User Manual

PSCT | Protection Analytic tool

RELAY CO-ORDINATION (RCD)

Table of Contents

1. INTRODUCTION 1
2. How to solve Relay Co-ordination 3
3. INPUT FILE FORMAT 22
Stream 1 : System Description 22
Stream 2 : System Specification 22
Stream 3 : Bus data 28
Stream 4 : Transformer data 29
Stream 5: Transmission line data 35
Stream 6: Series reactor and capacitor data 37
Stream 7 : Circuit breaker data 38
Stream 8 : Shunt connection (admittance) data 40
Stream 9: Shunt connection (impedance) data 41
Stream 10: Generator data 42
Stream 11: Load data 43
Stream 12: Filter data 44
Stream 13: HVDC converter data 45
Stream 14: Generator data for minimum generation condition 46
Stream 15: Co-ordination Type 47
Stream 16: Number of Overcurrent relays 47
Stream 17: Simulation type 47
Stream 18: Overcurrent Relay data 48
Stream 19: Co-ordination details 53
Stream 20: Number of faults to be Simulated 54
Stream 21: Partial Bus Bar Relay Data 54
Stream 22: Simulation data 55
File format for RCDBASE 56
Stream 1: RCDBASE Data 56
Stream 2: Relay type number 57
Stream 3: Manufacturer name 57
Stream 4: Relay name 57
Stream 5: Number of Current Settings 57
Stream 6: Current Settings Data 57

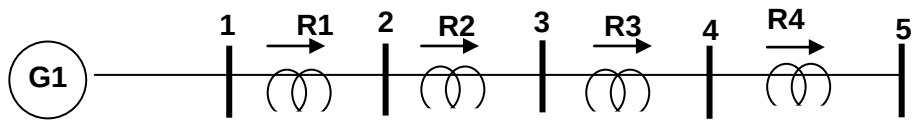
Stream 7: Number of plug Setting *58*
Stream 8: Plug Setting Data *58*
Stream 9: Time Dial Setting Data *58*
Stream 10: Characteristic Specification *59*
Stream 11: Curve Table *62*
Stream 12: Instantaneous Data *64*
Stream 13: Instantaneous Setting Data *65*
Stream 14: Overload capacity data *67*
Fuse Data 68
File format for RCDPAIR.PHS and RCDPAIR.EAR 68
Stream 1: Number of Relay pairs *68*
Stream 2: Relay pairs *69*
Interactive execution 69
Select Settings *70*
Base kV *70*
Option for graph generation *71*
Stream 16: Number of Distance relays *71*
Stream 17: Simulation type *71*
Stream 18: Distance Relay data *72*
Stream 19: Discrimination time *74*
Stream 20: Number of faults to be simulated *74*
Stream 21: Simulation data *74*
Error Messages *77*
Case 1 : 6 Bus Radial System Overcurrent Relay co-ordination *79*
Case 2 : 6 Bus Ring System Overcurrent Relay co-ordination *91*
Case 3 : 5 Bus Ring System Distance Relay Co-ordination *112*

1. INTRODUCTION

POWERRCD is designed to perform the overcurrent and distance relay co-ordination for the given system. Sparse storage and matrix ordering techniques are used in the program to reduce the memory requirements. Fast computational methods are employed to speed up the execution. The Overcurrent relay co-ordination program input data is through two ASCII files. One for the transmission/distribution system for which the relay co-ordination is to be carried out and the other for the relay characteristics as specified by the manufacturer. Chapter 2 describes how to solve the **RCD** example. Chapter 3 describes the format for input file **RCDIN** for overcurrent relay co-ordination and for overcurrent relay database file **RCDBASE**. Chapter 4 describes the format for input file **RCDIN** for distance relay co-ordination. Significance and contents of the input output files are explained in chapter 5. In Chapter 6 case studies are given, wherein the data file preparation for typical overcurrent and distance relay co-ordination are discussed along with the results.

2. How to solve Relay Co-ordination

1. Perform relay co -ordination study for the radial system shown below.



The relay make is as follows

Relay rated current = 5 Amps

Plug setting = 50% to 250% in steps of 25%

Time setting multiplier = 0.05 to 1.0 in steps of 0.01

Relay details

Relay Name	R1	R2	R3	R4
Primary Rating (1,2,3,4)	800	400	200	100
Secondary Rating	5	5	5	5
Load Current	800	400	200	100
Relay type	3sec	3sec	3sec	3sec

Transmission line details on 100 MVA base:

Bus - code	Impedance Zpq	Line charging
p-q	Zpq	Y'pq/2
1-2	0.00 + j0.1	0
2-3	0.00 + j0.1	0
3-4	0.00 + j0.1	0
4-5	0.00 + j0.1	0

Generator Details:

G1 = 100 MVA, 11kV

Maximum fault level = 1000 MVA.

Interpretation according to MiP-PSCT:

- Observe transmission line details. You find that all lines have similar parameters. Therefore no. of transmission line libraries = 1
- No of generator libraries = 1

As all the relays are of 3 sec type, no of relay libraries = 1

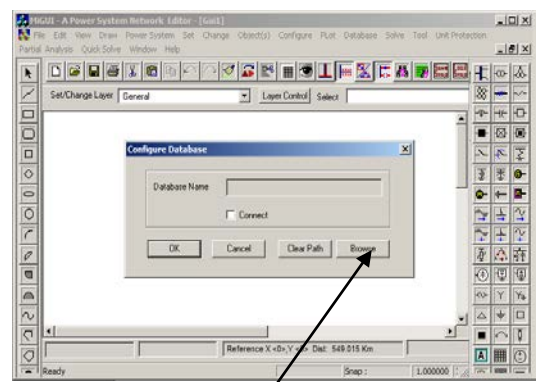
Procedure to enter the data for performing studies using MiP-PSCT.

Following are the two methods.

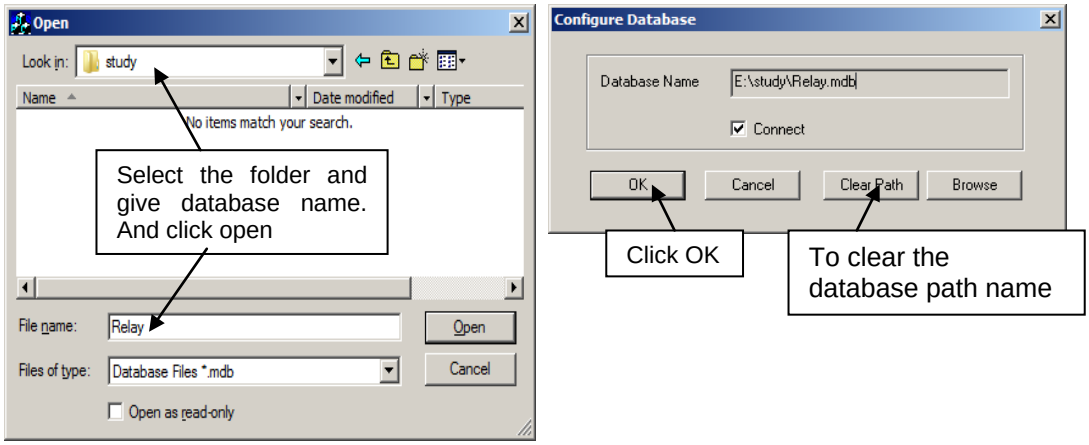
1. Drawing single line diagram and entering corresponding data in database manager separately.
2. Drawing single line diagram and entering the data simultaneously.

Method 2 follows:

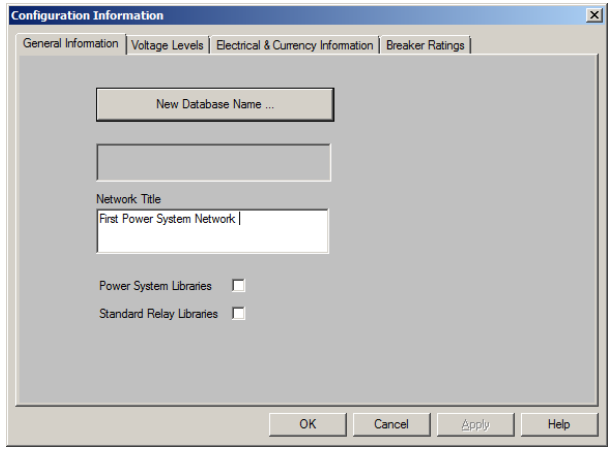
MiP-PSCT - Database Configuration
Open power system network editor. Select menu option Database → Configure. Configure Database dialog is popped up as shown below. Click Browse button.



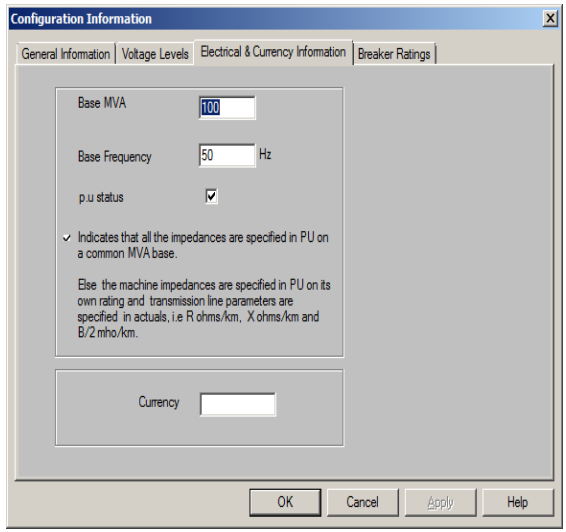
Open dialog box is popped up as shown below, where you are going to browse the desired directory and specify the name of the database to be associated with the single line diagram. Click Open button after entering the desired database name. Configure Database dialog will appear with path chosen.

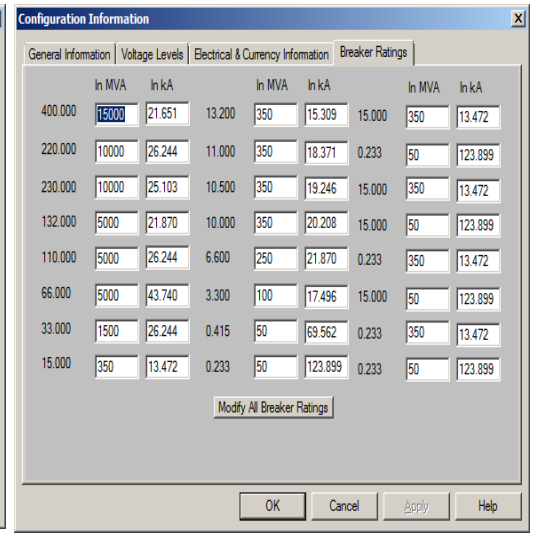


Click OK button on the **Configure database** dialog, the dialog shown below appears.



