Channabasaveshwara Institute of Technology

(Affiliated to VTU, Belgaum & Approved by AICTE, New Delhi)

(**NAAC Accredited & ISO 9001:2015 Certified Institution)**

NH 206 (B.H. Road), Gubbi, Tumkur – 572 216. Karnataka.

Department of Electrical & Electronics Engineering

Switchgear and Protection (IPCC)

BEE 701

Version 4.0

jul- 2026

Prepared by:

Mrs. Rekha D K &
Mr. Anand S
Assistant Professors

Reviewed& Approved by:

Mrs. Radha B N

Assistant Professor& Head,

Channabasaveshwara Institute of Technology

(Affiliated to VTU, Belgaum & Approved by AICTE, New Delhi)

(NAAC Accredited & ISO 9001:2015 Certified Institution)

NH 206 (B.H. Road), Gubbi, Tumkur – 572 216. Karnataka.

Department of Electrical & Electronics Engineering

INSTITUTION VISION
To create centres of excellence in education and to serve the society by enhancing the quality of life through value based professional leadership

INSTITUTION MISSION
1. To provide high quality technical and professionally relevant education in a diverse learning environment. 2. To provide the values that prepare students to lead their lives with personal integrity, professional ethics and civic responsibility in a global society. 3. To prepare the next generation of skilled professionals to successfully compete in the diverse global market. 4. To promote a campus environment that welcomes and honors women and men of all races, creeds and cultures, values and intellectual curiosity, pursuit of knowledge and academic integrity and freedom. 5. To offer a wide variety of off-campus education and training programmes to individuals and groups. 6. To stimulate collaborative efforts with industries, universities, government and professional societies. 7. To facilitate public understanding of technical issues and achieve excellence in the operations of the institute.

QUALITY POLICY

Our organization delights customers (students, parents and society) by providing value added quality education to meet the national and international requirements. We also provide necessary steps to train thestudents for placement and continue to improve our methods of education to the students through effective quality management system, quality policy and quality objectives.

Channabasaveshwara Institute of Technology

(Affiliated to VTU, Belgaum & Approved by AICTE, New Delhi)

(**NAAC Accredited & ISO 9001:2015 Certified Institution)**

NH 206 (B.H. Road), Gubbi, Tumkur – 572 216. Karnataka.

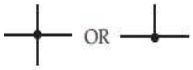
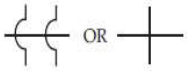
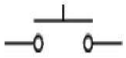
Department of Electrical & Electronics Engineering

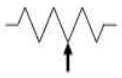
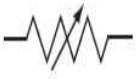
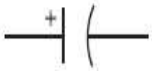
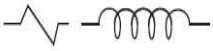
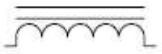
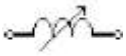
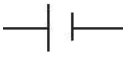
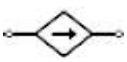
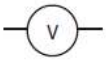
DEPARTMENT VISION
To establish a centre of excellence in Electrical and Electronics Engineering education and to foster the development of technically proficient professionals in Electrical Science and related fields while instilling a strong sense of ethics to serve the society efficiently.

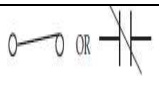
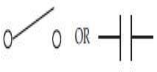
DEPARTMENT MISSION	
M1	To provide competent human resources, and to ensure that our students receive top-notch education and mentorship, enabling them to excel in electrical and electronics engineering and allied fields.
M2	To provide quality infrastructure, and to create an environment conducive to innovative learning and research, empowering our students to explore the frontiers of Electrical Sciences and related disciplines.
M3	To foster strong collaborations with industry and research institutions, and to facilitate the exchange of knowledge and ideas, allowing our students and faculty to remain at the cutting edge of technological advancements and practical applications in the field..
M4	To emphasize social responsibility and professional ethics in our curriculum and community engagement, and to prepare our graduates to be conscientious leaders who use their expertise to benefit society, making a positive impact through their work in Electrical Sciences and allied fields..

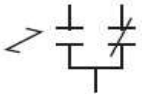
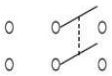
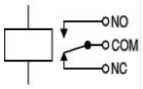
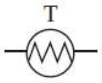
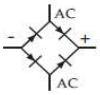
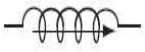
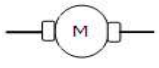
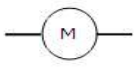
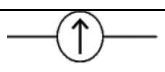
CONTENTS

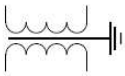
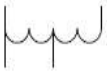
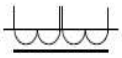
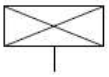
STUDY OF ELECTRICAL SYMBOLS

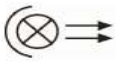
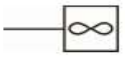
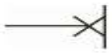
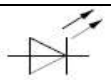
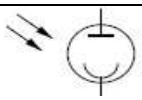
Sl. No.	Particulars	Symbol
1	Electrical wire	
2	Connected wires	
3	Not connected wires	
4	SPST Toggle switch	
5	SPDT Toggle switch	
6	Pushbutton Switch (N.O)	
7	Pushbutton Switch (N.C)	
8	Earth Ground	
9	Chassis ground	
10	SPST Relay	
11	SPDT Relay	
12	Digital Grounding	
13	Resistor	

14	Potentiometer	
15	Variable Resistor	
16	Polarized Capacitor	
17	Inductor	
18	Iron-core Inductor	
19	Variable Inductor	
20	DC Voltage Source	
21	Current Source	
22	AC Current Source	
23	Generator	
24	Battery Cell	
25	Battery	
26	Controlled Voltage Source- DC	
27	Controlled Current source	
28	Voltmeter	

29	Ammeter	
30	Ohm meter	
31	Wattmeter	
32	Lamp/Light/Bulb	
33	Motor	
34	Transformer	
35	Fuse	
36	Electrical Bell	
37	Buzzer	
38	Bus	
39	Loudspeaker	
40	Microphone	
41	Arial Antenna	
42	Circuit Breaker	
43	Contacts Closed – NC	
44	Contacts Open - NO	

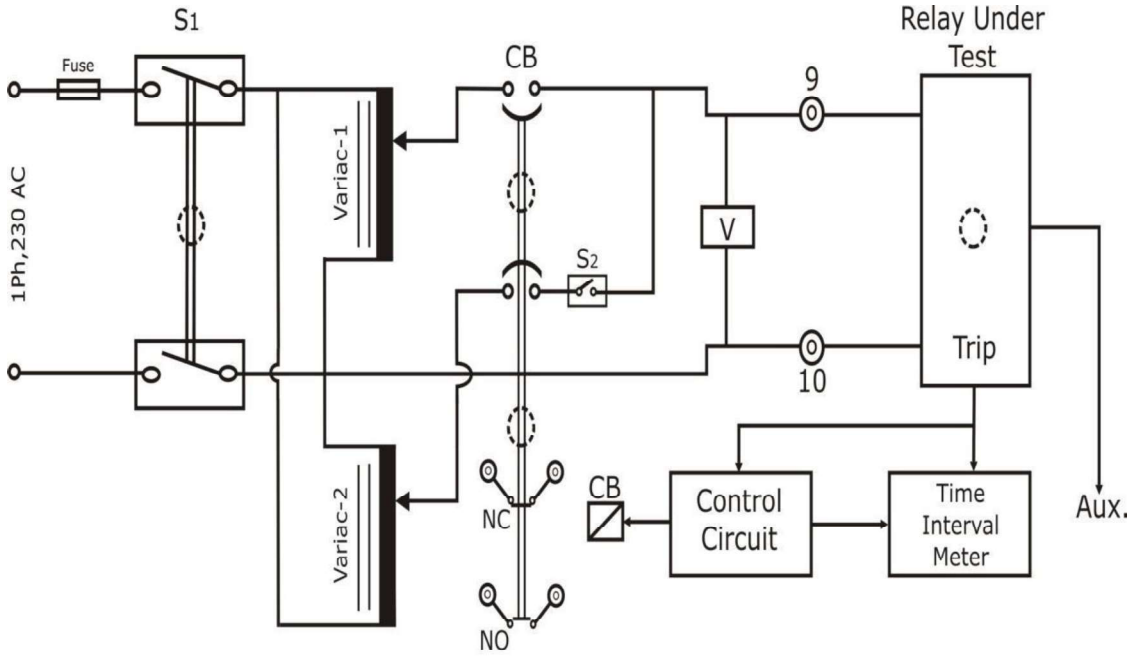
45	AC Generator	
46	DC Generator	
47	Relay with Transfer Contacts	
48	Current Transformer	
49	Loud Speaker	
50	Heater	
51	DPST	
52	DPDT	
53	Relay with Contacts	
54	Thermistor	
55	Full wave, Bridge Type Rectifier	
56	Inductor Solenoid / Coil	
57	DC Motor	
58	AC Motor	
59	Galvanometer	

60	VAR Meter	
61	Power-Factor Meter	
62	Isolation Transformer	
63	Variable Voltage Transformer	
64	Auto Transformer	
65	Current Transformer with Two Secondary Windings On One Core	
66	Motor Operated Valve	
67	Electrical Distribution Panel	
68	Junction Box	
69	Instrument Panel or Box	
70	Lightning Arrestor	
71	Lighting Rod	
72	Choke	
73	One-way switch	
74	Two-way switch	
75	Intermediate switch	

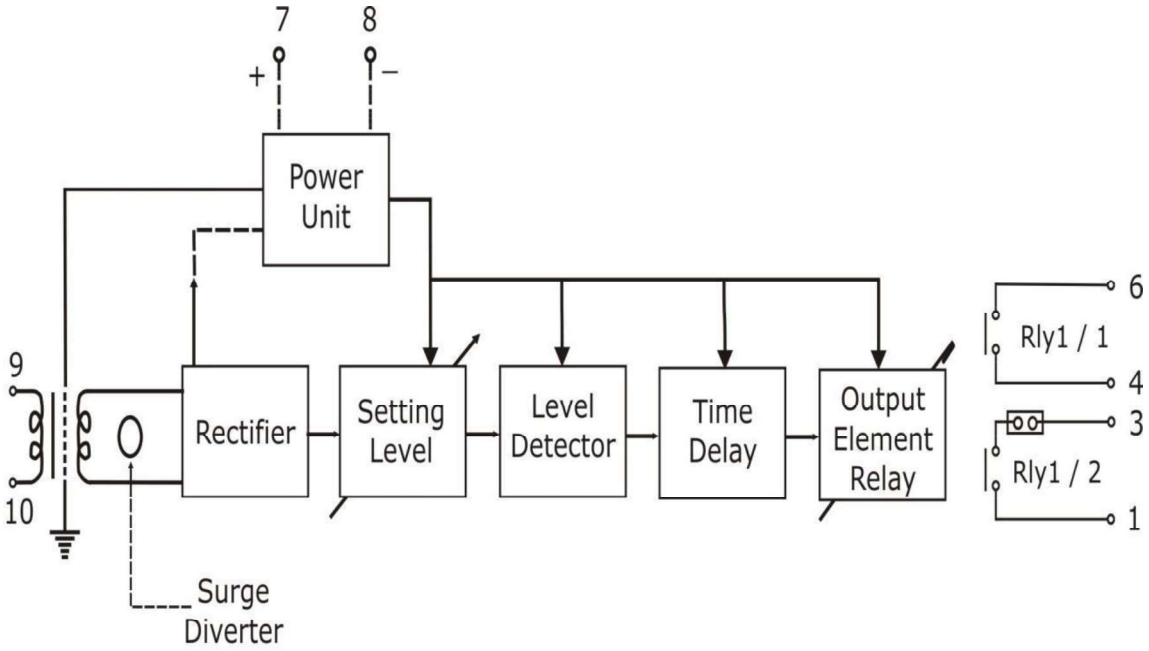
76	Spot light	
77	Distribution Board	
78	Fan	
79	Joint Box	
80	Short circuit device	
81	Emergency push button	
82	Lighting outlet position	
83	Lighting outlet on wall	
84	Connector	
85	Light Emitting Diode	
86	Photo Cell	
87	Voltage Indicator capacitive	
88	General caution	
89	Poisonous sign	
90	Radio Activity sign	

91	Ionizing radiation sign	
92	Non-ionizing radiation sign	
93	Biohazard sign	
94	Warning sign	
95	High voltage sign	
96	Magnetic field symbol	
97	Chemical weapon symbol	
98	Laser hazard sign	
99	First Aid	
100	Fire Extinguisher	

SOLID STATE UNDER VOLTAGE DEFINITE TIME RELAY



Under Voltage Relay Test Unit



Static Definite Time Under Voltage Relay Unit

Experiment No. 1 **Date: __ /__ /_____**

IDMT Characteristics of Over Voltage or Under Voltage Relay (Solid State or Electromechanical type

AIM: To study the operation of solid state under voltage relay and to plot the graph between trip time and % of closing voltage.

