Government of Karnataka
Department of Technical Education
Board of Technical Examinations, Bengaluru.

Course Title: **PROTECTIVE RELAYS AND SERVICING LAB**		Course Code:**15EE56P**	
Semester	:**V**	Course Group: **Core**	
Teaching Scheme (L:T:P)	: **0:2:4** (in Hours)	Credits	: **3 Credits**
Type of course	: **Tutorial + Practical**	Total Contact Hours	: **78**
CIE	: **25 Marks**	SEE	: **50 Marks**
Programme: ELECTRICAL AND ELECTRONICS ENGINEERING**.**			

Pre-requisites	: Knowledge about - Elements of Electrical Engineering ,Electrical Circuits, Electrical Wiring , Electrical Appliances and Protective Devices.
Course Objectives	**:** To Develop Technical Skills in the students to : a) Identify, Select and Test various Relays and Protective Devices. b) Trouble shoot faults in Electrical Appliances and suggest suitable remedies.

Course Outcomes:

On successful completion of the Course, the student will be able to:

a) *Test the operation of various protective devices and relays.*
b) *Trace the operating characteristics of different types of relays.*
c) *Identify the faults in domestic appliances and suggest suitable remedies.*
d) *Install and test- UPS system, commercial water level controller and interpret control panel wirings per drawings.*

LIST OF GRADED EXERCISES:

PART A

PROTECTIVE DEVICES AND RELAYS

SLNo.	STUDY EXPERIMENTS	09 Hours
01	**SI** symbols for most commonly used Electrical protective devices and their **ANSI Codes**. Identify different types of LV Fuses- Rewirable, Cartridge, HRC fuse, Switch Fuse Unit (SFU) and their applications. Note down the specifications. Identify different types of LV circuit breakers and their applications- MCB, MCCB, ELCB, RCCB and MPCB. Note down the specifications. Identify the class of MCB - B ,C, D and Z classes and their applications.	03

02	Identify and study power contactors and auxiliary contactors. Note down the specifications. Identify and Study- Spike busters and Domestic range Electronic Voltage Stabilizer. Note down the specifications.	**03**
03	Identify Time Multiplier Setting (TMS) and Plug Multiplier Setting (PMS) devices in Electro-mechanical relays. Note down the specifications of the Electro-mechanical Relay. Identify DIP switch settings and jumper settings in static relays (Microprocessor/microcontroller based relays) for setting Fault Voltage Level / Fault Current Level and Time Multiplier Settings as per supplier's user manual. Note down the specifications of the Static Relay. Understand time setting and current setting procedure in Numerical relays / Digital relays. Note down the specifications of the Relay. Identify CBCT and its applications. Identify lockout relay. Understand the meaning of 1.3 Sec and 3 Sec relays.	**03**
	CONDUCTING EXPERIMENTS	**30 Hours**
04	Plot the operating characteristics of (a) Fuse. (b) MCB	**03**
05	Test the operation of a digital or static type Earth leakage relay with CBCT (Adjust mA sensitivity and trip time using DIP switches).	**06**
06	Plot the operating characteristics of **ANY ONE** of the following electro-mechanical IDMT relays. a) Over voltage relay b) Under voltage relay. c) Over current and d) Earth Fault Relay.	**06**
07	Plot the operating characteristics of **ANY ONE** of the following: microprocessor / microcontroller based Over or Under voltage relay for Normal inverse time setting and Definite time setting.	**06**
08	Program , Test and Plot the operating characteristics of **ANY ONE** of the following numerical / digital relays: a) Over Voltage and Under Voltage Relay. b) Over Current Relay.	**06**
09	Conduct Break Down Voltage Test on transformer oil (dielectric strength test)	**03**

PART B
TROUBLE SHOOTING AND SERVICING

SLNo.	LIST OF GRADED EXERCISES	39 Hours
10	Trouble shoot and suggest suitable remedies for : Fluorescent lamp fitting, High pressure mercury vapour lamp and High pressure sodium vapour lamp sets.	06
11	Dismantle, Identify the parts and assemble:- Electric iron box (non automatic and automatic) .Trouble shoot and suggest suitable remedies for the above. Note down name plate details.	03
12	Dismantle, Identify the parts and assemble:- Table fan and Ceiling fan Trouble shoot and suggest suitable remedies for the above. Note down name plate details.	03
13	Dismantle, Identify the parts and assemble :- food mixer Trouble shoot and suggest suitable remedies for the above. Note down name plate details.	03
14	Dismantle, Identify the parts and assemble :- Electric Geyser and Electric Stove. Trouble shoot and suggest suitable remedies for the above. Note down name plate details.	03
15	Dismantle, Identify the parts and assemble:- Induction heater. Note down name plate details.	03
16	Dismantle, Identify the parts and assemble :- semi automatic washing machine Trouble shoot and suggest suitable remedies for the above. Note down name plate details.	03
17	Install and test the UPS with Batteries. Trouble shoot and suggest suitable remedies. Note down name plate details.	03
18	Panel wiring practice: - Wire up **ANY ONE** of the following as per standard practice. a) DOL or starter/star delta starter. b) Small control panel consisting of Isolator, MCB, voltmeter, Ammeter with CT, Indicators etc.. c) Small Distribution panel wiring and cable crimping.	06
19	Automatic water level controller (commercial type): - Identify the external connections, wire-up the level sensors and test the operation of electronic water level controller. Trouble shoot and suggest suitable remedies for the water level controller.	06
		78

Reference Books:

01. Electrical trade theory and trade practice (all volumes) – NIMMI
02. Principles of Power Systems by V K Mehtha –S. Chand and Company Ltd.
03. Electrical shop practice by Anwani -Danapatrai and sons
04. Electrical appliances – by Anwani- Danapatrai and sons
05. User Manuals of respective equipments.

e-Resource

http://www.electrical4u.com/low-voltage-switchgear

http://electrical-engineering-portal.com

http://myelectrical.com

http://www.nvistech.com/tutorials - Look for Electrical Portions.

Composition of Educational Components:

Questions for CIE and SEE will be designed to evaluate the various educational components (Bloom's taxonomy) such as:

Sl. No.	Educational Component	Weightage (%)
1	Remembering	20
2	Understanding	40
3	Application/ Analysis	30
4	Create	10
Total		**100**

Mapping Course Outcomes with Program Outcomes:

(Course Outcome linkage to Cognitive Level)

		Experiment linked	PO Mapped	Cognitive Level	Lab Sessions
CO1	*Test the operation of various protective devices*	7,10,11,12,13,14,15	2, 3, 8, 9, 10	***R/A/C***	21
CO2	*Trace the operating characteristics of different types relays*	6,8,9,16	2, 3, 8, 9, 10	***A/U***	12
CO3	*Identify the faults in domestic appliance and suggest suitable remedies.*	17,18,19,20,21,22,23	2, 3,4, 8, 9, 10	***R/U/A/E/C***	21
CO4	*Design, install and test UPS system, commercial water level controller and interpret control panel wiring drawings.*	24,25,26	2, 3,4, 8, 9, 10	***U/A/C***	9

U-Understanding; A-application/ Analysis; App-Application

Course-PO Attainment Matrix

Course	Programme Outcomes									
	1	2	3	4	5	6	7	8	9	10
PROTECTIVE RELAYS AND SERVICING LAB		3	3	3				3	3	3

LEVEL 3- HIGHLY ADDRESSED, LEVEL 2-MODERATELY ADDRESSED, LEVEL 1-LOW ADDRESSED.

METHOD IS TO RELATE THE LEVEL OF PO WITH THE NUMBER OF HOURS DEVOTED TO THE COS WHICH ADDRESS THE GIVEN PO.

IF ≥40% OF CLASSROOM SESSIONS ADDRESSING A PARTICULAR PO, IT IS CONSIDERED THAT PO IS ADDRESSED AT LEVEL 3

IF 25 TO 40% OF CLASSROOM SESSIONS ADDRESSING A PARTICULAR PO, IT IS CONSIDERED THAT PO IS ADDRESSED AT LEVEL 2

IF 5 TO 25% OF CLASSROOM SESSIONS ADDRESSING A PARTICULAR PO, IT IS CONSIDERED THAT PO IS ADDRESSED AT LEVEL 1

If < 5% of classroom sessions addressing a particular PO, it is considered that PO is considered not-addressed.

Course Delivery:

The laboratory Course will be delivered through Tutorial, laboratory interaction, group discussion, practical exercises, instructions, assignments and viva voice.

Tutorial - 1Hr:

The course co-ordinator will:

1. Explain the concept of the experiment to be conducted.
2. Ask the students to analyse circuit diagram and tabular column.
3. Guide the students to select appropriate components/ devices/ meters /equipments/ suitable accessories for the experiment to be conducted.
4. Give clear instructions about safety precautions to be followed while conductingthe experiments.

Conduction/ Execution- 2 Hr:

Student group (2 to 3) will rig up the circuits and conduct the experiment individually under the supervision of the course co-ordinator.

Course Assessment and Evaluation:

	What		To Whom	Frequency	Practical	Evidence Collected	Course Outcomes
Direct Assessment Method	CIE (Continuous Internal Evaluation)	I A Tests	Students	Two IA tests for Practical (Average marks of both the tests)	10	Blue Books	1 to 4
		Record Writing		Record Writing (Average of Marks allotted for each experiment.)	10	Lab Record	1 to 4
				Student Activity	05	3 pages Report	1 to 4
				TOTAL	**25**		
	SEE (Semester End Examination)	End Exam	Students	End of the Course	50	Answer Scripts	1 to 4
Indirect Assessment Method	Student Feedback on course		Students	Middle of The Course	Feed Back Forms		1 to 2
	End of Course Survey			End of The Course	Questionnaire		1 to 4

***CIE** – Continuous Internal Evaluation ***SEE** – Semester End Examination

Note:

1. I.A. test shall be conducted as per SEE scheme of valuation. However obtained marks shall be reduced to 10 marks. Average marks of two tests shall be rounded off to the next higher digit.
2. Rubrics to be devised appropriately by the concerned faculty to assess Student activities.

Suggested Student Activities:

ANY ONE to be submitted with 3 pages report:

THE FOLLOWING EXERCISES OR SIMILAR EXERCISES MAY BE DISTRIBUTED AMONG THE STUDENT GROUPS (3 STUDENTS/GROUP).

