltage system with low voltage.
- Control high current system with low current.
- Logic Functions

Advantages for Using Protective Relays

- Detect system failures when they occur and isolate the faulted section from the remaining of the system.
- Mitigating the effects of failures after they occur.
- Minimize risk of fire, danger to personal and other high voltage systems.

CIRCUIT BREAKER

- Low voltage circuit breaker
- Magnetic circuit breaker
- Medium voltage circuit breaker
- High voltage circuit breaker

Battery bank

- Battery bank are called as backbone of protection system
- Emergency use for power system

Fuse

- Fuses are selected to allow passage of normal current and of excessive current only for short periods.
- It is used to protect the low voltage or current rating devices

Lighting arrester

- A lightning arrester is a device used on electrical power system to protect the insulation damaging effect of lightning.
- All lighting arrester are earthed

What is Switchgear ?

- **Switchgear** is the combination of switches, fuses or circuit breakers(CB) used to control , protect & isolate electrical equipment.
- It is used de-energize equipment & clear faults.

Different elements of switchgear

- **Circuit breaker**

  Air ckt breaker **ACB**

  Vacuumed ckt breaker **VCB**

  Oil filled ckt breaker **OCB**

  SF_6 Ckt Breaker

- **MCCB** (Moulded Case Ckt Breakers)

- **MCB**

  (Miniature Circuit Breaker)

- **RCCB**

Residual current circuit breaker

- Load Breaking Switch **LBS**
- By pass and changeover switches
- Isolators(**switches**)
- Fuses

Function wise categories

- Automatic & Manual operation

  { **example:** **Circuit breaker ,MCB , MCCB** }

- Only automatic operation

  Fuse

- Only manually activated / operated

  Isolator, LBS

Voltage wise switchgear categories

- Low voltage Switchgear
  up to 11KV
- Medium voltage switchgear
  up to 66KV
- High Voltage switchgear
  up to 400KV
- Extra High Voltage switchgear
  up to 765KV
- HVDC Switchgear

Qualitative review of faults & fault currents

NATURE & CAUSES OF FAULTS

- Insulation failure.
- Conducting path failure.
- Over voltages due to lightening or switching surges.
- Puncturing or breaking of insulators.
- Failure of conducting path due to broken conductors.
- Failure of solid insulation due to aging, heat, moisture, overvoltage , accidental contact with earth or earth screens, flash over voltages and etc.,

FAULT IN POWER SYSTEM

- A power system fault may be defined as any condition or abnormality of the system which involves the electrical failure of primary equipment such as generators, transformers, busbars, overhead lines and cables and all other items of plant which operate at power system voltage.

- Electrical failure generally implies one or the other (or both) of two types of failure, namely insulation failure resulting in a short-circuit condition or conducting path failure resulting in an open-circuit condition, the former being by far the more common type of failure.

FAULT IN POWER SYSTEM

- **Symmetrical fault**

  Faults giving rise to equal currents in lines displaced by

  equal phase angles i.e 120^o in three phase systems.

  Example: short circuit of **all three phase** conductors of a cable at a single location

- **Unsymmetrical fault**

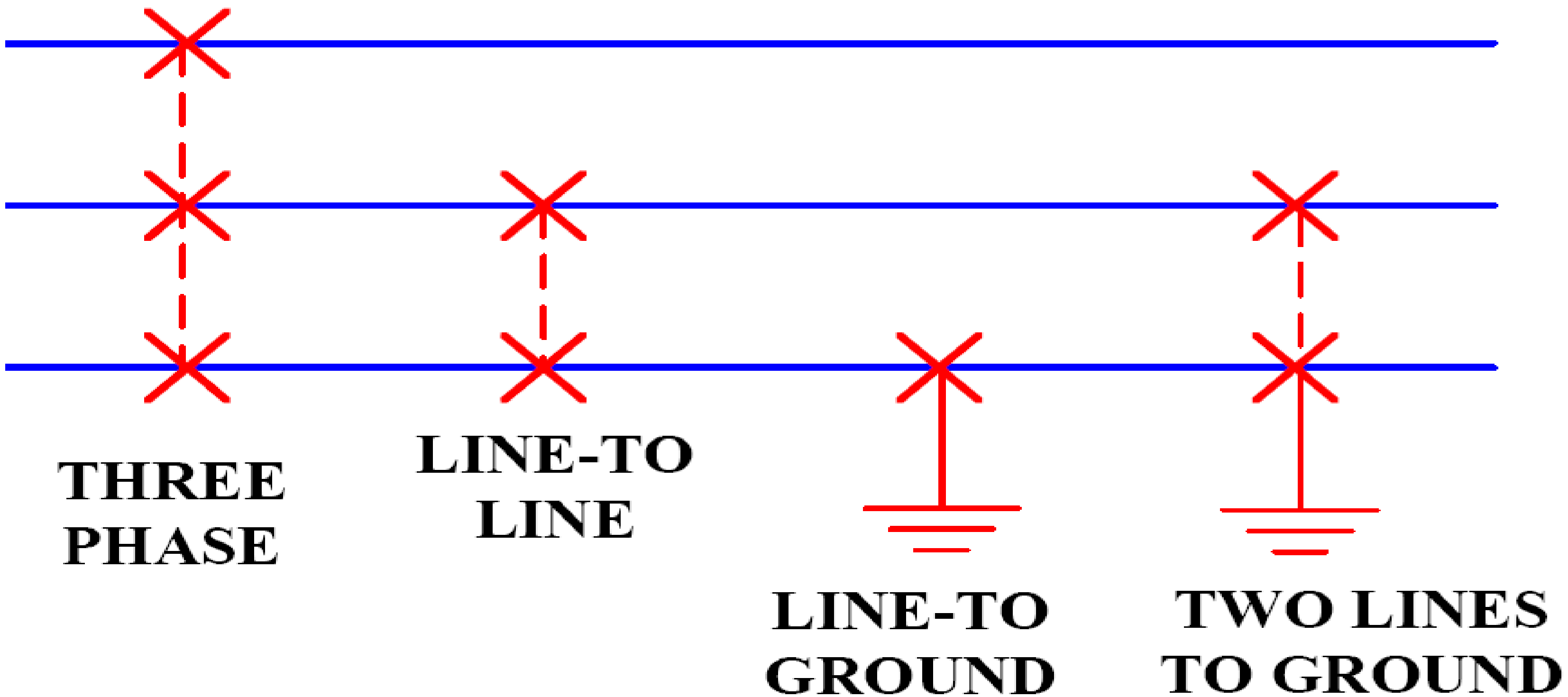
  Faults in which not all the line currents are equal and not all have the same phase.

  Example (any one): single phase line to ground fault (**L-G**), two phase to ground (**LL-G**) fault and phase to phase (**L-L**) fault.

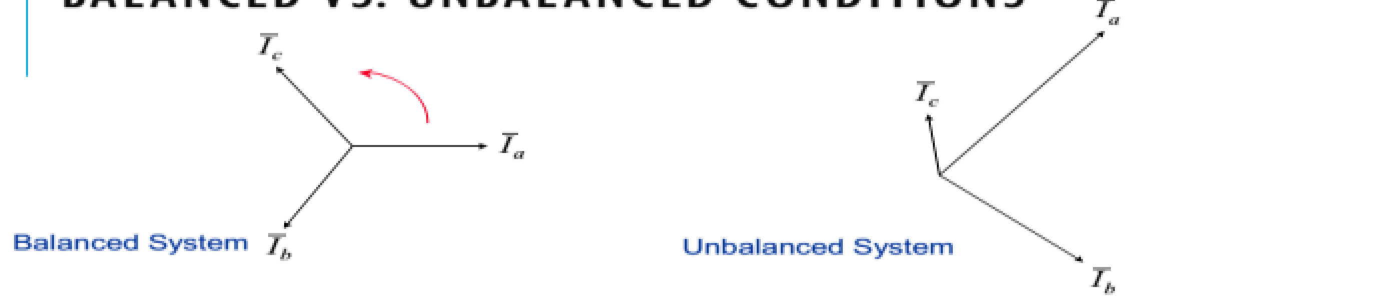
Abnormalities in Power Systems

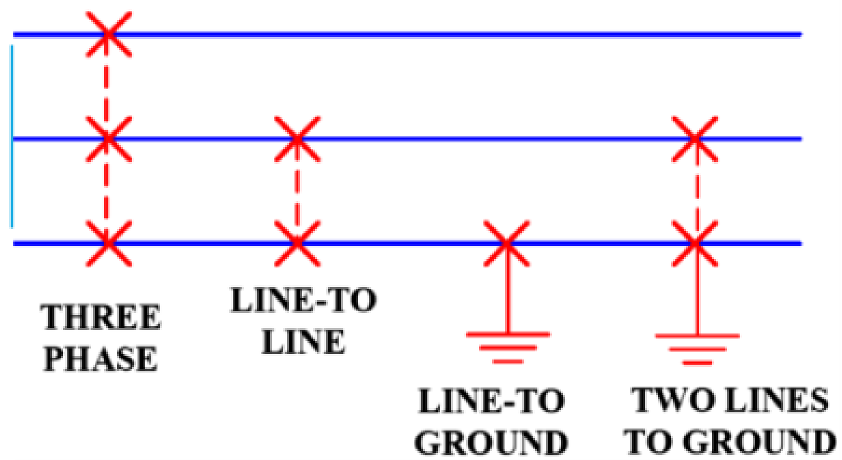
- Overcurrent **(overload, short circuit, open circuit)**
- Ground Potential **(ungrounded equipment, touch potentials, step potentials)**
- Surge Voltages **(lightning strokes, switching surges, harmonics)**

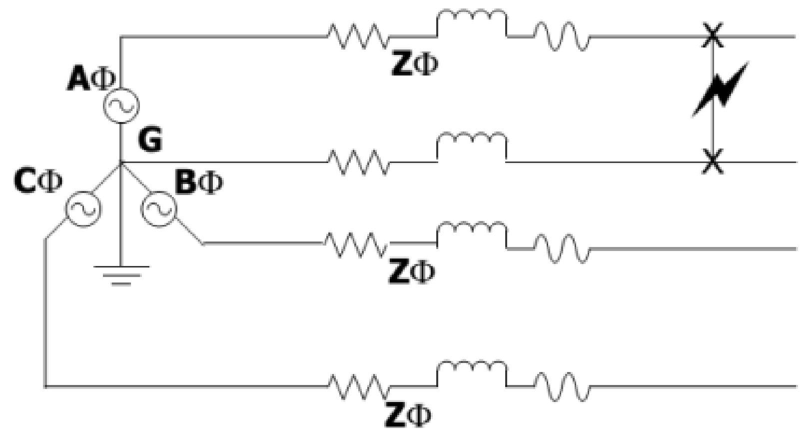
Fault Types (Shunt)



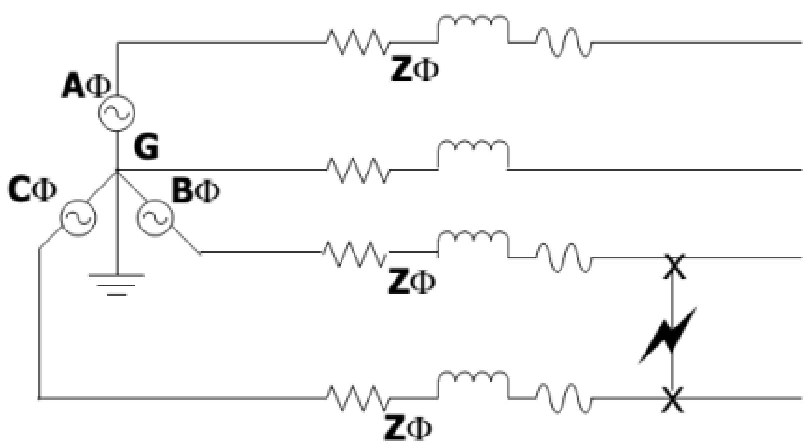
BALANCED VS. UNBALANCED CONDITIONS



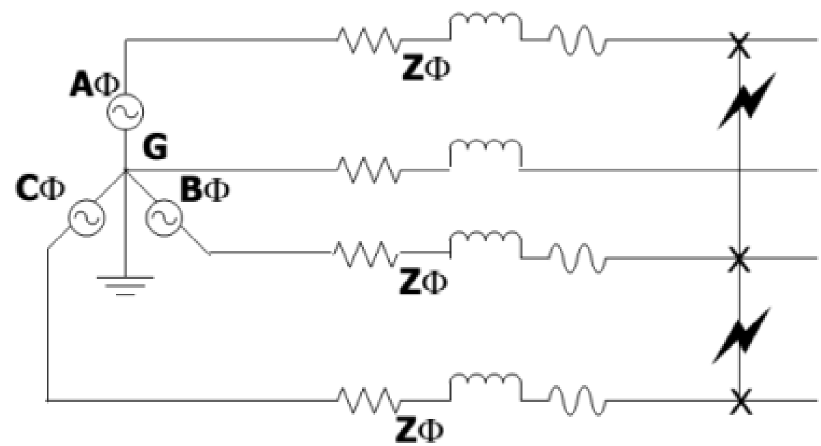




Short Circuit Calculation
Fault Types – Single Phase to Ground



Short Circuit Calculations
Fault Types – Line to Line



Short Circuit Calculations
Fault Types – Three Phase

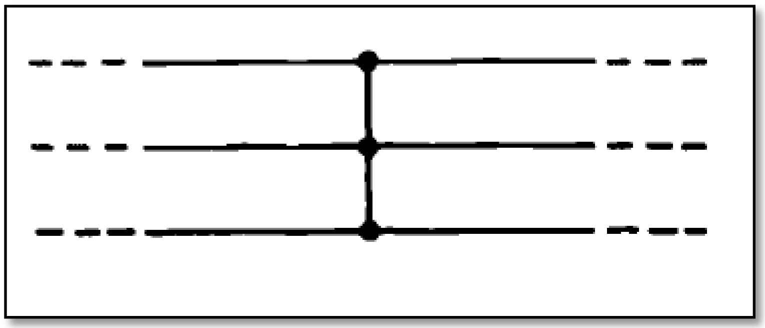
Frequency of Types of Faults

Type of Fault	% Occurrence
SLG	85
LL	8
DLG	5
3L	2 or less

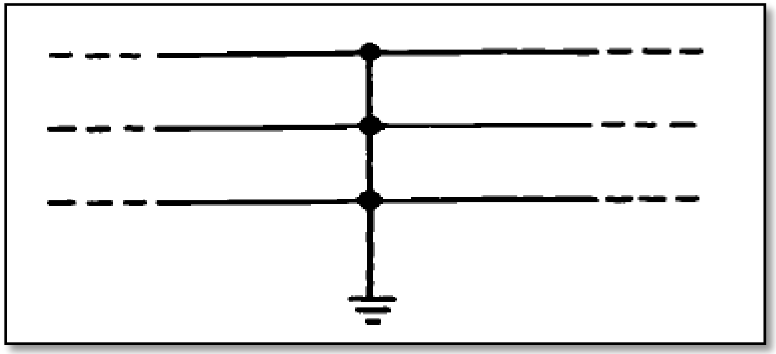
Frequency of Fault Occurrence

Equipment	% of Total
Overhead lines	50
Cables	10
Switchgear	15
Transformers	12
CTs and PTs	2
Control Equipment	3
Miscellaneous	8

SYMMETRICAL FAULT

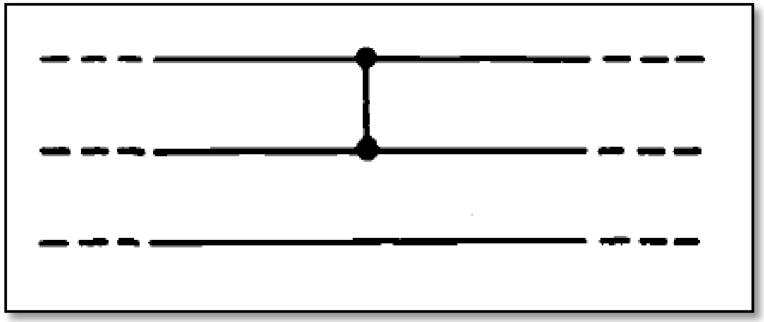


THREE- PHASE FAULT

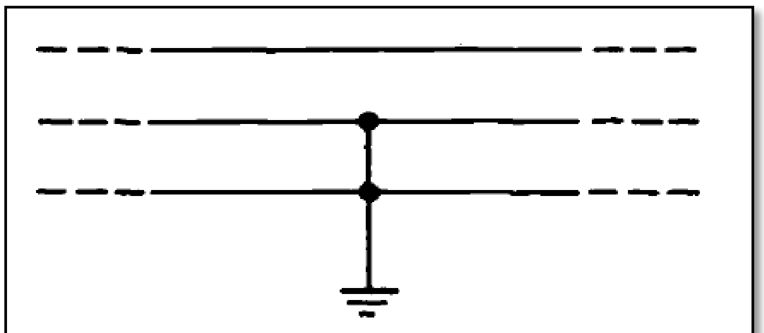


THREE PHASE - EARTH FAULT

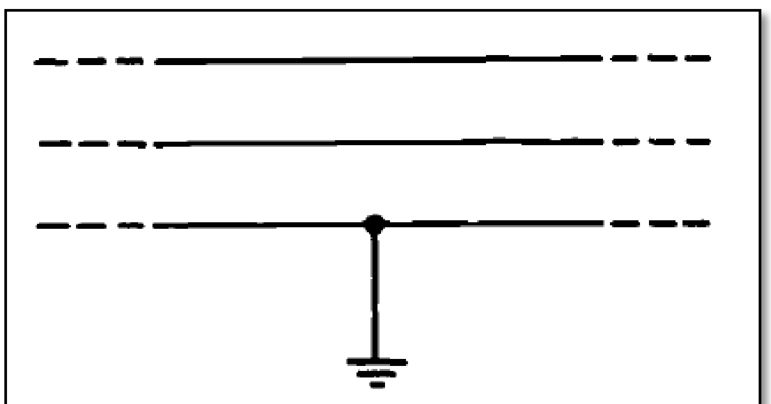
UNSYMMETRICAL FAULT



PHASE – PHASE FAULT

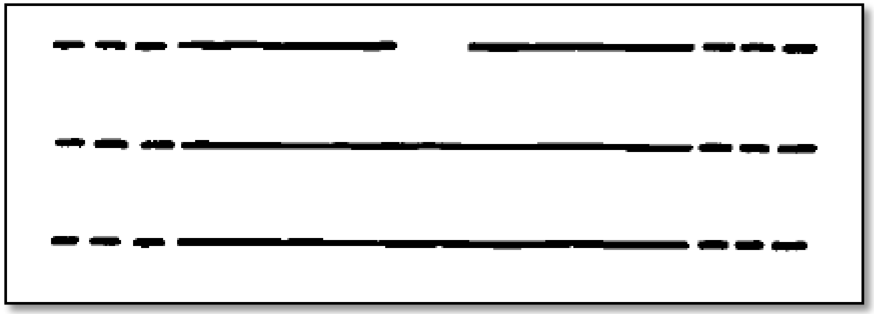


TWO PHASE – EARTH FAULT

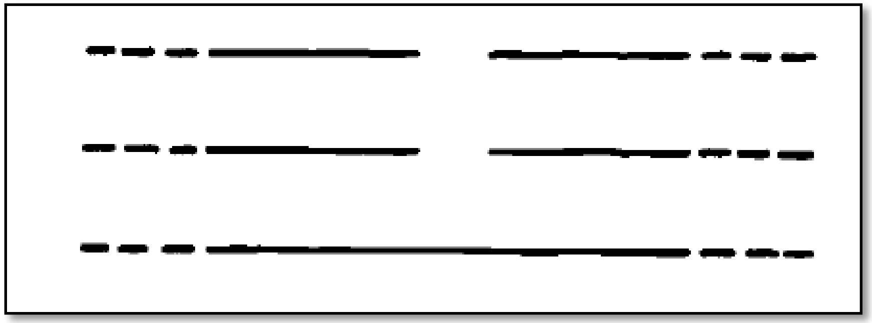


SINGLE PHASE - EARTH FAULT

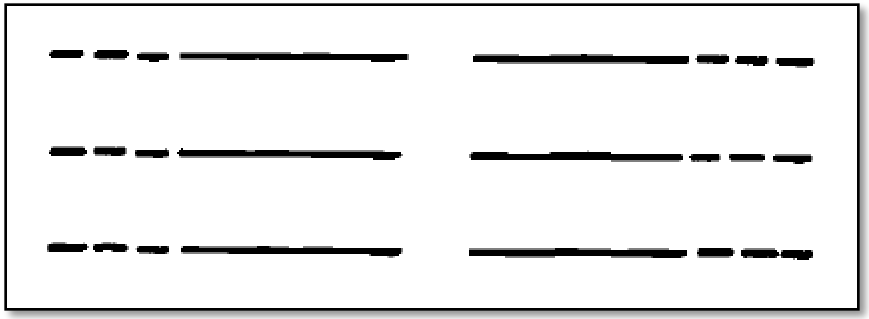
OPEN CIRCUIT FAULT



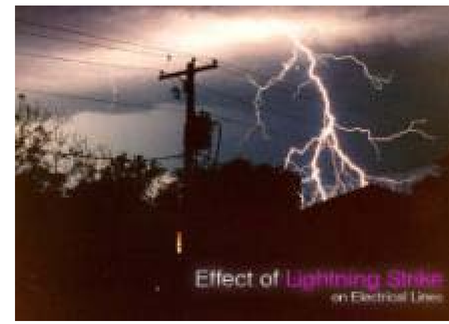
SINGLE- PHASE OPEN CIRCUIT



TWO- PHASE OPEN CIRCUIT

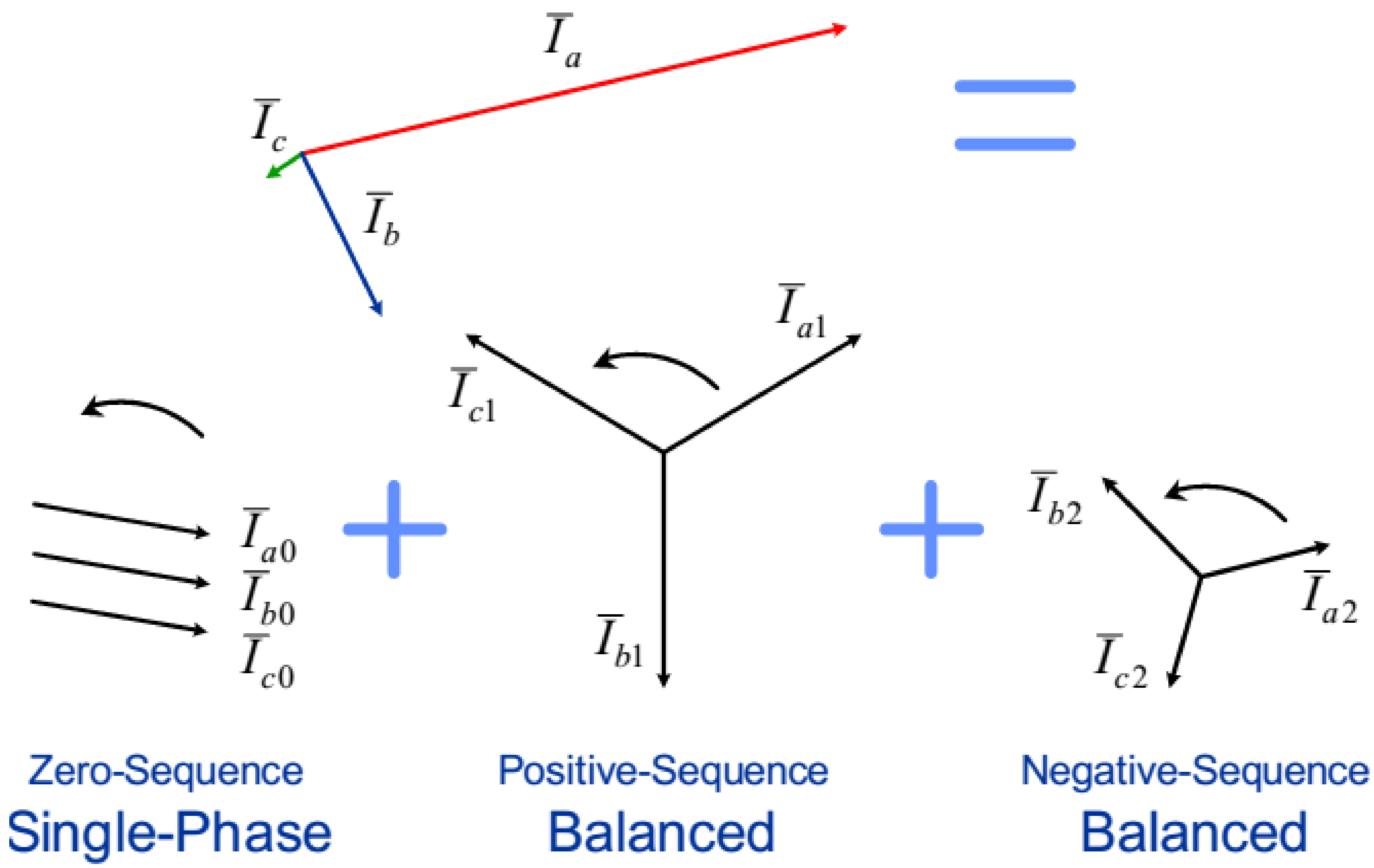


THREE- PHASE OPEN CIRCUIT

Equipments & % of total fault	Causes of Faults
Over head lines **(50%)**	•Lighting Stroke •Earthquake •Icing •Birds •Tree branches •Kite Strings •Internal Overvoltage 
Under ground Cable **(9%)** 	•Damage due to digging • Insulation failure due to temperature rise •Failure of Joints
Alternator **(7%)**	•Stator & Rotor faults

Equipments & % of total fault	Causes of Faults
Transformer **(10%)**	•Insulation Failure •Faults in tap changer •Overloading 
Current Transformer **&** **Potential Transformer** **(12%)**	•Overvoltage •Insulation Failure •Break of Conductors •Wrong Connections
Switch Gear **(12%)**	•Insulation failure •Leakage of air/oil/gas •Mechanical defect •Lack of Maintenance

DECOMPOSITION OF AN UNBALANCED SYSTEM



Fault Minimization

- ***Improving the quality*** of machines, equipments, installation etc., by improving the design techniques.
- ***Adequate & reliable*** protection system control
- ***Regular maintenance*** by trained professionals
- ***Effective management*** of electrical plant

Merits of Fast fault clearing

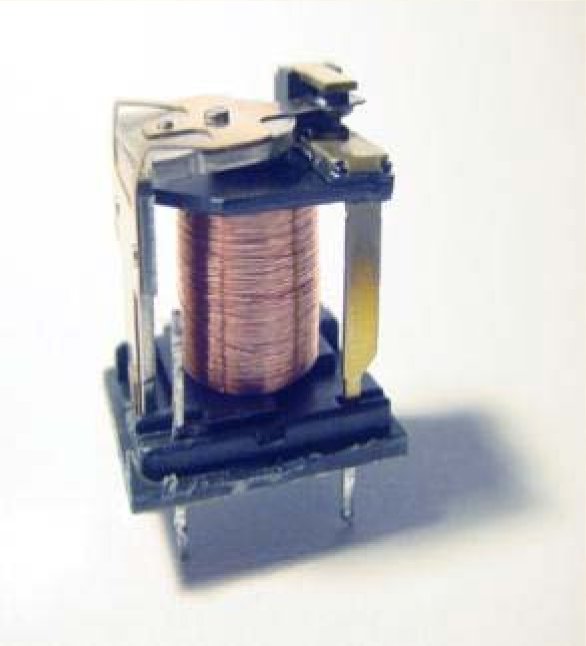
- Helps to avoid ***permanent damage to equipment & components of the apparatus***
- ***Reduces*** the chances of risks like ***fire hazards***
- Maintains the ***continuity*** of the power supply
- Brings back the power system to the ***normal state sooner***

Relay terminology – definitions

Same topic discussed in unit-2

What are Relays?

- Relays are electrical switches that open or close another circuit under certain conditions.



What is a protective relay?

Protective relays are devices which monitor power system conditions and operate to quickly and accurately isolate faults or dangerous conditions. A well designed protective system can limit damage to equipment, as well as minimize the extent of associated service interruption.

Relay Purpose

- Isolate controlling circuit from controlled circuit.
- Control high voltage system with low voltage.
- Control high current system with low current.
- Logic Functions

Relay Types

- Electromagnetic Relays (EMRs)

- Solid-state Relays (SSRs)
  - There is no mechanical contacts to switch the circuit.

- Microprocessor Based Relays
  Commonly used in power system monitoring and protection.

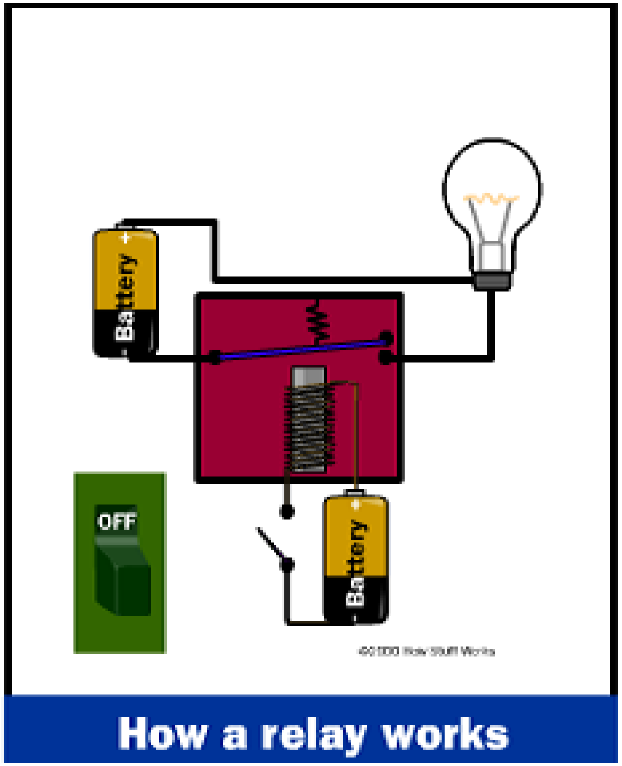
Advantages/Disadvantages

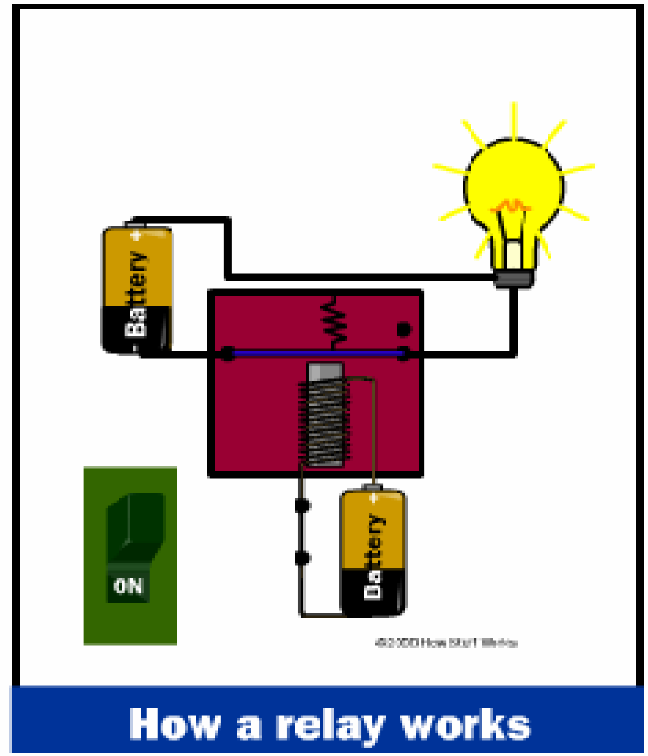
- Electromagnetic Relays (EMRs)
  - Simplicity
  - Not expensive
- Solid-state Relays (SSRs)
  - No Mechanical movements
  - Faster than EMR
- Microprocessor-based Relay
  - Much higher precision and more reliable and durable.
  - Capable of both digital and analog I/O.
  - Higher cost

Advantages for Using Protective Relays

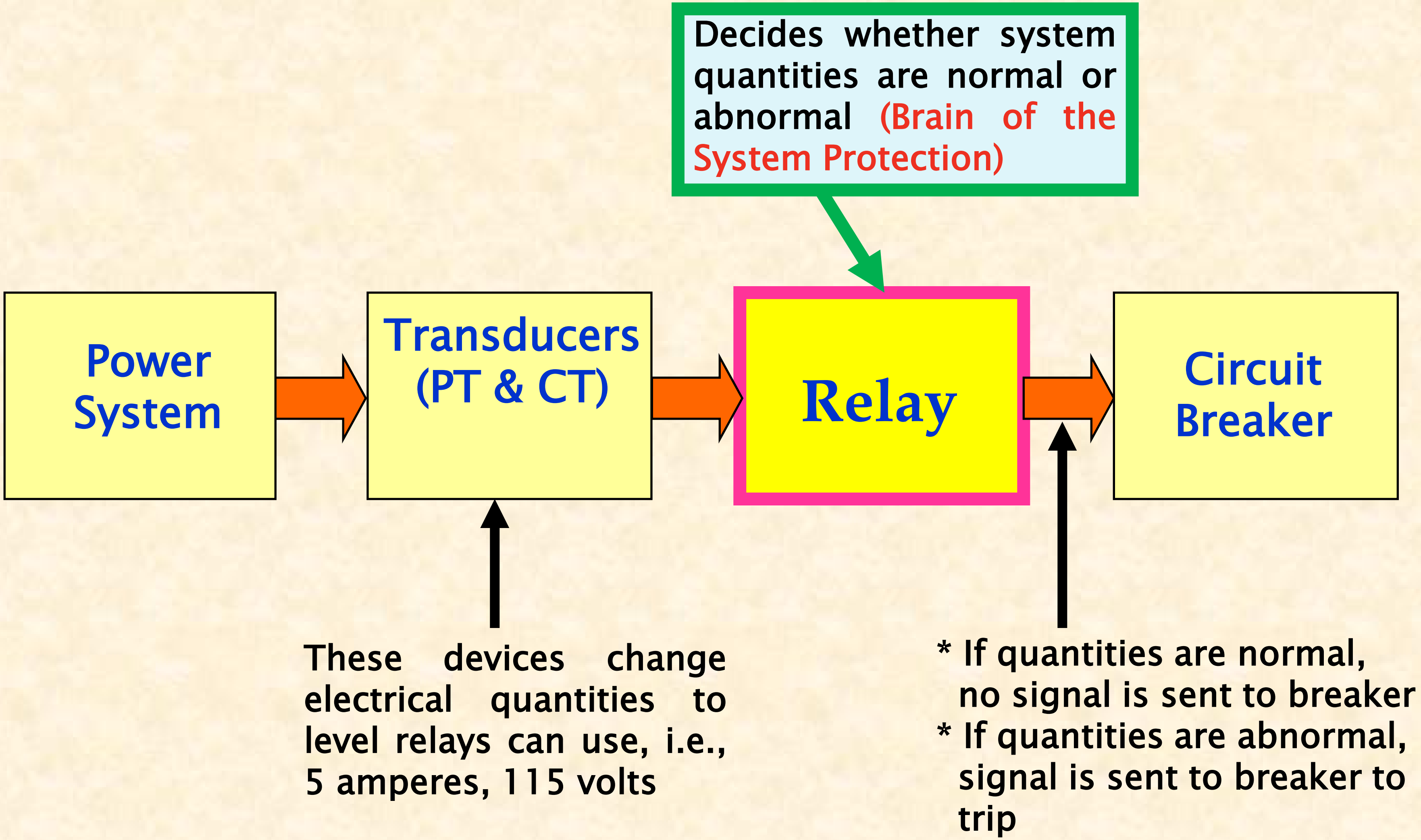
- Detect system failures when they occur and isolate the faulted section from the remaining of the system.
- Mitigating the effects of failures after they occur. Minimize risk of fire, danger to personal and other high voltage systems.

How a Relay Works





Components of Power System Protection



Relay-definitions

- **Primary Relay**: relay connected **directly** in the circuit
- **Secondary Relay**: relay connected to the **protected circuit** through CT & VT.
- **Auxiliary Relay**: relay operate in response to opening or closing of another relay.
- **Measuring Relay**: It performs the measurement of normal & abnormal conditions in the power system.
- **Electro Magnetic Relay**: It operates on the principle of Electromagnetic induction.
- **Static Relay(Solid-state relay)**: They use diodes , transistors , SCRs , Logic gates etc.

  (Static circuit is the measuring circuit & no moving parts)
- **Microprocessor Based Relay**: All functions of a relay can done by using microprocessor . Relays are programmable.

  μP can compare , compute and send trip signals.

- **Thermal Relay**: It operates on the principle of Electro-thermal effect.
- **Distance Relay**: relay measures the impedance or reactance or admittance.
- **Impedance Relay**: relay measures the impedance of the transmission line.
- **Reactance Relay**: relay measures the reactance of the transmission line.
- **Over-current Relay**: relay operates when the current exceeds a pre-set value.
- **Under-voltage Relay**: relay operates when the voltage falls a pre-set value.
- **Directional Relay**: relay able to sense whether fault lies in forward or reverse direction.
- **Polarized Relay**: relay depends on the direction of the current.

- **Differential Relay**: it measures the difference b/w 2 actual quantities.
- **Earth fault Relay**: It is used for protection of element of a power system against **Earth** faults.
- **Phase fault Relay**: It is used for protection of element of a power system against **phase** faults.
- **Negative Sequence Relay**: relay uses negative sequence current as its actuating quantity.
- **Zero Sequence Relay**: relay uses zero sequence current as its actuating quantity.

Essential Qualities of protection

or

Requirement of Protective System

- Reliability
  - Dependability
  - Security
- Selectivity
- Speed
  - System stability
  - Equipment damage
  - Power quality
- Sensitivity
  - High-impedance faults
  - Dispersed generation

Reliability	• assurance that the protection will perform correctly.
Selectivity	• maximum continuity of service with minimum system disconnection.
Sensitivity	• To detect even the smallest fault, current or system abnormalities and operate correctly at its setting
Speed	• minimum fault duration and consequent equipment damage and system instability.
Simplicity	• minimum protective equipment and associated circuitry to achieve the protection objectives.

Reliability

- The level of assurance that the relay will function as intended.
- Reliability denotes:
  - Dependability - certainty of correct operation
  - Security - assurance against incorrect operation

Sensitivity

- Relaying equipment must be sufficiently sensitive so that it will operate when required
- Must discriminate normal from abnormal conditions.

Selectivity

- Performance of protective devices to select between those conditions for which prompt operation and those for which no operation, or time delay operation is required.
- Isolate faulted circuit resulting in minimum interruptions.
- Implemented through "Zone of Protection"

Speed

- Remove a fault from the power system as quickly as possible
- Classification:
  - Instantaneous - no intentional delay
  - High Speed - less than 3 cycles
  - Time-Delay - intentional time delay

Power System Earthing

- Neutral Earthing/Grounding
- Peterson coil
- Arcing Grounds

- The process of connecting the **metallic frame** (i.e. non-current carrying part) of electrical equipment or some **electrical part** of the system to **earth** (i.e. **soil**) is called **grounding** or **earthing.**

- Grounding or earthing may be classified as :

(i) Equipment grounding

(ii) System grounding

Equipment Grounding

- The process of connecting non-current-carrying metal parts of the electrical equipment to earth.

System Grounding

•The process of connecting some electrical part of the power system to earth (i.e. soil) is called **system grounding.**

Neutral Earthing

Neutral Grounding

- Connecting neutral point to earth (i.e. soil) either directly or some circuit element

  (e.g. **resistance, reactance , Peterson coil** etc.) is called **neutral grounding.**

- Neutral grounding provides protection to equipment.

  (during earth fault, the current path is completed neutral)

Advantages of Neutral Grounding

(i) Voltages of the healthy phases do not exceed line to ground voltages i.e. they remain nearly constant.

(ii) The high voltages due to arcing grounds are eliminated.

(iii) Life of insulation is long.

(iv) The over voltages is reduced.

(v) It provides greater safety to personnel and equipment.

(vi) It provides improved service reliability.

(vii) Operating and maintenance expenditures are reduced.

Methods of Neutral Grounding

(i) Solid or effective grounding

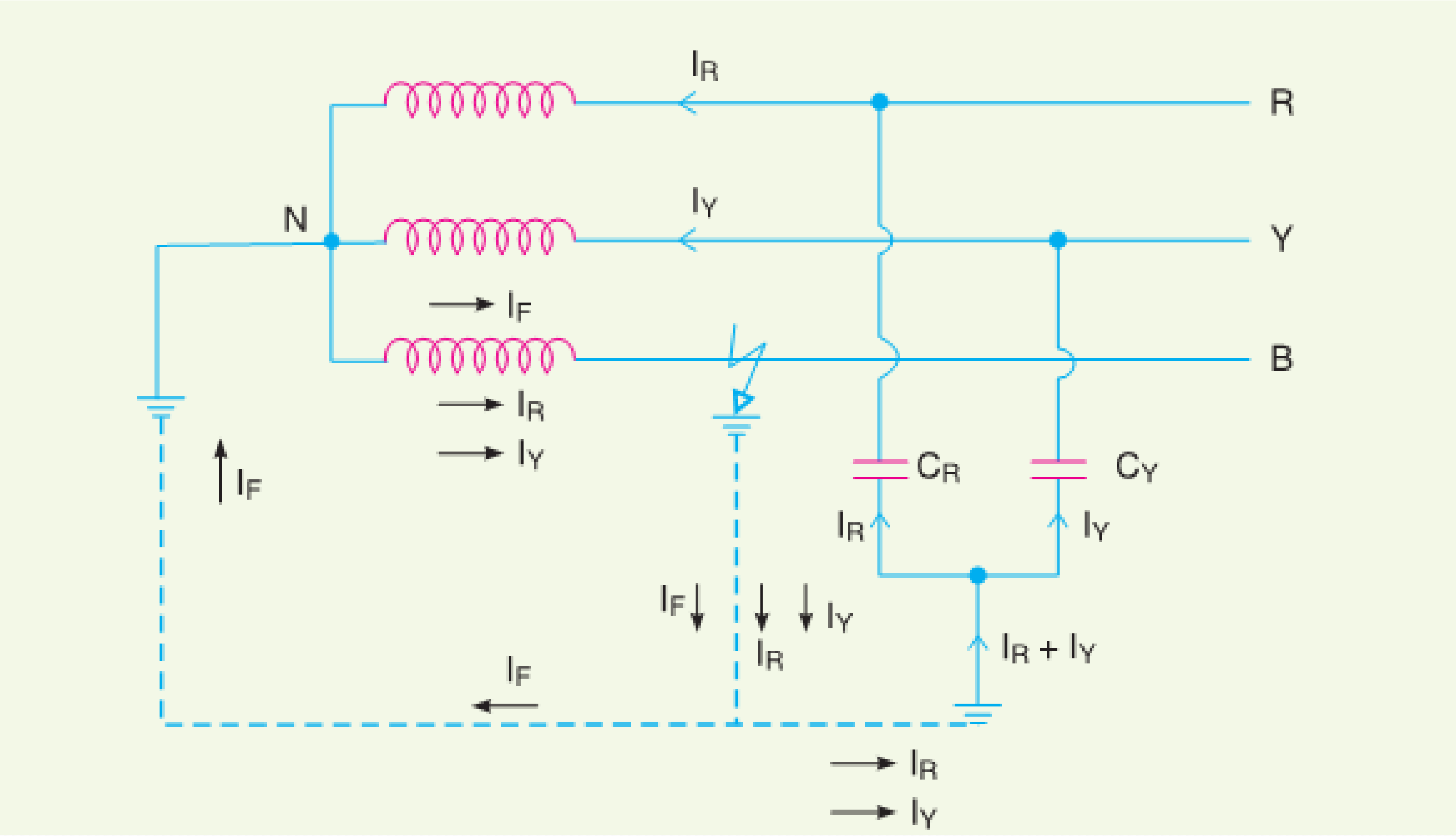
(ii) Resistance grounding

(iii) Reactance grounding

(iv) Peterson-coil grounding 

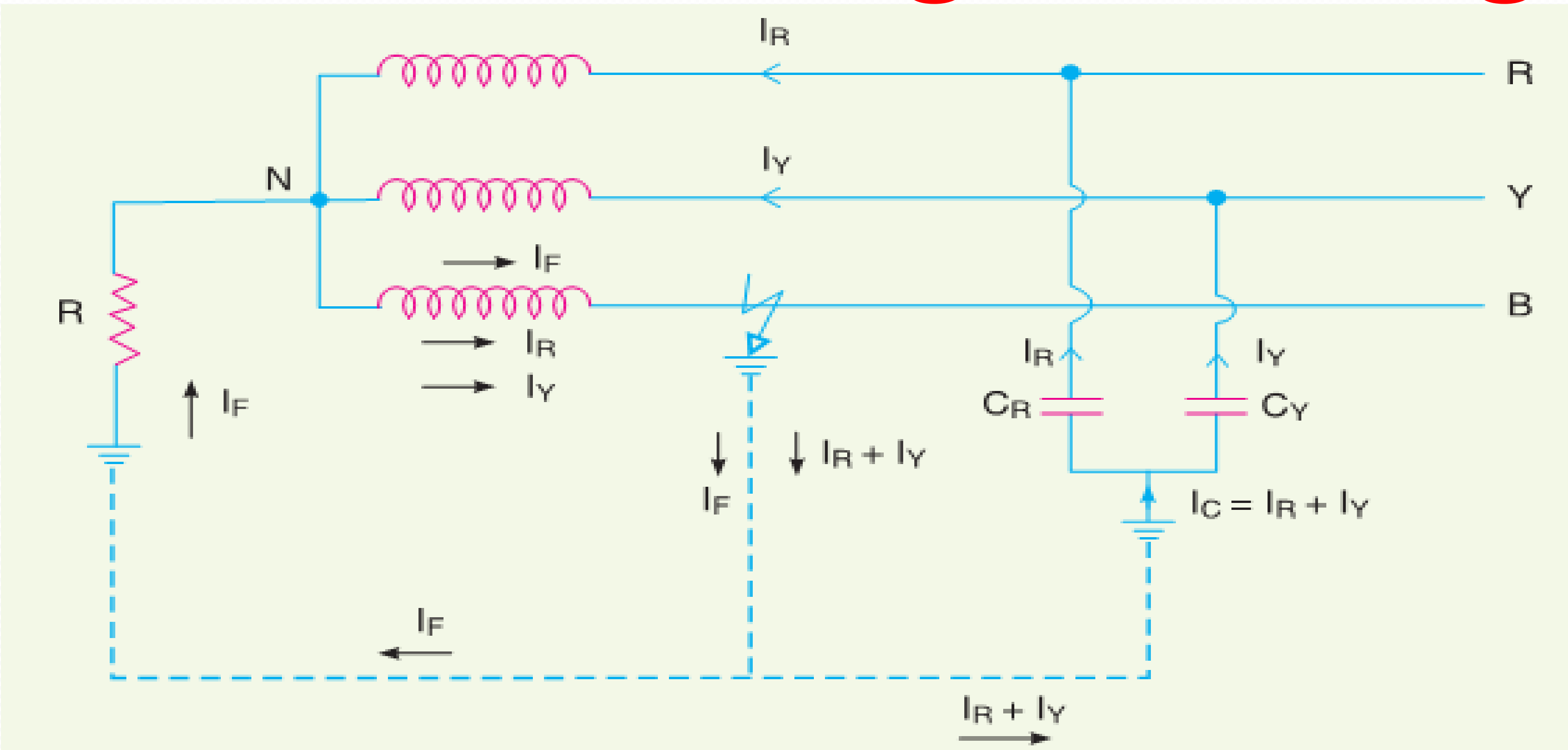
(v) Voltage transformer earthing

(i) Solid or effective grounding



- When the neutral point of a 3-phase system is directly connected to earth (i.e. soil) is called **solid grounding or effective grounding**.
- When an earth fault occurs between earth and any one phase , the voltage to earth of the faulty phase becomes zero, but the healthy phases remains at normal phase values.
- Fault current(I_F) completely nullified by capacitive current(I_C)

(ii) Resistance grounding



When the **neutral point** of a 3-phase system (e.g. 3-phase generator, 3-phase transformer etc.) is connected to **earth** (i.e. soil) through a resistor, it is called resistance grounding.

