Laboratory Manual

for

Power System Lab

Prepared by

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Aim: To study the ABCD Parameters of Transmission Line

Apparatus Required

- AC Transmission Line Trainer
- Patch chords
- 3 Phase Autotransformer

Connection procedure (Per phase)

- Connect 3 phase Auto transformer to Transmission line Trainer back side (terminals provided & marked as
- Connect **R1 Terminals** (generating station) to **P1 Terminals** (Transmission Line Model) using patch chords
- Connect **P2 Terminals** (Transmission Line Model) to **Ri1 Terminals** (generating station) using patch chords
- Connect **N Terminals** (generating station) to **N Terminals** (Transmission Line Model) using patch chords
- Connect **N Terminals** (Transmission Line Model) to **N Terminals** (Tx Line Input side) using patch chords
- **Connect R01 Terminals** (Transmission Line Model) to **P3 Terminals** (Transmission Line Model) using patch chords
- Switch **ON** the **MCB1** remaining switches **(MCB2, MCB3)** in **OFF** conditions
- Connect **N Terminals** (generating station) to **N Terminals** (Tx Line Input side) using patch chords

For Open Circuit Test

- Switch ON the power supply
- Apply the input AC voltage @ 20V by adjusting the auto transformer
- Note down the reading of sending end voltage **(V1 Meter)**, sensing end current **(A1 Meter)**& receiving end voltage**(V2 Meter)** & receiving end current**(A2 Meter)**

Angle Measurement (V_S/I_S)

- Connect **Terminal-VS** to **Input-1** (Phase angle meter) using patch chords &Connect **Terminal-IS** to **Input-2** (Phase angle meter) using patch chords & **GND terminal** to **GND terminal** (Phase Angle meter)
- Note down Angle between VS/IS

Angle Measurement (V_S/I_R)

- Connect **Terminal-VS** to **Input-1** (Phase angle meter) using patch chords &Connect **Terminal-IR** to **Input-2** (Phase angle meter) using patch chords & **GND terminal** to **GND terminal** (Phase Angle meter)
- Note down Angle between VS/IR

Angle Measurement (V_S/V_R)

- Connect **Terminal-VS** to **Input-1** (Phase angle meter) using patch chords &Connect **Terminal-VR** to **Input-2** (Phase angle meter) using patch chords & **GND terminal** to **GND terminal** (Phase Angle meter)
- Note down Angle between **VS/VR**

Angle Measurement (V_S/I_R)

- Since It is in open circuit-IR (Receiving end current is ZERO), so no need to measure **VS/IR** & it is equal to Zero

For Short Circuit Test

- Switch ON the power supply
- Apply the input AC voltage @ 20V by adjusting the auto transformer
- Short **P4** and **N** terminals.
- Note down the reading of sending end voltage **(V1 Meter)**, sensing end current **(A1 Meter)**& receiving end voltage**(V2 Meter)** & receiving end current**(A2 Meter)**

Angle Measurement (V_S/I_S)

- Connect **Terminal-VS** to **Input-1** (Phase angle meter) using patch chords &Connect **Terminal-IS** to **Input-2** (Phase angle meter) using patch chords & **GND terminal** to **GND terminal** (Phase Angle meter)
- Note down Angle between **VS/IS**

Angle Measurement (V_S/I_R)

- Connect **Terminal-VS** to **Input-1** (Phase angle meter) using patch chords &Connect **Terminal-IR** to **Input-2** (Phase angle meter) using patch chords & **GND terminal** to **GND terminal** (Phase Angle meter)
- Note down Angle between **VS/IR**

Angle Measurement (V_S/V_R)

- Since It is in Short circuit-VR (Receiving end voltage is ZERO), so no need to measure **VS/VR** & it is equal to Zero

Angle Measurement (V_S/I_R)

- Connect **Terminal-VS** to **Input-1** (Phase angle meter) using patch chords &Connect **Terminal-IR** to **Input-2** (Phase angle meter) using patch chords & **GND terminal** to **GND terminal** (Phase Angle meter)
- Note down Angle between VS/IR

Table

Exp	Voltmeter & Ammeter Reading				Phase Angle		
	VS	VR	IS	IR	VS/VR	VS/IS	VS/IR
OC Test							
SC Test							

Model Calculation

SHORT TRANSMISSION LINE

OPEN CIRCUIT

A=VS/VR

=20∟0°/20∟0°

A=1

C=IS/VR

=0/20∟0°

C=0

SHORT CIRCUIT

B=VS/IR

=20∟0°/0.711∟55°

=28.12∟55° FROMULA [r∟ϴ=r (cos ϴ+j sinϴ)]

B=16.12+j23.03

D=IS/IR

=0.711∟55°/0.711∟55°

=1∟0°

D=1

MEDIUM LINE TRANSMISSION LINE

T-NETWORK

OPEN CIRCUIT

A=VS/VR

A=20/21

=0.952∟2°

FROMULA [r∟ϴ=r (cos ϴ+j sinϴ)]

A=0.952+J0.033

C=IS/VR

=0.059∟113°/20∟0°

=0.00295∟113°

c=1.15*10^{-3}

SHORT CIRCUIT

B=VS/IR

=20∟0°/0.374∟-52°

=53.47∟52°

B=32.91+J42.13

D=IS/IR

=0.352∟-53°/0.374∟-52°

D=0.940∟-1°

D=0.940+J0.016

PI-NETWORK

OPEN CIRCUIT

A=VS/VR

A=20∟0°/23∟5°

=0.869∟-5°

FORMULA [r∟θ=r (cos θ+j sinθ)]

A=0.8656+J0.075

C=IS/VR

=0.119∟110°/23∟5°

=0.023∟105°

c=6.15*10^{-3}+J0.02

SHORT CIRCUIT

B=VS/IR

=20∟0°/0.36∟-49°

=55.47∟49°

B=36.41+J41.88

D=IS/IR

=0.322∟-50°/0.364∟-49°

D=0.884∟-1°

D=0.883+J0.0154

LONG TRANSMISSION LINE

OPEN CIRCUIT

A=VS/VR

=20∟0°/23∟-4°

=0.869∟4° FORMULA [r∟ϴ=r (cos ϴ+j sinϴ)]

A=0.866+j0.06

C=IS/VR

=0.062/23∟-4°

C=-1.26*10^{-3}+J0.0027

SHORT CIRCUIT

B=VS/IR

=20∟0°/0.211∟-50°

=94.786∟50° FORMULA [r∟ϴ=r (cos ϴ+j sinϴ)]

B=60.92+j72.6

D=IS/IR

=0.194∟-51°/0.211∟-50°

=0.919∟-1°

D=0.918-J0.0160

Note: The same TX line model Can be used as Short Tx-Line model (or) Medium TX Line model (or) Long Tx line model

- For **SHORT TRANSMISSION LINE** select the **XL1** and **XL2** line in any one of phase (R,Y,B)

- For **MEDIUM TRANSMISSION LINE** select the **XL1,XL2,XL3** and **XL4** line in any one of phase(R,Y,B).In **T** network select the capacitor **XC1** and **XC8.** In PI network select the capacitor **XC4** or **XC5.**
- **For LONG TRANSMISSION LINE** selects all inductance lines and all capacitors.

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Aim : To study the Ferranti effect of Long Transmission Line model

Apparatus Required

- AC Transmission Line Trainer
- Patch chords
- 3 phase autotransformer

Connection procedure

- Switch ON the power supply
- Connect 3 phase supply to input of autotransformer then connect autotransformer output to AC Transmission line trainer(left side of the panel).
- Fix the input AC voltage at 230v by adjusting the auto transformer
- Connect the terminals **Ri1** Transmission lines **XL1** to **XL6** and also capacitors(**XC1** to **XC12**)
- Connect the terminals **Yi1** Transmission lines **XL1** to **XL6** and also capacitors(**XC1** to **XC12**)
- Connect the terminals **Bi1** Transmission lines **XL1** to **XL6** and also capacitors(**XC1** to **XC12**
- Connect the terminals **R1** to **Ri1**and **Y1** to **Yi1** and **B1** to **Bi1**
- Connect the terminals **RO1** to **R2**and **YO1** to **Y2** and **BO1** to **B2** then **N** to **N**.
- Observe the boosted output voltage from receiving end meters
- Switch ON the MCB 1, 2, 3, then apply 230v supply(by varied the 3 phase autotransformer.
- Note down the necessary readings like **Input meter 1** sending end **Current** and **Voltage** and also receiving end **Current** and **Voltage** then **output meter 2** readings.

TABULAR COLUMN

SINO	SENDING END BEFORE COMPENSATION			SENDING END AFTER COMPENSATION		
	VS	IS	PF	VS	IS	PF

SINO	RECEVING END BEFORE COMPENSATION			RECEVING END AFTER COMPENSATION		
	VS	IS	PF	VS	IS	PF

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Experiment-1

Aim – To Plot the IDMT characteristics of electromagnetic Earth fault relay

Apparatus required

1. Earth Fault relay module
2. 3Ø Induction Motor
3. Patch Chords

Precautions

- Keep the MCB in off condition.
- Keep the Autotransformer in Minimum Position.
- Keep the Power ON/OFF switch in off position.

Procedure

1. Set the pick-up value of the current marked 2A by inserting the plug in the groove.
2. Connect motor body (MB) to Fault Simulator D1.
3. Connect fault Simulator D2 to Lamp terminal(R).
4. Lamp terminal (B) to any one phase to Earth fault simulator.
5. Set the Time Multiplier Setting (TMS) initially at 1.0.
6. Switch ON the 3Ø Input Power Supply.
7. Switch ON the Power using Power ON/OFF Switch (IRS SWITCH)
8. Switch ON the MCB
9. Now the set up is ready for applying Earth Fault current of 2A
10. Press the START Button (Circuit Breaker is in “ON” Condition)
11. If the Fault current is above the set current (In relay), then DISC in RELAY is start to rotate and timer is calculated in stop clock.
12. Once the RELAY is tripped and the STOP CLOCK is automatically stopped and indicate the relay trip time , note down this trip time in table.
13. Repeat the above procedure (Procedure 1 to 10) with different PLUG Setting and Time setting Multiplier.

TABLE

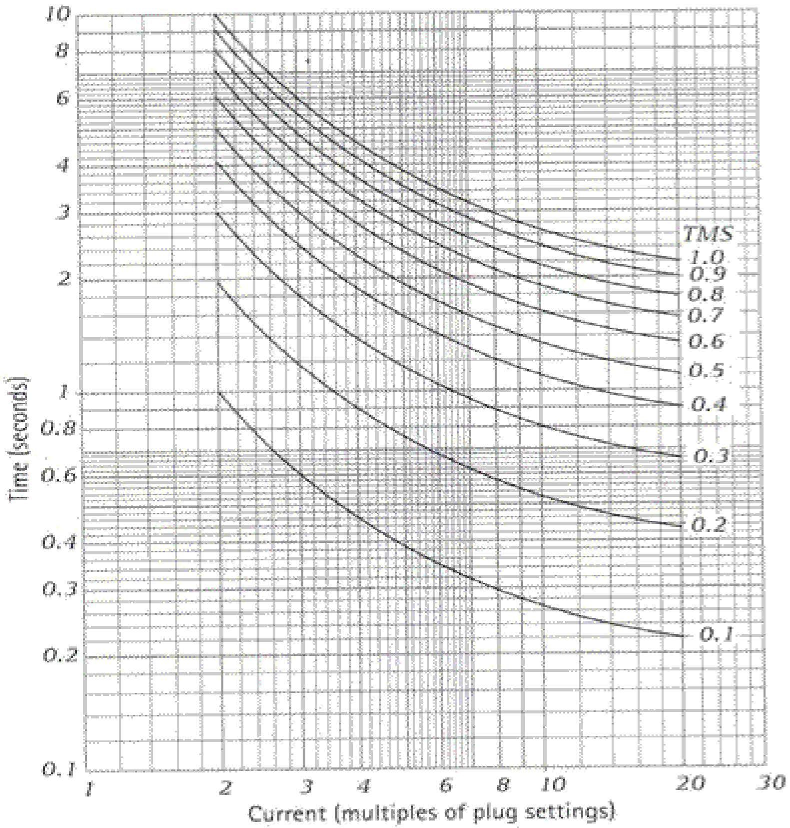
S.N	Applied Fault Current in Amp	Calculated tripping Time in ms	Measured Tripping Time in ms	TMS-Time setting multiplier	PSM-Plug setting multiplier
01	0.2A			1	2A
02	0.6A				
03	1A				
04	2A				

Calculation:

Plug setting multiplier = Fault current / Set current

Graph:

1. Draw graph Applied fault current Vs Measured tripping time- It gives IDMT Characteristics
2. Repeat the same with different TMS & PS



S.N	Applied Fault Current in Amp	Calculated tripping Time in ms	Measured Tripping Time in ms	TMS-Time setting multiplier	PSM-Plug setting multiplier
01	0.2A			**0.5**	**2A**
02	0.6A				
03	1A				
06	2A				

INTRODUCTION

The function of a relay is to detect abnormal conditions in the system and to initiate through appropriate circuit breakers the disconnection of faulty circuits so that interference with the general supply is minimized. Relays are of many types. Some depend on the operation of an armature by some form of electromagnet. A very large number of relays operate on the induction principle. When a relay operates it closes contacts in the trip circuit which is normally connected across 110 V D.C. supplies from a battery. The passage of current in the coil of the trip circuit actuates the plunger, which causes operation of the circuit breaker, disconnecting the faulty system.

A 3-phase contactor simulates the operation of the circuit breaker. The closure of the relay contacts short-circuits the 'no-volt ' coil of the contactor, which, in turn, disconnects the faulty system. The protective relaying which responds to a rise in current flowing through the protected element over a pre-determined value is called 'overcurrent protection' and the relays used for this purpose are known as overcurrent relays. Earth fault protection can be provided with normal overcurrent relays, if the minimum earth fault current is sufficient in magnitude. The design of a comprehensive protection scheme in a power system requires the detailed study of time-current characteristics of the various relays used in the scheme. Thus it is necessary to obtain the time current characteristics of these relays.

The Earth fault relay works on the induction principle. The moving system consists of an aluminum disc fixed on a vertical shaft and rotating on two jeweled bearings between the poles of an electromagnet and a damping magnet. The winding of the electromagnet is provided with seven taps (generally0, which are brought on the front panel, and the required tap is selected by a push-in -type plug. The pick-up current setting can thus be varied by the use of such plug multiplier setting.

