Ref No:

< Sri Krishna Institute of Technology, Bangalore>

COURSE PLAN

Academic Year 2019-20

Program:	B E – Electrical and Electronics Engineering
Semester :	7
Course Code:	15EEL77
Course Title:	RELAY AND HIGH VOLTAGE LAB
Credit / L-T-P:	4 / 4-0-0
Total Contact Hours:	50
Course Plan Author:	Avinash S

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15EEL77: RELAY AND HIGH VOLTAGE LAB

A. LABORATORY INFORMATION

1. Lab Overview

Degree:	B.Tech	*Program:*	EE
Year / Semester :	7 / 4	*Academic Year:*	2019-20
Course Title:	Relay and High Voltage Lab	*Course Code:*	15EEL77
Credit / L-T-P:	3 / 0-1-2	*SEE Duration:*	180 Minutes
Total Contact Hours:	30 Hrs	*SEE Marks:*	80 Marks
CIA Marks:	20	*Assignment*	1 / Module
Course Plan Author:	Mr.Avinash S	*Sign*	Dt :
Checked By:		*Sign*	Dt :

2. Lab Content

Unit	Title of the Experiments	Lab Hours	Concept	Blooms Level
1	Over Current Relay: (a)Inverse Definite Minimum Time(IDMT)Non-Directional Characteristics (b) Directional Features (c) IDMT Directional.	3	Analysis of over current relay	L4 Analyze
2	IDMT Characteristics of Over Voltage or Under Voltage Relay (Solid State or Electromechanical	3	Analysis of IDMT relay	L4
3	Operation of Negative Sequence Relay.	3	Analysis of Negative Sequence relay	L4
4	Operating Characteristics of Microprocessor Based (Numeric) Over –Current Relay.	3	Analysis of Mp over current relay	L4
5	Operating Characteristics of Microprocessor Based (Numeric) Distance Relay.	3	Analysis of Distance relay	L4
6	Operating Characteristics of Microprocessor Based (Numeric) Over/Under Voltage Relay.	3	Analysis of Under Voltage relay	L4
7	Generation Protection: Merz Price Scheme.	3	Analysis of Protection system for generating component s	L4
8	Feeder Protection against Faults.	3	Analysis of Protection system for Feeder	L4
9	Motor Protection against Faults.	3	Analysis of Protection system for Motors	L4
10	Spark Over Characteristics of Air subjected to High Voltage AC with Spark Voltage Corrected to Standard Temperature and Pressure for Uniform	3	Breakdown mechanism in air,	L4
11	Spark Over Characteristics of Air subjected to High voltage DC.	3	Breakdown mechanism of gases,	L4
12	Measurement of HVAC and HVDC using Standard	3	Breakdown	L4

	Spheres as per IS		mechanism in air,	
13	Measurement of Breakdown Strength of Transformer Oil as per IS	3	Breakdown mechanism of liquid ,	L4
14	Field Mapping using Electrolytic Tank for any one of the following Models: Cable/ Capacitor/ Transmission Line/ Sphere Gap.	3	Field mapping analysis	L4
15	(a) Generation of standard lightning impulse voltage and to determine efficiency and energy of impulse generator. (b) To determine 50% probability flashover voltage for air insulation subjected to impulse voltage.	3	Generation of Impulse voltage and current	L4

3. Lab Material

Unit	Details	Available
1	Text books	
	M.S. Naidu, V.Kamaraju McGraw Hill 5 th Edition, 2013.	In Lib
2	Reference books	
	E. Kuffel, W.S. Zaengl, J. Kuffel	In dept
3	Others (Web, Video, Simulation, Notes etc.)	
		Not Available

4. Lab Prerequisites:

-	-	Base Course:		-	-
SNo	Course Code	Course Name	Topic / Description	Sem	Remarks
1	15EE73	Power system Protection	Knowledge on protection systems	7	
			Knowledge of relays	-	

Note: If prerequisites are not taught earlier, GAP in curriculum needs to be addressed. Include in Remarks and implement in B.5.

5. General Instructions

SNo	Instructions	Remarks
1	Keep the lab neatly.	
2	Maintain silence.	
3	Maintain your lab observation and lab manual.	
4	Prepare your experiment in well advance.	
5	Do not leave the lab without in-charge staff permission.	
6	Do not move around in the lab.	
7	Do not misplace the equipments.	
8	Check the power supply before use.	
9	Maintain discipline in the lab.	
10	After completion of your experiment switch off the power supply.	

6. Lab Specific Instructions

SNo	Specific Instructions	Remarks
1	The equipment must be connected firmly to the mother ground	
2	The electrodes must be cleaned properly before use	

3	Before starting the experiment, make sure the electrodes are properly aligned to zero reading	
4	Any part of the equipment should not be touched	
5	Do not enter High-Voltage area without discharge	
6	Sudden High-Voltage should not be applied to the specimen	
7	Do not enter the test-bay while the equipments are in operation	
8	Ignore the first one reading as the air between the electrodes may be ionized	

B. OBE PARAMETERS

1. Lab / Course Outcomes

#	COs	Teach. Hours	Concept	Instr Method	Assessment Method	Blooms' Level
1	Experimentally verify the characteristics of over current, over voltage, under voltage and negative sequence relays both electromagnetic and static type.	3	Analysis of Protection system for Feeder	Demonstrate	Slip Test	L2
2	Experimentally verify the characteristics of microprocessor based over current, over voltage, under voltage relays and distance relay.	3	Analysis of Protection system for Motors	Demonstrate	Assignment	L2
3	Analyze the spark over characteristics for both uniform and non-uniform configurations using High AC and DC voltages	3	Breakdown mechanism in air,	Demonstrate	Assignment and Slip Test	L2
4	Analyze high AC and DC voltages and breakdown strength of transformer oil	03	Breakdown mechanism of gases,	Simulation	Assignment	L3
5	Draw electric field and measure the capacitance of different electrode configuration models.	03	Breakdown mechanism in air,	Tutorial	Slip test	L2
6	Understand knowledge of generating standard lightning impulse voltage to determine efficiency, energy of impulse generator and 50% probability flash over voltage for air insulation	03	Breakdown mechanism of liquid ,	Tutorial	Assignment	L2
7	verify the characteristics of microprocessor based over current, over voltage, under voltage relays and distance relay	03	Field mapping analysis	Demonstrate	Assignment and Slip Test	L3
8	Analyze high AC and DC voltages and breakdown phenomenon of air insulation	03	Generation of Impulse voltage and current	Demonstrate	Assignment	L2
-	**Total**	**24**	-	-	-	-

Note: Identify a max of 2 Concepts per unit. Write 1 CO per concept.