APPARATUS REQUIRED

1. Under voltage relay test unit.
2. Static Definite time Under voltage Relay unit
3. Connecting probes

PROCEDURE

1. Connect as per interconnection diagram
2. Set the relay for under voltage level.
3. Set TRIP TIME.
4. Ensure Time interval meter selection switch is in TIM position.
5. Ensure S2 switch is in ON position.
6. Bring both dimmer stats to zero position.
7. Bring toggle switch to SET mode.
8. Connect the power cord.
9. Put on the mains using MAINS ON switch.
10. Adjust the voltage level above the threshold level of under voltage relay setting. (Using dimmer-1).
11. Push TEST START BUTTON.
12. Adjust the under voltage level (ie.Less than relay set voltage) using dimmer-2.
13. Push TEST STOP/RESET button.

TABULAR COLUMNS

% of Closing Voltage = Fault Voltage/Set Voltage

Trip time:_____

Set Voltage	Fault Voltage	Trip time (sec)	%of closing voltage		Set voltage	Fault Voltage	Trip Time (sec)	%closing voltage

Trip Time: _____

Set Voltage	Fault Voltage	Trip Time (Sec)	% of closing voltage		Set Voltage	Fault Voltage	Trip Time (Sec)	% of closing voltage

14. Don't disturb the dimmer stats 1&2.

15. Bring the Toggle switch to TEST mode.

16. Push TEST START BUTTON, Note down the voltage just before tripping. (Circuit breaker ON, CB ON indicator will glow, time interval meter starts up counting. Under voltage relay trip occurs 'TRIP' indicator will glow).

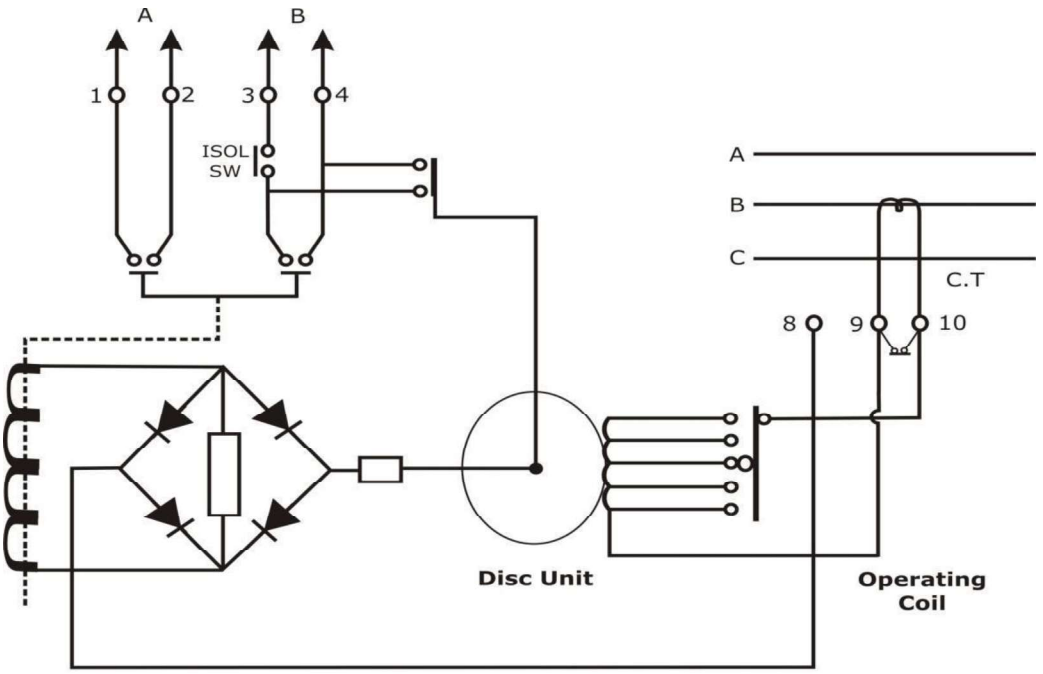
17. Note down the Time Interval Meter reading. (Drop off time)

18. Press the RESET button.

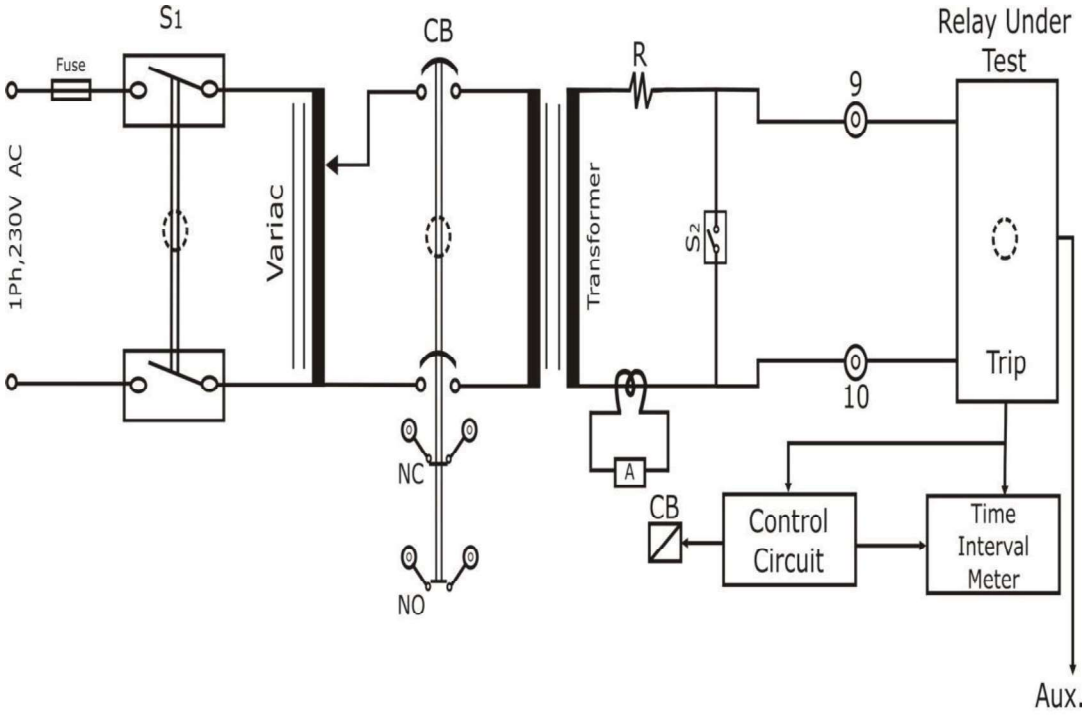
19. Repeat operation by adjusting different voltage & TMS

settings.

20. Draw the graph between Trip time Vs %of closing voltage.



Electro-mechanical Over Current Relay Unit



Secondary Currnet injection Unit for Over Current Relay

Experiment No. 2 **Date: __ /__ /_____**

IDMT characteristics ELECTRO MECHANICAL OVER CURRENT RELAY

AIM To study the operation of electro mechanical over current Relay and to plot the curve between Trip time Vs PSM.

APPARATUS REQUIRED

1. Electro-Mechanical Over current rely unit
2. Secondary Current injection Unit.
3. Connecting probes

PROCEDURE

1. Set the relay current using plug setting.
2. Set TSM.
3. Ensure Time interval meter selection switch is in TIM position.
4. Ensure protection time switch is ON position.
5. Connect the power cord.
6. Bring dimmer to zero position.
7. Put on the mains using MAINS ON switch then Mains on indicator, ammeter display, relay power and Timer display will glow.
8. Push TEST START BUTTON, CB ON indicator will glow.
9. Adjust the dimmer stat, set the approximate injection current (within 30 seconds otherwise protection timer will activate and circuit breaker and it will off).
10. Push TEST STOP/RESET BUTTON.
11. Don't disturb the dimmerstat.
12. Bring toggle switch to TEST mode.

TABULAR COLUMNS

PSM= Fault Current / Plug setting

TSM:_______ Plug setting:_____		
Fault current(A)	Operating Time(Sec)	PSM

TSM:_______ Plug setting:_____		
Fault current(A)	Operating Time(Sec)	PSM

TSM:_______ Plug setting:_____		
Fault current(A)	Operating Time(Sec)	PSM

TSM:_______ Plug setting:_____		
Fault current(A)	Operating Time(Sec)	PSM

TSM:_______ Plug setting:_____		
Fault current(A)	Operating Time(Sec)	PSM

TSM:_______ Plug setting:_____		
Fault current(A)	Operating Time(Sec)	PSM

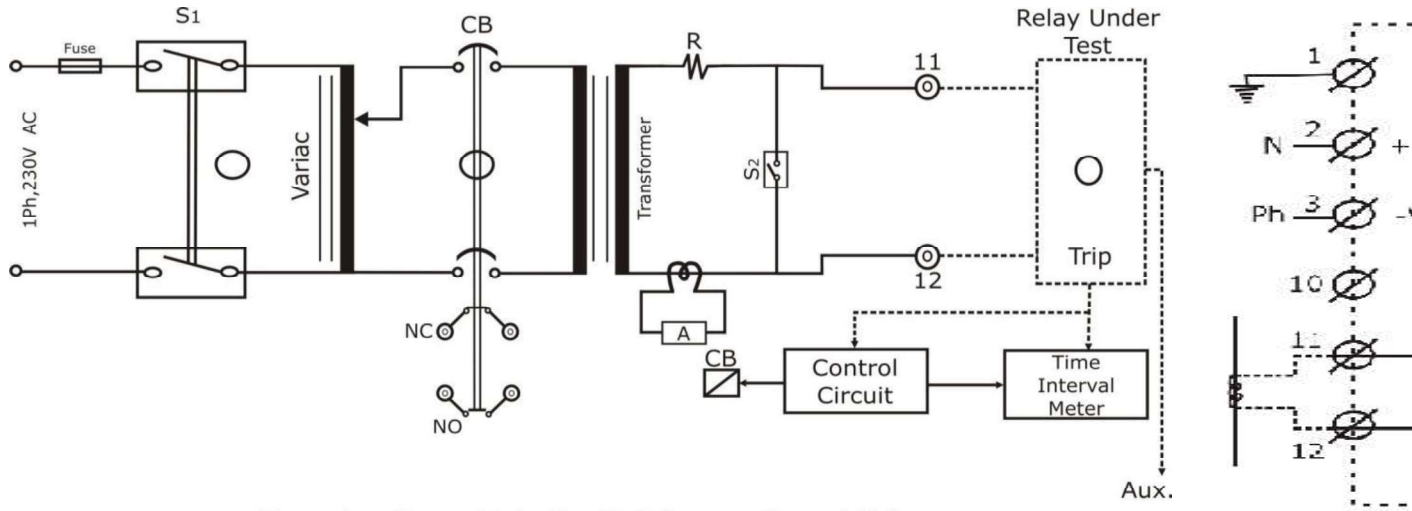
13. Push TEST START BUTTON, Note down the current. (Circuit breaker ON indicator will glow, time interval meter starts up counting, protection timer starts down counting, over current relay trip occurs TRIP indicator will glow at relay and injector unit also).