The pick-up current values of earth fault relays are normally quite low. The operating time of all overcurrent relays tends to become asymptotic to a definite minimum value with increase in the value of current. This is an inherent property of the electromagnetic relays due to saturation of the magnetic circuit. By varying the point of saturation, different characteristics can be obtained and these are

1. Definite time
2. Inverse Definite Minimum Time (IDMT)
3. Very Inverse
4. Extremely Inverse

This manual explains the Testing Procedure of IDMT – EARTH FAULT RELAY using PLT-10PS-OC1 Trainer kit from **POWER LAB INSTRUMENTS, Chennai.**

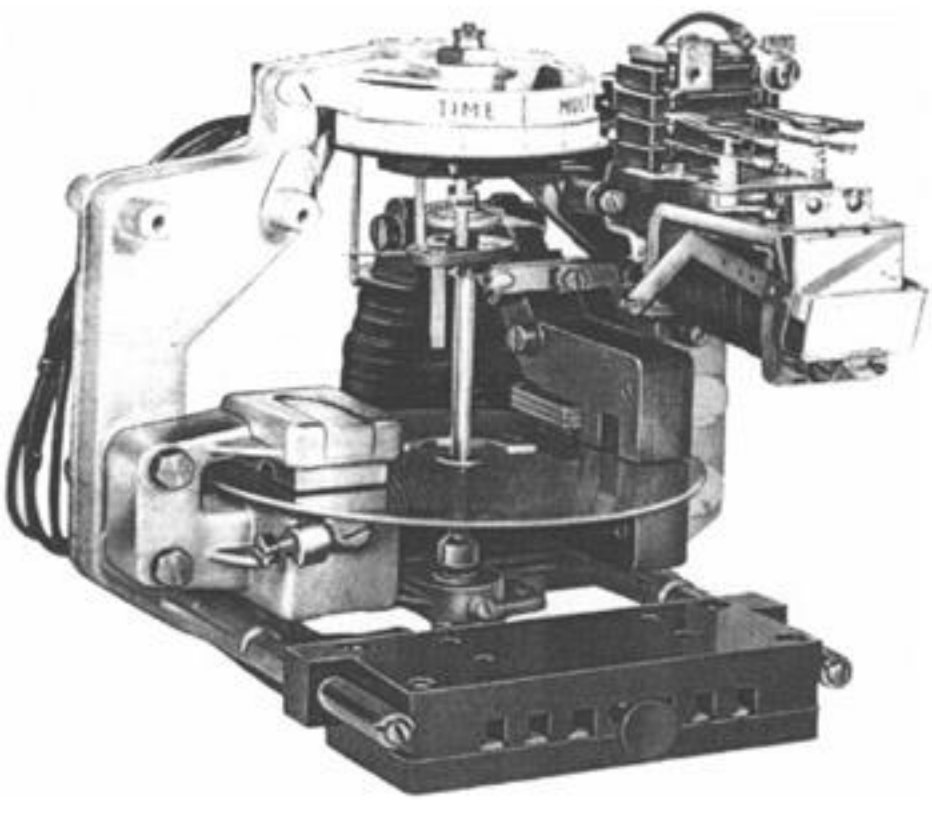
CHECK LIST:

S.No	Description	Qty
01	Earth Fault Relay Test Setup (PLI-10PS-OC1)	01
02	3 Pin PC Power card	01
03	User manual	01
04	Patch Chords	Few

Theoretical Details:

Principle of the Construction and Operation of the Electromechanical IDMT Relay

As the name implies, it is a relay monitoring the current, and has inverse characteristics with respect to the currents being monitored. This (electromechanical) relay is without doubt one of the most popular relays used on medium- and low-voltage systems for many years, and modern digital relays' characteristics are still mainly based on the torque characteristic of this type of relay. Hence, it is worthwhile studying the operation of this relay in detail to understand its characteristics



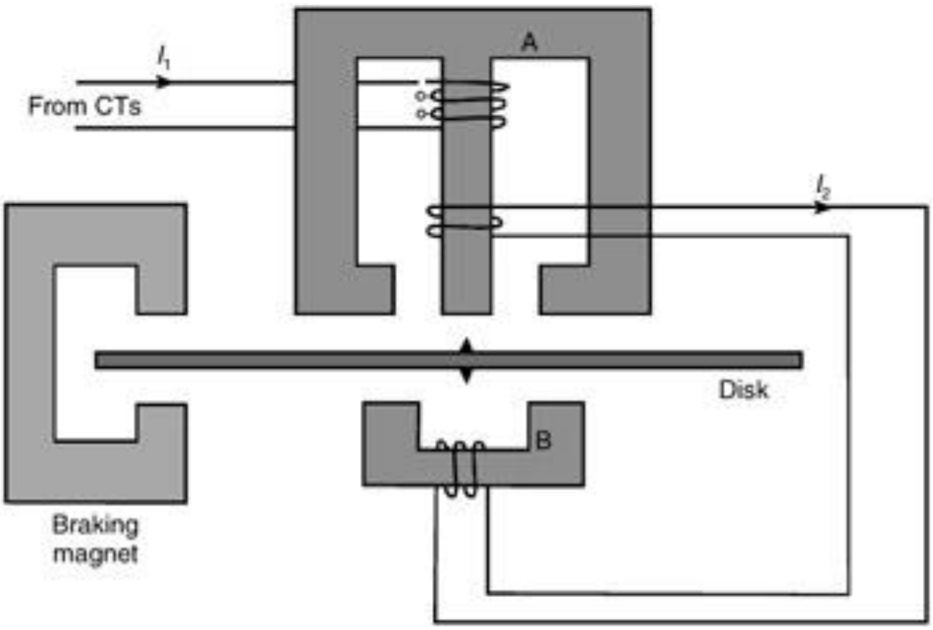
The current I_1 from the line CTs, sets up a magnetic flux A and also induces a current I_2 in the secondary winding which in turn sets up a flux in B. Fluxes A and B are out of phase thus producing a torque in the disk causing it to rotate. Now, speed is proportional to braking torque, and is proportional to driving torque. Therefore, speed is proportional to I^2.

But,

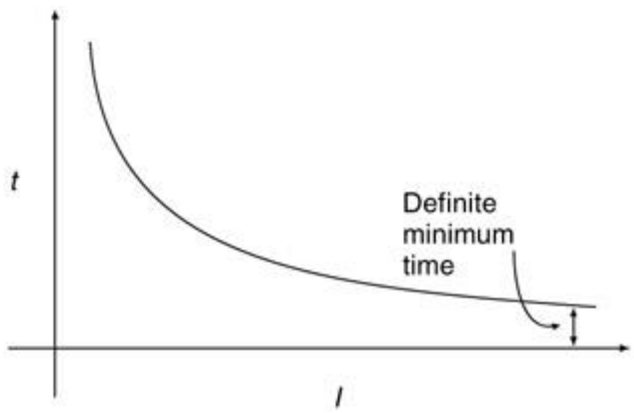
$$\text{Speed} = \frac{\text{Distance}}{\text{Time}}$$

Hence,

$$\text{Speed} = \frac{\text{Distance}}{\text{Time}} = \frac{1}{I^2}$$



This therefore gives an inverse characteristic (see Figure). It can be seen that the operating time of an IDMTL relay is inversely proportional to a function of current, i.e. it has a long operating time at low multiples of setting current and a relatively short operating...



The torque of these relays is proportional to f1f2 Sina, where f1 and f2 are the two fluxes and a is the angle between them. Where both the fluxes are produced by the same quantity (single quantity relays) as in the case of current or voltage operated, the torque T is proportional to I2, or T = K I2, for coil current below saturation. If the core is made to saturate at very early stages such that with increase of I, K decreases so that the time of operation remains the same over the working range. The time -current characteristic obtained is known as definite –time characteristic.

If the core is made to saturate at a later stage, the characteristic obtained is known as IDMT. The time-current characteristic is inverse over some range and then after saturation assumes the definite time form. In order to ensure selectivity, it is essential that the time of operation of the relays should be dependent on the severity of the fault in such a way that more severe the fault, the less is the time to operate, this being called the inverse-time characteristic.

This will also ensure that a relay shall not operate under normal overload conditions of short duration. It is essential also that there shall be a definite minimum time of operation, which can be adjusted to suit the requirements of the particular installation. At low values of operating current the shape of the curve is determined by the effect of the restraining force of the control spring, while at high values the effect of saturation predominates. Different time settings can be obtained by moving a knurled clamping screw along a calibrated scale graduated from 0.1 to 1.0 in steps of 0.05. This arrangement is called Time Multiplier Setting and will vary the travel of the disc required to close the contacts. This will shift the time-current characteristic of the relay parallel to itself. By delaying the saturation to a further point, the Very Inverse and Extremely Very Inverse time current characteristics can be obtained.

Hardware details

Name → Earth Fault Relay test set up

Power Input → 230vac 50 Hz

Description

1. **Power ON/OFF Switch** → Used to ON/OFF the input 230VAC of trainer kit
2. **MCB** → Used to ON/OFF the Variable current source output.
3. **S1** → START Button used to start the automatic relay tripping time measurement Circuit.
4. **S2** → MANUAL STOP Button used to stop the automatic relay tripping time measurement Circuit.
5. **Stop-Clock** → Used to measure the relay tripping time.
6. **RESET Switch** → Used to restart the stop clock.
7. **Ammeter (Relay current)** → Used to measure the Applied relay current.
8. **Banana terminals (NC Contacts 1,2)** → Earth Fault relay Output NC Contacts.
9. **Banana terminals (NO Contacts 1,2)** → Earth fault relay Output NO Contacts.
10. **Banana terminals (C1,C2 , CT Input)**→ Earth Fault relay Current input terminals – (Not connected).
11. **Left side Connectors** → 3Ø Input mains.
12. **Right side connectors** → Output to Motor terminals
13. **Right side Connectors** → Lamp Terminals
14. **Right side switches** → 1st Switch → 100W Selection
    2nd Switch → 200 W Selection
15. **Power input Connector (FM14-Back side)** → Used for Mains input supply.

Features:

- This module is designed to test the IDMT Earth Fault relay with different ampere of current injection. This test kit consists of
- IDMT Over current relay
- Variable current injection source
- Automatic trip time measurement circuit

IDMT Earth Fault relay

Make → ALSTOM

Current setting → 0 - 2A

Contacts → "NO" & "NC" Contacts

Automatic trip time measurement circuit

Automatic trip time measurement circuit is used to apply the set ac current to relay (from variable current source) and used to measure the relay tripping time. One number of **Digital Stop Clock** (mounted on the front panel) is used to measure the Relay tripping time .

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Experiment-1

Aim – To Plot the IDMT characteristics of electromagnetic IDMT Over voltage relay

Apparatus required

1. Over voltage relay module
2. Patch Chords

Precautions

- Keep the MCB in off condition
- Keep the Autotransformer in Minimum Position
- Keep the Power ON/OFF switch in off position.

Procedure

1. Set the pick-up value of the VOLTAGE marked ------V AC by inserting the plug in the groove.
2. Set the Time Multiplier Setting (TMS) initially at 1.0.
3. Connect front panel connector P1A to P1 By using connecting wires
4. Connect front panel connector P2A to P2 By using connecting wires
5. Connect Relay NC contact (1,2) to Trip circuit(1,2) (If not connected relay trip circuit will be open).
6. Switch ON the Power using Power ON/OFF Switch (IRS SWITCH)
7. Switch ON the MCB
8. Apply voltage ------ VAC Which should be GREATER THAN PLUG SETTING VALUE (voltage value is Indicated by front panel voltmeter) by Adjusting the Front panel Autotransformer
9. Now the set up is ready for applying Fault voltage of ----VAC
10. Press the START Button
11. If the Fault voltage is above the set voltage (In relay), then DISC in RELAY is start to rotate and timer is calculated in stop clock.
12. Once the RELAY is tripped and the STOP CLOCK is automatically stopped and indicate the relay trip time , note down this trip time in table

13. Repeat the above procedure (Procedure 1 to 10) with different PLUG Setting and Time setting Multiplier

TABLE

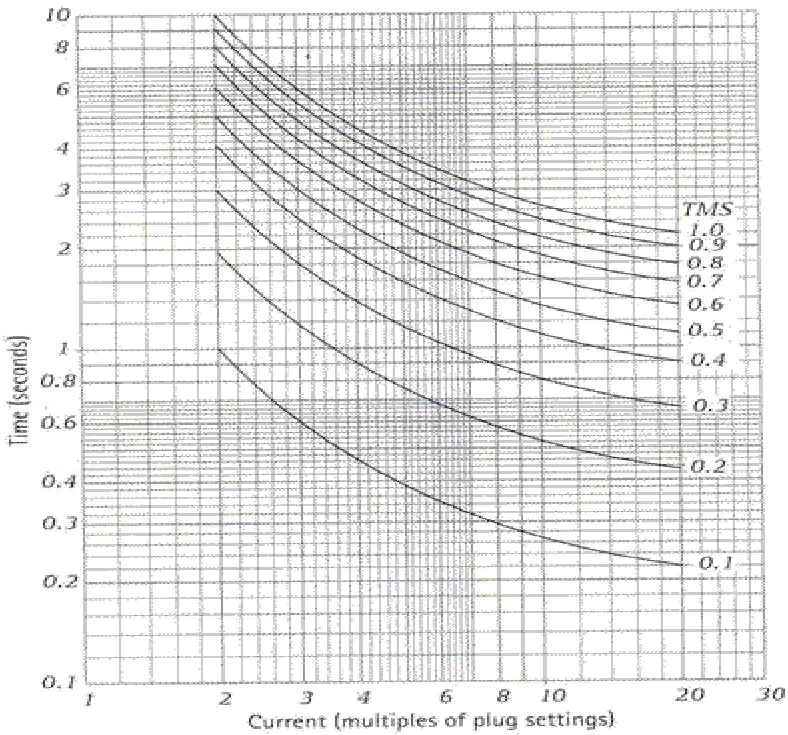
S.N	Applied Fault Voltage	Calculated tripping Time in ms	Measured Tripping Time in ms	TMS-Time setting multiplier	PSM-Plug setting multiplier
01					
02				**1**	**v**
03					
04					

Calculation:

Fault voltage = Plug setting voltage X Set voltage

Graph:

1. Draw graph Applied fault voltage Vs Measured tripping time- It gives IDMT Characteristics
2. Repeat the same with different TMS & PS



INTRODUCTION

The function of a relay is to detect abnormal conditions in the system and to initiate through appropriate circuit breakers the disconnection of faulty circuits so that interference with the general supply is minimized. Relays are of many types. Some depend on the operation of an armature by some form of electromagnet. A very large number of relays operate on the induction principle. When a relay operates it closes contacts in the trip circuit which is normally connected across 110 V D.C. supply from a battery. The passage of Voltage / current in the coil of the trip circuit actuates the plunger, which causes operation of the circuit breaker, disconnecting the faulty system.

A 3-phase contactor simulates the operation of the circuit breaker. The closure of the relay contacts short-circuits the 'no-volt ' coil of the contactor, which, in turn, disconnects the faulty system. The protective relaying which responds to a rise in Voltage flowing through the protected element over a pre-determined value is called 'over voltage protection' and the relays used for this purpose are known as over voltage relays. The design of a comprehensive protection scheme in a power system requires the detailed study of time-current characteristics of the various relays used in the scheme. Thus it is necessary to obtain the time current characteristics of these relays.

The over voltage relay works on the induction principle. The moving system consists of an aluminum disc fixed on a vertical shaft and rotating on two jeweled bearings between the poles of an electromagnet and a damping magnet. The winding of the electromagnet is provided with seven taps (generally0, which are brought on the front panel, and the required tap is selected by a push-in -type plug.