CONDUCTABLE EXPERIMENTS

1. Test the operation of an single phase ELCB.
2. Test the given Thermal OLR (used in DOL starter).
3. Test the given Phase failure relay/single phase preventer.
4. Test the given domestic range electronic voltage stabilizer.
5. Test the given MPCB (motor protection circuit breaker).
6. Conduct **Ratio test and Polarity** tests on CT and PT.
7. Conduct **accuracy test** on CT and PT
8. Conduct **Burden** test on CT and PT
9. Conduct Continuity test, Insulation resistance test and Secondary resistance test on CT and PT.
10. Connect and test any one type of mini Motor Protection Relay.
11. **Design, construct and test an open coil stove of 1 KW to operate on 230V 50 Hz AC supply.**
12. **Design and construct a small transformer (15 VA, 230 V/ 12 V).**

OR

STUDY EXPERIMENTS

13. Study any one control circuit drawing related to protective scheme and understand the **significance of ANSI Codes**.
14. Study the construction and working principle of MCCB and MPCB (Motor Protection Circuit Breaker.)
15. Study the construction, working principle and applications of Core Balance Current Transformer (CBCT).
16. Construction , operation and applications of lockout relay
17. Study the construction and working principle of ACB and VCB used in industries.
18. Study the Switch gear and protections in distribution transformer centre, HT and LT line/ feeders.
19. Study the LV control panels of a Apartment/Hotel / Hospital/ factory / commercial buildings. Draw SLD of Power distribution and protections.
20. Identify switch gear and protection schemes in substations.
21. Method of conducting Ratio test and polarity test on CT and PT at project sites.
22. **Study the construction, working, installation and testing of a submersible pump.**

MODEL OF RUBRICS / CRITERIA FOR ASSESSING STUDENT ACTIVITY (Course Coordinator)

Dimension	Scale					Students score (Group of five students)				
	1 Unsatisfactory	2 Developing	3 Satisfactory	4 Good	5 Exemplary	1	2	3	4	5
1	Descriptor	Descriptor	Descriptor	Descriptor	Descriptor	3				
2	Descriptor	Descriptor	Descriptor	Descriptor	Descriptor	2				
3	Descriptor	Descriptor	Descriptor	Descriptor	Descriptor	5				
4	Descriptor	Descriptor	Descriptor	Descriptor	Descriptor	4				
Note: Concerned faculty (Course coordinator) must devise appropriate rubrics/criteria for assessing Student activity for 5 marks **One activity on any one CO (course outcome) may be given to a group of FIVE students** **Grand Average/Total**						14/4 =3.5 ≈4				

Example only: MODEL OF RUBRICS / CRITERIA FOR ASSESSING STUDENT ACTIVITY-
Task given- Industrial visit and report writing

Dimension	Scale					Students score (Five students)				
	1 Unsatisfactory	2 Developing	3 Satisfactory	4 Good	5 Exemplary	1	2	3	4	5
1.Organisation	Has not included relevant info	Has included few relevant info	Has included some relevant info	Has included many relevant info	Has included all relevant info needed	3				
2. Fulfill team's roles & duties	Does not perform any duties assigned	Performs very little duties	Performs partial duties	Performs nearly all duties	Performs all duties of assigned team roles	2				
3.Conclusion	Poor	Less Effective	Partially effective	Summarises but not exact.	Most Effective	5				
4.Convensions	Frequent Error	More Error	Some Error	Occasional Error	No Error	4				
					Total marks	14/4=3.5 ≈4				

Scheme of Valuation for SEE(Semester End Examination):

Note: The SEE Question paper should be set in such a way that Questions in the Question paper should have equal nos. of Questions from Part A and Part B.

Sl. No.	Particulars	Marks
1.	Circuit diagram and procedure.	15
2.	Conduction /Execution	20
3.	Results	05
4.	Viva-voce	10
	Total Marks	**50**

Model Question Bank:

Course Title: PROTECTIVE RELAYS AND SERVICING LAB	Course Code: 15EE56P

PART A

1. Plot the operating characteristics of Fuse.
2. Plot the operating characteristics of single pole MCB
3. Test the operation of the given Earth leakage relay.
4. Plot the operating characteristics of Electro-Mechanical type Over voltage relay.
5. Plot the operating characteristics of Electro-Mechanical type under voltage relay.
6. Plot the operating characteristics of Electro-Mechanical type Over current Relay
7. Plot the operating characteristics of Electro-Mechanical type Earth Fault Relay.
8. Plot the operating characteristics of microprocessor / microcontroller based Over or Under voltage relay for Normal inverse time setting.
9. Plot the operating characteristics of static relay (microprocessor / microcontroller based Over or Under voltage relay)for Definite time setting.
10. Plot the operating characteristics of Over Voltage and Under Voltage numerical / digital relay.
11. Plot the operating characteristics of numerical/digital type Over Current Relay.

12. Conduct Break down Voltage Test on transformer oil (dielectric strength test).

PART B

13. Trouble shoot and suggest suitable remedies for Fluorescent lamp fitting
14. Trouble shoot and suggest suitable remedies for High pressure mercury vapour lamp
15. Trouble shoot and suggest suitable remedies for High pressure sodium vapour lamp set
16. Trouble shoot and suggest suitable remedies for Electric iron box (non automatic and automatic)
17. Trouble shoot and suggest suitable remedies for Table fan
18. Trouble shoot and suggest suitable remedies for Ceiling fan
19. Trouble shoot and suggest suitable remedies for food mixer.
20. Trouble shoot and suggest suitable remedies for Electric Geyser.
21. Trouble shoot and suggest suitable remedies for Electric Stove
22. Trouble shoot and suggest suitable remedies for Induction heater.
23. Trouble shoot and suggest suitable remedies for semi automatic washing machine.
24. Install and test UPS with batteries.
25. Wire up the panel board control wiring as per standard practice for DOL starter or star- delta starter.
26. Wire up the panel board control wiring as per standard practice for Small control panel consisting of Isolator, MCB, voltmeter, Ammeter with CT, Indicators etc..
27. Test the given commercial automatic water level controller.

List of Equipments:

Students Intake : 60

Students per Batch : 20

PART A

Note: The experiments may be conducted either by using trainer kits or by using discrete components or by combinations of both depending upon the resources available in the respective institutions. Please refer the example lab manual for further details.

LIST OF DISCRETE COMPONENTS.

Sl. No.	Name of Equipment and Specification	Quantity Required
1	Single phase Auto transformer , 0-270 Volts , 4 A.	06 Nos.
2	Transformer - 240V/500V (for voltage injection purpose)	04 Nos
3	Transformer - 240V/24V, 20A (for current injection purpose)	04 Nos
4	Rheostats 45ohms 8.5 A, 100 ohms 5 A, 300 ohms 2.5 A	02 Nos. each
5	Ammeter 0-5/10 /20A MI type or Digital Ammeter- Single Ph 0-20A, suitable for 1A CT secondary.	05 Nos.
6	Milli Ammeter 0-100 mA (required for earth leakage experiment)	02 Nos.
7	Voltmeter 0-300 V MI or Digital Voltmeter, Single Ph, 0-600V AC	06 N0s
8	DPST and SPST knife switches or 2 pole, 3way, 6A selector switch	06 Nos. each
9	6 A ,220 V single pole MCB	06 nos.
10	6A ,220 V 30 mA single phase ELCB	02 Nos.
11	10 A or 16 A 415 V 30 mA or 100 mA ELR with 5 A/1A CBCT	02 sets.
12	10A or 16 A or 32 A , 415 V 3 phase power contactor-any model.	05 Nos. each
13	10 A , 415 V 3 phase auxiliary contactor - any model with2 NO + 2 NC.	05 Nos. each

Sl. No.	Name of Equipment and Specification	Quantity Required
14	500 VA single phase domestic Electronic voltage stabilizer	02 Nos.
15	125 A 415V MCCB (for study / identification experiment only)	01 No.
16	3 Phase 415 V MPCB (Motor Protection Circuit Breaker) of any low current rating (for study / identification experiment only)	02 Nos.
17	3 Phase 415 V Thermal Over Load Relay 0-4.5 or 0-6 A or 0-10 A	04 Nos.
18	Motor Protection Relay – any model suitable for 3 HP, 3 Ph Induction Motor.	02 nos.
19	Digital multi-meter (for general purpose)	02 Nos.
20	Digital clamp on meter (for general purpose)	02 nos.
21	Digital Time Interval Meter 0-999 ms, 0-99.9 sec, 0-99.9 min (*Digital stop watch may also be used as alternative)	05 Nos
22	Single phase preventer (phase failure relay)	02 Nos.
23	Different types of fuses (kit-kat fuse, cartridge fuse, glass fuse etc.) (For identification experiment)	02 Nos each
24	Lock out relay with 2 NO and 2 NC (any low rating model).	02 Nos.

LIST OF TRAINER KITS

1	Electro-mechanical Relay Trainer Kit or module with 4 mm banana pin sockets and patch cords. (TYPE - Over Load Relay or Over Voltage Relay or Under Voltage Relay or Earth Fault Relay – **ANY ONE**)	01 set
2	Static Relay (OLR or OVR or UVR or EFR – **ANY ONE**) Trainer Kit or module with 4 mm banana pin sockets and patch cords.	01 set
3	Numerical relay or Digital relay (OLR or OVR or UVR or EFR – **ANY ONE**)-Trainer Kit or module with 4 mm banana pin sockets and patch cords.	01 set
4	15A AUX. Current source / current injection kit suitable for the above trainer kits with 4 mm banana pin sockets and patch cords.	03 Nos.
5	220 V AC /110 V DC AUX Voltage source / voltage injection kit suitable for the above trainer kits with 4 mm banana pin sockets and patch cords.	03 Nos.

6	Fuse and MCB testing- trainer kit	02 Nos.

NOTE: The trainer kits may be of any one of the following types.

1. **Relay with current / voltage injection source-complete set as a single unit.**

OR

2. **Separate relay module and separate current / voltage injection source.**

***PLEASE REFER THE EXAMPLE MANUAL FOR BLOCK DIAGRAMS.**

PART B

Sl. No.	Name of Equipment and Specification	Quantity Required
1	500 V Megger and multimeter (tong tester)	04 Nos.Each
2	Series Test lamp	06 Nos.
3	Tool kit consisting of spanner set, screw driver, combination plier hammer/mallet etc,	04 set
4	Fluorescent lamp fitting (electronic and non electronic)	10 Nos each
5	High pressure mercury vapour lamp	04 sets
6	High pressure sodium vapour lamp	04 sets
7	Electric Iron (non automatic and automatic)	04 Nos.Each
8	Table fan	04 Nos.
9	Ceiling fan	04 Nos.
10	Geyser (small capacity) and immersion heater	02 Nos. Each
11	Electric stove (three heat)	02 nos.
12	Food mixer	04 Nos.
13	Domestic Induction heater (1500 w)	02 nos.
14	Semi automatic washing machine (small capacity)	02 Nos.
15	Single phase induction motor (CSCR and CSIR types)	02 Nos.Each

Sl. No.	Name of Equipment and Specification	Quantity Required
16	Empty panel box with provision to fix various switch gears and accessories like Isolator, MCB, voltmeter, Ammeter with CT, Indicators etc(for DOL starter or main control panel or distribution panel)	04 Nos.
17	Commercial Electronic Automatic water level controller	02 Nos.
18	2 KVA 220 V ,36 V or 48 V DC OFF line UPS with batteries	01 set

Note: Any other similar domestic appliances already available in the laboratory may also be used.