14. Note down the Time interval Meter reading. (Pick up time)

15. Press the RESET button.

16. Repeat operation by adjusting different current & TSM settings.

17. Draw the graph of Trip time Vs PSM.



Secondary Current injection Unit for over Current Relay

TABULAR COLUMNS

PSM= Fault Current / Plug setting

TSM (Time setting multiplier)	Plug setting	Fault current	PSM	Operating time (seconds)

Experiment No. 3 **Date: __ /__ /_____**

Operating characteristics of microprocessor based (numeric) over –current relay

AIM To study the operation of microprocessor based over current relay and to plot the curve between Trip Time Vs PSM.

APPARATUS REQUIRED

1. Numerical over current relay kit (mp based)
2. Secondary Current injection Unit.
3. Connecting probes

PROCEDURE

1. Connect as per interconnection diagram
2. Set the relay current.
3. Set TSM.
4. Ensure Time interval meter selection switch is in TIM position.
5. Ensure Protection time switch is ON position.
6. Connect the power cord.
7. Bring both dimmers to zero position.
8. Put on the mains using “MAINS ON” switch. Then Mains ON indicator, ammeter display, relay power and Timer display will glow.
   [
9. Bring the Toggle switch to ‘TEST’ mode.
10. Push TEST START BUTTON, “CB ON” Indicator will glow.
11. Adjust the dimmer, set the approximate injection current

    (Within 30 seconds otherwise protection timer will activate and circuit breaker will be off).

12. Push TEST STOP/RESET button.

TSM (Time setting multiplier)	Plug setting	Fault current	PSM	Operating time (seconds)

CALCULATION

Setting the fault current level:

Fault current level Is is expressed as percentage of CT rating (In = 1A). This relay offers three ranges of Is i.e. 10 to 40%, 20 to 80% and 50 to 200% which can be set by using DIP switches. Is can be calculated as follows

$$Is = \left(0.1R + R \sum \quad a \right) * \ In$$

Where, Is = Set current level (fault current level) in A
In = CT rating (IA)
a = Weight of switch in ON position
R = Constant depending on the setting range given as below.

Sl. No.	Setting range	R
1	10 to 40%	1
2	20 to 80%	2
3	50 to 200%	5

Time multiplier settings:

This switch offers various options of trip time for a selected trip time characteristics. This can be done by using DIP switches. Trip time T is given by formula

$$T = K * \left(0.1 + \sum \quad t\right) \qquad TMS = \frac{K}{T}$$

Where, K = constant depending on trip time characteristics selected
t = Weight of switch in ON position

Characteristics	**Value of K**
Normal inverse (1.3 sec)	1.3
Normal inverse (3.0 sec)	3.0
Very inverse	1.5
Extremely inverse	0.8
Definite time (1.0 sec)	1.0
Definite time (10 sec)	10
Definite time (100 sec)	100

13. Don't disturb the dimmer.

14. Bring Toggle switch to 'TEST' mode.

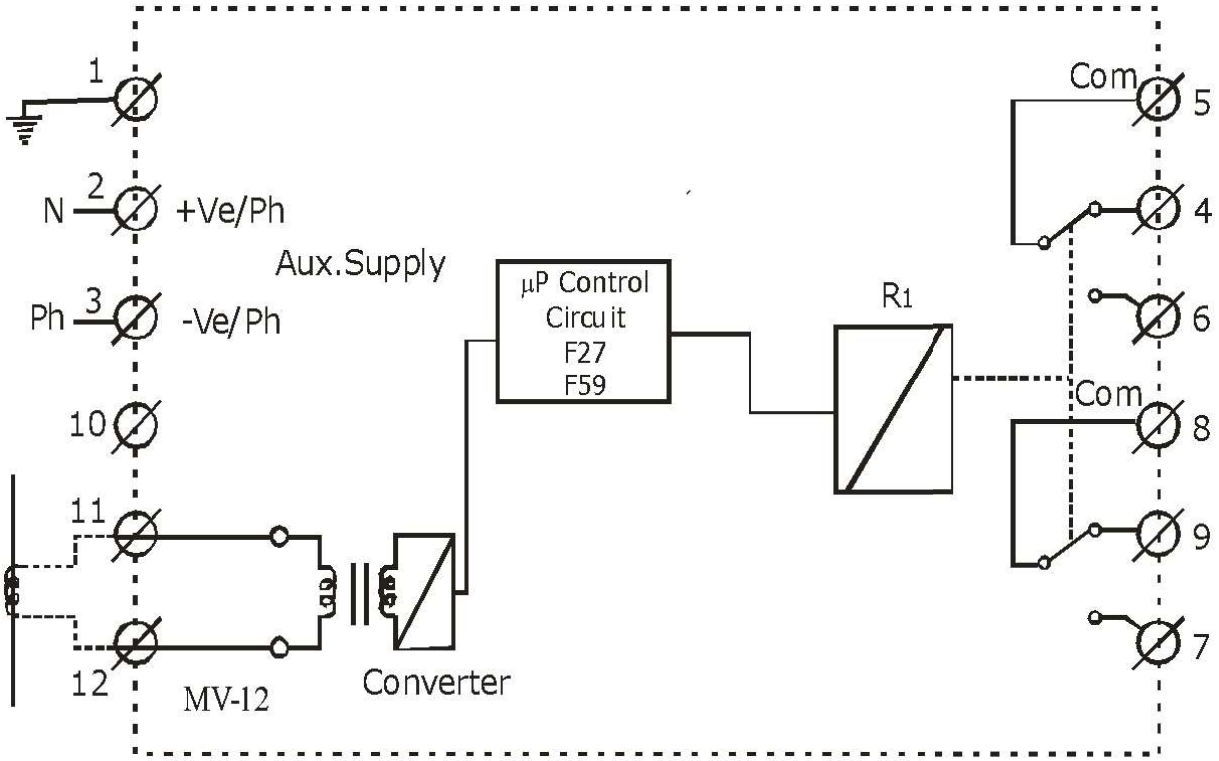
15. Push TEST START BUTTON, Note down the current. (Circuit breaker ON indicator will glow, time interval meter starts up counting, protection timer starts down counting, over current relay trip occurs TRIP indicator will glow at relay and injector unit also).

16. Note down the Time Interval Meter reading. (Pick up time)

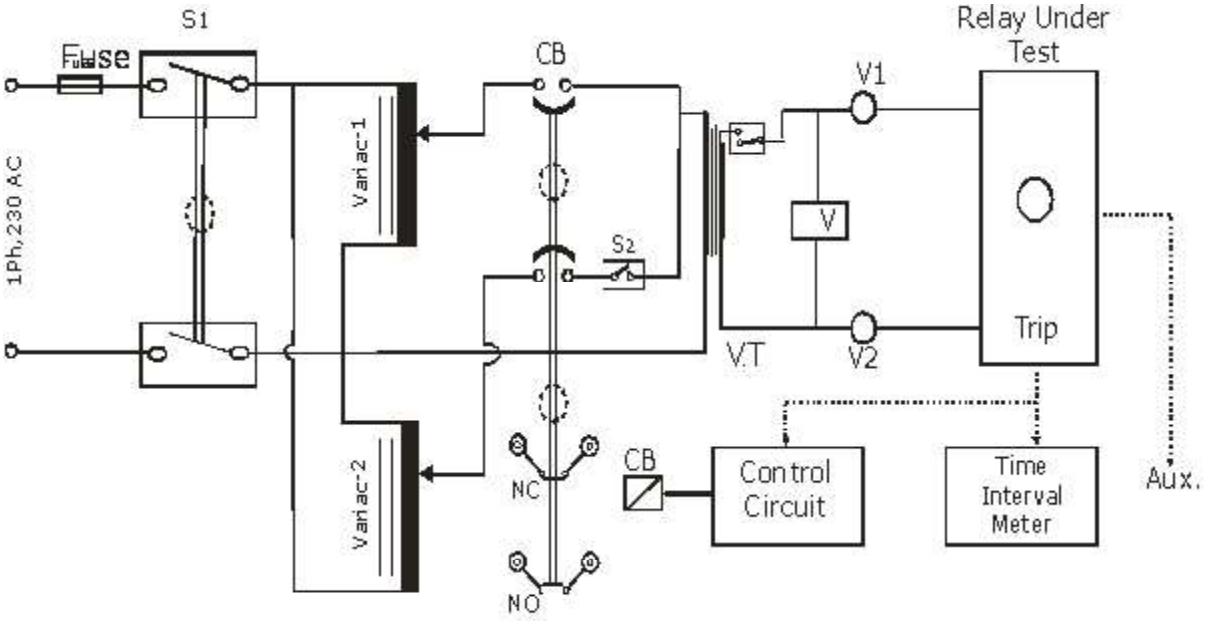
17. Press the RESET button.

18. Repeat operation by adjusting different Current & TMS Settings.

19. Draw the graph of Trip time Vs PSM (Plug setting Multiplier)



Microprocessor based over/Under voltage Relay



Over/Under Voltage Relay Test Unit

Experiment No. 4 **Date: __ /__ /_____**

Operating characteristics of microprocessor based (numeric) over/under voltage relay.

AIM To study the operation of micro processor based over/under voltage relay and to plot the curve between Trip Time Vs PSM.

APPARATUS REQUIRED

1. Numerical over/under voltage relay kit (µp based)
2. Secondary Current injection Unit.
3. Connecting probes.

PROCEDURE

1. Connect as per interconnection diagram
2. Set the relay over/under voltage.
3. Set TSM.
4. Ensure Time interval meter selection switch is in TIM position.
5. Ensure Protection time switch is ON position.
6. Ensure S2 switch is ON position.
7. Connect the power cord.
8. Bring both dimmers to zero position.
9. Put on the mains using “MAINS ON” switch. Then Mains ON indicator, ammeter display, relay power and Timer display will glow.
10. Bring the Toggle switch to ‘SET’ mode.
11. Push TEST START BUTTON, “CB ON” Indicator will glow.
12. Adjust the dimmer2, set the approximate injection voltage (Within 30 seconds other wise protection timer will activate and circuit breaker will be OFF).
13. Push TEST STOP/RESET button.
14. Don’t disturb the dimmer.
15. Bring Toggle switch to ‘TEST’ mode.