2. Lab Applications

SNo	Application Area	CO	Level
1	In power systems, varieties of insulation materials are used to protect the high voltage power apparatus such as transformer, switchgear, current transformer, potential transformer etc.	CO1	L2
2	The transformer oil is degraded due to the combination of the ageing processes such as partial discharge (PDs), electrical arcing	CO2	L2
3	the effects of different ageing processes on the optical absorption properties of insulating oil of a model transformer is studied using a UV-visible spectrophotometer diagnostic method which is presently becoming a popular method to identify the ageing of the insulating oil of high voltage transformers	CO3	L2

4	High voltage (HV) power apparatus determines the stability of any electrical power system	CO4	L3
5	Power Transformers are one of the most critical component of power system in which mineral oil is used for both insulation and cooling purposes. It acts a insulating medium between solid insulations like kraft paper, pressboard etc.	CO5	L2
6	The transformer oil is degraded due to the combination of the ageing processes such as partial discharge (PDs), electrical arcing	CO6	L2
7	the effects of different ageing processes on the optical absorption properties of insulating oil of a model transformer is studied using a UV-visible spectrophotometer diagnostic method which is presently becoming a popular method to identify the ageing of the insulating oil of high voltage transformers	CO7	L3
8	The transformer oil is degraded due to the combination of the ageing processes such as partial discharge (PDs), electrical arcing	CO8	L2

Note: Write 1 or 2 applications per CO.

3. Articulation Matrix

(CO – PO MAPPING)

-	Course Outcomes	Program Outcomes												
#	COs	PO1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	Level
15EEL77.1	Experimentally verify the characteristics of over current, over voltage, under voltage and negative sequence relays both electromagnetic and static type.	x	x	x		x								L3
15EEL77.2	Experimentally verify the characteristics of microprocessor based over current, over voltage, under voltage relays and distance relay.	x	x	x		x								L4
15EEL77.3	Analyze the spark over characteristics for both uniform and non-uniform configurations using High AC and DC voltages	x		x	x	x								L3
15EEL77.4	Analyze high AC and DC voltages and breakdown strength of transformer oil	x	x	x		x								L3
15EEL77.5	Draw electric field and measure the capacitance of different electrode configuration models.	x	x	x		x								L2
15EEL77.6	Show knowledge of generating standard lightning impulse voltage to determine efficiency, energy of impulse generator and 50% probability flash over voltage for air insulation	x	x			x								L2
15EEL77.7	Experimentally verify the characteristics of microprocessor based over current, over voltage, under voltage relays and distance relay	x	x	x		x								L3
15EEL77.8	Analyze high AC and DC voltages	x	x			x								L4

	and breakdown phenomenon of air insulation														
CS501PC.	Average														

Note: Mention the mapping strength as 1, 2, or 3

4. Mapping Justification

Mapping		Mapping Level	Justification
CO	**PO**	**-**	**-**
CO1	PO1	L2	Knowledge on Relay .
CO1	PO2	L4	Analyzing the performance characteristics under voltage and negative sequence relays
CO2	PO1	L2	Knowledge on microprocessor based over current, over voltage
CO2	PO2	L4	To analyze the performance characteristics of microprocessor based over current, over voltage
CO3	PO1	L2	Knowledge on
CO3	PO2	L4	To analyse the frequency domain reposes of a given second order system using discrete components.
CO4	PO1	L2	Knowledge on design of control systems
CO4	PO2	L4	To analyze Lead compensators for given specifications.
CO4	PO3	L6	Design and analyze Lead compensators for given specifications.
CO4	PO9	L3	Projects or internship on Lead compensator.
CO5	PO1	L2	Knowledge on design of control systems
CO5	PO2	L4	To analyze Lag compensators for given specifications.
CO5	PO3	L6	Design and analyze Lag compensators for given specifications.
CO5	PO9	L3	Projects or internship on Lag compensator.
CO6	PO1	L2	Knowledge on design of control systems
CO6	PO2	L4	To analyze Lag lead compensators for given specifications.
CO6	PO3	L6	Design and analyze Lag lead compensators for given specifications.
CO6	PO9	L3	Projects or internship on Lag Lead compensator.
CO7	PO1	L2	Knowledge on time domain analysis
CO7	PO2	L4	To analyse the time domain reposes of a given second order system using software package or discrete components.
CO7	PO5	L3	To determine frequency domain reposes of a given second order system using software package.
CO8	PO1	L2	Knowledge on design of control systems
CO8	PO2	L5	To analyze the effect of P, PI, PD and PID controller on the step response of a feedback control system (using control engineering trainer/process control simulator) and Verifying the same by simulation.
CO8	PO5	L3	To simulate a second order system and study the effect of (a) P, (b) PI, (c) PD and (d) PID controller on the step response using software package.
CO8	PO9	L3	Projects or internship on Controllers.

Note: Write justification for each CO-PO mapping.

5. Curricular Gap and Content

SNo	Gap Topic	Actions Planned	Schedule Planned	Resources Person	PO Mapping
1					
2					
3					

Note: Write Gap topics from A.4 and add others also.

6. Content Beyond Syllabus

SNo	Gap Topic	Actions Planned	Schedule Planned	Resources Person	PO Mapping
1					
2					
3					

Note: Anything not covered above is included here.