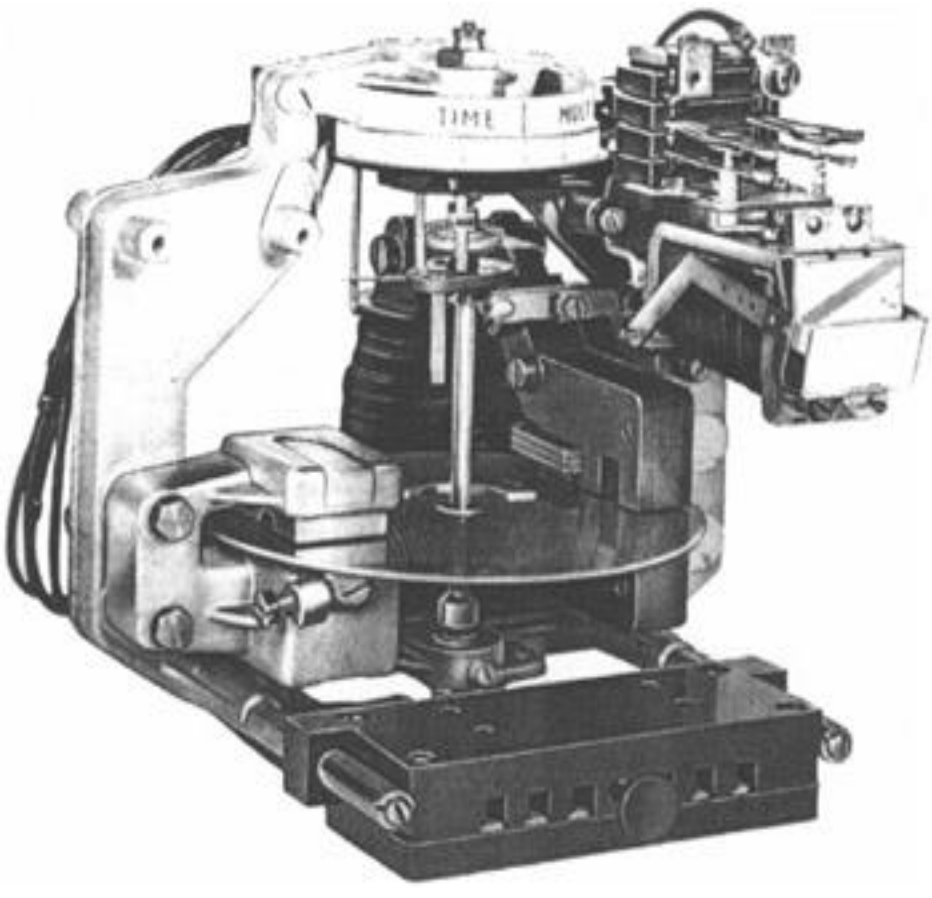
The pick-up voltage setting can thus be varied by the use of such plug multiplier setting. The pick-up values of relays are normally quite low. The operating time of all relays tends to become asymptotic to a definite minimum value with increase in the value of voltage. This is an inherent property of the electromagnetic relays due to saturation of the magnetic circuit. By varying the point of saturation, different characteristics can be obtained and these are

1. Definite time
2. Inverse Definite Minimum Time (IDMT)
3. Very Inverse
4. 4. Extremely Inverse

This manual explain the Testing Procedure of IDMT – OVER VOLTAGE RELAY using Over voltage relay test kit from **POWER LAB INSTRUMENTS, Chennai.**

Principle of the Construction and Operation of the Electromechanical IDMT Relay

As the name implies, it is a relay monitoring the current, and has inverse characteristics with respect to the currents being monitored. This (electromechanical) relay is without doubt one of the most popular relays used on medium- and low-voltage systems for many years, and modern digital relays' characteristics are still mainly based on the torque characteristic of this type of relay. Hence, it is worthwhile studying the operation of this relay in detail to understand its characteristics



The current I_1 from the line CTs, sets up a magnetic flux A and also induces a current I_2 in the secondary winding which in turn sets up a flux in B. Fluxes A and B are out of phase thus producing a torque in the disk causing it to rotate.

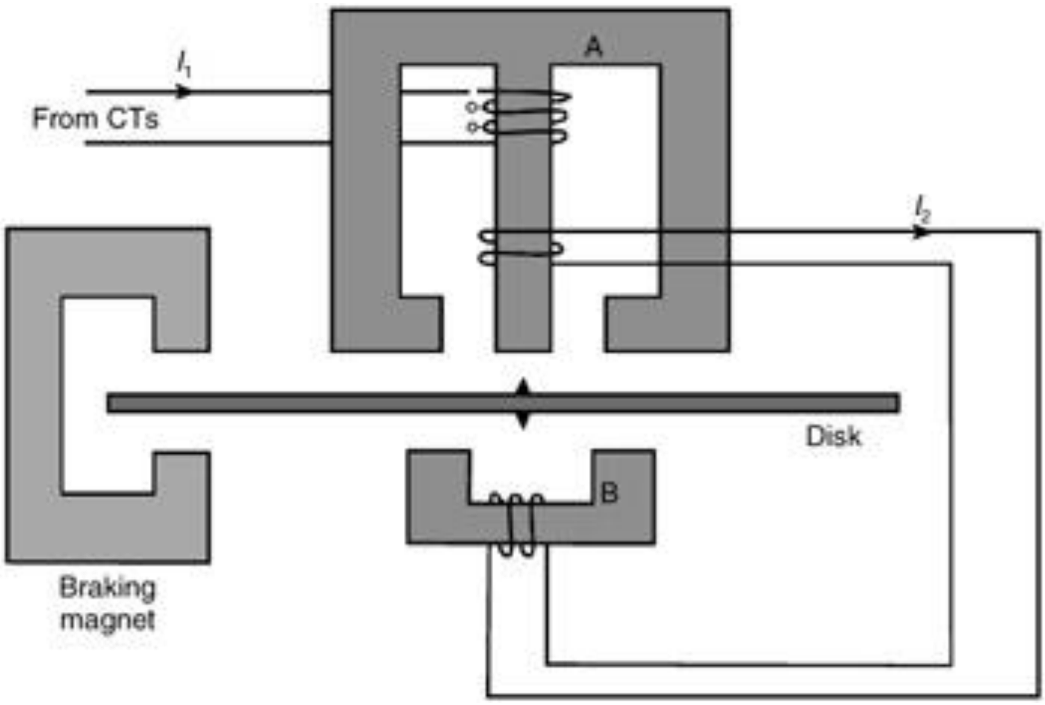
Now, speed is proportional to braking torque, and is proportional to driving torque. Therefore, speed is proportional to I^2.

But,

$$\text{Speed} = \frac{\text{Distance}}{\text{Time}}$$

Hence,

$$\text{Speed} = \frac{\text{Distance}}{\text{Time}} = \frac{1}{I^2}$$



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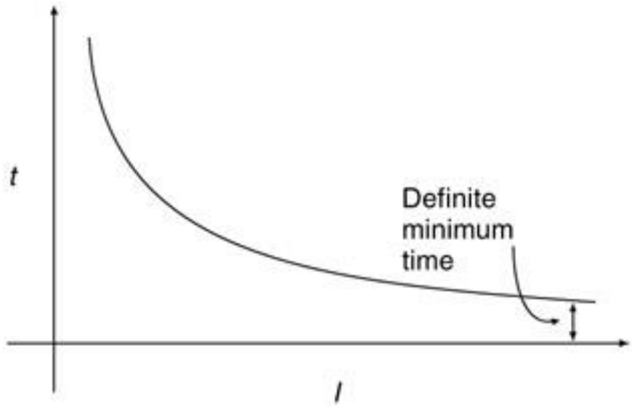

The torque of these relays is proportional to f1f2 Sina, where f1 and f2 are the two fluxes and a is the angle between them. Where both the fluxes are produced by the same quantity (single quantity relays) as in the case of current or voltage operated, the torque T is proportional to I2, or T = K I2, for coil current below saturation. If the core is made to saturate at very early stages such that with increase of I, K decreases so that the time of operation remains the same over the working range. The time -current characteristic obtained is known as definite –time characteristic.

If the core is made to saturate at a later stage, the characteristic obtained is known as IDMT. The time-current characteristic is inverse over some range and then after saturation assumes the definite time form. In order to ensure selectivity, it is essential that the time of operation of the relays should be dependent on the severity of the fault in such a way that more severe the fault, the less is the time to operate,this being called the inverse-time characteristic. This will also ensure that a relay shall not operate under normal overload conditions of short duration. It is essential also that there shall be a definite minimum time of operation, which can be adjusted to suit the requirements of the particular installation. At low values of operating current the shape of the curve is determined by the effect of the restraining force of the control spring, while at high values the effect of saturation predominates. Different time settings can be obtained by moving a knurled clamping screw along a calibrated scale graduated from 0.1 to 1.0 in steps of 0.05. This arrangement is called Time Multiplier Setting and will vary the travel of the disc required to close the contacts. This will shift the time-current characteristic of the relay parallel to itself. By delaying the saturation to a further point, the Very Inverse and Extremely Very Inverse time current characteristics can be obtained

Hardware details

Name → Over voltage Relay test set up

Power Input → 230vac 50 Hz

Description

1.	**Power ON/OFF Switch**	→	Used to ON/OFF the input 230VAC of trainer kit.
2.	**MCB**	→	**6A** Used to ON/OFF the Variable voltage source output.
3.	**S1**	→	START Button used to start the automatic relay tripping time measurement Circuit.
4.	**S2**	→	MANUAL STOP Button used to stop the automatic relay tripping time measurement Circuit.
5.	**Autotransformer**	→	Used to adjust the Variable ac voltage.
6.	**Stop-Clock**	→	Used to measure the relay tripping time.
7.	**RESET Switch**	→	Used to restart the stop clock.
8.	**Voltmeter (Relay Voltage)**	→	Used to measure the Applied relay voltage.
9.	**Banana terminals (NC Contacts 1,2)**	→	Relay closing contacts.
10.	**Banana terminals (N0 Contacts 1,2)**	→	Relay Output NO Contacts.
11.	**Banana terminals (P1,P2 , PT Input)**	→	Over Voltage relay Voltage input terminals.
12.	**Banana terminals (P1a,P2a , Output)**	→	Variable AC Voltage Output terminals.
13.	**Power input Connector (FM14-Back side)**	→	Used for Mains input supply.

Features:

- This module is designed to test the IDMT –Over voltage relay with different voltage injection. This test kit consists of
- IDMT Over voltage relay
- Variable voltage injection source
- Automatic trip time measurement circuit

IDMT Over voltage relay

Make → ALSTOM

Contacts → "NO" & "NC" Contacts

Variable voltage injection source

Variable ac voltage is obtained by using specially designed voltage source transformer, the input of this transformer is adjusted by using a single phase auto transformer which is mounted on the front panel of the trainer, **by using this autotransformer output voltage can be adjusted from 0-270VAC**

One number of 0-300 AC Voltmeter (Digital) is connected in parallel with this voltage output so that the applied voltage is measured by using this meter

Automatic trip time measurement circuit

This automatic trip time measurement circuit is used to apply the set ac voltage to relay (from variable voltage source) and used to measure the relay tripping time .One number of **Digital Stop Clock** (mounted on the front panel) is used to measure the Relay tripping time .

Laboratory Manual

for

Power System Lab

Prepared by

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Aim – To Plot the IDMT characteristics of UNDER **voltage relay**

The same procedure repeat the under voltage relay

1. Relay display will be

"Power lab instruments
Chennai-96"

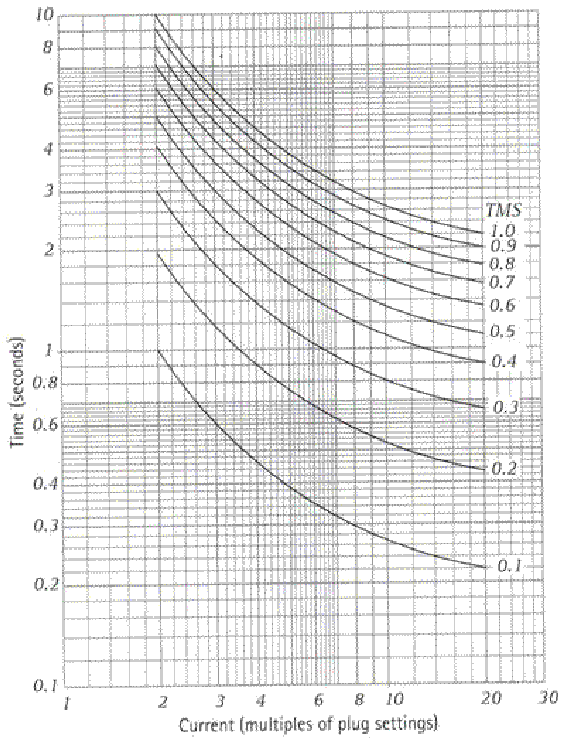
"Over voltage relay
Under voltage relay"

- press **down key** for Under voltage relay
- Press **Enter Key**
- Then the display will be
  "DMT
  IDMT"
- Press **down key** for IDMT Function
- Press **Enter Key**
- Set the time value by pressing keys (0.1 to 50ms)
- Press **Enter Key**
- Apply voltage ------ VAC Which should be LESS THAN SETTING VALUE (voltage value is Indicated by front panel voltmeter) by Adjusting the Front panel Autotransformer
  1. Now the fault voltage of ------- VAC is set
- Switch on the MCB1
- Now RELAY is tripped after calculated time
- Once the RELAY is tripped and the STOP CLOCK is automatically stopped and indicate the relay trip time , note down this trip time in table
- Repeat the above procedure (Procedure 1 to 10) with different voltage Setting and Time setting

TABLE :

S.N	Applied Fault Voltage	Calculated tripping Time in ms	indicated Tripping Time in ms	Time setting	Voltage setting
01				**0.1 sec**	
02					
03					
06					

- Draw graph Applied fault voltage Vs Measured tripping time- It gives IDMT Characteristics
- Repeat the same with different TMS & PS



S.N	Applied Fault Voltage	Calculated tripping Time in ms	indicated Tripping Time in ms	Time setting	Voltage setting
01				**0.5 sec**	
02					
03					
06					

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EXPERIMENT NO. 09

Aim

Aim: Measurement of Sequence impedances (Positive , Negative & zero sequence impedance) of 3 phase Transformer.