TABULAR COLUMNS

PSM= FAULT CURRENT/ PLUG SETTING

Normal INVERSE UNDERVOLTAGE

TSM (Time setting multiplier)	Set voltage	Fault voltage	Multiple of setting voltage(Vs)	Operating time (seconds)

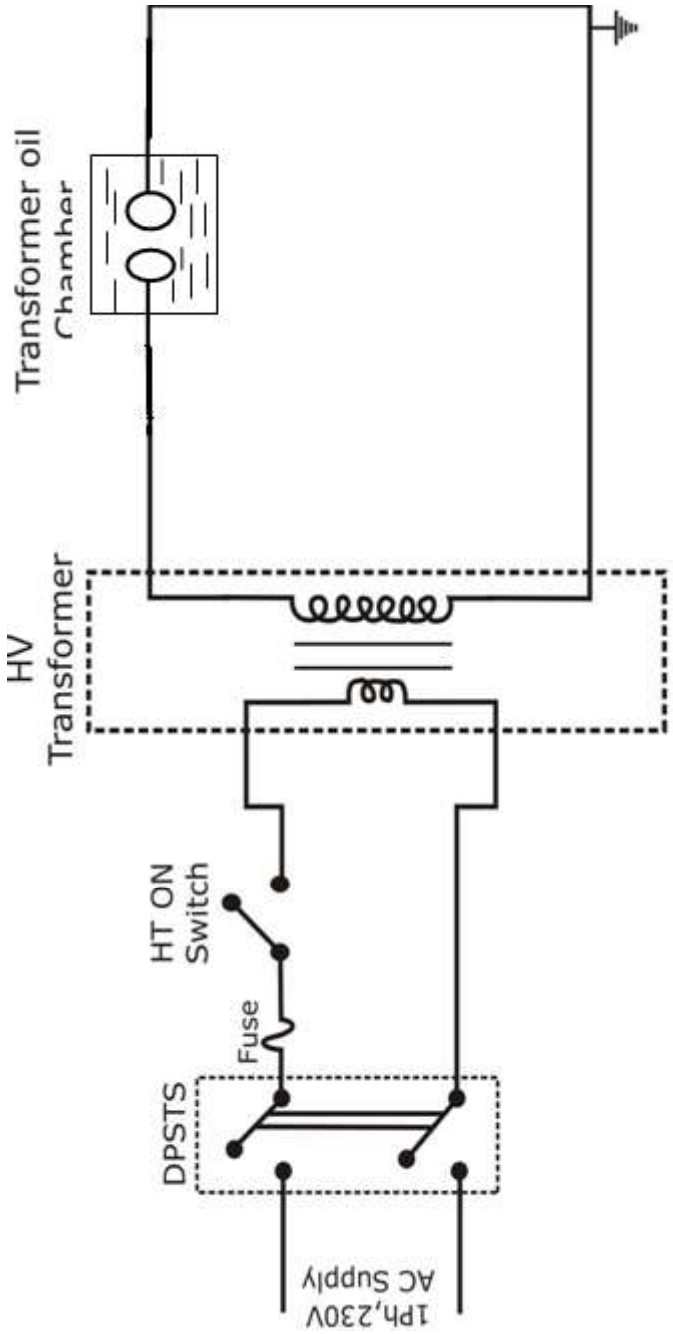
OVERVOLTAGE

TSM (Time setting multiplier)	Set voltage	Fault voltage	Multiple of setting voltage(Vs)	Operating time (seconds)

DEFINITE TIME: OVERVOLTAGE/ UNDERVOLTAGE

TSM (Time setting multiplier)	Set voltage	Fault voltage	Multiple of setting voltage(Vs)	Operating time (seconds)		TSM (Time setting multiplier)	Set voltage	Fault voltage	Multiple of setting voltage(Vs)	Operating time (seconds)

16. Push TEST START BUTTON, Note down the current. (Circuit breaker ON, CB indicator will glow, time interval meter starts up counting, protection timer starts down counting, over/under voltage relay trip occurs TRIP indicator will glow at relay and injector unit also).
17. Note down the Time Interval Meter reading. (Pick up time)
18. Press the RESET button.
19. Repeat operation by adjusting different voltage & TMS settings.
20. Draw the graph of Trip time Vs PSM (Plug setting Multiplier)



Circuit Diagram for Transformer Oil Test

Experiment No. 5 **Date: __ /__ /_____**

Measurement of Breakdown Strength of Transformer Oil

AIM To determine the Breakdown strength of the given Transformer oil at a specified gap distance.

APPARATUS REQUIRED

1. (0-60)KV manual oil test kit.
2. Transformer oil.
3. Gap measuring strip.

PROCEDURE

1. Clean the transformer oil container properly.
2. Adjust the electrodes in the oil test cup for the required gap and lock it in position with the help of screws provided.
3. The oil to be tested is poured slowly into the testing vessel, avoids bubble formation and then left to stand for about 5 min. before the voltage is applied.
4. Close the door and keep the dimmer stat in zero position. Switch ON the MAINS. Unit ready indicator will glow then press 'HT ON' push button, HT ON indicator will glow.
5. Increase the voltages gradually until the break down occurs.
6. Press the Memory push button and find the exact breakdown voltage.
7. Repeat the same procedure for 6 times and note down break over voltage at each case
8. The average value (from 2^{nd} to 6^{th} reading) gives the break over voltage of given insulating oil.

TABULAR COLUMN

V_1(kV)	V_2(kV)	V_3(kV)	V_4(kV)	V_5(kV)	V_6(kV)	V_{av} (kV)

$$V_{av} = \frac{V2+V3+V4+V5+V6}{5}$$

Average value of break over voltage is _____ kV

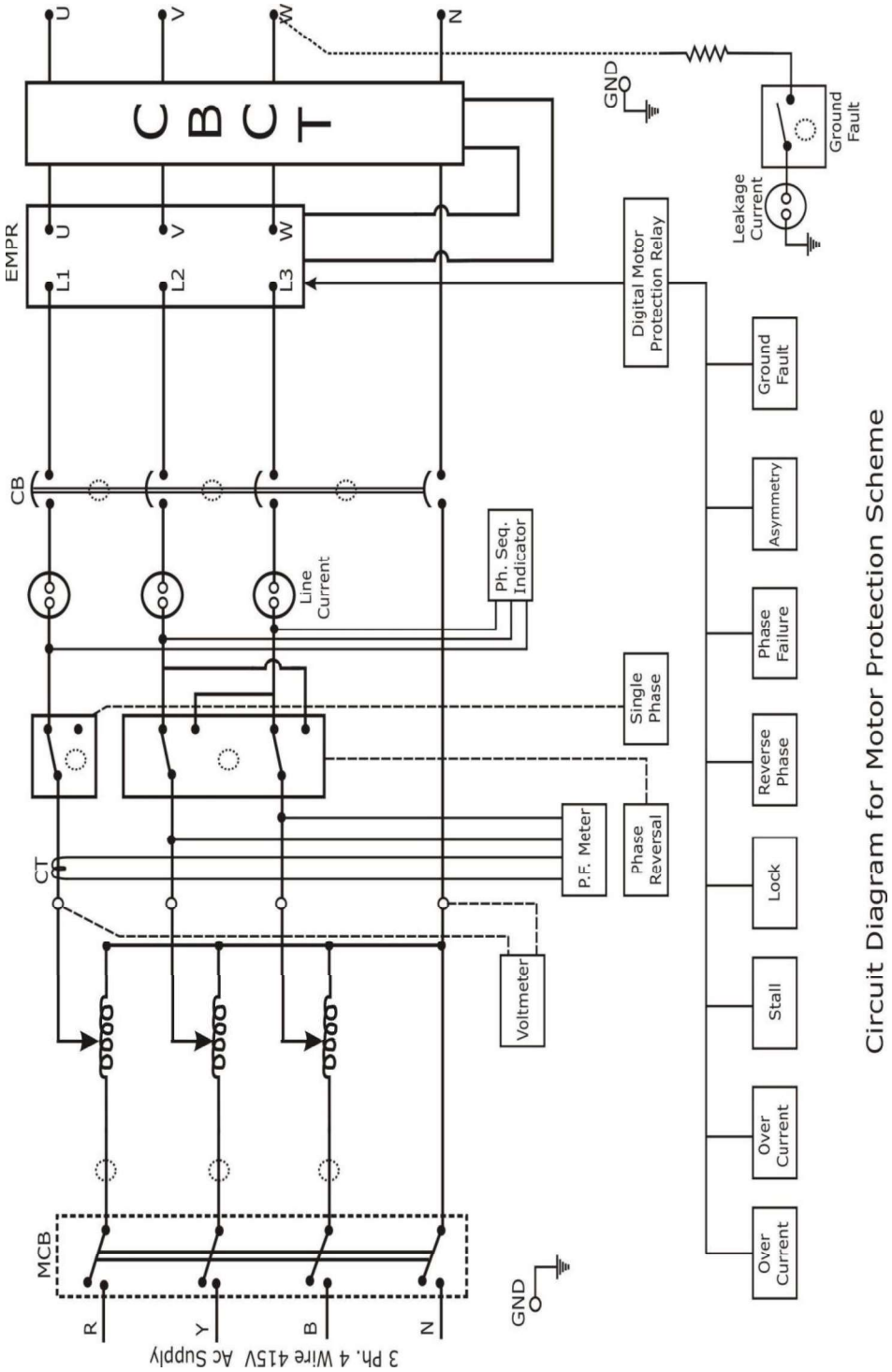
Dielectric strength of oil = $\frac{AverageBreakoverVoltage}{GapBetweenElectrodes}$ kV/Cm

$$= \frac{Vav}{0.25} \text{ kV / Cm}$$

Dielectric strength of insulating oil is _____ kV / Cm

NOTE

After each breakdown, path between the electrodes are flushed with new oil or by carefully passing a stirring rod between the gaps.



Circuit Diagram for Motor Protection Scheme

Experiment No. 6 **Date: __ /__ /_____**

Motor Protection against Faults.

AIM To study the protection scheme of motor for different faults.