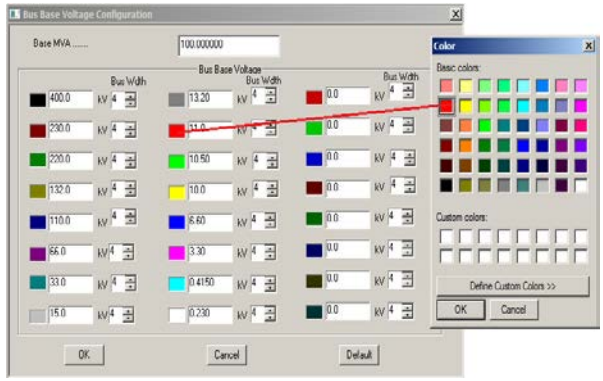
Uncheck the Power System Libraries and Check Standard Relay Libraries. If libraries are selected, standard libraries will be loaded along with the database. Click **Electrical Information** tab. Since the impedances are given on 100 MVA base check the pu status as shown below. Enter the Base MVA and Base frequency as shown below. Click OK button to create the database to return to Network Editor.





Bus Base Voltage Configuration

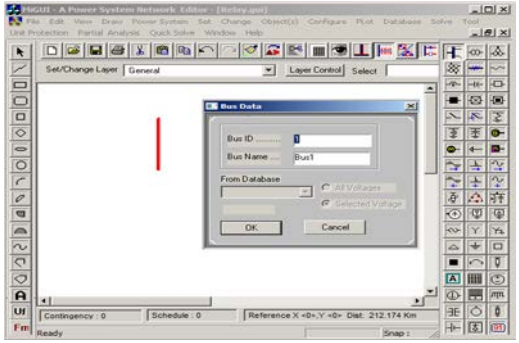
In the network editor, configure the base voltages for the single line diagram. Select menu option **Configure→Base voltage.** The dialog shown below appears. If necessary change the **Base-voltages, colour, Bus width** and click OK**.**

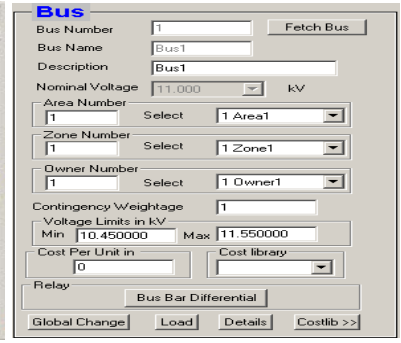


Procedure to Draw First Element - Bus

Click on Bus icon provided on power system tool bar. Draw a bus and a dialog appears prompting to give the Bus ID number and Bus Name. Click OK. Database manager with corresponding Bus Data form will appear.
Modify the Area number, Zone number and Contingency Weightage data if it is other than the default values. If this data is not furnished, keep the default values. Usually the minimum and maximum voltage ratings are ± 5% of the rated voltage. If these ratings are other than this, modify these fields. Otherwise keep the default values.

Bus description field can be effectively used if the bus name is more than 8 characters. If bus name is more than 8 characters, then a short name is given in the bus name field and the bus description field can be used to abbreviate the bus name. For example let us say the bus name is Northeast, then bus name can be given as NE and the bus description field can be North East.





After entering data click Save 🖫, which invokes Network Editor. Follow the same procedure for remaining buses. Following table gives the data for other buses.

Calculation of Xd, Xd', Xd" :

For maximum fault level, Xd = Xd' = Xd" = 100 / 1000 = 0.1 pu = Xn = X0

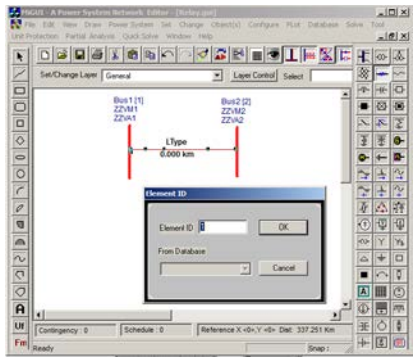
Bus Data					
Bus Number	1	2	3	4	5
Bus Name	Bus-1	Bus-2	Bus-3	Bus-4	Bus-5
Nominal voltage	11	11	11	11	11
Area number	1	1	1	1	1
Zone number	1	1	1	1	1
Contingency weightage	1	1	1	1	1

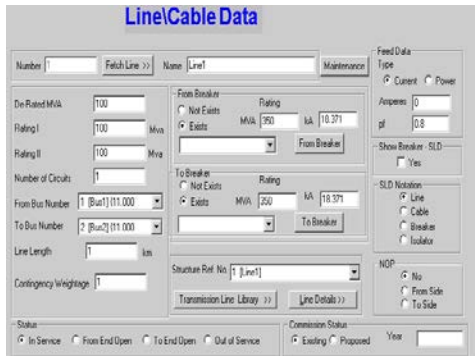
Procedure to Draw Transmission Line

Click on Transmission **Line** icon provided on power system tool bar. Draw the line by double clicking LMB (Left Mouse Button) first on the **From Bus** and join it to another bus by double clicking the mouse button on the **To Bus**. The **Element ID** dialog will appear.

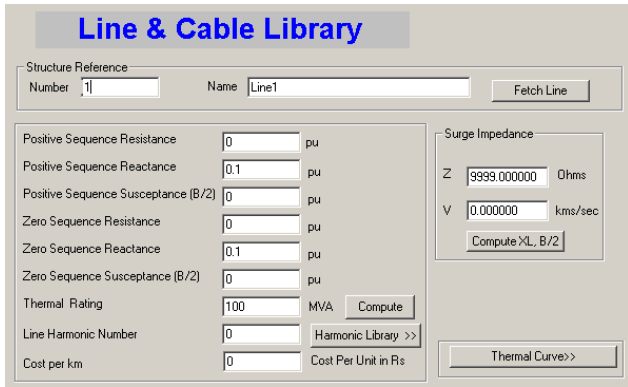
Enter **Element ID** number and click OK. Database manager with corresponding **Line\Cable Data** form will be open.

Enter the details of that line as shown. Enter **Structure Ref No. as 1** and click on **Transmission Line Library >>** button. **Line & Cable Library** form will appear.



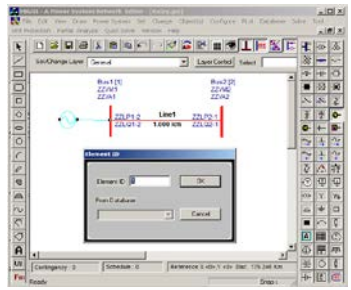


Enter transmission line library data in the form as shown below for Line1-2.

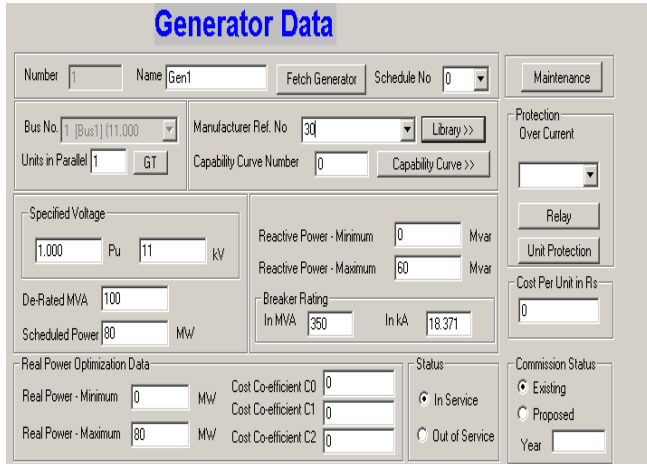


Element Details				
Line Number	1	2	3	4
Line Name	Line1-2	Line2-3	Line3-4	Line4-5
De-Rated MVA	100	100	100	100
No. Of Circuits	1	1	1	1
From Bus No.	1	2	3	4
To Bus No.	2	3	4	5
Line Length	1	1	1	1
From Breaker Rating	5000	5000	5000	5000
To Breaker Rating	5000	5000	5000	5000
Structure Reference No.	1	1	1	1

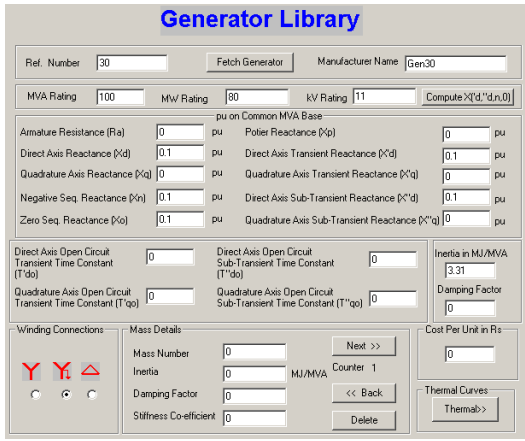
Procedure to Draw Generator



Click on Generator icon provided on power system tool bar. Connect it to Bus 1 by clicking the LMB on Bus 1. **Element ID** dialog will appear. Enter ID number and click OK. Database with corresponding **Generator Data** form will appear. Enter details as shown below.



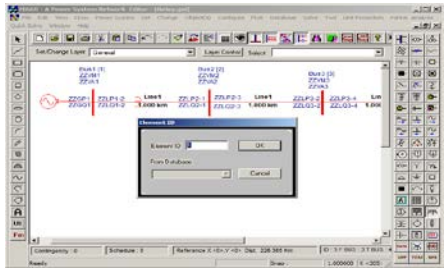
Enter Manufacturer Ref. No. as 30 and click on **Generator Library** button. Generator library form will appear. Click compute button to enter the 3 phase and SLG fault level as 1000 MVA.

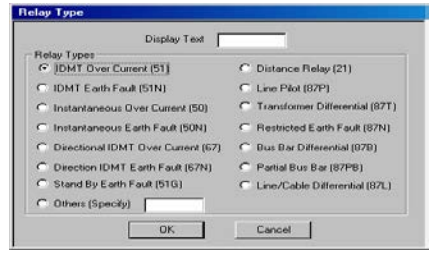


After entering data **Save** 🖫 and **close.** In **Generator Data** form, click **Save** 🖫**. Network Editor** Screen will be invoked.