Apparatus Required:

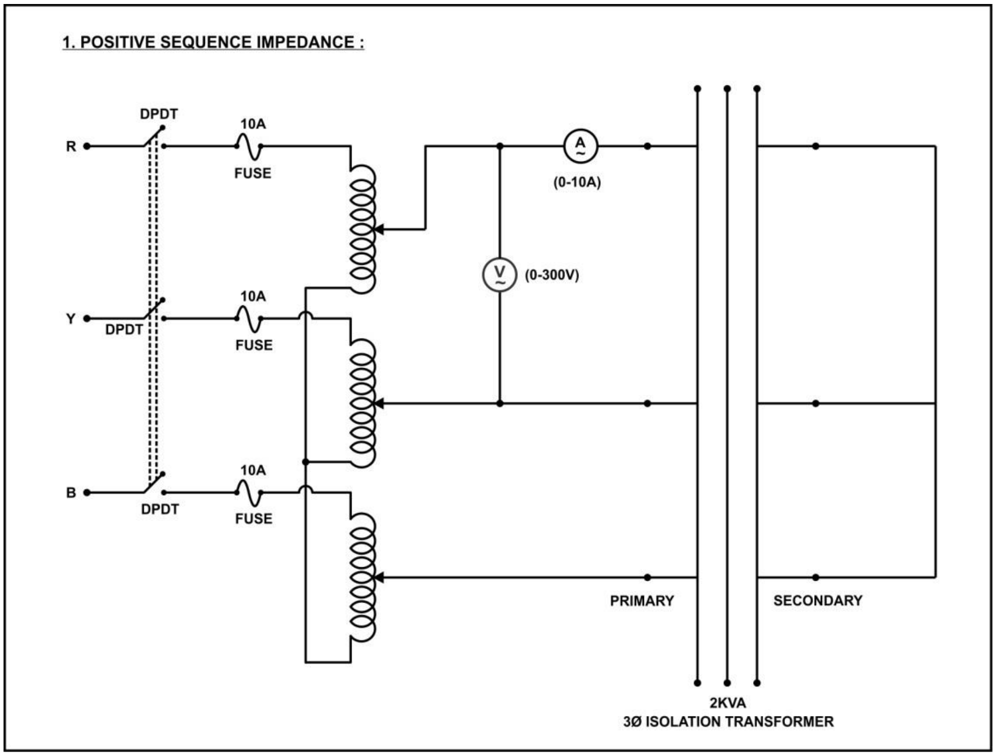
1. Trainer set up
2. Patch chords
3. Manual

- Main transforme
    - In

- Output 3 Phase ,110-0-110VAC@ All 3 phases
- Capacity 1KVA

Measurement of Positive Sequence impedance

Connection Diagram (Fig-1)



Formula:

$$\text{Z1 (per phase)} = \frac{Vprimary\ x\ (\sqrt{\mathbf{3}}\,)}{(IL)}$$

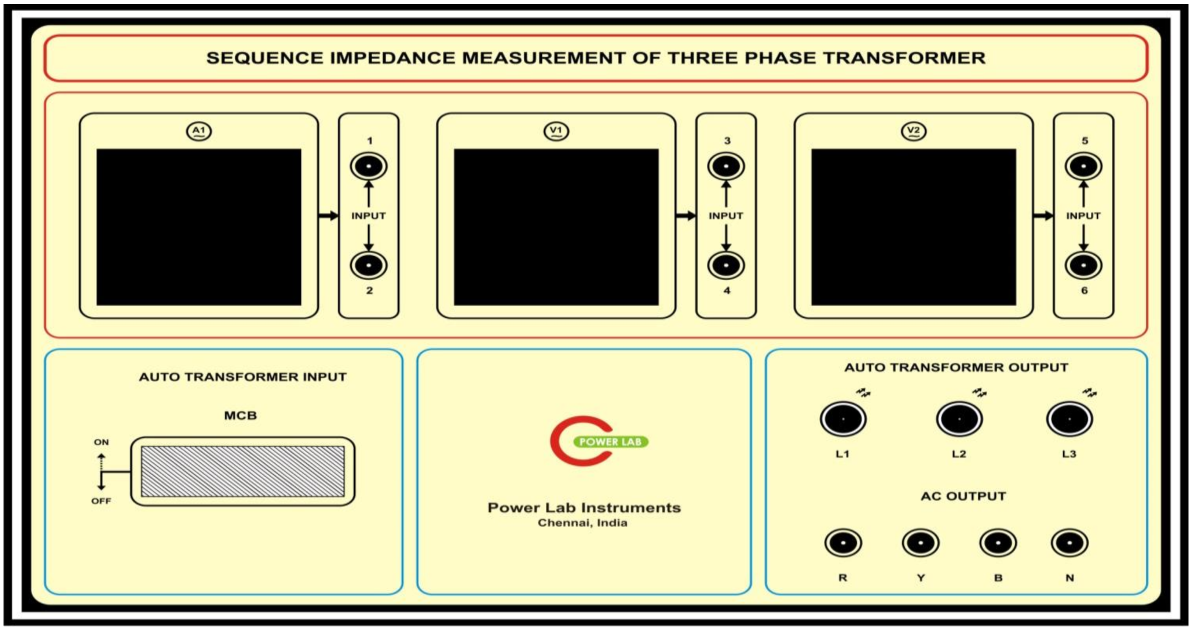
Where

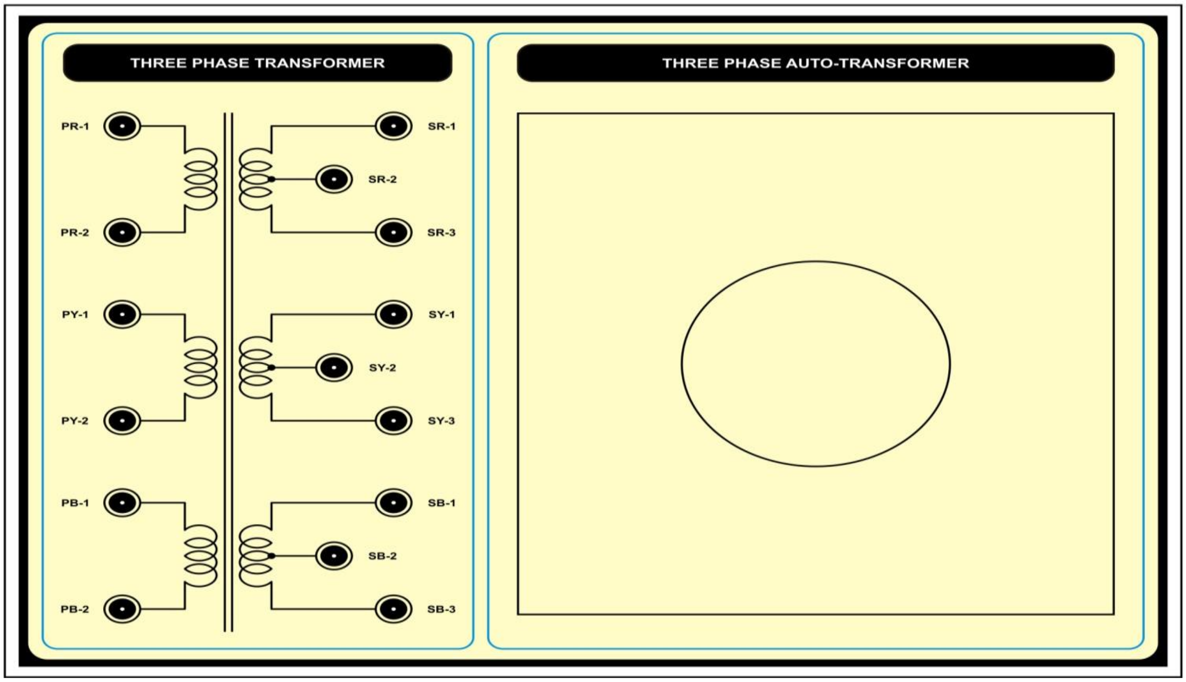
1. Z1 = Positive sequence Impedance

2. V primary = Transformer input Line Voltage which is measured by _____ Voltmeter in out trainer
3. IL = Transformer input Line Current which is measured by _____ Ammeter in out trainer

Precaution

1. Keep the 3 phase autotransformer is in minimum position
2. Keep the MCB in OFF position





Connection Procedure

1. Connect 3 phase transformer primary terminals PR2 to PY2 to PB2 terminated in front Panel using Patch Chords
2. Connect 3 phase transformer primary **Terminals PR1** to **Terminal –2 (Digital Ammeter)** terminated in front Panel using Patch Chords
3. Connect **Digital ammeter Terminals-1** to **Terminal –R (3 phase ac output)** terminated in front Panel using Patch Chords
4. Connect 3 phase transformer primary Terminals PY1 to Terminal –Y (3 phase ac output) terminated in front Panel using Patch Chords
5. Connect 3 phase transformer primary Terminals PB1 to Terminal –B (3 phase ac output) terminated in front Panel using Patch Chords
6. Connect Digital AC Voltmeter across 3 phase transformer primary Terminals PR1&PY1
   i. Digital AC Voltmeter Terminal-3 to terminals PR1 using patch chords
   ii. Digital AC Voltmeter Terminal-4 to terminals PY1 using patch chords

7. Connect 3 phase transformer Secondary terminals SR3 to SY3 to SB3 terminated in front Panel using Patch Chords
8. Connect 3 phase transformer Secondary terminals SR1 to SY1 to SB1 terminated in front Panel using Patch Chords

Working procedure

1. Switch 'ON' MCB
2. Slowly adjust the autotransformer from minimum to maximum(Upto the Maximum reading of Ammeter ___A)
3. Note down the Ammeter and voltmeter readings in table-1
4. Switch OFF the MCB & Keep the autotransformer in Minimum position for next experiments

Table:-1

S.l.No.	Primary Voltage (V)	Primary Current (A)	Impedance (Z)
1.	4.83	0.597	4.6
2.	6.77	0.974	4.0
3.	12.5	2.04	3.5
4.	17.14	2.952	3.3
5.	20.2	3.547	3.3
6.	29.4	5.3	3.2

Z1 (avg) = 3.65Ω

Positive Sequence impedance per phase = 3.65Ω

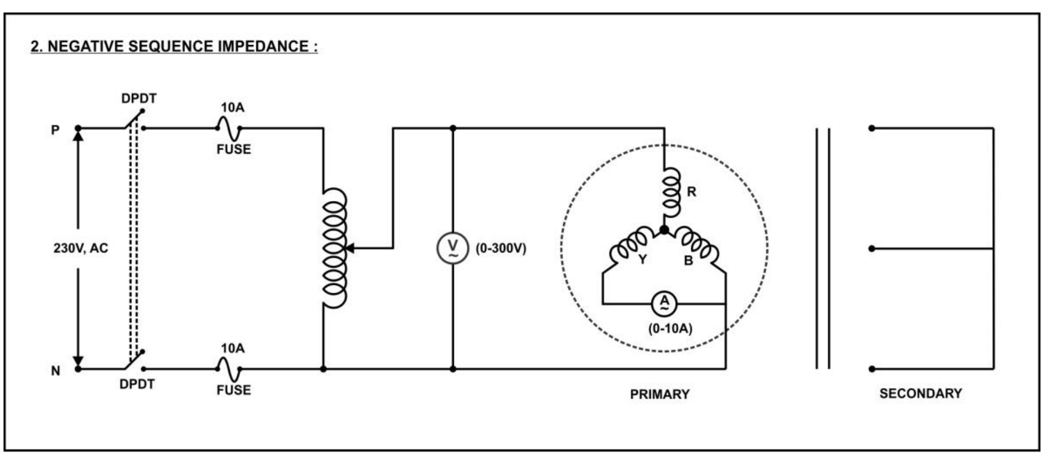
Model Calculation :

1) $Z = 4.83 /\sqrt{3}\ X\ 0.597 = 4.6$
2) $Z = 6.77 /\sqrt{3}\ X\ 1.974 = 4.0$
3) $Z = 12.5 /\sqrt{3}\ X\ 2.04 = 3.5$
4) $Z = 17.14 /\sqrt{3}\ X\ 2.952 = 3.3$
5) $Z = 20.2 /\sqrt{3}\ X\ 3.547 = 3.3$
6) $Z = 29.4 /\sqrt{3}\ X\ 5.3 = 3.2$

Z1 = 4.6+4.0+3.5+3.3+3.3+3.2 / 6

Z1 = 3.65Ω

Measurement of Negative Sequence impedance



Connection procedure:

1. Connect 3 phase transformer primary Terminals **PR2** to **PY2** to **PB2** terminated in front panel using patch chords (Star Connection).
2. Connect 3 phase transformer primary Terminals **PR1** to Terminal – **R** (3 phase ac output) terminated in front panel using patch chords.
3. Connect 3 phase transformer primary Terminal **PB1** to Terminal – **N** (3 phase ac output) terminated in front panel using patch chords.
4. Connect digital Ac voltmeter **Terminal 3** to Terminal **PR1** (3 phase transformer primary) and connect **Terminal 4** to **Terminal – N** (3 phase ac output).
5. Connect digital Ammeter across 3 phase transformer primary Terminals **PY1** and **PB1**
   i. Digital Ammeter **Terminal – 1** to Terminal **PY1**using the patch chords
   ii. Digital Ammeter **Terminal – 2** to Terminal **PB1** using the patch chords
6. Connect 3 phase transformer secondary Terminals **SR3** to **SY3** to **SB3** terminated in front panel by using patch chords.
7. Connect 3 phase transformer secondary Terminals **SR1** to **SY1** to **SB1** terminated in front panel by using patch chords.

Working procedure:

1. Switch ON **MCB**.

2. Slowly adjust the Auto transformer from minimum to maximum (Up to Maximum ratings of Ammeter ________A)

3. Note down the Ammeter and Voltmeter readings in table-2.

4. Switch OFF the MCB & Keep the auto transformer in minimum position for next experiment.

Formula:

$$Z_2(\text{per phase}) = \frac{V\ primary}{(\sqrt{3}).I\ primary}$$

Where

Z_2 = Negative sequence impedance.

$V_{primary}$ = Transformer line input voltage which is measured by _____voltmeter in out trainer.

$I_{primary}$ = Transformer line current which is measured by ____ Ammeter in out trainer.

Table:-2

S.I.No.	Primary Voltage (V)	Primary Current (A)	Impedance (Z)
1.	9.2	1.062	5.0
2.	18.4	2.05	5.18
3.	25	3.08	4.68
4.	34	3.98	4.93

$Z_2(avg) = 4.9\Omega$

Negative sequence impedance per phase= 4.9 Ω

Model Calculation :-

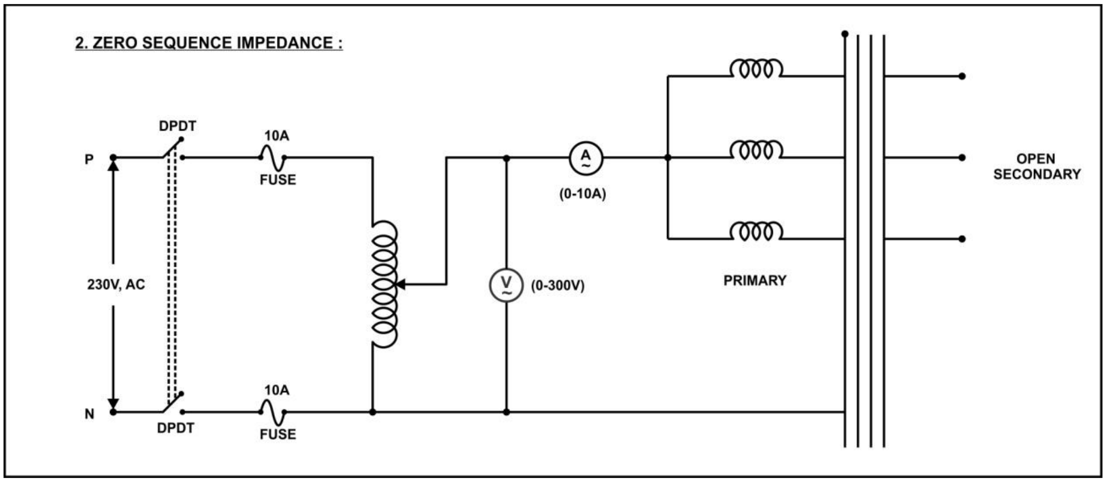
Z2 / Ph = Vprimary / √3 X Iprimary

1) $Z = 9.2 / \sqrt{3} \text{ X } 1.062 = 3.25$
2) $Z = 18.4 / \sqrt{3} \text{ X } 2.05 = 5.18$
3) $Z = 25 / \sqrt{3} \text{ X } 3.08 = 4.68$
4) $Z = 34 / \sqrt{3} \text{ X } 3.98 = 4.93$

$Z2 = 5+5.18+4.68+4.93 / 4$

$\mathbf{Z_2 = 4.9\Omega}$

Measurement of Zero Sequence impedance



Connection procedure:

1. Connect 3 phase transformer primary Terminals **PR1** to **PY1** to **PB1** terminated in front panel using patch chords.
2. Connect 3 phase transformer primary Terminals **PR2** to **PY2** to **PB2** terminated in front panel using patch chords.
3. Connect 3 phase transformer primary Terminals **PR2** to **PY2** to **PB2** common end to **Terminal –N** (3 phase AC output) using patch chords.
4. Connect Digital Ammeter Terminal **1** to Terminal – **R** (3 phase AC output) and Ammeter Terminal **2** to 3 phase transformer primary any Terminal of **PR1/ PY1/ PB1**.(as per diagram)
5. Connect Digital Voltmeter as below
   i. Connect Digital Voltmeter Terminal **3** to Ammeter Terminal **1**
   ii. **Connect Digital** Voltmeter Terminal **4** to Terminal - **N** (3 phase Ac output)
6. 3 phase transformer secondary terminals are opened.