APPARATUS REQUIRED

1. **PROCEDURE** Digital motor protection relay unit.
2. Three phase Induction Motor.
3. Connecting probes.

a) FOR NO LOAD

1. Connect the three phase power supply with Neutral and Ground.
2. Connect the probes for different measurements of motor.
3. Switch ON the power supply at source.
4. Switch ON the MCB, on the testing kit and look for the power ON indicator (R, Y, and B).
5. Trip indicator and buzzer will be ON, reset it.
6. Set the motor protection relay parameters.
    a) INVERSE / DEFINITE CHARACTERSTIC- **DEFINITE**.
    b) DEFINITE TIME – **2 Sec**.
    c) REVERSE PHASE PROTECTION - **ON**.
    d) UNDER CURRENT PROTECTION - **OFF**.
    e) GROUND FAULT - **0.05 Sec**
    f) STALL FUNCTION – **ON**
    g) LOCK FUNCTION- **ON** - **200%**
    h) CT RATIO - **1**.
    i) PHASE FAILURE - **ON**.
    j) STORE.
    k) CURRENT- **2A**.
7. Adjust the dimmer stats (R, Y and B) to 230V.
8. Push Motor ON button. Ensuring that there is no load on the motor and observes the current and voltage of all the phases and record

TABULAR COLUMNS

(For No Load)

Sl. No.	Motor Ammeter Reading			Voltmeter			RPM
	R	Y	B	RY	YB	BR	
1							
2							

(For Over Current)

Sl. No.	Motor Ammeter Reading			Voltmeter		
	R	Y	B	RY	YB	BR
1						
2						

(For Phase Failure)

Sl. No.	Motor Ammeter Reading			Voltmeter			RPM	Trip Time
	R	Y	B	RY	YB	BR		
1								
2								

b) OVER CURRENT PROTECTION

1. Set the Electronic Motor Protection Relay parameters.
    a) INVERSE / DEFINITE CHARACTERSTIC **- DEFINITE**.
    b) DEFINITE TIME - **2Sec**.
    c) REVERSE PHASE PROTECTION - **ON**.
    d) UNDER CURRENT PROTECTION - **OFF**.
    e) GROUND FAULT - **0.05 Sec**
    f) STALL FUNCTION – **ON**
    g) LOCK FUNCTION-ON - **200%**
    h) CT RATIO - **1**.
    i) PHASE FAILURE - **ON**.
    j) STORE.
    k) CURRENT – **2A**
2. Switch ON the motor by pressing the Motor ON push button.
3. Gradually load the motor by tightening the belts.
4. When the current exceeds the set value, relay trip occurs which results
    i) Motor will stop.
    ii) Relay display shows---> **O-L**.
    iii) Buzzer will ON.
    iv) Fault indicator will glow.
5. Now accept the fault by pressing the accept push button.
6. Note down the values of Voltmeter, RPM meter, TIM meter readings and tabulate it.
7. Press the display button in the EMPR and note down the each phase current value.
8. Reset the relay (EMPR) by pressing test/reset button. (i.e. Display should be 0.00)
9. Press the Reset button at control panel.
10. Loosen the belts of the motor.

(For Phase Reversal)

Sl. No.	Motor Ammeter Reading			Voltmeter			Trip Time
	R	Y	B	RY	YB	BR	
1							
2							

(For Ground Leakage)

Sl. No.	Motor Ammeter Reading			Voltmeter			RPM	TRIP TIME	Leakage current
	R	Y	B	RY	YB	BR			
1									
2									

c) PHASE FAILURE PROTECTION

1. Ensure motor is off.
2. Bring all fault simulation switches to position-1.
3. Ensure the EMPR settings.
    a) INVERSE / DEFINITE CHARACTERSTIC - **DEFINITE**.
    b) DEFINITE TIME - **2Sec**.
    c) REVERSE PHASE PROTECTION - **ON**.
    d) UNDER CURRENT PROTECTION - **OFF**.
    e) GROUND FAULT - **0.05 Sec**
    f) STALL FUNCTION – **ON**
    g) LOCK FUNCTION- **ON** - **200%**
    h) CT RATIO - **1**.
    i) PHASE FAILURE - **ON**.
    j) STORE.
    k) CURRENT - **2A**
4. Switch ON the motor by pressing the Motor ON push button.
5. Turn the single phase fault simulation switch to position-2.
6. Relay trip occurs which results
    a. Motor will stop
    b. Relay display shows---> **P.F**
    c. Buzzer will ON.
    d. Fault indicator will glow.
7. Now accept the fault by pressing the accept push button.
8. Note down the values of Voltmeter, RPM meter, TIM meter readings and tabulate it.
9. Press the display button in the EMPR and note down the each phase current value.
10. Reset the relay by pressing test / reset button.(i.e. display should be 0.00)
11. Press the Reset button at control panel.
12. Bring the single phase fault simulation switch to its home position. (i.e. position-1)

d) PHASE REVERSAL PROTECTION

1. Ensure motor is off.
2. Bring the all fault simulation to position-1.
3. Turn the Phase Reversal fault simulation switch to position-2.
4. Ensure the EMPR Settings.
    a) INVERSE / DEFINITE CHARACTERSTIC - **DEFINITE**.
    b) DEFINITE TIME - **2Sec**.
    c) REVERSE PHASE PROTECTION - **ON**.
    d) UNDER CURRENT PROTECTION - **OFF**.
    e) GROUND FAULT - **0.05 Sec.**
    f) STALL FUNCTION – **ON**
    g) LOCK FUNCTION – **ON** - **200%**
    h) CT RATIO - **1**.
    i) PHASE FAILURE - **ON**.
    j) STORE.
    k) CURRENT - **2A.**
5. Switch ON the motor by pressing the Motor ON push button.
6. Relay trip occurs which results
    a. Motor will stop
    b. Relay display shows---> **r-P**
    c. Buzzer will ON.
    d. Fault indicator will glow.
7. Now accept the fault by pressing the accept push button.
8. Note down the values of Voltmeter, RPM meter, TIM meter readings and tabulate it.
9. Press the display button in the EMPR and note down the each phase current value.
10. Reset the relay by pressing test / reset button. (i.e. display should be 0.00)
11. Press the Reset button at control panel.
12. Bring the phase reversal fault simulation switch to its home position. (i.e. position-1)

e) GROUND LEAKAGE / FAULT PROTECTION

1. Ensure motor is OFF.
2. Bring all the fault simulation to position-1.
3. Short the rheostat terminal with one phase of the motor using patch cord and to measure the leakage current connect ammeter terminals.
4. Ensure the EMPR Settings
    a. INVERSE / DEFINITE CHARACTERSTIC - **DEFINITE**.
    b. DEFINITE TIME - **2Sec**.
    c. REVERSE PHASE PROTECTION - **ON**.
    d. UNDER CURRENT PROTECTION – **ON.**
    e. GROUND FAULT - **0.05 Sec**
    f. STALL FUNCTION – **ON**
    g. LOCK FUNCTION - **ON** - **200%**
    h. CT RATIO - **1**.
    i. PHASE FAILURE - **ON**.
    j. STORE.
    k. CURRENT - **2A**
5. Switch ON the motor by pressing the Motor ON push button.
6. Turn the Ground Leakage simulation switch to position-2
7. Relay trip occurs which results
    a. Motor will STOP.
    b. Relay display shows---> **g-F**.
    c. Buzzer will ON.
    d. Fault indicator will glow.
8. Now accept the fault by pressing the accept push button.
9. Press the display button in the EMPR and note down the each

    phase current value.

10. Reset the relay by pressing test / reset button. (i.e. display should be 0.00)
11. Press the Reset button at control panel.
12. Bring the Ground Leakage fault simulation switch to its home Position. (I.e. position-1)

Experiment No. 7 **Date: __ /__ /_____**

Generation Protection: Merz Price Scheme.

AIM: To study the operation of Generator Protection and synchronization.

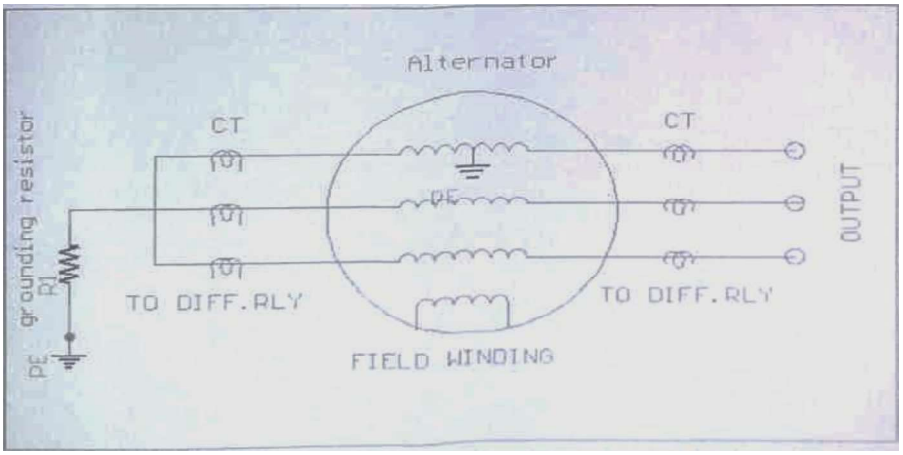
APPARATUS REQUIRED:

1. Generator Protection simulation unit.
2. Connecting probes.

PROCEDURE:

MERZ-Price Protection or Differential Protection for Generators:

The principle of differential protection of the circulating current protection - % relay. This type of protection provides a continuous check on the faults within the points, where the CTs are used as illustrated in the Fig1. There are two sets of C.T.s each set is mounted on either end of the rotor phase. The secondary of these current transformers connected to the differential relay. If there is no fault in the generator, the same current will pass through the C.Ts at both ends and there will be no current spilling into the relay. Now assume that there is an earth fault in the rotor winding it will cause an increase in current through set CTs as compared to current through CT2 . thus there is no current balance any more resulting into spilling ofa current through the relay R will trip the circuit.



Starting the Alternator:

1. Connect 3 phase 4 wire power supply to the panel.
2. All the fault selector switch must be position 1
3. Switch on the mains MCB

4. All meter display and power indication of R,Y,B will be glow
5. If fault indicator will glow,hooter also on
6. Press the acknowledgement and rest button
7. Press the inverter ON(VFD) push button
8. Inverter display will be on
9. Motor starts to rotate.
10. Adjust the RPM reaches 1500 rpm by potentiometer.
11. Bring the dimmer to zero position.
12. If rpm of the motor >40Hz and dimmer zero gen ready indicator will starts glow.
13. Press the generator ON/CB1 Push button.
14. Switch on the load push button.
15. Adjust the motor rpm using the multiturn Pot to get 1500 rpm OR 50c/s.

NOTE:

Unit ready indicator condition:

1. Invertor frequency should be >35hz.
2. Excitation Variac should be zero.
3. There is no fault indication in the panel

Invertor speed is interlocked >35hz then unit ready indicator will glow Differential relay setting is : id1-10% id2-15%-20% High set is 5*In (In=1)

Internal faults/external faults.

1. Ensure internal faults switch should be position 1.
2. All toggle switch must be ON position.-for earth leakage,%relay ,
   over current relay R,Y,B.
3. %relay set at 40% and time delay should be '0' position i.e. minimum.
4. Set the operating time of all over current relay definite time mode-10 sec.
5. Press the timer reset button.
6. Turn the fault switch LG(line to ground fault).
7. R phase in % relay Blue LED glow and trip immediately.
8. Alternator gets stripped.
9. HOOTER will give the sound and fault indicator will be glow.

10. Accept the fault and reset it.
11. Again switch on the alternator and observe the faults LL(line to line & LLG-line to line and ground).
12. Again switch on the alternator and observe the external faults.
13. If the fault is external load circuit breaker only trip.
14. If the internal fault generator will be OFF.

Synchronization with bus bar

1. Connect the panel to both 1 phase and phase3 supply appropriately.
2. Switch on the control MCB.All meters will turn on.