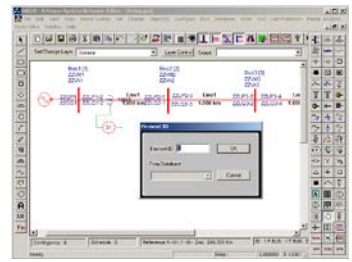
Procedure to Draw Relay

Select current transformer from power system tool bar and place it on from side of the line as shown in the following diagram. Select relay element from power system tool bar or from the main menu select **Power system->Relay** and click on GUI. Relay type dialog appears



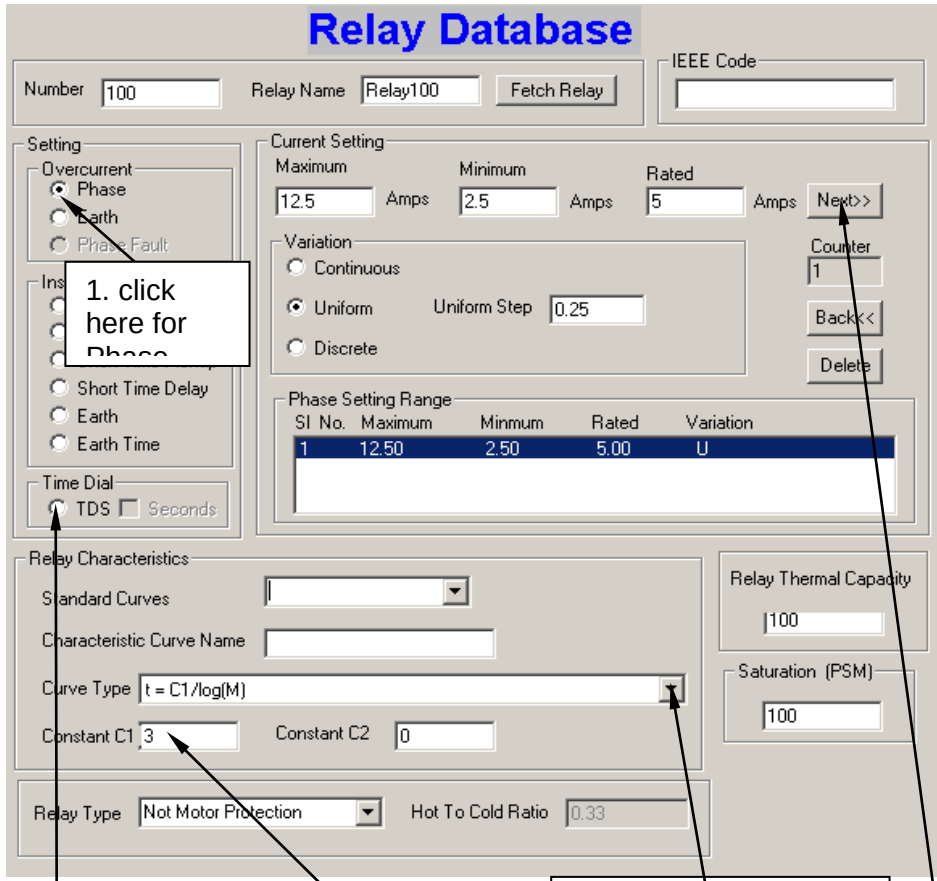


Select IDMT Over Current (51) and click OK. Terminate the relay on current transformer which invokes Relay Database form.

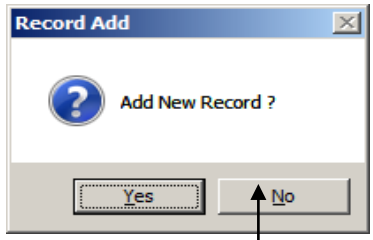


Select menu option **Libraries → Protection → Relay Database.**

Enter relay number as 100 and other details as shown below


Relay Database
Number 100
Relay Name Relay100
Fetch Relay
IEEE Code
Setting
Overcurrent
Phase
Earth
Phase Fault
Short Time Delay
Earth
Earth Time
Time Dial
TDS
Seconds
Current Setting
Maximum
Minimum
Rated
12.5 Amps
2.5 Amps
5 Amps
Next>>
Variation
Continuous
Uniform
Uniform Step 0.25
Discrete
Counter
1
Back<<
Delete
Phase Setting Range
Sl No. Maximum Minmum Rated Variation
1 12.50 2.50 5.00 U
Relay Characteristics
Standard Curves
Characteristic Curve Name
Curve Type t = C1/log(M)
Constant C1 3
Constant C2 0
Relay Thermal Capacity
100
Saturation (PSM)
100
Relay Type Not Motor Protection
Hot To Cold Ratio 0.33
1. click here for Phase
5. Click here to Select TDS
Type 3 here
2. Select t = C1 / log (M) here (3 sec relay characteristics)
4. After entering all data click Next compulsory to save. A dialog as below is displayed

When **Next** button on relay database form is clicked, record add dialog box appears.



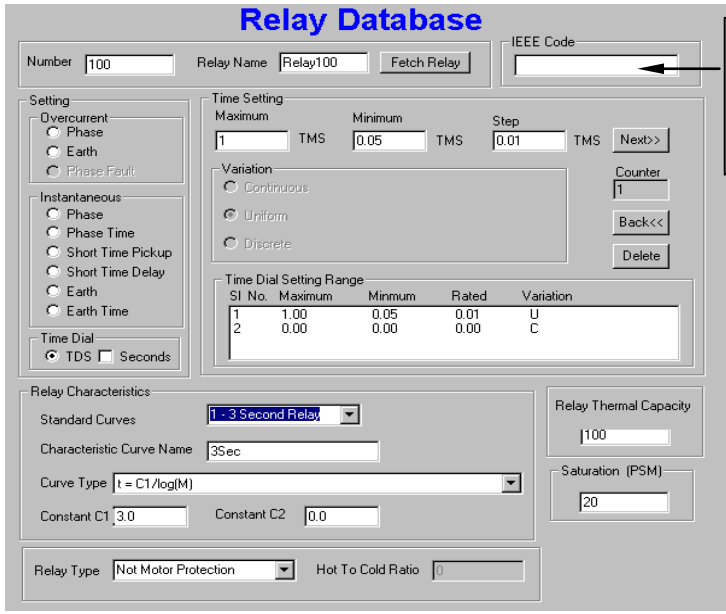
If you have one more setting click **Yes** to add next setting.
If not, say **No** first setting will be saved

Relay rated current = 5 Amps

Current setting Max = 250 % of % 5 amps = 2.5 x 5 = 12.5
Min = 50 % of % 5 amps = 0.5 x 5 = 2.5

Uniform variation step = 0.25

Enter time dial setting as below



Click Next, a dialog displayed as above, to **Add** record. If No button is clicked first setting will be **Saved.**

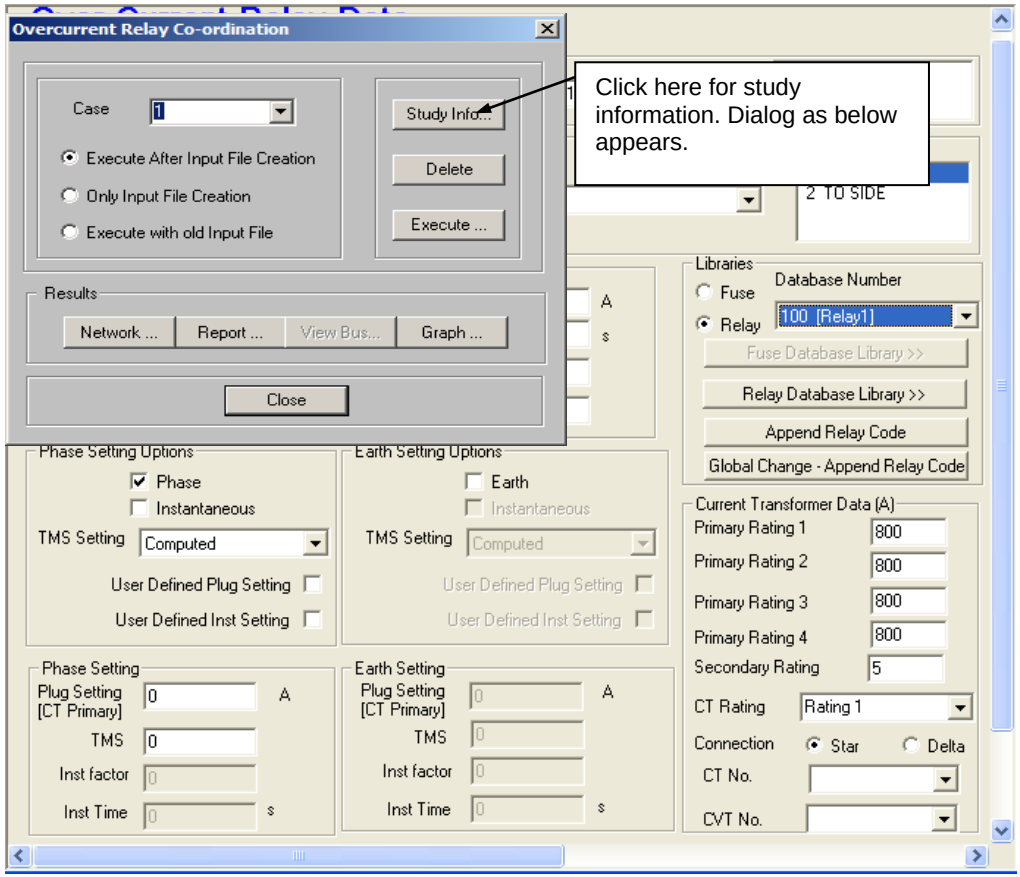
Time setting multiplier = 0.05 to 1.0 in steps of 0.01

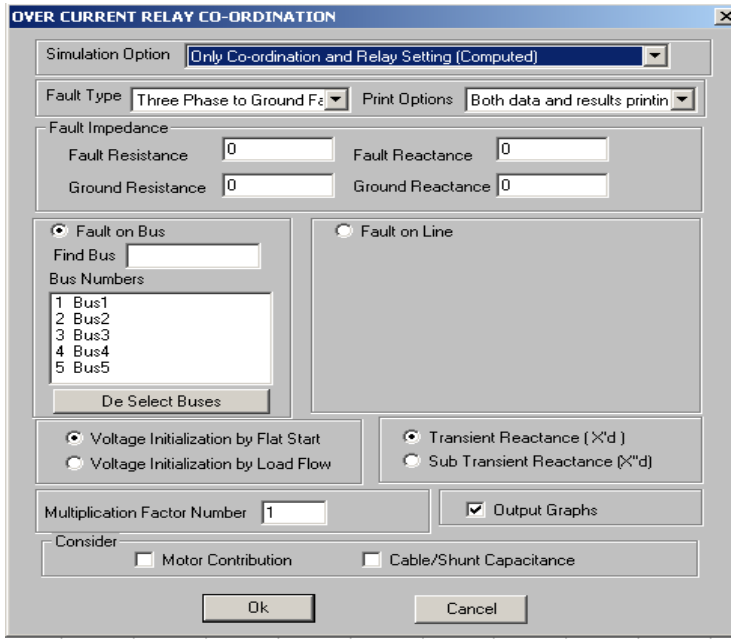
After entering the details save it and close it Over current Relay Data form appears. Enter the IDMT1 relay data as shown below. Select relay database library number 100 from the drop down list.