Working procedure:

1. Switch ON MCB.

2. Slowly adjust the Auto transformer for minimum position to maximum position maximum (Up to

Maximum ratings of Ammeter ________A)

3. Note down the ammeter and voltmeter readings in table 3.

4. Switch OFF the MCB and Keep the auto transformer in minimum position.

Table:-3

S.I.No.	Primary Voltage (V)	Primary Current (A)	Impedance (Z)
1.	19	1.06	53.77
2.	35.8	1.95	55.076
3.	56.4	3.00	56.4
4.	73.4	3.97	55.46

Z_0 (avg) = 55.17Ω

Zero sequence impedance per phase =50.63Ω

Formula:

$$\mathbf{Z_0\,(per\ phase)} = \frac{(\mathbf{3}\,)X\,(\boldsymbol{V\ primary})}{\boldsymbol{I\ primary}}$$

Where

Z_0 = Zero sequence impedance.

$V_{primary}$ = Transformer line input voltage which is measured by _____voltmeter in out trainer.

$I_{primary}$ = Transformer line current which is measured by ____ Ammeter in out trainer.

Model calculation:

Z_0 / Ph= 3 X Vprimary / Iprimary

1) Z = 3 X 19 / 1.067 = 35.62

2) Z = 3 X 35.8 / 1.95 = 55.076

3) Z = 3 X 56.4 / 3.0 = 56.4

4) Z = 3 X 73.4 / 3.97 = 55.46

Z0 = 35.62+55.076+56.4+55.46 / 4

Z0 = 50.63Ω

RESULT:

Sequence impedance (Positive, Negative and Zero sequence) of 3 phase transformer was calculated by using the trainer set up and the result is

Positive sequence (Z_1) = **3.65Ω**

Negative sequence (Z_2) =**4.9Ω**

Zero sequence (Z_0) =**50.63Ω.**

Laboratory Manual

for

Power System Lab

Prepared by

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Aim : To study the Over Current (over load) Protection of Transmission Line

Apparatus Required

- AC Transmission Line Trainer
- Patch chords
- 3 Phase AC Induction Motor and Lamp Load set up
- 3 Phase autotransformer.

Connection procedure

- Switch ON the power supply
- Connect 3 phase supply to input of autotransformer then connect autotransformer output to AC Transmission line trainer(left side of the panel).
- Fix the input AC voltage at 230v by adjusting the auto transformer
- Connect the terminals **Ri1** Transmission lines **XL1** to **XL6**
- Connect the terminals **Yi1** Transmission lines **XL1** to **XL6**
- Connect the terminals **Bi1** Transmission lines **XL1** to **XL6**
- Connect the terminals **R1** to **Ri1**and **Y1** to **Yi1** and **B1** to **Bi1**
- Connect the terminals **RO1** to **R2**and **YO1** to **Y2** and **BO1** to **B2** then **N** to **N**.
- Connect the terminals **R3** to **Ri3** and **Y3** to **Yi3** and **B3** to **Bi3**
- Connect the lamp load right side of the transmission line trainer.
- Switch ON the MCB 1,2,3,4,5then apply 230v supply(by varied the 3 phase autotransformer)
- Different load stage create the over current and observe the behavior

M/C type relay display below parameters only appear

Relay display will be

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Chennai-96”

“Over current relay

- Press **UP key** for Over current relay
- Press **Enter Key**
- Then the display will be

  "DMT

  IDMT"
- Press **down key** for IDMT Function
- Press **Enter Key**
- Set the time value by pressing keys (0.1 to 50ms)
- Press **Enter Key**
- -Fault current Which should be GREATER THAN SETTING VALUE (current value is Indicated by front panel ammeter) by Adjusting load

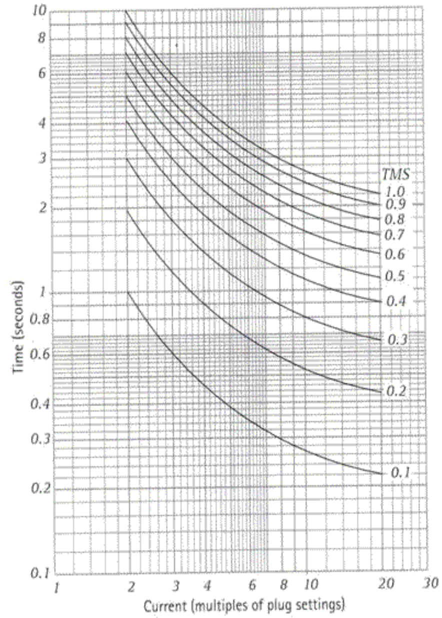
  1. Now the set current of ------- A is set

- Switch on the MCB1
- Now RELAY is tripped after calculated time
- Once the RELAY is tripped and the STOP CLOCK is automatically stopped and indicate the relay trip time , note down this trip time in table
- Repeat the above procedure (Procedure 1 to 10) with different voltage Setting and Time setting

TABLE :

S.N	Applied Fault Current	Calculated tripping Time in ms	indicated Tripping Time in ms	Time setting	Current setting
01				**0.1 sec**	
02					
03					
06					

- Draw graph Applied fault current Vs Measured tripping time- It gives IDMT Characteristics
- Repeat the same with different TMS & PS



S.N	Applied Fault current	Calculated tripping Time in ms	indicated Tripping Time in ms	Time setting	current setting
01				**0.5 sec**	
02					
03					
06					

Laboratory Manual

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Aim : To study the Over Voltage (& Under voltage) Protection of Transmission Line

Apparatus Required

- AC Transmission Line Trainer
- Patch chords
- 3Phase Autotransformer

Connection procedure

- Switch ON the power supply
- Connect 3 phase supply to input of autotransformer then connect autotransformer output to AC Transmission line trainer(left side of the panel).
- Fix the input AC voltage at 230v by adjusting the auto transformer
- Connect the terminals **Ri1** Transmission lines **XL1** to **XL6**
- Connect the terminals **Yi1** Transmission lines **XL1** to **XL6**
- Connect the terminals **Bi1** Transmission lines **XL1** to **XL6**
- Connect the terminals **R1** to **Ri1**and **Y1** to **Yi1** and **B1** to **Bi1**
- Connect the terminals **RO1** to **R2**and **YO1** to **Y2** and **BO1** to **B2** then **N** to **N**
- Connect the terminals **R3** to **Ri3** and **Y3** to **Yi3** and **B3** to **Bi3**
- Switch ON the **MCB 1,2,3,4,5**then apply **230v** supply(by varied the 3 phase autotransformer)
- Different voltage setup create the over /under voltage and observe the behavior
- M/C type relay display below parameters only appear

“Power lab instruments
Chennai-96”

“Over voltage relay
Under voltage relay”

- Press **UP key** for Over voltage relay (or) press **down key** for Under voltage relay
- Press **Enter Key**
- Then the display will be

"DMT

IDMT"

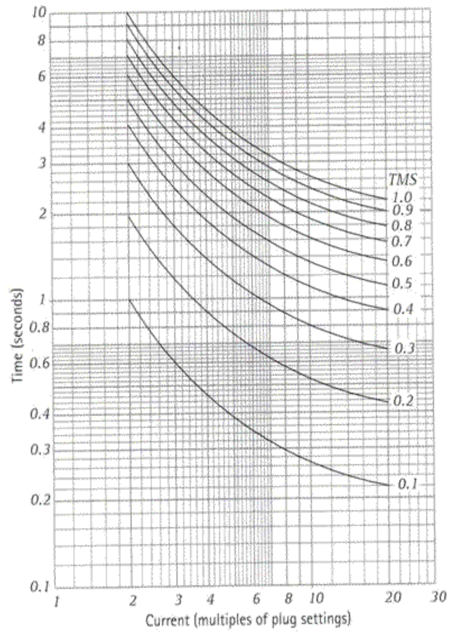
- Press **down key** for IDMT Function
- Press **Enter Key**
- Set the time value by pressing keys (0.1 to 50ms)
- Press **Enter Key**
- Apply voltage ------ VAC Which should be GREATER THAN SETTING VALUE (voltage value is Indicated by front panel voltmeter) by Adjusting the Front panel Autotransformer
  1. Now the fault voltage of ------- VAC is set

- Switch on the MCB1
- Now RELAY is tripped after calculated time
- Once the RELAY is tripped and the STOP CLOCK is automatically stopped and indicate the relay trip time , note down this trip time in table
- Repeat the above procedure (Procedure 1 to 10) with different voltage Setting and Time setting

TABLE :

S.N	**Applied Fault Voltage**	**Calculated tripping Time in ms**	**indicated Tripping Time in ms**	**Time setting**	**Voltage setting**
01				**0.1 sec**	
02					
03					
06					

- Draw graph Applied fault voltage Vs Measured tripping time- It gives IDMT Characteristics
- Repeat the same with different TMS & PS



S.N	Applied Fault Voltage	Calculated tripping Time in ms	indicated Tripping Time in ms	Time setting	Voltage setting
01				**0.5 sec**	
02					
03					
06					

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AIM :

To study the working principle of BUCHHOLZ relay with practical set up

APPARATUS REQUIRED:

BUCHHOLZ relay with transformer set up

PROCEDURE:

- ❖ Close all the gate valve in transformer set up.
- ❖ Fill the oil in transformer via conservator up to Bucholtz relay.
- ❖ If the oil fills the Buchholtz relay, the NC contact in relay will changes to NO contact and the lamp will stops glowing.
- ❖ If you want to trip the Bucholtz relay open the Left side gate valve, now the oil flow towards the Bottom Tank at the same time open the right side gate valve and collect the oil in oil can.
- ❖ When the oil level getting down from Max to Min, relay will be tripping same as Bulb will be glowing.
- ❖ To repeat the experiment, close all the gate valves, now refill the oils to conservator.

DEFINITION

Buchholz relay is a special type of relay which is widely used for internal protection of a transformer. According to the history, this relay is named after Max Buchholz in 1921. This relay is mainly used in oil immersed transformer for providing protection against all types of internal faults like any insulation breakdown. By definition, **Buchholz relay** is oil and gas actuated relay which is located in the pipeline connecting the transformer main tank and the conservator. This is a simple definition of **what is Buchhloz relay**. As we proceed further, we will know the construction and working principle of Buchloz relay.

Buchholz relay is a safety device which is generally used in large oil immersed transformers (rated more than 500 kVA). It is a type of oil and gas actuated protection relay. It is used for the protection of a transformer from the faults occurring inside the transformer, such as impulse breakdown of the insulating oil, insulation failure of turns etc.

BUCHHOLZ RELAY PRINCIPLE

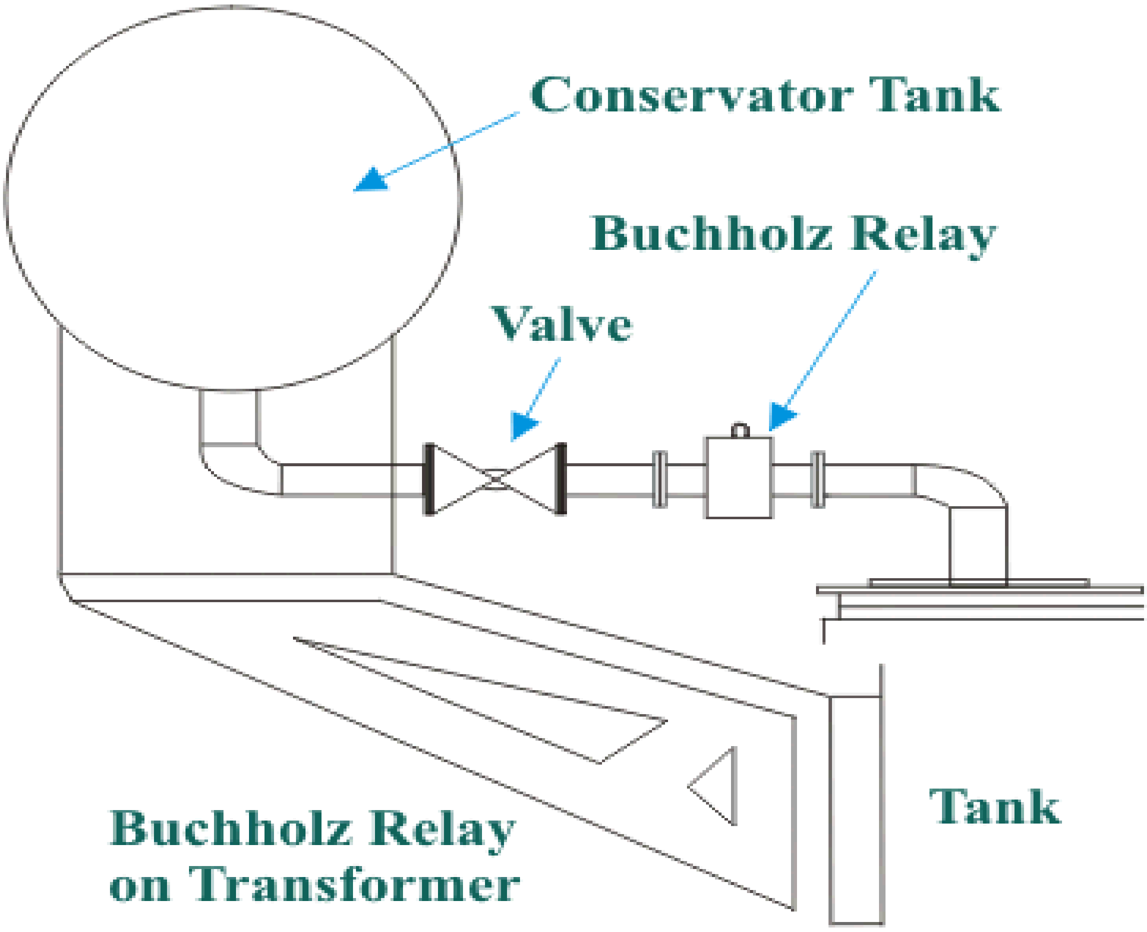
The **Buchholz Relay working principle** of is very simple. **Buchholz Relay function** is based on very simple mechanical phenomenon. It is mechanically actuated. Whenever there will be a minor internal fault in the transformer such as an insulation faults between turns, break down of core of transformer, core heating, the transformer insulating oil will be decomposed in different hydrocarbon gases, CO_2 and CO. The gases produced due to decomposition of transformer insulating oil will accumulate in the upper part the Buchholz Container which causes fall of oil level in it.