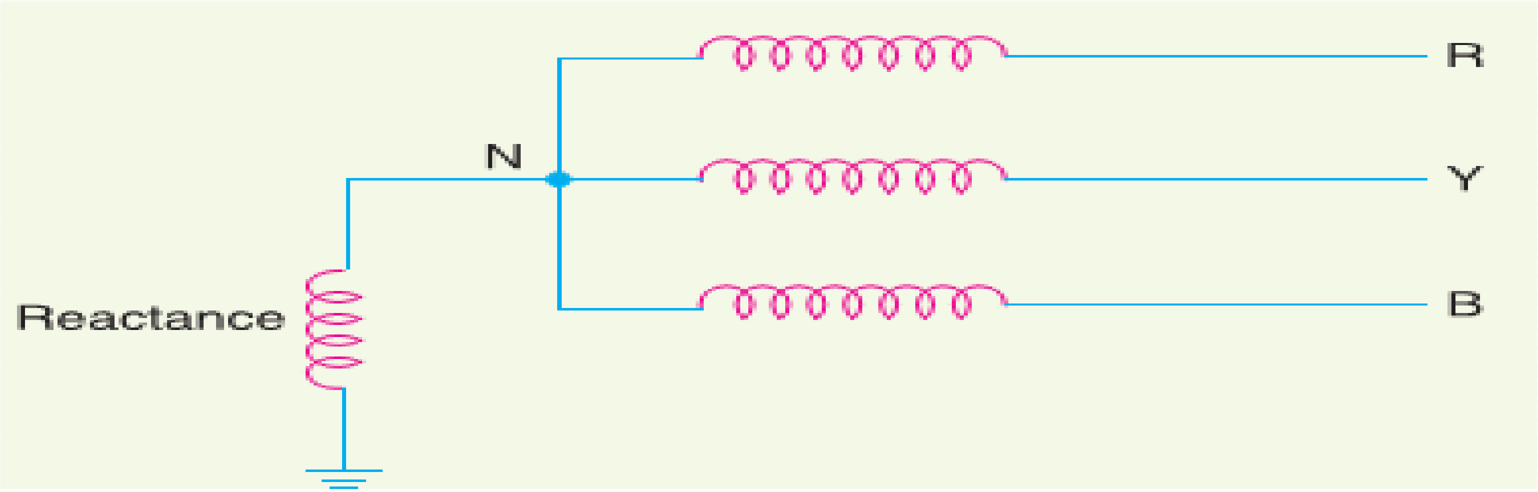
Advantages:

- By adjusting the value of R, the arcing grounds can be minimized.
- It improves the stability
- Less interference
- Minimize hazards

Disadvantages:

- By adjusting the value of R, the arcing grounds can be minimized.
- It improves the stability
- Less interference
- Minimize hazards

(iii) Reactance grounding



•In this system, a reactance is inserted between the neutral and ground
•The purpose of reactance is to limit the earth fault current.

Disadvantages :

(i) In this system, the fault current required to operate the protective device is higher than that of resistance grounding for the same fault conditions.
(ii) High transient voltages appear under fault conditions.

iv. PETERSON COIL

or

Arc Suppression Coil Grounding

or

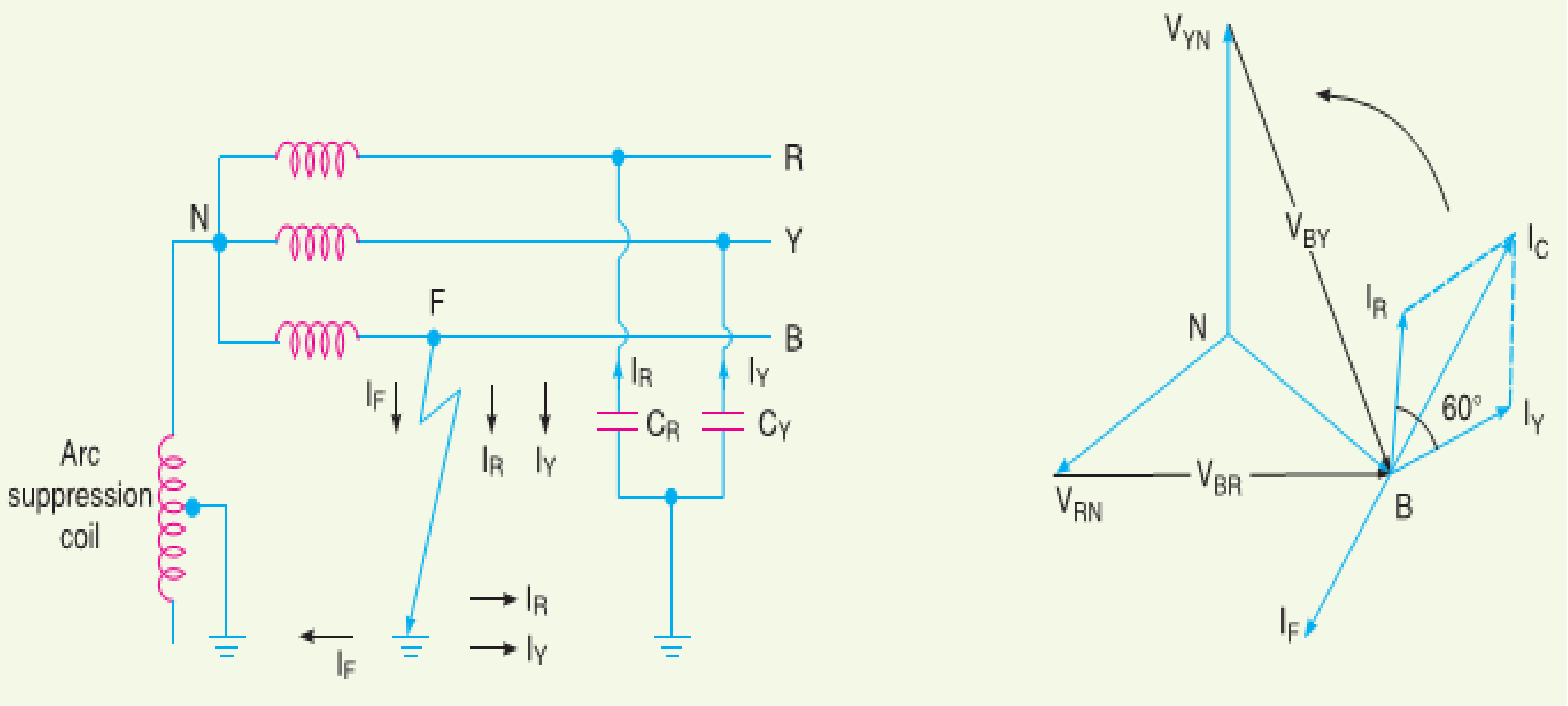
Resonant Grounding

- If inductance L of appropriate value is connected in parallel with the capacitance of the system, the fault current I_F flowing through L will be in phase opposition to the capacitive current I_C of the system. If L is so adjusted that

$$I_L = I_C$$

then resultant current in the fault will be zero. This condition is known as **Resonant Grounding**.

When the value of **L** of arc suppression coil is such that the fault current I_F exactly balances the capacitive current I_C, it is called resonant grounding.



•An arc suppression coil (also called Peterson coil) is an iron-cored coil connected between the neutral and earth.

•The reactor is provided with tappings to change the inductance of the coil.

•By adjusting the tappings on the coil, the coil can be tuned with the capacitance of the system i.e. resonant grounding can be achieved.

- Suppose line to ground fault occurs in the line B at point F. The fault current I_F and capacitive currents I_R and I_Y will flow as shown in Fig
- Note that I_F flows through the Peterson coil (or Arc suppression coil) to neutral and back through the fault. The total capacitive current I_C is the phasor sum of I_R & I_Y as shown in phasor diagram in Fig.
- The voltage of the faulty phase is applied across the arc suppression coil. Therefore, fault current I_F lags the faulty phase voltage by 90°.
- The current I_F is in phase opposition to capacitive current I_C [See Fig].

By adjusting the tappings on the Peterson coil, the resultant current in the fault can be reduced. If inductance of the coil is so adjusted that $I_L = I_C$, then resultant current in the fault will be zero.

Value of L for resonant grounding. For resonant grounding, the system behaves as an un-grounded neutral system. Therefore, full line voltage appears across capacitors C_R and C_Y.

$$\therefore \qquad I_R = I_Y = \frac{\sqrt{3}V_{ph}}{X_C}$$

$$\therefore \qquad I_C = \sqrt{3}\, I_R = \sqrt{3} \times \frac{\sqrt{3}V_{ph}}{X_C} = \frac{3V_{ph}}{X_C}$$

Here, X_C is the line to ground capacitive reactance.

Fault current, $$I_F = \frac{V_{ph}}{X_L}$$

Here, X_L is the inductive reactance of the arc suppression coil.

For resonant grounding, $I_L = I_C$.

or $$\frac{V_{ph}}{X_L} = \frac{3V_{ph}}{X_C}$$

or $$X_L = \frac{X_C}{3}$$

or $$\omega L = \frac{1}{3\omega C}$$

$$\therefore \qquad L = \frac{1}{3\omega^2 C} \qquad \text{...}(i)$$

Exp. (*i*) gives the value of inductance L of the arc suppression coil for resonant grounding.

Advantages. The Peterson coil grounding has the following advantages:

(*i*) The Peterson coil is completely effective in preventing any damage by an arcing ground.

(*ii*) The Peterson coil has the advantages of ungrounded neutral system.

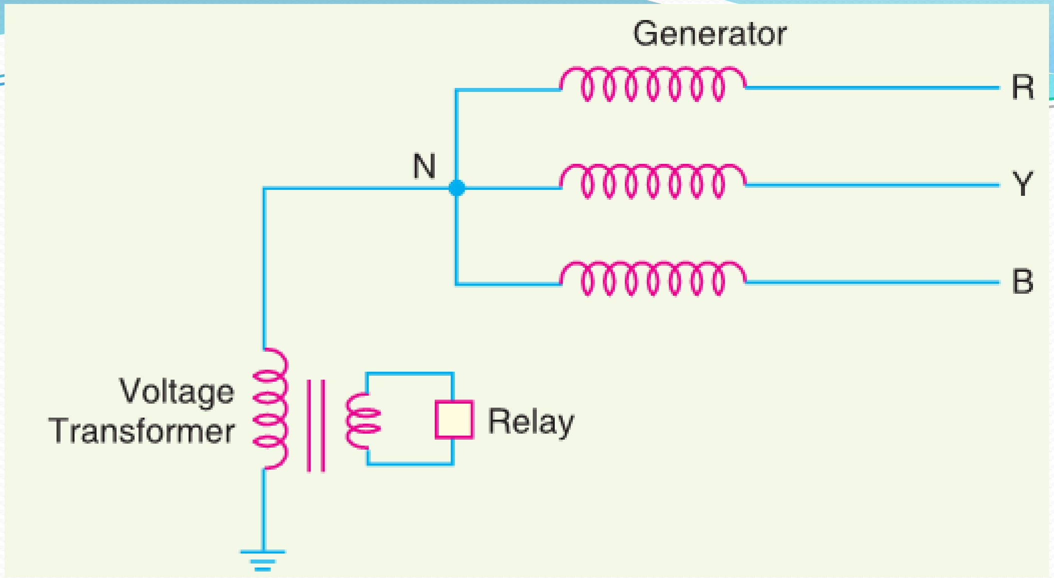
Disadvantages. The Peterson coil grounding has the following disadvantages :

(*i*) Due to varying operational conditions, the capacitance of the network changes from time to time. Therefore, inductance L of Peterson coil requires readjustment.

(*ii*) The lines should be transposed.

v. Voltage Transformer Earthing

- In this method of neutral earthing , the primary of a single-phase voltage transformer is connected between the neutral and the earth as shown in Fig
- A low resistor in series with a relay is connected across the secondary of the voltage transformer. The voltage transformer provides a high reactance in the neutral earthing circuit and operates virtually as an ungrounded neutral system.



Advantages:

•Arcing grounds are reduced.
•Transient overvoltage are reduced

Protection against over voltages due to lightning and switching

Protection Against Over Voltage Due to Lightning & Switching

- During Operation , PS equipments such as Generator, transformer, Tx.lines may subject to Over Voltage.
- OV occurs due to Lightning, opening of CB & so on.

Causes Of OV

- Internal Cause
  - External Cause

External

- Lightning
- Tree falls on Tx.lines causes SC

Internal

- Insulation Failure
- Resonance
- Arching Ground
- Switching Surges

Types of Over Voltages

*Power Frequency OV

* Switching OV

* Lightning OV

Power Frequency OV

- Does not have damaging effects like switching or lightning surges
- It will be harmful, if sustained for longer duration
- Mainly due to
  - ✓ Ground faults
  - ✓ Sudden load rejection
  - ✓ Loose connection

Switching OV

- Also known as ***Switching surge*** or ***over voltage transient***
- Sudden ***rise*** of voltage for a ***very short duration*** in PS network is known as ***transient voltage or voltage surge***
- An electrical transient appears, if there is **sudden change** in the state of energy in PS network. This sudden change is due to
    i. ***Closing a Switch***
    ii. ***Opening a Switch***
    iii. ***Occurrence of fault in system***
- To control the switching OV , ***Resistor*** is inserted between the ***contacts*** while switching off the circuit

Lightning OV

- Lightning is an ***electric discharge*** between cloud & Earth or **between clouds**.
- It is basically a ***huge spark***
- A large number of ***discharge*** occurs ***between or with in clouds*** than to earth & enough of them ***terminate on the earth*** causing serious hazards.

SURGE DIVERTER

What is surge ?

- Surges disturbances on a power waveform that can damage, or destroy equipment within any home, commercial building, or manufacturing facility.
- Surges are measured in microseconds.

Surge diverters

- A surge diverter is a piece of equipment that **diverts** excess voltages to earth, thus protecting sensitive electrical and electronic equipment.

- The surge diverter is normally installed in the main switchboard.

Requirement of surge diverter :

- It should not pass any current at normal and abnormal power frequency voltage.
- It should breakdown as quickly as possible after the abnormal high frequency voltage arrives.
- It should not only protect the equipment for which it is used but should discharge current **without** damaging itself.
- It should interrupt power frequency follow current after the **surge is discharge to ground**.

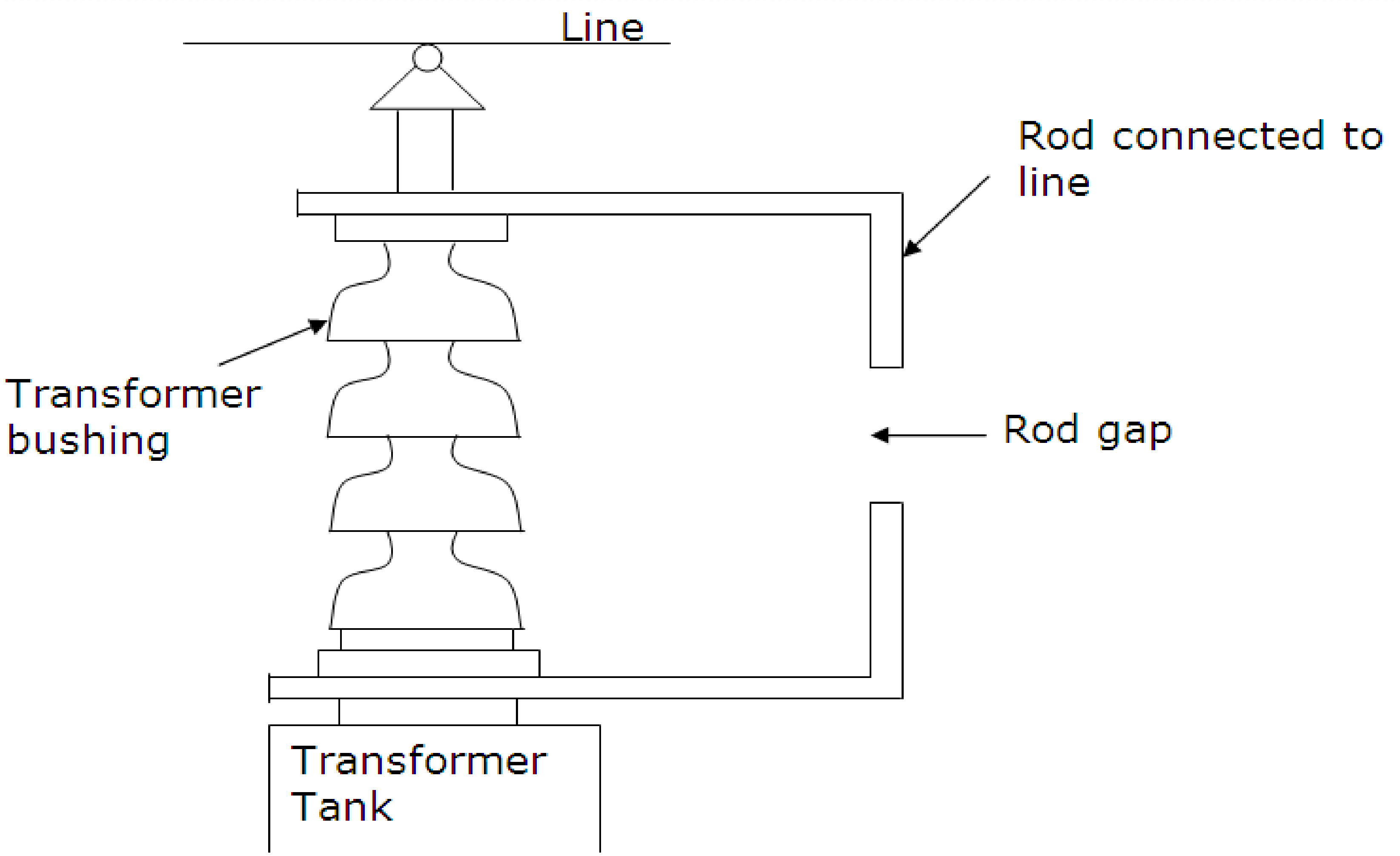
Types of surge diverters

- Rod gap
- Protector tube or expulsion type surge diverter
- Valve type surge diverter

1. Rod gap :

- It is a very simple type of diverter and consists of two 1.5 cm rods.
- One rod is connected to the line circuit and the other rod is connected to **earth**.
- The distance between gap and insulator must not be less than one third of the gap length so that the arc may not reach the insulator and damage it.
- The rod gap should be so set that it breaks down to a voltage not less than 30% below the voltage withstand level of the equipment to be protected.

Rod gap type surge diverter :



- The string of insulators for an overhead line on the bushing of transformer has frequently a rod gap across it.
- Under normal operating conditions, the gap remains non-conducting.
- On the occurrence of a high voltage surge on the line, the gap sparks over and the surge current is conducted to earth.

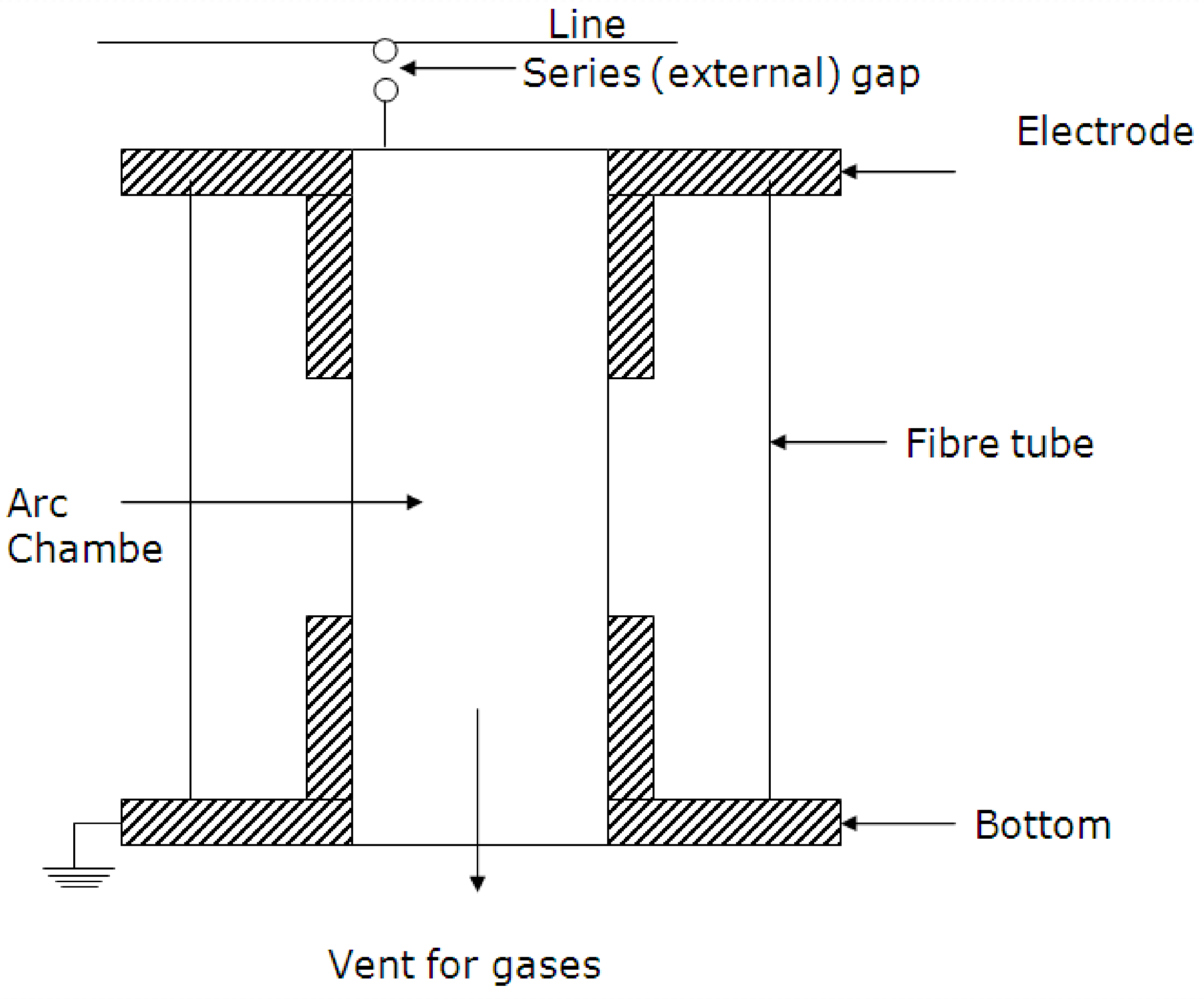
Limitations :

- After the surge is over, the arc in the gap is maintained by the normal supply voltage, leading to short-circuit on the system.
- The rods may melt or get damaged **due to** excessive heat produced by the arc.
- The climatic conditions (e.g. rain, temperature etc.) affect the performance of rod gap arrester.

2.Expulsion type surge diverter

- This type of arrester is also called '**protector tube**' and is commonly used on system operating at voltages up to 33kV.
- It essentially consists of a rod gap in series with a second gap enclosed within the fiber tube.
- The gap in the fiber tube is formed by two electrodes.
- The upper electrode is connected **to** rod gap and the lower electrode **to** the earth.

Expulsion type lightning arrester



- The series gap is set to arc over at a specified voltage lower than the withstand voltage of the equipment to be protected.
- The follow-on current is confined to the space inside the relatively small fiber tube.
- Part of the tube material vaporizes, and the high pressure gases so formed are expelled through the vent at the lower end of the tube, causing the power follow-in arc to be extinguished.
- The device, therefore, has the desired self-clearing property.

Advantages

- They are not very expensive.
- They can be easily installed.
- They are improved form of rod gap arresters as they block the flow of power frequency follow currents.

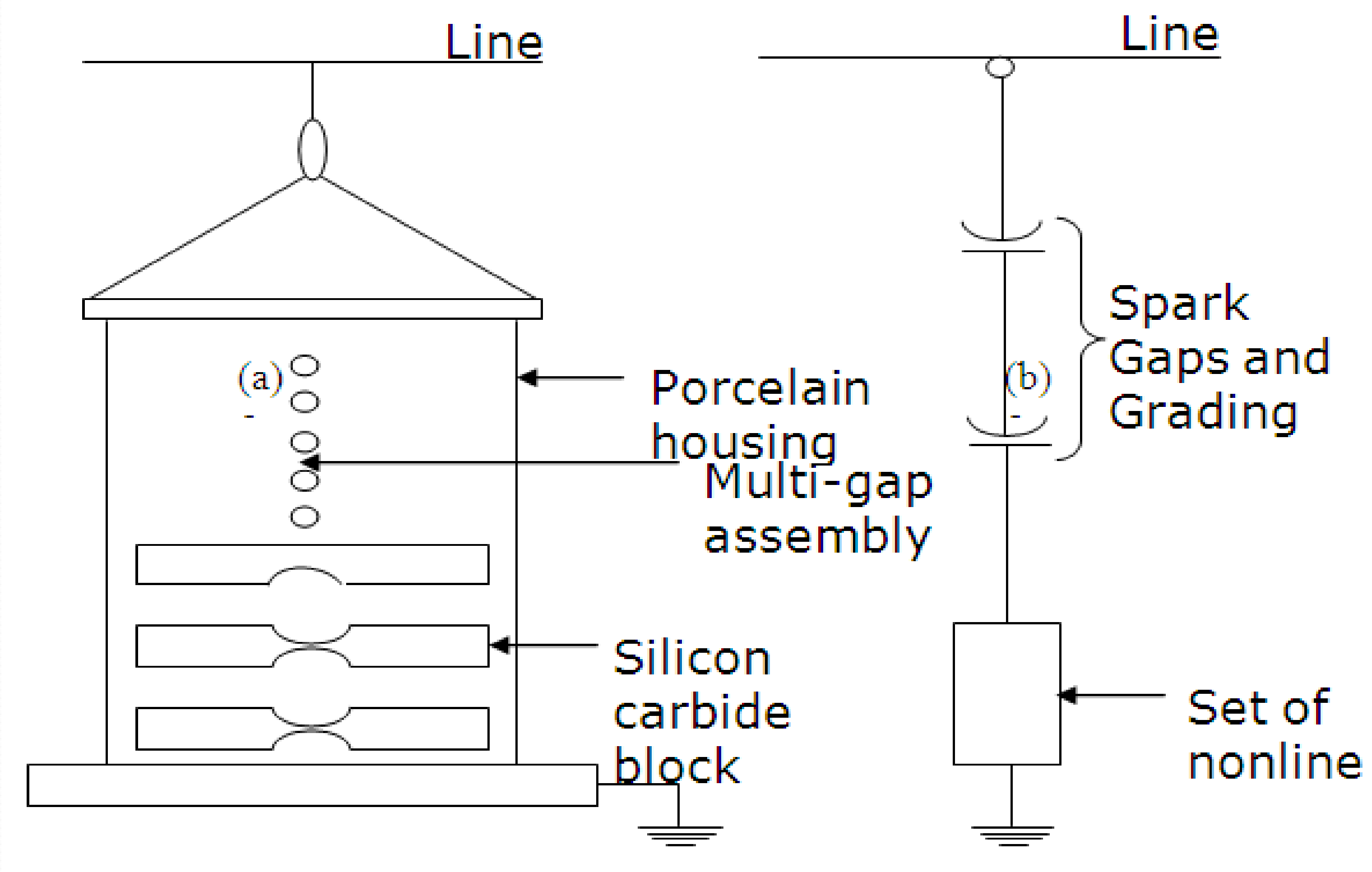
Limitations

- An expulsion type arrester can perform only limited number of operations as during each operation some of the fiber material is used up.
- This type of arrester cannot be mounted on enclosed equipment due to discharge of gases during operation.
- Due to the poor volt/amp characteristic of the arrester, it is not suitable for protection of expensive equipment

3. Valve type

- **Valve type arresters** incorporate non linear resistors and are extensively used on systems, operating at high voltages.
- It consists of two assemblies (i) series spark gaps and (ii) non-linear resistor discs
- The non-linear elements are connected in series with the spark gaps. Both the assemblies are accommodated in tight porcelain container.
- The **spark gap** is a multiple assembly consisting of a number of identical spark gaps in series.
- Each gap consists of two electrodes with fixed gap spacing.

- The spacing of the series gaps is such that it will withstand the normal circuit voltage.
- An over voltage will cause the gap to break down causing the surge current to ground via the non-linear resistors.
- **The non-linear resistor discs** are made of inorganic compound such as thyrite or metrosil.
- These discs are connected in series.
- The non-linear resistors have the property of offering a high resistance to current flow when normal system voltage is applied, but a low resistance to the flow of high surge currents.



- When the surge is over the non linear resistor assume high resistance to stop the flow of current.

- Under normal conditions, the normal system voltage is insufficient to cause the breakdown of air gap assembly.
- On the occurrence of an over voltage, the breakdown of the series spark gap takes place and the surge current is conducted to earth via the nonlinear resistances.
- Since the magnitude of surge current is very large, the nonlinear elements will offer a very low resistance to the passage of surge.
- The surge will rapidly go to earth instead of being sent back over the line.

ADVANTAGES :

- They provide very effective protection against surges.
- They operate very rapidly taking less than a second
- The impulse ratio is practically unity.

Limitations :

- They may fail to check the surge of very steep wave front reaching the terminal apparatus. This calls for additional steps to check steep fronted waves.
- Their performance is adversely affected by the entry of moisture into the enclosure. This necessitates effective sealing of the enclosure at all times.

Surge Absorber

Surge Absorber

- The Device which ***reduces the steepness*** of the wave front of a particular surge & thus minimizes the danger due to over voltage is known as surge absorber.

Note:

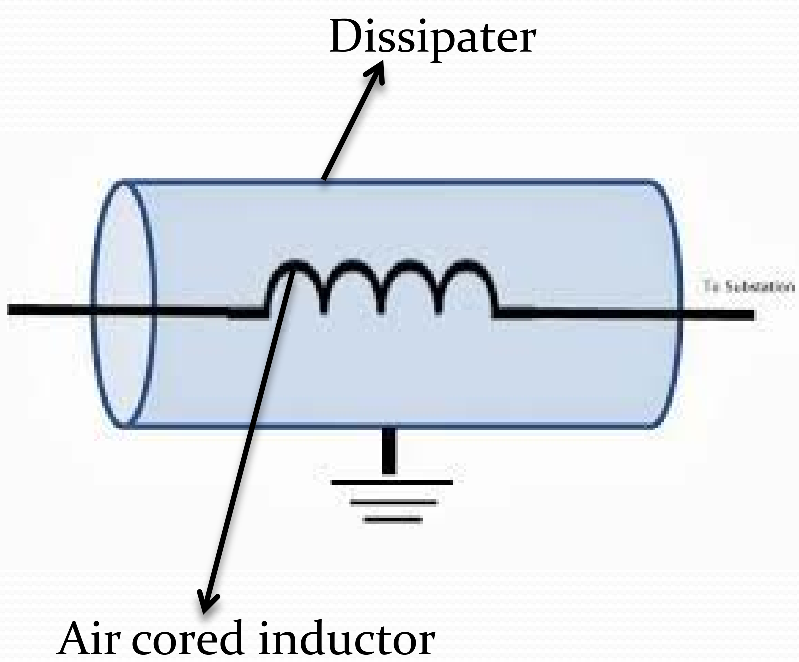
Surge Diverter : **Diverts the Surge to earth**

Surge Absorber : **Absorbs the Surge energy**

Types of Surge Absorber

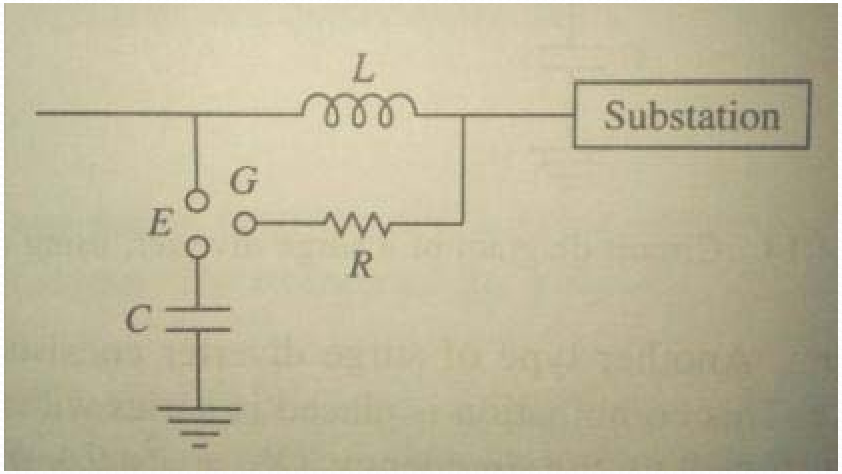
- Ferranti Surge absorber
    - ERA Surge absorber

Ferranti Surge absorber



- It consists of an ***air core inductor*** connected ***Series*** in line & surrounded by an earth metallic sheet (ie) ***dissipater***.
- Whenever a travelling wave is incident on the surge absorber, ***energy is transformed by mutual inductance between coil & dissipater. ie., the energy contained in the wave is dissipated in the form of heat.***
- Because of the series inductance the steepness of the ***wave is also reduced.***

ERA Surge Absorber



- Improved form of Surge absorber is the ***Electrical Research Association*** type surge filter.
- G – ***Gap*** ; E – ***Expulsion gap***
- When a wave reaches the ***L***, a high voltage is induced across it causing the gap ***G*** to ***breakdown*** putting the ***R and E*** into circuit.
- Thus incoming wave get ***flattened*** by ***L & R*** and its amplitude is reduced by ***E***.

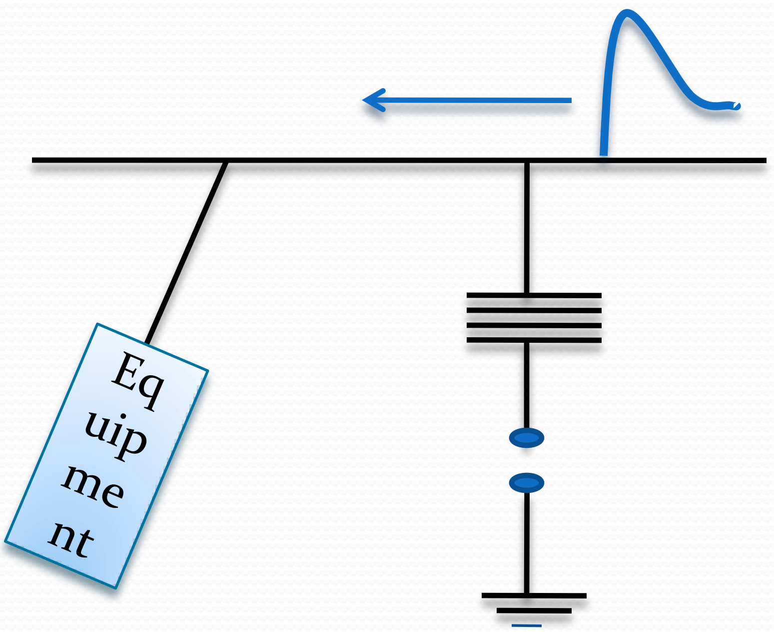
Basic ideas of insulation coordination

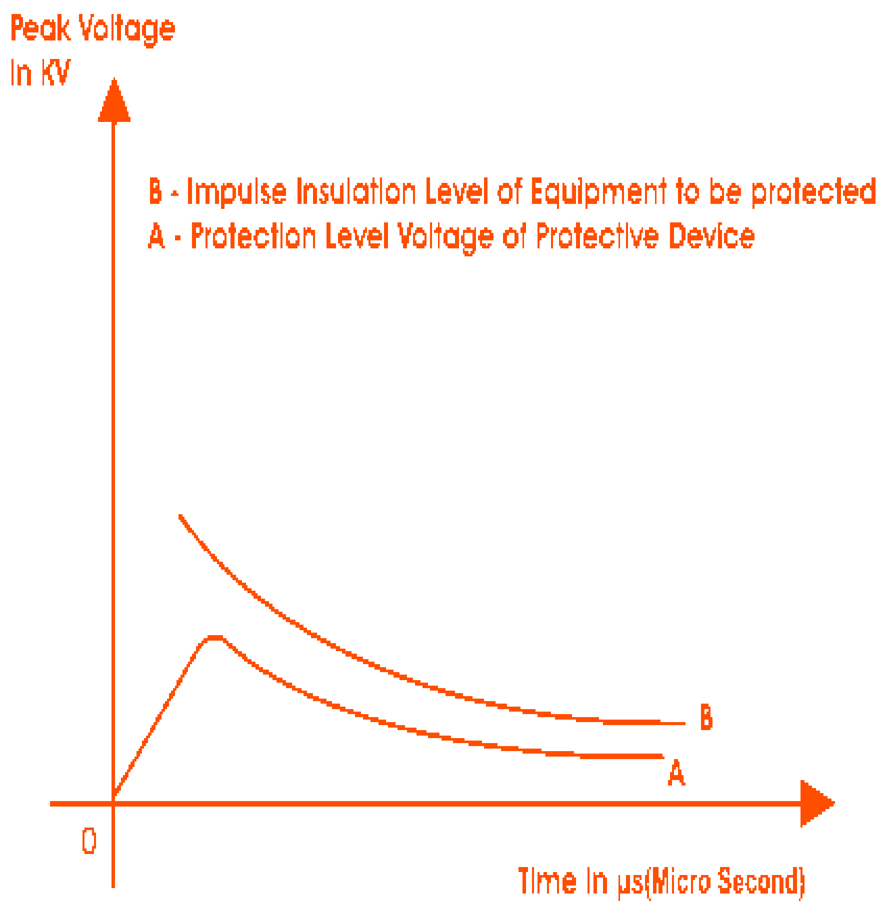
- Insulation Coordination is the process of **determining** the **proper insulation levels** of **various components** in a power system.

- The **insulation strength** of various equipments **should be** ***higher*** than that of lightning arresters and other surge protective devices.

- In its simplest form, Insulation Coordination is ***the selection of insulation strength.***

- Characteristics of lightning arrestor should be correlated with equipment isolation





Voltage - Time Curve used for Insulation Coordination

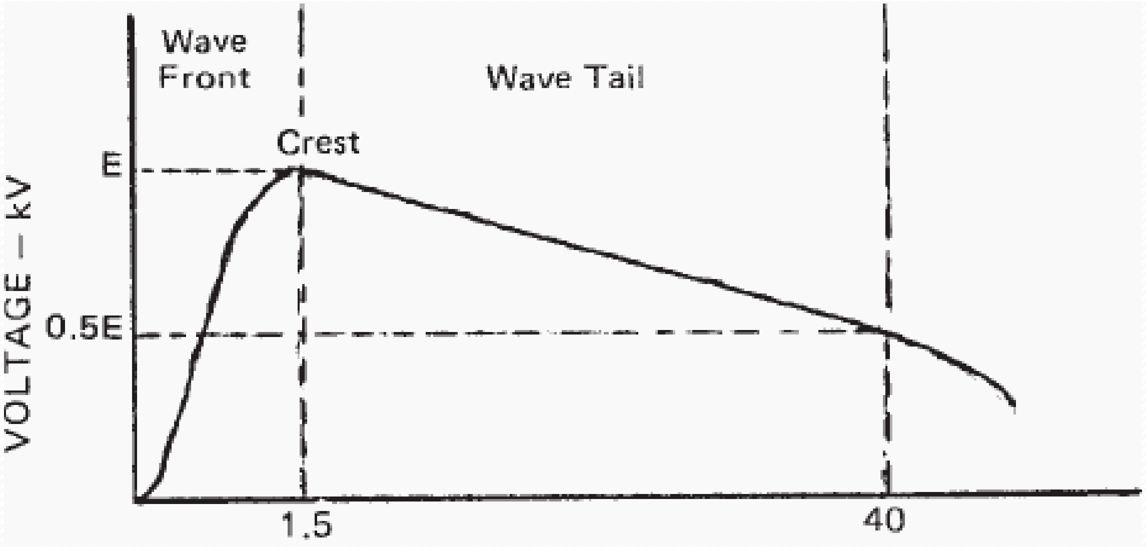
- The insulation of the line lightning arrestor & equipment should be **coordinated**.
- **Curve A** relates to ***Protective device***
- **Curve B** – *equipment to be protected*
- ***Protective device*** must have insulation characteristics which **must be lie** *below* the insulation characteristics of **instrument** to be protected.

A perfect insulation coordination must satisfy the following conditions:

- The insulation should **withstand** both **operating voltage & voltage surges**
- The discharge of OV due to **internal or external causes** must flow to **ground** efficiently.
- Only external flashover should cause breakdown

Basic Impulse Insulation Level (BIL)

- This is the reference insulation level expressed as an impulse crest (or peak) voltage with a standard wave not longer than a **1.2 x 50 microsecond** wave.
- A **1.2 x 50 microsecond** wave means that the **impulse** takes **1.2 microseconds** to reach the peak and then **decays to 50%** of the peak in 50 microseconds.



Withstand Voltage

- This is the BIL level that can repeatedly be applied to an equipment electrical failure under **test conditions**.

Critical Flashover Voltage

- This is the peak voltage for a 50% probability of flashover

Impulses Ratio

- It is the ratio of breakdown voltage at surge frequency to breakdown voltage at normal system frequency .

Chopped Wave Insulation Level

- The Chopped Wave Level is 1.15 times the BIL level

Over voltages that need to be considered when doing an Insulation Coordination Study.

There are three types of overvoltages that may occur on a power system:

- **Internal Overvoltages**
- **Switching Surges**
- **External Overvoltages**

UNIT-1 University Two marks

- Define the term “pick up” value in a protective relay.
- Mention the desirable qualities of a protective relay.
- Define arcing grounds.
- Define relay. State any two functions of relay.
- Define switchgear.
- Define surge diverter.
- List out the different types of faults occurring in power systems.
- Mention the necessity for earthing .
- Mention the various methods of earthing.

UNIT-1 University Two marks

- List out the causes of faults in the power system.
- List out the importance of ground wire.
- Differentiate between a fuse and a protective relay.
- Define surge absorber.
- Define insulation coordination.
- Define backup protection.
- Define static relay.
- List out the applications of Electromagnetic relays.
- Define protective zone.
- List out the importance of ground wire.

UNIT-1 University BIG questions

1. i. Explain any one type of Surge Diverter in detail. (8)

   ii. Define Peterson coil. Explain the protective function performed by this device with necessary diagram. (8)

2. Describe the different types of power system earthing. (16)

3. Explain in detail about

   i. Insulation coordination. (8)

   ii. Surge absorber. (8)

   i. Describe the fundamental requirements of protective relaying. (8)

   ii. Describe the essential qualities of protection. (8)

UNIT

2

RELAY

Presented by
C.GOKUL,AP/EEE
Velalar College of Engg & Tech , Erode

UNIT 2 Syllabus

- Electromagnetic relays 

  (attracted armature , solenoid, balanced beam)
- over current relay
- directional relay
- non-directional relay
- distance relay 

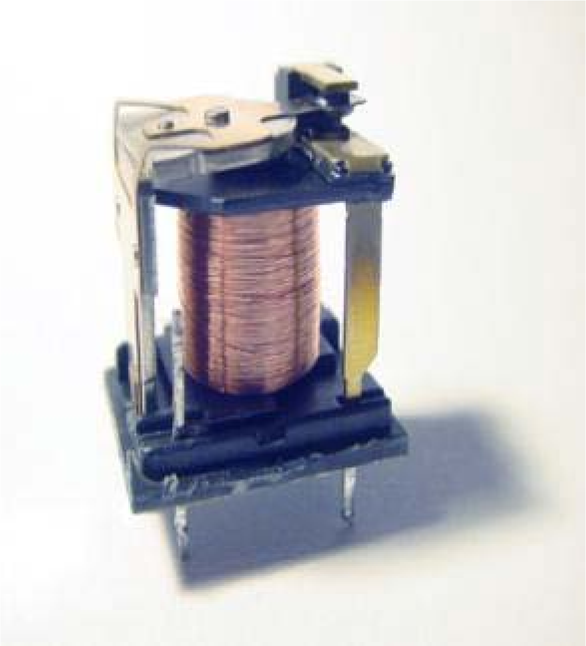
  (Impedance , Reactance, admittance(mho))
- negative sequence relay
- differential relay 

  (current , voltage, biased beam)
- under frequency relay
- Introduction to static relays 

Relay Overview

What are Relays?

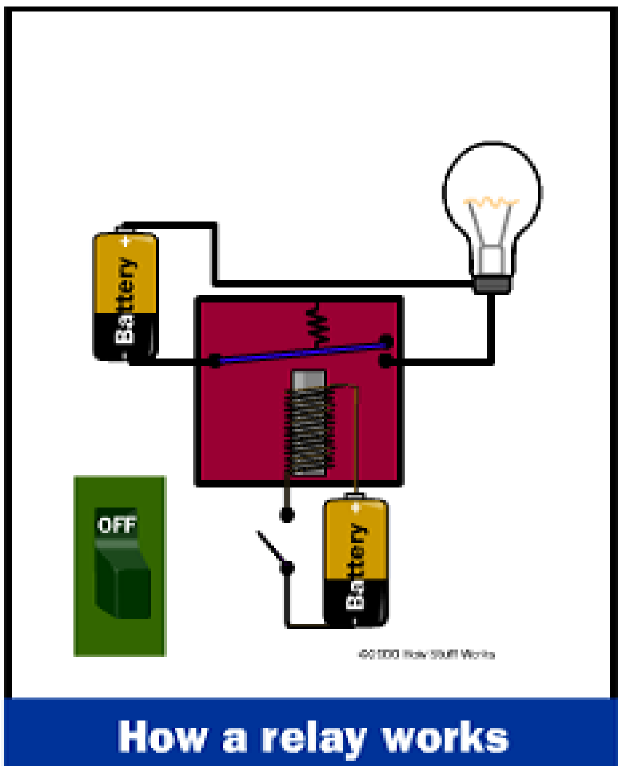
- Relays are electrical switches that open or close another circuit under certain conditions.