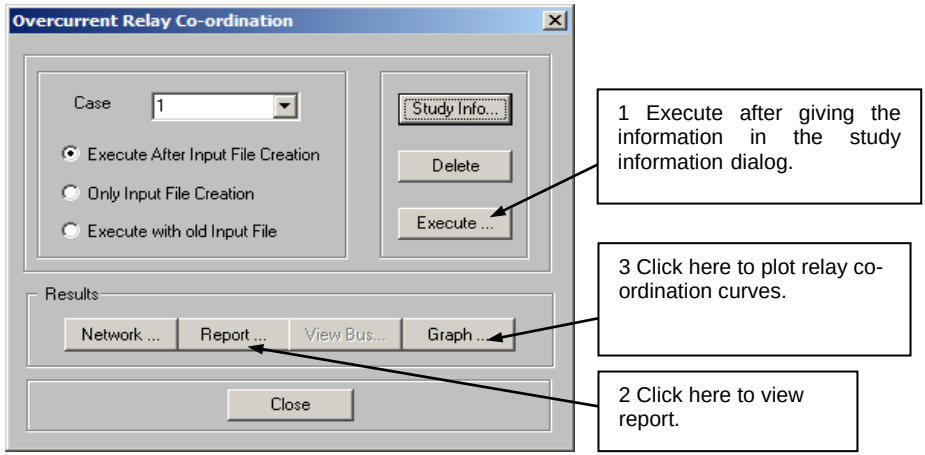
After entering the details click save button which invokes Network editor. Enter other three relays details.

Executing Over Current Relay Co - ordination

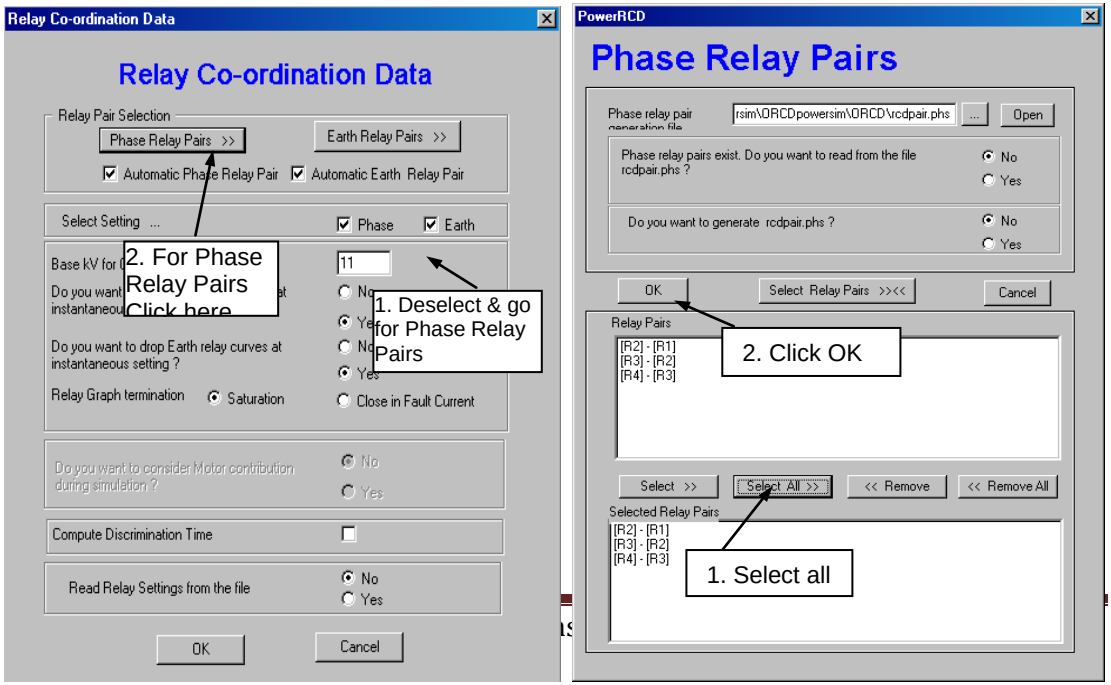
Select the menu option **Solve → Over Current Relay Co-ordination**


Overcurrent Relay Co-ordination
Case
1
Study Info...
Delete
Execute ...
Execute After Input File Creation
Only Input File Creation
Execute with old Input File
Results
Network ...
Report ...
View Bus...
Graph ...
Close
Click here for study information. Dialog as below appears.
2 TO SIDE
Libraries
Fuse
Relay
Database Number
100 [Relay1]
Fuse Database Library >>
Relay Database Library >>
Append Relay Code
Global Change - Append Relay Code
Phase Setting Options
Phase
Instantaneous
TMS Setting
Computed
User Defined Plug Setting
User Defined Inst Setting
Earth Setting Options
Earth
Instantaneous
TMS Setting
Computed
User Defined Plug Setting
User Defined Inst Setting
Current Transformer Data (A)
Primary Rating 1
800
Primary Rating 2
800
Primary Rating 3
800
Primary Rating 4
800
Secondary Rating
5
Phase Setting
Plug Setting [CT Primary]
0
A
TMS
0
Inst factor
0
Inst Time
0
s
Earth Setting
Plug Setting [CT Primary]
0
A
TMS
0
Inst factor
0
Inst Time
0
s
CT Rating
Rating 1
Connection
Star
Delta
CT No.
CVT No.


OVER CURRENT RELAY CO-ORDINATION
Simulation Option
Only Co-ordination and Relay Setting (Computed)
Fault Type
Three Phase to Ground Fa
Print Options
Both data and results printin
Fault Impedance
Fault Resistance
0
Fault Reactance
0
Ground Resistance
0
Ground Reactance
0
Fault on Bus
Find Bus
Bus Numbers
1 Bus1
2 Bus2
3 Bus3
4 Bus4
5 Bus5
De Select Buses
Fault on Line
Voltage Initialization by Flat Start
Voltage Initialization by Load Flow
Transient Reactance (X'd)
Sub Transient Reactance (X"d)
Multiplication Factor Number
1
Output Graphs
Consider
Motor Contribution
Cable/Shunt Capacitance
Ok
Cancel



Then click on execute button. While executing, following dialogs will be displayed.

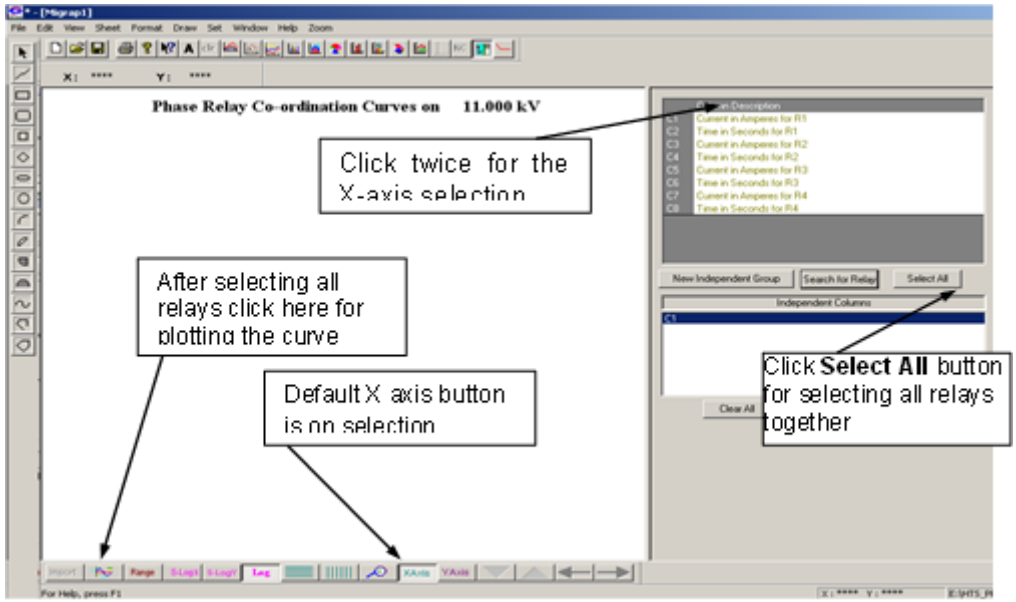


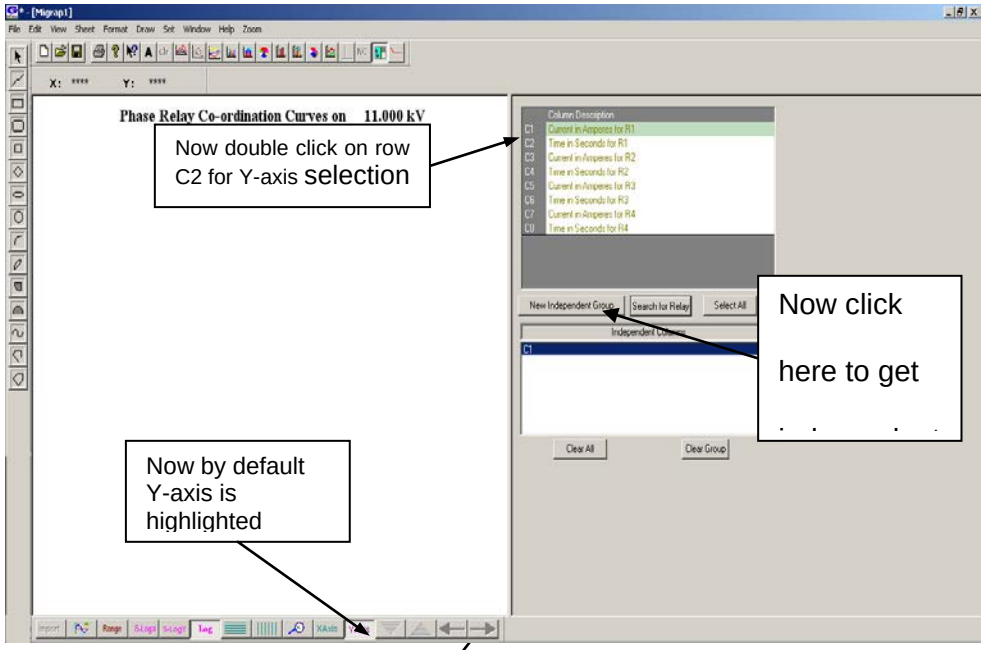
The relay co - ordination will be executed. Go to graph and plot Current **in X - axis and Time in Y - Axis.**