C. COURSE ASSESSMENT

1. Course Coverage

Unit	Title	Teaching Hours	No. of question in Exam							CO	Levels
			CIA-1	CIA-2	CIA-3	Asg-1	Asg-2	Asg-3	SEE		
1	Over Current Relay: (a)Inverse Definite Minimum Time(IDMT)Non-Directional Characteristics (b) Directional Features (c) IDMT Directional.	03	1	-	-	-	-	-	1	CO1	L2
2	IDMT Characteristics of Over Voltage or Under Voltage Relay (Solid State or Electromechanical	03	1	-	-	-	-	-	1	CO2	L3
3	Operation of Negative Sequence Relay.	03	1	-	-	-	-	-	1	CO3	L3
4	Operating Characteristics of Microprocessor Based (Numeric) Over –Current Relay.	03	1	-	-	-	-	-	1	CO4	L3
5	Operating Characteristics of Microprocessor Based (Numeric) Distance Relay.	03	1	-	-	-	-	-	1	CO5	L4
6	Operating Characteristics of Microprocessor Based (Numeric) Over/Under Voltage Relay.	03	-	1	-	-	-	-	1	CO6	L4
7	Generation Protection: Merz Price Scheme.	03	-	1	-	-	-	-	1	CO7	L4
8	Feeder Protection against Faults.	03	-	1	-	-	-	-	1	CO8	L4
9	Motor Protection against Faults.	03	-	1	-	-	-	-	1	CO9	L4
10	Spark Over Characteristics of Air subjected to High Voltage AC with Spark Voltage Corrected to Standard Temperature and Pressure for Uniform	03	-	1	-	-	-	-	1	CO10	L4
11	Spark Over Characteristics of Air subjected to High voltage DC.	03	-	-	1	-	-	-	1	CO11	L4
12	Measurement of HVAC and HVDC using Standard Spheres as per IS	03	-	-	1	-	-	-	1	CO12	L4
13	Measurement of Breakdown Strength of Transformer Oil as per IS	03	-	-	1	-	-	-	1	CO13	L3
14	Field Mapping using Electrolytic Tank for any one of the following Models: Cable/ Capacitor/ Transmission Line/ Sphere Gap.	03	-	-	1	-	-	-	1	CO14	L4
-	**Total**	**45**	**5**	**5**	**5**	**5**	**5**	**5**	**20**	**-**	**-**

Note: Write CO based on the theory course.

2. Continuous Internal Assessment (CIA)

Evaluation	Weightage in Marks	CO	Levels
CIA Exam – 1	30	CO1, CO2, CO3, CO4	L23, L3
CIA Exam – 2	30	CO5, CO6, CO7,	L1, L2, L3 . .
CIA Exam – 3	30	CO5, CO6,	L1, L2, L3 . .
Assignment - 1	05	CO1, CO2, CO3, CO4	L2, L3, L4 ...
Assignment - 2	05	CO5, CO6, CO7,	L1, L2, L3 ...

Assignment - 3	05	CO8,	L1, L2, L3 ...
Seminar - 1	05	CO1, CO2, CO3, CO4	L2, L3, L4 . ..
Seminar - 2	05	CO5, CO6,	L2, L3, L4 . ..
Seminar - 3	05	CO8,	L2, L3, L4 . ..
Other Activities – define – Slip test		CO1	L2, L3, L4 . ..
Final CIA Marks	**40**	**-**	**-**

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SNo	Description	Marks
1	Observation and Weekly Laboratory Activities	05 Marks
2	Record Writing	10 Marks for each Expt
3	Internal Exam Assessment	25 Marks
4	Internal Assessment	15 Marks
5	SEE	80 Marks
-	**Total**	**100 Marks**

D. EXPERIMENTS

Experiment 01 : Over Current Relay:

(a)Inverse Definite Minimum Time(IDMT)Non-Directional Characteristics
(b) Directional Features
(c) IDMT Directional.

-	Experiment No.:	1	Marks		Date Planned		Date Conducted	
1	Title	Over Current Relay						
2	Course Outcomes	To analyze the inverse Definite minimum Time characteristic						
3	Aim	To find Inverse Definite Minimum Time(IDMT)Non-Directional Characteristics (b) Directional Features (c) IDMT Directional.						
4	Material / Equipment Required	1] Electro-mechanical over current relay. 2] Secondary current injection unit including dimmer VRPS. 3] AC to DC supply. 4] Timer. 5] Patch Chords.						
5	Theory, Formula, Principle, Concept							
6	Procedure, Program, Activity, Algorithm, Pseudo Code	1. Connections are made as shown in the circuit diagram. 2. Set a required PSM and TSM in the relay. 3. Ensure time interval meter switch is in TIM position and Protection timer switch in ON position. 4. Keeping the dimmer in zero position switch on the mains. 5. Push test start button, CB ON indicator, ammeter will glow. 6. Adjust the dimmer to test approximate injection current (Greater than the test relay current). 7. Push test stop/reset button without disturbing the dimmer position. 8. Push test start button, note down the current , time interval meter starts up counting ,over current relay trip occurs and TRIP indictor will glow.						

		9. Note down the time taken for tripping of the relay. 10. The above procedure is once again repeated for different values of PSM and TSM. 11. Draw a graph of trip time v/s fault current.
7	Block, Circuit, Model Diagram, Reaction Equation, Expected Graph	
8	Observation Table, Look-up Table, Output	Holding ratio = Reset value / Pick-up value . PSM=.......Amps **TSM=........secs** **TSM=..........secs**

Sl No	Fault current in Amps	Operating time in sec	Sl No	Fault current in Amps
1			1	
2			2	
3			3	
4			4	
5			5	

PSM-Plug setting multiplier TSM-Time setting multiplier

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9	Sample Calculations	
10	Graphs, Outputs	
11	Results & Analysis	the current-time characteristics of a non directional over current relay at

		different plug setting multiplier (PSM) and time setting multiplier (TSM) and to also determine the pick- up current, drop-off (reset) current and holding ratio
12	Application Areas	Used to protected highly sensitive and high rating electrical equipments
13	Remarks	
14	Faculty Signature with Date	

Experiment 02 : MICROCONTROLLER BASED OVER CURRENT RELAY

-	Experiment No.:	1	Marks		Date Planned		Date Conducted	
1	Title	**MICROCONTROLLER BASED OVER CURRENT RELAY**						
2	Course Outcomes							
3	Aim	To obtain operational characteristic of µP based over current relay and also determine the pick–up and drop off current.						
4	Material / Equipment Required	µP based over current relay module, Patch chords						
5	Theory, Formula, Principle, Concept							
6	Procedure, Program, Activity, Algorithm, Pseudo Code							
7	Block, Circuit, Model Diagram, Reaction Equation, Expected Graph							
8	Observation Table, Look-up Table, Output	• **PSM** =……… Amps TSM =……… TSM **=………**						

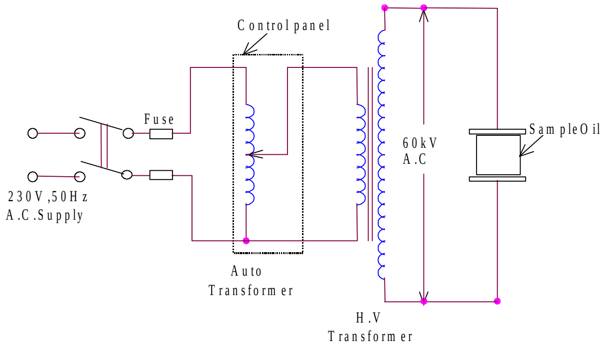
Sl No	Load current in Amps	Operating time in sec	Sl No	Load current in Amps
1			1	
2			2	
3			3	
4			4	
5			5	
6			6	
7			7	