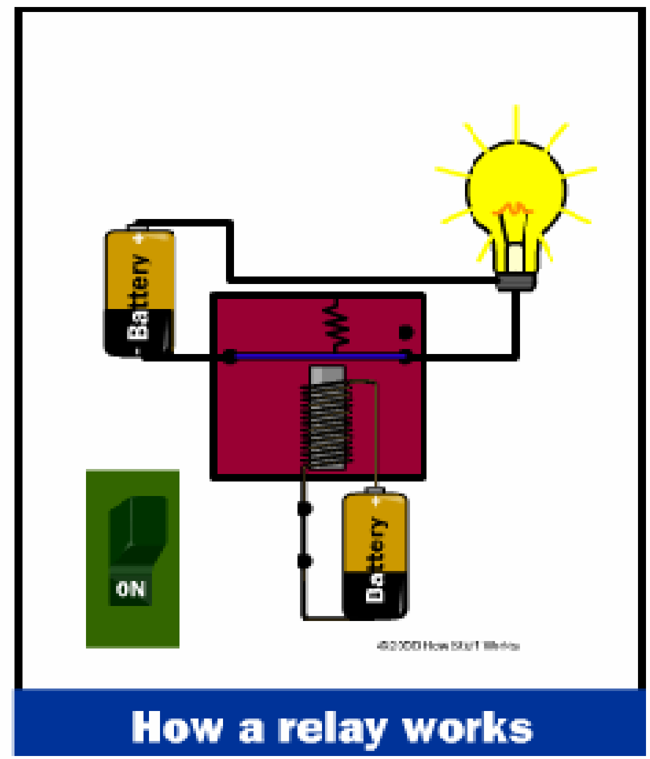


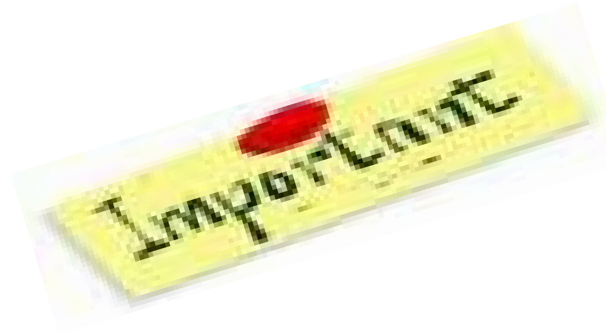
Relay Purpose

- Isolate controlling circuit from controlled circuit.
- Control high voltage system with low voltage.
- Control high current system with low current.
- Logic Functions

How a Relay Works







Electromagnetic Relay

They work on the following two main operating principles :
(i) Electromagnetic attraction
(ii) Electromagnetic induction

Electromagnetic Attraction Relays

(i) Attracted armature type relay
(ii) Solenoid type relay
(iii) Balanced beam type relay

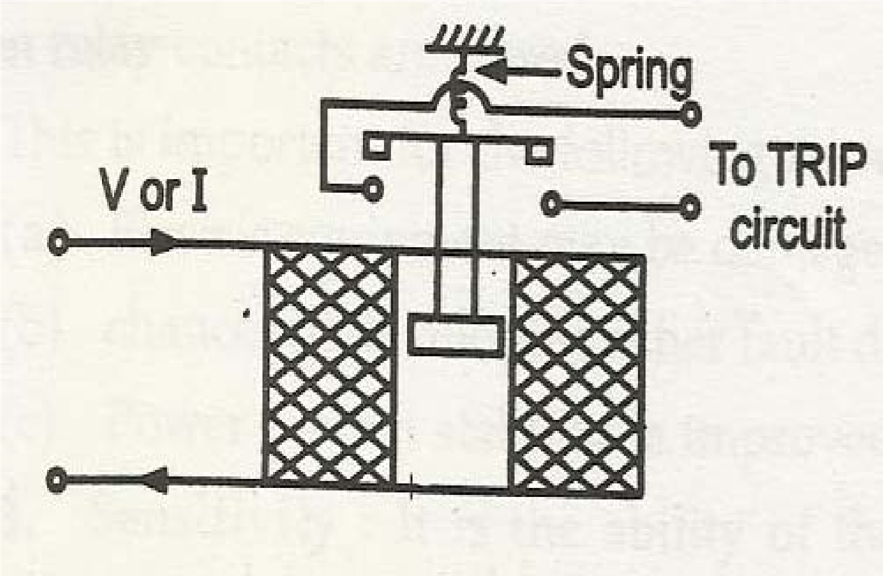
Induction Relays / Electromagnetic induction

(i) Induction type overcurrent Relay (**Non Directional Relay**)
(ii) Induction Cup Relay (**Directional Relay**)

1. Attracted Armature Type Relays

These have a coil or electromagnet energized by a coil .The coil is energized by operating quantity like V or I.

Under normal conditions the coil cannot attract the plunger due to spring force. Under fault condition the fault current increases so armature or plunger gets attracted to close the contacts .



Operating Principle : The electromagnetic force developed on moving element is proportional to square of the flux in air gap. If saturation is neglected force will be proportional to I^2.

$$\boxed{F = K_1 I^2 - K_2}$$

F = Net force

K_1 = Constant

K_2 = Restraing force including friction

I = Current in the relay coil

When relay is on the verge of operation.

$$K_1 I^2 = K_2$$

$$\therefore \quad I = \sqrt{\frac{K_2}{K_1}} \text{ ...... constant}$$

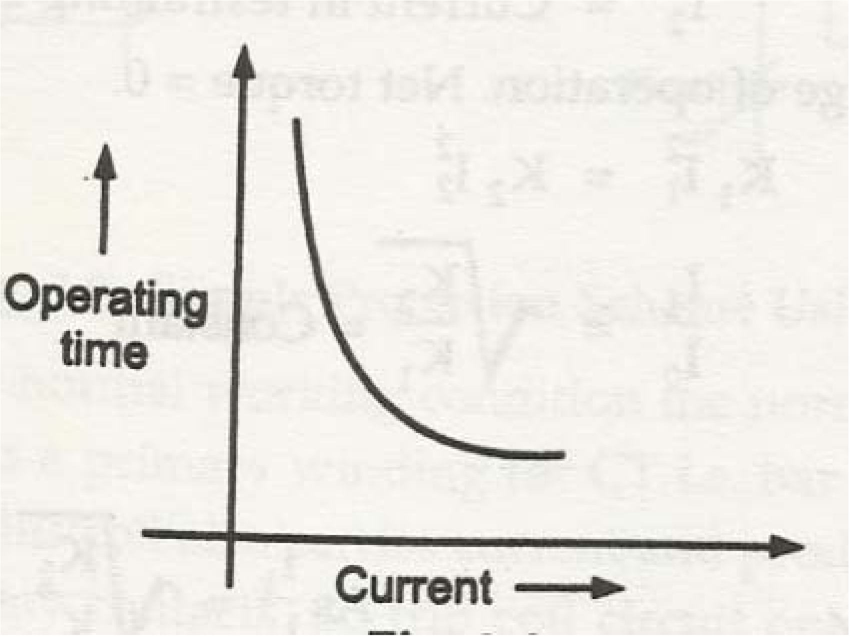
Advantages :

1. Relay responses to both A.C. and D.C. ($\because$ Torque $\propto I^2$).
2. Light moving parts, small length of travel of armature or plunger in air gap. Therefore, relays are fast in operation.
3. These relays are instantaneous but operating time varies with current (see characteristics). **The operating time and resetting time can be adjusted by adjusting the air gap so relays can be made slow operating relay.**

Attracted Armature Type Relays

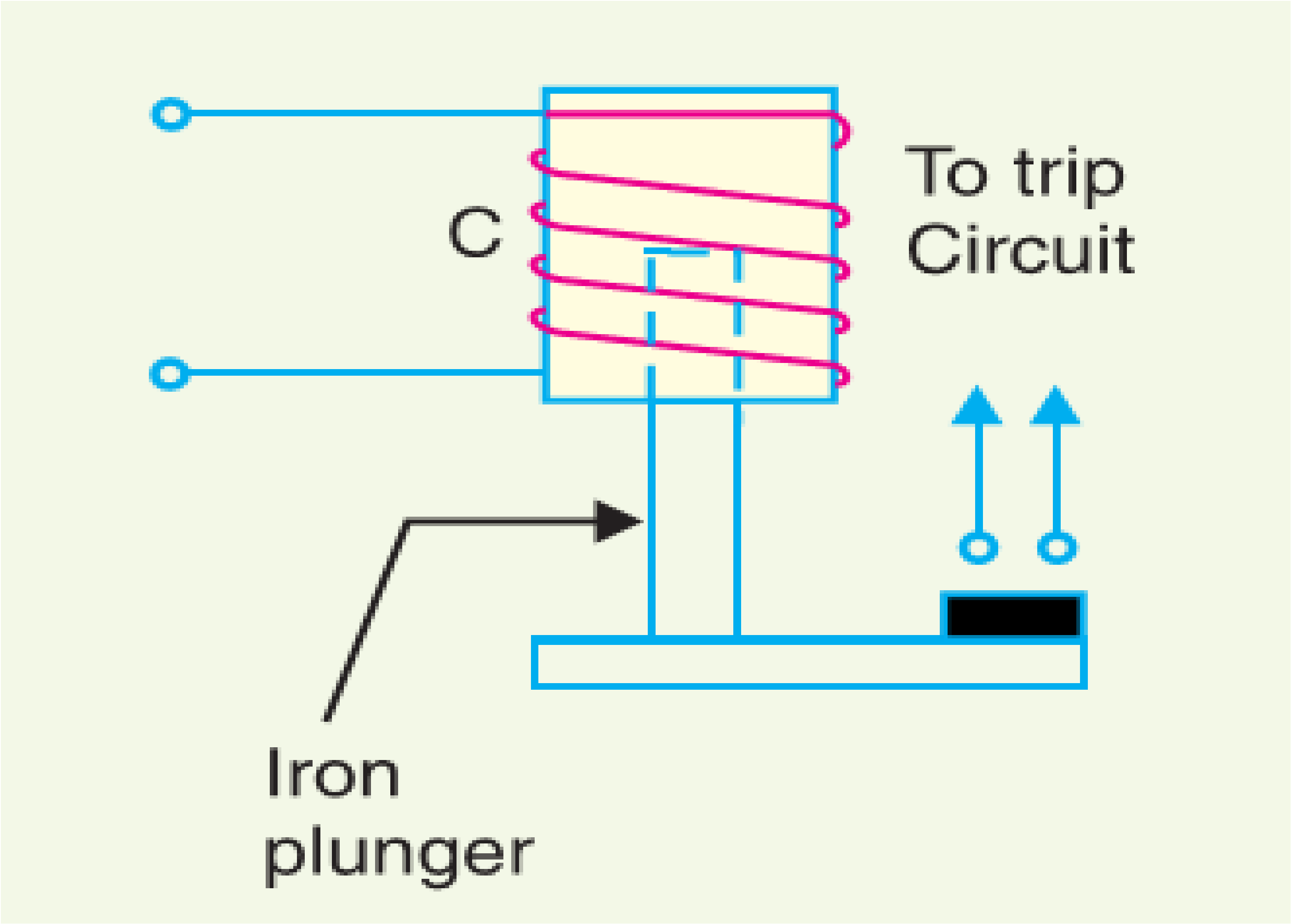
Applications

1. For over current protection
2. Differential Protection
3. Auxiliary Relays
4. Definite time lag over current and earth fault protection



(ii) Solenoid type relay

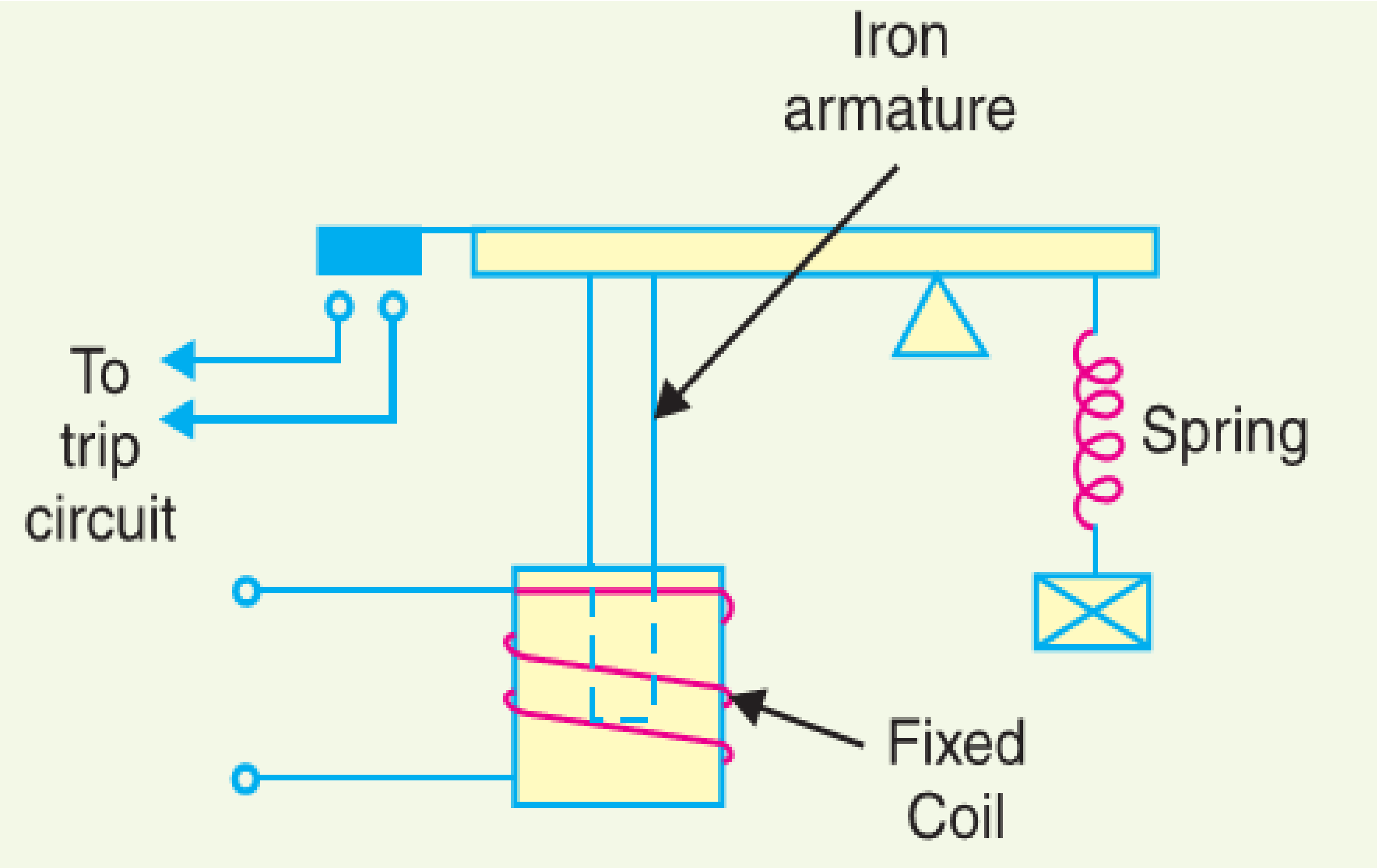
- It consists of a solenoid and movable iron plunger arranged as shown.
- Under normal operating conditions, the current through the relay coil C is such that it holds the plunger by gravity or spring in the position shown.
- However, on the occurrence of a fault, the current through the relay coil becomes more than the pickup value, causing the plunger to be attracted to the solenoid. The upward movement of the plunger closes the trip circuit, thus opening the circuit breaker and disconnecting the faulty circuit.



Solenoid type relay

(iii) Balanced beam type relay

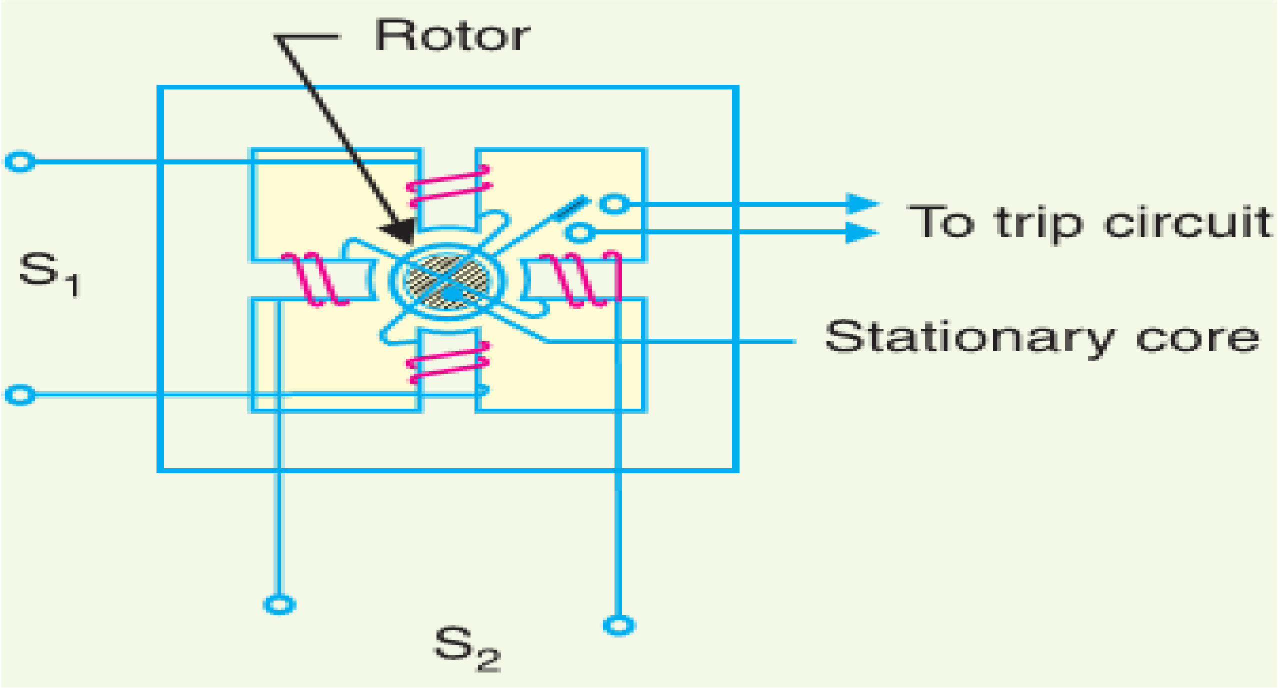
- It consists of an iron armature fastened to a balance beam. Under normal operating conditions , the current through the relay coil is such that the beam is held in the horizontal position by the spring.
- When a fault occurs, the current through the relay coil becomes greater than the pickup value and the beam is attracted to close the trip circuit. This causes the opening of the circuit breaker to isolate the faulty circuit.



Balanced beam type relay

Induction cup structure

- An induction motor, except that the rotor iron is stationary, rotor conductor portion being free to rotate.
- Moving element is a hollow cylindrical rotor which turns on its axis. The rotating field is produced by two pairs of coils wound on four poles as shown.
- The rotating field induces currents in the cup to provide the necessary driving torque.



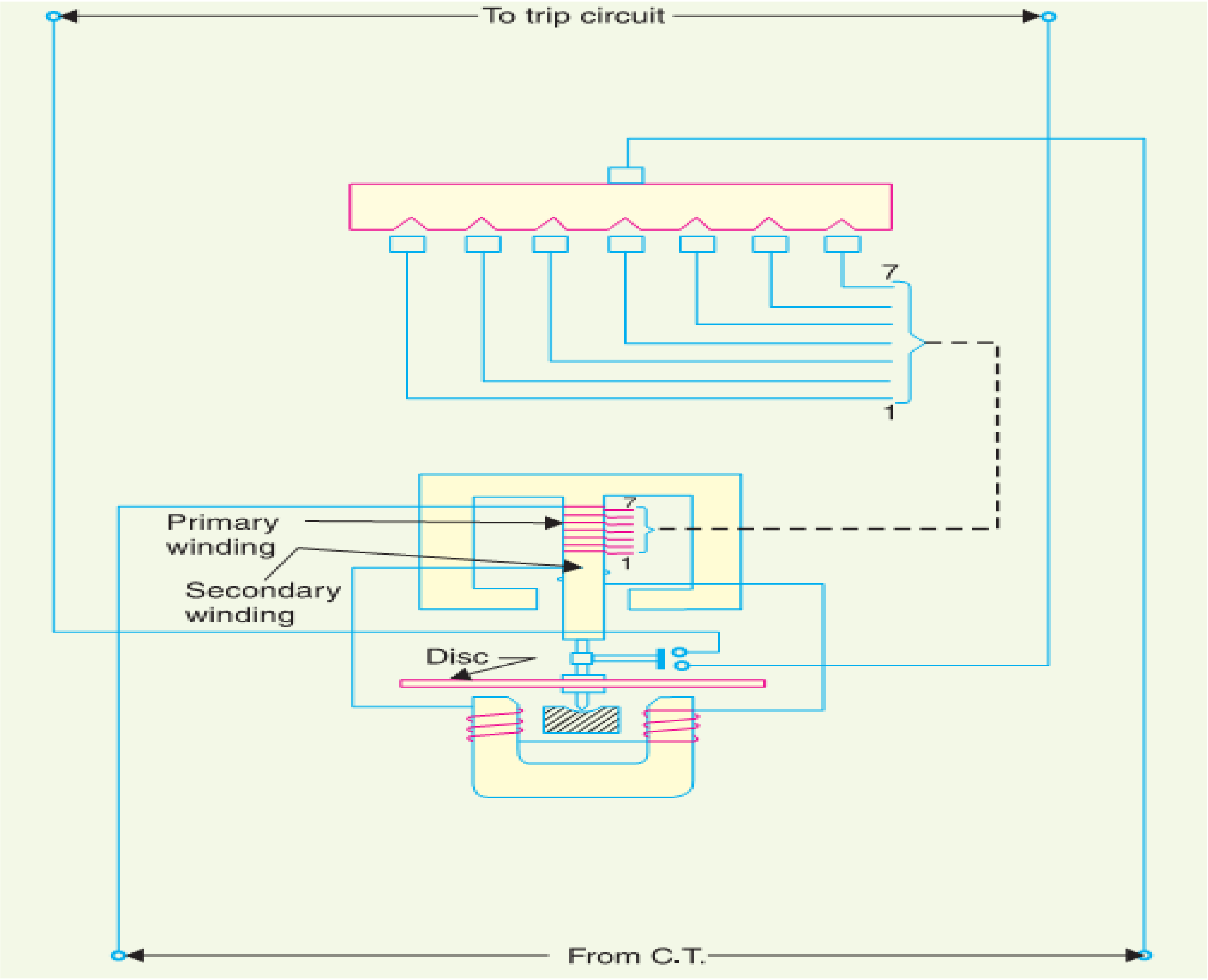
- If **φ1** and **φ2** represent the fluxes produced by the respective pairs of poles, then torque produced is proportional to $\mathbf{\Phi_1 \Phi_2 \sin \alpha}$.
- Where **α** is the **phase difference** between two fluxes.
- Induction cup structures are **more efficient torque** producers than either the shaded-pole or watt hour meter structures.

ADVANTAGES:

- type of relay has **very high speed**
- operating time **less then 0.1** second.

Induction type overcurrent Relay (**Non Directional Relay**)

- This type of relay works on the **induction principle** and **initiates corrective** measures when **current** in the circuit **exceeds** the **predetermined** value.
- These relays are used on **a.c. circuits only** and can operate for fault **current** flow in **either direction**.
- The actuating **source** is a current in the circuit supplied to the relay from a **current transformer**.


To trip circuit
7
1
7
1
Primary winding
Secondary winding
Disc
From C.T.

Constructional details

- It consists of a metallic (aluminum) disc which is free to rotate in between the poles of two electromagnets.
- The **upper** electromagnet has a primary and a secondary winding. The primary is connected to the secondary of a C.T. in the line to be protected and is tapped at intervals.
- The secondary winding is energized by induction from primary and is connected in series with the winding on the lower magnet. The **controlling torque** is provided by a **spiral spring**.
- The spindle of the disc carries a moving contact which bridges two fixed contacts (connected to trip circuit).
- This angle can be adjusted to value between **0° to 360°**

Operation

- The driving torque on the aluminium disc is set up due to the induction principle. This torque is opposed by the **restraining torque** provided by the spring.
- Under **normal** operating conditions, restraining torque is **greater** than the driving torque produced by the relay coil current. Therefore, the aluminium **disc** remains **stationary**.
- If the **current** in the protected circuit **exceeds** the pre-set value, the **driving torque** becomes **greater** than the **restraining torque**. Consequently, the disc rotates and the moving contact bridges the fixed contacts when the **disc** has **rotated** through a **pre-set angle**. The trip circuit operates the circuit breaker which isolates the faulty section.

DIRECTIONAL RELAY

Induction relays are two types

non directional relays

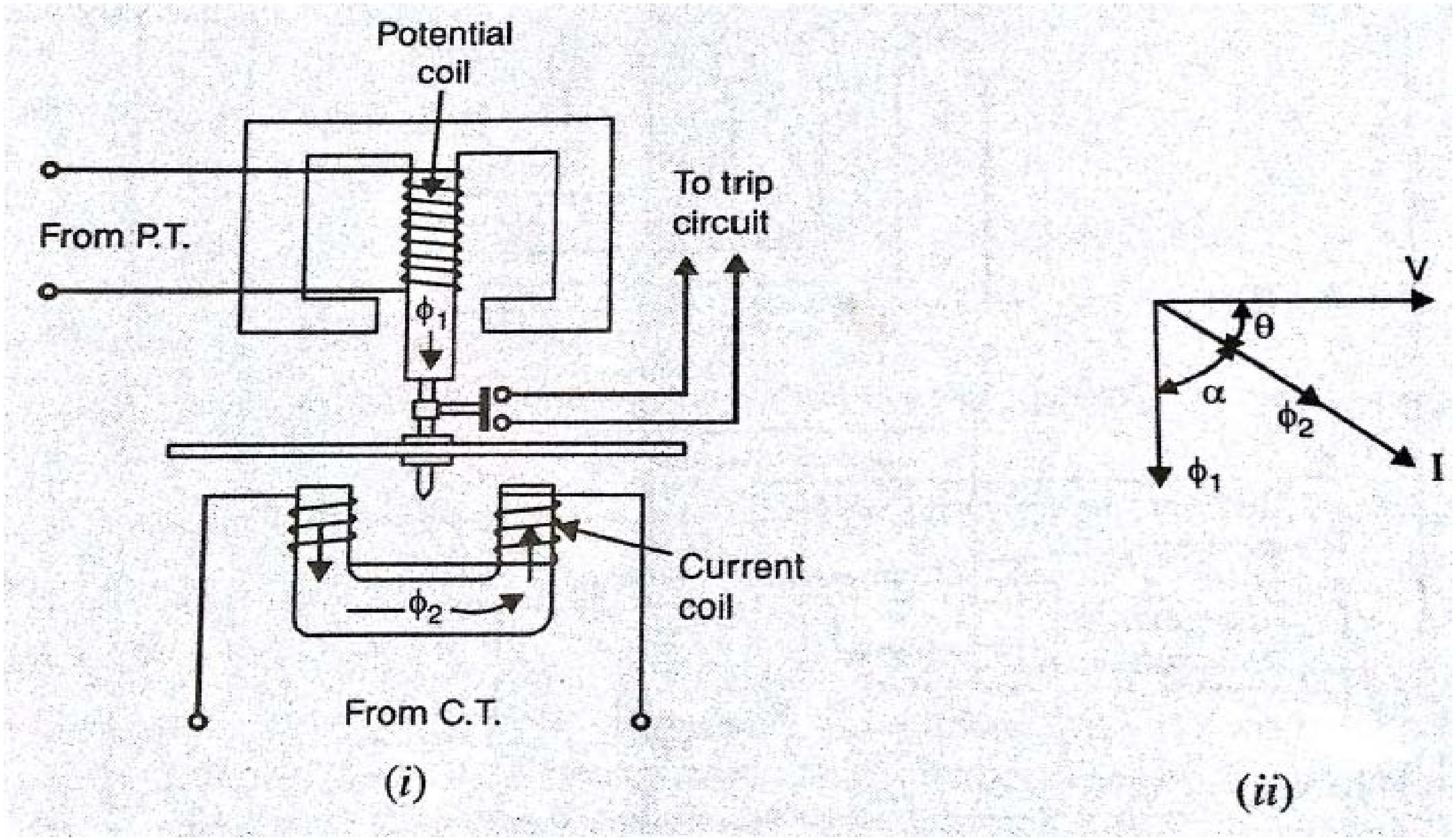
directional relays

Difference between the two:…………?

- Non directional relays are activated by only **current flowing in the circuit to be protected**.

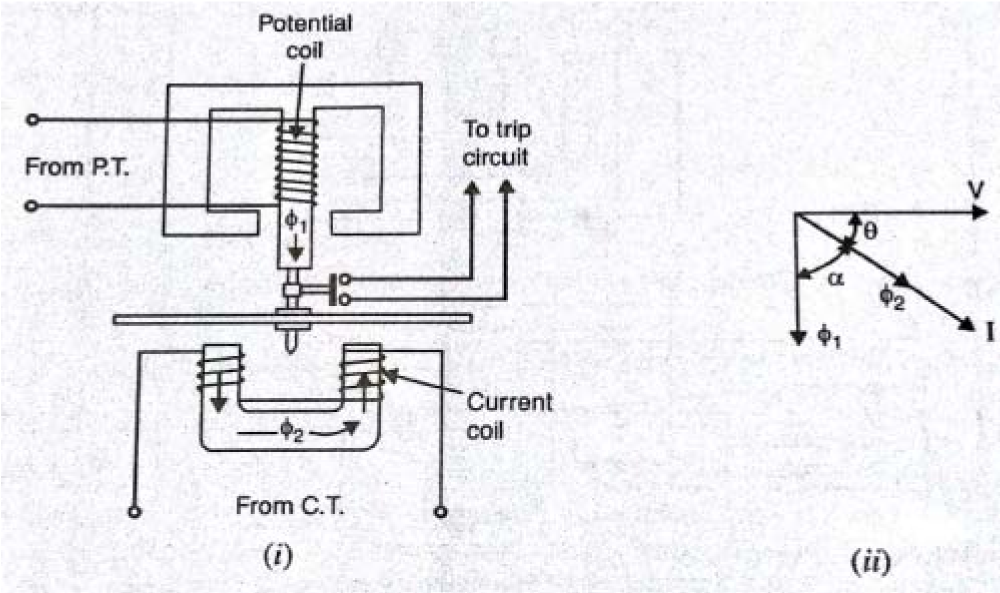
- It requires **specific direction of current flow**

DIRECTIONAL POWER RELAY



(i)

(ii)



Constructional details:

It consist of two electro magnets

1) upper magnet which is **E- shaped**
2) lower magnet which is **U- shaped**

➢ The **upper magnet** consist of **primary winding** on the central limb which is energized by voltage from **secondary of P.T**

➢ lower magnet houses **secondary winding** which is energized by current of the circuit from secondary of C.T

- This alumunium disc carries a moving contact which can bridge fixed contact by rotating though a pre set angle.

- The time of operation depends upon the pre set angle

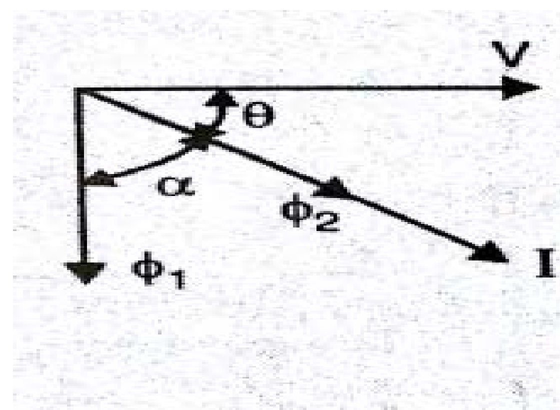
- Restraining torque is provide by spring which twists in reverse direction.

Operation:

from the diagram we can conclude that we have two flux quantities: φ_1 & φ_2 .

always φ_1 lags V by 90^0

φ_2 inphase with current I



Due to phase difference between two flux quantities i.e., $\alpha = 90-\theta$

$$\Phi_1 \ \alpha \ V \quad \& \quad \varphi_2 \ \alpha \ I$$

$$\text{Hence } T = \varphi_1 \varphi_2 \sin \alpha$$
$$= \varphi_1 \varphi_2 \sin(90-\theta)$$
$$= VI \cos \theta$$
$$= \text{POWER}$$

- Hence the relay activated only when there is a specific direction of power flow
- when power flows in **normal** direction both driving torque and restraining torque twists in **same** direction and relay does not operates.

when the power flow is in **reverse** direction, driving torque and restraining torque acts in **opposite** direction and relay operates.

- Therefore CB operates and disconnects faulty section.

DIRECTIONAL OVER CURRENT RELAY:

From the previous discussion

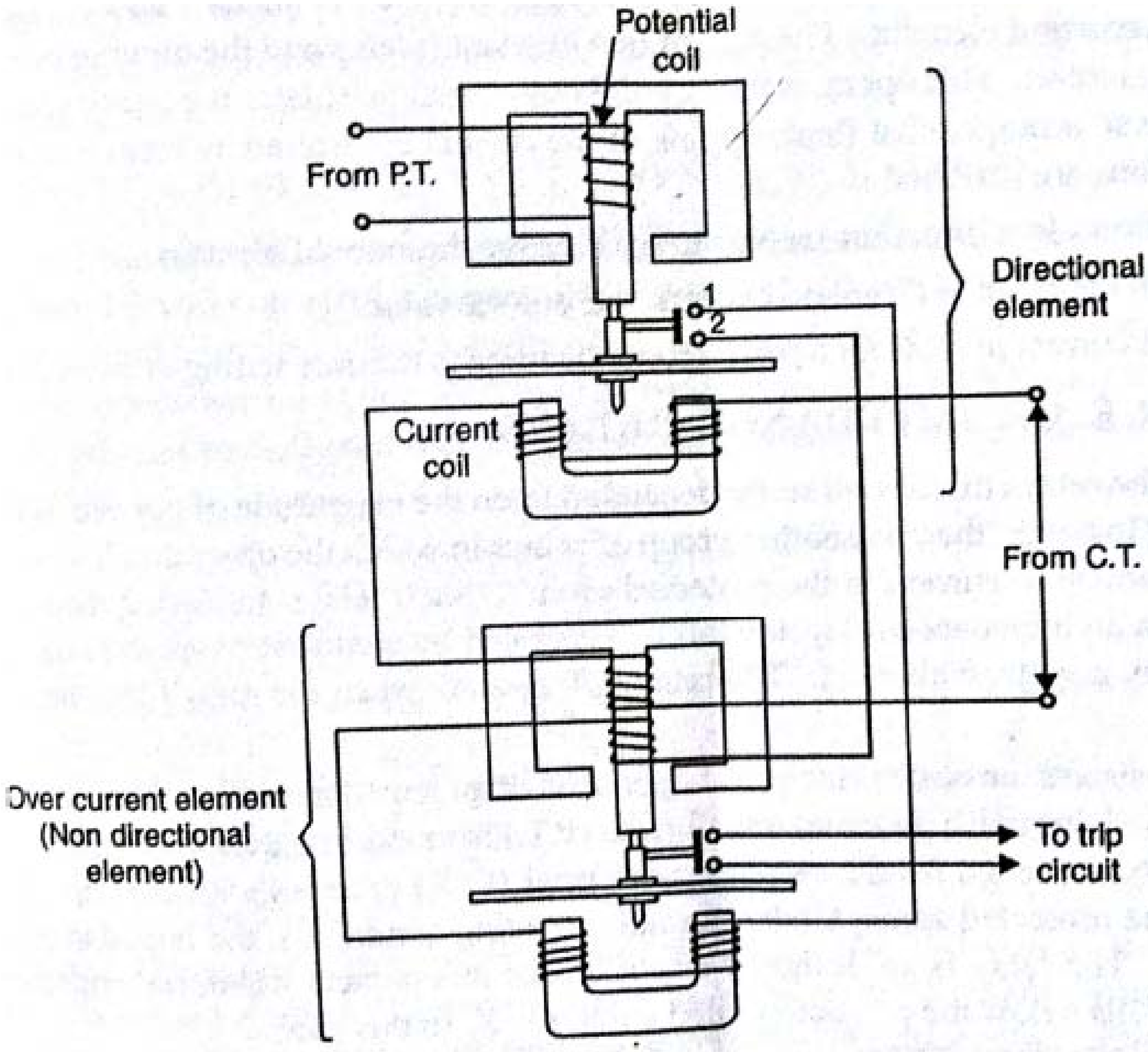
$$T = V\ I\ COS\ \theta$$

Under abnormal conditions voltage in the circuit is **too low**. Therefore the driving torque becomes abnormally too small . Hence the relay does not operate.

i.e., the directional power relay is not suitable for short circuit conditions.

This problem can be overcome by directional over current relay.

Directional overcurrent relay:



Directional over current relay makes use of two relays

i) directional power relay (directional element)
ii) Non directional current relay (non-directional element)

Construction:

1) Directional element :

It is similar in construction to directional power relay.

- It consists of upper magnet which is E-shaped and carries primary winding which is excited by voltage of the circuit to be protected through secondary of PT.
- The lower magnet is U-shaped carries secondary winding which is excited by current of the circuit to be protected through secondary of CT.
- The secondary winding is extended to lower magnet primary winding as shown.
- The trip contacts 1 & 2 are connected in series with secondary winding of lower magnet.

  therefore for the relay to operate, at first directional element should be activated first.

2) Non directional element:

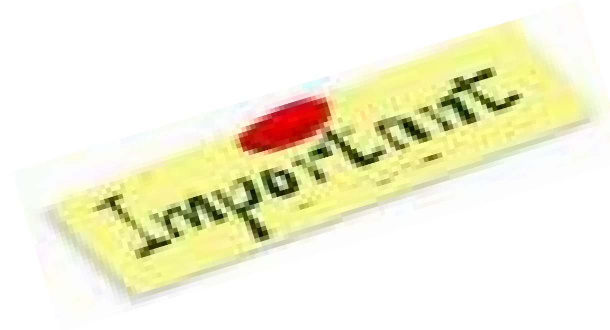
*** It is activated only by current flowing in the circuit***

- it is similar in construction to non-directional over current relay. For this element to operate ,at first directional element should be activated first.
- the secondary winding is further connected to PSM(not shown), for current setting.

Operation :

- When short circuit occurs current tend to be reversed .Hence directional element starts operating and closes the trip contact.

- with closing of trip contact, the secondary winding of non directional element is complete and disc starts rotating. When moving contact bridges fixed contact the circuit breaker operates and separates the faulty section.



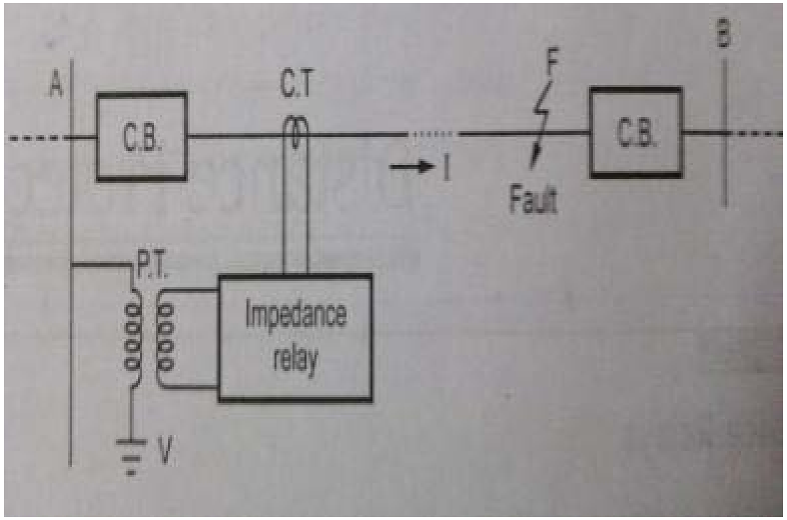
Distance Relay

(one of the type is

<u>mho relay</u>)

DISTANCE RELAY :-

1.IMPEDANCE RELAY



- +ve (operative)Torque by current element
- -ve(restraining)Torque by voltage element

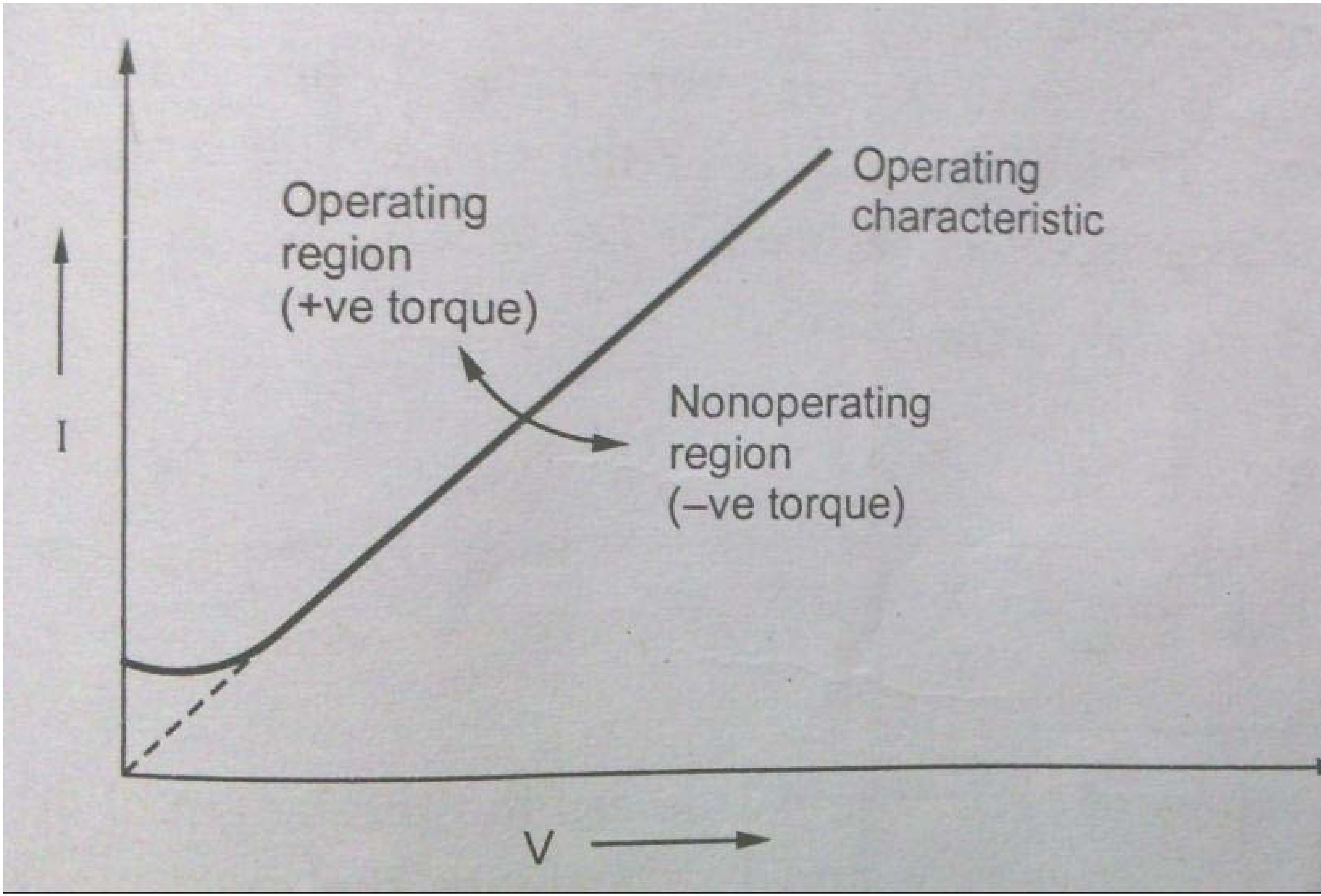
✓At normal condition

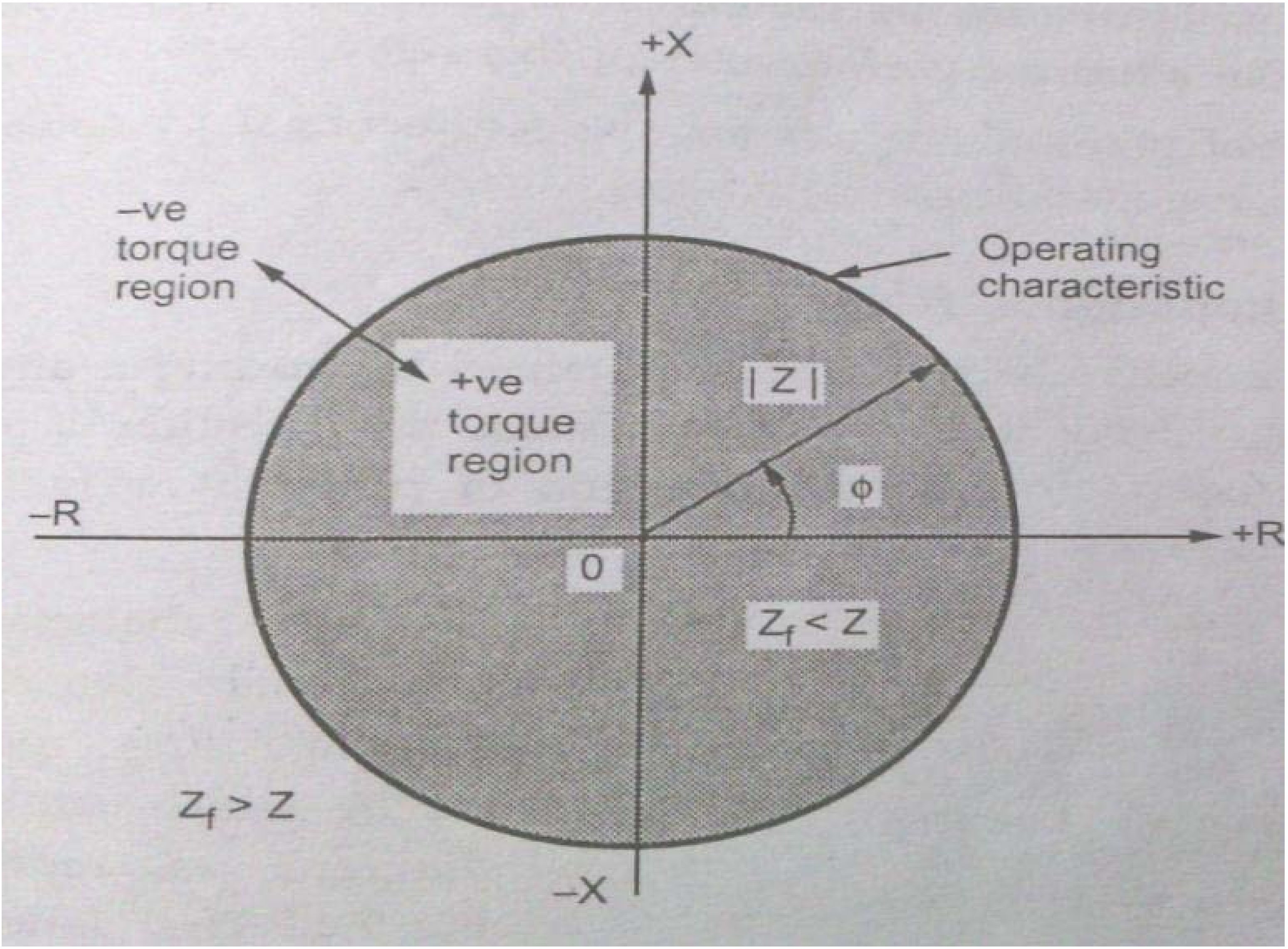
operative torque = restraining torque

✓At fault

operative torque > restraining torque

➢Also called voltage restrained over current relay.