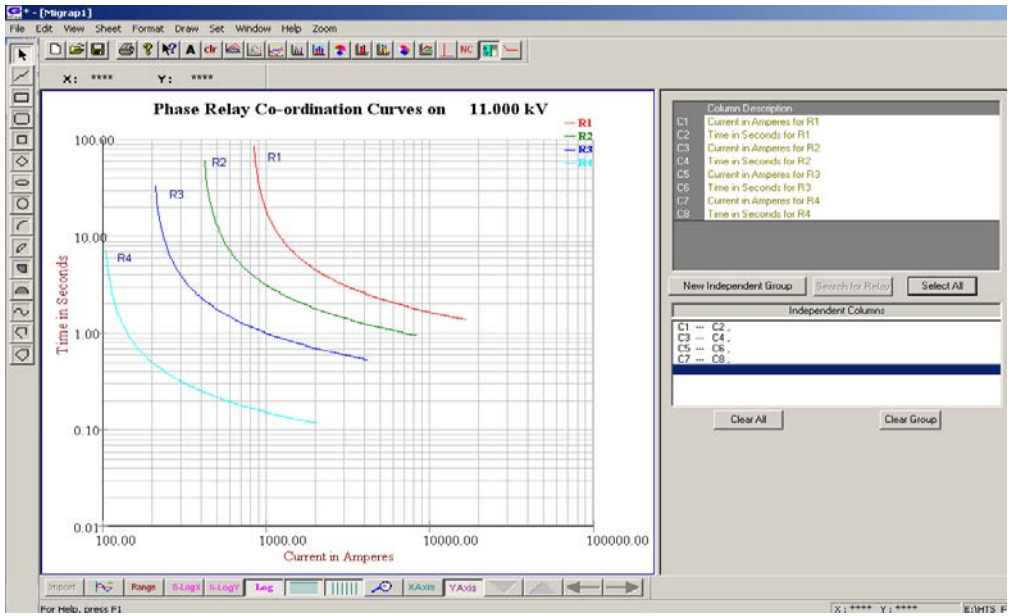
Results of Relay Co - ordination: (For maximum fault condition)

```
------------------------------------------------------------------------------
---
RELAY SETTINGS FOR PHASE FAULTS
------------------------------------------------------------------------------
---
   RELAY CLOSE IN FAULT PLUG SETTING RATIO RELAY REMARKS
   NAME CURRENT (Amps)  (Amps) CAPACITY
-------- ---------------  ------------ -------- -------- -------------
      R1      52486.3750     800.0000   65.608    100.00   Within Limit
      R2      26243.1875     400.0000   65.608    100.00   Within Limit
      R3      17495.4609     200.0000   87.477    100.00   Within Limit
      R4      13121.5918     100.0000  131.216   100.00   Exceeds Limit
------------------------------------------------------------------------------
---
   RELAY CT PRIM PLUG    T.D.S CLOSE IN  OP. TIME  REMOTE    OP.TIME  INSTANT
   NAME   CHOSEN SETTING       FAULT     FOR CLOSE BUS FALT  REMOTE   SETTING
          (Amps) (%)          CURRENT   IN FAULT  CURRENT   BUS FALT
                               (Amps)     (Secs)    (Amps)     (Secs) (%)
-------- ------- ------- ----- --------- --------- --------- -------- ---------
---
 R1  800  100.00 0.600  52486.38  0.990668  26243.19   1.1874  *****   Relay1    3.000
0.000
 R2  400  100.00 0.470  26243.19  0.776023  17495.46   0.8593  *****   Relay1    3.000
0.000
 R3  200  100.00 0.290  17495.46  0.448016  13121.59   0.4788  *****   Relay1    3.000
0.000
 R4  100  100.00 0.050  13121.59  0.070822  DOES NOT BACK-UP   **      Relay1    3.000
0.000
------------------------------------------------------------------------------
```

To plot relay co-ordination curves click on **Graph** as shown in **Over-Current Relay Co-ordination** dialog.


Phase Relay Co-ordination Curves on 11.000 kV
Click twice for the X-axis selection
After selecting all relays click here for plotting the curve
Default X axis button is on selection
Click Select All button for selecting all relays together


Phase Relay Co-ordination Curves on 11.000 kV
Now double click on row C2 for Y-axis selection
Now click here to get
Now by default Y-axis is highlighted
After you get the plot, click on the screen


File Edit View Sheet Format Draw Set Window Help Zoom
Phase Relay Co-ordination Curves on 11.000 kV
R1
R2
R3
R4
100.00
10.00
1.00
0.10
0.01
Time in Seconds
100.00
1000.00
10000.00
100000.00
Current in Amperes
Column Description
C1 Current in Amperes for R1
C2 Time in Seconds for R1
C3 Current in Amperes for R2
C4 Time in Seconds for R2
C5 Current in Amperes for R3
C6 Time in Seconds for R3
C7 Current in Amperes for R4
C8 Time in Seconds for R4
New Independent Group
Search for Relay
Select All
Independent Columns
Clear All
Clear Group
Import
Range
S-Logx
S-LogY
Log
XAxis
YAxis
For Help, press F1

3. INPUT FILE FORMAT

Input data to **POWERRCD** is through two **ASCII** files. The file names are "**RCDIN**" and "**RCDBASE**". Result is written to file "**RCDOUT**". Significance and contents of the output file is explained in chapter 4. If **POWERRCD** is run in the integrated environment, "**RCDIN**" file is automatically generated using the centralised database, whenever execution of **POWERRCD** is selected.

Input File Format For Over Current Relay Co-ordination

The input data is read in free format. Input data is divided into different heads called streams for explanation purposes. `int' is used to indicate that the data type is an integer. `float' is used to reference the floating point (real) variable. Character streams (string) are indicated by `char' type.

Stream 1 : System Description

This consists of 3 lines of data for the description of the power system for which the study is done. Each line data is of char type, and maximum number of alphanumeric characters (including blanks) in a line should not exceed 179. Any useful information, which has to appear in the report file ("**RCDOUT**") can be given in this stream.

After the three lines of system description (stream 1), comment lines can be given in the data file by entering % in the first column. Comment line is not written in the output file. These lines are simply read and skipped. If the comment line has to appear in the output file, then % should be given in the second column also.

Stream 2 : System Specification

This consists of 5 lines of data that specifies the system. Data types/specifications are separated by blanks. Since the data is read in free format, data appearing in a line can be given in successive lines also. In line 1, system size specifications are given. Table 3.1 gives the data appearing under different columns of line 1. Explanations for the entries in table 3.1 are as follows –

- In **POWERRCD** bus numbers need not be assigned continuously and there can be cases wherein some buses are deleted. Total number of buses (nbt) in column 1 is equal to the bus number of the last bus (having maximum bus number).

- Actual number of buses refers to total buses that are physically present in the system.

- Two winding transformers, three winding transformers, lines, series reactors (inductor), series capacitors and bus couplers are together referred as series elements (branches). Maximum number of series elements should not exceed 2500. Each three winding transformer results in three series elements, since equivalent ***Star*** connection data is considered. Sum of total number of two winding transformers and 3 times the number of 3 winding transformers should not exceed 2000. Even though the terminology bus coupler is used in column 8 of table 3.1, it can refer to switches, isolators and disconnecting switches, and are modelled as low impedance paths.

- Shunt reactors (inductor), shunt capacitors and shunt impedances are together referred as shunt elements. Maximum number of shunt elements should not exceed 2000.

- An unique feature of specifying the user defined filter is provided in **POWERRCD**. Total number of filters should not exceed 20.

- Number of Wind turbine generators present in the system

Table 3.1 - System Specification - Line 1 : Size Definition

Col no.	Description	Type	Min	Max
1.	Maximum bus number	Int	1	9999
2.	Actual number of buses	Int	1	9999
3.	Number of 2 winding transformers	Int	0	2000
4.	Number of 3 winding transformers	int	0	2000
5.	Number of transmission lines	int	0	500
6.	Number of series reactors (inductors)	int	0	2000
7.	Number of series capacitors	int	0	500
8.	Number of bus couplers	int	0	100
9.	Number of shunt reactors (inductors)	int	0	2000
10.	Number of shunt capacitors	int	0	2000
11.	Number of shunt impedances	int	0	2000
12.	Number of generators	int	0	2000
13.	Number of motors	int	0	2000

14.	Number of loads	int	0	2000
15.	Number of filters	int	0	20
16	Number of HVDC converters	int	0	16
17	Number of wind turbine generators	int	0	2000

Different control inputs are read by **POWERRCD** to control the program flow, results printing and model selection. These inputs are specified in line 2. In table 3.2, the data appearing in different columns of line 2 are given.

Table 3.2 - System Specification - Line 2 : Control Option

Col no.	Description	Type	Min	Max
1.	Number of zones	int	0	20
2.	Print option	int	0	4
3.	Graph option	int	0	12
4.	Base MVA	float	0.1	10000.0
5.	Nominal system frequency	float	0.1	100.0
6.	Prefault voltage option	int	0	1

Explanation to entries given in table 3.2 are as follows.

- In power system, the equipments are owned by different utilities, and in a same utility, equipments belong to different zones. Hence each bus is associated with a number called zone. All the equipments (shunt elements) connected to the bus are attributed to the zone of the bus. In case of series elements, the line belongs to the zone of the from bus (sending bus). Number of zones in the given power system data are given in column 1.

- Print option in table 3.2 is interpreted as -
  - 0 : No printing of data or results.
  - 1 : Data printing only.
  - 2 : Results printing only.
  - 3 : Both data and results printing.
  - 4 : Detailed printing of data and results.

- Graph option is interpreted as -
  - 0 : No graph file is generated.
  - 1 : Graph file for all the relays is generated. Graph file format is compatible to graphic user interface, so that the graphs of relay co-ordination can be plotted.

- When the fault occurs in a system, the fault current depends on the location of the fault and also the pre-fault voltages in the system. Pre-fault voltages are computed by performing the load flow analysis for the system under consideration. Pre-fault volt option in table 3.2 is interpreted as -

- 0 : Pre-fault voltage of 1.0 PU is assumed at all the buses.
- 1 : Pre-fault voltage is read from the file.

Data for pre-fault voltage and operating condition of the system are given in bus data stream.

In line 3, fault impedance data are given. Table 3.3 gives the entries appearing in different columns of line 3. Fault impedance values are in PU on a common MVA base and voltage base.

Table 3.3 - System Specification - Line 3 : Fault Impedance

Col no.	Description	Type	Min	Max
1.	Resistance (Zf.re) in PU	float	0.0	1.0e5
2.	Reactance (Zf.im) in PU	float	0.0	1.0e5
3.	Ground fault resistance (Zg.re)	float	0.0	1.0e5
4.	Ground fault reactance (Zg.im)	float	0.0	1.0e5

POWERRCD is designed such that even if exact values of certain parameters are not known, some approximate values can be considered. In line 4 of this stream, multiplication factor values and default values are given. Entries appearing in different columns of this line are given in table 3.4. Explanations to entries given in table 3.4 are as follows -

- Two techniques are used to model the circuit breaker or switches in closed position. One technique is to merge buses connected between the circuit breakers and treat the buses as single bus for all computation purposes. Other technique is to consider the circuit breaker as a low impedance path. Latter is used in the modelling of circuit breakers in **POWERRCD**. In this model the resistance value of circuit breaker is zero and reactance value is 0.0001 p.u. But if the impedances of other elements are relatively large, then the circuit breaker impedance can also be of higher value. Resistance and reactance values of circuit breaker in PU. are given in columns 1 and 2 of table 3.4, respectively. In some applications (especially for distribution systems), higher values have to be used. Typical values are 0.0 and 0.0001 respectively for resistance and reactance of the circuit breaker.