Fall of oil level means lowering the position of float and thereby tilting the mercury switch. The contacts of this mercury switch are closed and an alarm circuit energized. Sometime due to oil leakage on the main tank air bubbles may be accumulated in the upper part the Buchholz Container which may also cause fall of oil level in it and alarm circuit will be energized. By collecting the accumulated gases from the gas release pockets on the top of the relay and by analyzing them one can predict the type of fault in the transformer.

Whenever a fault occurs inside the transformer, such as insulation failure of turns, breakdown of core or excess core heating, the fault is accompanied by production of excess heat. This excess heat decomposes the transformer insulating oil which results in production of gas. The generation of gases depend on intensity the of fault. Gas bubbles tend to flow in upward direction towards conservator and hence they are collected in the buchholz relay which is placed on the pipe connecting the transformer tank and conservator.

CONSTRUCTION

Buchholz relay consists of an oil filled chamber. There are two hinged floats, one at the top and other at the bottom in the chamber. Each float is accompanied by a mercury switch. The mercury switch on the upper float is connected to an alarm circuit and that on the lower float is connected to an external trip breaker. The construction of a buchholz relay is shown in the figure.



How Does A Buchholz Relay Work?

Whenever a minor fault occurs inside the transformer, heat is produced by the fault currents. The produced heat causes decomposition of transformer oil and gas bubbles are produced. These gas bubbles flow in upward direction and get collected in the buchholz relay. The collected gas displaces the oil in buchholz relay and the displacement is equivalent to the volume of gas collected. The displacement of oil causes the upper float to close the upper mercury switch which is connected to an alarm circuit. Hence, when minor fault occurs, the connected alarm gets activated. The collected amount of gas indicates the severity of the fault occurred. During minor faults the production of gas is not enough to move the lower float. Hence, during minor faults, the lower float is unaffected.

During major faults, like phase to earth short circuit, the heat generated is high and a large amount of gas is produced. This large amount of gas will similarly flow upwards, but its motion is high enough to tilt the lower float in the buccholz relay. In this case, the lower float will cause the lower mercury switch which will trip the transformer from the supply, i.e. transformer is isolated from the supply.

Advantages of Buchholz Relay

- Buchholz relay indicates the internal faults due to heating and it helps in avoiding the major faults.
- Severity of the fault can be determined without even dismantling the transformer.
- If a major fault occurs, the transformer can be isolated with the help of buchholz relay to prevent accidents.

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Experiment-1

Aim – To Test the Biased / Un biased differential relay using variable ac current source

Apparatus required

1. PLT – 10PS – 0C1 module

Precautions

- Keep the Power ON/OFF switch in off position (provided in back panel).
- Keep the Autotransformer in Minimum Position
- Keep the Power ON/OFF switch in off position (IN AC CURRENT SOURCE SECTION).

Procedure

1. Switch ON the Power using Power ON/OFF Switch (provided in back panel)
2. Connect current source output to Relay CT input as below
   a) I1 to 1(CT1)
   b) I2 to 2 (CT1)
   c) I3 to 3(CT2)
   d) I4 to 4(CT2)
3. Switch ON the Power using Power ON/OFF Switch (IRS SWITCH – IN CURRENT SOURCE SECTION)
4. Apply current of 5A (Indicate the front panel ammeter) by Adjusting the Front panel Autotransformer – SIMULTANOUSLY (Now Both meter indicate same Value)
5. Press the RESET key provided in Relay.
6. Now Set the Relay parameters

7. The display in Relay will be
   I. Biased type
   II. Un Biased type
      a. Press UP Key for **Biased type** selection
      b. Enter bias setting value by using front panel keys
      c. Enter tripping time value by using front panel keys
8. Now slowly reduce/increase any one current by using Autotransformer. So the different of current is increased (which is the bias difference)
9. The difference of Bias Value in % will be display in LCD, When it will reaches above set Bias value the relay will trip , corresponding Trip time also indicate In Same LCD in Relay
10. Repeat the above procedure with UN BIASED SETTING (Press down key to select un biased mode in procedure-6)
11. Tabulate the reading

BIASED TYPE

S.N	Set % Bias Value	I1 in Amp	I2 in Amp	Tripping Bias Value	Set Time	Tripping Time

UN BIASED TYPE

S.N	I1 in Amp	I2 in Amp	Set Time	Tripping Time

Experiment-2

Aim – To test the differential relay with **TRANSFORMER METRZ PROTECTION** Scheme.

Apparatus Required

1. PLT – 10PS – 0C1 module

Precautions

- Keep the power ON/OFF switch in off position (provided in back panel).
- Keep the Auto Transformer in minimum Position.
- Keep the Power ON/OFF switch in OFF position (IN AC CURRENT SOURCE SECTION).

Procedure

1. Switch ON the power using ON/OFF Switch (Provided in back panel).
2. Connect the transformer input and output as below,
    a. P1 to P3.
    b. P2 to P4.
    c. P5 to CT-1 Input's 1.
    d. P6 to CT-1 Input's 2.
    e. P9 to CT-2 Input's 1.
    f. P10 to CT-2 Input's 2.
    g. P11 to P12.
    h. P7 to P8.
    i. D1 to 24V tapping of transformer primary.
    j. R2 to Rheostat One end.
    k. R1 to 0V tapping of transformer primary and Rheostat another end.

3. Now Set the Relay parameters
   a. The display in Relay will be
      I. Biased type
      II. Un Biased type
   b. Press UP Key for **Biased type** selection
   c. Enter bias setting value by using front panel keys
   d. Enter tripping time value by using front panel keys

4. Now Press the START Button – This will make fault on transformer primary side (SHORT CIRCUIT) & Simultaneously the stop clock is start to indicate counting time

5. The relay is tripped after some time (PRE SET TIME)

6. Once the RELAY is tripped and the STOP CLOCK is automatically stopped and indicate the relay trip time , note down this trip time in table

7. The difference of Bias Value in % will be display in LCD, & Trip time also indicate In Same LCD in Relay note down this trip time in table

8. Repeat the above procedure (Procedure 1 to 8) with different BIAS Setting and Time setting

9. Repeat the above procedure with DIFFERENT FAULT ON TRANSFORMER BOTH PRIMARY & SECONDARY SIDE

10. Tabulate the reading

BIASED TYPE

Fault Type : Short in Primary side (24 & 0v tappings)

S.N	Set % Bias Value (in relay lcd)	Set Time (in relay lcd)	AFTER RELAY TRIPPING	Tripping time (stop clock)	Tripping Bias (in relay lcd)

RESULT:

THEORY:

In electrical engineering, a **protective relay** is a complex electromechanical apparatus, often with more than one coil, designed to calculate operating conditions on an electrical circuit and trip circuit breakers when a fault is detected. Unlike switching type relays with fixed and usually ill-defined operating voltage thresholds and operating times, protective relays have well-established, selectable, time/current (or other operating parameter) curves. Such relays may be elaborate, using arrays of induction disks, shaded-pole magnets, operating and restraint coils, solenoid-type operators, telephone-relay contacts, and phase-shifting networks. Protection relays respond to such conditions as over-current, over-voltage, reverse power flow, over- and under- frequency. Distance relays trip for faults up to a certain distance away from a substation but not beyond that point. An important transmission line or generator unit will have cubicles dedicated to protection, with many individual electromechanical devices. The various protective functions available on a given relay are denoted by standard ANSI Device Numbers. For example, a relay including function 51 would be a timed over-current protective relay.

Design and theory of these protective devices is an important part of the education of an electrical engineer who specializes in power systems. Today these devices are nearly entirely replaced with microprocessor or microcontroller-based digital protective relays (numerical relays) that emulate their electromechanical ancestors with great precision and convenience in application. By combining several functions in one case, numerical relays also save capital cost and maintenance cost over electromechanical relays. However, due to their very long life span, tens of thousands of these "silent sentinels" are still protecting transmission lines and electrical apparatus all over the world

The varies types of protective relays are , Over current relays , Earth fault relays , Over/under voltage relays and Differential current relays.

Current differential protection (Differential Current Relays)

One of the common forms of protection for high voltage apparatus such as transformers and power lines is current differential. This type of protection works on the basic theory of Kirchhoff's current law which states that the sum of the currents entering a node will equal zero. It is important to note the direction of the currents as well as the magnitude, as they are vectors. It requires a set of current transformers (smaller transformers that transform currents down to a level which can be measured) at each end of the power line, or each side of the transformer. The current protection relay then compares the currents and calculates the difference between the two.

As an example, a power line from one substation to another will have a current differential relay at both substations which communicate with each other. In a healthy condition, the relay at substation A may read 500 amps (power exporting) and substation B will read 500 amps (power importing). If a path to earth or ground develops there will be a surge of current. As supply grids are generally well interconnected the fault in the previous example will be fed from both ends of the power line.

The relay at substation A will see a massive increase in current and will continue to export. Substation B will also see a massive increase in current; however it will now start to export as well. In turn the protection relay will see the currents travelling in opposite directions (180 degrees phase shift) and instead of cancelling each other out to give a summation of zero it will see a large value of current. The relays will trip the associated circuit breakers. This type of protection is called unit protection, as it only protects what is between the current transformers.

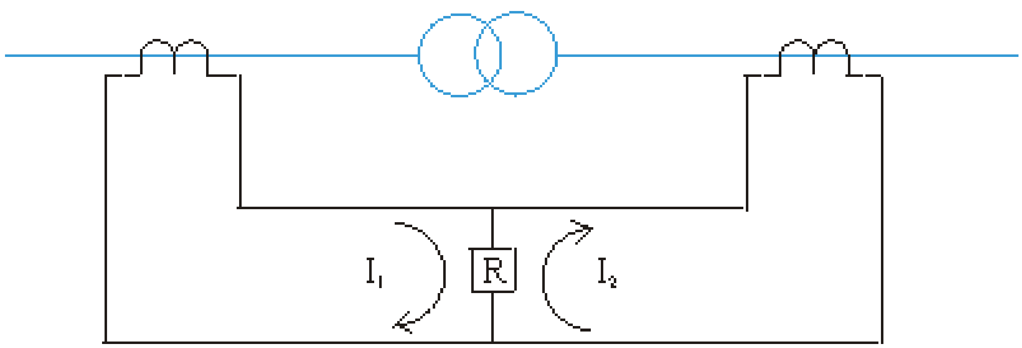
It is important to note that generally the higher the currents in the lines the larger the differential current required for the relay to see it as a fault. This is basically done due to small mismatches in current transformers. Small errors will increase as current increases to the point where the error could cause a false trip if the current differential relay only had an upper limit instead of the rising differential characteristic. It is also important to note that CTs have a point where the core saturates and the current in the CT is no longer proportional to the current in the line. A CT can become inaccurate or even saturate because of a fault outside of its protected zone (through fault) where the CTs see a large magnitude but still in the same direction.

This manual explains the working / Tripping procedure Differential Current Relay by using ***DIFFERENTIAL CURRENT RELAY TEST SET UP*** trainer from **POWER LAB INSTRUMENTS, Chennai.**

Differential Protection

Differential protection is a unit scheme that compares the current on the primary side of a transformer with that on the secondary side. Where a difference exists (other than that due to the voltage ratio) it is assumed that the transformer has developed a fault and the plant is automatically disconnected by tripping the relevant circuit breakers.

The principle of operation is made possible by virtue of the fact that large transformers are very efficient and hence under normal operation power-in equals power-out. Differential protection detects faults on all of the plant and equipment within the protected zone, including inter-turn short circuits.



The operating principle employed by transformer differential protection is the Merz-Price circulating current system as shown above. Under normal conditions $I_1$and I_2 are equal and opposite such that the resultant current through the relay is zero. An internal fault produces an unbalance or 'spill' current that is detected by the relay, leading to operation.

Types of differential Relays

The most commonly used type differential Relays in power system protections are

1. Un Biased Differential Relays
2. Percentage biased Differential Relays

UN Biased Differential Relays

This is the simplest type, in which the vector difference of two currents gives raise to relay operation. This scheme lacks stability under unbalance current caused by difference in two CT's during steady state or transient conditions.

Percentage biased Differential Relays

This type of relay has bias setting (or winding in E-M type) to provide stability on CT ratio different or Transformer small un balance ratio etc. usually the % Bias setting is provided up to 50%.

Relay is tripped when the difference of current is greater than the bias setting %.This type of relays are mostly used for Transformer protection (differential protection)

Note

Our Trainer is provided the Relay having the facilities to test both type of Biased & Un Biased Type of Differential relay.

HARDWARE SPECIFICATIONS

The above trainer consists of

1. Static Differential current Relay
2. Current injection source
3. Fault simulating transformer (for MERTZ PRIZE PROTECTION)
4. Automatic trip time measurement circuit
5. Meter set up

Differential Current Relay

- Type → Static (Microcontroller based)
- Operation → Biased & UN-Biased type of operation
- CT Input-1 → 0-5A
- CT Input-2 → 0-5A
- Contacts → 'NO', 230V@5A Ratings
- 'NC', 230V@5A Ratings
- PC Interface → Future development -/ program down loading at factory
- Reset → To restart the relay functions
- Two numbers of digital AC Ammeter (0-20A) → To display CT Input current 1 & Current 2.
- Banana terminals (NC Contacts 1,2) → Relay Output NC Contacts
- Banana terminals (N0 Contacts 1,2) → Relay Output NO Contacts
- Banana terminals (C1,C2 , CT1 Input)→ relay Current input-1 terminals
- Banana terminals (C1,C2 , CT2 Input)→ relay Current input-2 terminals

Current injection source

Two numbers of variable AC Current sources of 0-10A is provided to apply current to Relay CT input for testing

- Banana connectors (I1&I2) → Current Output-1 (0-10A AC)
- Banana connectors (I3&I4) → Current Output-2 (0-10A AC)
- Autotransformer 1&2 → Used to vary the current output 1 &2
- Power ON/OFF Switch → Used to ON/OFF The variable current output

Fault simulating transformer (for MERTZ PRIZE PROTECTION)

- Banana connectors (P1&P2) → 48VAC@4A Output - used to apply fault simulating transformer.
- Switch S1 → Used to ON/OFF 48VAC.
- Banana connectors (P3&P4) → Circuit breaker input.
- Banana connectors (P5&P6) → Circuit breaker Output

F.S.Transformer Specifications

- TYPE → 1:1
- PRIMARY → 0v , 6v , 12v , 24v , 48v @ 4A
- SECONDARY → 0v , 6v , 12v , 24v , 48v @1A
- Banana connectors (P7&P8) → Fault simulating Transformer Input (0 & 100%)
- Banana connectors (P9&P10) → Fault simulating Transformer OUTPUT (0 & 100%)
- Banana connectors (P11&P12) → Lamp load Input

Automatic trip time measurement circuit

1. **S1** → START Button used to start the automatic relay tripping time measurement Circuit.
2. **S2** → MANUAL STOP Button used to stop the automatic relay tripping time measurement Circuit.
3. **Banana connectors (C1&C2)** → Fault Crating contact –it will closed when START button is pressed.
4. **Banana connectors (R1&R2)** → Short circuit resistor –it can connect in series with C1&C2.
5. **Stop-Clock** → Used to measure the relay tripping time.