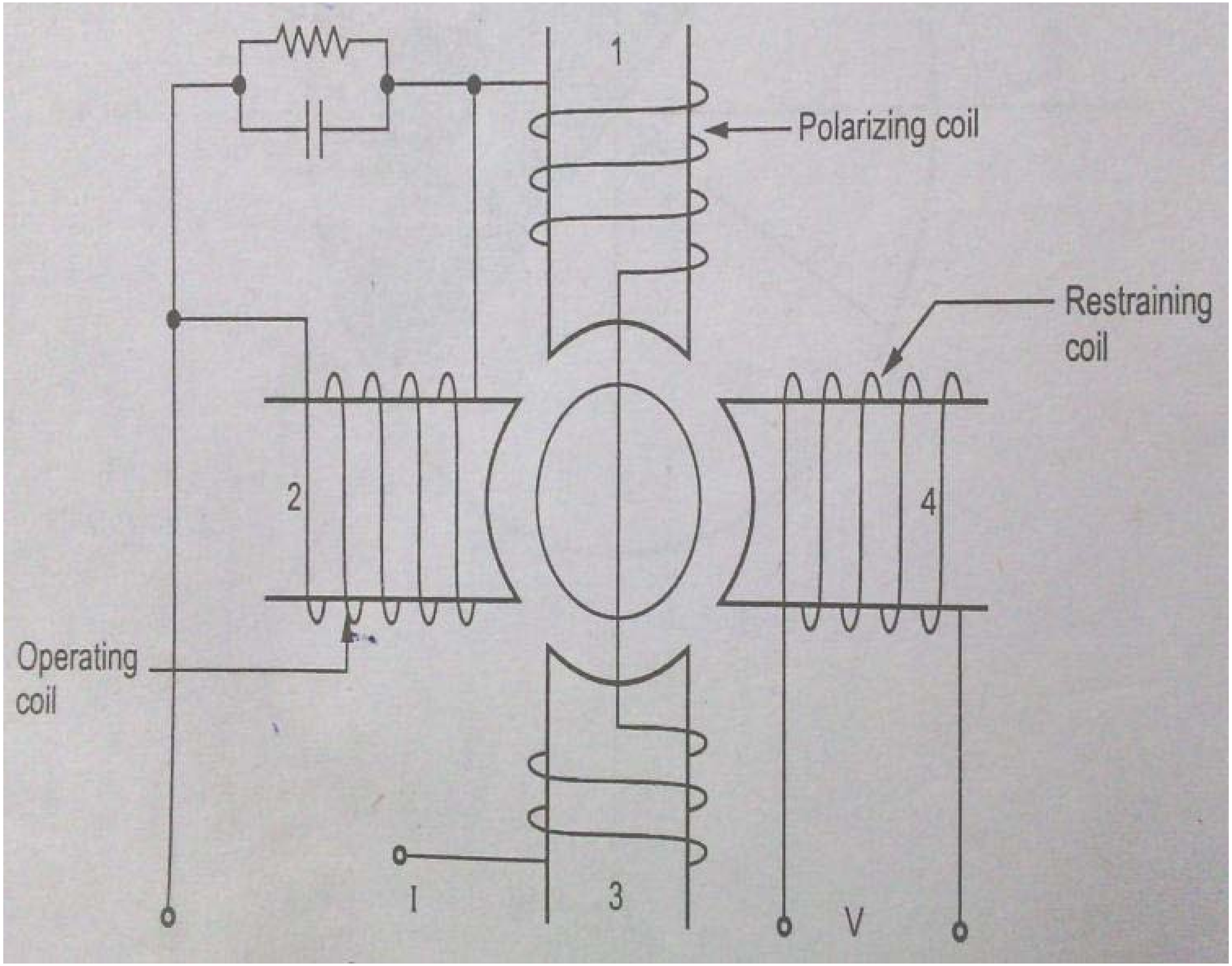

Operating region (+ve torque)
Operating characteristic
Nonoperating region (–ve torque)
I
V



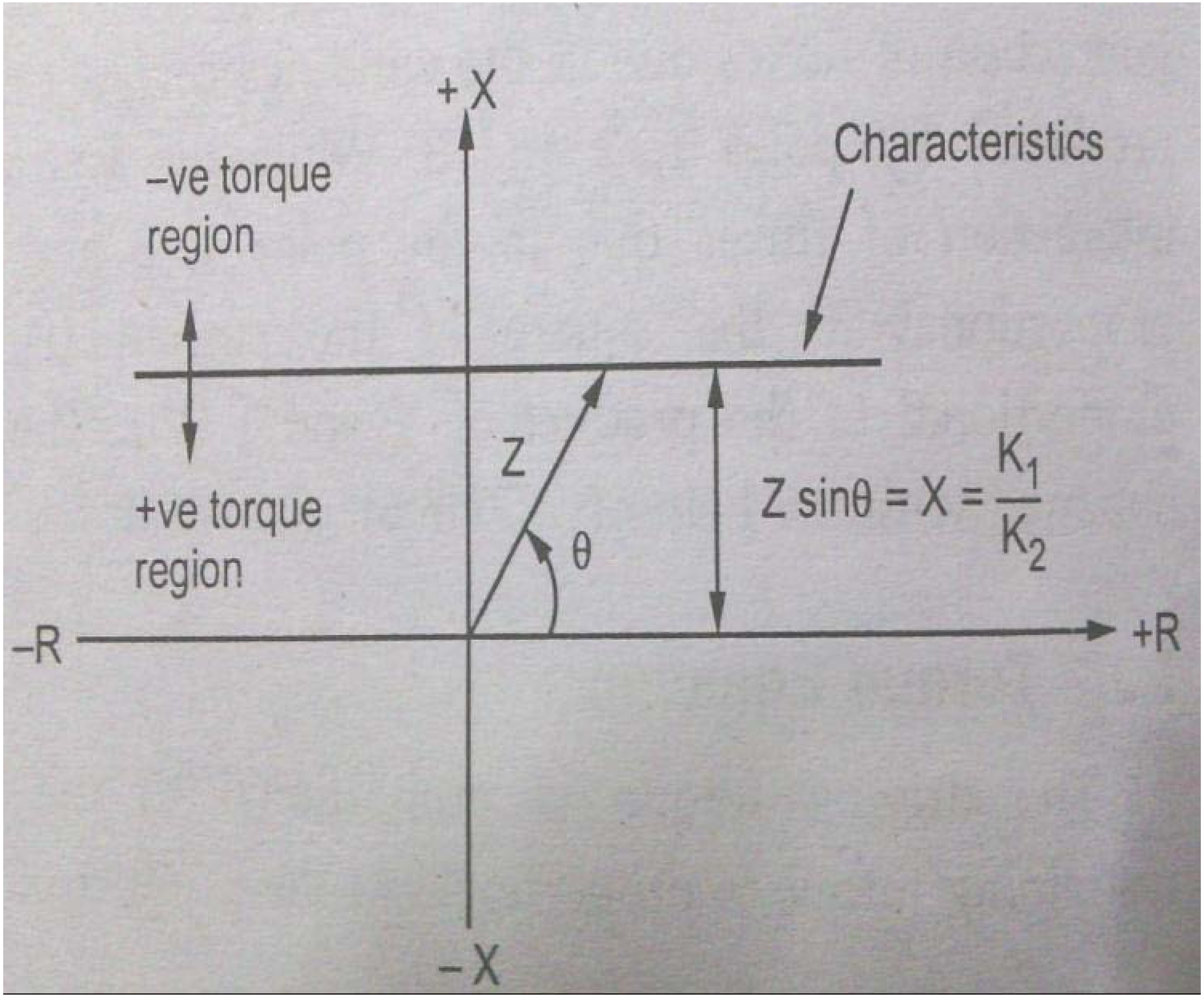
+X
–ve
torque
region
Operating
characteristic
+ve
torque
region
| Z |
φ
–R
+R
0
Z_f < Z
Z_f > Z
–X

2.REACTANCE RELAY :-

- o Operative Torque by current
- o Restraining Torque by Current-Voltage Directional relay
- ❖ +ve torque by over current element
- ❖ -ve torque by directional unit
- ✓Directional element designed for maxi. Torque angle = 90 degree



1
Polarizing coil
Restraining
coil
2
4
Operating
coil
I
3
V



+X
Characteristics
–ve torque region
Z
+ve torque region
θ
Z sinθ = X = $\frac{K_1}{K_2}$
–R
+R
–X

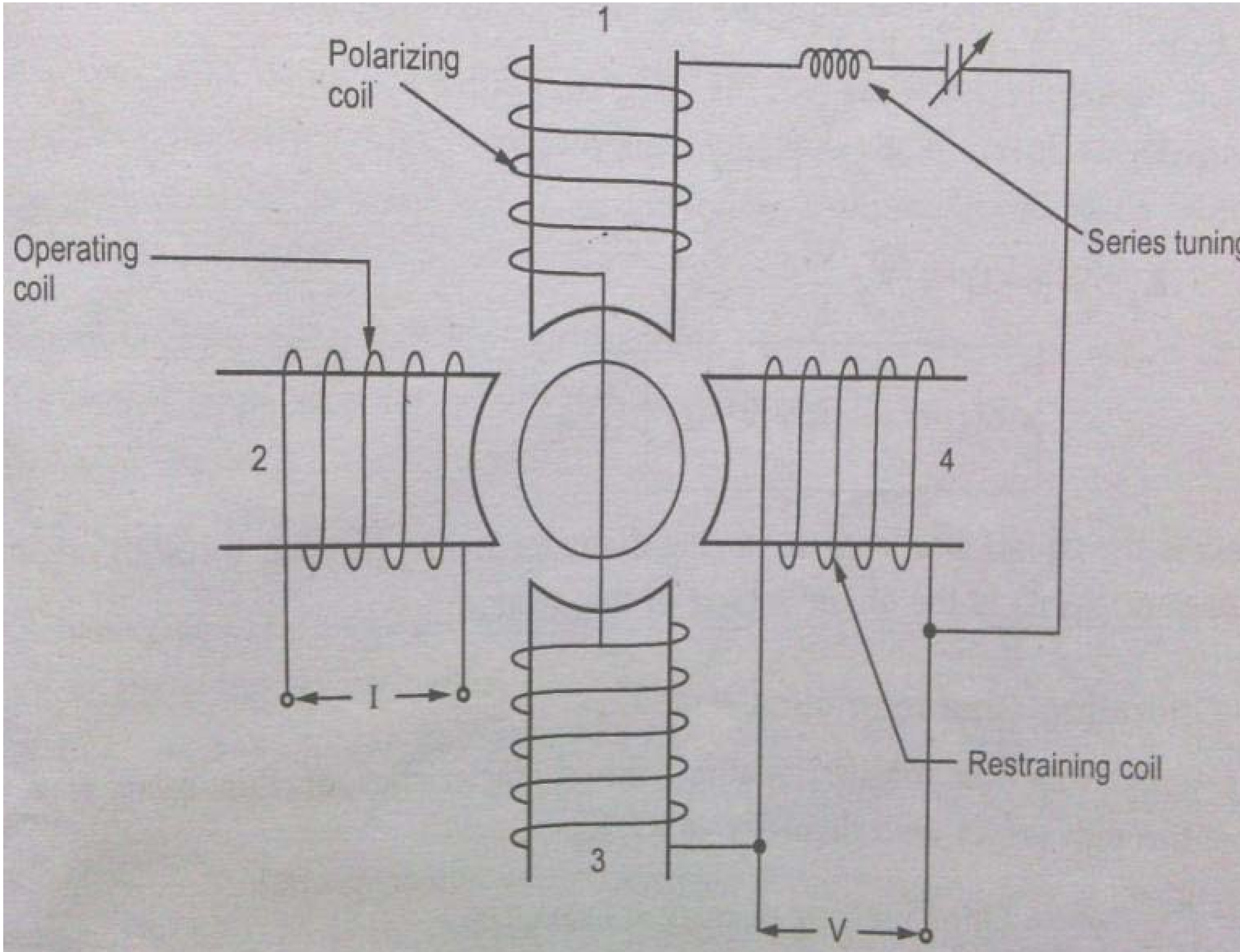
3.MHO RELAY (*Admittance relay*):-

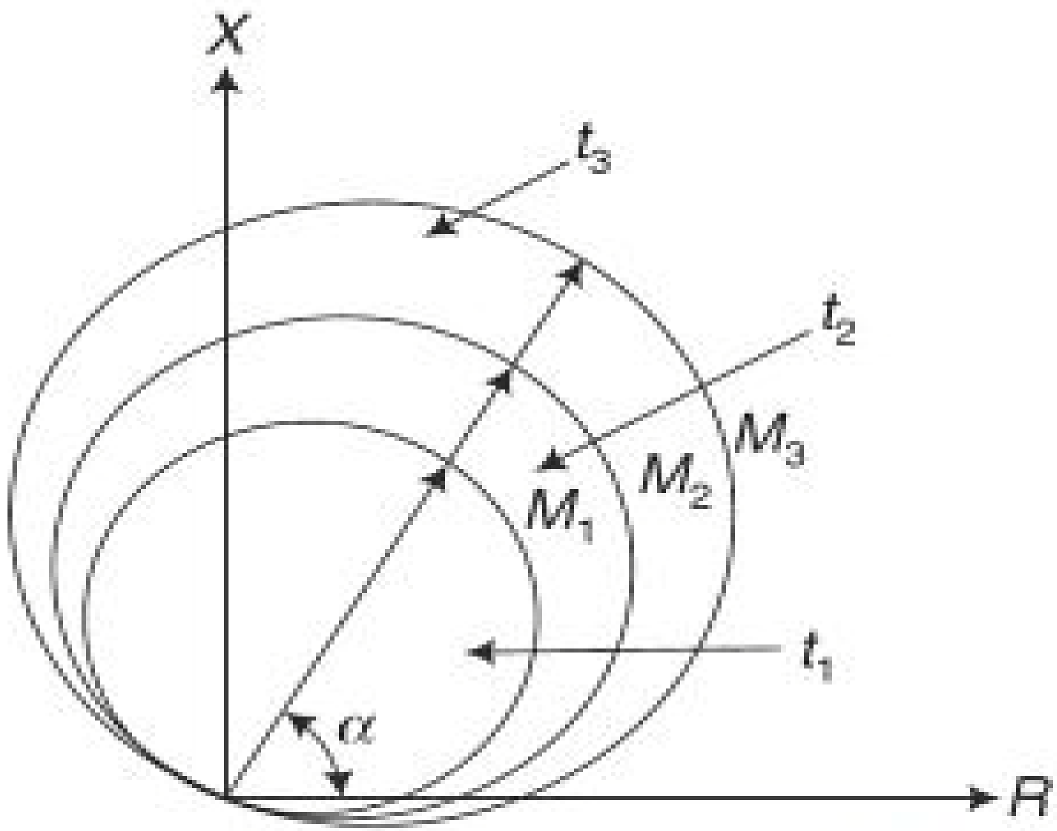
- Induction cup type structure.

- Operative Torque produced by V & I element.

- Restraining Torque by Voltage element.

- Also called ***Admittance relay.***


1
Polarizing coil
Series tuning
Operating coil
2
4
3
I
V
Restraining coil

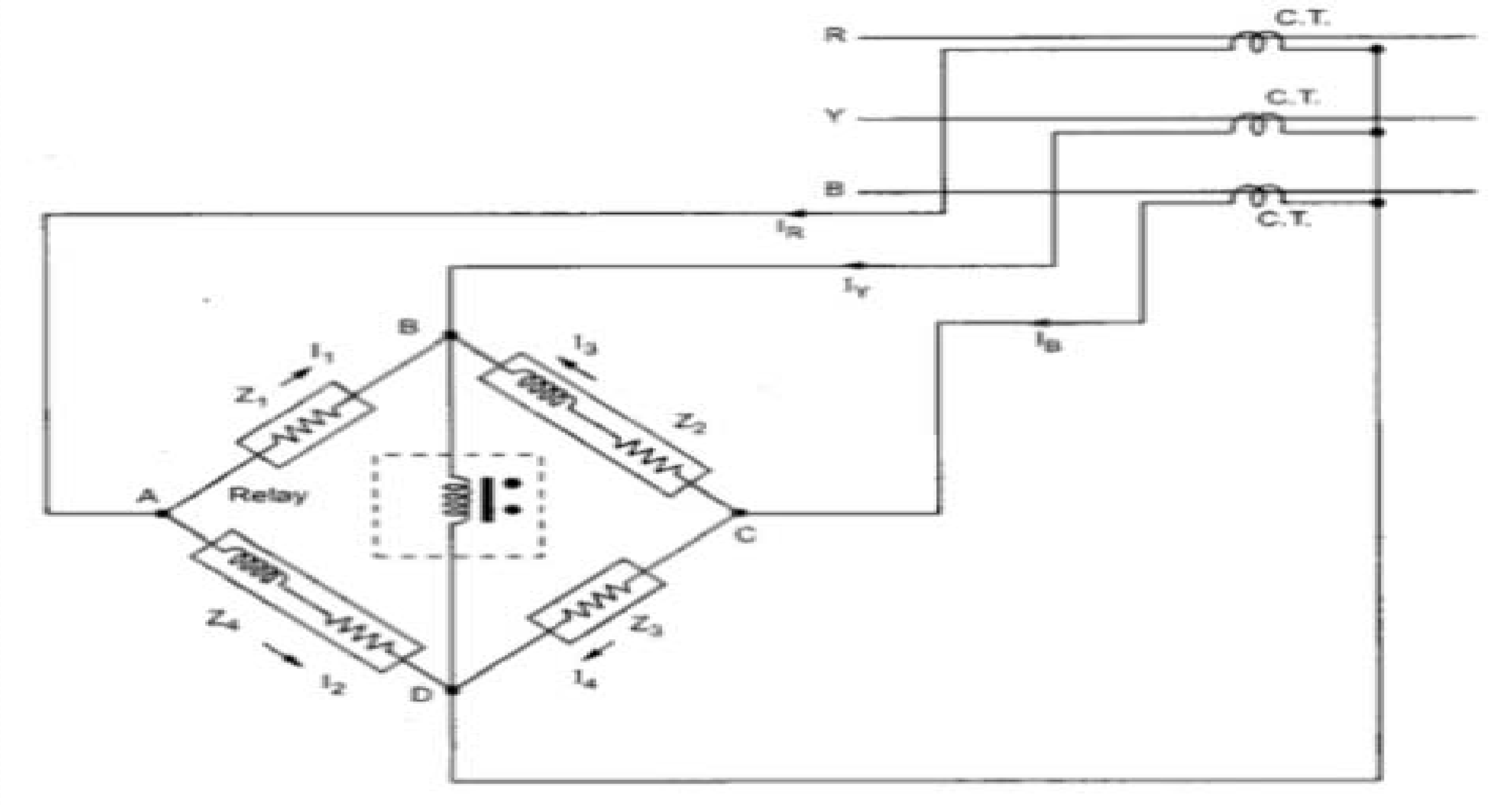

X
t_3
t_2
M_3
M_2
M_1
t_1
α
R

NEGATIVE SEQUENCE RELAYS

NEGATIVE SEQUENCE RELAY

- The negative relays are also called phase unbalance relays because these relays provide protection against negative sequence component of unbalanced currents existing due to unbalanced loads or phase-phase faults.
- The unbalanced currents are dangerous from generators and motors point of view as these currents can cause ***overheating***.
- Negative sequence relays are generally used to give protection to **generators** and **motors** against unbalanced currents.

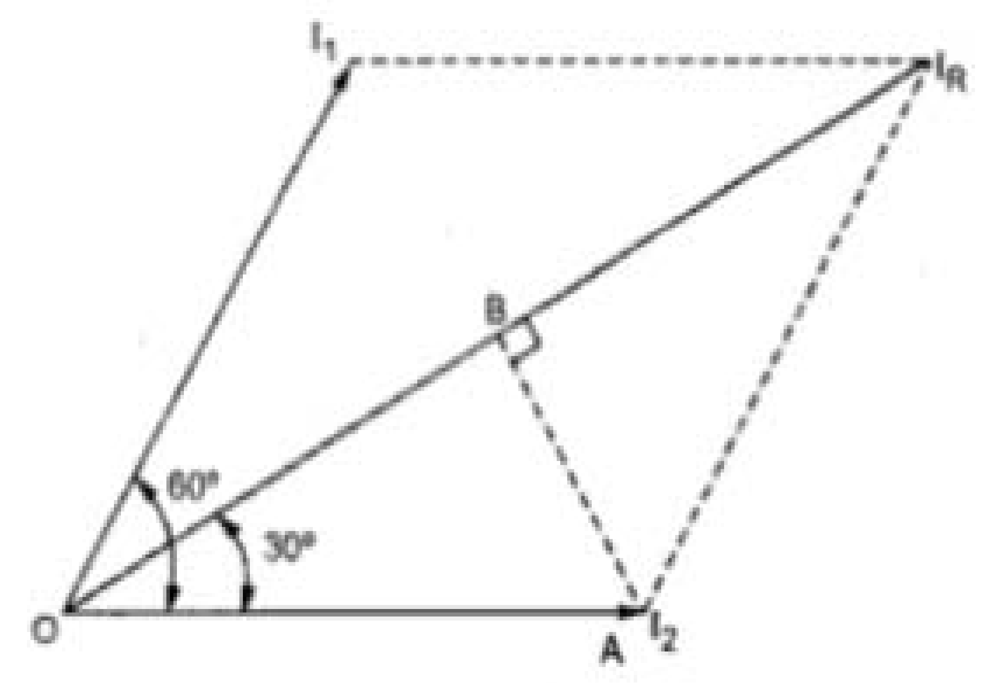
DIAGRAM:



CONSTRUCTION:

- It consists of a resistance bridge network.
- The magnitudes of the impedances of all the branches of the network are equal.
- The impedances Z_1 and Z_3 are purely resistive while the impedances Z_2 and Z_4 are the combinations of resistance and reactance.
- The currents in the branches Z_2 and Z_4 lag by 60^o from the currents in the branches Z_1 and Z_3.

PHASOR DIAGRAM:



The current I_R gets divided into two equal parts I_1 and I_2.
I_2 lags **I_1** by 60^o.

$$\bar{I}_1 + \bar{I}_2 = \bar{I}_{rs}$$

Let $$I_1 = I_2 = I$$

The perpendicular is drawn from point A on the diagonal meeting it at point B. This bisects the diagonal.

$\therefore$ $$OB = I_R / 2$$

Now in triangle OAB,

$$\cos 30 = OB/OA$$

$\therefore$ $$\sqrt{3}/2 = (I_R/2)/I$$

$\therefore$ $$I = I_R/\sqrt{3} = I_1 = I_2 \qquad \text{............(1)}$$

Now I_1 leads I_R by 30° while I_2 lags I_R by 30°.

Similarly the current I_B gets divided into two equal parts I_3 and I_4. The current I_3 lags I_4 by 60°. From equation (1) we can write,

$$I_B/\sqrt{3} = I_3 = I_4 \qquad \ldots\ldots\ldots\ldots\ldots(2)$$

The current I_4 leads by I_B while current I_3 lags I_B by 30°.

The current entering the relay at the junction point B in the Fig. 1 is the vector sum of , and .

$$I_{relay} = \bar{I}_1 + \bar{I}_3 + \bar{I}_Y$$

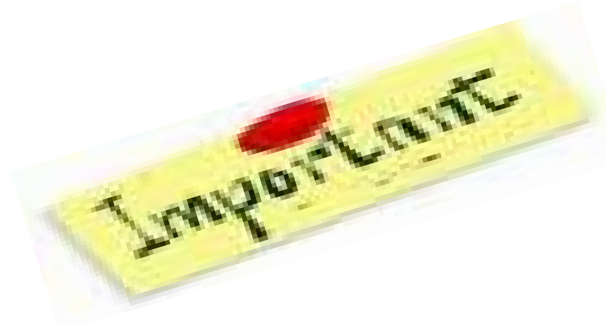
$$= (I_R/\sqrt{3})\ (\text{leads } I_R \text{ by } 30°) + I_B/\sqrt{3}(\text{lags } I_B \text{ by} 30°) + I_Y$$

- **when the load is balanced and no negative sequence currents exist.**

UNDER FAULTY CONDITION:

Now consider that there is unbalanced load on generator or motor due to which negative sequence currents exist.

The component I_1 and I_3 are equal and opposite to each other at the junction point B. Hence I_1 and I_3 cancel each other. Now the relay coil carries the current I_Y and when this current is more than a predetermined value, the relay trips closing the contacts of trip circuit which opens the circuit breaker.



DIFFERENTIAL RELAYS

Definition

- A two-winding relay that operates when the difference between the currents in the two windings reaches a predetermined value is called differential relays.

- A two-winding relay that operates when the difference between the currents in the two windings reaches a predetermined value.

- In case of electrical quantities exceed a predetermined value, a current differential relay is one that compares the current entering a section of the system with current leaving the section.
- Under normal operating conditions, the two currents are equal but as soon as fault occurs, this condition no longer applies. The difference between the incoming and outgoing currents is arranged to flow through relay operating coil. If this difference is equal to or greater than the pick up value the relay will operate and open the circuit breaker and isolate the faulty section.
- Any type of relay when connected in a particular way can be made to operate as a differential relay. It is not the relay construction but the way in which relay is connected in a circuit makes it a differential relay.

There are three fundamental systems of differential or balanced protection:

I. current differential relay
II. voltage differential relay
III. Biased beam relay or percentage differential relay

(i) Current balance protection

Fig 16 a shows an arrangement of an over current relay connected to operate as a differential relay. A pair of identical current transfonners is fitted on either end of the section to be protected (alternator winding in this case). The secondaries of CT's are connected in series in such a way that they carry the induced currents in the same direction. The operating coil of over current relay is connected across the CT secondary circuit. This differential relay compares the current at the two ends of the alternator winding.

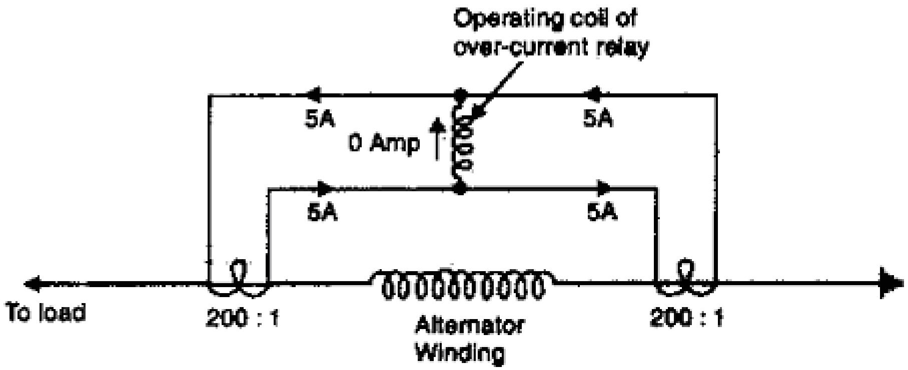


fig 16 a

Under normal operating conditions, suppose the alternator winding carries a normal current of 1000 A. Then the current in the two secondaries of CT's are equal as in figure. These currents will merely circulate between the two CT's and no current will flow through the differential relay as shown in the diagram fig 16 a. Therefore, the relay remains inoperative.

If a ground fault occurs on the alternator winding as shown in fig 16 b. the two secondary currents will not be equal and the current flows through the operating coil of the relay, causing the relay to operate. The amount of current flow through the relay will depend upon the way the fault is being fed.

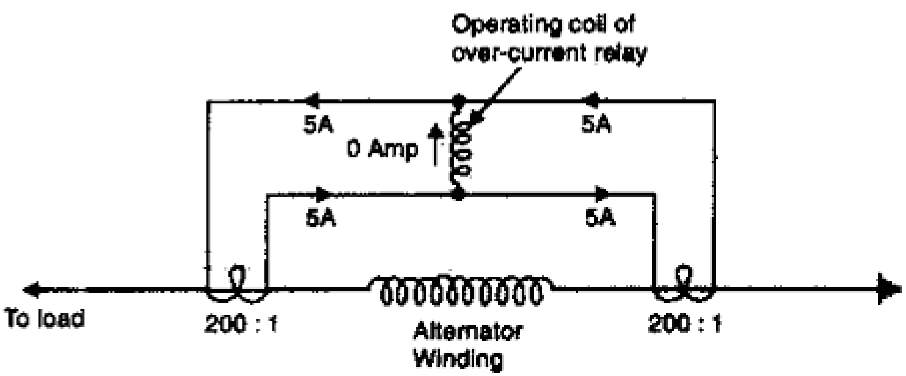


fig 16 a

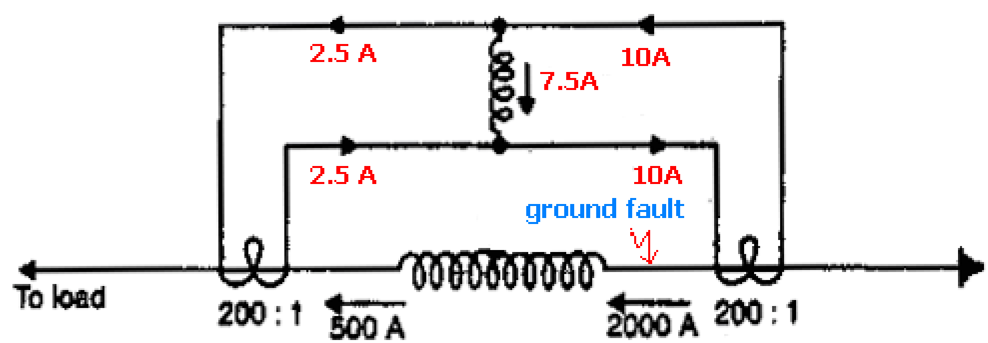


fig 16 b

Disadvantages

- The impedance of the pilot cables generally causes a slight difference between the currents at the two ends of the section to be protected, then the small differential current flowing through the relay may cause it to operate even under no fault conditions.

- Pilot cable capacitance causes incorrect operation of the relay when a large current flows

- Accurate matching of current transformers cannot be achieved due to pilot circuit impedance

(ii) voltage differential relay

❖In this scheme of protection, two similar current transformers are connected at either end of the element to be protected (e.g. an alternator winding) by means of pilot of wires.

❖The secondary of current transformers are connected in series with a relay in such a way that under normal conditions, their induced e.m.f's are in opposition

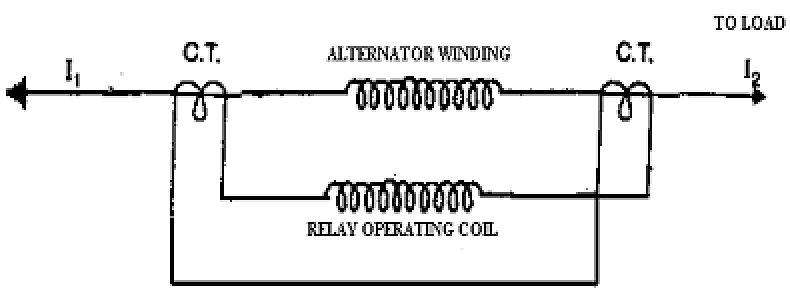


fig 18

❖Under healthy conditions, equal currents will flow in both primary windings. Therefore, the secondary voltages of the two transformers are balanced against each other and no current will flow through the relay-operating coil.

❖When a fault occurs in the protected zone, the currents in the two primaries will differ from one another and their secondary voltages will no longer be in balance.

❖This voltage difference will cause a current to flow through the operating coil of the relay, which closes the trip circuit.

Disadvantages

The voltage balance system suffers from the following drawbacks

- A multi-gap transformer construction is required to achieve the accurate balance between current transformer pairs.

- The system is suitable for protection of cables of relatively short, lengths due to the capacitance of pilot wires.

III. Biased beam relay or percentage differential relay

➢The biased beam relay also called percentage differential relay is designed to respond to the differential current in terms of its fractional relation to the current flowing through the protected section.

➢It's called percentage differential relay because the ratio of differential operating current to average restraining current is a fixed percentage.

➢It's called bias relay because restraining known as biased coil produces the bias force. Fig 17 a, shows the schematic arrangements of biased beam relay. It is essentially an over current balanced beam type relay with an additional restraining coil. The restraining coil produces a bias force in the opposite direction to the operating force.

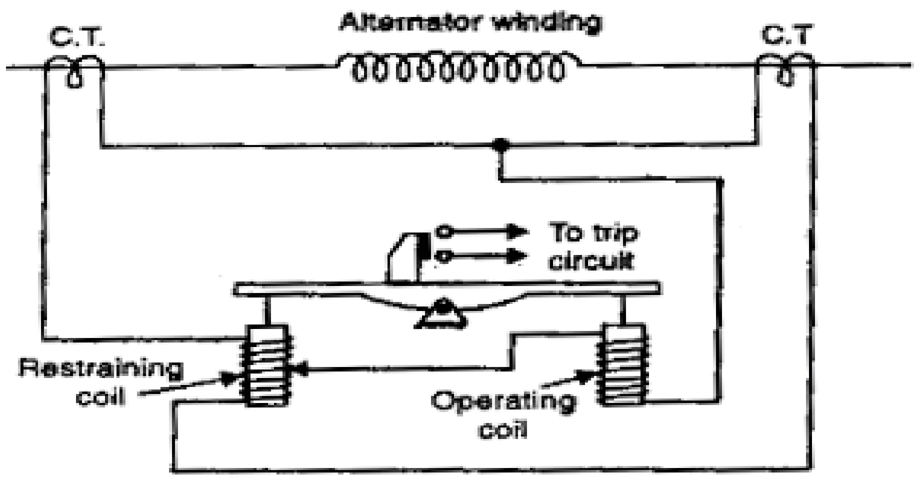


fig 17 a

Under normal and through load conditions, the bias force due to restraining coil is greater than operating force. Therefore, the relay remains inoperative.

UNDER NORNAL OPERATION

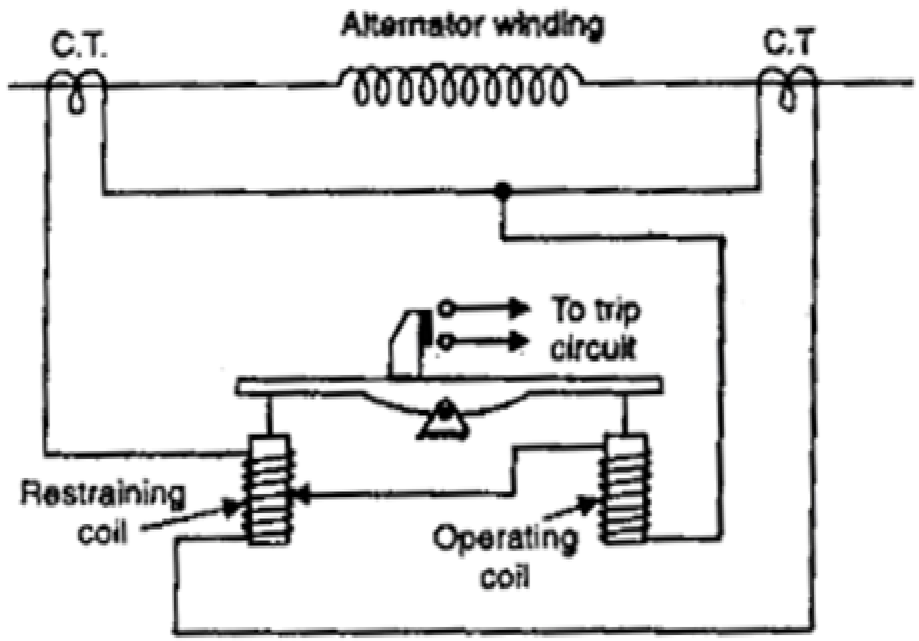


fig 17 a

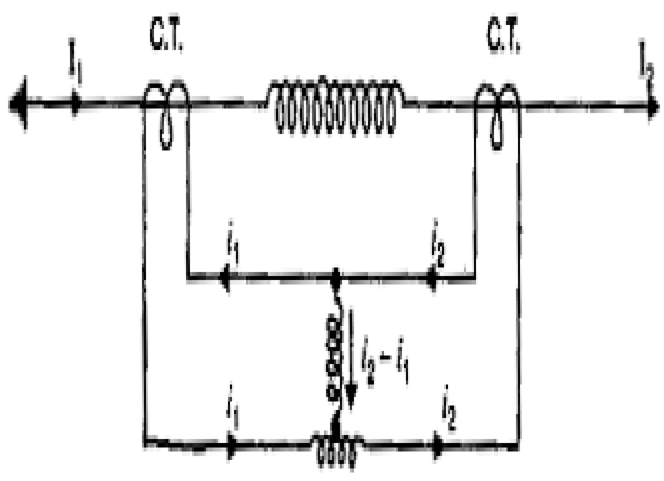
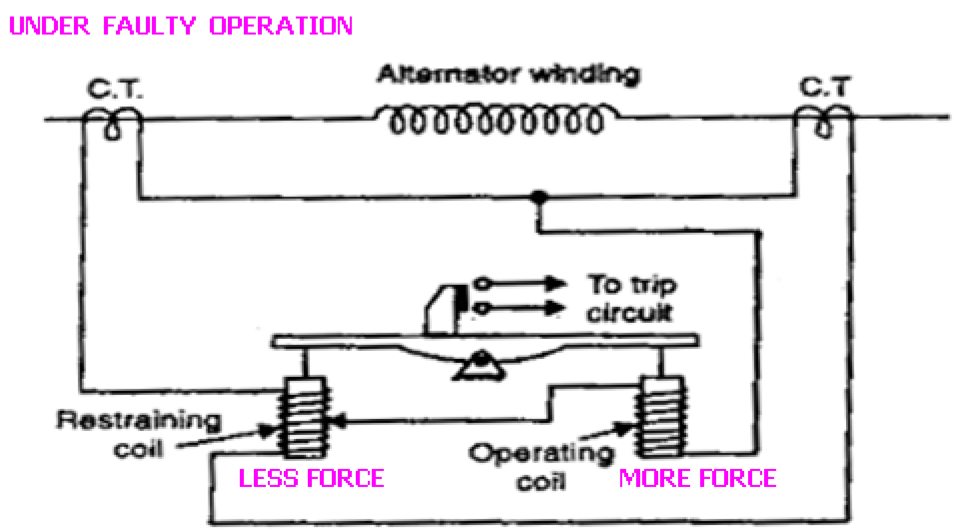


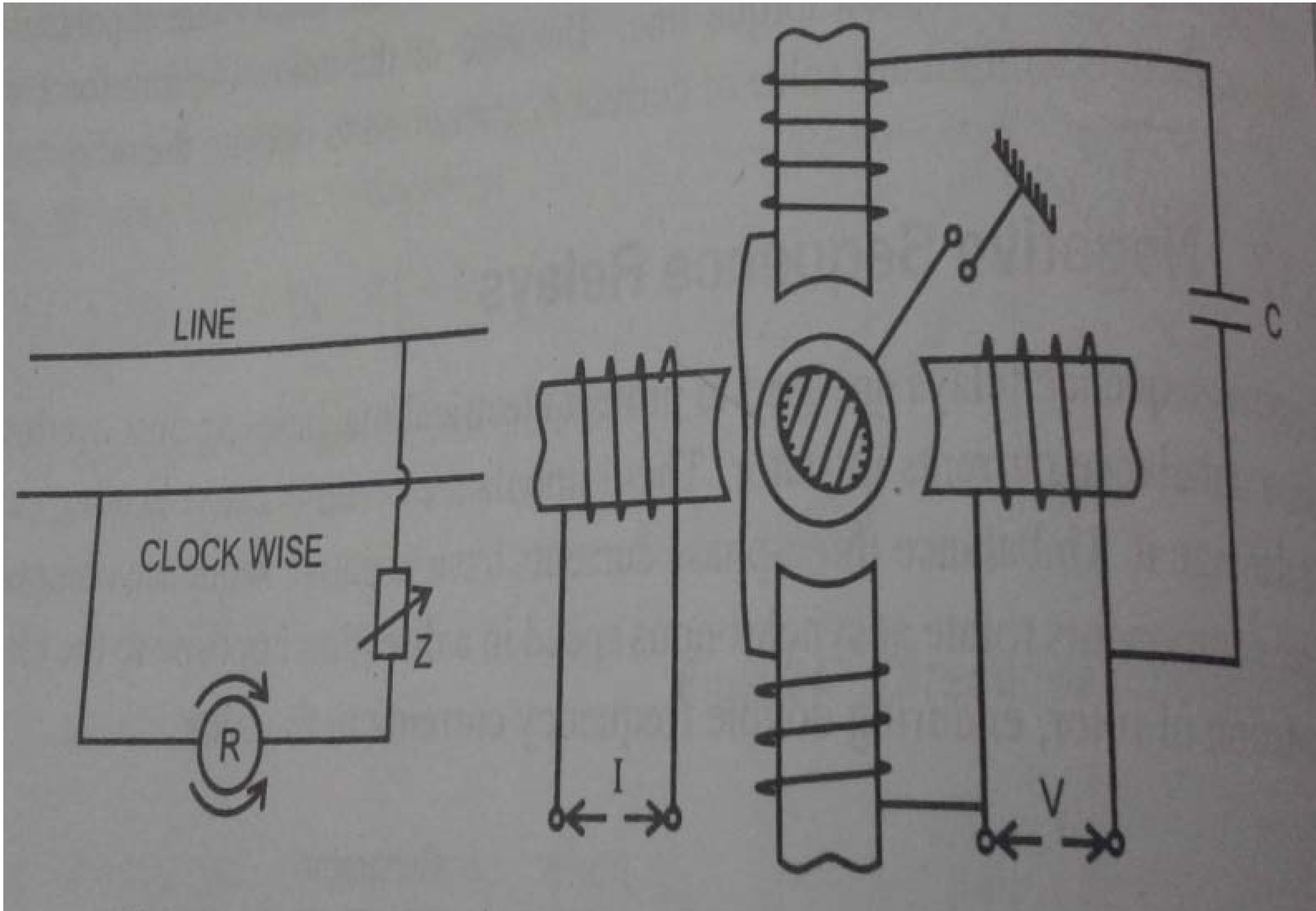
fig 17 b

➢When an internal fault occurs, the operating force exceeds the bias force. Consequently the trip contacts are closed to open the circuit breaker.

➢The bias force can be adjusted by varying the number of turns on the restraining coil.



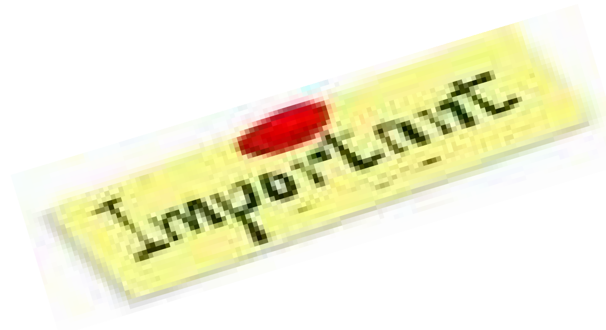
UNDER FREQUENCY RELAY



(a) Anticlockwise (b) Cup rotor relay(R)

Frequency based can either be under frequency or over frequency. The frequency relays are normally used in Generator protection and for Load-frequency control. The frequency of induced e.m.f of synchronous generators, is maintained constant by constant speed. Over speeding of the generator occurs due to loss of load and under speeding occurs due to increase in load. In both the above cases, the frequency varies from normal value. In order to avoid damage to the generator under the above two conditions, frequency relays are used. Under frequency relay trips the feeder on load at set value of frequency, so as to give relief to the generator, thereby saving the unit. Under frequency relay thus aids load shedding programme to save the grid.

The frequency relay is connected to the secondary of the V.T. The relay monitors the frequency continuously. It has two pairs of coils and are connected in parallel to the supply voltage through the impedance 'Z'. The impedance will vary with frequency. Under normal conditions, the impedance is so tuned, that no torque is applied on the cup-rotor. Under fault conditions, a torque is applied on the cup rotor due to change in impedance either in the clock-wise direction or in the anti-clockwise direction, depending on the frequency is higher or lower than the desired frequency. The frequency setting varied by the sliding resistor and the pickup can be varied by the restraining spring.

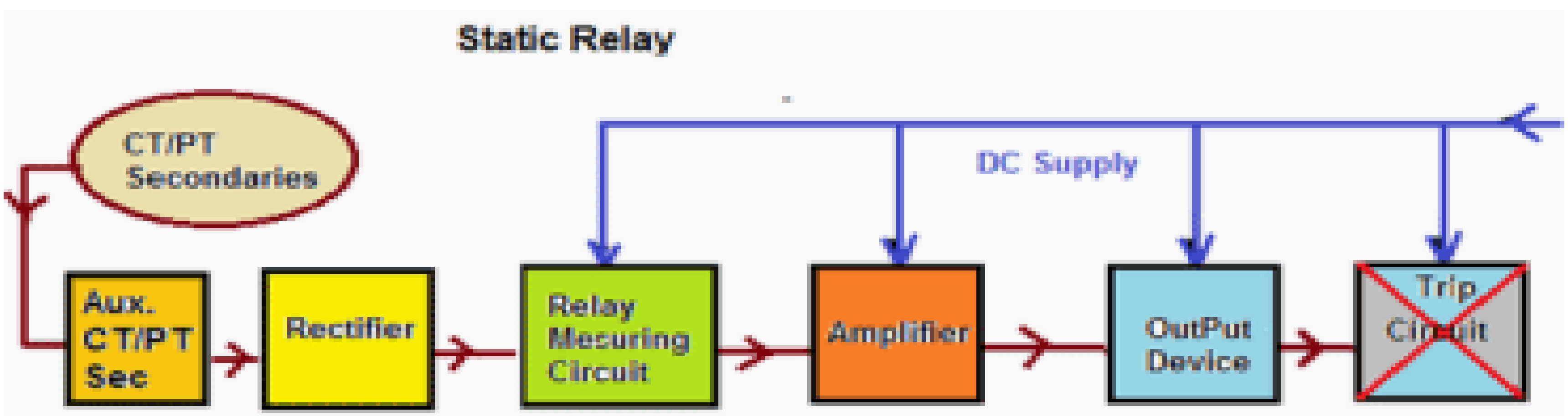


Introduction to Static Relay

- The **static relay** is the next generation relay after electromechanical type.
- The Solid Static relays was first introduced in 1960's. The term '***static***' implies that the relay ***has no moving mechanical parts*** in it.
- Compared to the Electromechanical Relay, the Solid Static relay has ***longer life-span, decreased noise*** when operates and faster respond speed.
- The static relays have been designed to replace almost all the functions which were being achieved earlier by **electromechanical relays**.

Principle of operation

- The essential components of static relays are shown in figure below. The output of CT and PT are not suitable for static components so they are brought down to suitable level by auxiliary CT and PT. Then auxiliary CT output is given to rectifier.
- Rectifier rectifies the relaying quantity i.e., the output from a CT or PT or a Transducer.