Table 3.4 - System Specification - Line 4 : Multiplication factors

Col no.	Description	Type	Min	Max
1.	Circuit breaker resistance in pu	float	0.0	1.0
2.	Circuit breaker reactance in pu	float	1.0e-5	1.0
3.	Transformer R/X ratio	float	0.0	1.0

4.	Transformer zero sequence impedance multiplication factor	float	0.5	1.0
5.	Number of transmission voltage levels	int	1	20
6.	Transmission line voltage in kV	float	0.001	1.0e4
7.	Transmission line zero sequence resistance multiplication factor	float	0.0	10.0
8.	Transmission line zero sequence reactance multiplication factor	float	1.0	10.0
9.	Transmission line zero sequence admittance multiplication factor	float	0.5	1.0
10.	Generator negative sequence resistance multiplication factor	float	0.0	2.0
11.	Generator negative sequence reactance multiplication factor	float	0.5	2.0
12.	Generator zero sequence resistance multiplication factor	float	0.0	2.0
13.	Generator zero sequence reactance multiplication factor	float	0.5	2.0
14.	Load negative sequence impedance multiplication factor	float	0.1	2.0
15.	Load zero sequence impedance multiplication factor	float	0.1	2.0
16.	Series reactor zero sequence impedance multiplication factor	float	0.5	2.0
17.	Shunt reactor zero sequence impedance multiplication factor	float	0.5	2.0

- Transformer ***R/X*** ratio (ratio of resistance to reactance) is usually 0.05. In certain cases the resistance value is unknown and hence ***R/X*** ratio is used to compute the resistance value, when the reactance value is given. If the transformer resistance is 0.0 then the resistance is computed as the product of ***R/X*** ratio and the transformer reactance. ***R/X*** ratio should be given as zero to neglect the transformer resistance in the computation. Entry in column 3 of table 3.4 corresponds to transformer ***R/X*** ratio. 0.05 is the typical value.

- Transformer negative sequence impedance is same as positive sequence impedance. Zero sequence impedance of the transformer is approximately 90 % of the transformer positive sequence impedance. If the transformer zero sequence resistance and reactance values are 0.0, then zero sequence values are computed by multiplying the positive sequence values by the factor given in column 4 of table 3.4. Transformer zero sequence value between the connected buses exists only if the transformer is star grounded on either side. Hence this computation is valid when both the transformer windings are solidly grounded (Star Grounded). Typical value for this multiplication factor is 0.9.

- In case of transmission lines, zero sequence multiplication factors depend on the transmission line voltage level. Hence for each voltage level, separate multiplication factors are given. In column 5 of table 3.4, numbers of voltage levels are given.

- In column 6, transmission line voltage level in kV is given.

- Transmission line negative sequence impedance is same as positive sequence impedance. Zero sequence impedance of the transmission line depends on the ground wires, and earth resistivity. Normally the zero sequence impedance is 2.5 to 3 times the positive sequence impedance. If the zero sequence resistance and reactance of the transmission lines are

0.0, then the values are computed by multiplying the positive sequence values by the factor given in column 7 of table 3.4. Typical value for this multiplication factor is 1.5.

- Zero sequence susceptance of the transmission line is much lesser compared to positive sequence susceptance. It is normally 0.6 to 0.8 times the positive sequence susceptance. If the zero sequence susceptance entry is 0.0, then the value is computed by multiplying the positive sequence susceptance by the factor given in column 8 of table 3.4. Typical value for this multiplication factor is 0.75.

- Column 6, 7 and 8 are repeated for number of voltage levels specified. If the voltage levels are more than 1, then the column numbers referred below gets shifted.

- For rotating machines, negative sequence reactance differs from the positive sequence reactance. In case of generators, negative sequence reactance is approximately equal to the sub-transient reactance. Negative sequence resistance is same as positive sequence resistance. The multiplication factors to compute the negative sequence resistance and reactance from the positive sequence values are given in columns 9 and 10 respectively. Typical value for the multiplication factors is 1.0.

- Multiplication factors to compute the zero sequence resistance and reactance of the generator from the positive sequence values are given in columns 11 and 12 respectively. Typical value for the multiplication factors is 1.0.

- Loads are normally neglected in short circuit study. But facility is provided in **POWERRCD** to consider the loads for short circuit study. Multiplication factors for negative and zero sequence load values are given in columns 13 and 14 respectively. Typical value for the multiplication factors is 1.0.

- Negative sequence impedance of the series reactor (inductor or capacitor) is same as positive sequence impedance. In most of the studies, zero sequence impedance value is taken same as positive sequence impedance value. Multiplication factor given in column 15 is used to compute the zero sequence impedance from the positive sequence impedance. Typical value for the multiplication factor is 1.0.

- Negative sequence impedance of the shunt reactor (inductor or capacitor) is same as positive sequence impedance. In most of he studies, zero sequence impedance value is taken same as positive sequence impedance value. Multiplication factor given in column 16 is used to compute the zero sequence impedance from the positive sequence impedance. Typical value for the multiplication factor is 1.0.

Stream 3 : Bus data

In this stream of data, bus details are given. Total number of lines of data is equal to actual number of buses as given at system specification. The data in columns of each line is given in table 3.5.

Table 3.5 - Bus Data

Col no.	Description	Type	Min	Max
1.	Bus number	int	1	9999
2.	Bus status	int	0	1
3.	Zone number	int	1	20
4.	Bus voltage in kV	float	0.001	1.0e5
5.	Bus name	char	1	8
6.	Voltage magnitude in pu	float	0.5	2.0
7.	Voltage angle in degrees	float	-360.0	360.0
8.	Real power generation at bus in MW	float	-1.0e6	1.0e6
9.	Reactive power generation at bus in Mvar	float	-1.0e6	1.0e6
10.	Real power load at bus in MW	float	-1.0e6	1.0e6
11.	Reactive power load at bus in Mvar	float	-1.0e6	1.0e6
12.	Reactive compensation provided at bus in Mvar	float	-1.0e6	1.0e6

Explanations to entries given in table 3.5 are as follows -

- Bus number refers to the number by which the buses are identified. Bus numbers need not be contiguous and buses belonging to different zones can be referenced by having different starting numbers (i.e., buses in zone 1 can have the bus numbers from 1 to 200, buses in zone2 can have the numbers from 201 to 300 and so on. When "**RCDIN**" file is created through integrated environment, the buses are numbered automatically and the numbers are transparent to the user.

- Status field is interpreted as -

  - 0 : Bus doesn't exist.
  - 1 : Bus exists.

- As explained earlier, zone field refers to the zone number to which the bus belongs.

- Bus voltage entry given in column 4 of table 3.5 is in Kilovolts and it is also the base voltage for the bus.
- Names rather than numbers more commonly refer buses. Bus name is a string of maximum 8 characters. Any alphanumeric characters can constitute the bus name. Bus name should be unique.

- Columns 6 to 12 in table 3.5 are of significant only if the pre-fault voltage option is selected as one. Even though the fields are to be present for pre-fault voltage option equal to zero, numerical values are ignored. If the pre-fault voltage option is zero, voltage magnitude at all the buses are initialised to 1.0 PU and voltage angles are initialised to 0.0.
- Pre-fault bus voltage magnitude, voltage angle, power generation at the bus, load at the bus are obtained from the initial load flow run on the system under consideration. When **POWERRCD** is executed from MiP-PSCT's integrated environment with prefault voltage option as 1 after executing the POWERLFA program (program for load flow analysis), columns 6 to 12 are automatically generated.

Stream 4 : Transformer data

In this stream of data, transformer details are given. Figure 3.1 shows the modeling of the transformer with off nominal turns ratio. Figure 3.2 shows the modeling of phase shifting transformer. Three winding transformers are modeled using equivalent ***star c***onnection between the windings. Figure 3.3 shows the modeling of 3 winding transformer.

Total number of lines of data in this stream is equal to sum of number of 2 winding transformers and three times the number of three winding transformers. The data in columns of each line is given in table 3.6.

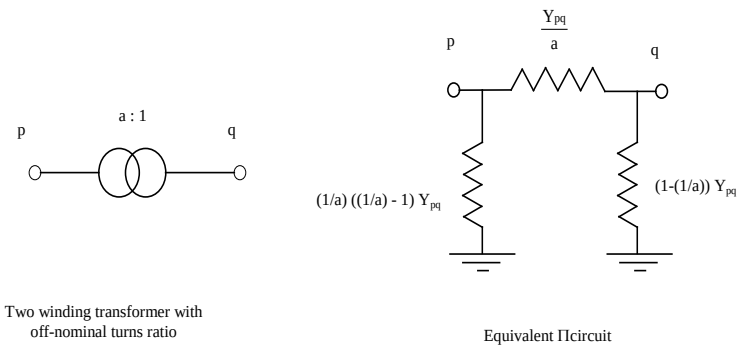


Figure 3.1 - Two winding transformer representation

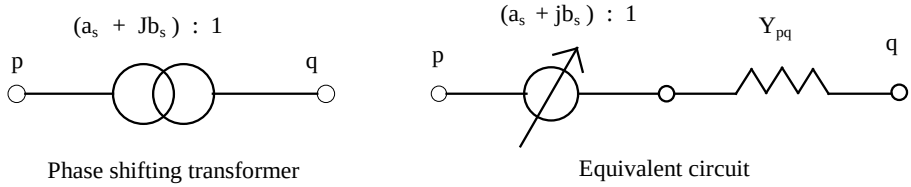


Figure 3.2 - Phase shifting transformer representation

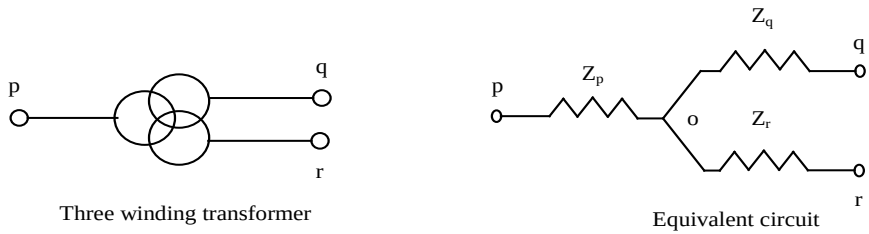


Figure 3.3 - Three winding transformer representation

Table 3.6 - Transformer Data

Col no.	Description	Type	Min	Max
1.	Connection status	int	0	3
2.	Numbers in parallel	int	1	10
3.	From bus number	int	1	9999
4.	To bus number	int	1	9999
5.	Positive sequence resistance in pu	float	0.0	1.0e2
6.	Positive sequence reactance in pu	float	1.0e-4	1.0e2
7.	Zero sequence resistance in pu	float	0.0	1.0e2
8.	Zero sequence reactance in pu	float	0.0	1.0e2
9.	Nominal tap setting in pu	float	0.5	1.5
10.	Phase shift	float	0.0	360.0
11.	From side breaker MVA rating	float	1.0	1.0e6
12.	To side breaker MVA rating	float	1.0	1.0e6
12.	To side breaker MVA rating	float	1.0	1.0e6
13.	Primary winding connection	char	1	1
14.	Secondary winding connection	char	1	1

Explanations to entries given in table 3.6 are as follows -

- Connection status is interpreted as
  - 0 : Transformer is open on either ends.
  - 1 : Transformer is open on from end.
  - 2 : Transformer is open on to end.
  - 3 : Transformer is closed on either ends.
- Values 0 and 3 are significant. If the status value is 3, then only the transformer is modeled in the analysis.