MODEL LAB MANUAL

STUDY EXPERIMENTS

SOME OF THE TYPES OF FUSES

PORCELAIN KIT KAT FUSEGLASS FUSE FUSE HOLDER



PVC KIT KAT FUSE


HRC FUSE (BOX TYPE) TUBULAR TYPE BOTTLE TYPE

HORN GAP FUSE DOLO FUSE

TYPE OF MCBs

SP MCB DP MCB TP MCB TPN MCB

MCCB MPCB

EARTH FAULT RELAY

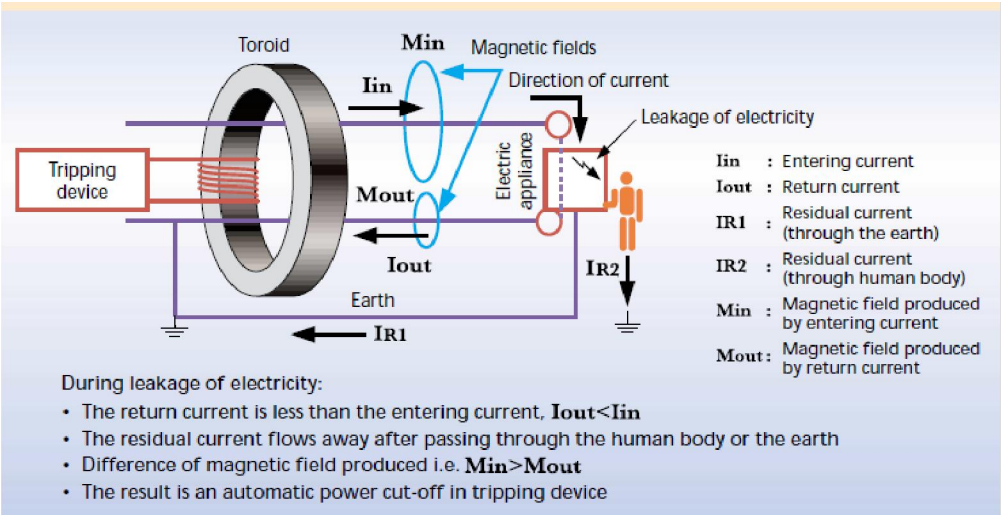
EARTH LEAKAGE CIRCUIT BREAKER

ELECTRO-MECHANICAL RELAY

STATIC RELAY (MICROPROCESSOR BASED)

NUMERICAL RELAYS

Earth Leakage Circuit Breaker or ELCB

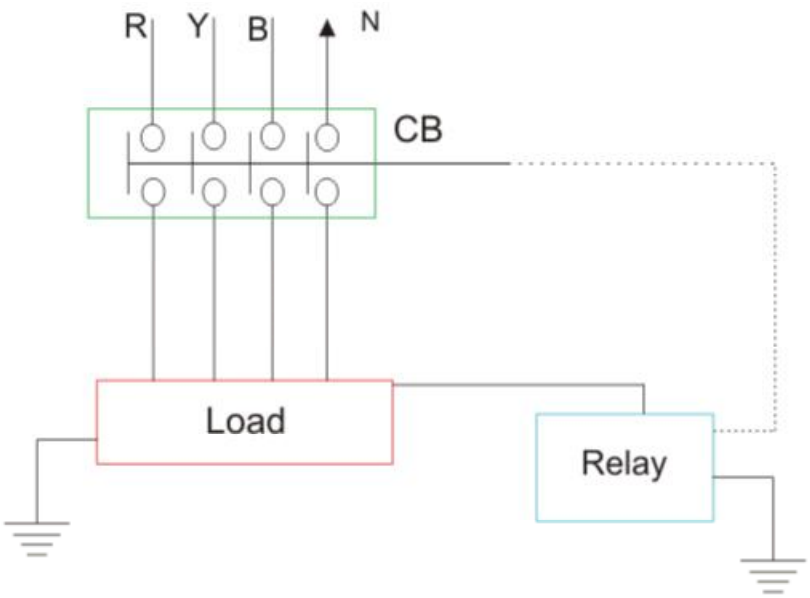


If any current leaks from any electrical installation, there must-be any insulation failure in the electrical circuit, it must be properly detected and prevented otherwise there may be a high chance of electrical shock if-anyone touches the installation. An **earth leakage circuit breaker** does it efficiently. Means it detects the earth leakage current and makes the power supply off by opening the associated circuit breaker. There are two types of **earth leakage circuit breaker**, one is **voltage ELCB** and other is **current ELCB**.

Voltage Earth Leakage Circuit Breaker

The **working principle of voltage ELCB** is quite simple. One terminal of the relay coil is connected to the metal body of the equipment to be protected against earth leakage and other terminal is connected to the earth directly. If any insulation failure occurs or live phase wire touches the metal body, of the equipment, there must be a voltage difference appears across the terminal of the coil connected to the equipment body and earth.

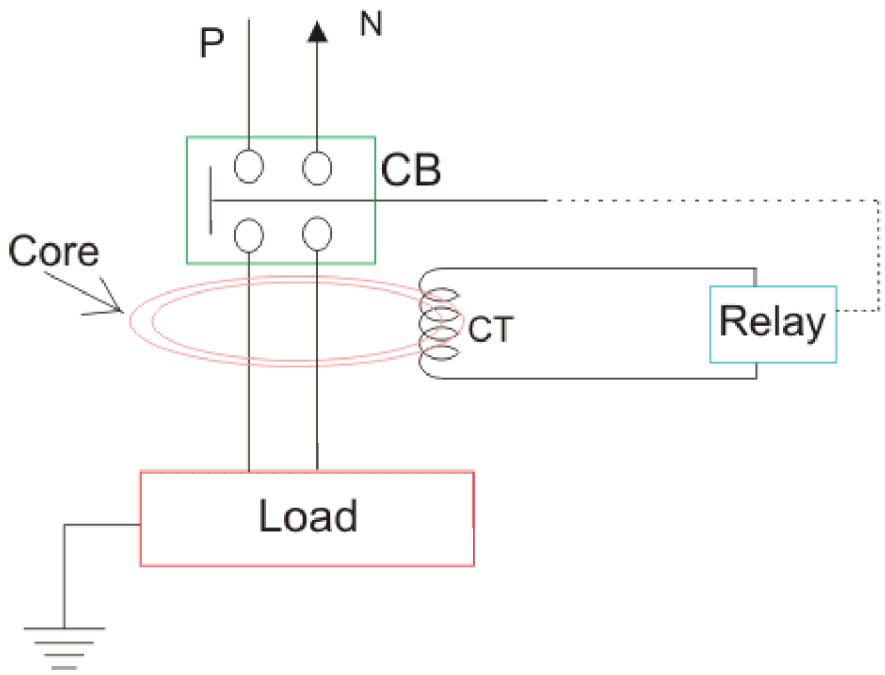
This voltage difference produces a current to flow the relay coil.



If the voltage difference crosses, a predetermined limit, the current through the relay becomes sufficient to actuate the relay for tripping the associated circuit breaker to disconnect the power supply to the equipment. The typicality of this device is, it can detect and protect only that equipment or installation with which it is attached. It cannot detect any leakage of insulation in other installation of the system.

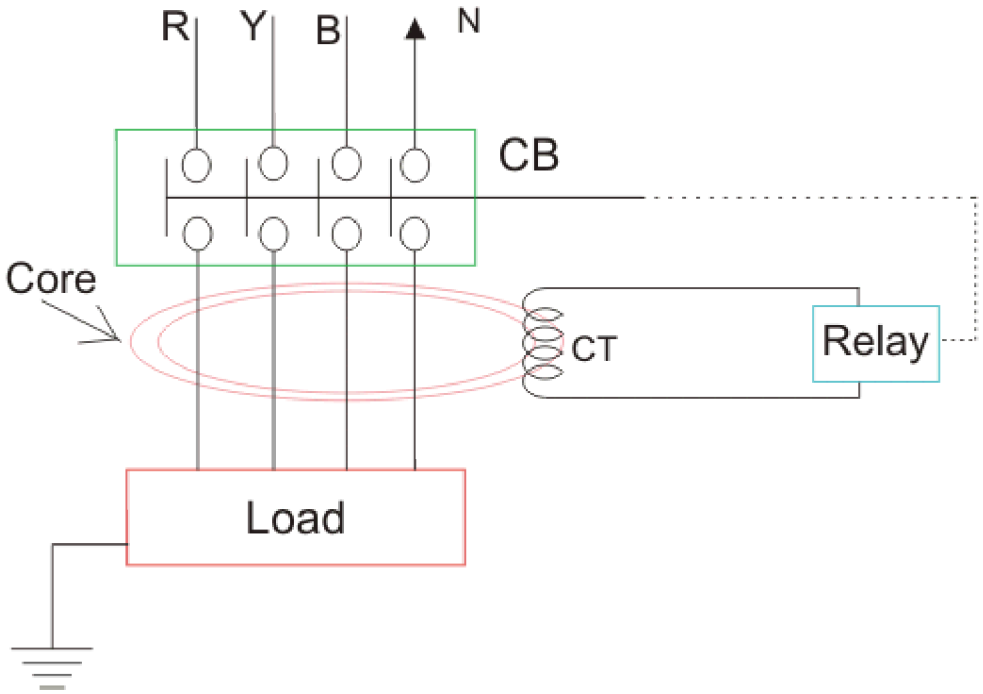
Current ELCB or RCCB or Residual Current Circuit Breaker

The **working principle of current earth leakage circuit breaker** or **RCCB** is also very simple as voltage operated ELCB but the theory is entirely different and **residual current circuit breaker** is more sensitive than ELCB. Actually, ELCBs are of two kinds, but it is general practice to refer voltage based ELCB as simple ELCB. And current based ELCB is referred as RCD or RCCB. Here one CT core is energized from both phase wise and neutral wire.