- The rectified output is supplied to a measuring unit comprising of comparators, level detectors, filters, logic circuits.
- The output is actuated when the dynamic input (*i.e., the relaying quantity*) attains the threshold value. This output of the measuring unit is amplified by amplifier and fed to the output unit device, which is usually an electromagnetic one.
- *The output unit energizes the trip coil only when relay operates.*

Advantages of Solid State Relay

- Low Weight
- Arc less switching
- Static Relay burden is less than electromagnetic type of relays. Hence error is less.
- Fast response.
- Long life
- Less power consumption
- More Accurate compared to electromechanical Relay

University 2 mark Questions:

- Mention the principle of directional relay
- State the function of protective relays
- List out the types of fuses
- State the function of under frequency relay
- Define under frequency relay
- Mention the advantages of static relay
- List out the types of distance relay.
- Define negative sequence relay.

University 2 mark Questions:

- State the merits of static relay
- List out the applications of static relays.
- Compare Static and Electromagnetic relay.
- A relay is connected to 400/5 ratio current transformer with current setting of 150%. Calculate the Plug Setting Multiplier when circuit carries a fault current of 4000 A.

University 16 mark Questions:

- Electromagnetic relay (15)
- Distance relay (15)
- Under frequency relay (8)
- Static relay-Introduction (8)
- Negative sequence relay (8)
- Directional relay (16)
- MHO relay (8)

UNIT 3

Apparatus Protection

Presented by

C.GOKUL,AP/EEE
Velalar College of Engg & Tech , Erode

UNIT 3 Syllabus

UNIT III APPARATUS PROTECTION 9

Main considerations in apparatus protection - transformer, generator and motor protection - protection of busbars. Transmission line protection - zones of protection. CTs and PTs and their applications in protection schemes.

MAIN CONSIDERATIONS IN APPARATUS PROTECTION

Introduction

The two major items of equipment in a power system are the generators and transformers. They have very high chance of fault occurrence and usually takes much time and money to repair the damage.

Fault and Abnormal Conditions

- **Generator :** Over Current, Over Voltage, Under Voltage, Under Frequency, Unbalanced Current, Loss of Excitation, Reverse Power, Winding Inter turn Fault, Winding Earth Fault etc.

- **Transformer :** Over Current, Winding Inter turn fault, Excessive Temperature Rise, Unbalance Current, Over fluxing etc.

- **Motors** : Over Current, Under Voltage, Unbalance Current, Winding Short Circuit, Stator Earth Fault, etc.

- **Transmission Line** : Single Phase to ground fault, Phase to Phase Fault, three phase to ground fault, Over Current etc.

Zones of Protection

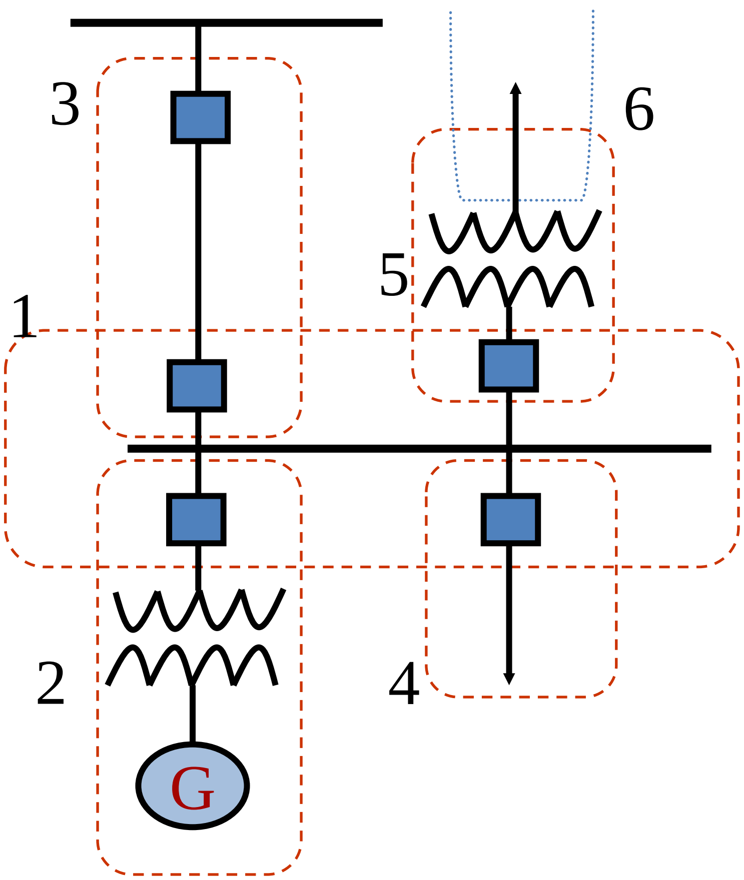
Zones of Protection

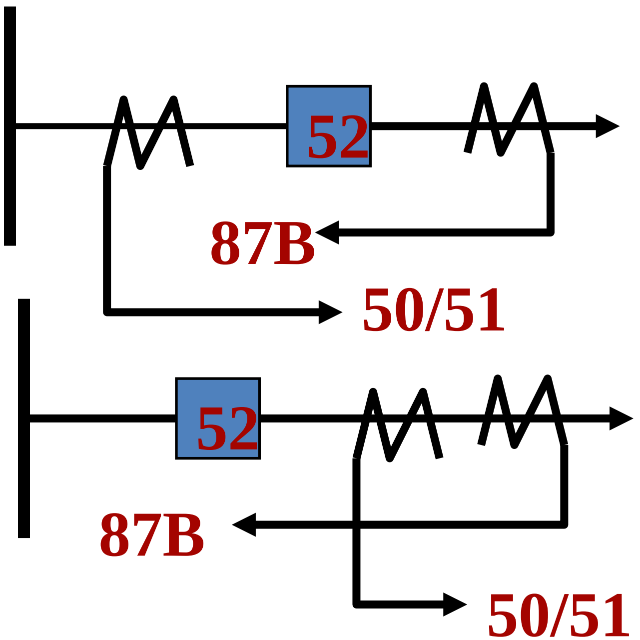
Regions (zones) of power system that can be protected adequately with fault recognition and removal resulting in isolation of a minimum amount of equipment.

Requirements: All power system elements must be encompassed by at least one zone

- Zones of protection must overlap to prevent any system element from being unprotected (no "blind spots").

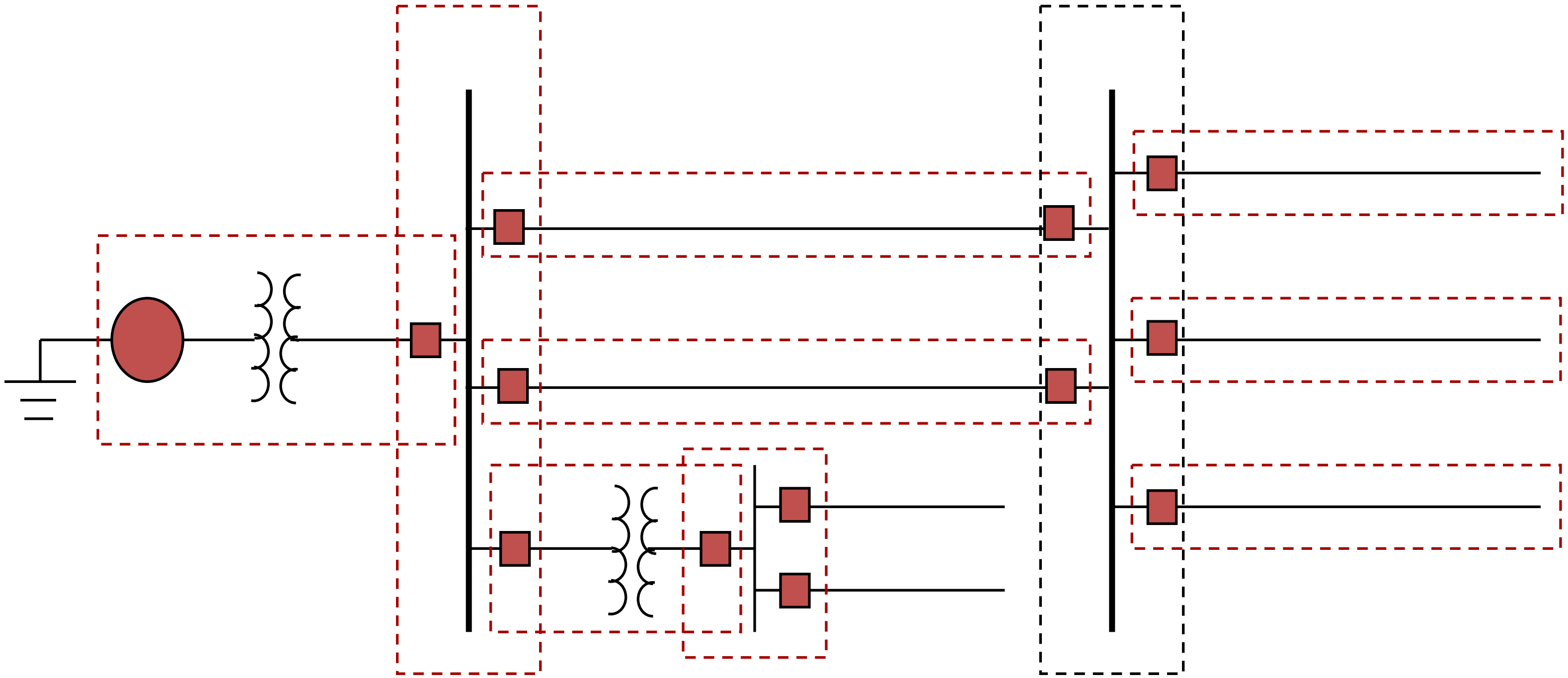
Zones of Protection





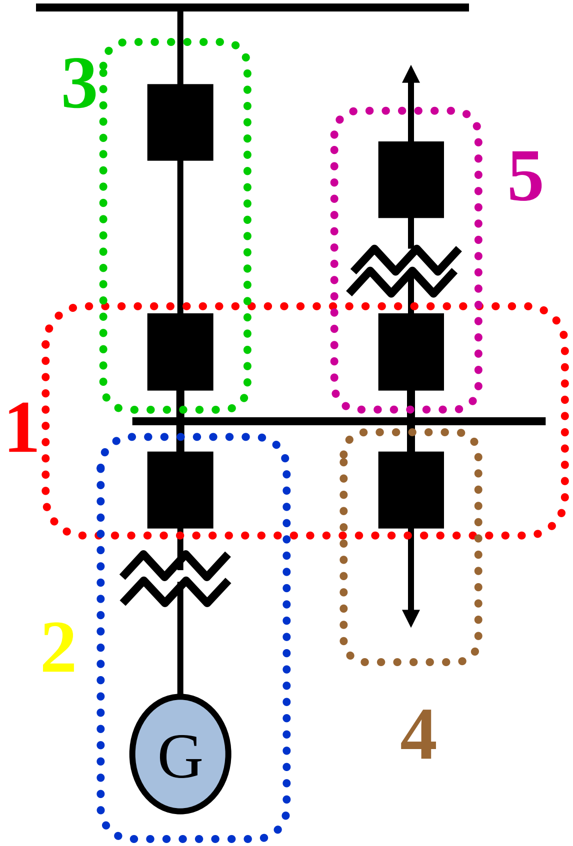
CT REQUIREMENTS FOR OVERLAPPING ZONES

Zones of Protection



Overlapping zones of protection

Zones of Protection



1 - Bus Protection

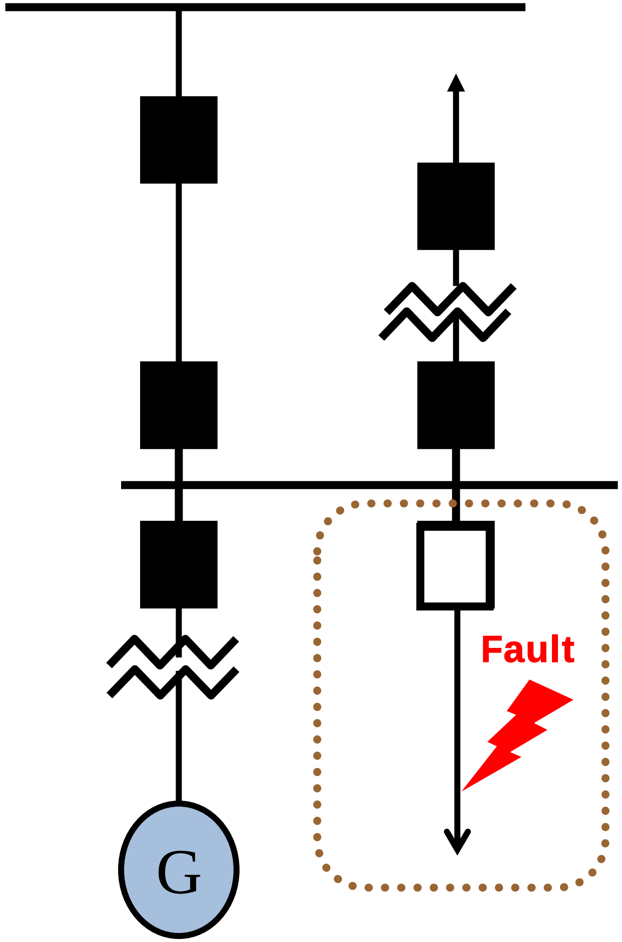
2 - Generator Protection

3 - Subtrans Line Protection

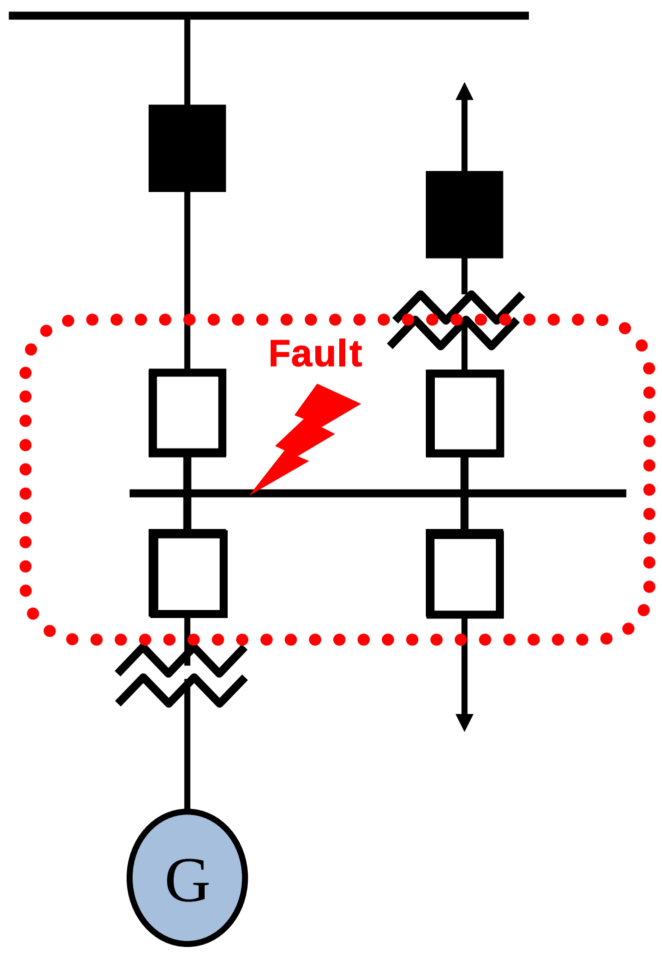
4 - Feeder Protection

5 - Transformer Protection

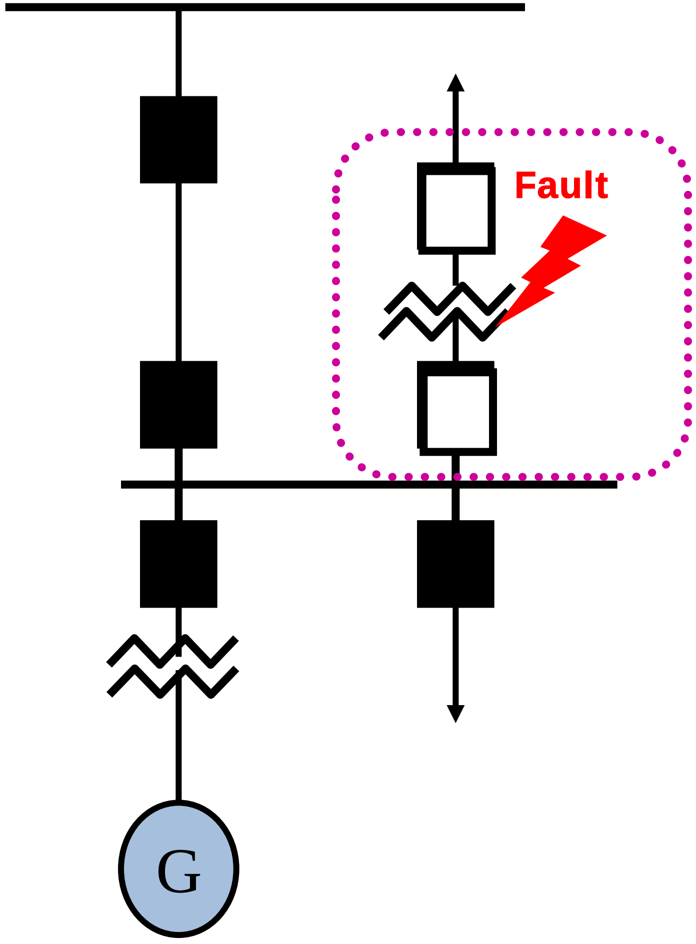
Feeder Protection



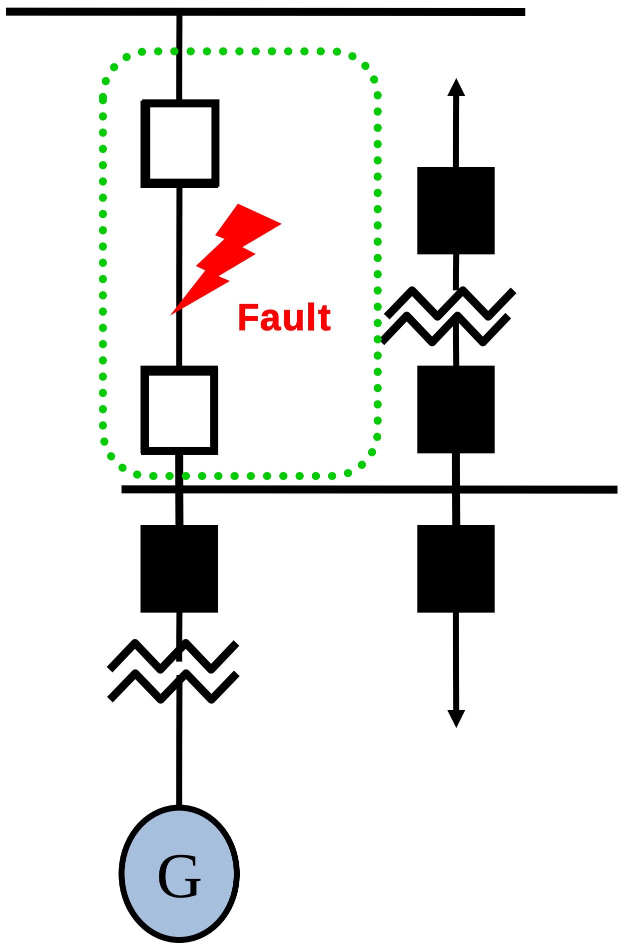
Bus Protection



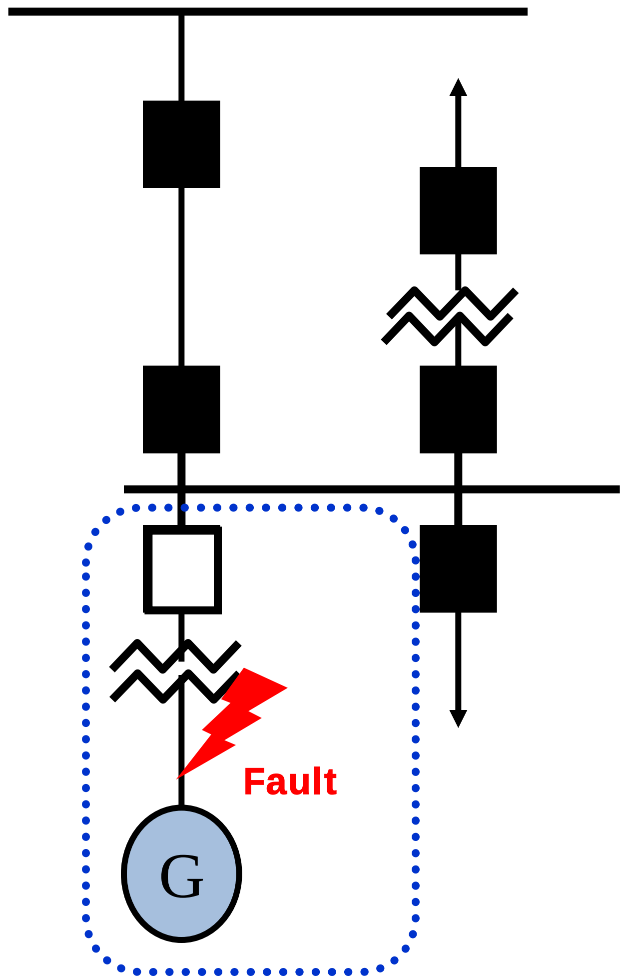
Transformer Protection



Sub transmission Line Protection



Generator Protection



Transformer Protection

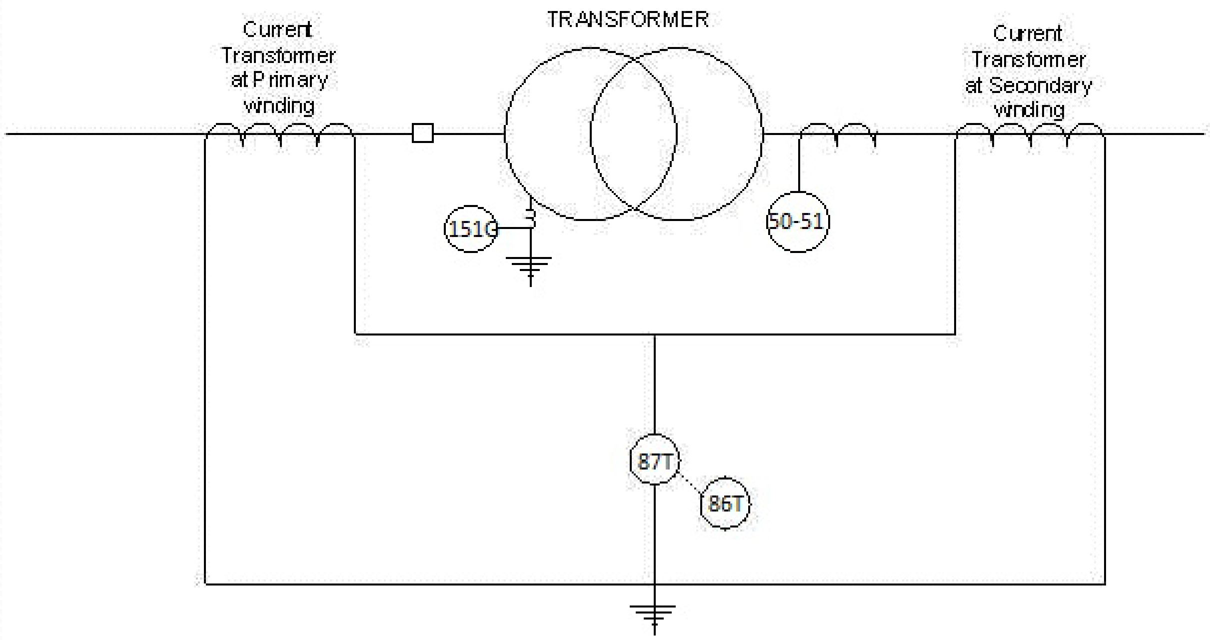
Faults occurring in Transformers

- Open-Circuit faults
- Earth faults
- Phase-to-Phase faults
- Inter-Turn faults
- Overheating

Factors in choosing Protective Gear for a Transformer

- Type of Transformer
- Size of the Transformer
- Type of Cooling
- System where used
- Importance of service for which it is required

Transformer Relaying Scheme



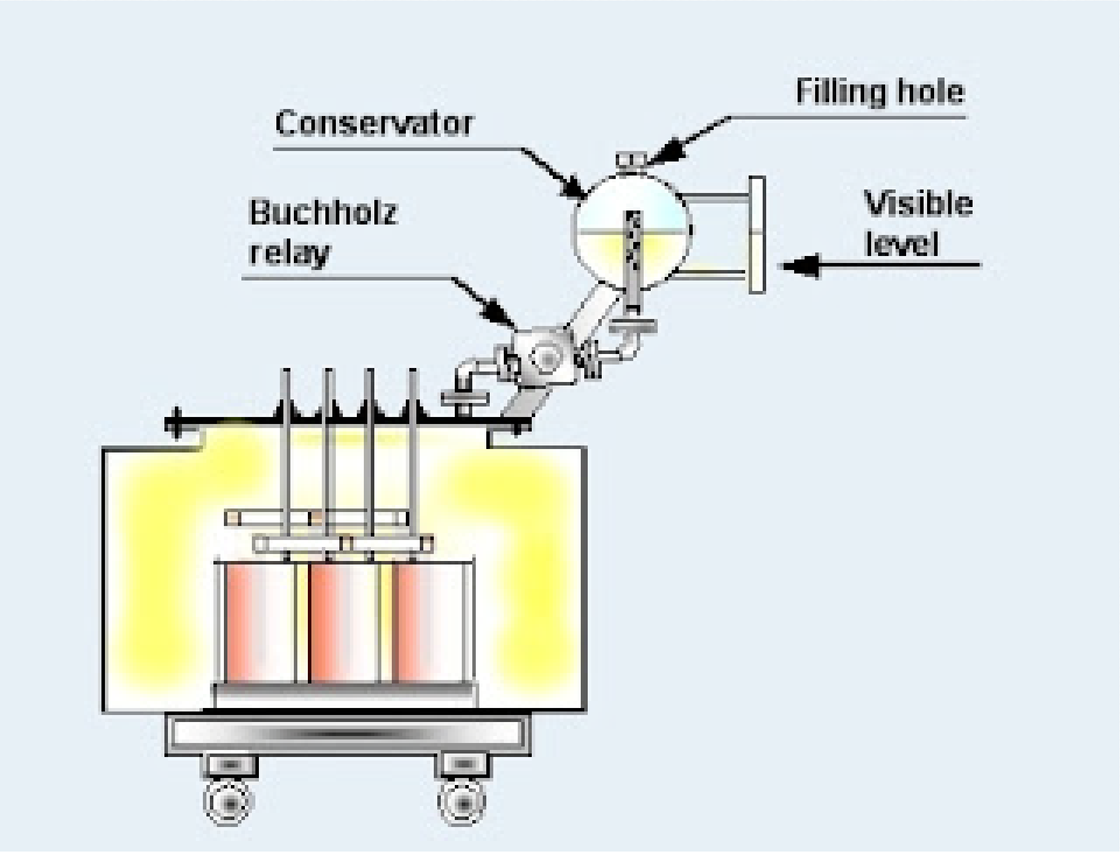
1. Buchholz Protection

Also known as gas accumulator relay, commonly used on all oil-immersed transformer provided with conservator.

Working Principle:

Whenever a fault occur inside the transformer, the oil of the tank gets overheated and gases are generated. The heat generated by the high local current causes the transformer oil to decompose and produce gas which can be used to detect the winding faults

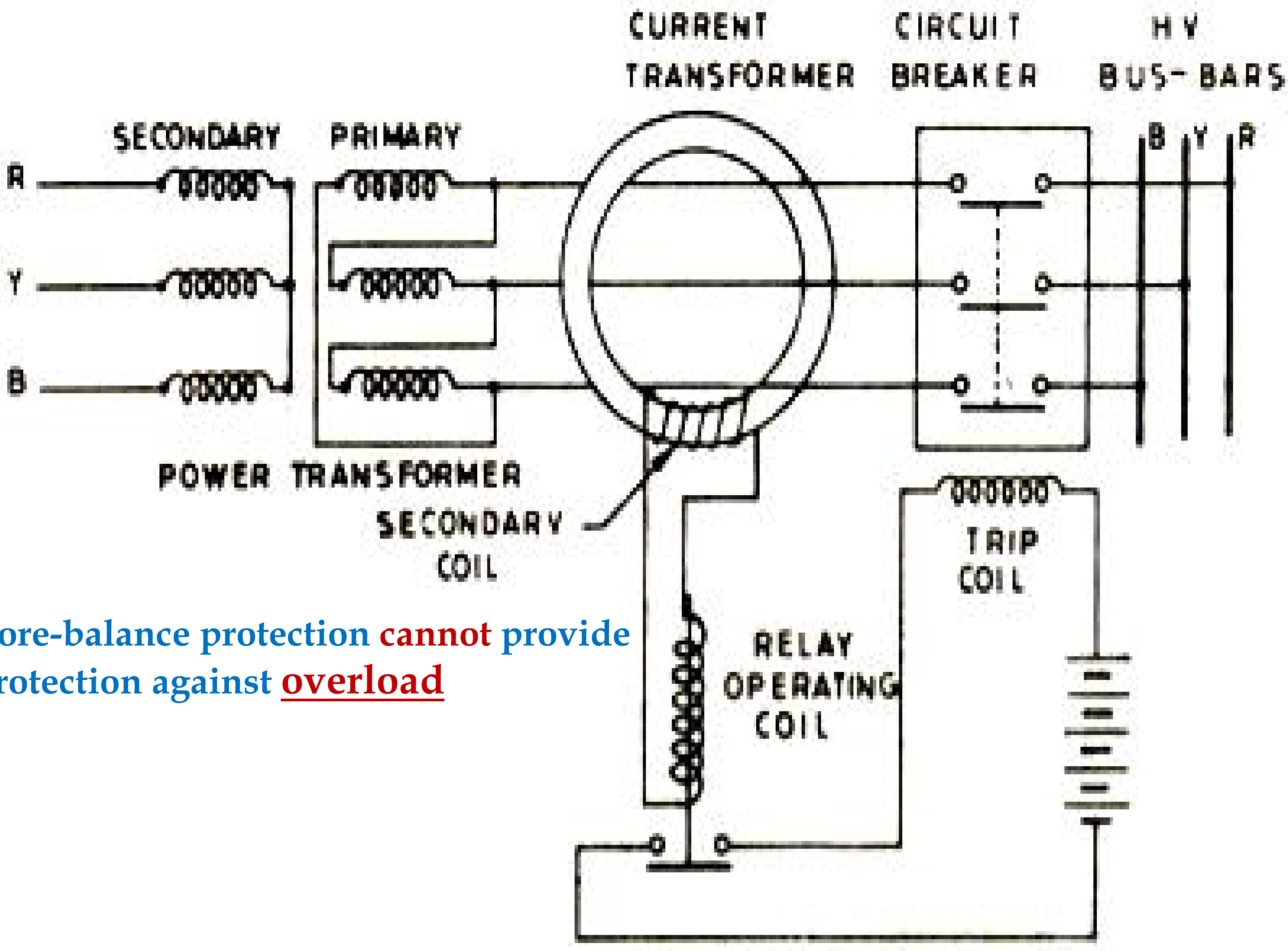
Buchholz Protection



2. Core-Balance Leakage Protection

This system is used to provide protection against **earth faults** on high voltage winding.

When earth fault occurs, the sum of the three currents is no longer zero and a current is induced in the secondary of the CT causing the trip relay to operate and isolate the transformer from the bus-bars.



core-balance protection cannot provide protection against overload

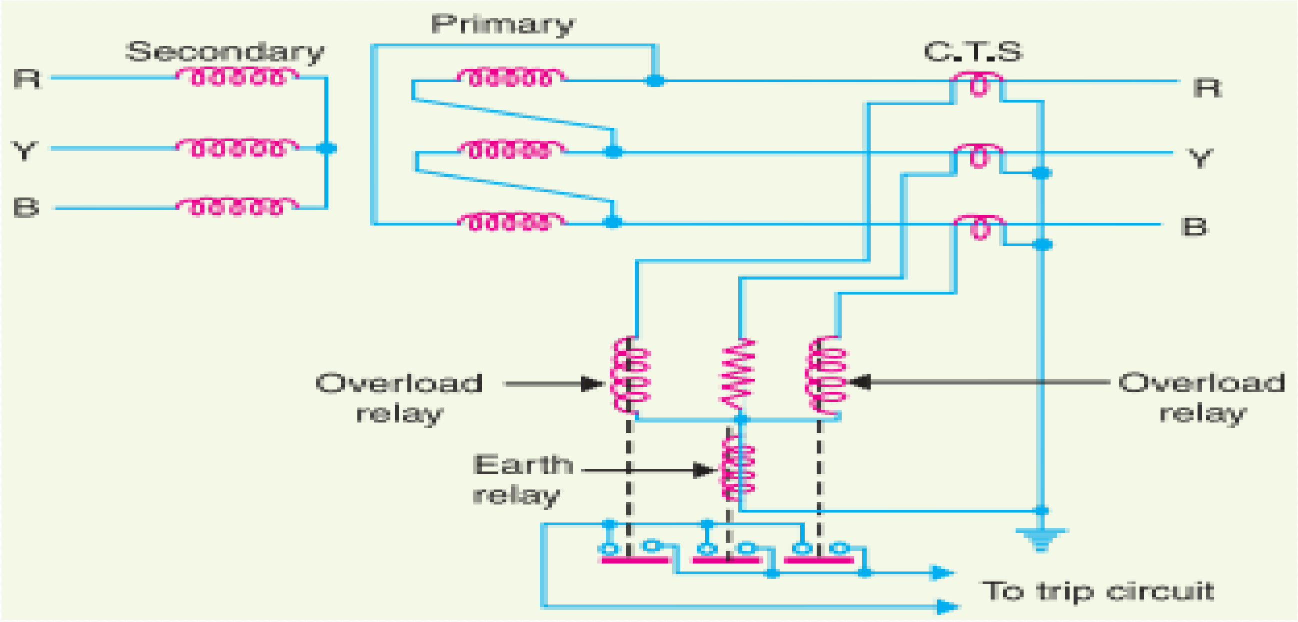
3. Combined Leakage and Overload Protection

The core-balance protection cannot provide protection against overload. It is usual practice to provide combined leakage and overload protection for transformer.

The **earth relay** has ***low current setting*** and operates **under earth faults** only.

The **overload relays** have ***high current setting*** it arranged to operate against **faults between the phases**

- In this system, two overload relay and one earth relay are connected. The two overload relays are sufficient to protect against phase to phase faults.
- The trip contacts of overload relays and earth fault relay are connected in **parallel**. Therefore the energizing of either one of them, the circuit breaker will **tripped**.



Transformer Protection

- **Overheating**

  Normal maximum working temp. = **95 °C**

  8-10 °C rise will reduce the life of the transformer.

- **Overcurrent**
  - **Fuses** for distribution transformer
  - Overcurrent relaying for **5MVA** and above

  Characteristics:

  – Must be below the damage curve

  – Must be above magnetizing inrush

Conclusion

- Open-circuit faults, earth faults, phase-to-phase faults, inter-turn faults and overheating are the fault that are likely occur in a transformer
- Relays control output circuits of a much higher power.
- Safety is increased
- Protective relays are essential for keep equipment from being damaged.

Generator Protection

Introduction

- Generator ? Sources ?

  Generator is the most precious/valuable equipment in PP which actually converts the mechanical energy of turbine into electricity.

  Various relays are used to detect abnormalities and whenever fault conditions appear, they can give warning alarms to trip the unit automatically.

- Generally *automatic tripping* are provided if the time for operator to take *corrective action is less* or the fault is likely to *cause serious damage* to the unit.

FAULT IN THE GENERATOR

- Stator
  - Phase to Phase fault.
  - Inter – turn fault
  - Earth fault (80% & 100%)

- Rotor
  - Two stage relay:

    a) Alarm b) Trip
  - Over voltage in the rotor.

ABNORMAL OPERATING CONDITIONS:

Which affects the generator

- Negative Phase sequence
- Loss of Excitation
- Over fluxing protection
- Reverse power
- Over-speeding
- Pole slipping/ Out of Step

EARTH FAULT:

- When fault current flows through earth return path, the fault is called **Earth Fault**.
- Possible causes are

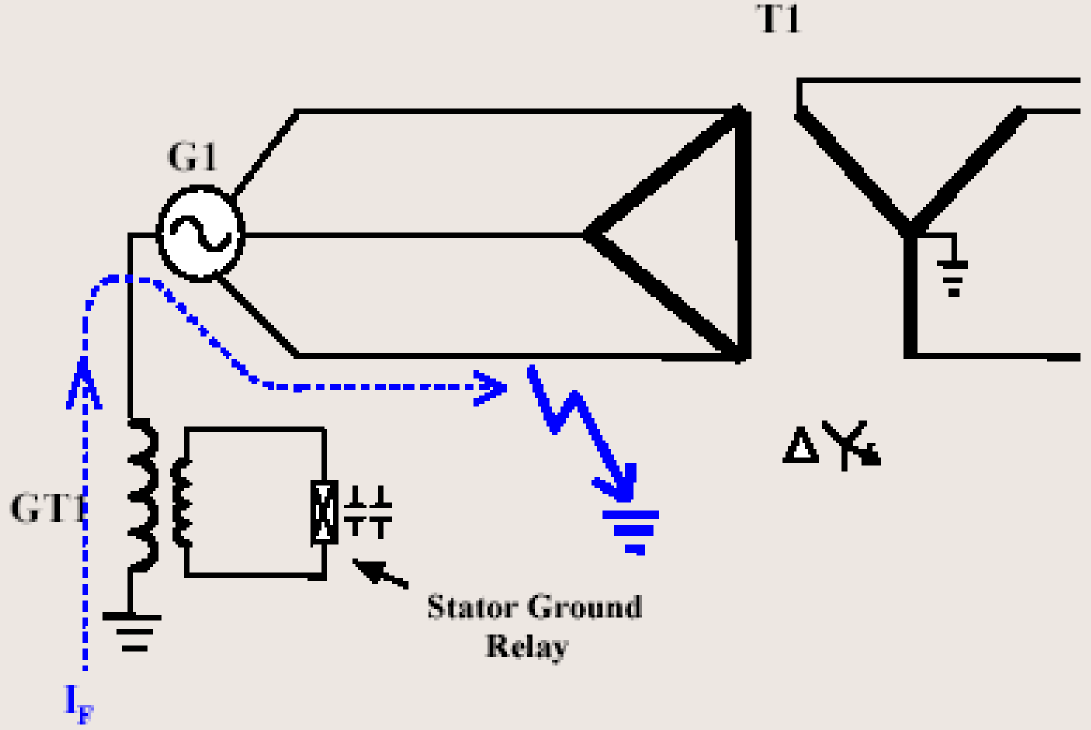
  (a) **Insulation failure**,

  (b) due to **over heating** (Failure of water/air circulation through stator conductor).
- Earth fault may occur between any phase conductor and core.
- It is usually practice to **limit the earth fault** current to **avoid damage** to the stator.

STAND BY EARTH FAULT:

- This protection is practically **protects 95% of generator winding**. Therefore a current setting of 5% of in to be set.
- E/F current is generally limited to about **15/20Amps**.
- Earth fault current of even 100A for few seconds can cause external damage. So the earth fault is restricted to 100Amps. By providing NGR of 63.5 ohms at 11KV Voltage Level.
- This is a Back-Up protection.

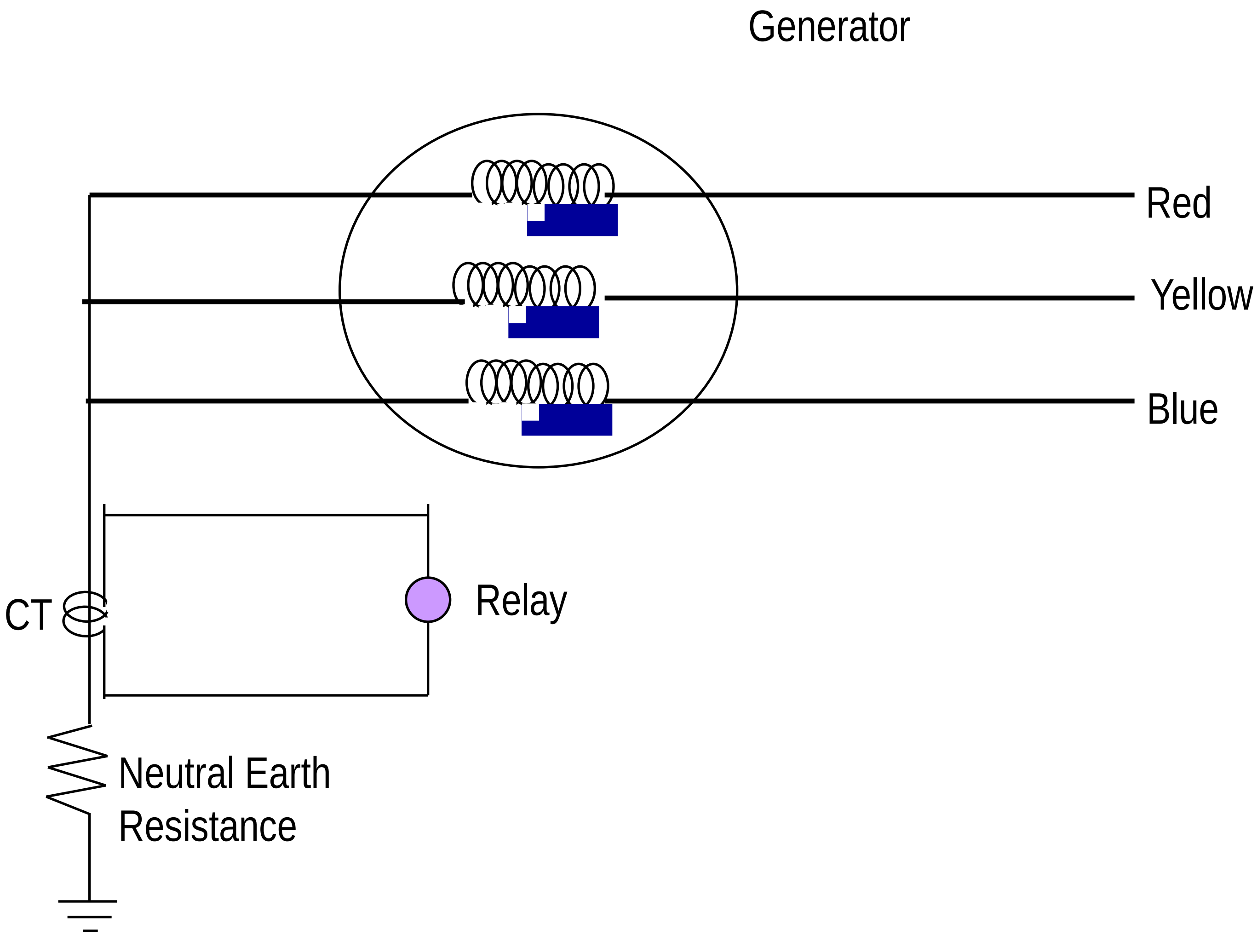
Ground Fault Protection



100% STATOR EARTH FAULT:

- In this protection, where neutral voltage measurement is made at generator terminals, (By Broken Delta), the third harmonic voltage element is used.
- First earth fault very near to neutral produces negligible current as driving voltage is nearly zero. But if a 2nd earth fault occurs at machine terminal, line to ground fault is not limited by NGR. The resulting fault current can be high. Hence, the 1st E/F very near to neutral has to be detected early and isolated.
- All generators produce continuous current of 3rd harmonic voltage. Under normal condition, 3rd harmonic voltage is present. If there is a fault near neutral, the amount of 3rd harmonic voltage comes down and this is used for detection.