Select the mode of operation

Modes:

1. Generator with Dead bus. 2. Generator with Live Bus

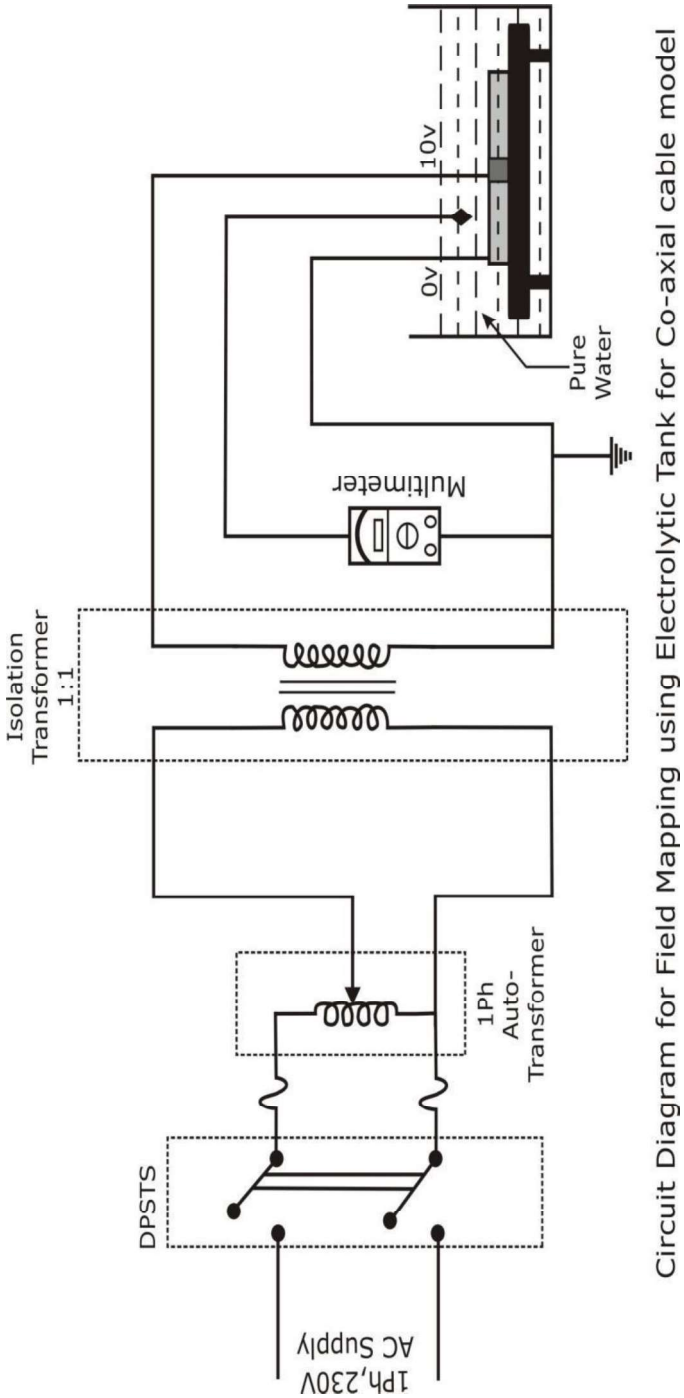
Mode1:Generator with Dead Bus

1. Switch on the control MCB.All meters will turn on.
2. Switch on the excitation and generator MCB.
3. switch on the Motor/VFD by pressing VFD ON/OFF push button.
4. Bring the generator excitation variac to zero indicator glows.
5. Switch on generator by pressing generator on/off push button.
6. Increase the excitation to the generator by varying the excitation variac until the voltage generated in the generator is 220 V(line to neutral) or 400V(line to line).
7. Switch on CB-1 to give the output to the line.
8. Switch on the synchronization switch to connect generator 1 bus bar with load bus bar.
9. Connect the load unit to the load terminals.
10. Switch on the load MCB .
11. Switch on the load on/off push button.
12. Apply load.

Mode 2: Generator with live bus

1. Switch on the control MCB. all the meters will turn on.
2. Switch on the infinite bus MCB.
3. Switch on the excitation and generator MCB.

4. Switch on the motor/VFD by pressing VFD on/OFF push button.
5. Bring the generator excitation variac to zero, indicator glows
6. Switch on generator by pressing generator on/OFF push button.
7. Increase the excitation to the generator by varying the excitation variac until the voltage generated in the generator is 220V (line to neutral)or 400V(line to line).
8. Note down the voltage in the generator Power Analyzer.
9. Switch on CB-1 to give output to the line.
10. Connect the lamp terminals, frequency meter and synchroscope as shown in the connection diagram for synchronization with the live bus.
11. Switch on the bus bar ON/OFF push button.
12. The lamp on the both sides should flicker simultaneously. if the lamps alternate within itself then interchange any two phase on the same side.
13. Control the flickering of the lamp by varying the frequency and voltage generation.
14. Variation in frequency is controlled by changing its speed and variation in generated voltage is controlled by varying the excitation.
15. Check for synchronization. this can be done by either checking the synchroscope or examining the lamp for complete darkness.(Dark lamp test).
16. Then switch on the synchronization switch to connect generator-1 bus bar with infinite bus bar and load bar.
17. Connect the load unit to the load terminals.
18. Switch on the load MCB.
19. Switch on load on/off push button and apply load.



Circuit Diagram for Field Mapping using Electrolytic Tank for Co-axial cable model

Experiment No.8 **Date: __ /__ /_____**

FIELD MAPPING USING ELECTROLYTIC TANK FOR CO-AXIAL CABLE MODEL

AIM To calculate the capacitance of the co-axial cable model, plot the equipotential and field lines.

APPARATUS REQUIRED

1. Electrolytic tank with pantograph arrangement.
2. Isolation transformer.
3. Multi meter.
4. Co-axial cable model.

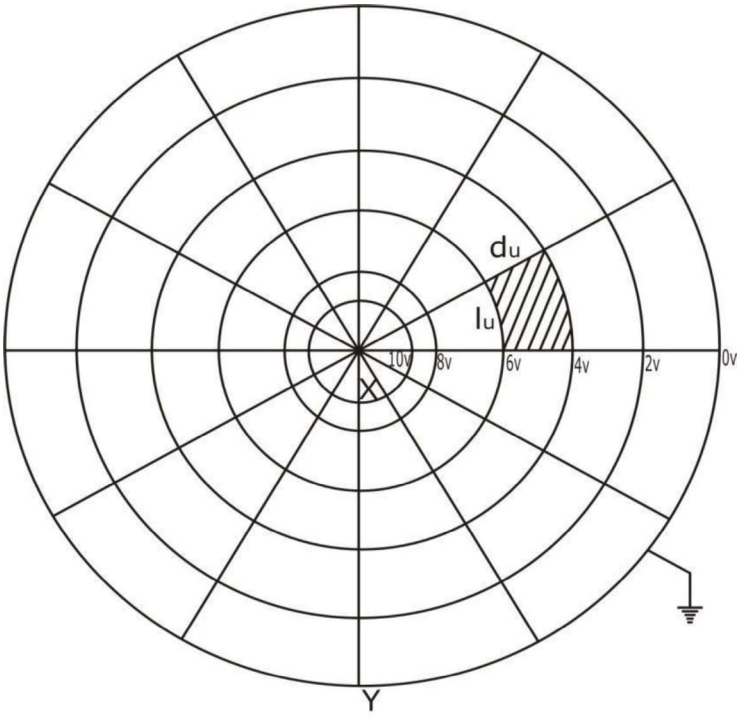
PROCEDURE

1. The electrodes as well as the inside surface of the tank should be cleaned.
2. The co-axial cable model is placed inside the electrolytic tank.
3. Clean water is poured into the electrolytic tank up to the tips of the 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.

[

8. First trace both the plates by using pantograph then trace equipotential lines corresponding to voltages of 1V, 2V, 3V…….. 9V.

MODEL GRAPH



For co-axial cable model

CALCULATIONS

i) The unit capacitance can be found by

Cu = ∑0*lu /du ---- F/m

ii) Total capacitance (practical) CP = $\frac{Cu * m}{n}$ ----- F/m

Where ∑0 = Permittivity=8.854*10^{-12} : ∑r = 1

m = Number of capacitors in series

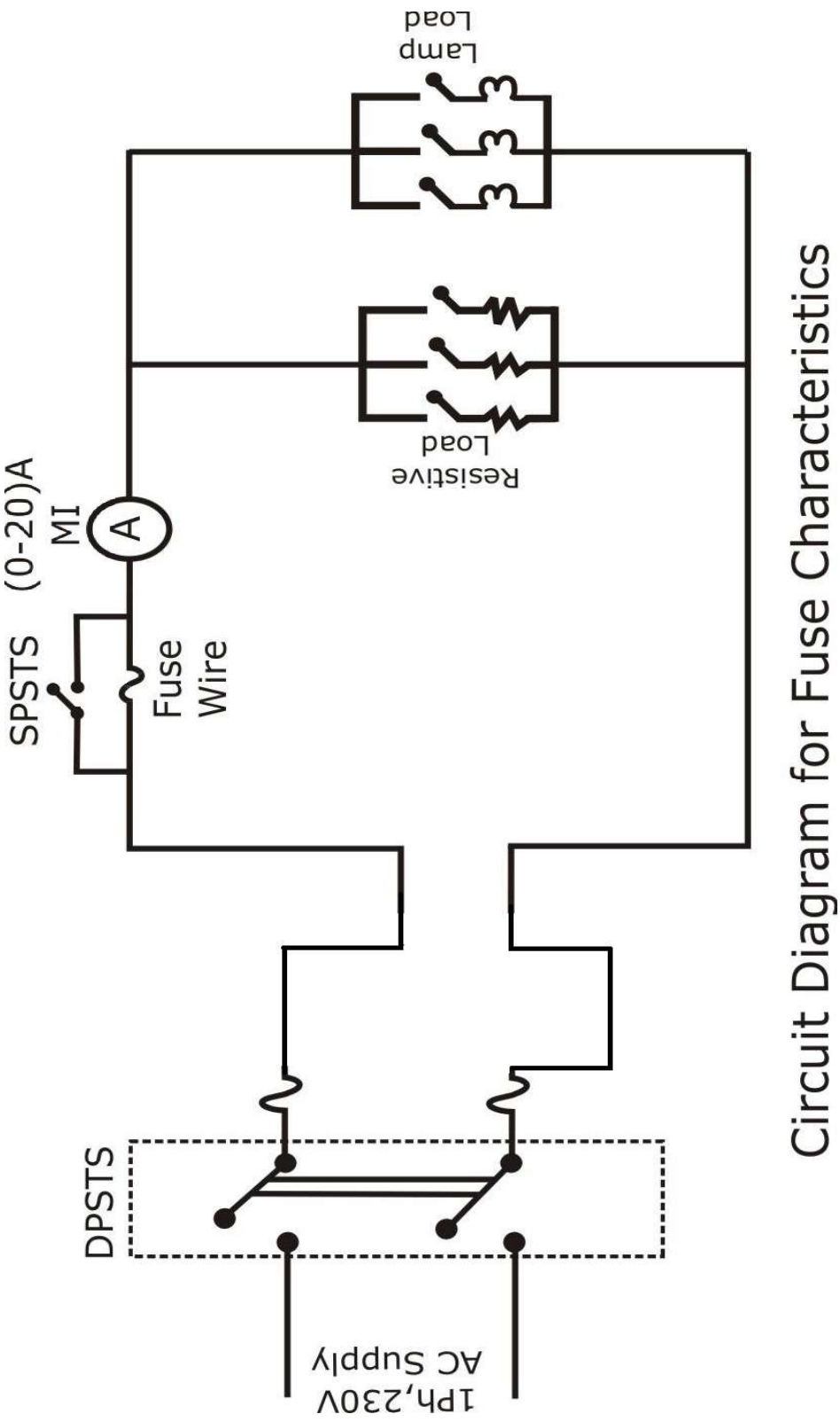
n = Number of capacitors in parallel

iii) Theoretical equation for capacitance of a co-axial cable model is

$$CT = \frac{2\prod\sum 0}{Log(b/a)} \text{ ----- F/m[}$$

Where a=Radius of the inner circle, b=Radius of the outer circle

iv) %Error = $\left(\frac{Cp - Ct}{Ct}\right)$X100



Circuit Diagram for Fuse Characteristics

Experiment No. 9 **Date: __ /__ /_____**

FUSE CHARACTERISTICS

AIM To plot the current Vs Time characteristic of a given fuse wire.