SINGLE PHASE RCCB OR CURRENT ELCB:

The polarity of the phase winding and neutral winding on the core is so chosen that, in normal condition mmf of one winding opposes that of another. As it is assumed that, in normal operating conditions the current goes through the phase wire will be returned via neutral wire if there's no leakage in between. As both currents are same, the resultant mmf produced by these two currents is also zero-ideally. The relay coil is connected with another third winding wound on the CT core as secondary. The terminals of this winding are connected to a relay system. In normal operating condition there would not be any current circulating in the third winding as here is no flux in the core due to equal phase and neutral current. When any earth leakage occurs in the equipment, there may be part of phase current passes to the earth, through the leakage path instead of returning via mental wire. Hence the magnitude of the neutral current passing through the RCCB is not equal to phase current passing through it.



THREE PHASE RESIDUAL CURRENT CIRCUIT BREAKER OR CURRENT ELCB:

When this difference crosses a predetermined value, the current in the third secondary winding of the core becomes sufficiently high to actuate the electromagnetic relay attached to it.

This relay causes tripping of the associated circuit breaker to disconnect the power supply to the equipment under protection. Residual current circuit breaker is sometimes also referred as residual current device (RCD) when we consider the device by disassociating the circuit breaker attached to RCCB. That means, the entire parts of RCCB except circuit breaker are referred as RCD.

DIFFERENCE BETWEEN EARTH LEAKAGE RELAY AND ELCB:

According to IEC 60947-2, Annex B,earth fault current is the current flowing to earth due to insulation fault and Earth leakage current is the current flowing from the live parts of the installation to earth in the absence of an insulation fault. Earth Leakage Circuit breaker (ELCB or RCCB) has integral current breaking device. It detects as well as protects

the system by opening the protected circuit when the residual current exceeds the set value.

ELR is a relay that send a signal to the shunt coil of a circuit breaker (MCCB or ACB) whenever the leakage current exceeds the set level.

DIFFERENT BETWEEN MCB AND MCCB.

MCB

- These are thermal / thermo-magnetic devices
- Provides protection against over currents and short circuits.
- Available up to 100A and have a maximum short circuit capacity of 25kA.
- Commonly used in lighting circuits.
- Trip level cannot be varied.

MCCB

- May be Thermal/ Thermo-Magnetic/ Electronic trip type
- Primarily provide protection against over-current and short circuit.
- Can provide protection against Earth Fault, Residual Currents, Under voltage etc
- Available up to the rating of2500A.
- Trip level can be varied in adjustable trip type MCCBs.
- Remote ON/OFF is possible with additional accessories
- Commonly used is loads over 100A and motor protection circuits.
- Some MCCBs are microcontroller based.
- Available in single, two, three and four pole versions.

DIFFERENCE BETWEEN MPCB AND MCCB

Motor Protection Circuit Breaker	Moulded Case Circuit Breakers
MPCBs are used to manually turn on and off electric motors and at the same time protect them from different types of faults occurring in motors	MCCBs are used in power distribution and protect Low voltage distribution circuits as well as motor loads.
MPCBs can protect motors against overload, short circuits, phase loss and under-voltage faults.	MCCBs can protect motors against overload and short circuits. MCCBs can also provide under-voltages, earth faults and phase failure faults but these features are made available with additional accessories.
MPCBs are specially designed for motor protection.	MCCBs are used for general purpose circuit protection.
Maximum load current can be set based on the full load current of motor.	Overload, short circuit and trip delay time can be set based on the application.
MPCBs are selected based on the full load current of motors and maximum possible short circuit current.	MCCBs are selected based on the maximum load current and maximum short circuit current it must interrupt safely.
MPCBs can withstand the starting currents without interrupting the circuit.	When an MCCB is used as backup protection for a motor, it may interrupt the circuit if it is selected based on its full load current. So while selecting backup MCCB for motor it must be selected based on starting current of the motor.
MPCBs have adjustable bimetallic strip for overload protection. This strip can be adjusted between two set values.	Overcurrent value of MCCBs can be adjusted from 40% to 100% of its rated value.
Overload relay is not required for motor circuits with MPCB backup.	Overload relay is required.
MPCBs can protect motor against overload and short circuit.	MCCBs, when used in motor protection circuits can protect against short circuits only. Hence additional overload relay and contactor is required.

Motor can be directly turned ON and OFF manually using a MPCB. Contactor is optional.	Contactor is a must in these cases.
Some MPCBs come with an auto resetting feature which allows motors to resume its operation after a short period from the occurrence of overload trip.	This feature is not available in MCCBs

STANDARD SIZE OF MCB / MCCB / ELCB / SFU / FUSE

MCB	Up to 63 Amp (80Amp and 100 Amp as per Request)
MCCB	Up to 1600 Amp (2000 Amp as per Request)
ACB	Above 1000 Amp
Sen. of ELCB	30mA (Domestic),100 mA (Industrial),300mA
TPN Fuse Unit (Rewire-able)	16A,32A,63A,100A,200A
Change over switch (Off Load)	32A,63A,100A,200A,300A,400A,630A,800A
SFU (Switch Fuse Unit)	32A,63A,100A,125A,160A,200A,250A,315A,400A,630A
HRC Fuse TPN (Bakelite)	125A,160A,200A,250A,400A, 630A

TESTING OF CT AND PT

Installation of protective relays at project sites has a number of possibilities for **errors while implementation of the scheme due to** incorrect connection of CT/PTs. The impact of such errors may result in unwanted tripping or **failure to trip under fault conditions**, leading to major equipment damage, disruption to supplies and potential hazards to personnel.

Commissioning tests at site are therefore invariably performed before protection equipment is set to work. The aims of commissioning tests are:

1. To ensure that the equipment has not been damaged during transit or installation
2. To ensure that the installation work has been carried out correctly
3. To prove the correct functioning of the protection scheme as a whole

Instruments transformers (CT and PT) are devices through which current and voltage are sensed for operating the relays.

The following are some of the important tests conducted on CTs and PTs

Continuity test.

Ratio test

Polarity test

Insulation resistance test

Secondary resistance test

Accuracy test.

Burden test.

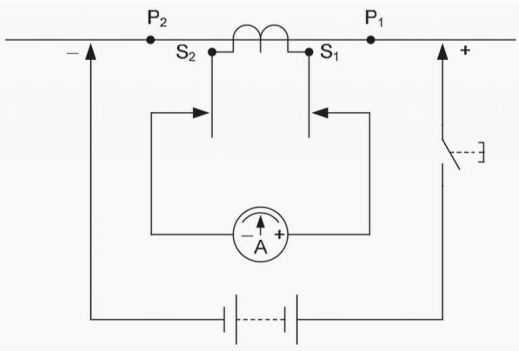
Burden test is to ensure that the connected burden to CT is within the rated burden as per the name plate details.

Inject the rated secondary current of the CT, from CT terminals towards load side by isolating the CT secondary with all connected load and observe the voltage drop across the injection points. The burden VA can be calculated as

Burden VA = Voltage drop x rated CT sec. Current.

Limits:

The calculated burden should be less than rated CT burden.



The ammeter connected to the secondary of the current transformer should be a robust moving coil, permanent magnet, centre-zero type. A low voltage battery is used, via a single-pole push-button switch, to energize the primary winding. On closing the push-button, the DC ammeter, A, should give a positive flick and on opening, a negative flick.

The voltage transformer polarity can be checked **using the method for CT polarity tests**. Care must be taken to connect the battery supply to the primary winding, with the polarity ammeter connected to the secondary winding.

ANSI CODE FOR SWITCH GEAR AND PROTECTION DEVICES.

1 – Master Element
2 – Time delay Starting or Closing Relay
3 – Checking or Interlocking Relay
4 – Master Contactor
5 – Stopping
6 – Starting Circuit Breaker
7 – Rate of Change Relay
8 – Control Power Disconnecting Device
9 – Reversing Device
10 – Unit Sequence Switch
11 – Multi-function Device
12 – Overspeed Device
13 – Synchronous-speed Device
14 – Underspeed Device

15 – Speed – or Frequency, Matching Device
16 – Data Communications Device
17 – Shunting or Discharge Switch
18 – Accelerating or Decelerating Device
19 – Starting to Running Transition Contractor
20 – Electrically Operated Valve
21 – Distance Relay
22 – Equalizer Circuit Breaker
23 – Temperature Control Device
24 – Volts Per Hertz Relay
25 – Synchronizing or Synchronize-Check Device
26 – Apparatus Thermal Device
27 – Under voltage Relay
27s- DC under voltage Relay
28 – Flame detector
29 – Isolating Contactor or Switch
30 – Annunciator Relay
31 – Separate Excitation
32 – Directional Power Relay or Reverse Power Relay
33 – Position Switch
34 – Master Sequence Device
35 – Brush-Operating or Slip-Ring Short-Circuiting Device
36 – Polarity or Polarizing Voltage Devices
37 – Undercurrent or Under power Relay
38 – Bearing Protective Device
39 – Mechanical Condition Monitor
40 – Field (over/under excitation) Relay
41 – Field Circuit Breaker
42 – Running Circuit Breaker
43 – Manual Transfer or Selector Device
44 – Unit Sequence Starting Relay
45 –DC over voltage Relay
46 – Reverse-phase or Phase-Balance Current Relay
47 – Phase-Sequence or Phase-Balance Voltage Relay
48 – Incomplete Sequence Relay
49 – Machine or Transformer, Thermal Relay-OLR
50 – Instantaneous Over current Relay
50G - Instantaneous Earth Over Current Relay (Neutral CT Method)
50N - Instantaneous Earth Over Current Relay (Residual Method)
50BF - Breaker failure
51 – AC Inverse Time Over current Relay
51G- AC Inverse Time Earth Over current Relay (Neutral CT Method)

51N- AC Inverse Time Earth Over current Relay (Residual Method)
52 – AC Circuit Breaker
52a- AC Circuit Breaker Position (Contact Open when Breaker Open)
52b- AC Circuit Breaker Position (Contact Closed when Breaker Open)
53 – Exciter or DC Generator Relay
54 – Turning Gear Engaging Device
55 – Power Factor Relay
56 – Field Application Relay
57 – Short-Circuiting or Grounding Device
58 – Rectification Failure Relay
59 – Overvoltage Relay
60 – Voltage or Current Balance Relay
61 – Density Switch or Sensor
62 – Time-Delay Stopping or Opening Relay
63 – Pressure Switch
64 – Ground Detector Relay
64R - Restricted earth fault
64S - Stator earth fault
65 – Governor
66 – Notching or Jogging Device
67 – AC Directional Over current Relay
68 – Blocking Relay
69 – Permissive Control Device
70 – Rheostat
71 – Liquid Level Switch
72 – DC Circuit Breaker
73 – Load-Resistor Contactor
74 – Alarm Relay
75 – Position Changing Mechanism
76 – DC Over current Relay
77 – Telemetering Device
78 – Phase-Angle Measuring Relay or "Out-of-Step" Relay
79 – AC Reclosing Relay (Auto Reclosing)
80 – Flow Switch
81 – Frequency Relay
82 – DC Reclosing Relay
83 – Automatic Selective Control or Transfer Relay
84 – Operating Mechanism
85 – Communications, Carrier or Pilot-Wire Relay
86 – Lockout Relay/Master Trip
87 – Differential Protective Relay
88 – Auxiliary Motor or Motor Generator