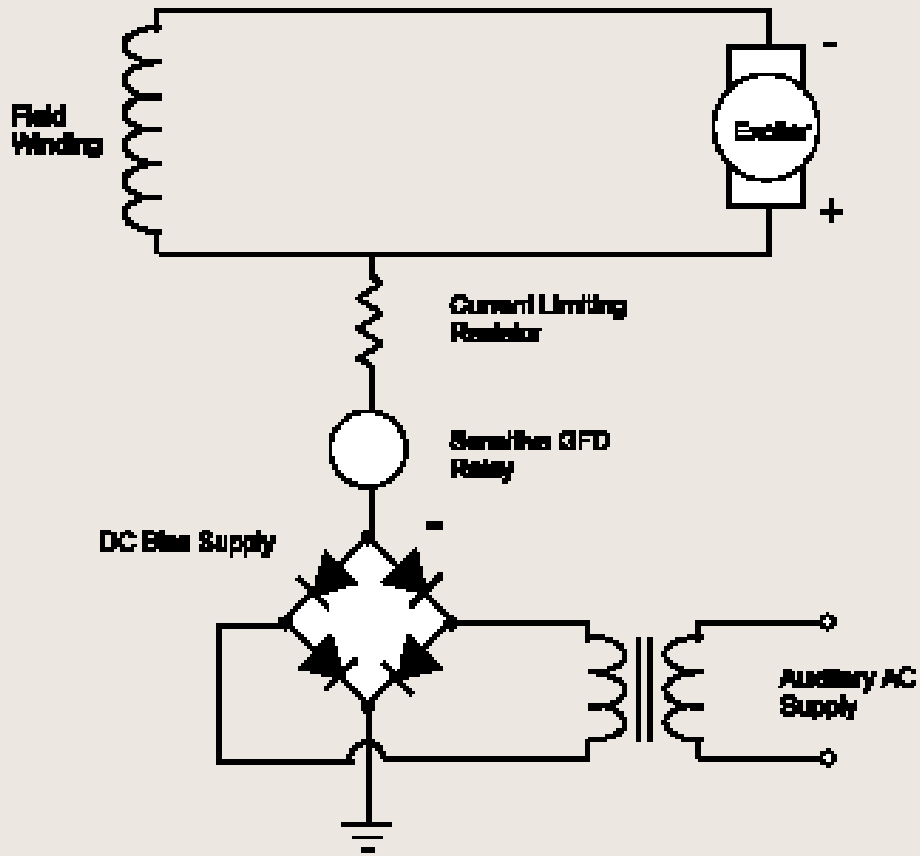
STATOR EARTH FAULT PROTECTION



ROTOR EARTH FAULT:

- **Since rotor** circuits operate ungrounded, a single earth fault is caused by insulation failure due to moisture, ageing of insulation or vibration of rotor etc. But existence of single ground fault increases the chance of a second ground fault. The occurrence of second earth fault can cause fault current flows. This results unsymmetrical flux distribution. The air gap flux is badly distorted. The rotor is displaced enough to rub stator leading to severe vibrations and can damage the bearing.
- **Although a machine can continuously run on a single earth fault but second rotor earth fault, if allowed to occur, should be detected immediately and generator should be tripped.**

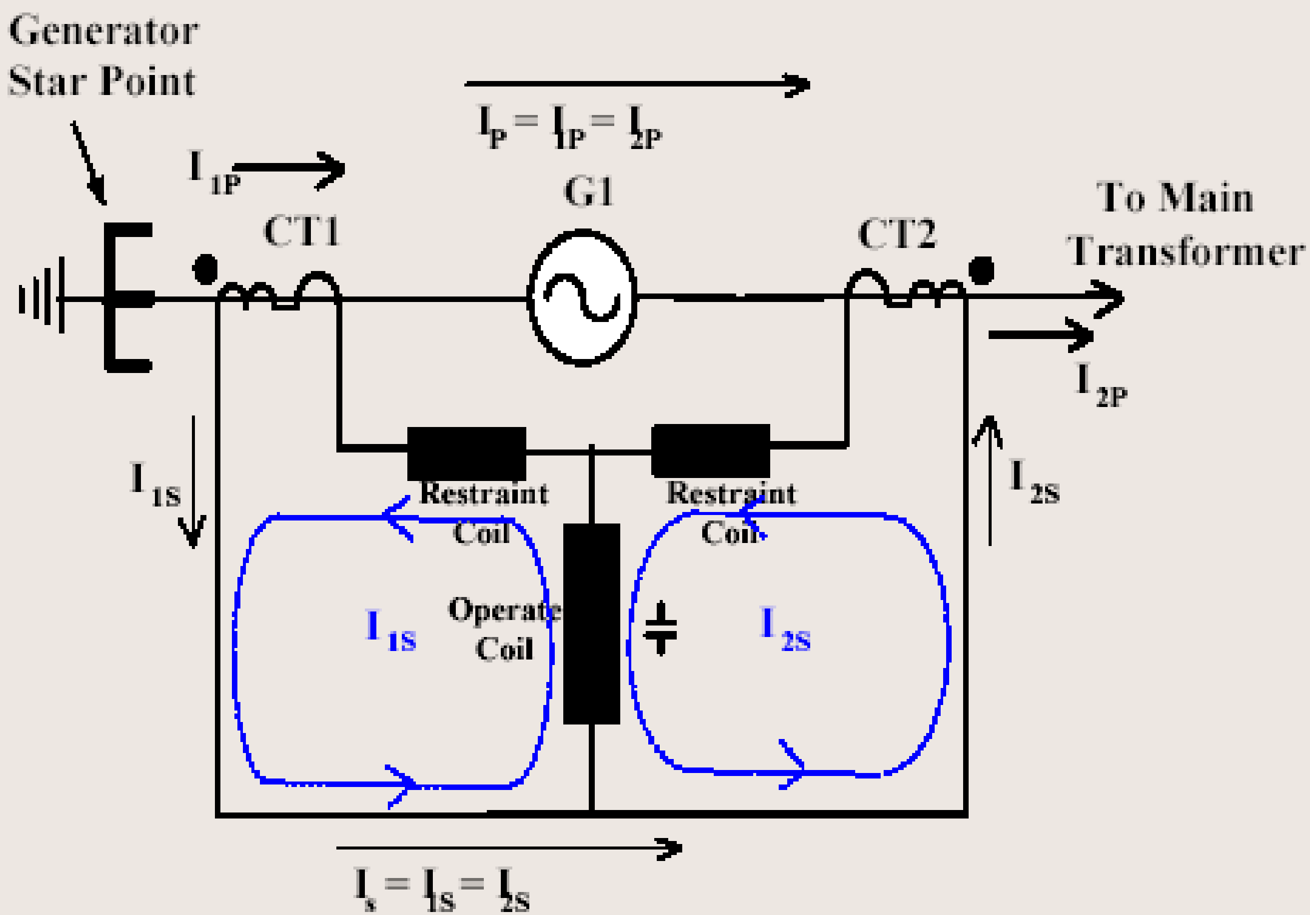
Rotor Ground Fault



DIFFERENTIAL PROTECTION

- Differential protection is very reliable method for stator winding phase to phase fault. In this, currents on both sides of the generator are compared.
- Under normal condition or for a fault outside of the protected zone, current i1s is equal to current i2s. Therefore, the currents in the CTs secondary's are also equal, i1s=i2s and no current flows through the current relays.
- If a fault develops inside of the protected zone, current i1s and i2s are no longer equal, therefore i1s and i2s are not equal and therefore a current flowing in the current relay.

Differential



Negative Phase Sequence Protection:

- When the generator is connected to a balanced load, the phase currents are equal in magnitude and displaced electrically by 120°. The ATs wave produced by the stator currents rotate synchronously with the rotor and no eddy currents are induced in the rotor parts.
- If there is an unbalanced loading of the generator, and then the stator currents have a –ve sequence component. The stator field due to these –ve sequence currents rotates at synchronous speed but in a direction opposite to the direction of the field structure on the rotor. Thus, the –ve sequence stator armature mmf rotates at a speed –Ns, while the rotor field speed is +Ns. There is a relative velocity of 2Ns between the two.
- These causes double frequency currents, of large amplitude to be induced in the rotor conductors and iron part. So both the eddy currents as well as the hystersis losses increase due to these double frequencies induced currents in the rotor.
- Unbalanced loading affects ;(a) Rotor heating (b) Severe vibration & heating of stator.

FIELD FAILURE PROTECTION:

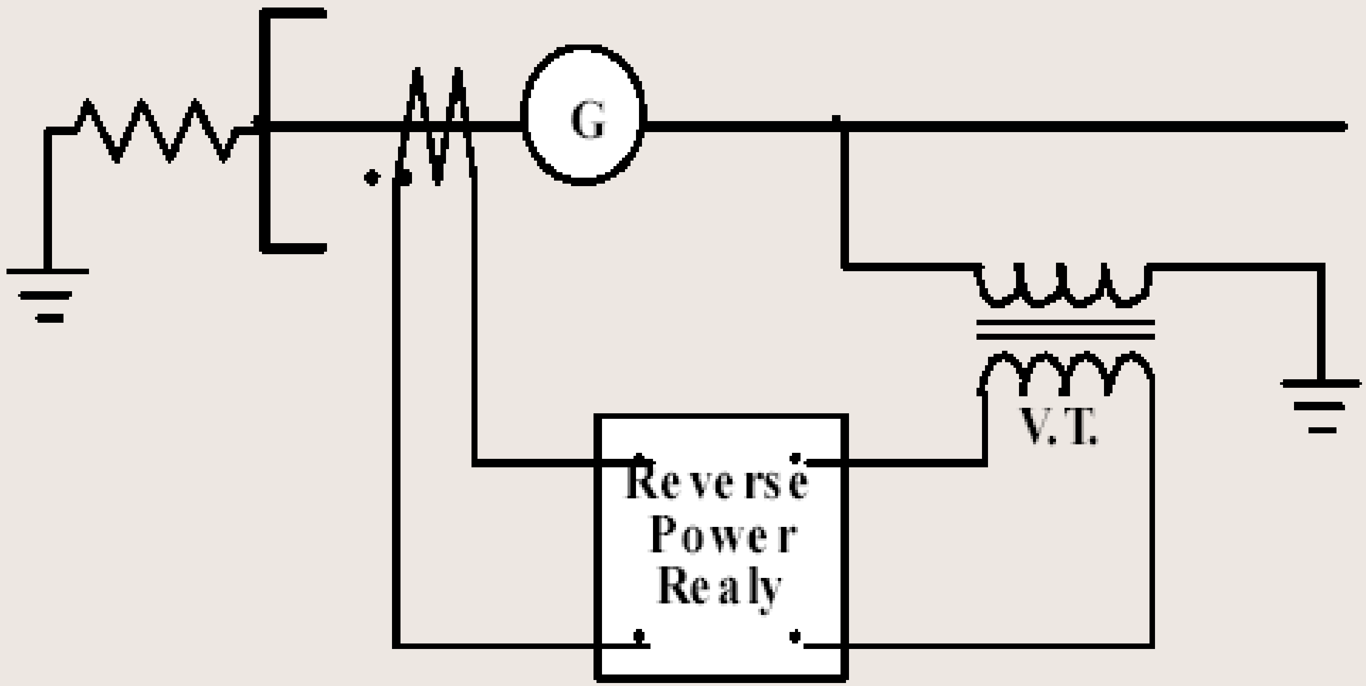
- Acts as an Induction Generator.
- Possible Causes;
  - AVR Fault
  - Tripping of Field C.B.
  - Open circuit or Short circuit occurring in the D.C. circuit.
  - PMG failure
- In normal condition, generator when running shares the reactive demand of the system. If excitation fails, synchronous generator runs at a super-synchronous speed, draws reactive power from the power system instead of supplying the Qe. In case, the other generators can't meet the requirement of reactive power, this shall result in large voltage drop which may ultimately result in instability.
- In this case, slip becomes –Ve result in slip frequency currents. Rotor gets heated up due to induced currents in the rotor winding, core or damage the winding if this condition is sustained. Stator heats up due to high stator currents due to increase in reactive current from the system.
- By monitor (i) Field current, If

  (ii) Phase current & voltage.

REVERSE POWER PROTECTION:

- This protection is provided to protect against motoring.
- A generator is expected to supply active power to the connected system in normal operation. If the generator primover fails, a generator that is connected in parallel with another source of electrical supply will to begin to motor. This reversal of power flow due to loss of prime mover can be detected by reverse power element.
- Possible Causes:
- When immediately after Synchronising control valves are not operated which may happen due to some fault in the system or some delay by the operating personnel.
- In case of sudden closure of stop valves or control valves when the generator unit is still connected to the grid.
- Reverse power operation is harmful to the turbine since without steam flow in the turbine. If the turbine continues to rotate, it will result in heating of turbine blades due to churning action. However, the period for the turbine to overheat may vary from a few seconds to minutes depending upon the turbine & operating conditions.

Reverse Power



OVER FLUXING PROTECTION:

- Fundamental Voltage- Flux relation:

$$V = 4.44 * N * f * ø$$
$$V/f = 4.44 * N * ø$$
$$= K * ø = K * B/A$$

- V/f is a measure of flux in machine. That means, over fluxing can occur if the ratio of voltage to frequency exceeds certain limits. High voltage or low frequency, causing a rise in the V/f ratio, will produce high flux densities in the magnetic core of the generator. This could cause the core of the machine to saturate & stray flux to be induced in the unlamilated components that have not designed to carry flux. The resulting eddy currents in the solid components e.g. core bolts & clamps and end of core laminations can cause rapid overheating and damage.

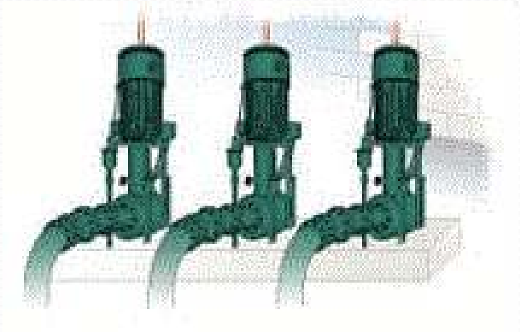
POSSIBLE CAUSES:

- AVR failure
- Load rejection under manual AVR control
- Excessive excitation with Generator Offline.
- Decreasing Speed with operator tries to maintain rated stator voltage.
- AUTO to Manual transfer of AVR.

Motor Protection

Various Industry Motor Applications

- Fan, Blower
- Pump, Compressor
- Conveyor
- Mixer
- Cranes



Types of Fault in Motors

External Fault	Internal Fault
Mechanical Load	Bearing Failure
Unbalance Supply Voltage	Winding phase and earth fault
Single Phasing	
Phase Reversal	

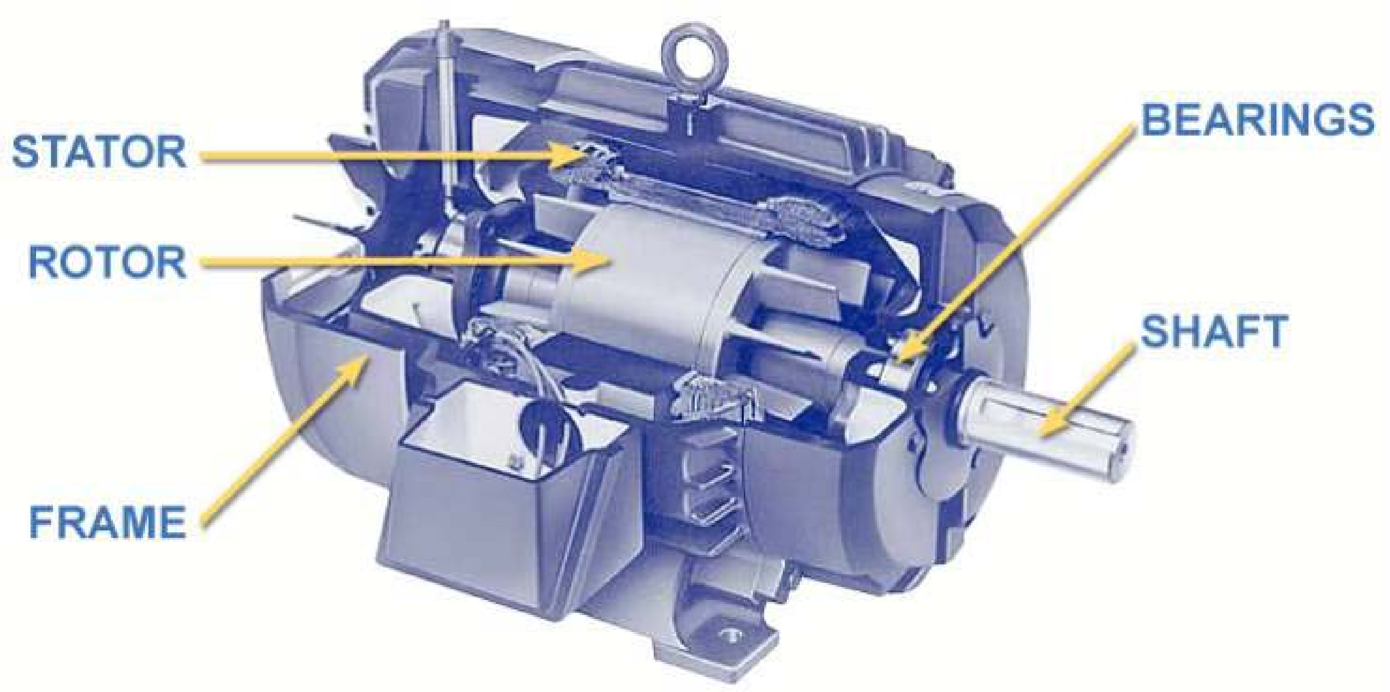
Motor Protection Summary

- THERMAL OVERLOAD
- SHORT CIRCUIT
- EARTH FAULT
- UNBALANCE
- BLOCKED ROTOR/STALLING PROTECTION

Thermal Stress Causes Motor Failure

- Most of the motor failure contributors and failed motor components are related to motor overheating.

- Thermal stress potentially can cause the failure of all the major motor parts: Stator, Rotor, Bearings, Shaft and Frame.

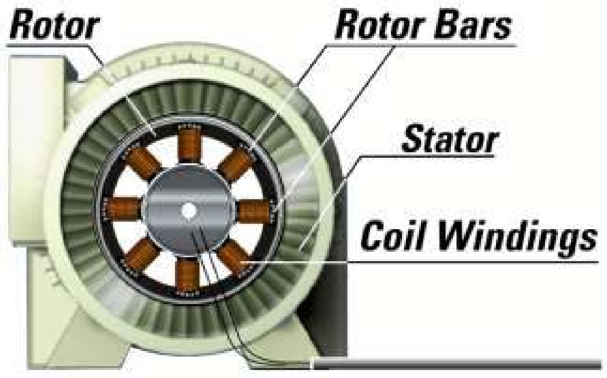


Thermal Overload

- Consider a motor is as homogenous body
- Developing heat at constant rate.
- Dissipating heat at constant rate.

Heat disspation is proportional to temperature rise

$$T = KI_R^2\ (1-e^{-t/\tau})$$

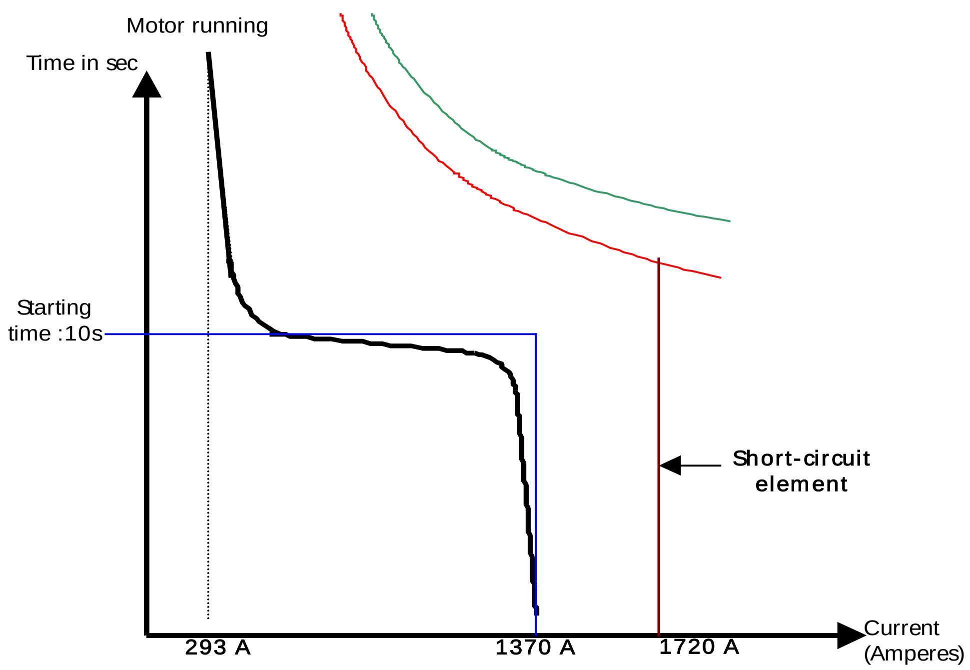


Overload Protection - Thermal Model

- Main Factors and Elements Comprising the Thermal Model are:
  - Overload Pickup Level
  - Overload Curve
  - Cooling Time Constants
  - Hot/Cold Stall Time Ratio

THERMAL OVERLOAD cont……

SETTING CRITERIA : Thermal Element



HOT & COLD CURVES OF THE RELAY ARE TO BE MATCHED WITH THAT OF THE MOTOR

$$\text{PICKUP} = \frac{\textbf{FULL LOAD CURRENT X CT SECONDARY}}{\text{CT PRIMARY X 1.05}}$$

THERMAL ALARM (PRETRIP)

MONITORS THERMAL CONTENT & GIVES AN ALARM WHEN CONTENT REACHES 75% OF HOT TRIP TIME

LED INDICATION

THERMAL LOCKOUT

LOCKOUT RELAY PICKSUP WHEN THERMAL CONTENT EXCEEDS TRIP LEVEL & INDICATES

SHORT CIRCUIT PROTECTION

- What is:-Motor short-circuit protection - provided to cater for major stator winding faults and terminal flashovers.
- Settings - Definite time over current relay element, set to about 130% of motor starting current and time delay set at 100ms.

SHORT CIRCUIT ELEMENT

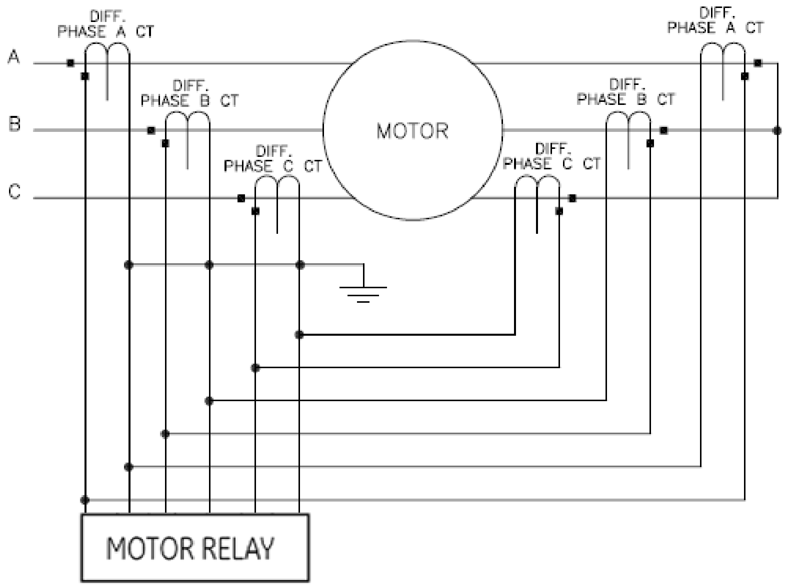
$$\text{SETTING} = \frac{\text{1.3 X STARTING CURRENT X CT SEC.}}{\text{CT PRIMARY}}$$

Differential Protection

- Differential protection may be considered the first line of protection for internal phase-to-phase or phase-to-ground faults.

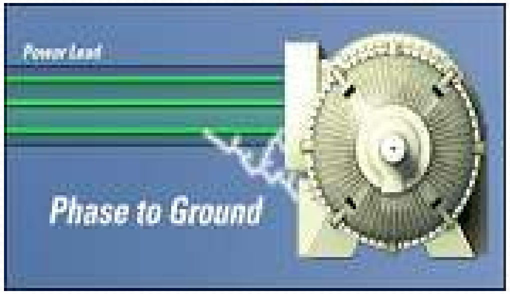
<u>Summation method with six CTs:</u>

- If six CTs are used in a summing configuration, during motor starting, the values from the two CTs on each phase may not be equal as the CTs are not perfectly identical and asymmetrical currents may cause the CTs on each phase to have different outputs.
- The running differential delay can then be fine tuned to an application such that it responds very fast and is sensitive to low differential current levels.



Ground Fault Protection

- **What is:-**A ground fault is a fault that creates a path for current to flow from one of the phases directly to the neutral through the earth bypassing the load

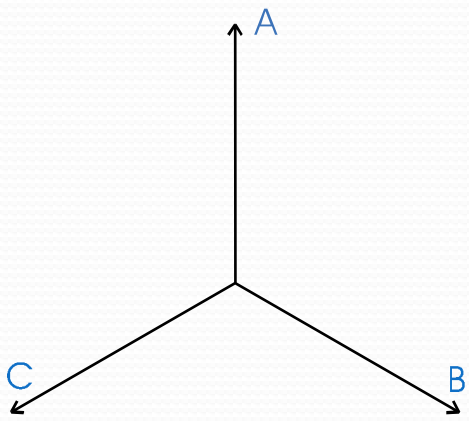


- **Ground faults in a motor occur:**
    - When its phase conductor's insulation is damaged for example due to voltage stress, moisture or internal fault occurs between the conductor and ground
- **To limit :-**the level of the ground fault current connect an resistance known as stablising resistance

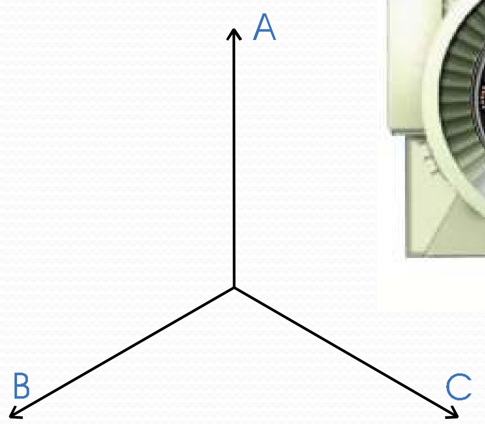
$$R_{stab} = \frac{I_{st}}{I_0}\left(R_{ct} + kR_l + R_r\right)$$

Phase Unbalance

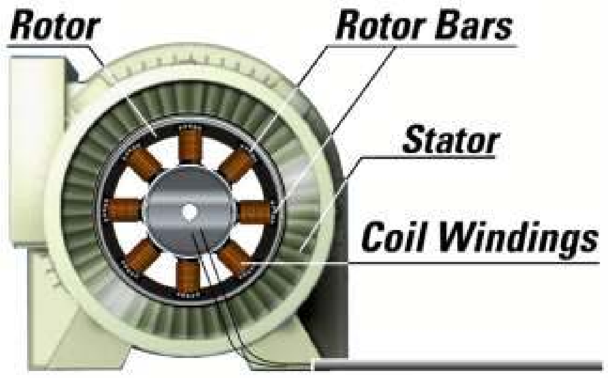
- What is:-In a balanced system the three line-neutral voltages are equal in magnitude and are 120 degrees out of phase with each other. Otherwise, the system is unbalanced.



Positive Sequence



Negative Sequence



Main causes of current unbalance

- Blown fuses
- Loose connections
- Stator turn-to-turn faults
- System voltage distortion and unbalance
- Faults

Effects

- Motor winding overheating
- Excessive vibrations
- Cause motor insulation/winding/bearing damage

Motor Protection Stalling

What is:-It happens when motor circuits are energized, but motor rotor is not rotating. It is also called locked rotor.

- Effects:

This will result in excessive currents flow given the same load. This will cause thermal damage to the motor winding and insulation.

Motor Protection Stalling

Required for

Stalling during starting

Stalling during running

Cases

- **Starting time < Stall withstand time**
- **Stall withstand time< Starting time**

CURRENT RELAYS

IDMT RELAYS :

These relays have inverse characteristic and the operating time decreases as the magnitude of current increases.

GENERAL RELAY EQUATION :

$$t = TMS \times K/((I/In)^n - 1)$$

t = RELAY OPERATING TIME

I = FAULT CURRENT

n = CONSTANT

K = CONSTANT

In = RELAY PLUG SETTING (PICK UP)

TMS = TIME MULTIPLIER SETTING

Pilot Relays

Why needed:-Overcome diffculties of overcurrent Relay ie

•Coordination

•Excessive fault clearance times

Principle:-

•Measurement of current at each end feeders

•Transmission of information

•No time and current gradation required

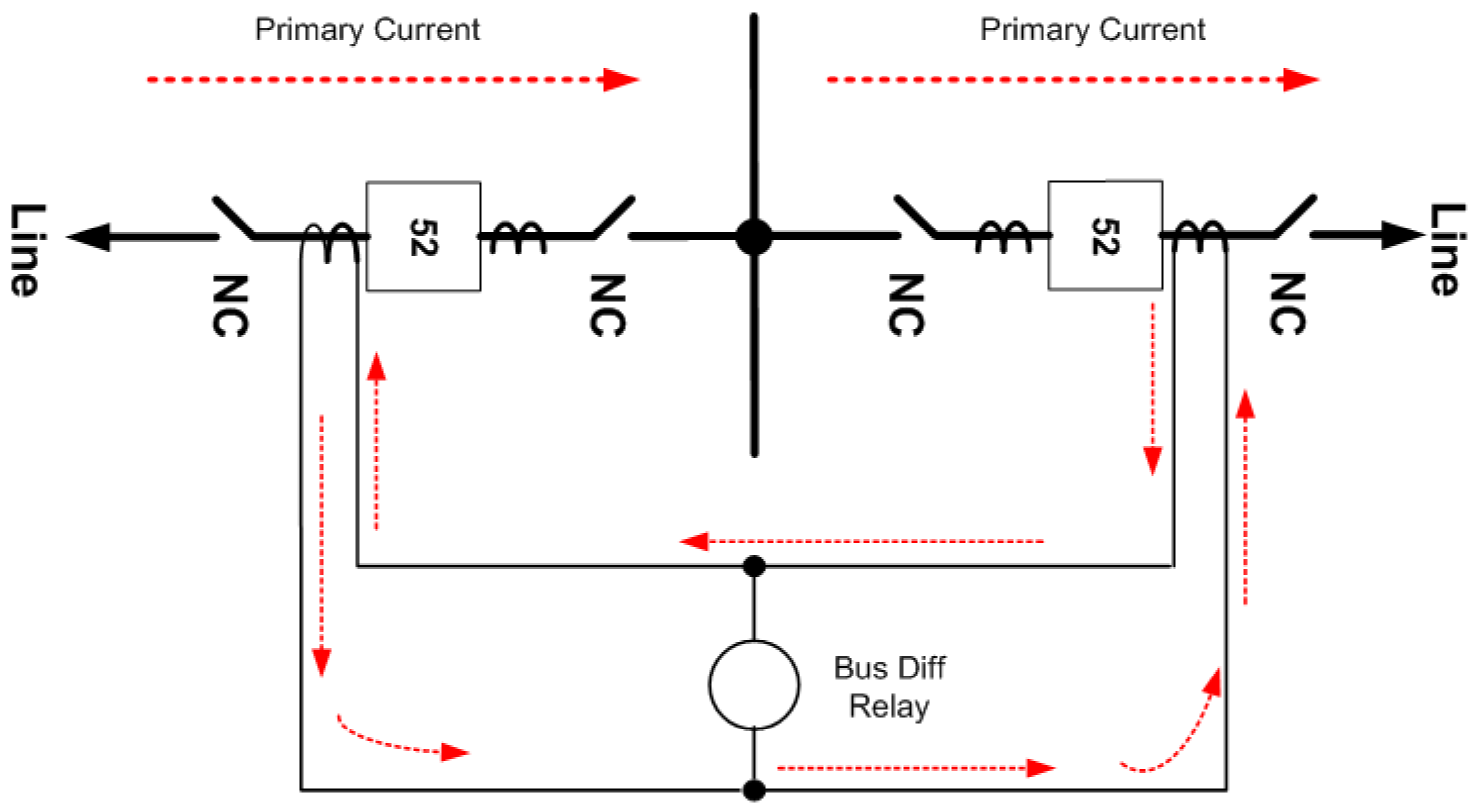
•Supervision facility.

•Merz price Circulating scheme

Protection of Bus bars

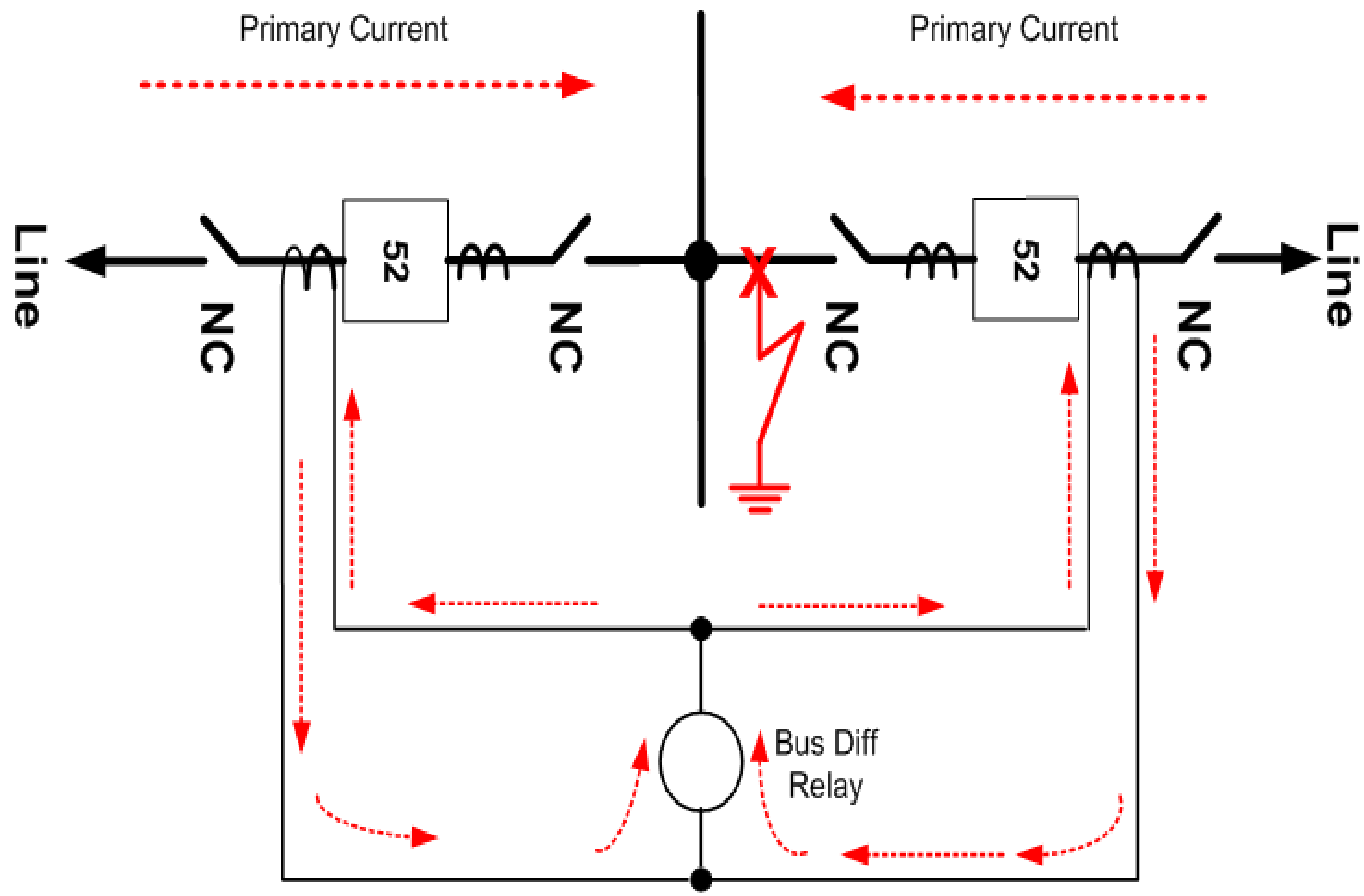
Bus Bar Protection

Bus Differential: Current into bus must equal current out of bus



Bus Protection

Bus Fault



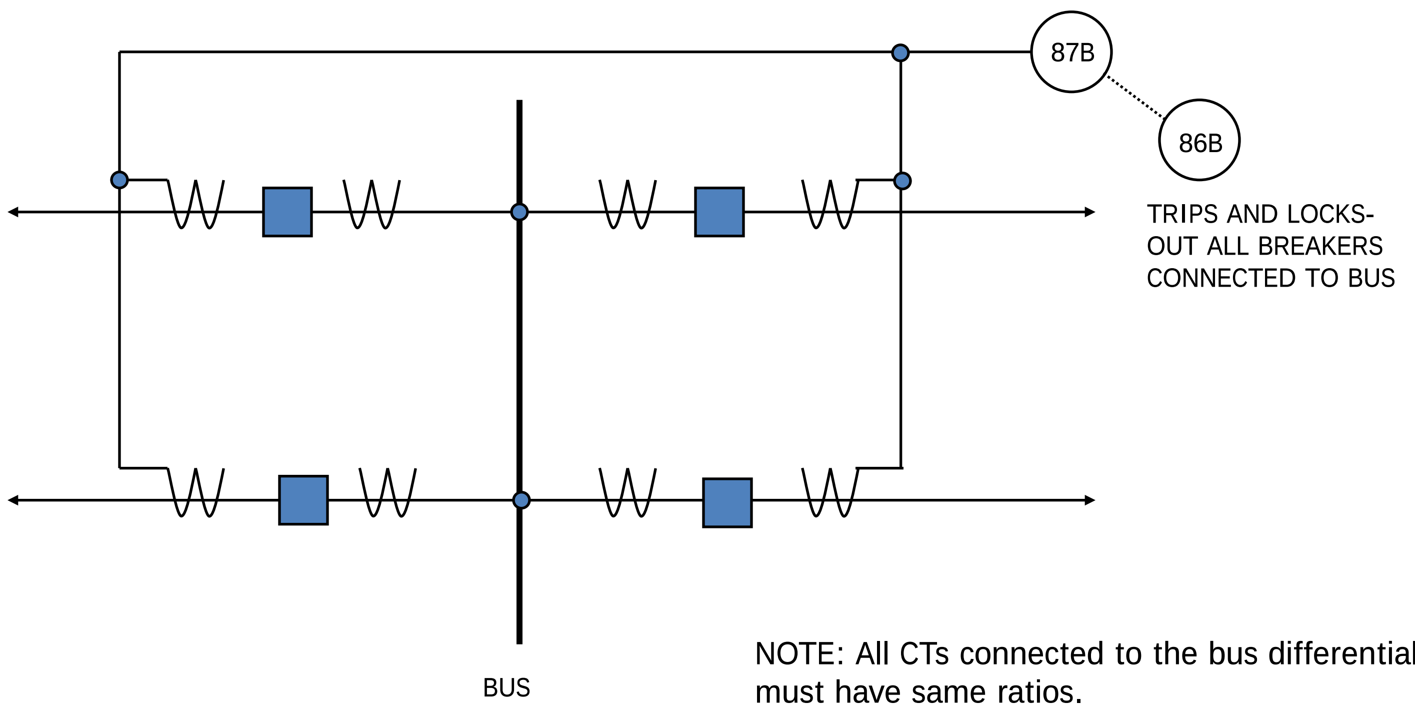
Busbar Protection

Typical Bus Arrangements:

- Single bus
- Double bus, double breaker
- Breaker-and-a-half
- Main and transfer buses with single breaker
- Ring bus

Busbar Protection

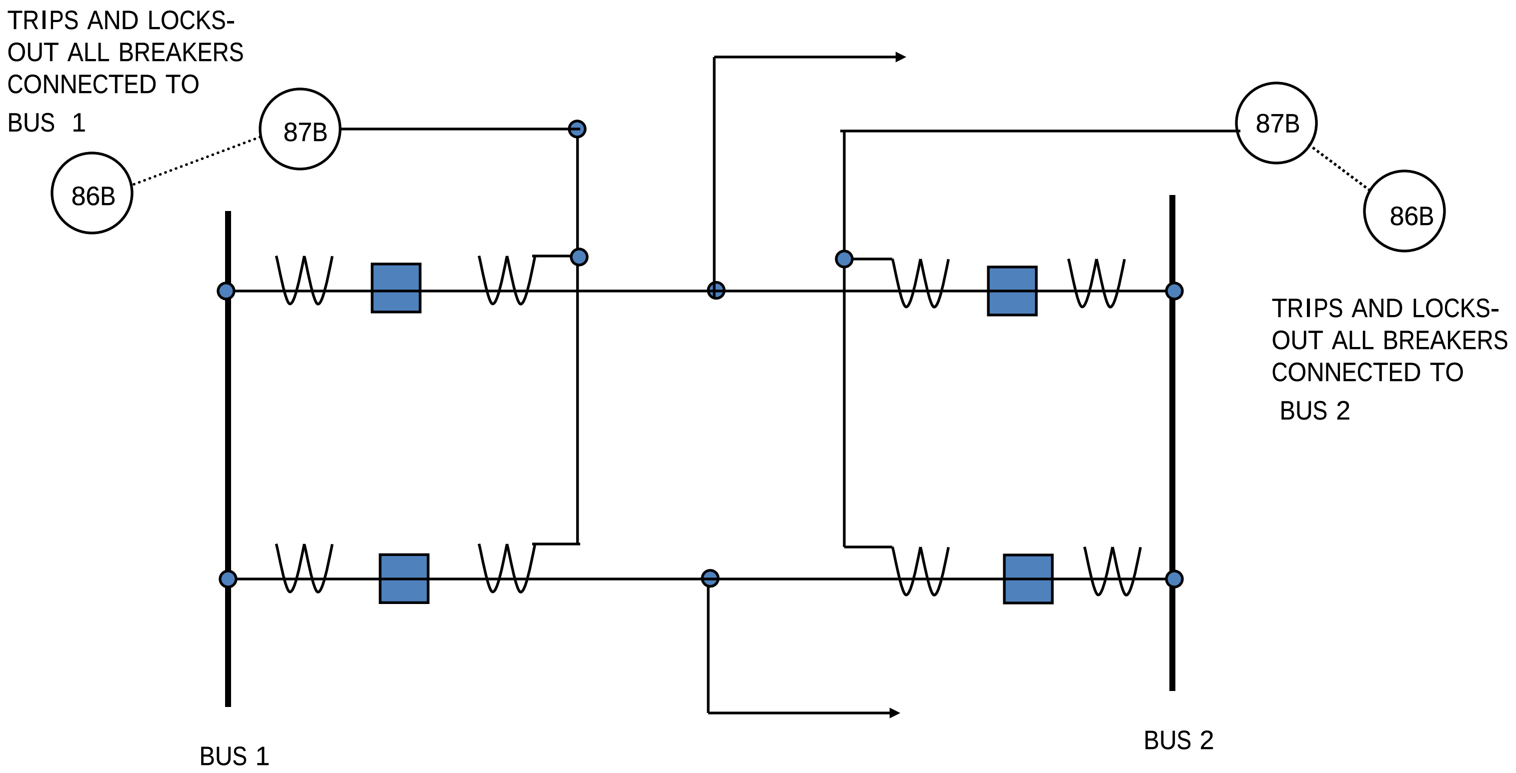
Bus differential connection (single-bus)



NOTE: All CTs connected to the bus differential must have same ratios.

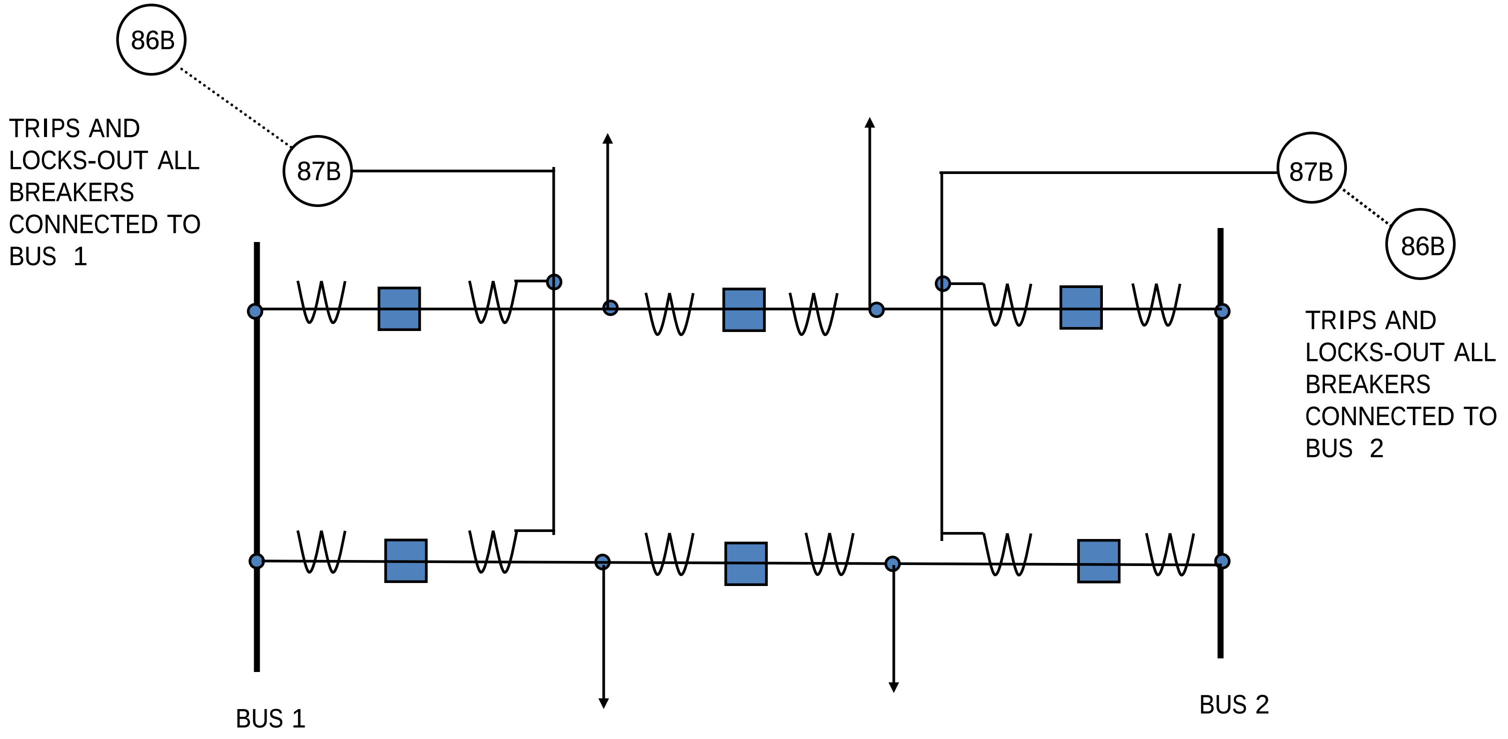
Busbar Protection

Bus differential connection (double-bus, double-breaker)



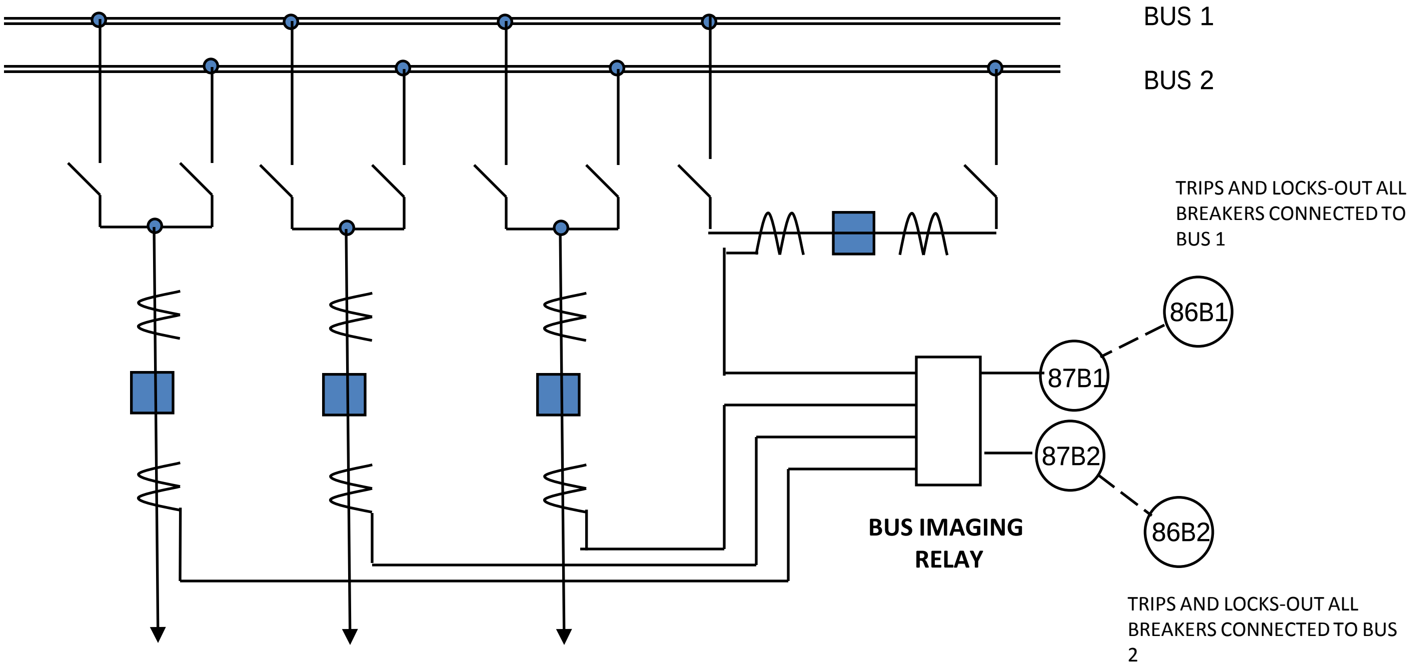
Busbar Protection

Bus differential connection (breaker-and-a-half)



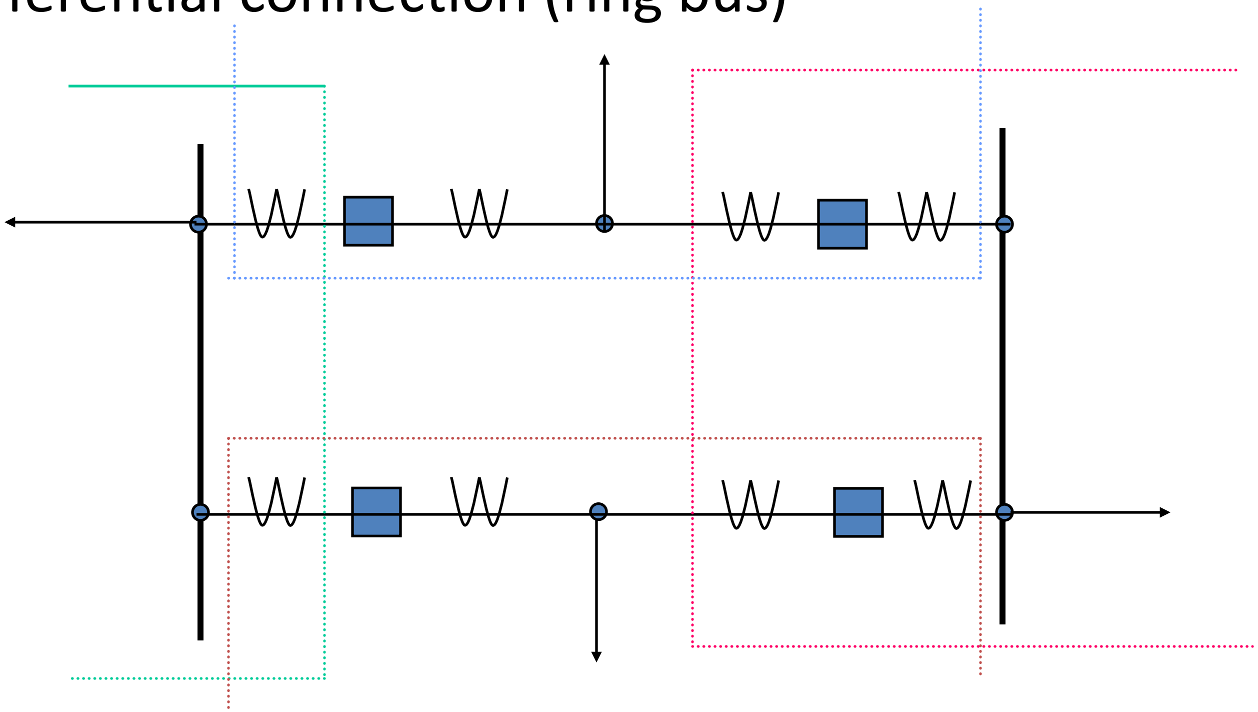
Busbar Protection

Bus differential connection (main and transfer bus)



Busbar Protection

Bus differential connection (ring bus)



NOTE: No bus differential protection is needed. The busses are covered by line or transformer protection.