11	Results & Analysis	
12	Application Areas	Used to protect highly sensitive and high rating electrical equipments
13	Remarks	
14	Faculty Signature with Date	

Experiment 03 : ESTIMATION OF BREAKDOWN STRENGTH OF TRANSFORMER OIL

-	Experiment No.:	1	Marks		Date Planned		Date Conducted	-
1	Title	ESTIMATION OF BREAKDOWN STRENGTH OF TRANSFORMER OIL						
2	Course Outcomes	To analyze the break-down strenght of transformer oil						
3	Aim	To determine breakdown voltage and breakdown strength of the given transformer oil						
4	Material /	Observation						

	Equipment Required	Manual Testing oil test kit, Transformer oil
5	Theory, Formula, Principle, Concept	
6	Procedure, Program, Activity, Algorithm, Pseudo Code	1. Connections are made as per the circuit diagram. 2. The electrodes in the oil test cup is adjusted for the required distance. 3. 80% of the transformer oil is filled in the oil container cup. 4. Keep the oil container cup on the HV transformer bushings. 5. Close the top door and bring the variac to minimum position. 6. Switch ON the mains and press the HT push button, the HT ON indicator will glow and UNIT READY indicator will also glow. 7. Now gradually increase the voltage until the breakdown occurs. 8. Note down the breakdown voltage in the voltmeter by pressing MEMORY push button. 9. Bring the variac to minimum position and switch OFF the main supply. 10. Repeat the same procedure and note down 3 to 4 breakdown voltages.
7	Block, Circuit, Model Diagram, Reaction Equation, Expected Graph	



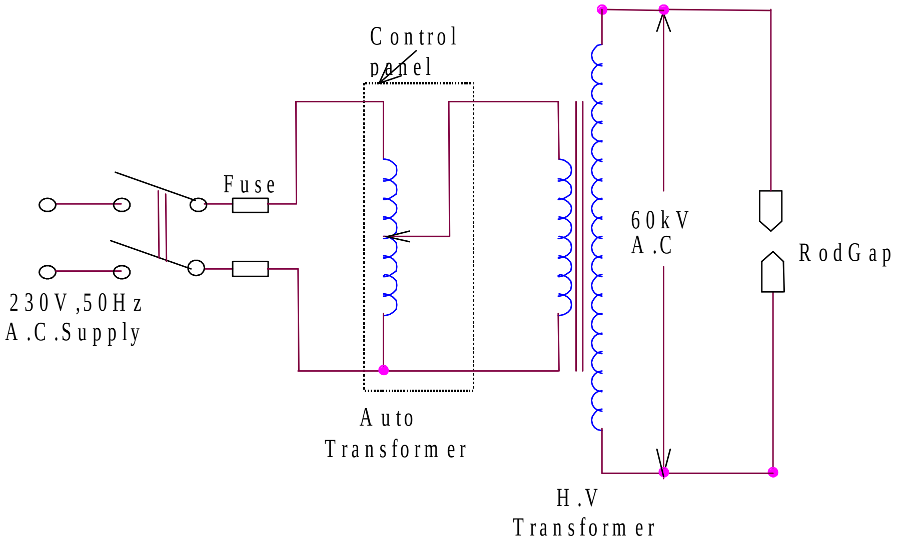
8 Observation Table, Look-up Table, Output

Sl. No.	Breakdown voltage in kV	Breakdown strength of the oil in kV/ mm		
1				
2				
3				
4				
5				
6				
7				
8				

9	Sample Calculations	
10	Graphs, Outputs	
11	Results & Analysis	Breakdown strength of oil = (Breakdown voltage/ Distance between the two electrodes) in kV/ mm
12	Application Areas	
13	Remarks	
14	Faculty Signature with Date	

Experiment 04 : Keywords and identifiers

-	Experiment No.:	3	Marks	3	Date Planned		Date Conducted	
1	Title	HIGH VOLTAGE AC FLASH OVER CHARACTERISTICS OF DIFFERENT ELECTRODE CONFIGURATION						
2	Course Outcomes							
3	Aim	To obtain the flash over characteristics of the following electrode configuration in air subjected to HVAC 1 Plane - plane electrodes 2 Point - point electrodes 3 Plane - point electrodes						
4	Material / Equipment Required	Control panel, HV transformer, Rod gap apparatus, Discharge rods.						
5	Theory, Formula, Principle, Concept							
6	Procedure, Program, Activity, Algorithm, Pseudo Code	Connections are made as per the circuit diagram. 2. The control panel output is connected to the primary of HV transformer and secondary of the HV transformer is connected to the rod gap unit 3. Required electrodes gap distance is adjusted with the help of hand wheel and Variac (dimmer) of the control panel is kept in minimum position 4. All the apparatus are grounded firmly to the mother ground. 5. Connect 230 Volts, AC supply to the control panel 6. Switch ON the main supply, press the MAINS ON button, UNIT READY indicator will glow. 7. Press the HT ON push button, the HT ON indicator will glow. 8. Now gradually increasing the voltage by using variac knob, at certain voltage break down will takes place between the electrodes and simultaneously HT ON will glow OFF. 9. Press MEMORY push button to note down the break down voltage. 10. Bring the variac to minimum position and switch OFF main supply. 11. The bushings of the transformer and electrodes of rod gap is discharged by using DISCHARGE RODS 12. The above procedure is repeated for different gap distance **NOTE:** The same procedure is repeated for different combination of electrodes, [ii) plane - point electrodes iii) point - point electrodes]. 13. Vary the dimmer to minimum position and switch OFF the supply and all the parts of the apparatus are discharged by using DISCHARGE RODS. 14. Plot the break down voltage verses sphere gap distance and Electric stress verses sphere gap distance						