89 – Line Switch
90 – Regulating Device
91 – Voltage Directional Relay
92 – Voltage and Power Directional Relay
93 – Field Changing Contactor
94 – Tripping or Trip-Free Relay(trip circuit supervision Relay)
95 – For specific applications where other numbers are not suitable
96 – Busbar Trip Lockout relay
97 – For specific applications where other numbers are not suitable
98 – For specific applications where other numbers are not suitable
99 – For specific applications where other numbers are not suitable
150 – Earth Fault Indicator
AFD – Arc Flash Detector
CLK – Clock or Timing Source
DDR – Dynamic Disturbance Recorder
DFR – Digital Fault Recorder
DME – Disturbance Monitor Equipment
ENV – Environmental Data
HIZ – High Impedance Fault Detector
HMI – Human Machine Interface
HST – Historian
LGC – Scheme Logic
MET – Substation Metering
PDC – Phasor Data Concentrator
PMU – Phasor Measurement Unit
PQM – Power Quality Monitor
RIO – Remote Input/output Device
RTU – Remote Terminal Unit/Data Concentrator
SER – Sequence of Events Recorder
TCM – Trip Circuit Monitor
LRSS - LOCAL/REMOTE SELECTOR SWITCH
SOTF - Switch On To Fault

CONDUCTING EXPERIMENTS

NOTE:

01. Relay based experiments may be done using trainer kits and other experiments may be done using discrete components.

02. Proper protections like fuse and MCB should be used for all circuits as a safety precaution.

03. All the experiments shall be done for low current and voltage ranges.

04. The circuit diagrams given are for reference only. Alternate safe methods may be adopted.

EXPERIMENT NO.01

FUSE

AIM: TO STUDY THE OPERATION OF A FUSE AND PLOT THE TIME-CURRENT CHARACTERISTICS.

Rationale / importance of this experiment*:* A fuse is a simplest, cheapest and most reliable protective device which provides protection against over current and short circuit. One or the other type of fuse is used in all the equipments/ power circuit wirings/meter boards/ metering panels/ service connections/LT lines/HT lines/Auto-electricals/control panels etc.***It is the most fundamental element of any electrical circuit***. A fuse is definitely present in all electrical circuits irrespective of other protective device like MCBs.

The study of fuse characteristics forms the base / foundation for interpreting the characteristics of protective relays. Because the reliability of any protection scheme depends on the ***time taken by the relay to sense ,operate and open the circuit breaker*** . ***The more the delay, greater will be the damage due to fault current.*** Hence by plotting the time-current characteristics the students will be able practically understand the importance of time (quick operation) when the magnitude of fault current is high.

After doing this experiment, the students will be able to interpret the characteristic of fuse, identify the different types of fuses and fuse elements.

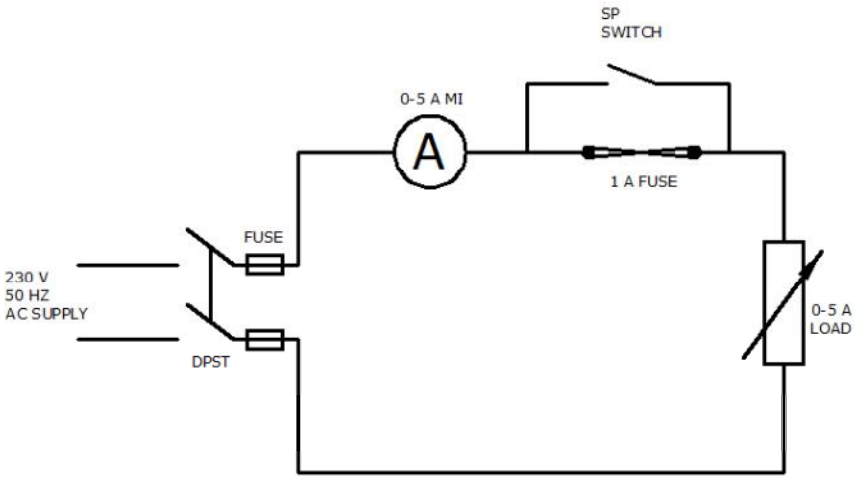
APPARATUS REQUIRED

01. Fuse wire (preferably lower rating like 1 A ,2 A ,2.5Aand 5 A).
02. Ammeter 0-5/10A MI
03. SPST Knife switch
04. 5A,230V single phase variable lamp/resistive load.

05. Stop clock / digital watch.
06. Rheostat (38 Ohm, 8.5 A) **may be used in series with ammeter for adjusting the current.**
07. Single phase 0-300 V,10 A Auto transformer.
08. Single phase 220 V / 24V 20 A, transformer (for current injection)

(Items 7 and 8 are used in alternate circuit in which current can be injected without actual load)

CIRCUIT DIAGRAM (**see alternate circuit also**)

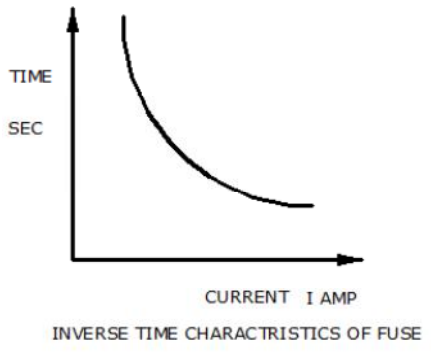


PROCEDURE :

1. Connections are made as per the circuit diagram.
2. Switch ON the main supply by keeping the Auto-transformer in zero position and SPST switch in open position.
3. Close the SPST switch and adjust the autotransformer and the load until the ammeter reads 1.25 times the rated current of the fuse.
4. Now open the SPST switch and observe the fuse to melt.
5. Replace the fuse wire and repeat the above procedure for 2, 3, 4 times the rated current of the fuses.
6. In each step note down the time taken by the fuse to melt (from the instant the SPST switch is opened till the fuse melts and ammeter reads zero).

7. Plot the time- current characteristics.

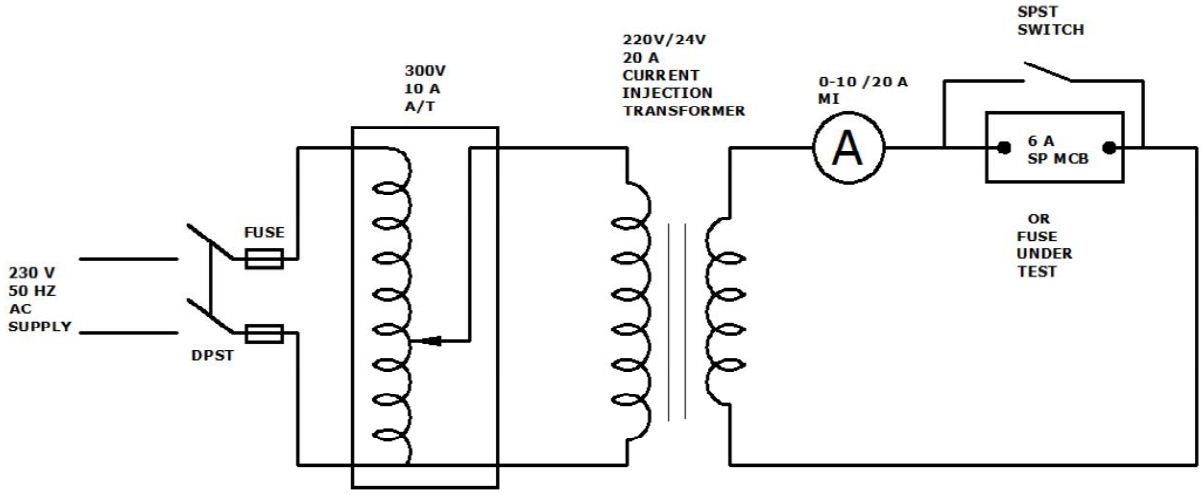
Sl no	Current I amps	Time in seconds



INVERSE TIME CHARACTRISTICS OF FUSE

Viva Questions
1 Characteristics of fuse wire.
2 Comparisons of fuse and circuit breaker
3 Types of fuses and their applications
4 Type of fuse required for protection of transformer, generator and induction motor

ALTERNATE CIRCUIT ARRANGEMENT FOR TESTING FUSE / MCB.



EXPERIMENT NO 2

AIM : STUDY THE OPERATION OF MCB AND PLOT THE OPERATING CHARACTERISTICS

MCB has two characteristics.

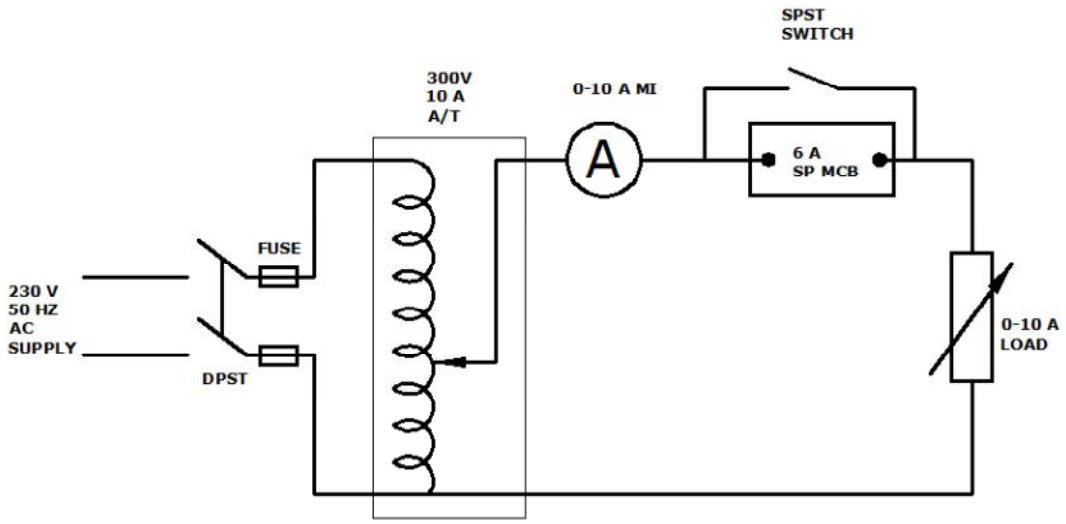
1. Inverse time characteristics during over load.
2. Instantaneous characteristics during short circuit.