Busbar Protection

Two Busbar Protection Schemes:

- ❑ Low Impedance - using time overcurrent relays
  - ✓ inexpensive but affected by CT saturation.
  - ✓ low voltage application; 34.5kV and below

- High Impedance - using overvoltage relays (*this scheme loads the CTs with a high impedance to force the differential current through the CTs instead of the relay operating coil*.)
  - ✓ expensive but provides higher protection security.
  - ✓ 115kV and above voltage application or some 34.5kV bus voltages which require high protection security.

Transmission Line Protection

Transmission Line Protection

- Distance Protection
- Over Current Protection
- Differential Protection.
- Main and Back up Protection

Distance Relay Protection

- The basic principle is that the apparent impedance seen by the relay reduces drastically in case of line fault.
- If the ratio of apparent impedance to the positive sequence impedance is less than unity, it indicates a fault.
- This protection scheme is inherently directional.
- Impedance relay and Mho relay use this principle.

Distance Relay Protection

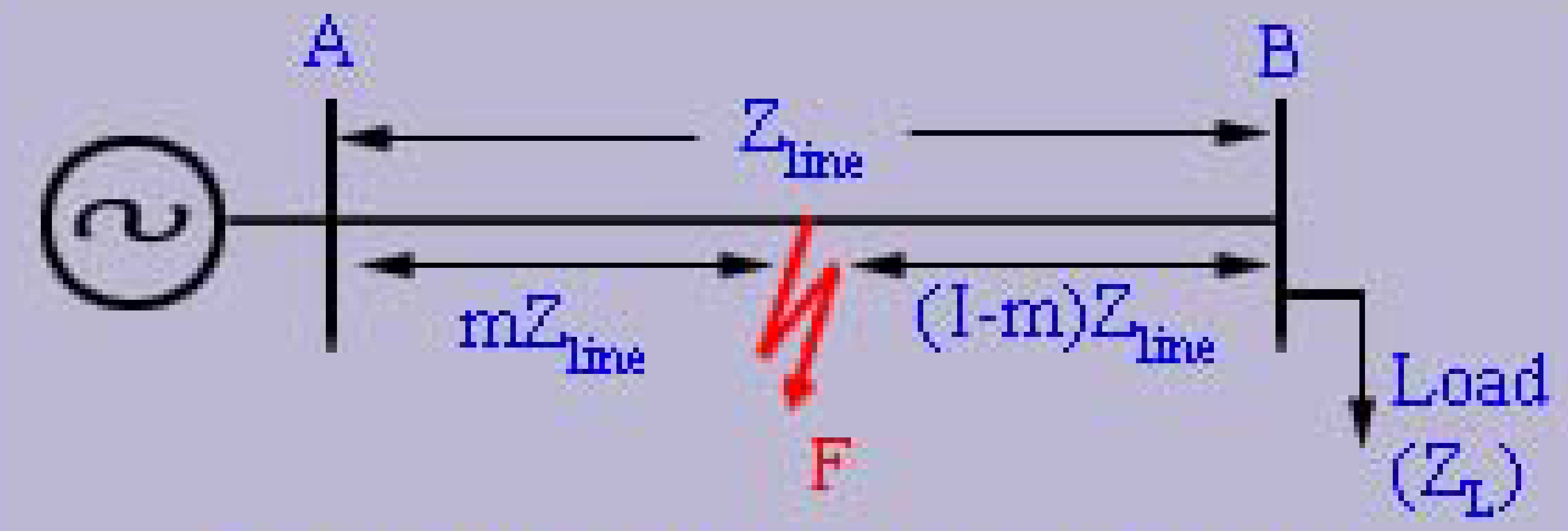


Fig 2.3 Fault in Transmission Line

Over Current Relay Protection

Principle of Over current Protection

- When the current in a system exceeds a predetermined value, it indicates the presence of a fault.
- Relaying decision is based solely on the magnitude of current.
- Over current relaying and fuse protection uses this principle
- Used in radial distribution systems.

Over Current Relay Protection

Fig 2.1 Radial Distribution System

Directional Over Relay Protection

- Directional Over current Protection Uses both magnitude of current and phase angle information for decision making.
- Used in radial distribution systems with source at both ends

Directional Over Relay Protection

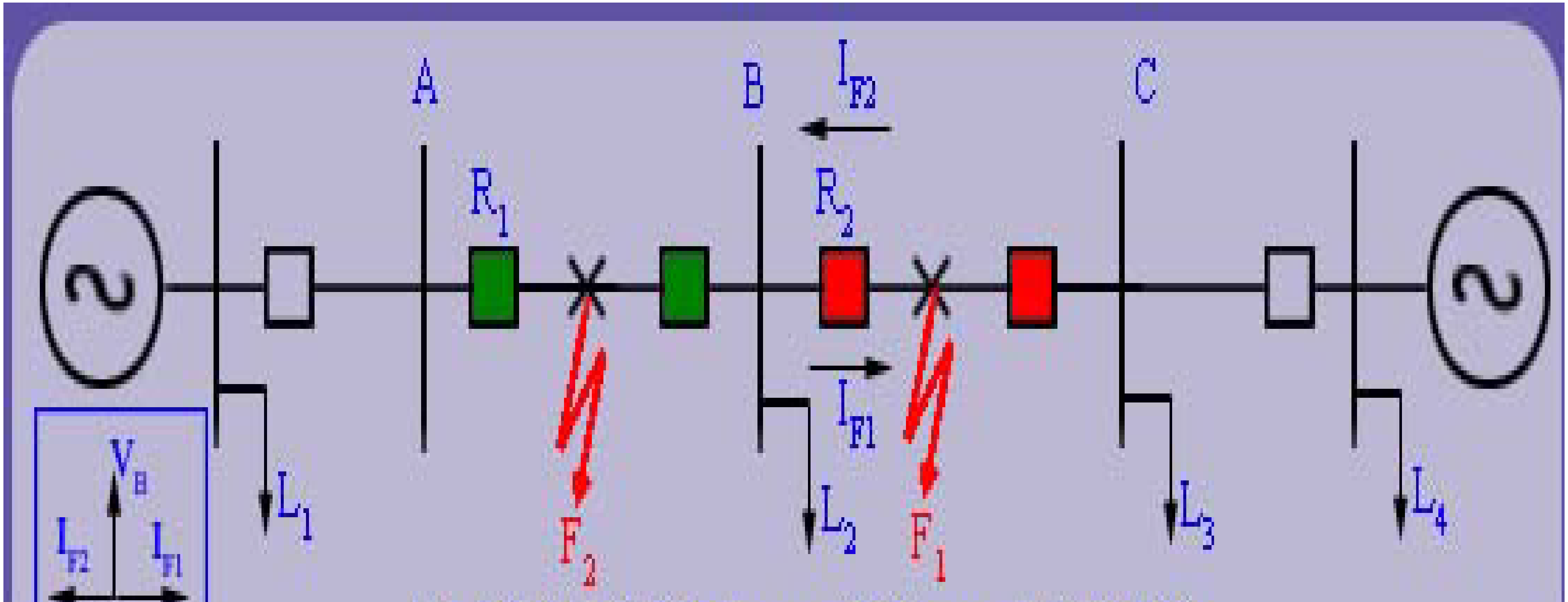


Fig 2.2 A Radial System with Source at Both Ends

Differential Relay Protection for Transmission Line

- By comparing the two currents either in magnitude or in phase or in both, fault can be determined.
- Its implementation requires a communication channel.
- It is extremely accurate.

Differential Relay Protection for Transmission Line

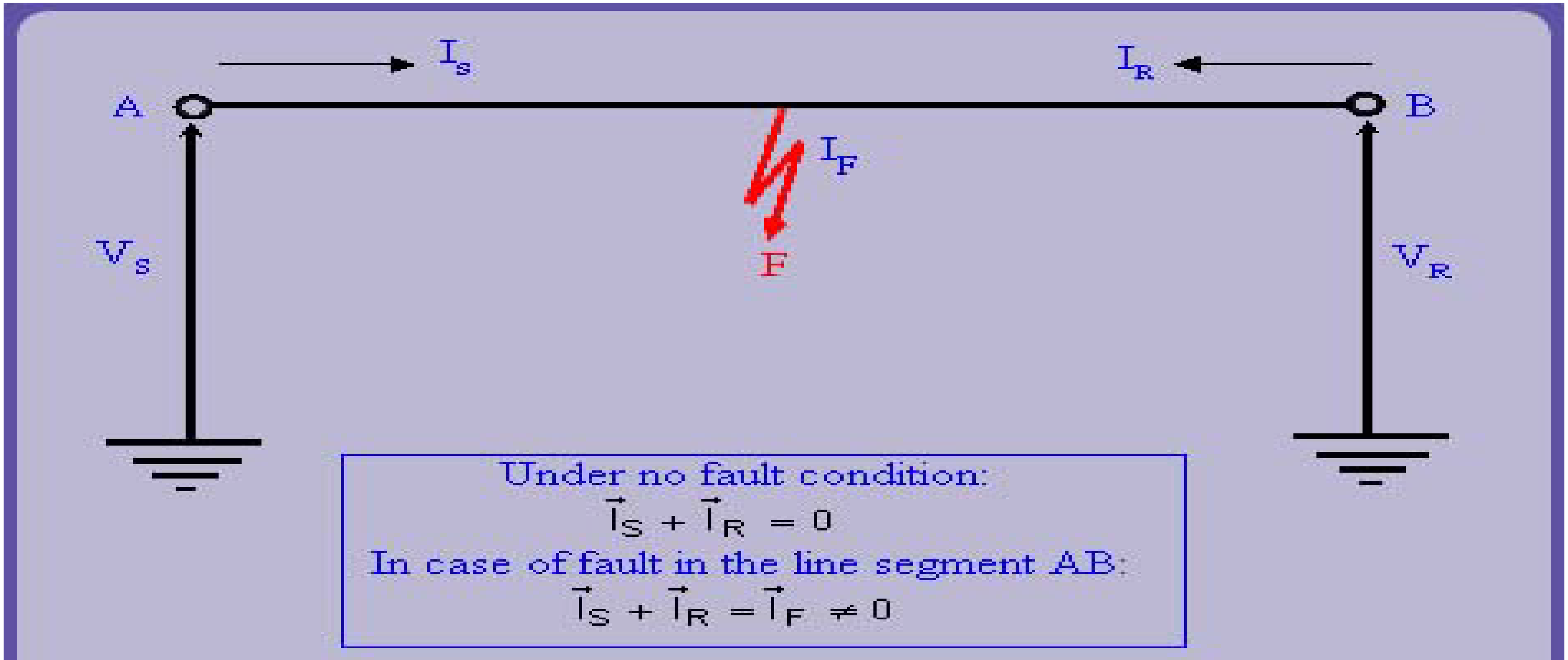


Fig 2.6 Differential Protection of Short Transmission Line

CT,PT & their applications in protective schemes

Current and Voltage Transformers in Protective Relaying System

- Protective Relays in A.C. Power Systems are connected from the secondary circuits of C.T. & P.T.
- Current Transformers : C.T. are used for measurement and Protection. Its step down the current from high value to low current value. Their ratio is constant for given range of Primary & Secondary Current.
- Potential Transformer : P.T. are used for measurement and Protection. Its step down the high voltage to low voltage value. The ratio is constant for given range of Primary and Secondary voltage.

Current Transformers

Current Transformer (CT) :

A device which transforms the current on the power system from large primary values to safe secondary values. The secondary current will be proportional (as per the ratio) to the primary current.

Potential Transformers

Potential Transformer (PT):
A device which transforms the voltage on the power system from primary values to safe secondary values, in a ratio proportional to the primary value.

University 2 Mark Questions

- Can current transformers secondary winding be open circuited? Justify your answer.
- What are the various faults that would affect an alternator ?
- State the methods of production of bus bars.
- Why the secondary of current transformer should not be open in a power system?
- What are the different types of zones of protection?
- Write the inference of resistance switching.
- Write the function of earth fault relay.
- What is meant by relay operating time?

University 16 Mark Questions

- Briefly the types of stator fault protection of alternators.
- Explain the carrier current protection of transmission line with relevant diagrams.
- Briefly discuss the protective devices used for the protection of an large transformer.
- Explain steeped time distance characteristics of 3 distance relaying units used for I,II,III zone of protection.
- Describe with a neat sketch the percentage differential protection of a modern alternator .
- Explain impedance relay characteristics on the R-X diagram .Also discuss the range setting of three impedance relays placed at a particular location.
- Describe the differential protective scheme of transformer
- Enumerate the protective scheme employed for the bus bar.
- With neat sketch, explain the different types of protective scheme for transmission line.
- Describe the types of protective schemes employed for the protection of field winding and loss excitation of alternator.
- With aid of neat schematic diagram, describe the percentage differential protection scheme of a transformer.

UNIT 4

Theory of circuit interruption

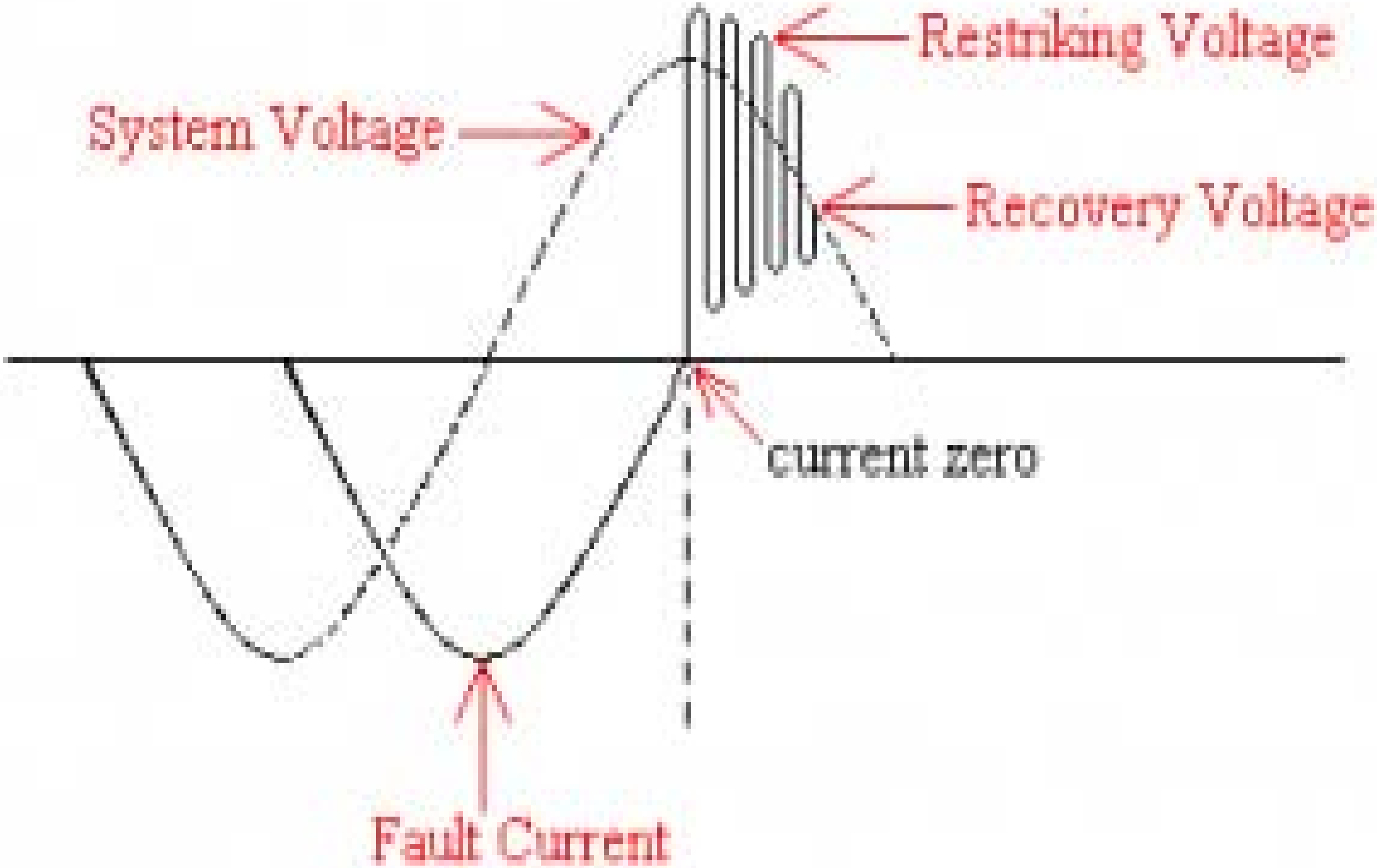
Presented by
C.GOKUL,AP/EEE
Velalar College of Engg & Tech , Erode

UNIT 4 Syllabus

UNIT IV THEORY OF CIRCUIT INTERRUPTION 9

Physics of arc phenomena and arc interruption.

DC and AC circuit breaking - restriking voltage and recovery voltage - rate of rise of recovery voltage - resistance switching - current chopping - interruption of capacitive current.


Restriking Voltage
System Voltage
Recovery Voltage
current zero
Fault Current

The ARC

The electric arc constitute a basic ,indispensable and active element in the process of current interruption.

1.Basic theory of electric discharge

The conduction of electricity is through the gases or vapors which contain positive and negative charge carriers and all types of discharge involve the very fundamental process of production ,movement & absorption of these carriers which is the mode of carrying the current between the electrodes. The gas discharge phenomena can broadly classified as:

a. The non-self sustained discharge
b. The self sustaining discharges

Initiation of an Arc

- By high voltage gradient at the cathode resulting into field emission.

- By increase of temperature resulting into thermo ionic emission

Maintenance of Arc

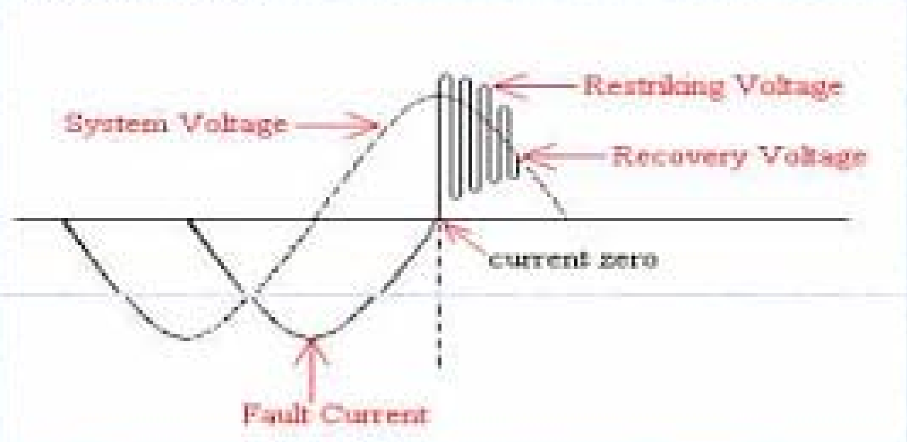
- High temperature of the medium around the contacts caused by high current densities, with high temp the kinetic energy gained by moving electrons increased.
- The field strength or volt. gradient which increases the kinetic energy of the moving electrons and increases the chances of detaching electrons from neutral molecule.
- An increase in mean free path-the distance through which the electron moves freely.

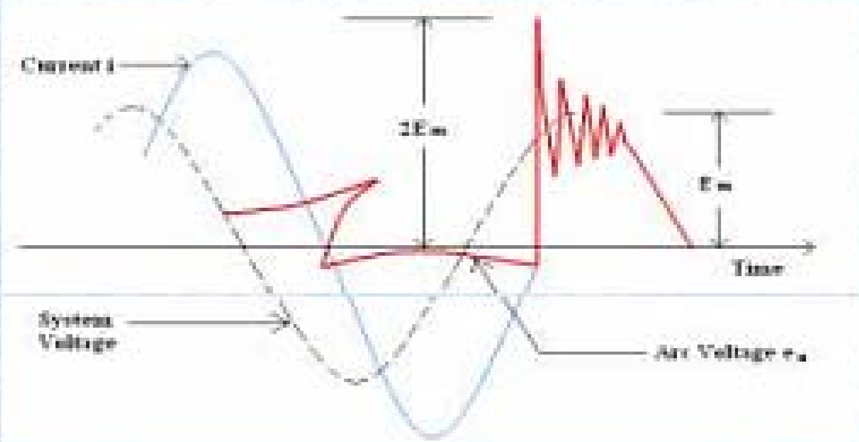
ARC VOLTAGE

The voltage that appears across the contacts of circuit breaker during the arcing period is known as arc voltage. It tends to maintain the current flow in the form of arc.

RESTRIKING VOLTAGE

It's the transient voltage that appear across the contacts at or near current zero during arcing Period.





RECOVERY VOLTAGE

It's the normal frequency voltage (rms) that appear across the contacts of circuit breaker after final arc extinction. It is approximately equal to the system voltage. When contacts are opened current drops to zero at every half cycle. At current zero dielectric strength of the medium can be increased and thus prevent the break down by restriking voltage. Consequently the final arc extinction takes place and circuit current is interrupted. After this current interruption the voltage appearing across the contacts is known as recovery voltage

CURRENT CHOPPING

- It is the phenomenon of circuit interruption before the natural current zero is reached.

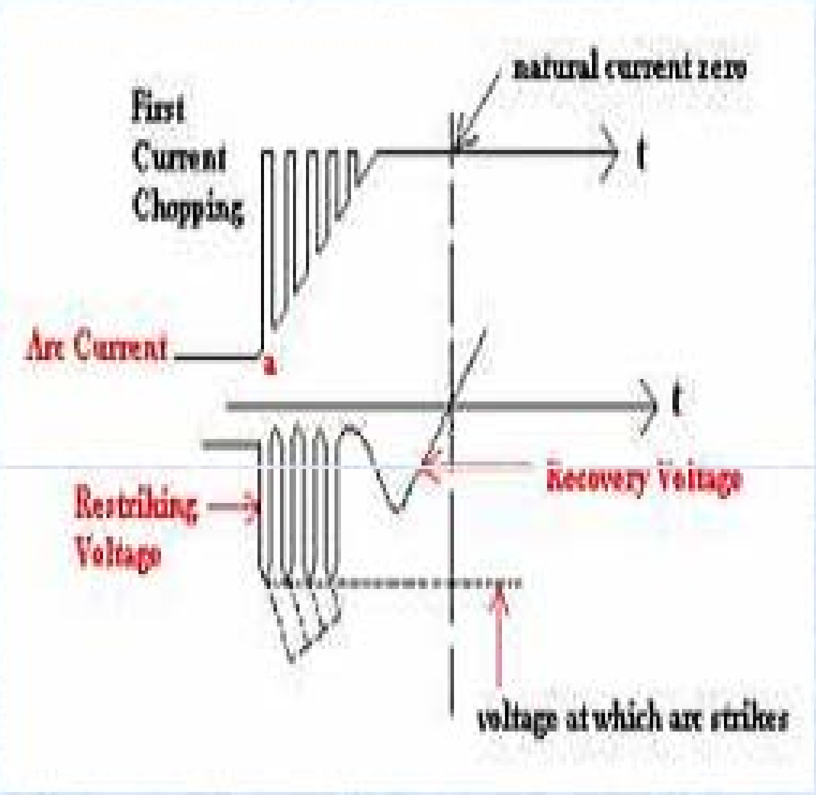
- It mainly occurs in air blast circuit breakers because they retain the same extinguishing power irrespective of the magnitude of current to be interrupted.

-

The powerful deionising effect of air blast causes the current to fall abruptly to zero well before the natural current zero is reached.

- This phenomenon is known as current chopping and results in high voltage transient across the contacts of the circuit breaker.

- The arc current *i* is chopped down to zero value as shown by point

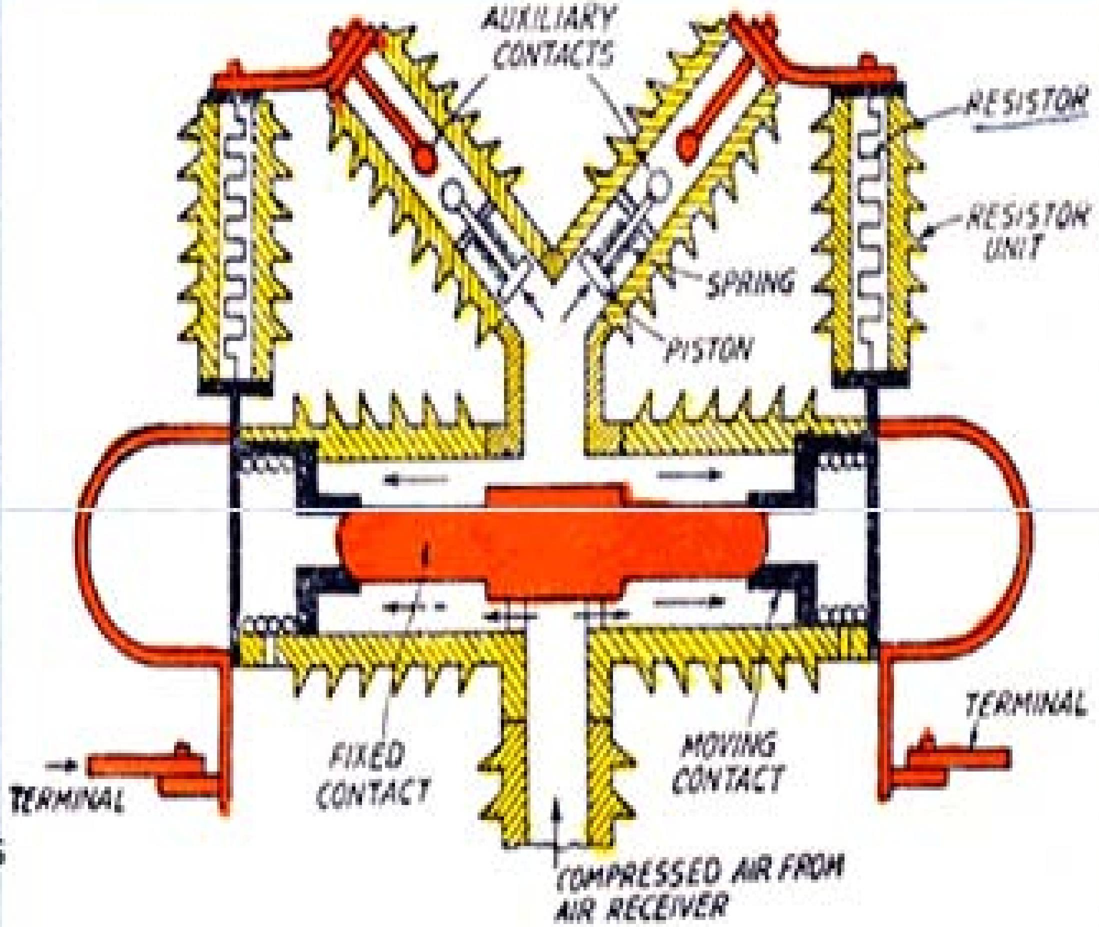


Resistance Switching

- The post zero resistance of contact space is high in air blast circuit breakers.

- This is because the contact clearance space is filled with high pressure air after final current zero and high pressure air has high dielectric strength.

- The high restriking voltage appears across the contacts does not damp out through the gap because of the high post zero resistance.



Configuration of switching resistors.

Methods of Arc Extinction

- High resistance method
  - a. cooling of arc
  - b. increasing the arc length
  - c. reducing the cross section of arc
  - d. splitting of arc
- Low resistance or current zero interruption
  - a. Lengthening of the gap
  - b.increasing the pressure in the vicinity of the arc
  - c. Cooling
  - d. Blast Effect

Phenomenon of arc extinction

- Energy Balance or Cassie Theory

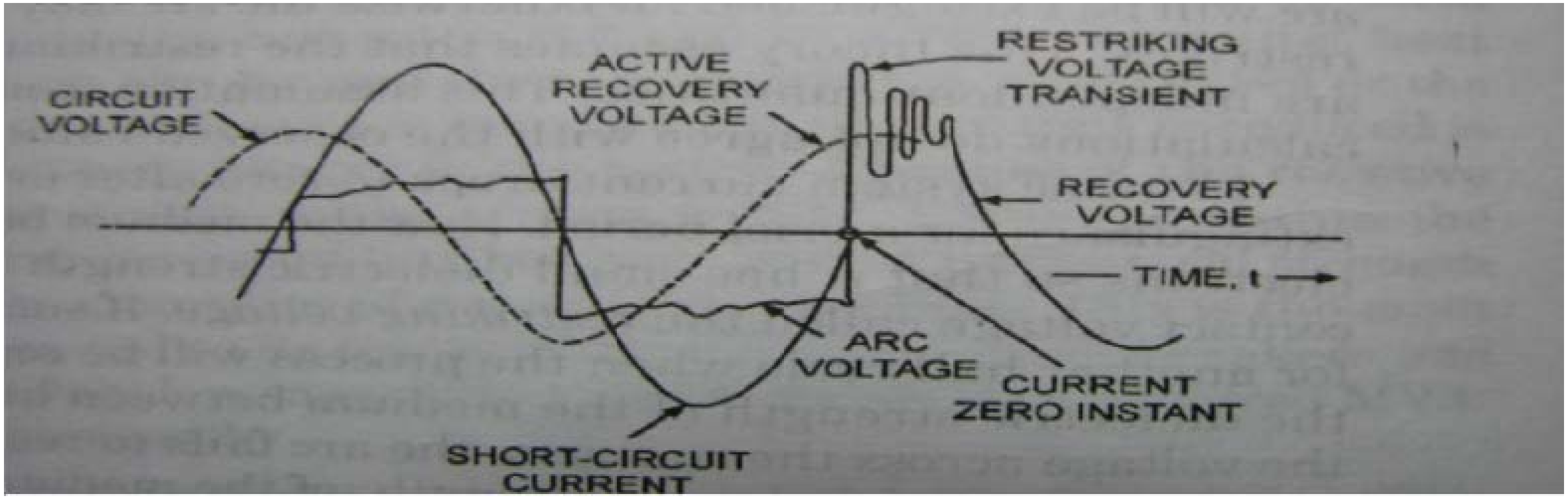
  This theory states that if the rate of heat dissipation between the contacts is greater then the rate at which heat is generated ,the arc will be extinguished ,otherwise it will restrike.

- Recovery rate or Slepian's Theory

  This theory states that if the rate at which the ions and electrons combine to form or replaced by neutral molecules.

Restriking Voltage & Recovery Voltage

- The transient voltage which appears across the breaker contacts at the instant of arc being extinguished is known as restriking voltage.
- The power frequency rms voltage ,which appears across the breaker contacts after the arc is finally extinguished and transient oscillation die out is called recovery voltage.



Arc Extinction

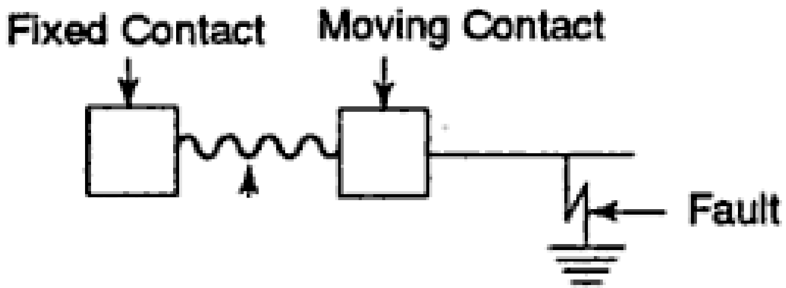


FIGURE 9.1 Separation of the contacts of circuit breaker

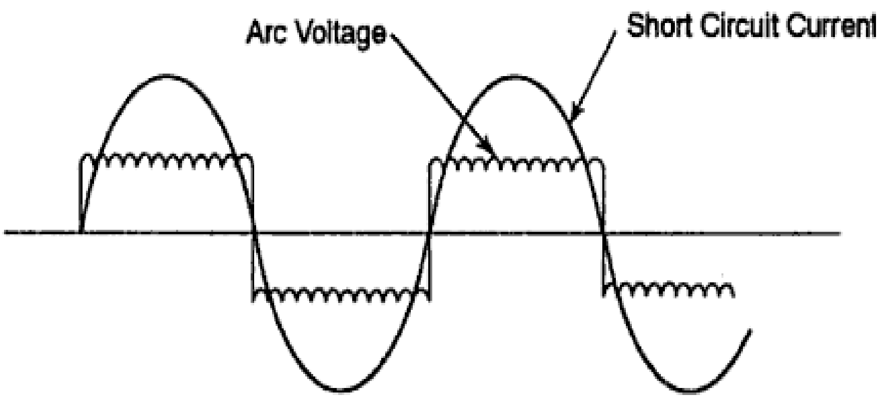


FIGURE 9.2 Short circuit current and arc voltage

Arc Voltage:

The Voltage drop across the arc is called Arc Voltage.

Arc Quenching: (C.B)

- The Arc Produced not only delays the current interruption process but it also generates enormous heat which may cause damage to the system or to the circuit breaker itself.
- Therefore main problem in a C.B is to extinguish the arc within the shortest possible time so the heat generated by it may not reach a dangerous value.

ARC PHENOMENON

During arcing period, the current flowing between the contacts depends upon the resistance. The greater resistance smaller the current that flows between the contacts.

The arc resistance depends upon

i) Degree of ionisation (Arc resistance increases with the decrease in number of ionised particles b/w the contact)

ii) Length of Arc (Arc resistance increases with the length of arc)

iii) Cross section of Arc (Arc resistance increases with the decrease in X- section of the arc)

The factors that are responsible for maintenance of arc between the contacts are:

i) Potential Difference between the contacts.

ii) ionised particles between the contacts.

Methods of Arc Interruption

- There are two methods of Arc Interruption or Extinction are

    i) High resistance interruption

    ii) Current zero interruption

High resistance interruption

The arc resistance can be increased by cooling, lengthening, reducing x- section and splitting the arc.

It is employed for low power AC and DC circuit breakers.

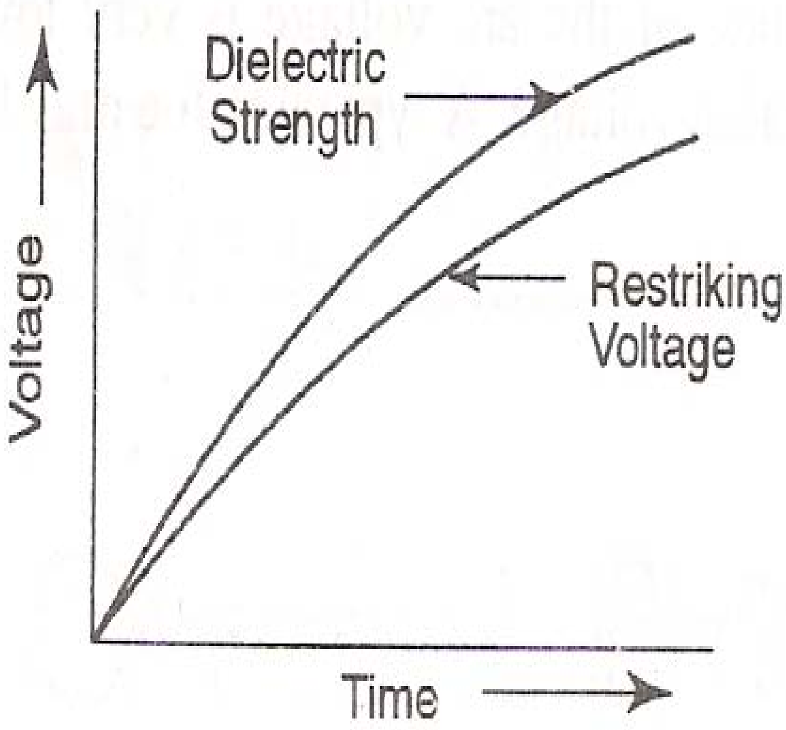
Current zero interruption

There are two theories to explain the zero current interruption of the arc.

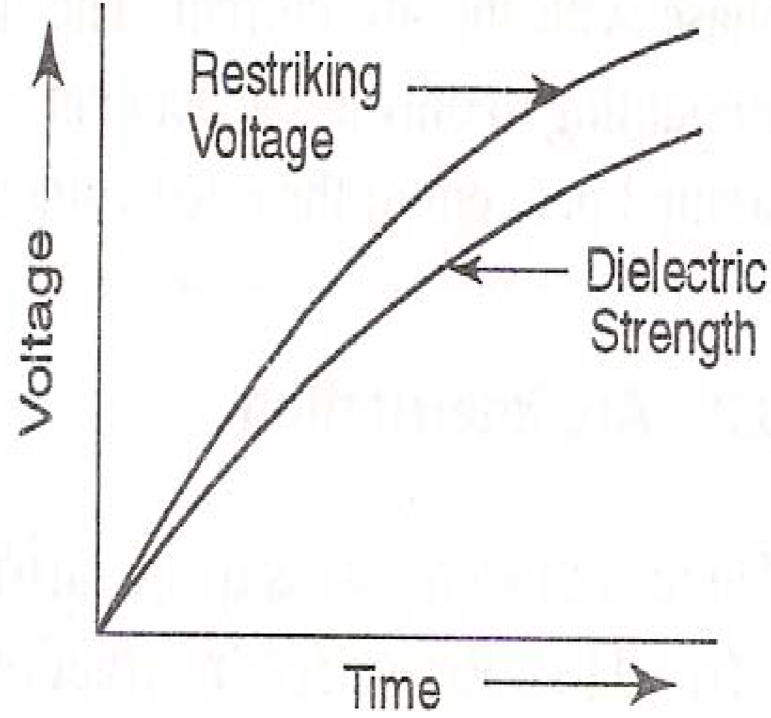
i) Recovery rate theory(Slepain’s Theory)

ii) Energy balance theory(Cassie’s Theory)

Recovery rate theory

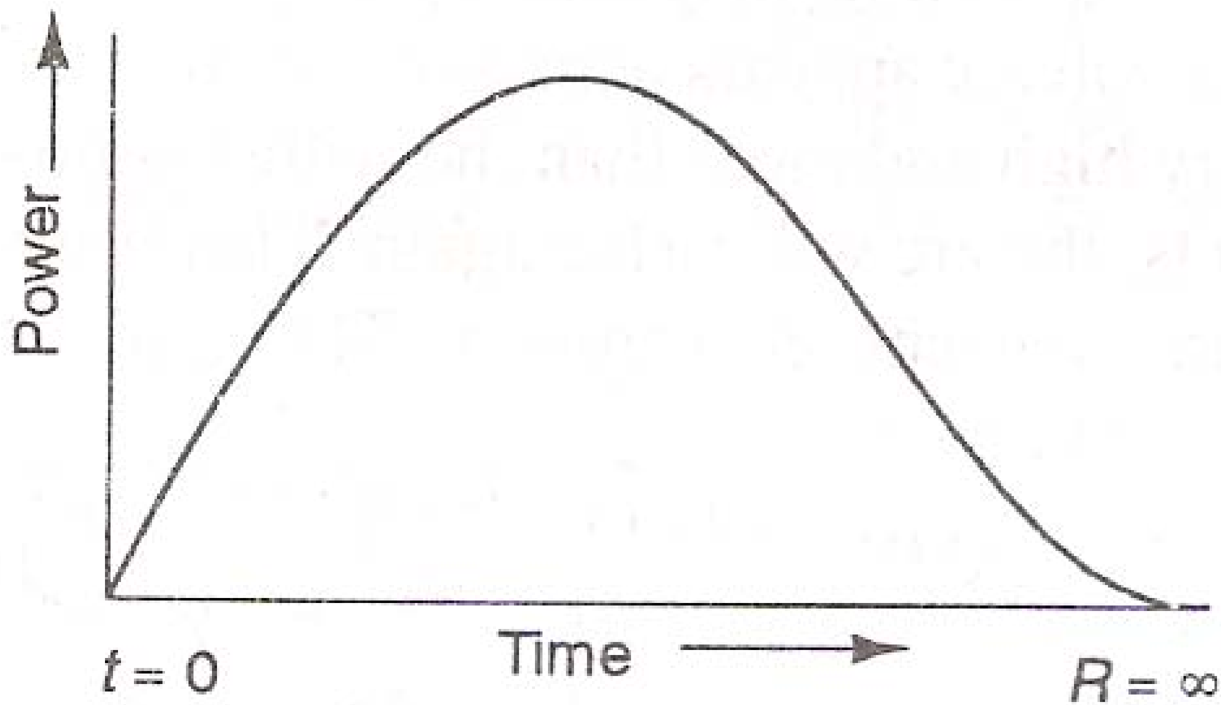


(a) Arc extinguishes



(b) Arc does not extinguishes

Energy balance theory



Arc Extinction in oil Circuit Breaker

In case of oil circuit breaker the opening of contact which heats the oil surrounds the contact due to arc which causes hydrogen gas bubble to evolve and its removes the heat from the surface. If the rate of heat removal is faster than its generation then the arc is extinguished.

Arc interruption (or) Extinction methods

(1) High resistance

(2) Low resistance or zero point-interruption.

(3) Artificial current zero interruption.

The arc resistance depends upon the following factors :

(i) *Degree of ionisation*— the arc resistance increases with the decrease in the number of ionised particles between the contacts.

(ii) *Length of the arc*— the arc resistance increases with the length of the arc *i.e.*, separation of contacts.

The high resistance interruption is obtained by increasing the resistance of the arc.

$$r_{arc} = \frac{V_{arc}}{i_{arc}}$$

Assuming i_{arc} to be constant the resistance of the arc can be increased by increasing voltage of the V_{arc}.

$$V_{arc} = A + Bd + \frac{C + Dd}{i_{arc}}$$

hence the arc resistance can be increased by increasing length of the arc.

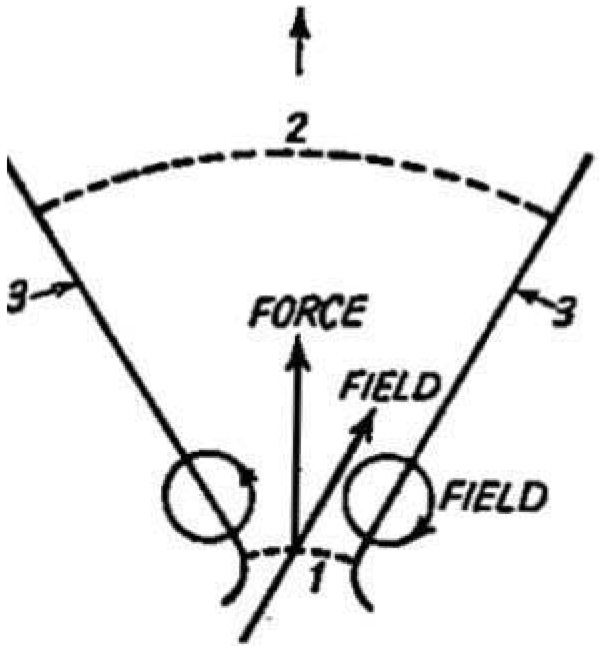
In high resistance interruption method the length of the arc is increased so as to increase the voltage across the arc.

The voltage of the arc is increased till it more than the system voltage across the contacts. At this point the arc gets extinguished.