7	Block, Circuit, Model Diagram, Reaction Equation, Expected Graph	

8	Observation Table, Look-up Table, Output	

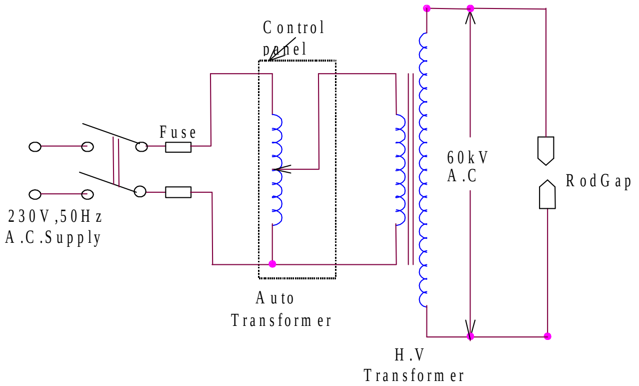
Sl No	Electrodes gap distance in mm	Primary Input Voltage	Breakdown voltage in KV	
			Tr1	Tr2
PLANE TO PLANE				
1	5 mm			
2	10 mm			
3	15 mm			
4	20 mm			
5	25 mm			
POINT TO POINT				
1	5 mm			
2	10 mm			
3	15 mm			
4	20 mm			
5	25 mm			
POINT TO PLANE				
1	5 mm			
2	10 mm			
3	15 mm			
4	20 mm			
5	25 mm			

9	Sample Calculations	Laboratory temperature t = in °centigrade Laboratory pressure P = 680 mm of Hg Air density is expressed as = (P* 293)/(760(273 + t)) Transformer ratio=V_2/ V_1 **TABLE: AIR DENSITY CORRECTION FACTOR** For different values of gives different values of K

	0.70	0.75	0.80	0.85	0.90	0.95	1.00	1.05
K	0.72	0.76	0.81	0.86	0.90	0.95	1.00	1.05

11	Results & Analysis	
12	Application Areas	
13	Remarks	
14	Faculty Signature with Date	

Experiment 05 : HIGH VOLTAGE AC FLASH OVER CHARACTERISTICS OF DIFFERENT ELECTRODE CONFIGURATION

-	Experiment No.:	5	Marks		Date Planned		Date Conducted	
1	Title	HIGH VOLTAGE AC FLASH OVER CHARACTERISTICS OF DIFFERENT ELECTRODE CONFIGURATION						
2	Course Outcomes							
3	Aim	To obtain the flash over characteristics of the following electrode configuration in air subjected to HVAC 4 Plane - plane electrodes 5 Point - point electrodes 6 Plane - point electrodes						
4	Material / Equipment Required							
5	Theory, Formula, Principle, Concept							
6	Procedure, Program, Activity, Algorithm, Pseudo Code							
7	Block, Circuit, Model Diagram, Reaction Equation, Expected Graph							
8	Observation Table, Look-up Table,							

Output

Sl No	Electrodes gap distance in mm	Primary Input Voltage	Breakdown v…
			Tr1
PLANE TO PLANE			
1	5 mm		
2	10 mm		
3	15 mm		
4	20 mm		
5	25 mm		
POINT TO POINT			
1	5 mm		
2	10 mm		
3	15 mm		
4	20 mm		
5	25 mm		
POINT TO PLANE			
1	5 mm		
2	10 mm		
3	15 mm		
4	20 mm		
5	25 mm		

9 Sample Calculations

- CALCULATION:
- Laboratory temperature t = in °centigrade

Laboratory pressure P = 680 mm of Hg

Air density is expressed as = (P* 293)/(760(273 + t))

Transformer ratio=V_2/ V_1

TABLE: AIR DENSITY CORRECTION FACTOR

For different values of gives different values of K

	0.70	0.75	0.80	0.85	0.90	0.95	1.00	1.05
K	0.72	0.76	0.81	0.86	0.90	0.95	1.00	1.05

10 Graphs, Outputs

11 Results & Analysis

Theoretical breakdown voltage $V_T = V_{rms}$*K*Transformer ratio=

Where K – Correction factor

S – Sphere gap distance in cm

12 Application Areas — To check the break-down voltage of a

13 Remarks

14 Faculty Signature with Date

Experiment 06 :SOLID STATE NEGATIVE PHASE SEQUENCE RELAY

-	Experiment No.:	1	Marks		Date Planned		Date Conducted	
1	Title	SOLID STATE NEGATIVE PHASE SEQUENCE RELAY						
2	Course Outcomes							
3	Aim	To study the operation of a negative phase sequence relay						

4	Material / Equipment Required	Negative - sequence relay module, connecting wires, Rheostat, Induction motor.
5	Theory, Formula, Principle, Concept	
6	Procedure, Program, Activity, Algorithm, Pseudo Code	Connections are made as shown in circuit diagram. 1. The auxiliary power closed and 3-4 input is connected. 2. Keeping the rheostat in cut in position switch ON the mains. Push CB ON button. CB ON indicator will glow and the motor starts running. 3. Note down the ammeter reading. 4. Adjust the rheostat to create the negative sequence i.e. unbalance. 5. Negative sequence relay gets active and 'Trip' signals. 6. Push CB off/Reset. 7. Without adjusting/disturbing the rheostat , switch ON the CB ON and note the ammeter readings and trip timings. 8. Interchange the 3- RYB sequence and observe and tabulate the readings.
7	Block, Circuit, Model Diagram, Reaction Equation, Expected Graph	
8	Observation Table, Look-up Table, Output	(see table below)
9	Sample Calculations	
10	Graphs, Outputs	
11	Results & Analysis	
12	Application Areas	
13	Remarks	
14	Faculty Signature with Date	

•	• Current in R-Ph (A)	• Current in Y-Ph (A)	• Current in B-Ph (A)
Normal condition			
Unbalanced conditional			
One Phase is open			

Experiment 02 : **CHARACTERISTICS OF ELECTRO MECHANICAL UNDER VOLTAGE RELAY**

-	Experiment No.:	1	Marks		Date Planned		Date Conducted	
1	Title	CHARACTERISTICS OF ELECTRO MECHANICAL UNDER VOLTAGE RELAY						
2	Course Outcomes	Analyze electro mechanical under voltage relay.						
3	Aim	To conduct test on electro mechanical under voltage relay.						
4	Material / Equipment Required	Under voltage relay module, Patch chords.						