MCB TYPE	TRIPPING CURRENT
TRIP CURVE CLASS B	Above 3 to 5 times rated current. Suitable for cable protection
TRIP CURVE CLASS C	Above 5 to 10 times the rated current. Suitable Domestic and residential applications and electromagnetic starting loads with medium starting currents
TRIP CURVE CLASS D	Above 10(excluding 10) to 20 times the rated current. Suitable for inductive and motor loads with high starting currents.
TRIP CURVE CLASS K	Above 8 to 12 times the rated current. Suitable for inductive and motor loads with high inrush currents.
TRIP CURVE CLASS Z	Above 2 to 3 times the rated current. These type of MCBs are highly sensitive to short circuit and are used for protection of highly sensitive devices such as semiconductor devices

APPARATUS REQUIRED:

01. Single Pole MCB (preferably lower rating like 6 A)
02. Ammeter 0-10A MI
03. 15 A SPST switch.
04. Single phase Auto-transformer (dimmer-stat) 0-300 V 10A
05. Resistive load,10 A single phase.
06. Stop clock / digital watch.

CIRCUIT DIAGRAM: (**see alternate circuit also**)



PROCEDURE :

1. Connections are made as per the circuit diagram.

2. Switch ON the main supply by keeping the Auto-transformer in zero position and SPST switch in

open position.

3. Close the SPST switch and adjust the autotransformer and the load until the ammeter reads 1.5

times the rated current of the MCB.

4. Now open the SPST switch and observe the MCB to Trip.

5. Repeat the above procedure for 2 and 3 times the rated current of the MCB.

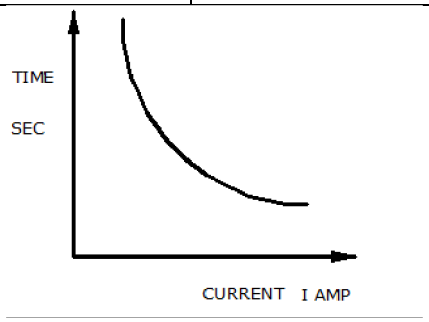
6. In each step note down the time taken by the MCB to Trip (from the instant the SPST

switch is opened till the MCB Trips)

7. Plot the time-current characteristics.

TABULAR COLUMN

Sl no	Current I amps	Time in seconds

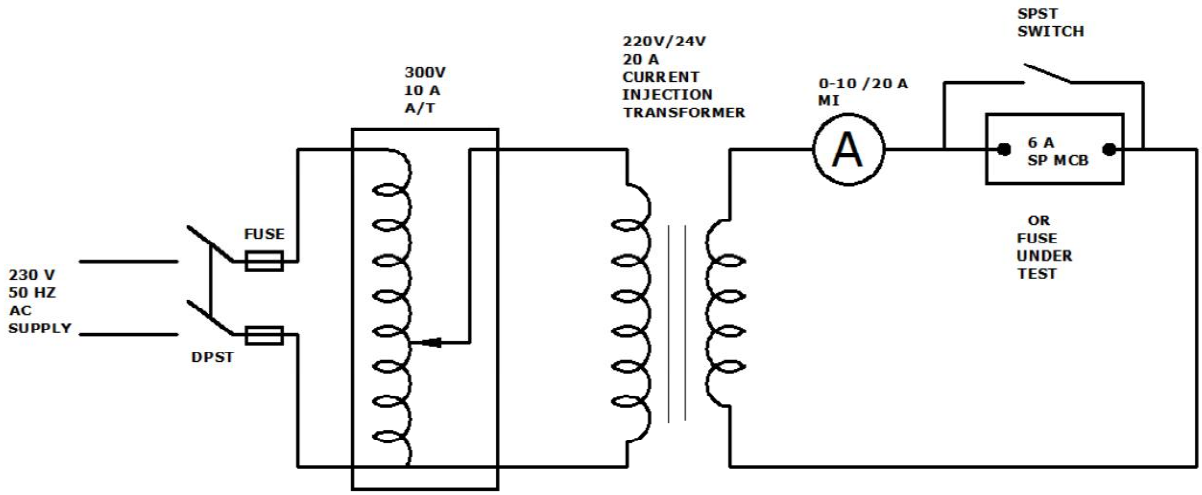


Note:(1500 W Electric Iron or Hair drier or heating coil may be used as load)

Viva questions:

1. What is an MCB.
2. Different Classes of MCB.
3. Which class of MCB is choosen for motor protection.
4. What is meant by instantaneous characteristics and inverse time characteristics of MCB.

ALTERNATE CIRCUIT ARRANGEMENT FOR TESTING FUSE / MCB.



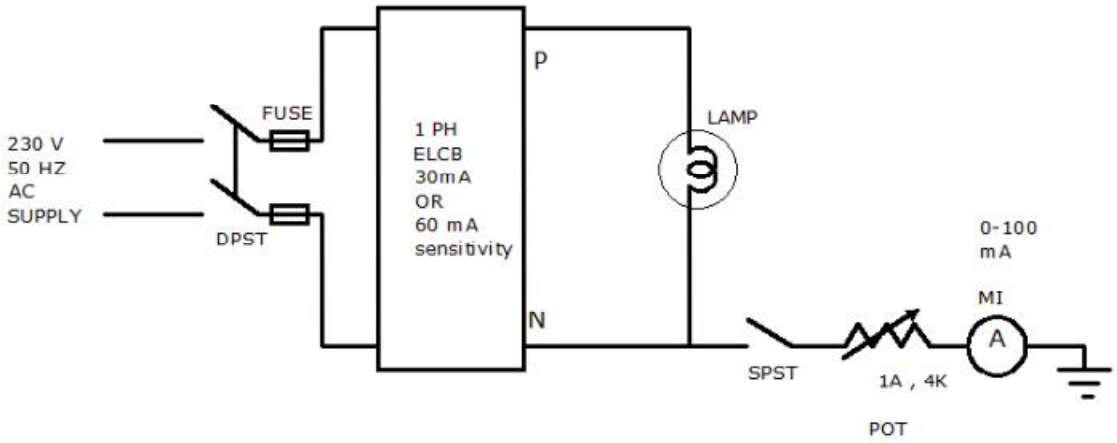
EXPERIMENT NO 3

AIM : TO TEST THE OPERATION OF SINGLE PHASE ELCB / RCCB

APPARATUS REQUIRED:

1. 10 A /16 A ,30 mA / 60mA sensitivity single phase ELCB.
2. 5 A socket with Earth pin connected to the earthing.
3. 0-100 mA Ammeter.
4. 1 A 250 V ,4k POT
5. 100 W incandescent bulb.

CIRCUIT DIAGRAM



PROCEDURE:

1.Connections are made as per the circuit diagram.

2. Switch ON the main supply and ELCB.

3. Switch ON SPST .

4. Vary the POT and note down the current at which the ELCB trips.

5. Verify the whether the ELCB tripped as per current sensitivity specification.

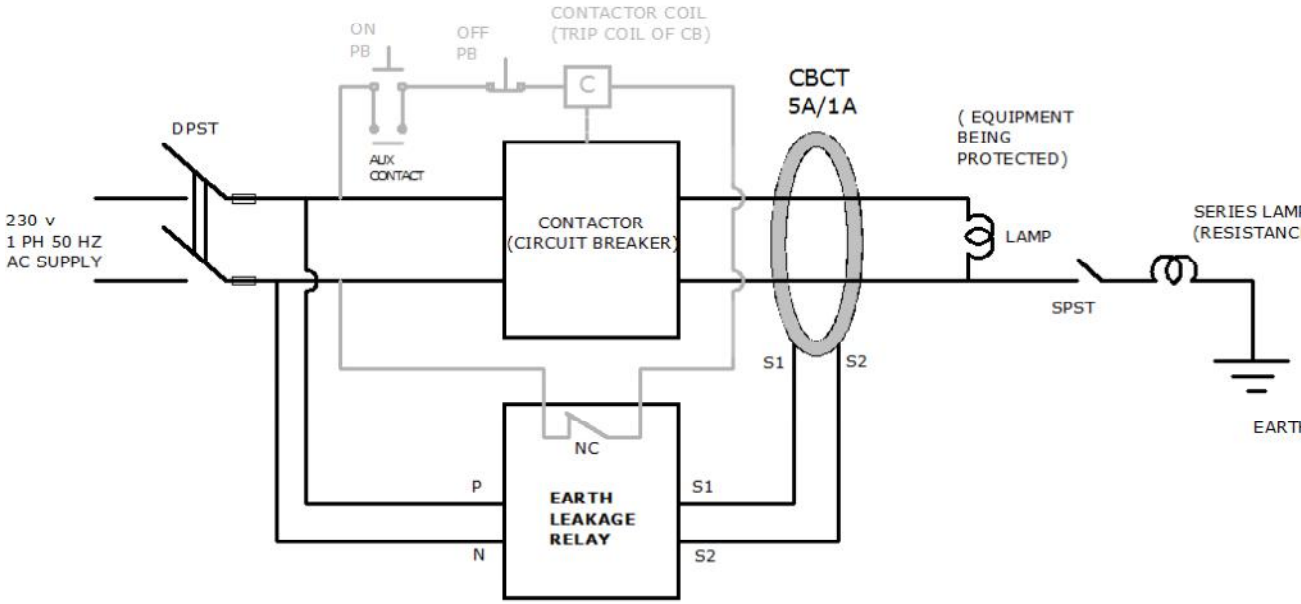
EXPERIMENT NO 4

AIM : TO TEST THE OPERATION OF A EARTH FAULT/ EARTH LEAKAGE RELAY

APPARATUS REQUIRED:

01. Power contactor with 230 V coil voltage.
02. Earth Leakage Relay with suitable CBCT set.
03. Push button switches
04. SPST
05. Lamps

CIRCUIT DIAGRAM



Note: The circuit given above is basically a DOL starter circuit. This may be treated as equivalent to a circuit breaker (MCCB or ACB)with Earth Fault/Leakage Relay and CBCT .
The lamp load may be assumed as the equipment (motor or generator or transformer) being protected against earth fault.