The method is used in low and medium voltage a.c. and d.c. circuit breakers

The arc resistance is increased by the following methods :

a) Lengthening the arc : by arc runners

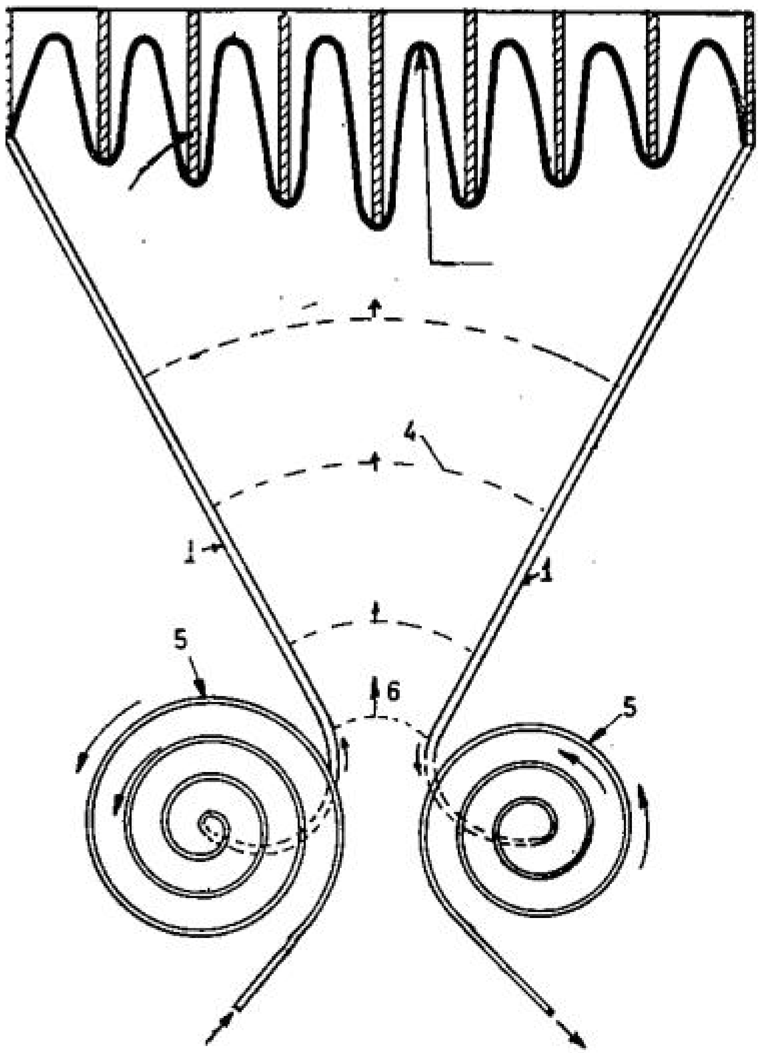


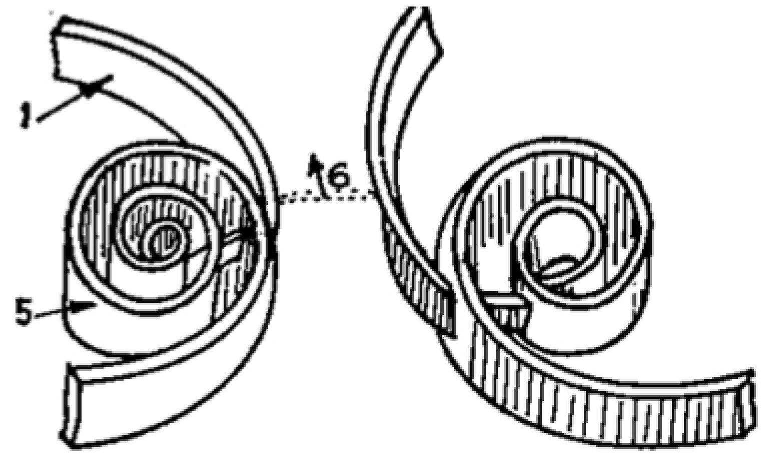
1. Initial position of arc
2. Final position of arc.
3. Arc runners (in vertical plane)
4. Field (in horizontal plane)
5. Force due to electrodynamic forces (in vertical plane)

Function of the arc runners.

b) Splitting the Arc:

In this method the arc is elongated and splitted by arc splitters. These are made with plates of resin bonded fiber gas. These are placed perpendicular to arc and arc is pulled into them by electromagnetic forces.





1. Arc runners (metallic)
2. Arc splitters
3. Elongated arc
4. Arc in process of travelling
5. Blow-out coils (metallic)
6. Origin of Arc

c) Cooling of Arc :

It causes recombination of ionized particles. Cooling remove the heat from the Arc. Efficient cooling may be obtained by gas blast directed along Arc .

2) Low resistance (or) current zero interruption:

This method is used for Arc Extinction in A.C circuit breakers. In this method the resistance kept low until current is zero.

In a.c. circuit-breakers the arc is interrupted at a current zero. At current zero, the space between contacts is deionized quickly by introducing fresh unionized medium such as oil or fresh air, or SF_6 gas, between the contacts.

The dielectric strength of the contact space increases to such an extent that the arc does not continue after current zero. A high voltage may appear across the contacts. The voltage may re-established the arc if the dielectric strength of gap is less than the restriking voltage. In that case the arc continues for another half cycle and may get extinguished at next current zero.

The rapid increase of dielectric strength of the medium near current zero can be achieved by

1)Lengthening of Arc
2)Cooling
3)Blast effect

AC CIRCUIT BREAKING

Refer Book

DC CIRCUIT BREAKING

How is dc breaking done?

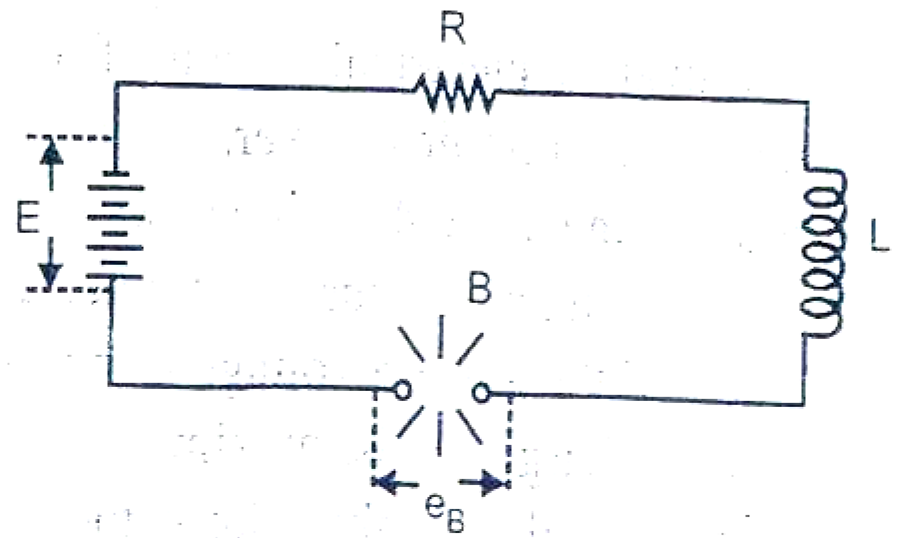
The contacts of the DC breaker separate and the arc is transferred from contacts to the runners where it rises upwards and extinguishes on its own.

Drawbacks of HVDC circuit breaking

- The amount of energy to be dissipated during the short interval of breaking is very high as compared to the conventional a.c circuit breakers

- The natural zero current does not occur as in the case of a.c cb, resistance switching and the efficient cooling by forcing the liquid or air blast are used to dissipate the high amount of energy.

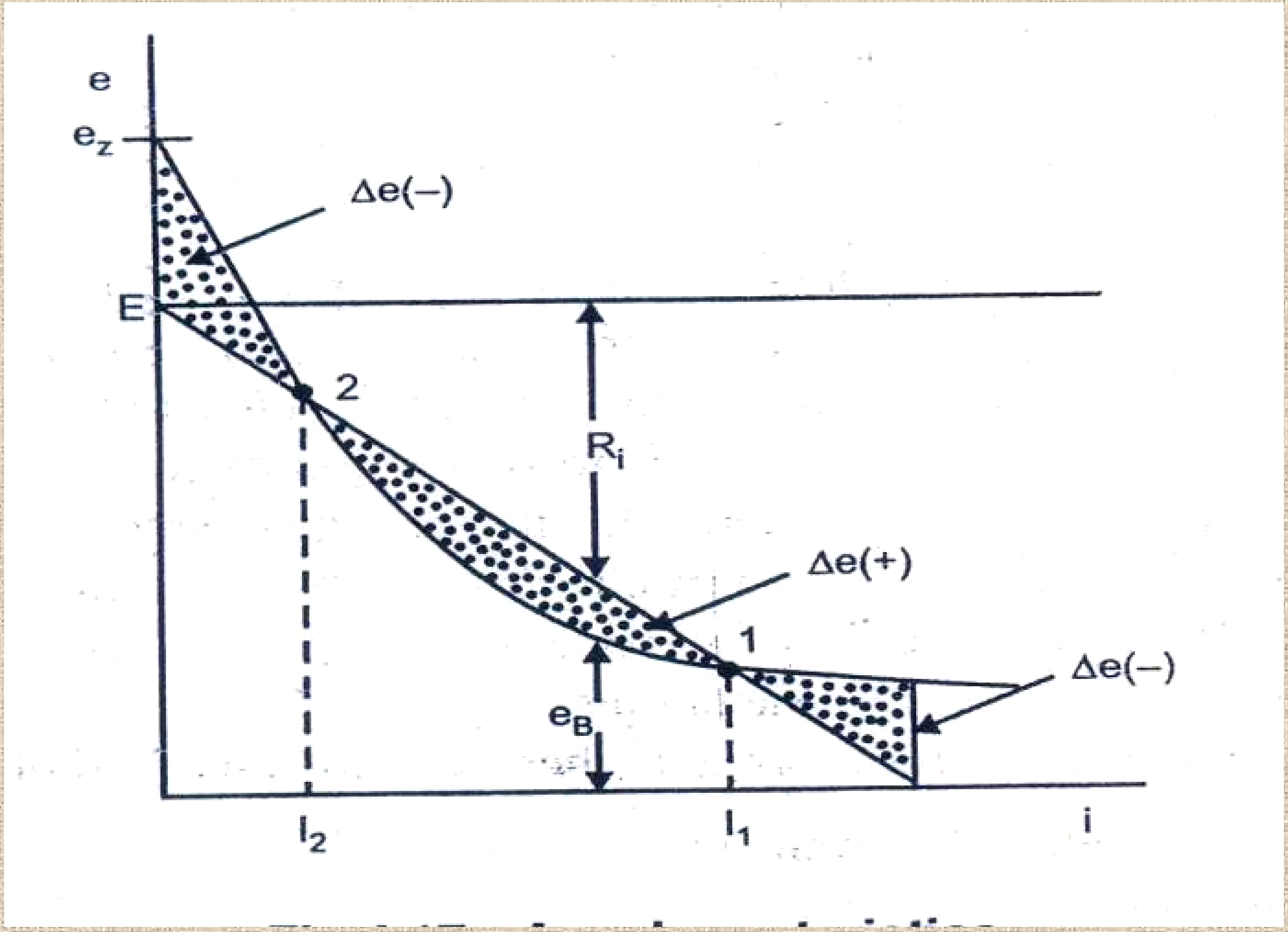
SIMPLE D.C CIRCUIT



16 An inductive d.c circuit showing the burn

- B → circuit breaker.
- Assuming CB "B" breaks the current I (=E/R)

ARC CHARACTERISTICS



- The diff equn of the ckt is,

L(di/dt)+Ri+eb=E

$\Longrightarrow$ L(di/dt)=(E – Ri)-eb(i)=Δe

- *Δe negative:*

Current will decrease

- *Δe positive:*

Increase the current

Basic requirement

- Progressive lengthening of arc is a basic requirement of dc circuit breakers.

In designing an HVDC circuit breaker there are there main problems to be solved

- How to produce a current zero?
- How to prevent restriking?
- How to dissipate the stored energy?

Producing current zero

- This approach involves changing the form of arc current by commutation principle
- Quenching gear of well proven HVAC ckt breaker
- Principle of oscillatory circuit

Prevention of restrikes

- To produce a good ionizing arc the space between two walls of arc chute can be narrowed to restrict the arc
- At the same time it can be broken into number of arcs by inserting a grating of vertical metal plane

Dissipation of stored energy

- A protective spark gap can be used across the CB to reduce the size of the commuting capacitor.
- It will keep the abnormal voltage produced at the switching time below the undesired level
- By means of high frequency currents the spark gap acts as an energy dissipating device

Interruption of capacitive current

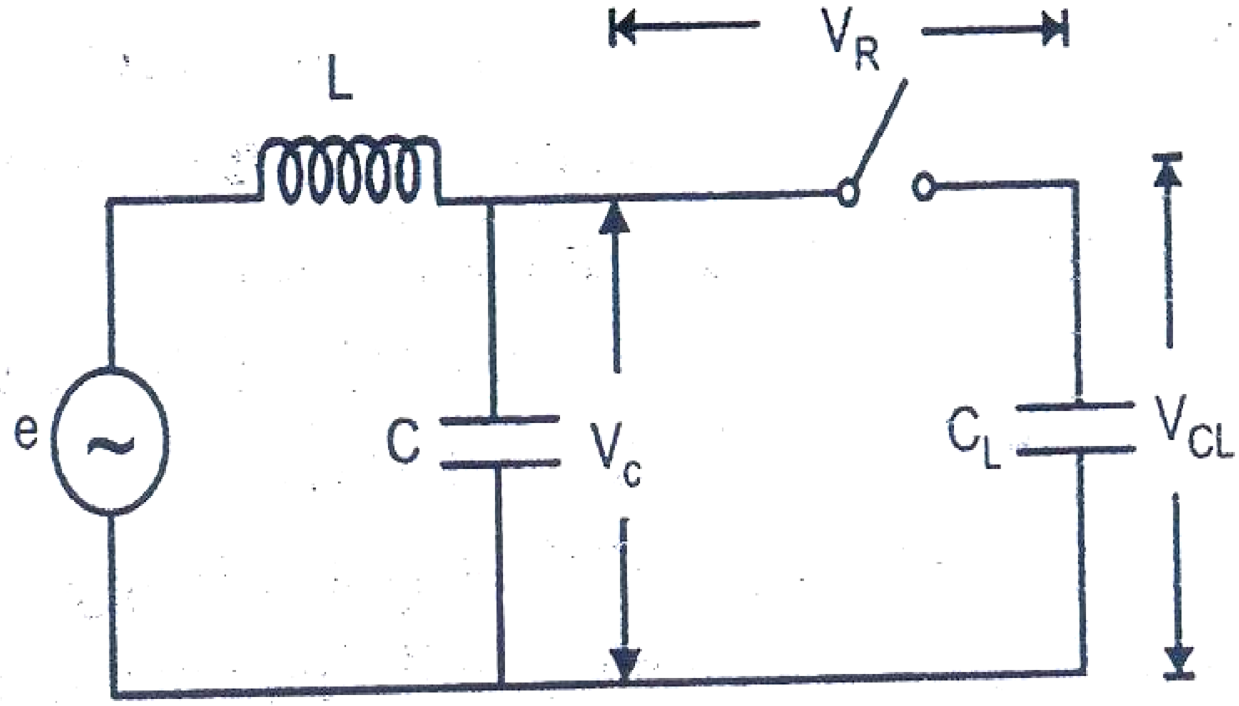
Interruption of capacitive current

Effect:

- The interruption of capacitive current produces high voltage transients across the gap of the circuit breaker.

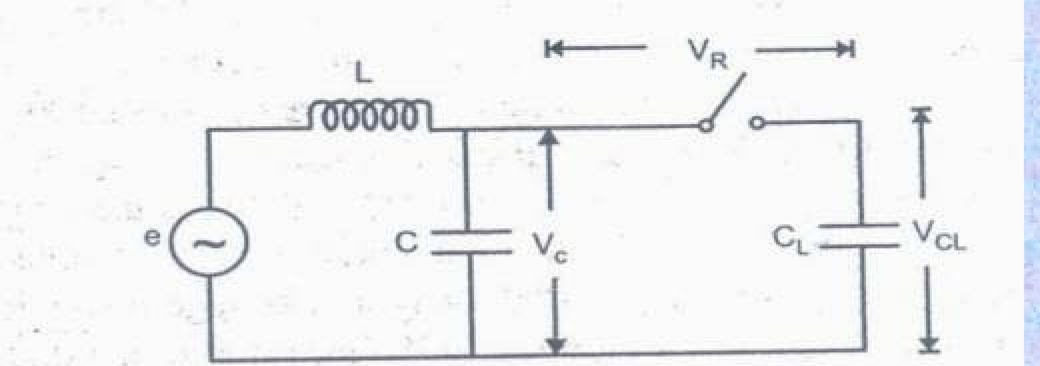
When?

- This occurs when an unloaded long transmission line or a capacitor bank is switched off.



(a) Electrical circuit of a simple power system

•Considering a electrical circuit of a simple power system

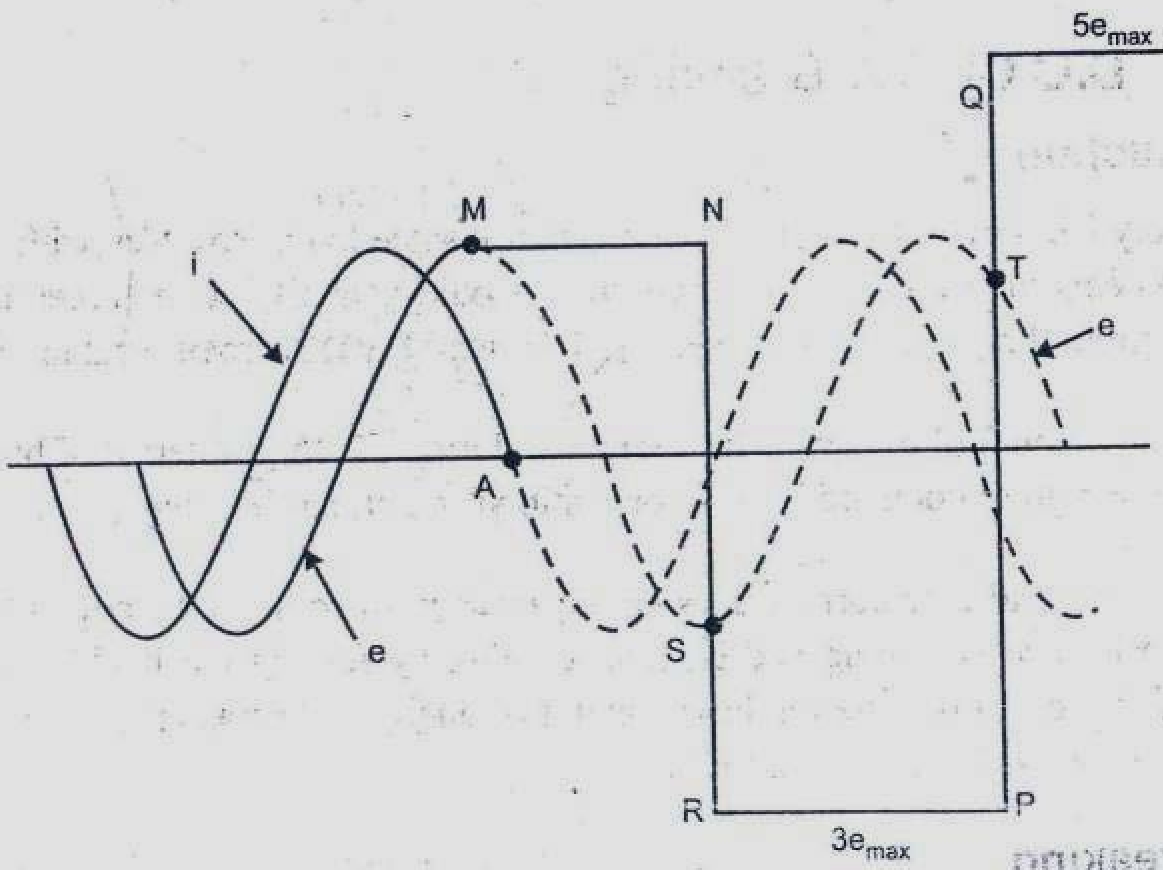


(a) Electrical circuit of a simple power system

•C → stray capacitance of the circuit breaker

•C_L → line capacitance

Transient voltage across the gap of the circuit breaker when the capacitive current is interrupted



(b) Transient voltage across the gap of the circuit breaker

At the instant M

- The capacitive current is 0.
- System voltage is maximum
- ***If interruption occurs***
- Capacitor C_L remains charged at the maximum value of system voltage.

After the instant M

- Voltage across the breaker gap is
  the difference of V_c and V_{cL}.

At the instant N

- The voltage across the gap is twice the maximum
- Value of Vc.

If the breaker restrikes

- The voltage across the gap become partially zero.
- Voltage falls from $2Vc_{max}$ to zero.
- A severe high frequency oscillation occurs (about the point S)
- Interrupted again.(if restriking current=0)
- The capacitor C_L at the voltage $-3e_{max}$.

At the instant P

- The system voltage reaches its positive maximum.(point T)
- Voltage across the gap becomes $4e_{max}$.
- The capacitive current reaches zero again and there may be an interruption.
- The transient voltage oscillates between $-3e_{max}$ and $+5e_{max}$. (point P—Q)

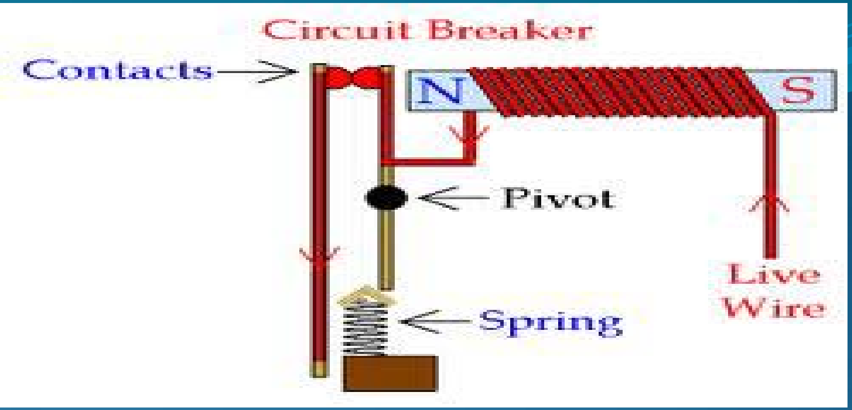
✓ Thus voltage across the gap goes on increasing

University 2 Mark Questions

- Give the two methods of arc interruption.
- What is RRRV?
- Mention any two advantages of vacuum circuit breakers.
- List the different types of circuit breakers.
- What is meant by auto reclosing?
- Write the function of isolating switch.
- List out the various methods of arc interruption.
- How do you classify the circuit breakers?

University 16 Mark Questions

- Derive the expression for restriking voltage.
- Explain about current zero interruption theories.
- Explain i)interruption of capacitive current ii)current chopping
- With necessary diagrams describe the recovery rate theory and energy balance theory of arc interruption in C.B.
- Explain the terms: restriking voltage, recovery voltage, recovery voltage and RRRV. Derive expressions for restriking voltage and RRRV in terms of system voltage, inductance and capacitance.
- Derive the expression for restriking and rate of rise of recovery voltages.
- Explain the operation of zero crossing in the circuit breaker.
- Write the brief notes on i)current chopping ii)interruption of capacitive current.
- Discuss the recovery rate theory and energy balance theory of arc interruption in a circuit breaker.
- Explain the phenomenon of current chopping in a circuit breaker. What measures are taken to reduce it?
- Discuss the problem associated with the interruptions of low inductive current and the fault occurs nearer to the substation.



CIRCUIT BREAKERS

UNIT 5

CIRCUIT BREAKERS

Presented by

C.GOKUL,AP/EEE

Velalar College of Engg & Tech , Erode

UNIT 5 Syllabus

- Types of circuit breakers

1. Air Blast circuit breaker
2. Vacuum circuit breaker
3. Oil circuit breaker
4. SF_6 circuit breaker

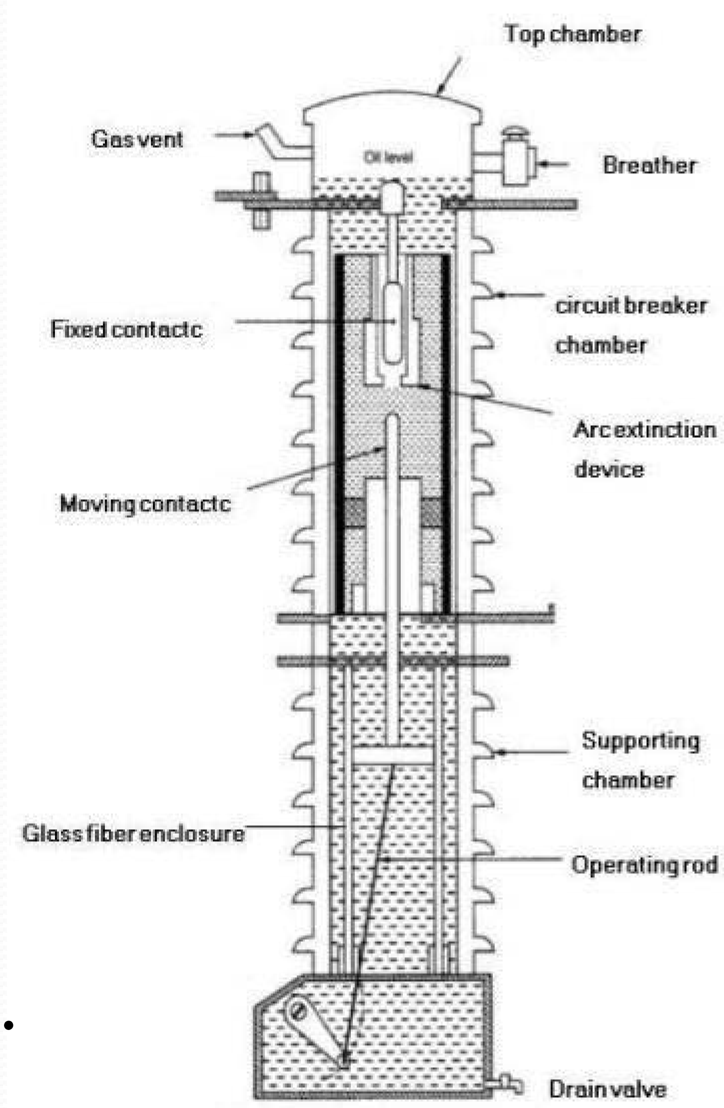
- Comparison of Airblast,Vacuum,Oil,SF6
- Testing of circuit breakers.

Types Of Circuit Breakers

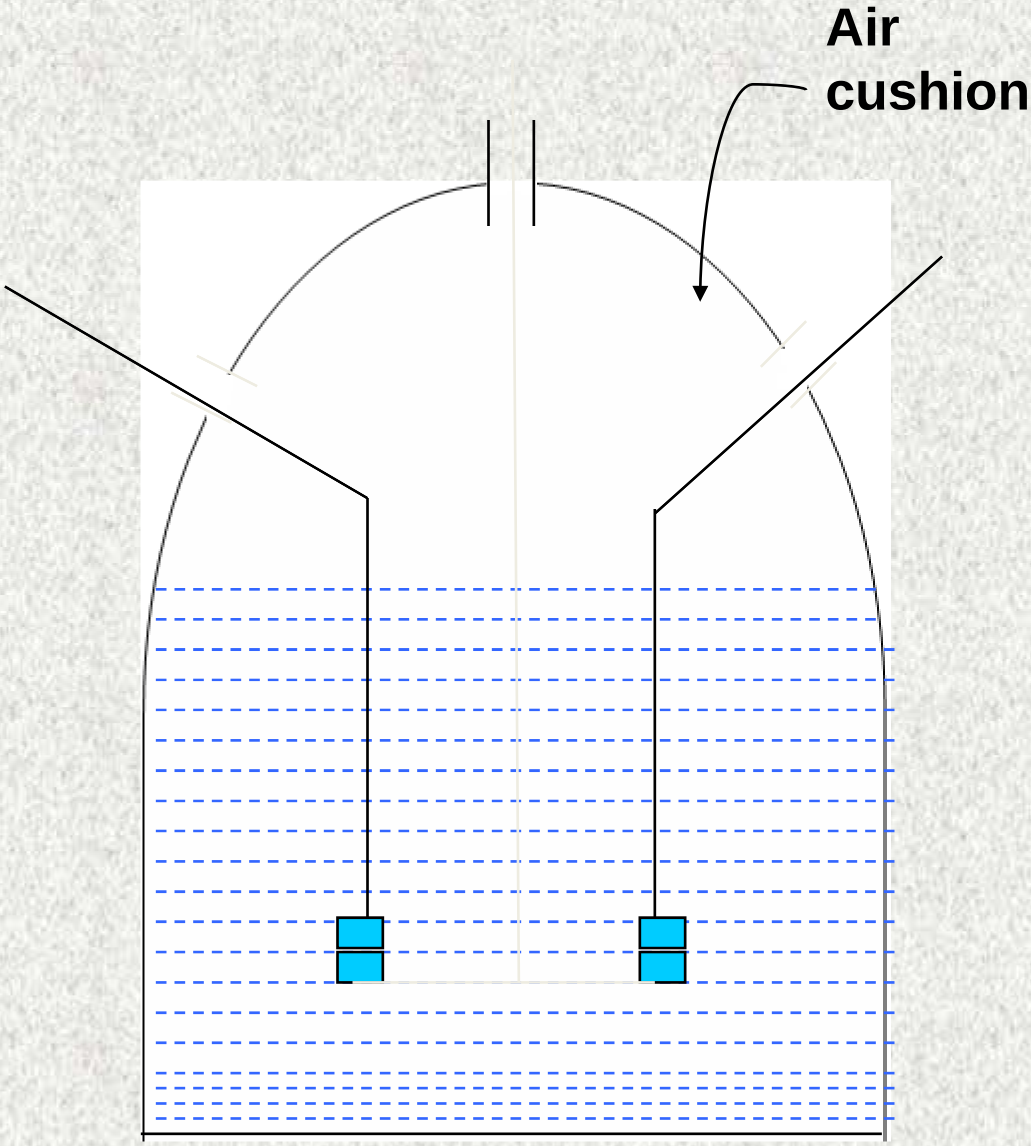
- Oil Circuit Breakers
- Vacuum Circuit Breakers
- Air Blast Circuit Breakers
- SF_6 Circuit Breakers

1. OIL CIRCUIT BREAKER

- It is designed for 11kv-765kv.
- These are of two types
  - BOCB (Bulk oil Circuit Breaker)
  - MOCB (Minimum oil Circuit Breaker)
- The contacts are immersed in oil bath.
- Oil provides cooling by hydrogen created by arc.
- It acts as a good dielectric medium and quenches the arc.



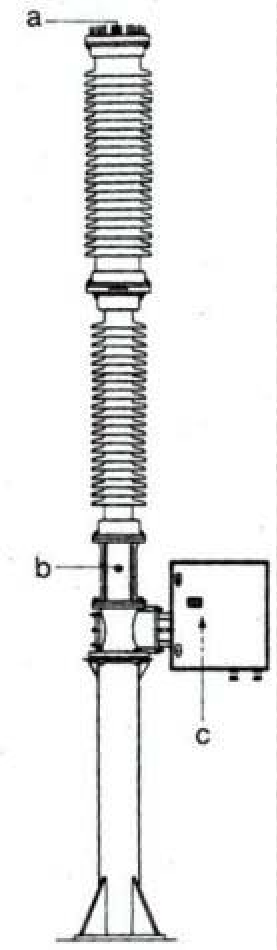
Bulk Oil Circuit breaker



Low Oil Circuit Breaker

Consists of two parts.

- Supporting Chamber.
- Circuit-Breaking chamber(consist of fixed and moving contact)



Advantages:

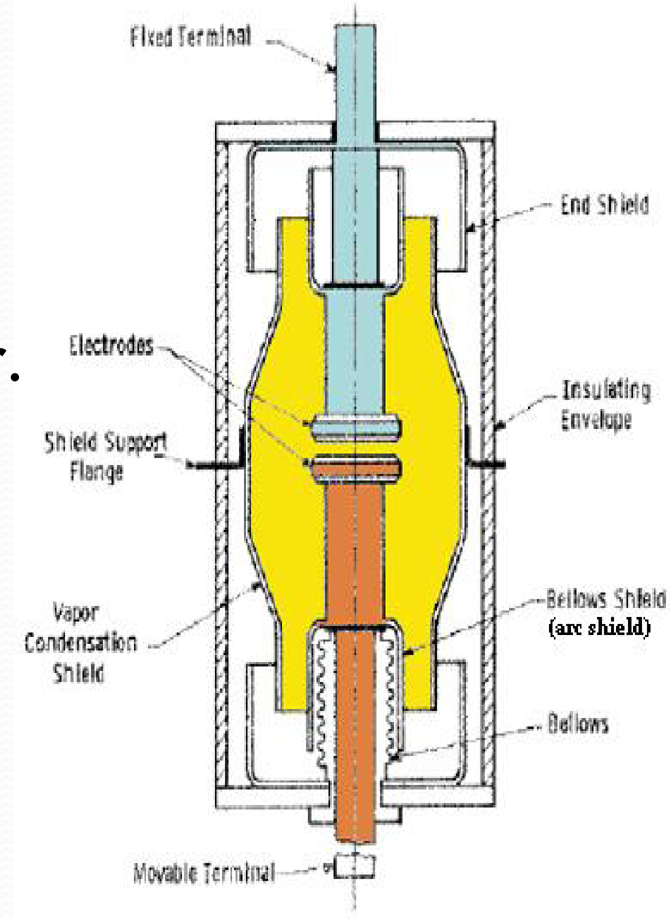
- Oil has good dielectric strength.
- Low cost.
- Oil is easily available.
- It has wide range of breaking capability.

Disadvantages:

- Slower operation , takes about 20 cycles for arc quenching.
- It is highly inflammable , so high risk of fire.
- High maintenance cost.

2. VACCUM CIRCUIT BREAKER

- It is designed for medium voltage range (3.3-33kv).
- This consists of vacuum of pressure ($1*10^{-6}$) inside arc extinction chamber.
- The arc burns in metal vapour when the contacts are disconnected.
- At high voltage , it's rate of dielectric strength recovery is very high.
- Due to vacuum arc extinction is very fast.
- The contacts loose metals gradually due to formation of metal vapours.



Representation of vacuum interrupter chamber in vacuum circuit breaker

Advantages:

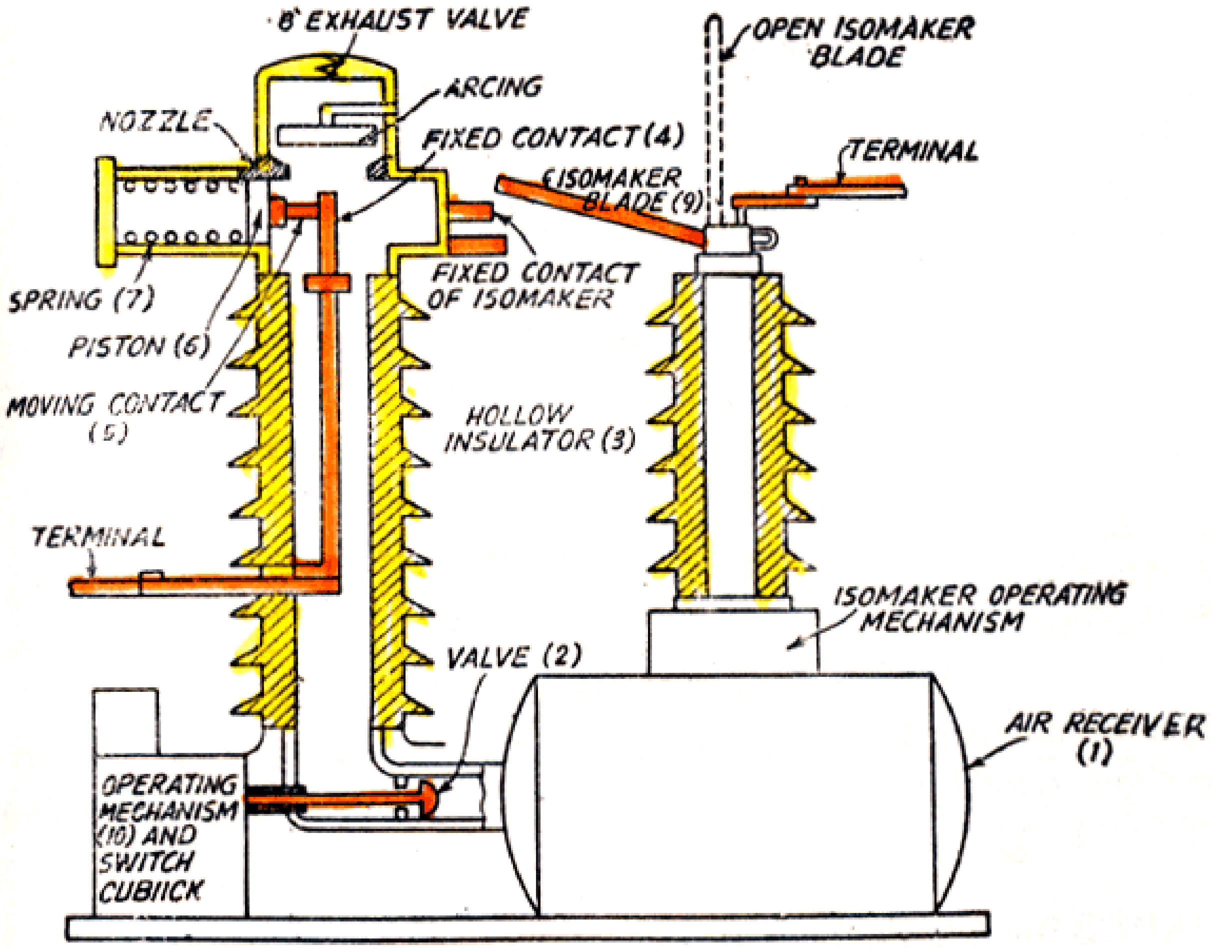
- Free from arc and fire hazards.
- Low cost for maintenance & simpler mechanism.
- Low arcing time & high contact life.
- Silent and less vibrational operation.
- Due to vacuum contacts remain free from corrosion.
- No byproducts formed.

Disadvantages:

- High initial cost due to creation of vacuum.
- Surface of contacts are depleted due to metal vapours.
- High cost & size required for high voltage breakers.

3. AIR BLAST CIRCUIT BREAKERS

- This operates using high velocity blast of air which quenches the arc.
- It consists of blast valve , blast tube & contacts.
- Blast valve contains air at high pressure.
- Blast tube carries the air at high pressure & opens the moving contact attached to spring.
- There is no carbonization of surface as in VCB.
- Air should be kept clean & dry to operate it properly.

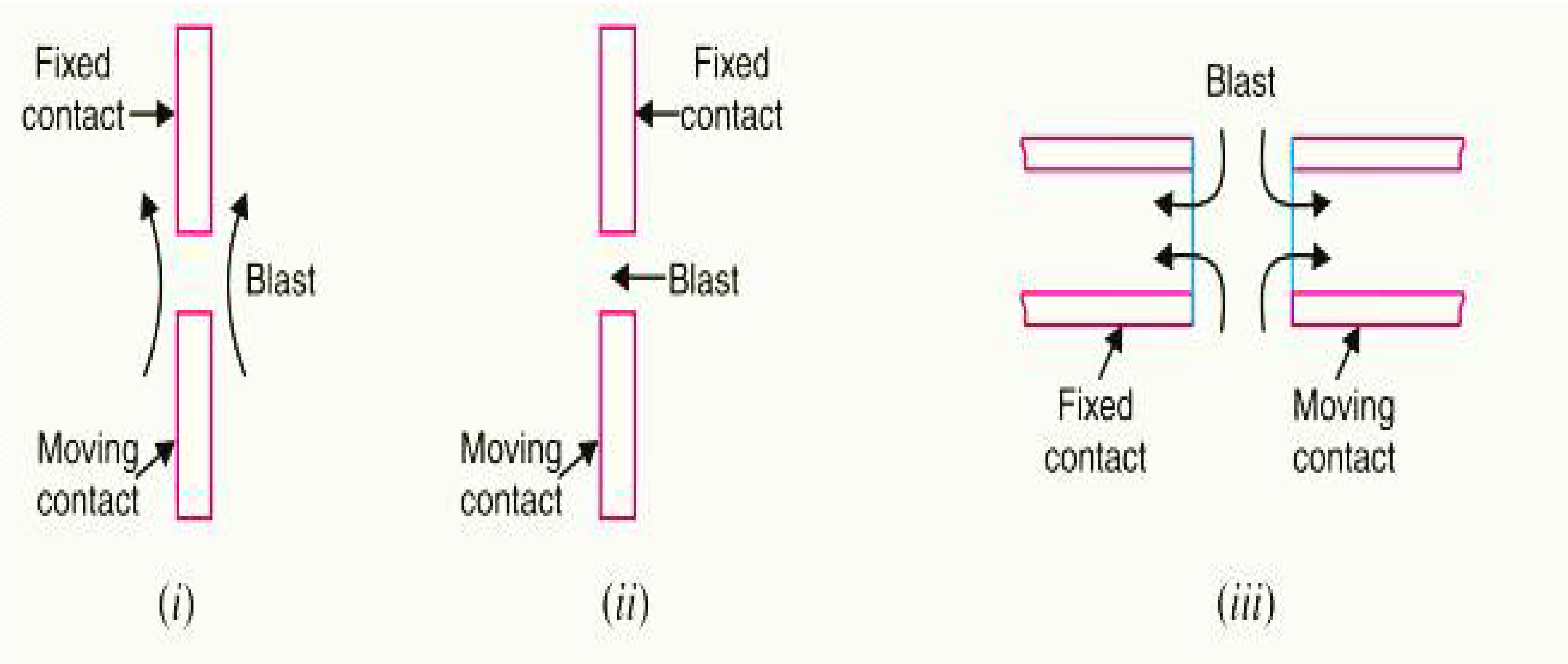


1. Air receiver, 2. Valve, 3. Hollow insulator.
4. Fixed contact, 5. Moving contact, 6. Piston.
7. Spring, 8. Exhaust valve, 9. Isomaker,
10. Operating mechanism.

25 kV Single Phase Air Circuit Breaker.

Types

(*i*) Axial-blast type **(*ii*)Cross-blast type** **(*iii*)Radial-blast type**



Advantages:

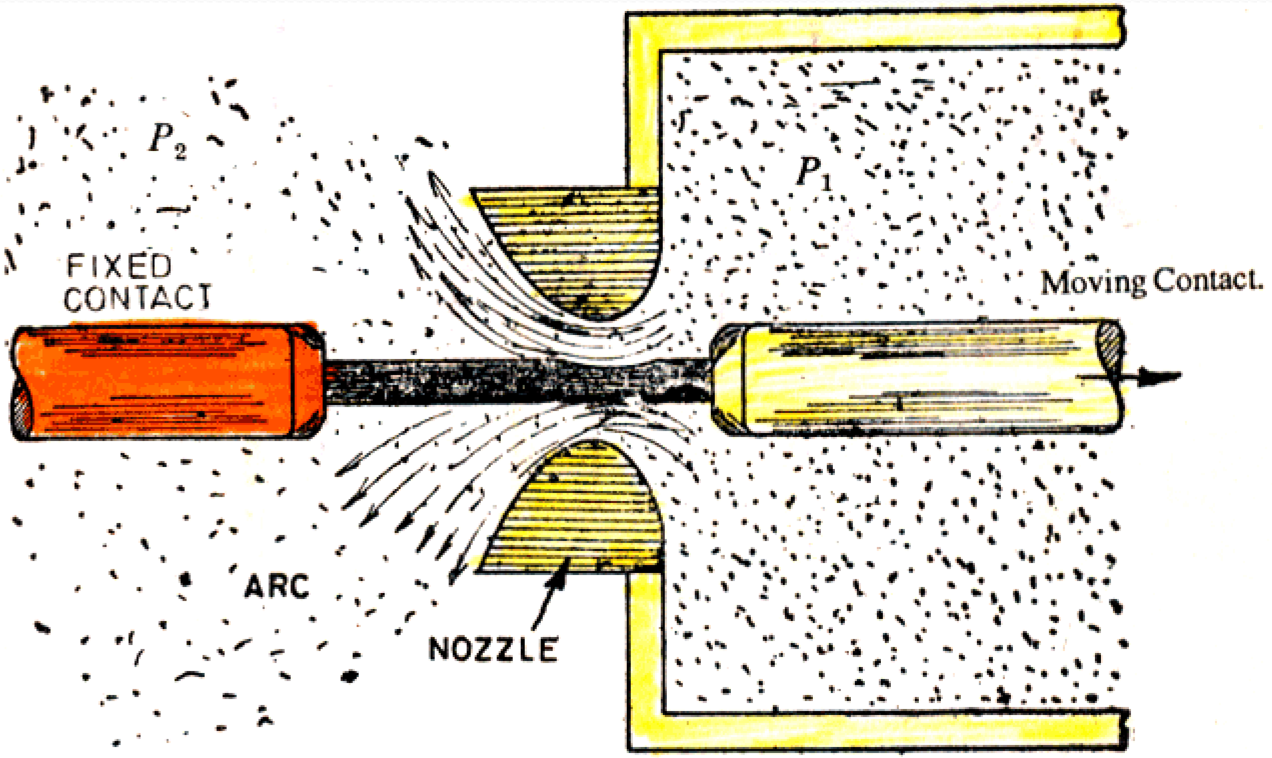
- High speed operation as compared to OCB.
- Ability to withstand frequent switching.
- Facility for high speed reclosure.
- Less maintenance as compared to OCB.

Disadvantages:

- Little moisture content prolongs arcing time.
- Pressure should be checked frequently for frequent operation.
- Risk of fire hazards due to over voltages.
- It can't be used for high voltage operation due to prolonged arc quenching.

4. SF_6 CIRCUIT BREAKERS

- It contains an arc interruption chamber containing SF_6 gas.
- In closed position the contacts remain surrounded by SF_6 gas at a pressure of 2.8 kg/cm^2 .
- During opening high pressure SF6 gas at 14 kg/cm^2 from its reservoir flows towards the chamber by valve mechanism.
- SF_6 rapidly absorbs the free electrons in the arc path to form immobile negative ions to build up high dielectric strength.
- It also cools the arc and extinguishes it.
- After operation the valve is closed by the action of a set of springs.
- Absorbent materials are used to absorb the byproducts and moisture.



(*a*) Arc extinction in gas flow circuit-breakers (Gas flow from high pressure P_1 to low pressure P_2 *via* an insulating nozzle)

Advantages:

- Very short arcing period due to superior arc quenching property of SF_6 .
- Can interrupt much larger currents as compared to other breakers.
- No risk of fire.
- Low maintenance, light foundation.
- No over voltage problem.
- There are no carbon deposits.

Disadvantages:

- SF_6 breakers are costly due to high cost of SF_6.
- SF_6 gas has to be reconditioned after every operation of the breaker, additional equipment is required for this purpose.

Comparison of Circuit Breakers

Factor	Oil Breakers	Air Breakers	Vacuum/SF6
Safety	Risk of explosion and fire due to increase in pressure during multiple operations	Emission of hot air and ionized gas to the surroundings	No risk of explosion
Size	Quite large	Medium	Smaller
Maintenance	Regular oil replacement	Replacement of arcing contacts	Minimum lubrication for control devices
Environmental factors	Humidity and dust in the atmosphere can change the internal properties and affect the dielectric		Since sealed, no effect due to environment
Endurance	Below average	Average	Excellent

CONCLUSION:

Therefore, we conclude that circuit breaker is the most essential part of the electrical networks as it protects every device from damage. It helps us to detect the fault and area affected by it. Nowadays vacuum and SF_6 circuit breakers are widely used due to their reliable and fast operations.

Testing of circuit breaker

Necessary of Testing of circuit breaker:-

Why "Testing of Circuit Breaker" is Necessary?

- **A Circuit Breaker should be capable of carrying, making, and breaking under normal and abnormal conditions. In any power system circuit breaker has to withstand power frequency over voltages and transient over voltages due to switching and lightning.**

- **The performance of a circuit breaker under normal and abnormal conditions can be verified by performing different type of tests on circuit breakers. The main purpose of testing of circuit breakers is to confirm if circuit breaker is able to work on particular voltage and current ratings or not.**