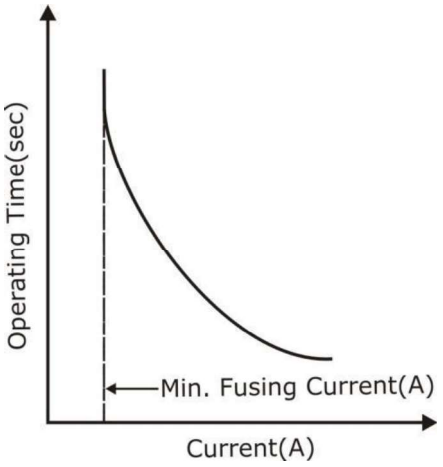
APPARATUS REQUIRED

1. Fuse wires of different ratings
2. Fuse fixing board
3. Ammeter -20A (MI)
4. Single Phase Auto transformer
5. Stop watch.

PROCEDURE

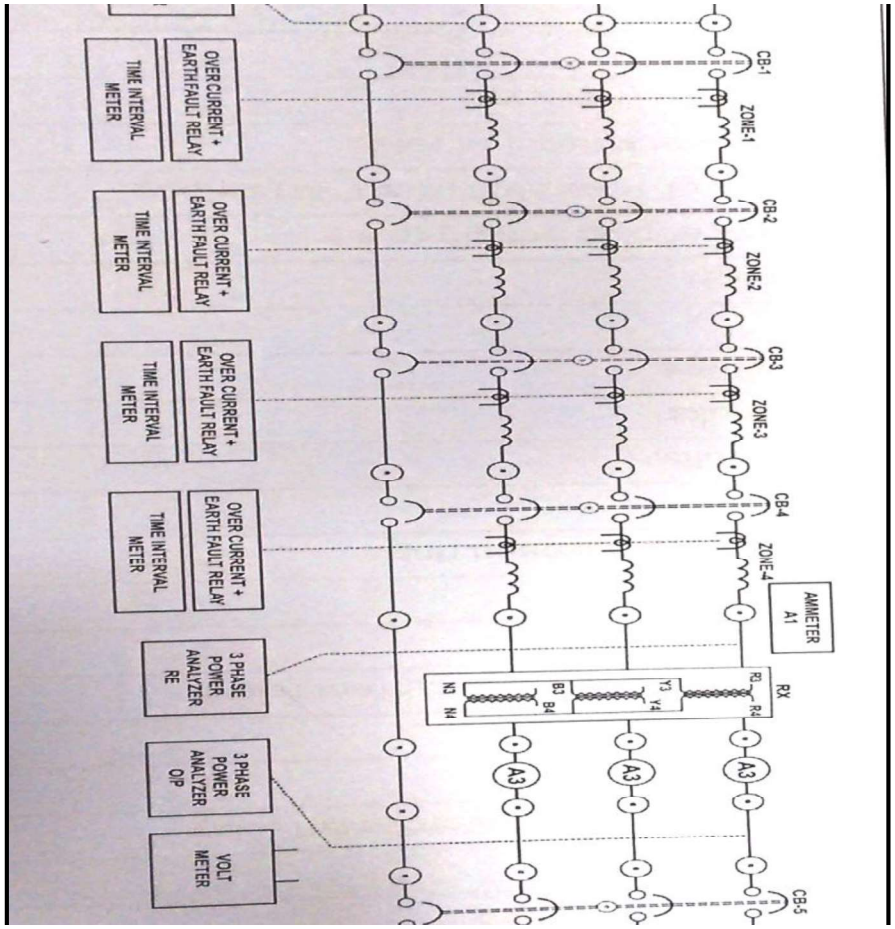
1. Connections are made as shown in the circuit diagram.
2. One strand of fuse is put on the fuse holder and its length is noted down.
3. Keeping the SPST switch in closed position, then supply switch is closed.
4. Load is applied gradually such that the reading of the ammeter is above the rated value of the fuse wire and ammeter reading is noted down.
5. The SPST switch is opened and simultaneously the stop watch is started and time taken for the fuse to blow out is noted.
6. Experiment is repeated for different values of current above the rating of the fuse.
7. Experiment is repeated for different Lengths of fuse wire.
8. The graph between the Time Vs Current is drawn. (The minimum fusing current which is the minimum current at which the fuse blows out is found from the graph).

Model Graph



TABULAR COLUMN

Current rating of the Fuse wire (Amps)	Length of the Fuse wire	Load Current	Time taken for the fuse to blow out



Feeder Protection Kit

Experiment No. 10 **Date: __ /__ /_____**

STUDY ON FEEDER PROTECTION SCHEME

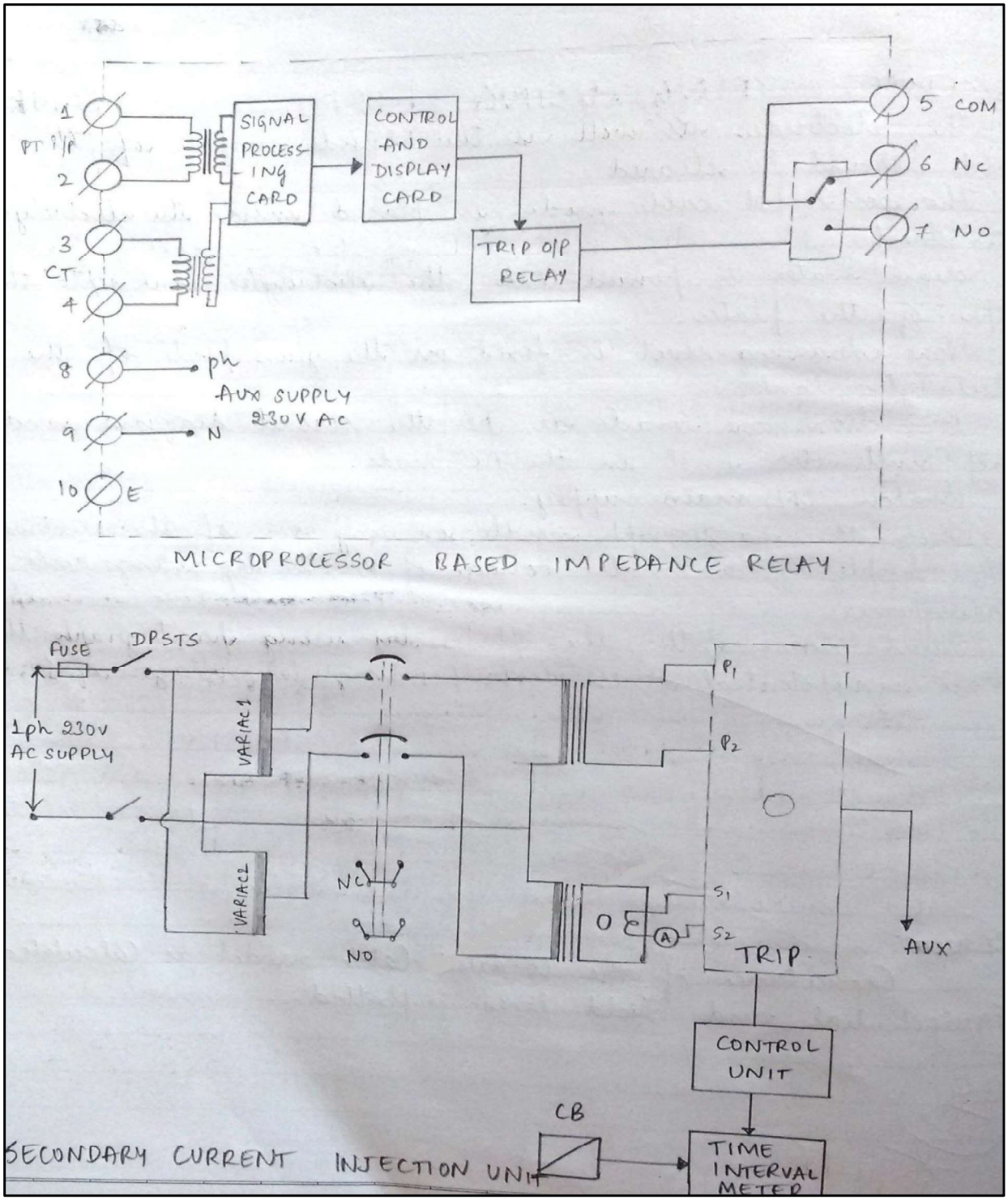
AIM: To study the operation of feeder protection circuit.