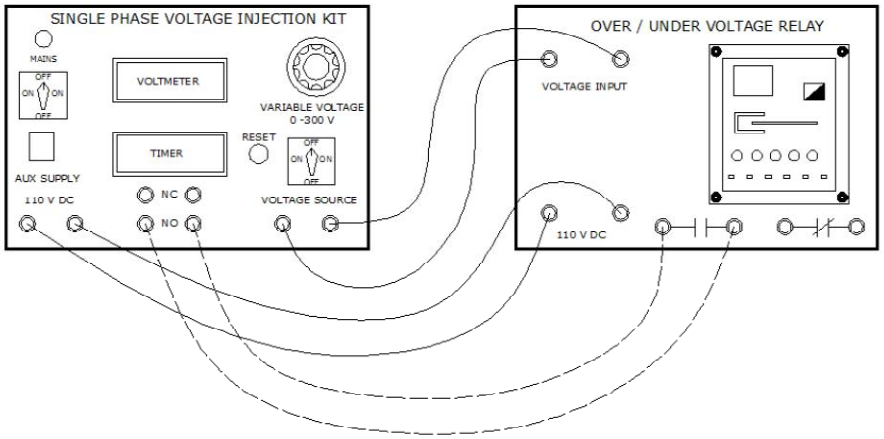
The pick up current and trip time should be adjusted using the DIP switches provided on the front face of the Earth Leakage/fault relay. (static type relays have dip switches whereas digital relays have touch key pads).

PROCEDURE:

01. Connections are made as per the circuit diagram.
02. Switch ON the main supply switch with SPST switch in open condition.
03. Press the ON push button switch so that the lamp is ON.
04. Now close SPST switch and observe the Earth Leakage Relay which will trip the contactor (Circuit Breaker)
05. Note down and Verify the tripping time and current as per DIP settings.
(The secondary current of CBCT may be measured using a ammeter in the CT circuit or using a clamp-on meter)

TRIANER KITS BASED EXPERIMENTS

EXAMPLE WIRING FOR TESTING - OVER / UNDER VOLTAGE RELAY USING



Relay testing may be done using discrete components / devices or by using trainer kits.

Keeping the cost of relays in mind and multiple handling /usage of the components, it is preferred to conduct relay testing experiments using trainer kits. The above diagram shows two kits namely **voltage injection kit and the other one is the relay under test**. (similarly, for testing over current relay **current injection kit** will be used). The wirings are made using patch cords as shown in the diagram.

The concept of wiring is same for testing other relays like over current relay, earth fault relay.

The voltage injection kit has the following features:

01. DC, 110 V Aux power supply for relay.
02. Variable Voltage Source to test the operation of the relay (over voltage or under voltage).
03. Digital timer for measuring the time taken by the relay to operate when the voltage exceeds the set value.

CONDUCTION OF THE EXPERIMENT

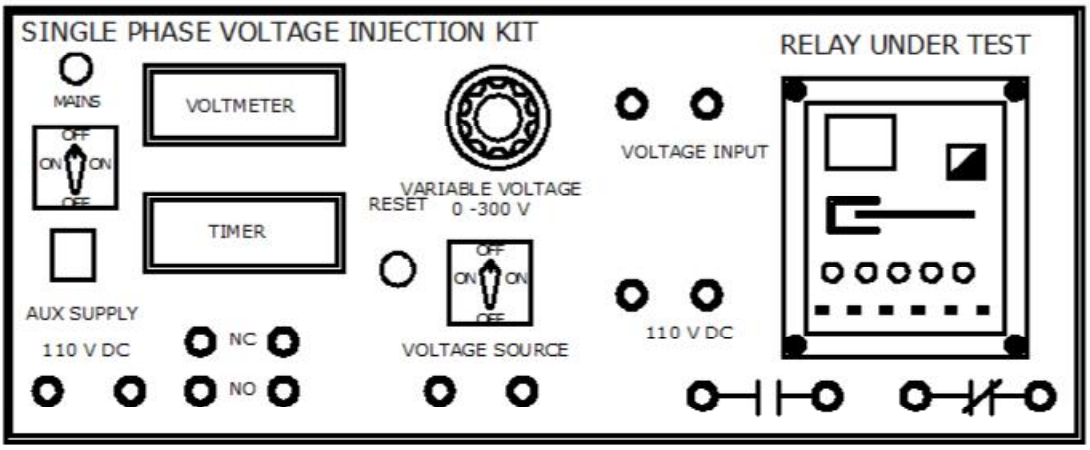
Initially the plug setting and the time setting will be made on the relay.(In case of static relays, DIP switches will be adjusted as per requirement and in case of digital / numerical relays , programming will be done by using touch pads / buttons / keys on the numerical relay)

Selector switches are provided for **set and test positions** on the voltage injection kit.

First the selector switch will be put on**set position** and the voltage source will be varied until the relay operates. After setting the voltage at which relay operates, the position of variable voltage will be kept constant (i.e, it will be not be disturbed) and the relay and the timer will be reset. Now the selector switch will be put on test position and the time taken by the relay to operate is noted. The experiment is repeated for different voltages, plug setting and time settings.

The above procedure is common for all trainer kit based relay experiments.

NOTE: The trainer kits may of separate voltage / current injection kit and separate relay kits as shown above OR combine kits as shown below.



ACTIVITY EXPERIMENTS

EXPERIMENT NO. 5

AIM: TO STUDY THE OPERATION OF DOMESTIC VOLTAGE STABILZER AND TEST IT.

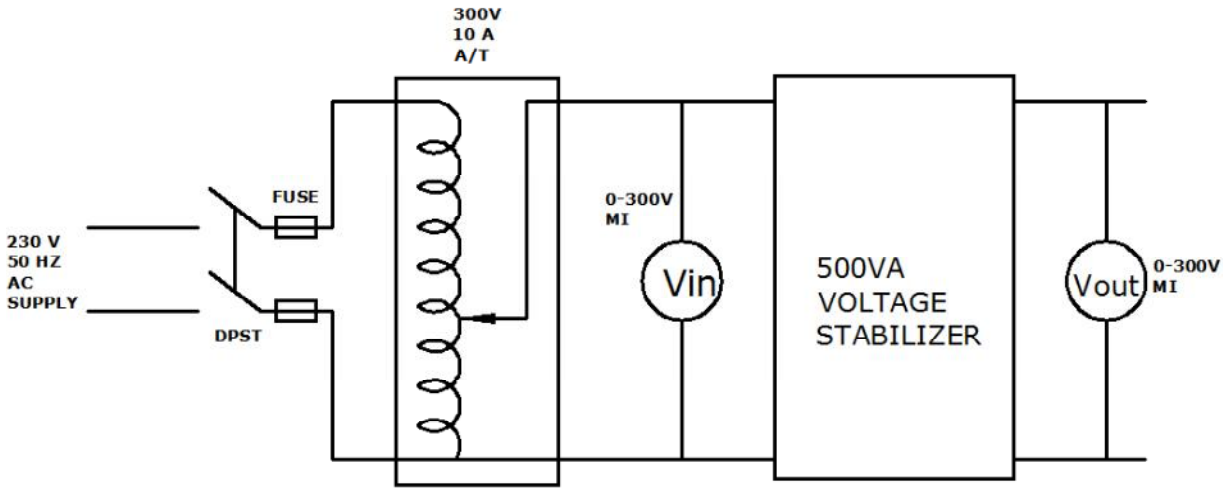
RATIONALE: Voltage stabilizer is the most common protective device used in every house hold for protection of expensive gadgets like LED TV , Fridge, Air conditioner etc., against over voltage.

By doing this experiment the student will learn to test the operating voltage range of the stabilizer specified the manufacturer.

APPARATUS.

01. Single phase Voltage stabilizer 500 VA .
02. Voltmeter 0-300V MI
03. 10A 0-30 V Single phase Auto-transformer (dimmer-stat)

CIRCUIT DIAGRAM



PROCEDURE:

1. Connections are made as shown in the circuit diagram.
2. Keep the power ON switch of the stabilizer in OFF condition.
3. Switch On the main supply and set the voltmeter Vin to normal operating voltage (220 V)
4. Switch on the stabilizer and note the output voltage Vout.

5. Now slowly increase the voltage by varying the autotransformer and observe both Vin and Vout until the stabilizer trips. Note down the over voltage Vin at trip.
6. Repeat the above procedure for under voltage trip by decreasing the input voltage.

TABULAR COLUMN

Low voltage trip in volts	High voltage trip in volts

EXPERIMENT NO.6

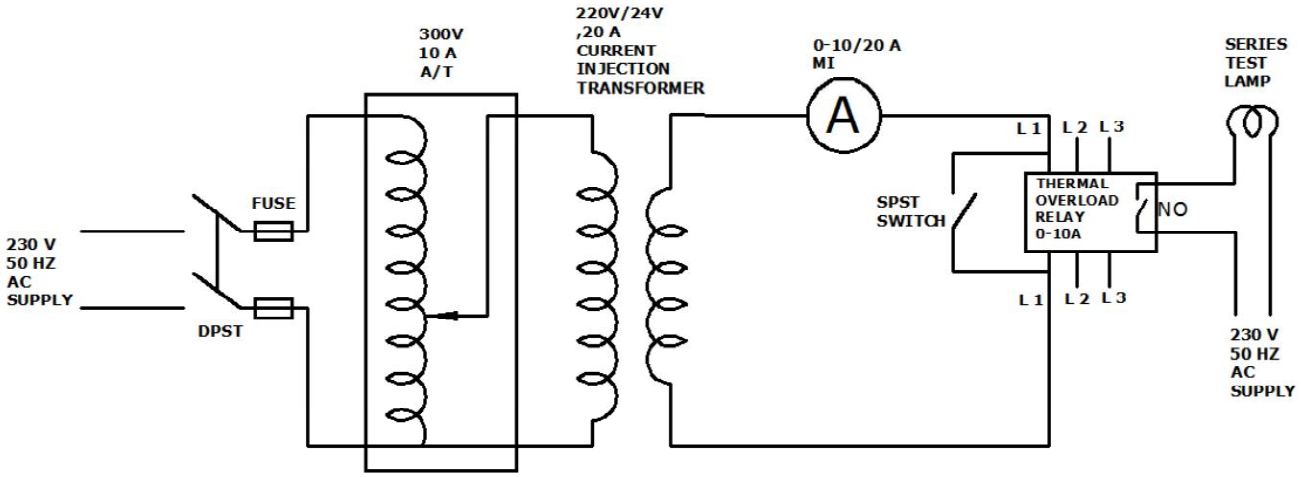
AIM: TO TEST THE OPERATION OF THERMAL OVER LOAD RELAY AND PLOT THE TIME - CURRENT CHARACTERISTICS.