6. **RESET Switch** → Used to restart the stop clock.
7. **Power input Connector (FM14-Back side)** → Used for Mains input supply.
8. **Inbuilt Rheostat(R1 & R2)** → **(0 – 15 – 30) ohms**
9. **Lamp load** → 200W maximum.
10. **Switch** → used to ON/OFF input Power (230vac).

Laboratory Manual

for

Power System Lab

Prepared by

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EXPERIMENT NO. -05

Aim: To study radial feeder performance when a) fed at one end b) fed at both ends.

Theoretical Background:

Whole of the power system can be subdivided into number of radial feeders fed from one end. Generally, such radial feeders are protected by over current and earth fault relays used as primary relays for 11 kV and 66 kV lines. For lines of voltage rating beyond 66 kV, distance protection is applied as a primary protection whereas over current and earth fault relays are used as back up relays.
A simplified radial feeder network without transformers (in actual practice transformers do exist at substations) is shown in single line diagram of fig. 1.1 below.

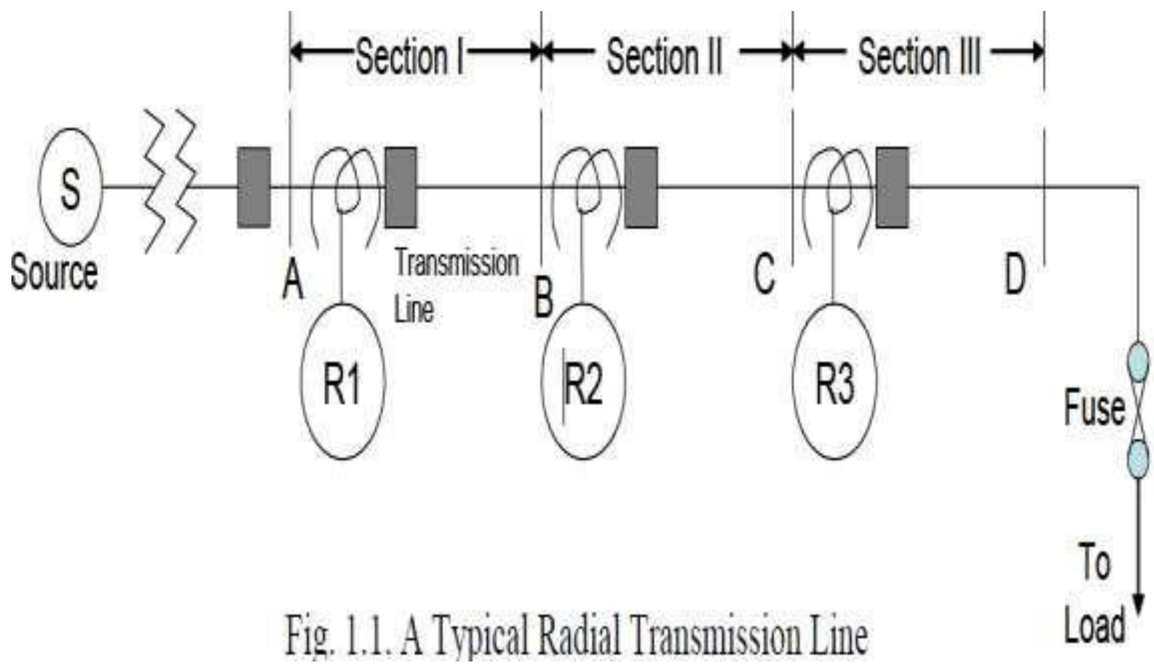

Fig. 1.1. A Typical Radial Transmission Line

If the fault occurs in distribution network, fuse should isolate the faulty section. Should the fuse fail, relay R_3 shall give back-up protection. Relays R_1, R_2, and R_3 act as primary relays for faults in section I, section I, and section III respectively. If fault in section III is not cleared by relaying scheme at relaying point R_3, relay R_2 will act as a back-up. Similarly, back-up protection is provided by relay R_1 for faults in section II. A, B, C and D are substations in fig. 1.1.
Generally Inverse time over current relays with Definite Minimum Time feature (IDMT relays) are used in practice. There are many types of such relays available in relay market, viz. normal inverse relays, very inverse relays and extremely inverse relays. The characteristics of these relays are shown in fig. 1.2. The other types of o/c relays are 3 second relay and 1.3 second relay. This means the time of operation of the relay is either 3 or 1.3 second at Plug Setting Multiplier (PSM) equal to 10. Long time inverse relays are used for o/c cum overload application. Voltage restrains o/c relays have their own application.

Very inverse relays are less prone to the ratio Z_S/Z_L. Extremely inverse relays are yet better. Very inverse relays are faster in operation for close-in faults yet maintaining the discrimination with fuse and other relays. Extremely inverse relays are more meritorious in this aspect too. Instantaneous o/c relays are not immune to Z_S/Z_L ratio. Definite time o/c relays are 100 % immune to this ratio. Very inverse relays can be used with an additional advantage while protecting a machine or a transformer as they match with the heating characteristic of equipment better than their normal inverse equivalent.

Extremely inverse relays can best co-ordinate with the fuse characteristic. The aim of this experiment is to reveal these facts experimentally.

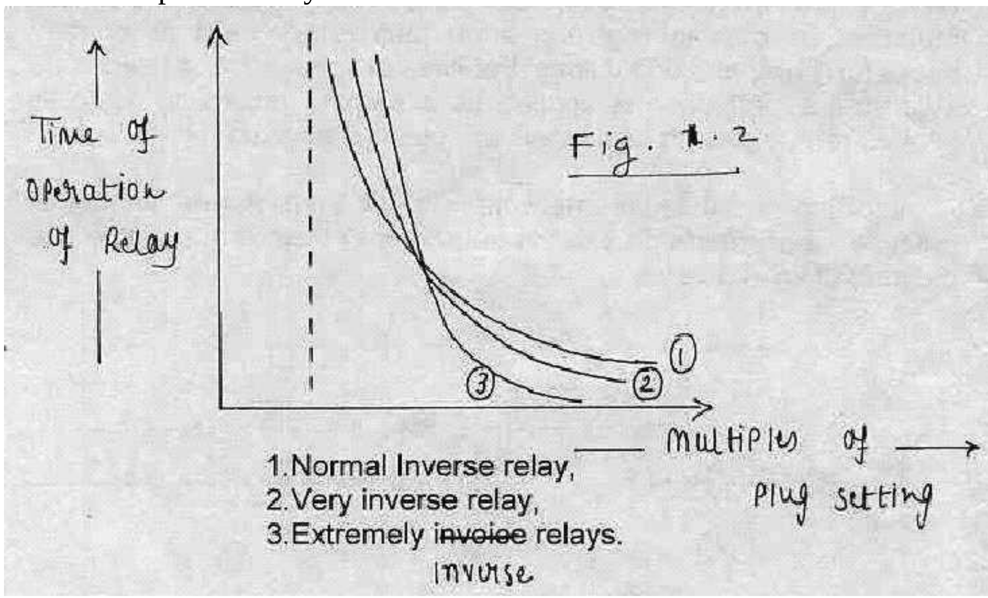

Fig. 1.2 Normal, Very and Extremely Inverse Characteristics

Laboratory Simulations:

Referring to a.c. circuit of fig. 1.3. A live model of a radial feeder fed from one end can be self- understood.

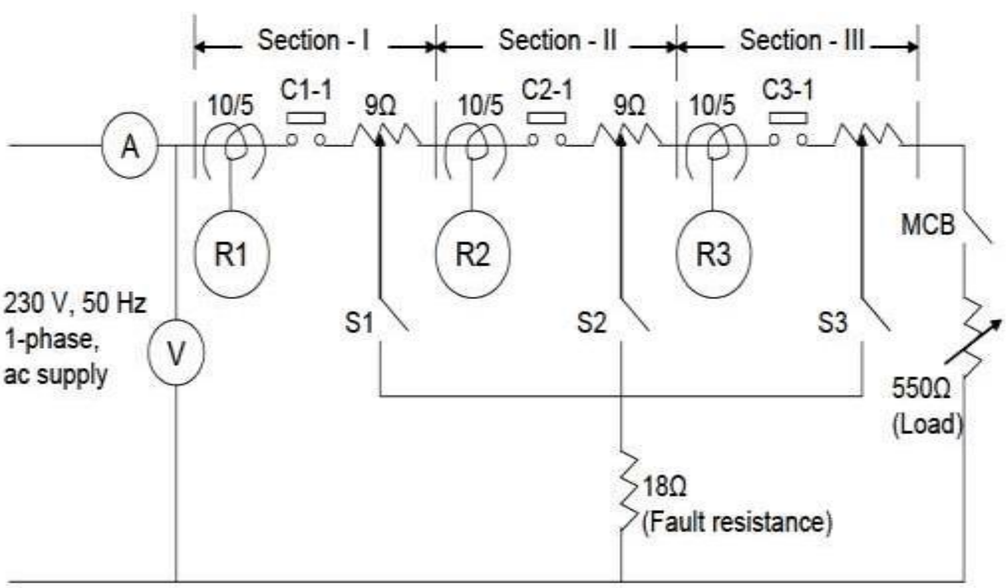

Fig. 1.3 Main AC Circuit in the Experiment.

This is only a single-phase version of a radial feeder. Faults in different sections can be created by switches S1, S2 and S3. Fault limiting resistance of 18 ohms is used for practical purposes only. Here C.T. secondary rating is 5 Amp and relay rating is 1 Amp. This is contradicting the practice for practical purpose.

Observation Table:

Table:1.1 Measured fault currents for extreme faults in each section

Fault Location	Fault current (A)

Table:1.2 Calculated relay settings

Relay	P.S.	TMS
R1		
R2		
R3		

Table:1.3 Normal Inverse Relays

Fault Location	Relay R1				Relay R2				Relay R3			
	PSM	Obs time of op (sec)	Measured time of op (sec)	% Error	PSM	Obs time of op (sec)	Measured time of op (sec)	% Error	PSM	Obs time of op (sec)	Measured time of op (sec)	% Error
F1												
F1’												
F2												
F2’												
F3												
F3’												

Table 1.4

Relays	Difference in time of operation of relay for extreme faults		
	Section	Observed	Calculated
R1	I		
R2	II		
R3	III		

Procedure:

1. Measure the fault currents for corresponding rheostat in minimum (zero resistance) and maximum (full resistance) positions and using the corresponding fault-switch S_1, S_2, or S_3 (refer fig. 1.3). Maximum fault currents in sections I, II and III are denoted by F_1, F_2, F_3 respectively and the minimum fault currents by F_1’, F_2’, F_3’ respectively. Deactivate the relays for this purpose. Record the readings in table 1
2. Calculate the plug –settings (or Tap Value) of relays R_1, R_2 and R_3. (Plug settings will be same irrespective of type of relays). For this purpose, assume the number of distributors each of 0.5 Amp rating from the following possibilities (The experiment is a simulation and hence the distributor current is 0.5 Amp. In actual practice it may be 500 Amp or more or less):
   Number of distributors: 1, 2, 3 or 4.
   (Calculations of the plug setting shall be done w.r.t. following considerations)
   (I) The plug setting shall be more than or equal to the maximum full-load current passing through the relay.
   (II) The pickup of the relay varies from 1.05 to 1.3 times the plug setting of the relay
   (III) For back up, relay R_1 shall reach for the fault F'_2 and R_2 for the fault F'_3.
3. Time Settings. (Normal Inverse Relays)
   For deciding time-settings, co-ordinate the characteristics of relay R3 with that of an MCB. Use discriminating time-interval of 1.0 sec. b/w two characteristics. This will decide TMS of R_3. Why discrimination time of 1.0 second? (Try answer to this question.)
   For coordinating R2 & R3 use the worst possible current to decide TMS of R2 (F3 in table:1.1). Similarly decide TMS of R_1 by using F_2 and setting of R_2. Use discriminating time interval between two successive relays as 0.4 seconds (why 0.4 seconds?) for these calculations. Tabulate the results as in table (2).

4 Time-settings (Very Inverse Relays) can be carried out for very inverse relays also. The results are to be tabulated as in the case of normal inverse relays as per calculated settings.
5 Set the normal inverse relays as per the settings in table 1.2
6 Calculate the time of operation of the main and back-up relay for extreme fault in each section using the relay settings in table:1.2 and the fault current readings recorded in table:1.1. Enter these in table:1.3 as "Calculated Time of Operation"
7 Vary the 550 ohms load resistance such that the current in the radial feeder varies from 0.5 Amp to about 4 Amp. See that MCB trips and relay R_3 does not trip.
8 Now create extreme faults (one by one) in each section starting from section III. For each fault, measure the time of operation of the main and the back-up relay (to measure time of operation of back-up relay, the main relay has to be deactivated using switches T_2 or T_3 (as the case may be) in fig. 1.4). Record these in table 1.3 as "Measured Time of Operation". Calculate the error between the calculated and the measured time of operation for each fault and record it in table: 1.3.
9 Derive the table 1.4 from table 1.3.
10 Replace the normal inverse relays by very inverse relays.
11 Repeat steps at Sr. No. 5 to 9 for very inverse relays.
12 Draw your own conclusion.