- Numbers in parallel is used to determine whether the fault level exceeds the breaker MVA rating.

- From bus number and to bus number are the buses on either side to which the transformer is connected. The numbers must be present in the bus data stream.

- Transformer impedance values are in PU on a common base. If n number of transformers exists between same nodes, then a transformer can be represented as a single equivalent transformer, or individual transformer data can be specified between the same nodes n times. For the equivalent circuit i.e., the impedance value per transformer on its own rating is divided by n and then converted to a common base. If the resistance value is zero, effective resistance is computed by multiplying the transformer reactance by the ***r/x*** ratio.

- Nominal tap setting is the tap setting at which the study is to be carried out. It is assumed that the transformer tap is provided on the from bus side. Hence, since the transformer taps are usually provided on the high voltage winding, it is always preferred to specify the from bus side as the high voltage bus number. In case of three winding transformer, tap is specified from the HT winding to additional node arising because of the equivalent star connection representation. For branches from other two windings, the nominal tap is unity. At unity tap setting, one pu voltage applied at the from bus produces one pu voltage at the to bus on no load. In case of phase shifting transformers, the phase shift is represented in polar form. The phase shift magnitude is entered in the nominal tap position, while phase shift angle is provided in the phase shift position. Phase shift angle is in degrees.

- If the transformer is grounded through any impedance, 3 times the ground impedance value should be added to the zero sequence impedance. Figures 3.4, 3.5 and 3.6 show the transformer positive and zero sequence network connections. If the entries for zero sequence values are 0.0, then zero sequence values are computed from the positive sequence values using the multiplication factors given above.

- Primary and secondary winding connections are interpreted as -

D/d : Delta connection.
S/s : Star ungrounded connection.
G/g : Star grounded connection.

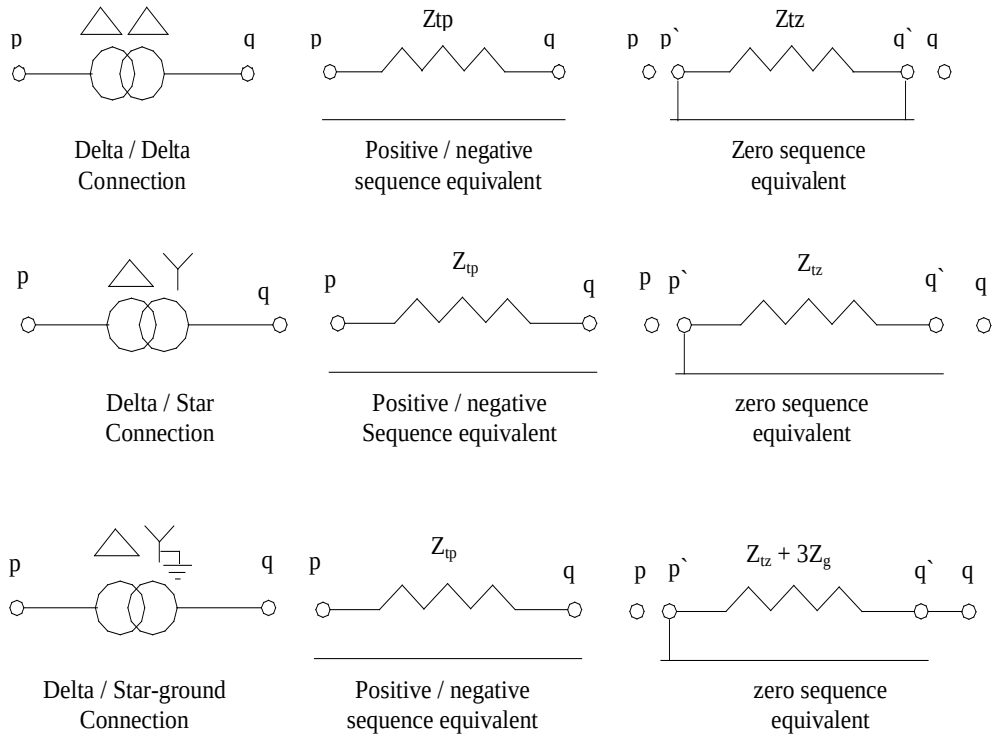


Figure 3.4 - Positive, negative and zero sequence representation of two winding transformer.

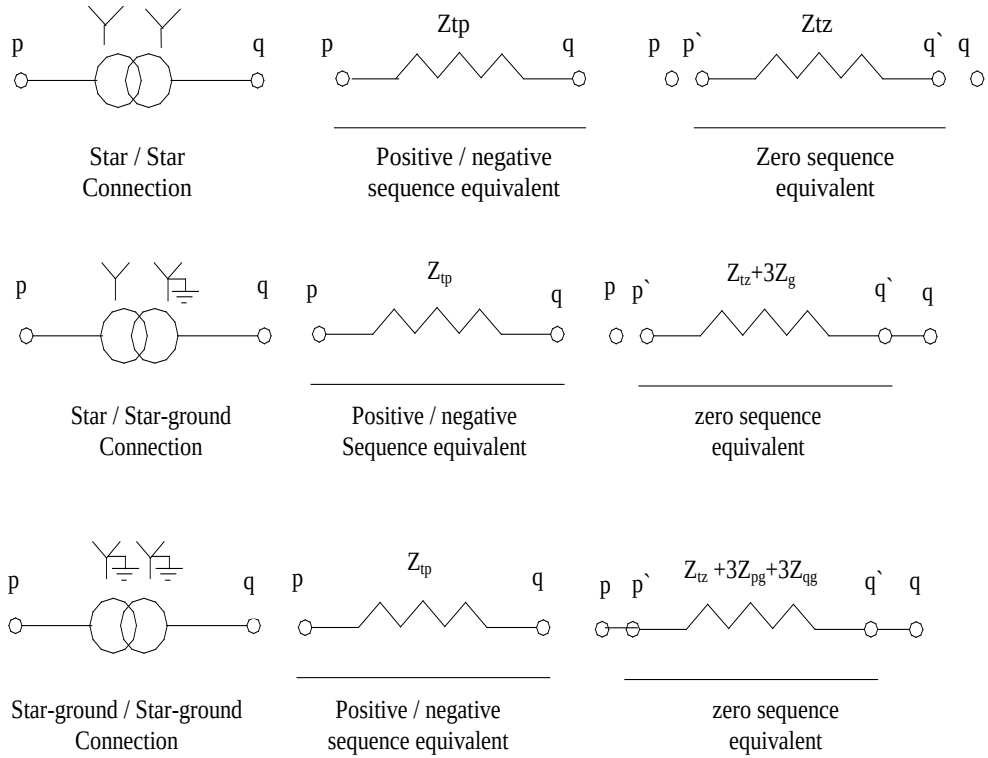
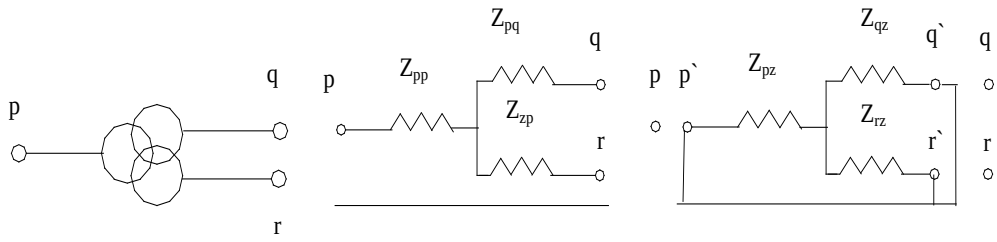
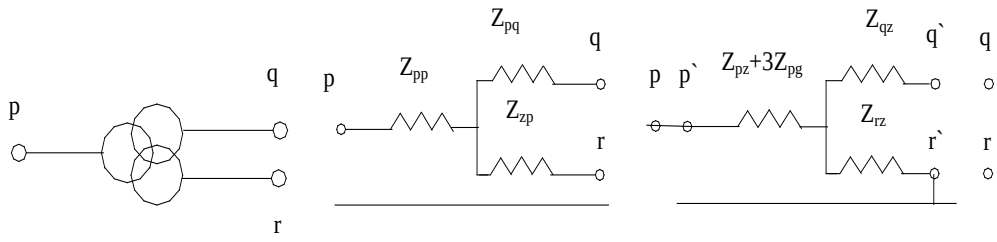


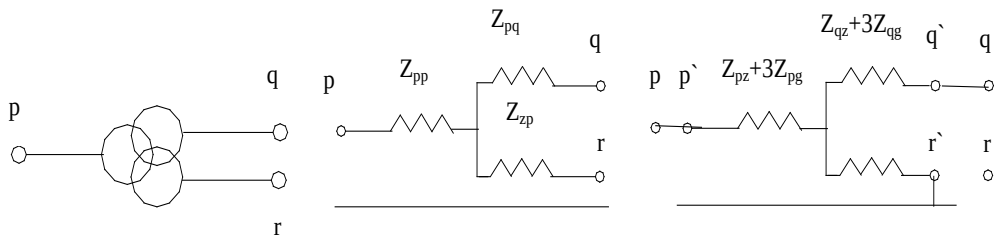
Figure 3.5 : Positive, negative and Zero sequence representation of two winding transformer for different connections



Delta / Delta / Delta



Star-ground / star /delta



Star-ground / Star-ground / Delta

Figure 3.6 positive, negative and zero sequence representation of three phase transformer

Stream 5: Transmission line data

In this stream of data, transmission line details are given. Lines/Cables are modelled using equivalent **Pi** circuit as shown in figure 3.7.

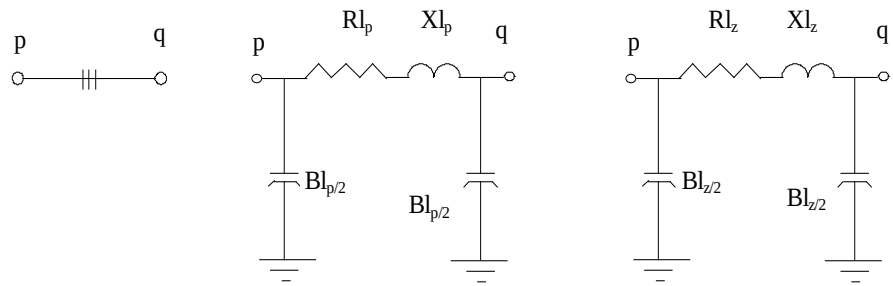


Figure 3.7 - Three phase overhead line modeling

Total number of lines of data in this stream is equal to number of transmission lines as given in specification stream. The data that appears in different columns of each line is given in table 3.7.