APPARATUS REQUIRED

01. Themal over load relay0-10 A ,415 V
02. Ammeter 0-10A MI
03. 15 A SP switch

04. 10A 0-300 V Single phase Auto-transformer (dimmer-stat)
05. 220V/12V ,20 A Single phase transformer(CURRENT INJECTION).
06. Stop clock / digital watch.

CIRCUIT DIAGRAM



PROCEDURE:

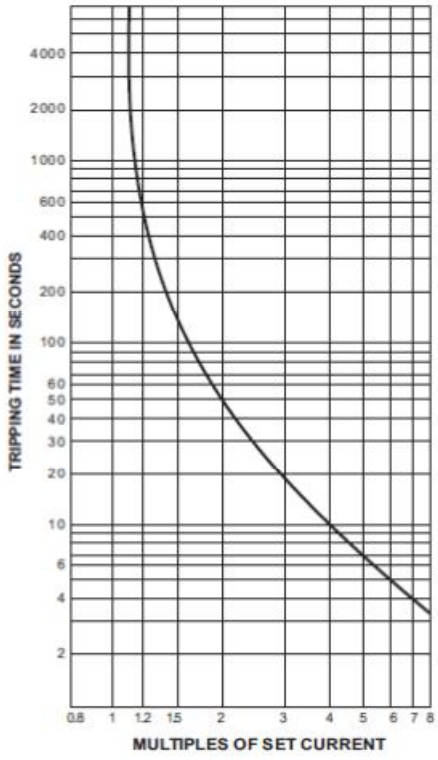
1. Connections are made as per the circuit diagram.
2. Adjust the current rating on OLR (using pointer or knob in the frontside).
3. Switch ON the main supply by keeping SPST in closed position.
4. Switch ON and the vary the autotransformer and set the ammeter current to the desired test current (say 1.5 or 2 times the rated current of the OLR)
5. Now open the SPST and observe the OLR to trip.
6. Note down the time for tripping.

7. Reset the OLR and wait for 10 minutes for the OLR to cool down.
8. Repeat the above experiment for 2.5, 3 , 4 times the rated current of OLR).
9. The operation of NO and NC of OLR while tripping may be checked with the help of series test lamp as shown in the circuit diagram.
10. Plot the time-current characteristics.

TABULAR COLUMN

Sl. No.	Current setting on OLR in Amps	Tripping current Amps	Tripping Time in secs.

Example graph.



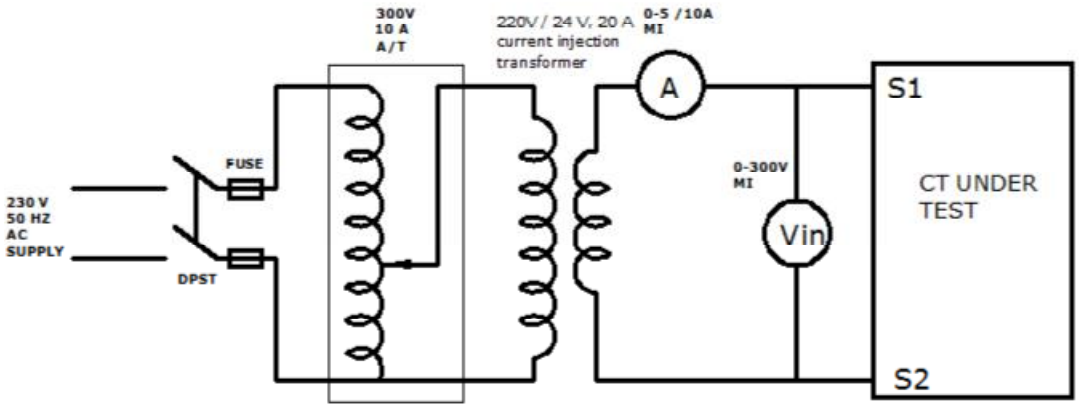
EXPERIMENT NO. 7

AIM: TO CONDUCT **BURDEN TEST** ON CT AND DETERMINE ITS**VA** RATING.

APPARATUS REQUIRED:

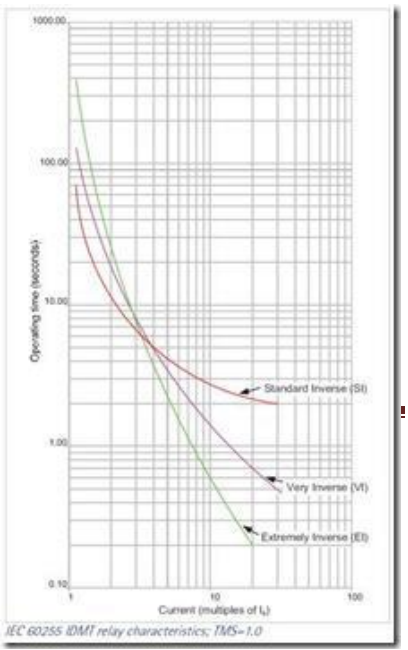
01. CT on which burden test has to be conducted.
02. Ammeter 0-5A MI
03. Voltmeter 0-300 V MI
04. Auto-transformer 0-300 V , 10 A
05. Current injection transformer- 220/12 V, 20 A

CIRCUIT DIAGRAM



PROCEDURE:

01. Connections are made as per the diagram.
02. Switch ON the main supply and slowly vary the autotransformer till rated current passes through secondary of the CT.
03. Note down the voltage drop across the secondary of the CT.
04. Calculate the **VA burden** = Voltmeter reading x Ammeter reading.



SOME USEFUL TIPS / INFORMATION

Evolution of Relays:

Mechanical relays developed in the 1800s were the first form of electrical protection. While still being reliable and widely used these were superseded by static relays in the early 1980s. Static relays have no moving parts (hence the name) and operated on the basis of analogue circuitry. More recently static relays have been superseded by first digital relays and now numerical microprocessor based devices.

Tripping Curves

IEC 60255 Characteristics

The IEC 60255 standard defines four standard current time characteristics – standard inverse (SI), very inverse (VI), extremely inverse (EI) and long-time inverse. Each characteristic can be calculated from:

$$t = \frac{k}{\left(\frac{I}{I_s}\right)^{\alpha} - 1} \cdot TMS$$

where:

t = tripping time in (S)

I = fault (actual) secondary CT current (A)

I_s = relay pick-up current setting)

TMS = time multiplier setting

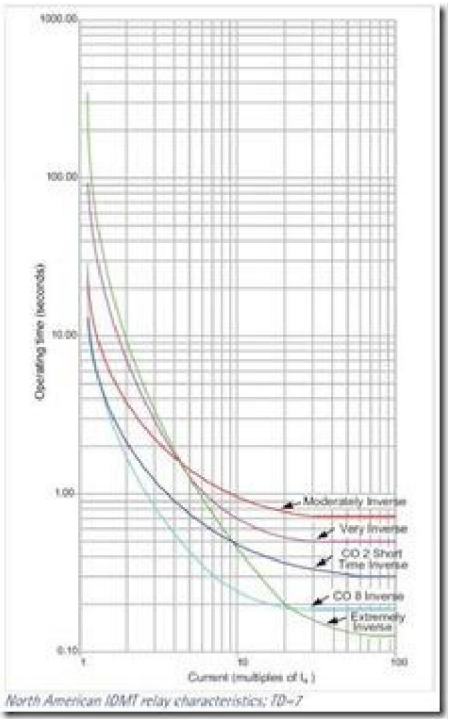
Characteristic	**α**	**K**
Standard Inverse	0.02	0.14
Very Inverse	1.0	13.5
Extremely Inverse	2.0	80
Long-time	1.0	120

Inverse

Relay characteristics are sometimes classified according to the tripping time at 10 times the setting current (i.e. [3s/10] - a standard inverse curve which will trip in 3 seconds at 10 times the current setting). Tripping times for the various relays are:

Standard Inverse (SI)	[3s/10] or [1.3s/10]
Very Inverse (VI)	[1.5s/10]
Extremely Inverse (EI)	[0.8s/10]
Long Time Standard Earth Fault	[13.3s/10]

North American Characteristics



North American IDMT relay characteristics; TD=7

Current time characteristics in North America as classified as IEEE Moderately Inverse, IEEE Very Inverse, IEEE Extremely Inverse, US $C0_8$ Inverse and US CO_2 Short Time Inverse. These are given by:

$$t = \frac{TD}{7} \times \left(\frac{K}{\left(\frac{I}{I_s} \right)^{\alpha} - 1} + \beta \right)$$

where:

t = tripping time in (S)

I = fault (actual) secondary CT current (A)

I_s = relay pick-up current setting

TD = time dial setting (multiplier)

Characteristic α β K

IEEE Moderately Inverse	0.02	0.114	0.0515
IEEE Very Inverse	2.0	0.491	19.61
IEEE Extremely Inverse	2.0	0.1217	28.2
US CO_8 Inverse	2.0	0.18	5.95
US CO_2 Short Time Inverse	0.02	0.01694	0.02394

Setting Example (IEC 60255)

An 1000 Amp breaker protected by relay with Standard Inverse characteristic. The relay pick-up current value is set at 0.8, time multiplier setting is 7 and the fault current is 8000 A. What will be the tripping time?

- - from the table α = 0.02, K = 0.14
- - pick-up current setting = 1000 A x 0.8 = 800 A
- - using the IEC 60255 equations, the tripping time is:

$$t = \frac{0.14}{\left(\frac{8000}{800}\right)^{0.02} - 1} \times 7 = 20\,s$$

CDG11/16 Curves

If you have the 3sec relay's trip curve, you can just multiply the time with 1.3 and divide the answer with 3. That is the time for the 1.3sec relay.

GEC / English Electric / Alstom /Areva

Labeling the model from left to right, using number CDG31 etc. 1=C, 2=D c=G etc.:

1. operating quantity (C - current, D - differential, V- voltage)
2. basic movement (D - induction disc, M - balanced armature, T - static)
3. Application (G- general or generator, E - earth, U - definite time, F - flag, M - motor, D - directional)
4. number of units (ie CDG3x is a 3 element / unit CDG relay)

5. characteristic (for CDG, 1= std inverse (3s), 2= long time delay, 3=very inverse (1.55s), 4=extremely inverse (0.6s), 6=Long Time Standard Earth Fault)
6. case size (15 different cases, A=size 1 draw out, 10 terminal etc.)
7. case mounting (F=flush etc.)
8. identification (identifies rating, contact arrangement etc. 2= 'metricated')
9. suffix ('5' is for 50Hz only relays, '6' for 60Hz)

Example - CDG 34EG0022A5 is a current operated, induction disc general relay, with three extremely inverse elements and is a 50 Hz unit.

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