5	Theory, Formula, Principle, Concept	
6	Procedure, Program, Activity, Algorithm, 1. Pseudo Code	1. Relay connections are made as shown in figure. 2. Set a required PSM and TSM in the relay. 3. Ensure time interval meter switch is in TIM position and Protection timer switch in ON position. S2 switch is in ON position. 4. Keeping the dimmer in zero position, toggle switch in set mode switch on the mains. 5. Adjust the voltage level above the threshold level if under voltage relay using dimmer 1. 6. Push TEST START button and adjust the under voltage level using dimmer 2.(Less than the set voltage) 7. Push TEST STOP/RESET button. Do not disturb the dimmer 1 and 2. 8. Once the disc stops rotating bring toggle switch to TEST mode and push TEST START button. 9. Under voltage trip occurs and trip indicator will glow. Note down time interval meter and voltmeter reading after the tripping of the relay. 10. Press RESET button and repeat the operation by adjusting different voltage and TMS setting. 11. Draw the graph between trip time v/s % closing voltages. 12.
7	Block, Circuit, Model Diagram, Reaction Equation, Expected Graph	
8	Observation Table, Look-up Table, Output	Plug setting= Time multiplier setting= Pick up voltage= Drop off voltage= **Setting voltage V_s= Volts Setting voltage V_s= Volts**

Sl No	Applied voltage in Volts > V_s	Operating time in sec	Sl No	Applied voltage in Volts > V_s
1			1	
2			2	
3			3	
4			4	
5			5	
6			6	
7			7	

9	Sample Calculations	
10	Graphs, Outputs	
11	Results & Analysis	
12	Application Areas	
13	Remarks	
14	Faculty Signature with Date	

Experiment 07 : MICROPROCESSOR BASED UNDER VOLTAGE RELAY

-	Experiment No.:	1	Marks		Date Planned		Date Conducted	
1	Title	MICROPROCESSOR BASED UNDER VOLTAGE RELAY						
2	Course Outcomes	Draw the operating characteristics of microprocessor based under voltage relay						
3	Aim	To draw the operating characteristics of microprocessor based under voltage relay						
4	Material / Equipment Required	Microprocessor based under voltage relay model, Patch chords.						
5	Theory, Formula, Principle, Concept	$V_s = [1 - [0.05 - a]]V_n$ Where V_s - set level voltage V_n- 110 Volts a - weight of switch in ON position $V_s = [1 - [0.05 - a]]V_n$ - for under voltage T=K(0.1+∑t)= åå						
6	Procedure, Program, Activity, Algorithm, Pseudo Code	1. Ensure both the dimmers in OFF position. 2. Connections are made for the relay and injection unit. 3. Set the over/under voltage by opening the glass plate. Using SW2 block switches set normal inverse or definite inverse time as required. 4. Ensure the time interval meter position in TIM position, protection timer switch in ON position bring both the dimmer to zero position. 5. Set the time multiplier setting. 6. Switch on the main, push TEST START button CB gets on. Adjust the dimmer voltage to set approximate injection voltage. 7. Push test Stop/Reset button. 8. Without disturbing dimmer 1 and dimmer 2 bring the toggle switch to test mode and push test to start button. 9. Note down the voltage at which under voltage relay trips and also the time interval meter reading. 10. Repeat the operation by adjusting different voltage and TMS setting. 11. Draw the graph of trip time V/S Multiple of set voltage.						
7	Block, Circuit, Model Diagram, Reaction Equation, Expected Graph							
8	Observation Table, Look-up Table, Output							

Sl.No	Fault Voltage	Multiple of set voltage=Fault voltage *100 / Set PSM	Operating Time	
			TMS=	TMS=
1				
2				
3				

		4				
		5				
		6				
		7				

9	Sample Calculations	
10	Graphs, Outputs	
11	Results & Analysis	Conducted test on electo mechanical under voltage relay
12	Application Areas	To protect electrical device against under voltage fault
13	Remarks	
14	Faculty Signature with Date	

Experiment 08 :HIGH VOLTAGE DC FLASH OVER CHARACTERISTICS OF DIFFERENT ELECTRODE CONFIGURATION

-	Experiment No.:	1	Marks		Date Planned		Date Conducted	
1	Title	HIGH VOLTAGE DC FLASH OVER CHARACTERISTICS OF DIFFERENT ELECTRODE CONFIGURATION						
2	Course Outcomes							
3	Aim	To obtain the flash over characteristics of the following electrode configuration in air subjected to HVDC Plane - plane electrodes. Point - point electrodes. Plane - point electrodes.						
4	Material / Equipment Required	Control panel, HV transformer, Rectifier, RC-Filter, Bleeding resistor. Rod gap apparatus, Discharge rods,						
5	Theory, Formula, Principle, Concept	Laboratory temperature t = in °centigrade Laboratory pressure P = 680 mm of Hg Air density is expressed as = (P* 293)/(760(273 + t)) Transformer ratio=V_2/ V_1 For different values of gives different values of K						

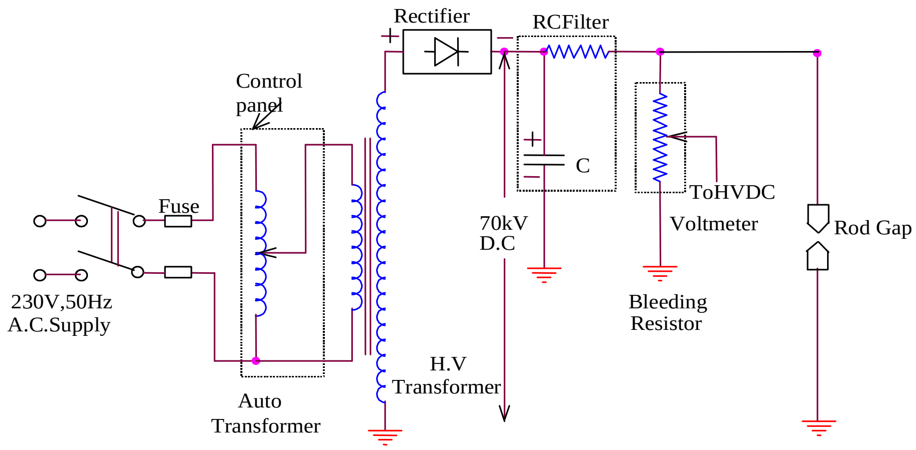
	0.70	0.75	0.80	0.85	0.90	0.95	1.00	1.05
K	0.72	0.76	0.81	0.86	0.90	0.95	1.00	1.05