Laboratory Manual

for

Power System Lab

Prepared by

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Aim- To test VCB under Earth protection with different current setting

Apparatus required

1. VCB Kit
2. Wires
3. Earth fault motor set up

Precautions

1. Keep the Power ON/OFF is in off condition
2. Keep the Autotransformer is in Minimum Position
3. Check the VCB SPRING CHARGE STATUS in VCB is fully charged and “ON” condition (Refer procedure in page number 34), in this condition the breaker input & output indicator is in “ON” condition. If not manually ON the VCB using procedure in page number 34
4. Connect 3 phase supply to breaker input (Panel back side)
5. Connect the 3 phase supply to breaker output (terminated front panel) to earth fault motor set up

Procedure

1. Set the pick-up value of current marked 200% by inserting the plug in the groove.
2. Set the timer multiplier timing(TMS) intially at 1.0
3. Connect CT output terminal C1(E/F motor set up) to one end of OC relay Current input terminal-1 by using given wires (don’t change the given wire)
4. Connect CT output terminal C2(E/F motor set up)to one end of OC relay Current input terminal-1 by using given wires (don’t change the given wire)
5. Switch ON the Power supply using IRS Switch
6. Simulate the Earth fault in any one phase(Refer to page number 32) using short circuit resistor
7. Now the DISC in RELAY is start to rotate and relay is tripped after some time
8. Once the relay is tripped the following operations are automatically done
    i. VCB is tripped
    ii. VCB output indicator is Switch “OFF”
    iii. STOP CLOCK is automatically stopped and indicate the VCB/relay trip time, note down this trip time
9. Manually switch “ON” the VCB using procedure page number 34

Experiment-2

Aim-To test the VCB under over current protection with different current setting and to plot IDMT Characteristics

Apparatus required

1. VCB test kit
2. Wires

Precautions

1. Keep the Power ON/OFF is in off condition
2. Keep the Autotransformer is in Minimum Position
3. Check the VCB SPRING CHARGE STATUS in VCB is fully charged and “ON” condition (Refer procedure in page number 34), in this condition the breaker input & output indicator is in “ON” condition. If not manually ON the VCB using procedure in page number 34

Procedure

1. Set the pick-up value of current marked 200% by inserting the plug in the groove.
2. Set the timer multiplier timing(TMS) intially at 1.0
3. Connect CT output terminal C1 to one end of OC relay Current input terminal-1 by using given wires (don’t change the given wire)
4. Connect CT output terminal C2 to one end of OC relay Current input terminal-1 by using given wires (don’t change the given wire)
5. Switch ON the Power supply using IRS Switch
6. Press the START Button
7. Apply current of 5A(indicate the front panel ammeter) by adjusting the Front panel Autotransformer

–(Now the disc in over current relay is rotate and relay may trip-but don’tconsider this function

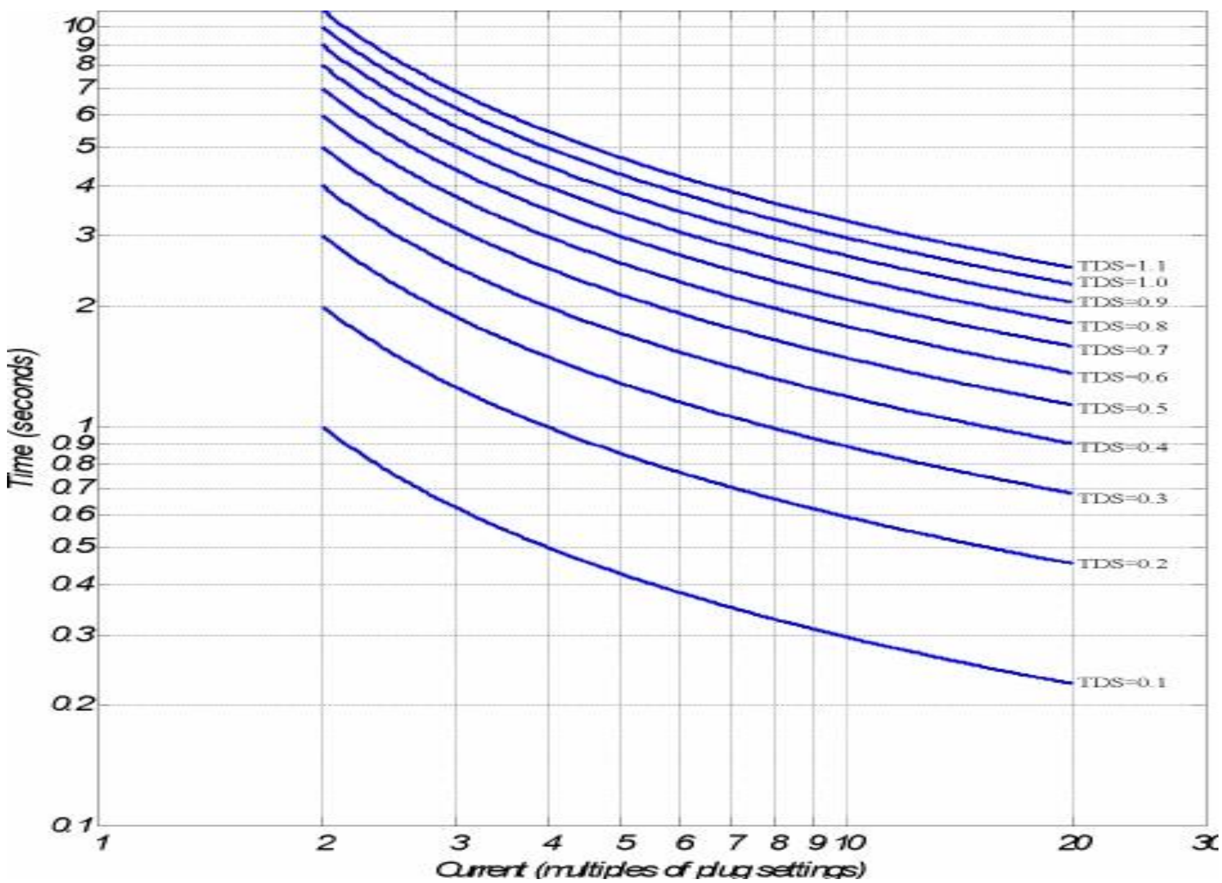
   a. Now the fault current of 5A is set
   b. Press Manual STOP Button
   c. Now the set up is ready for applying Fault current of 5A
   d. Wait for some time to settle the DISC in over current relay in intial/home position

8. After the disc setting in home position in relay then press the START Button
9. Now the DISC in RELAY is start to rotate and relay is tripped after some time
10. Once the relay is tripped the following operations are automatically done
    i. VCB is tripped
    ii. VCB output indicator is Switch “OFF”
    iii. STOP CLOCK is automatically stopped and indicate the VCB/relay trip time, note down this trip time
11. Manually switch “ON” the VCB using procedure page number 34
12. Repeat the above procedure (Procedure 1 to 11) with different PLUG Setting and Time setting Multiplier

TABLE

S.no.	Applied Fault current (in Amp)	Calculated tripping time (in Amp)	Measured tripping time (in ms)	TMS-Time setting multiplier in Sec	PMS- Plug setting multiplier in amp
1.	5			1	2(200%)
2.	7.5				
3.	10				
4.	12.5				
5.	15				
6.	17.5				

13. Draw graph Applied fault Current Vs Measured tripping time- It gives IDMT characteristics



14. Repeat the same with different Current setting and tabulate the result in below table

TABLE

S.no.	Applied Fault current (in Amp)	Calculated tripping time (in Amp)	Measured tripping time (in ms)	TMS- Time Setting Multiplier in Sec	PMS- Plug setting multiplier in amp
1.	2.5			1	1(100%)
2.	5				
3.	7.5				
4.	10				

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Experiment-1

Aim-To test the ACB with different current setting and to PLOT IDMT characteristics.

Apparatus required

1. ACB Test kit
2. Wires

Precautions

1. Keep the MCB is in off condition
2. Keep the power ON/OFF switch is in off condition
3. Keep the Autotransformer is in Minimum Position
4. Check the ACB SPRING CHARGE STATUS in ACB front panel, the correct status is ACB is fully charged and “ON” condition (Refer procedure in page number 25), in this condition the breaker input & output indicator is in “ON” condition. If not manually ON the ACB using procedure in page number 25

Procedure

1. Set the Digital OVER CURRENT as per procedure
   M/C type display below parameters will appear
   Relay display will be
   “Power Lab Instrument
   Chennai-96”“Over Current relay

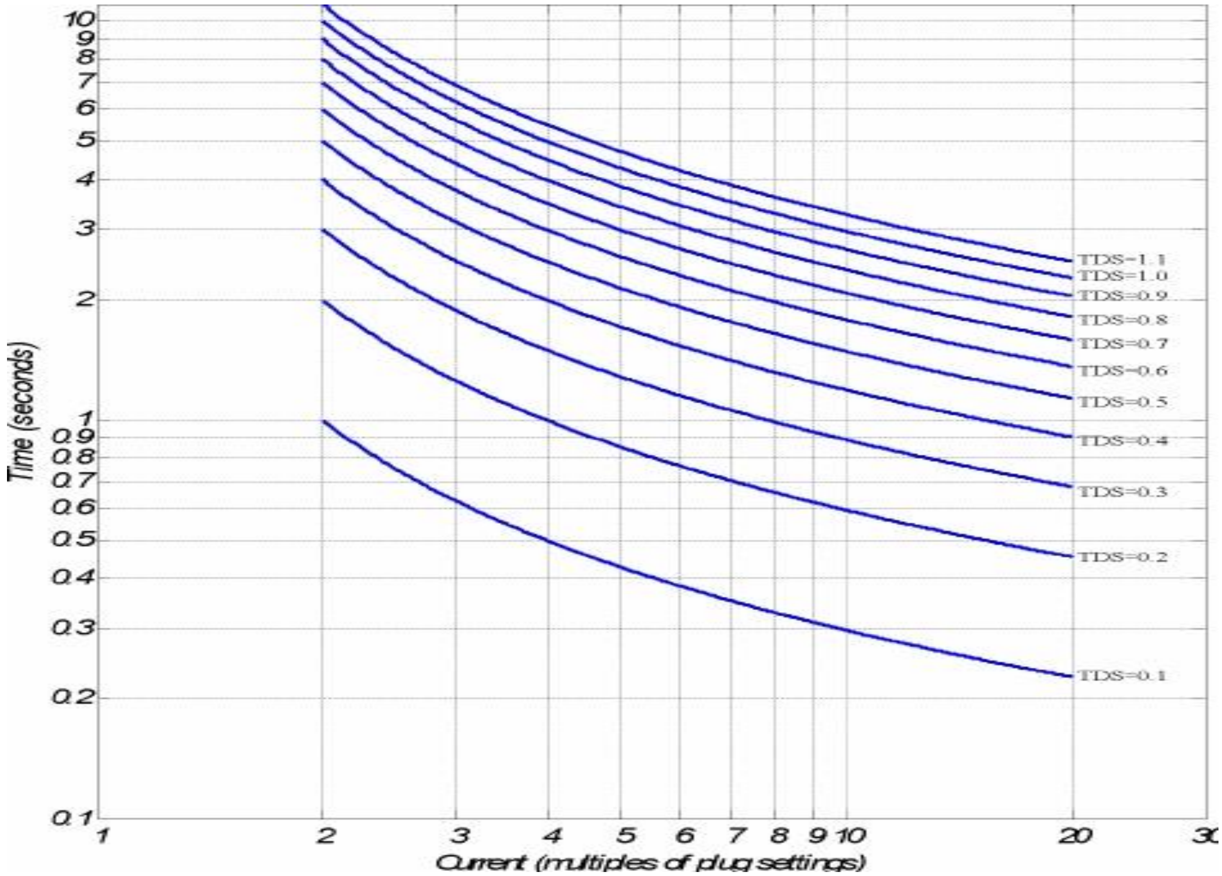
   a. Press **UP Key** for Over Current Relay
   b. Press **Enter Key**
   c. Press **UP Key** for Over Current Relay
   d. Press **Enter Key**
   e. Then the display will be
      “DMT”
      “IDMT”
   f. Press **down Key** for IDMT Function
   g. Press **Enter Key**
   h. Set the time value by pressing keys(0.1 to 50ms)
   i. Press **Enter Key**
2. Switch ON the MCB
3. Switch ON the Power using Power ON/OFF Switch(IRS Switch)
4. Press the START Button
5. Apply current of 5A(indicate the front panel ammeter) by adjusting the Front panel Autotransformer
   1. Now the fault current of 5A is set
   2. Press Manual STOP Button
   3. Now the set up is ready for applying Fault current of 5A
6. Press the START Button

7. Now the Relay is tripped after some time
8. Once the Relay is tripped the following is automatically done
    a. ACB is tripped
    b. ACB output indicator is Switch "OFF"
    c. STOP CLOCK is automatically stopped and indicate the ACB/relay trip time, note down this trip time
9. Manually switch "ON" the ACB using procedure page number_____
10. Repeat the above procedure (Procedure 1 to 9) with different PLUG Setting and Time setting Multiplier

TABLE

<table>
<tr><th>S.no.</th><th>Applied Fault current
(in Amp)</th><th>Calculated tripping time
(in Amp)</th><th>Measured tripping time
(in ms)</th><th>Time setting in Sec</th><th>Current setting in amp</th></tr>
<tr><td>1.</td><td>1.5</td><td></td><td></td><td rowspan="6">1</td><td rowspan="6">14</td></tr>
<tr><td>2.</td><td>2</td><td></td><td></td></tr>
<tr><td>3.</td><td>3</td><td></td><td></td></tr>
<tr><td>4.</td><td>4</td><td></td><td></td></tr>
<tr><td>5.</td><td>5</td><td></td><td></td></tr>
<tr><td>6.</td><td>6</td><td></td><td></td></tr>
</table>

11. Draw graph Applied fault Current Vs Measured tripping time- It gives IDMT characteristics



12. Repeat the same with different Current setting and tabulate the result in below Table

TABLE

S.no.	Applied Fault current (in Amp)	Calculated tripping time (in Amp)	Measured tripping time (in ms)	Time setting in Sec	Current setting in amp
1.	10			1	14
2.	12.5				
3.	15				
4.	17.5				

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Aim- To test ACB under Earth protection with different current setting

Apparatus required

1. ACB Kit
2. Wires
3. Earth fault motor set up

Precautions

1. Keep the Power ON/OFF is in off condition
2. Keep the Autotransformer is in Minimum Position
3. Check the ACB SPRING CHARGE STATUS in ACB is fully charged and “ON” condition (Refer procedure in page number 34), in this condition the breaker input & output indicator is in “ON” condition. If not manually ON the ACB using procedure in page number 34
4. Connect 3 phase supply to breaker input (Panel back side)
5. Connect the 3 phase supply to breaker output (terminated front panel) to earth fault motor set up

Procedure

1. Set the Digital OVER CURRENT as per procedure
   M/C type display below parameters will appear
   Relay display will be
   “Power Lab Instrument
   Chennai-96”“Over Current relay

   j. Press **UP Key** for Over Current Relay
   k. Press **Enter Key**
   l. Press **UP Key** for Over Current Relay
   m. Press **Enter Key**
   n. Then the display will be
      “DMT”
      “IDMT”
   o. Press **down Key** for IDMT Function
   p. Press **Enter Key**
   q. Set the time value by pressing keys(0.1 to 50ms)
   r. Press **Enter Key**
2. Connect CT output terminal C1(E/F motor set up) to one end of OC relay Current input terminal-1 by using given wires (don’t change the given wire)
3. Connect CT output terminal C2(E/F motor set up)to one end of OC relay Current input terminal-1 by using given wires (don’t change the given wire)
4. Switch ON the Power supply using IRS Switch

5. Simulate the Earth fault in any one phase(Refer to page number 32) using short circuit resistor
6. Now the DISC in RELAY is start to rotate and relay is tripped after some time
7. Once the relay is tripped the following operations are automatically done
   i. ACB is tripped
   ii. ACB output indicator is Switch “OFF”
   iii. STOP CLOCK is automatically stopped and indicate the ACB/relay trip time, note down this trip time
8. Manually switch “ON” the ACB using procedure page number 34