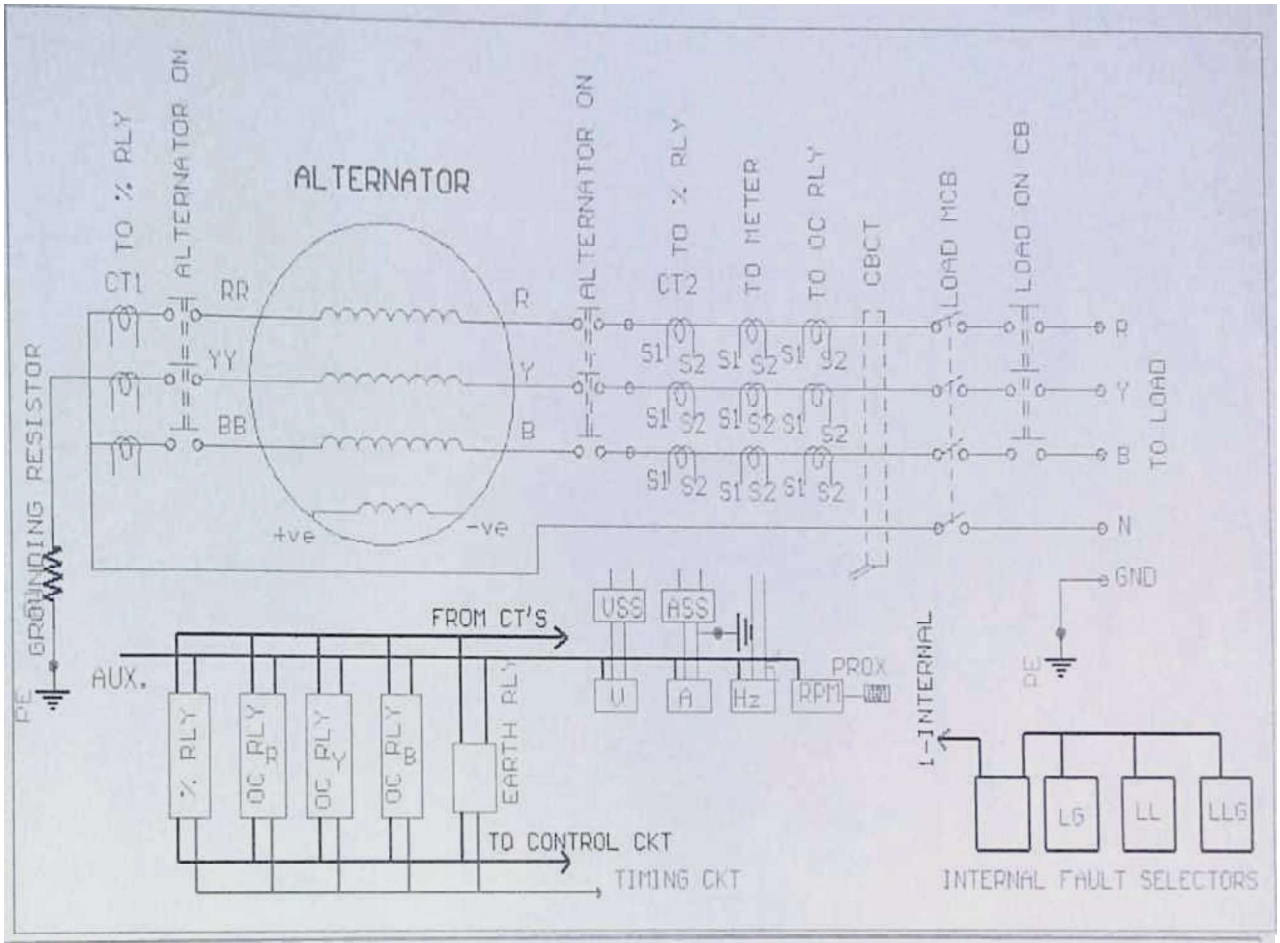
Apparatus Required:

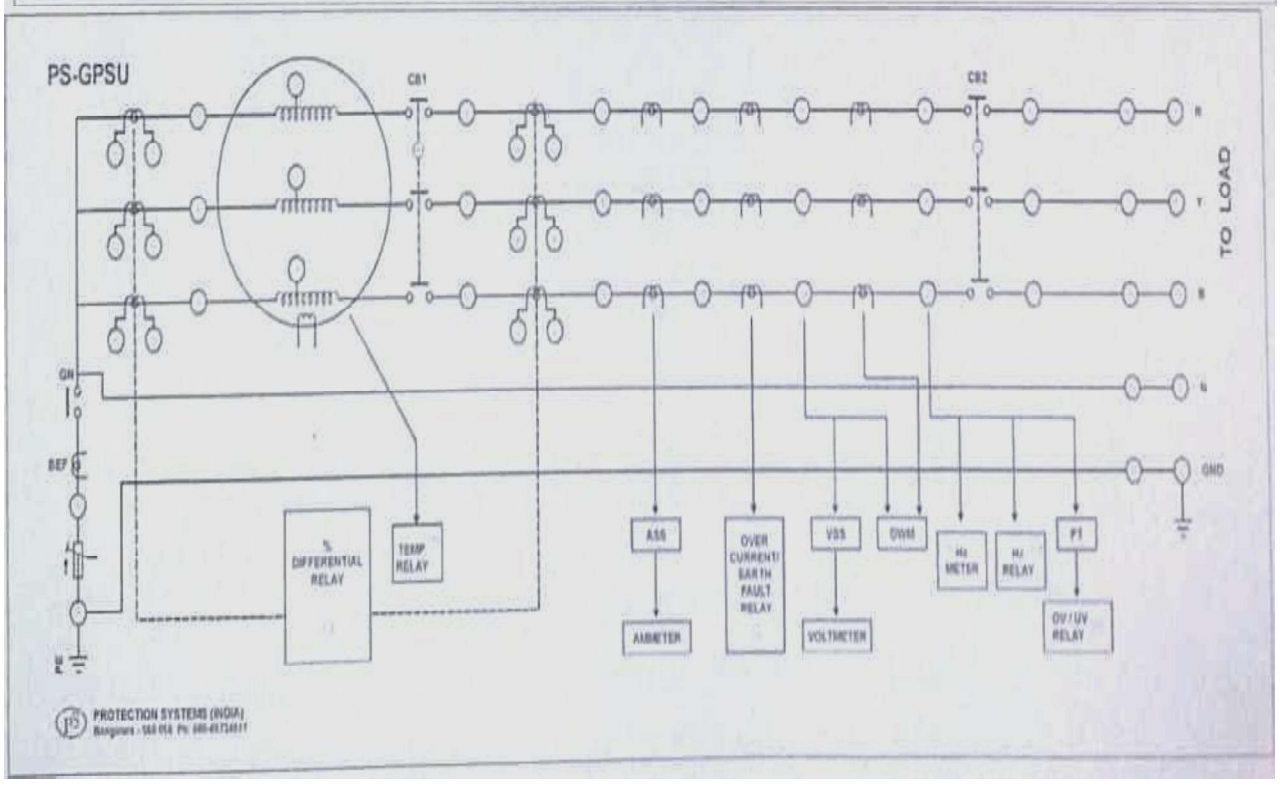
1. Feeder protection kit.
2. Resistive load.
3. Connecting probes

Procedure:

1. Connections are made as shown in figure.
2. Switch on the supply for feeders and relay
3. Connect the feeder zone by closing the corresponding switch.
4. Check whether all relays are turned on
5. Set the time setting and current setting for the relays.
6. Close the load switches and create the fault by applying load.
7. When the relay operates, note down the zone number, time taken for relay operation.
8. Note down the voltage, power energy at the sending end and receiving end in the power analysis meter.
9. Accept the fault and RESET the kit.
10. Repeat the above steps by passing the one or two relays


1
PT i/p
2
3
CT
4
8
ph
AUX SUPPLY
230V AC
9
N
10
E
SIGNAL PROCESSING CARD
CONTROL AND DISPLAY CARD
TRIP O/P RELAY
5 COM
6 NC
7 NO
MICROPROCESSOR BASED IMPEDANCE RELAY
FUSE
DPSTS
1ph 230V AC SUPPLY
VARIAC 1
VARIAC 2
NC
NO
P1
P2
S1
S2
A
TRIP
AUX
CONTROL UNIT
CB
TIME INTERVAL METER
SECONDARY CURRENT INJECTION UNIT


ALTERNATOR
CT1
TO % RLY
ALTERNATOR ON
RR
YY
BB
R
Y
B
+ve
-ve
ALTERNATOR ON
CT2
TO % RLY
TO METER
TO OC RLY
CBCT
LOAD MCB
LOAD ON CB
TO LOAD
S1 S2
GROUNDING RESISTOR
FROM CT'S
AUX.
% RLY
OC RLY R
OC RLY Y
OC RLY B
EARTH RLY
TO CONTROL CKT
TIMING CKT
USS
ASS
V
A
Hz
RPM
PROX
GND
PE
1-INTERNAL
LG
LL
LLG
INTERNAL FAULT SELECTORS


PS-GPSU
CB1
CB2
TO LOAD
GND
BEF
% DIFFERENTIAL RELAY
TEMP RELAY
ASS
AMMETER
OVER CURRENT EARTH FAULT RELAY
VSS
VOLTMETER
OWM
Hz METER
Hz RELAY
PF
OV/UV RELAY
PROTECTION SYSTEMS (INDIA)

REFERENCES

Text Books

1.Power System Protection and Switchgear Badri Ram, D.N. Vishwakarma McGraw Hill 2nd Edition

2. Power System Protection and Switchgear Bhuvanesh Oza et al McGraw Hill 1st Edition, 2010

Reference Books

1. Protection and Switchgear Bhavesh et al Oxford 1st Edition, 2011

2. Power System Switchgear and Protection N. Veerappan S.R. Krishnamurthy S. Chand 1st

Edition, 2009

3. Fundamentals of Power System Protection Y.G.Paithankar S.R. Bhide PHI 1st Edition, 2009

4. Switchgear and Protection, Sunil S.Rao, Khanna Publishers, 13th Edition, 2008

Viva-voce Questions

- What is a Relay?
- Name the components of protective relay scheme
- Explain the functions of protective relaying
- What is meant by primary protection?
- What is meant by back-up protection?
- What is the important requirement of back-up relaying system?
- Name the various methods used for back-up protection.
- List the essential qualities of protective relaying
- What is the reliability of relay system?
- Explain sensitivity, speed, and selectivity of the relay system.
- Explain the working principle of Reverse power relay Based on the operation time
- Name the various types of distance relays
- What is differential relay?
- What is static relay?
- Explain the terms
    - Relay time
    - Fault clearing Time
    - Pick up value
    - Reset or Drop out value
    - Current setting
- What is PSM?
- What is TSM?
- What are the advantages of having an auxiliary switch in the trip circuit?List the applications of Electro-magnetic Relays
- List the applications of Reverse Power Relay
- Define a Directional Relay
- What are the advantages of plain impedance relay?
- Name the various faults which can occurs associated with a Generator
- List out the various Transformer faults
- What is mean by Restricted Earth fault protection of Generator?

- Name the Various problems encountered in Differential Protection
- What is a Fuse?
- Name the types of Fuses
- What is an open Fuse?
- Define fusing factor
- What is HRC Fuse?
- What is meant by cut-off current of a Fuse?
- Define pre-arcing time of a Fuse
- Define arcing time of a Fuse
- What are the desirable characteristics of a Fuse?
- State the Advantages and Disadvantages of Fuse
- What is the difference between Fuse and Circuit-breaker?

Questions

1. Draw the characteristic curve for induction relay with TSM = _____; PSM=_____A, between operating current & trip time.
2. Conduct an experiment to show that the time of operation of a relay is quite independent of the magnitude of current and also draw the characteristic curves for % of V=_____ & trip time of _____sec
3. Find the breakdown voltage for the uniform conductors which are subjected to HV multi conductor system in the atmospheric pressure.
4. Find the breakdown voltage for the non-uniform conductors which are subjected to HV multi conductor system in the atmospheric pressure.
5. Find the breakdown voltage for the uniform conductors which are subjected to HV two conductor system in the atmospheric pressure.
6. Find the breakdown voltage for the non-uniform conductors which are subjected to HV two conductor system in the atmospheric pressure.
7. Find the breakdown voltage for the point-point conductors which are subjected to HV multi conductor system in the atmospheric pressure.
8. Find the breakdown voltage for the point-point conductors which are subjected to HV two conductor system in the atmospheric pressure.
9. Draw the equipotential lines which are lying between two parallel plates.
   Find the capacitance between them & verify theoretically.

11.Draw the equipotential lines which are lying between co-axial cable model plates. Find the capacitance between them & verify theoretically.

12.Find the dielectric strength of the given liquid insulating media by using the step up transformer arrangement.

13.Draw the characteristic curve for microprocessor based relay between operating current & trip time.

14. Find the current in each phase when the motor circuit is
    under the following fault conditions.

    i. The two phases are interchanged.

    ii. One phase is connected with ground.

15. Find the current in each phase when the motor circuit is under the following fault conditions.

    i. When the input is in two phases.

    ii. When three phase current exceeds the rated value.