6	Procedure, Program, Activity, Algorithm, Pseudo Code	1. Connections are made as per the circuit diagram. 2. All the apparatus and control panel should be properly grounded to the mother ground. 3. The required rod gap distance is adjusted with the help of hand

wheel

4. Now connect 1-phase, 230 Volt AC supply to the control panel
5. Switch ON the main supply
6. Bring the variac (Auto transformer) to zero position; as a result UNIT READY indicator will glow.
7. Press the HT ON button, then gradually increase the voltage until the breakdown occurs (SAMPLE FAILED indicator will glow)
8.
9. **NOTE:** In case HVDC sphere gap when we applying voltage observing the DC voltmeter.
10.
11. When breakdown occurs note down the voltage.
12. Once again bring the variac to minimum position, press RESET button, then SAMPLE FAIL indicator will OFF, and then switch off the supply.
13. Using discharge rods discharges all the apparatus.
14. The above procedures are repeated for the different values of rod gap distance
    NOTE: The same procedure is repeated for different combination of electrodes, [ii) plane - point electrodes iii) point - point electrodes].
15. Vary the dimmer to minimum position and switch OFF the supply and all the parts of the apparatus are discharged by using DISCHARGE RODS.
16. Plot the break down voltage verses sphere gap distance and Electric stress verses sphere gap distance.

7 Block, Circuit, Model Diagram, Reaction Equation, Expected Graph



8 Observation Table, Look-up Table, Output

SI No	Electrodes gap distance in mm	Primary Input Voltage	Breakdown voltage in k	
			Tr1	Tr2
PLANE TO PLANE				
1	5 mm			
2	10 mm			
3	15 mm			
4	20 mm			
5	25 mm			
POINT TO POINT				
1	5 mm			
2	10 mm			
3	15 mm			
4	20 mm			
5	25 mm			
POINT TO PLANE				

			1	5 mm			
			2	10 mm			
			3	15 mm			
			4	20 mm			
			5	25 mm			

9	Sample Calculations	Laboratory temperature t = in °centigrade Laboratory pressure P = 680 mm of Hg Air density is expressed as = (P* 293)/(760(273 + t)) Transformer ratio=V_2/ V_1 rr
10	Graphs, Outputs	
11	Results & Analysis	
12	Application Areas	
13	Remarks	
14	Faculty Signature with Date	

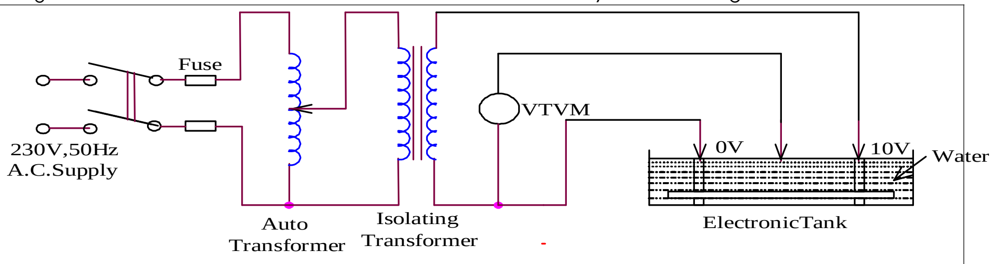
Experiment 09 : SIMULATION STUDY OF DIGITAL MOTOR PROTECTION

-	Experiment No.:	9	Marks		Date Planned		Date Conducted	
1	Title	SIMULATION STUDY OF DIGITAL MOTOR PROTECTION						
2	Course Outcomes	Analyze the motor protection under different types of faults.						
3	Aim	To study the motor protection principle by simulating different types of faults.						
4	Material / Equipment Required	Motor protection study unit.						
5	Theory, Formula, Principle, Concept							
6	Procedure, Program, Activity, Algorithm, Pseudo Code	1. Connect the three phase supply with neutral and ground. 2. Connect the motor(terminals provided at the top side of the mimic). 3. Switch on the supply of source. 4. Switch ob the MCB on the testing kit and look for power on indication (RYB). 5. Trip indication and buzzer will be on reset it. 6. Set the motor protection relay parameter . i) Inverse/ Definite characteristic-definite. ii) Definite time -2sec. iii) Reverse phase protection-ON. iv) Under current protection –OFF. v) Ground fault-0.05sec. vi) Stall function-ON. vii) Lock function –ON-200%. viii) CT ratio -1 ix) Phase fail –ON. x) Store. Adjust the dimmer to 415V. Push motor ON button, ensuring that there is no load on the motor and observe the current and voltage of all the phases and record it.							
7	Block, Circuit, Model Diagram, Reaction							

	Equation, Expected Graph	
8	Observation Table, Look-up Table, Output	
9	Sample Calculations	
10	Graphs, Outputs	
11	Results & Analysis	
12	Application Areas	
13	Remarks	
14	Faculty Signature with Date	

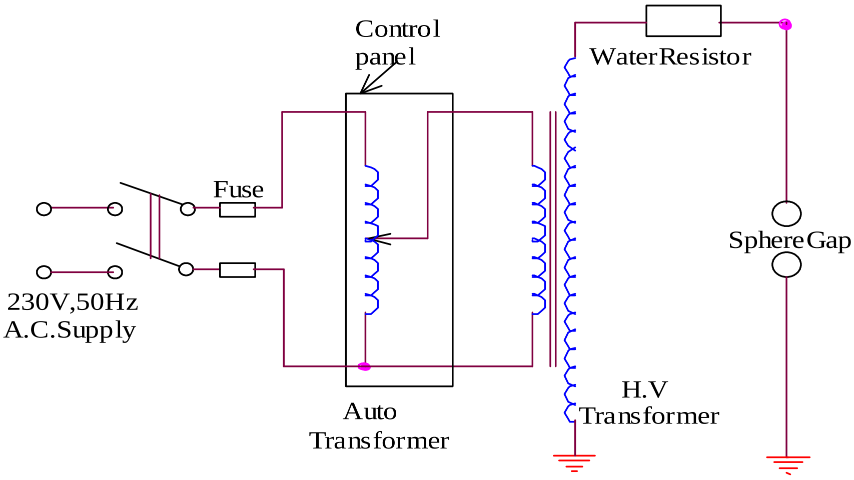
Experiment 10 : FIELD MAPPING USING ELECTROLYTIC TANK FOR
i) PARALLEL PLATE CAPACITOR MODEL

-	Experiment No.:	10	Marks		Date Planned		Date Conducted	
1	Title	FIELD MAPPING USING ELECTROLYTIC TANK FOR i) PARALLEL PLATE CAPACITOR MODEL						
2	Course Outcomes							
3	Aim	**To plot the equipotential field lines and calculates the capacitance and energy and to plot capacitance and energy as a function of distance for a give a) parallel plate capacitor model and b) co-axial cable capacitor model electrode configurations**.						
4	Material / Equipment Required	Auto Transformer, electrolytic tank with pantograph arrangement, Isolation transformer, 10 Volts digital A.C voltmeter or multi meter, two drawing sheets, pencil and eraser.						
5	Theory, Formula, Principle, Concept	Stress can be found by considering any cell between the parallel plates is given by E = dv/dx = 2/b in Volts/cm Capacitance as a function of distance $C_1 = {}_{0\,r}$ (h/a) a = b/l ; ℓ = length of the flux line; b = width of the each cell h = height of the parallel plates ee						
6	Procedure, Program, Activity, Algorithm, Pseudo Code	1. Parallel plate model 2. The parallel plate capacitor model is placed inside the electrolytic tank. 3. Clean water is poured (added) into the electrolytic tank up to the tips of the parallel plates. 4. Now drawing sheet is fixed on the glass plate of the electrolytic tank. 5. Connections are made as per the circuit diagram and keep multimeter knob in the AC mode. 6. Switch ON main supply. 7. Keep the pantograph needle on any one of the electrodes, then applying a small voltage of 10 Volts by using auto transformer with the help of multimeter. 8. First trace both the plates by using pantograph then trace equipotential lines corresponding to voltage of 2 Volts, 4 Volts, 6 Volts and 8 Volts respectively.						
7	Block, Circuit, Model Diagram,							

	Reaction Equation, Expected Graph	
8	Observation Table, Look-up Table, Output	
9	Sample Calculations	
10	Graphs, Outputs	
11	Results & Analysis	Total capacitance of plate C = ...F
12	Application Areas	To find capacitance of any cable
13	Remarks	
14	Faculty Signature with Date	

Experiment 11 : MEASUREMENT OF HVAC AND HVDC BY USING SPHERE GAP MODEL

-	Experiment No.:	11	Marks		Date Planned		Date Conducted	
1	Title	MEASUREMENT OF HVAC AND HVDC BY USING SPHERE GAP MODEL						
2	Course Outcomes							
3	Aim	: 1) Measurement of HVAC and HVDC using sphere gap model and comparing obtained values with the STP values.						
4	Material / Equipment Required	Control panel, HV transformer, Sphere gap apparatus, Rectifier, Capacitor, Water resister, Bleeding resistor, Thermometer, Discharge rod.						
5	Theory, Formula, Principle, Concept							
6	Procedure, Program, Activity, Algorithm, Pseudo Code	1. Connections are made as per the circuit diagram 2. All the apparatus and control panel should be properly grounded to the mother ground. 3. 3. The required sphere gap distance is adjusted with the help of hand wheel 4. 4. The laboratory temperature and pressure should be note down and calculate the correction factor 5. 5. Now connect 1-phase, 230 Volt AC supply to the control panel 6. Switch ON the main supply						

		7. Bring the dimmer (Auto transformer) to zero position, as a result UNIT READY indicator will glow. 8. Press the HT ON button, then gradually increase the voltage until the breakdown occurs (SAMPLE FAILED indicator will glow) 9. Press MEMORY push button to note down the breakdown AC voltage. 10. Once again bring the variac to minimum position, press RESET button, then SAMPLE FAIL indicator will OFF, and then switch off the supply. 11. Using discharge rods discharges all the apparatus. 12. The above procedures are repeated for the different values of spear gap distance. 13. Plot the break down voltage verses sphere gap distance and Electric stress verses sphere gap distance.
7	Block, Circuit, Model Diagram, Reaction Equation, Expected Graph	
8	Observation Table, Look-up Table, Output	

Sl No	Sphere gap	Practical break down	Theoretical

	distance in mm	voltage $V_{P(RMS)}$ in KV	breakdown voltage $V_T/\sqrt{2}$ in KV (rms)
1	10 mm		
2	15 mm		
3	20 mm		
4	25 mm		
5			

9	Sample Calculations	
10	Graphs, Outputs	
11	Results & Analysis	
12	Application Areas	
13	Remarks	
14	Faculty Signature with Date	

Experiment 12 : FUSE CHARACTERISITICS

-	Experiment No.:	12	Marks		Date Planned		Date Conducted	
1	Title	FUSE CHARACTERISITICS						
2	Course Outcomes							
3	Aim	To determine the characteristic of a given fuse wire by i) Constant length ii) Constant current and also determine the fuse constants and fusing factor						
4	Material / Equipment Required	1) Fuse wire 2) Ammeter (0 – 20A) AC 3) Inductive load 4) SPST Switch 5) Stop watch 6) Fuse board						
5	Theory, Formula, Principle, Concept							
6	Procedure, Program, Activity, Algorithm, Pseudo Code	1. Connections are made as shown in figure. 2. Given fuse wire is fixed on the fuse board (for given length). 3. The SPST in closed position, the supply switch is closed. 4. By gradually varying the inductive load such that Ammeter shows current greater than the current rating of the fuse wire. 5. The SPST switch is opened and simultaneously the stop watch is operated. 6. The time taken for the blowout of the fuse wire is noted. If fuse wire doesn't blow-out slightly increase the load current by varying the inductive load. 7. The above procedure are repeated for different values of load currents . 8. Similarly repeat the above procedure for different values of current ratings of fuse wire and also for different lengths . 9. Plot the graphs.						
7	Block,Circuit, Model Diagram, Reaction Equation, Expected Graph							

8	Observation Table, Look-up Table, Output	<table><tr><td></td><td colspan="2">**Length L = 6cms**</td><td colspan="2">**Length L = 12cms**</td></tr><tr><td>Sl No</td><td>Load current in Amps</td><td>Melting time in sec</td><td>Load current in Amps</td><td>Melting time in sec</td></tr><tr><td>1</td><td></td><td></td><td></td><td></td></tr><tr><td>2</td><td></td><td></td><td></td><td></td></tr><tr><td>3</td><td></td><td></td><td></td><td></td></tr><tr><td>4</td><td></td><td></td><td></td><td></td></tr><tr><td>5</td><td></td><td></td><td></td><td></td></tr></table>
9	Sample Calculations	
10	Graphs, Outputs	
11	Results & Analysis	
12	Application Areas	Used in domestic application to protect electrical Devices
13	Remarks	
14	Faculty Signature with Date	