Explanations to entries given in table 3.7 are as follows -

- Connection status is interpreted as
  - 0 : Line is open on either ends.
  - 1 : Line is open on from end.
  - 2 : Line is open on to end.
  - 3 : Line is closed on either ends.

Values 0 and 3 are significant. If the status value is 3, then only the line is modeled in the analysis.

- Number of circuits is used to find whether the fault level exceeds the circuit breaker MVA rating.

- From bus number and to bus number are the buses on either side to which the line is connected. The numbers must be present in the bus data stream.

- Line impedance values are in PU on a common base for the equivalent circuit. i.e., if there are n lines in parallel, then impedance value per line is divided by n and then converted to a common base.

Table 3.7 - Transmission Line Data

Col no.	Description	Type	Min	Max
1.	Connection status	int	0	3
2.	Numbers of circuits	int	1	10
3.	From bus number	int	1	9999
4.	To bus number	int	1	9999
5.	Positive sequence resistance in pu	float	-1.0e3	1.0e3
6.	Positive sequence reactance in pu	float	-1.0e3	1.0e3
7.	Positive sequence susceptance (B/2) in pu	float	0.0	1.0e3
8.	Zero sequence resistance in pu	float	-1.0e3	1.0e3
9.	Zero sequence reactance in pu	float	-1.0e3	1.0e3
10.	Zero sequence susceptance (B/2) in pu	float	0.0	1.0e3
11.	From side breaker MVA rating	float	1.0	1.0e6
12.	To side breaker MVA rating	float	1.0	1.0e6
13.	Maximum transmittable power	float	0	1.0e4
14.	Minimum power factor	float	0	1
15.	Maximum power factor	float	0	1
16.	Minimum arc current	float	0	100000
17.	Arc Length	float	0	100
18.	Safety Margin	float	0	100000
19.	Ratio of earth fault current local to remote	float	0	100000
20.	Effective tower footing resistance	float	0	100
21.	Mutual coupling factor	float	0	1
22.	Frequency of oscillation, initial maximum	float	0	100000
23.	Frequency of oscillation, consecutive maximum	float	0	100000

- If the zero sequence impedance entries are 0.0, then the value is computed from the positive sequence impedance value using the multiplication factors discussed in multiplication factor stream.
- Data in column number 13 to 23 are read only for distance relay coordination
- Maximum transmittable power, maximum and minimum power factor is used while calculating the reach impedance of distance relay.
- Minimum arc current and arc length are used to compute the arc resistance. This along with Effective tower footing resistance is used to compute the earth reach

Stream 6: Series reactor and capacitor data

In this stream, data for series reactor and capacitor are given. Series reactor and capacitor are modeled as series element consisting of resistance (usually zero or negligible value) in series with the reactance. Reactance value is positive for inductor and negative for capacitor. Figure 3.8 and 2.9 show the modelling of series inductor and capacitor respectively.

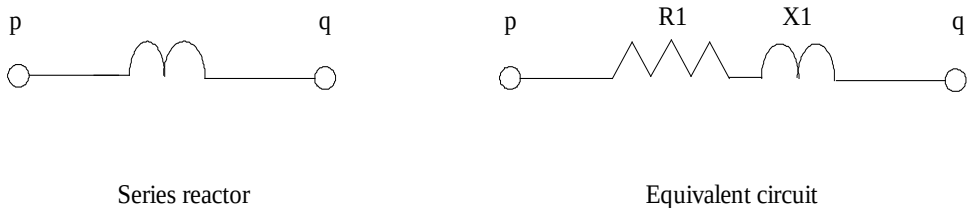


Figure 3.8: Series reactor (inductor) representation

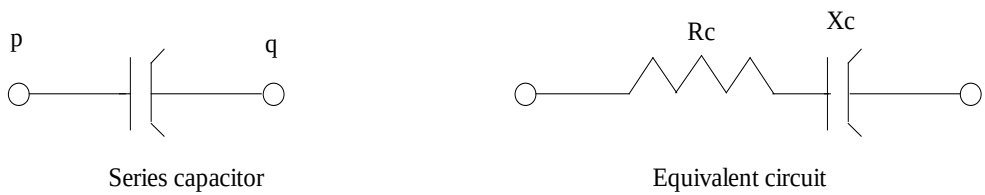


Figure 3.9: Series capacitor representation

Total numbers of lines of data in this stream are equal to the sum of number of series reactors and capacitors as given in specification stream. The data that appears in different columns of each line is given in table 3.8.

Table 3.8 - Series Reactor/Capacitor Data				
Col no.	**Description**	**Type**	**Min**	**Max**
1.	Connection status	int	0	3
2.	From bus number	int	1	9999
3.	To bus number	int	1	9999
4.	Positive sequence resistance in pu	float	0.0	1.0e3
5.	Positive sequence reactance in pu	float	-1.0e3	1.0e3
6.	Zero sequence resistance in pu	float	0.0	1.0e3
7.	Zero sequence reactance in pu	float	0.0	1.0e3
8.	From side breaker MVA rating	float	1.0	1.0e6
9.	To side breaker MVA rating	float	1.0	1.0e6

Explanations to entries given in table 3.8 are as follows -

- Connection status is interpreted as
  - 0 : Series reactor/capacitor is open on either ends.
  - 1 : Series reactor/capacitor is open on from end.
  - 2 : Series reactor/capacitor is open on to end.
  - 3 : Series reactor/capacitor is closed on either ends.

Values 0 and 3 are significant. If the status value is 3, then only the reactor/capacitor is modeled in the analysis.

- From bus number and to bus number are the buses on either side to which the reactor/capacitor is connected. The numbers must be present in the bus data stream.
- Reactor/capacitor impedance values are in p.u on a common base. (Negative for capacitance) Resistance value of the reactor/capacitor is usually zero or of negligible value.
- If the zero sequence impedance entries are 0.0, then the values are computed from the positive sequence values using the multiplication factors.

Stream 7 : Circuit breaker data

In this stream, data for circuit breakers and isolating switches are given. Switches are modeled as series element consisting of resistance (usually zero or of negligible value) and reactance (small non zero value) whose values are given in system specifications. Figure 3.10 shows the circuit breaker in closed position.

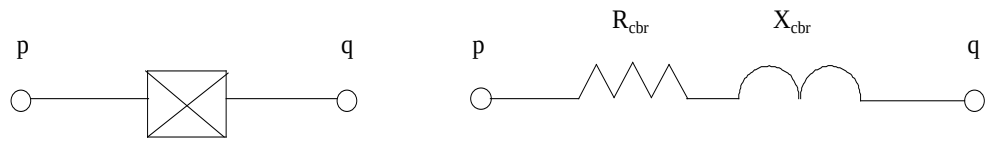


Figure 3.10: Circuit breaker representation in closed position

Total numbers of lines of data in this stream are equal to the number of circuit breakers. The data that appears in different columns of each line is given in table 3.9.

Table 3.9 - Circuit Breaker Data

Col no.	Description	Type	Min	Max
1.	Connection status	int	0	3
2.	From bus number	int	1	9999
3.	To bus number	int	1	9999
4.	Breaker MVA rating	float	1	1.0e6

Explanations to entries given in Table 3.9 are as follows -

- Connection status is interpreted as
  - 0 : Circuit breaker is opened.
  - 3 : Circuit breaker is closed.

- From Bus Number
  The breaker from bus number

- To Bus Number
  The bus to which the breaker is connected

- Breaker MVA rating
  MVA rating of the breaker

Stream 8 : Shunt connection (admittance) data

In this stream, data for shunt reactors and capacitors in admittance form is given. Admittance value in PU consists of conductance and susceptance. For shunt inductive reactor, susceptance is negative and for shunt capacitor, susceptance value is positive. Conductance value is zero or of negligible value.

Total numbers of lines of data in this stream are equal to the sum of shunt reactors and capacitors, whose values are given in admittance form. The data that appears in different columns of each line is given in table 3.10.

Table 3.10 - Shunt Reactor/Capacitor (Admittance form) Data

Col no.	Description	Type	Min	Max
1.	From bus number	int	1	9999
2.	Positive sequence conductance in p.u.	float	-1.0e-4	1.0e4
3.	Positive sequence susceptance in p.u.	float	-1.0e4	1.0e4
4.	Zero sequence conductance in p.u.	float	-1.0e-4	1.0e4
5.	Zero sequence susceptance in p.u.	float	-1.0e4	1.0e4
6	Breaker MVA rating	float	1	1.0e6
7	Shunt status	int	0	3
8	Shunt location	int	0	2

Explanations to entries given in table 3.10 are as follows -

- From bus number is the bus number to which the shunt inductor/capacitor is connected.
- Usually the reactor value will be specified in MVAR at the rated voltage. If the rated voltage is the base voltage at the bus, then the magnitude of susceptance value in p.u is equal to the specified MVAR value in p.u. The sign is positive for capacitive reactor and negative for inductive reactor. Thus the susceptance value of 63 MVAR inductor at 420 kV is -0.57143 p.u on 100 MVA base at 400 kV. Similarly susceptance value of 50 MVAR capacitor at 420 kV is 0.45351 p.u on 100 MVA base at 400 kV.
- If the zero sequence entries are 0.0, then the zero sequence values are obtained from the positive sequence values using the multiplication factor.
- Shunt status is interpreted as -
  0 : Reactor does not exist.
  3 : Reactor exists.

- Shunt location is interpreted as
  0 : Reactor is connected to bus.
  1 : Line reactor connected to the From side of the series element.
  2 : Line reactor connected to the To side of the series element.

Stream 9: Shunt connection (impedance) data

In this stream, data for shunt reactors and capacitors in impedance form is given. Impedance value in PU consists of resistance and reactance. For shunt inductive reactor, reactance is positive and for shunt capacitor, reactance value is negative. Resistance is zero or of negligible value. In some particular system studies, shunt element data is readily available in impedance form. Also, in some studies loads are represented in impedance form. When a network is reduced, all the loads can be lumped at a bus as impedance load. In these cases this stream of data is used.

Total numbers of lines of data in this stream are equal to the shunt impedance number as given in specification stream. The data that appears in different columns of each line is given in table 3.11.

Table 3.11 - Shunt Impedance Data

Col no.	Description	Type	Min	Max
1.	From bus number	int	1	9999
2.	Positive sequence resistance in p.u.	float	0.00	1.0e3
3.	Positive sequence reactance in p.u.	float	-1.0e3	1.0e4
4.	Zero sequence resistance in p.u.	float	0.00	1.0e3
5.	Zero sequence reactance in p.u.	float	-1.0e3	1.0e4
6.	Shunt status	int	0	3
7.	Shunt location	int	0	2

Explanations to entries given in table 3.11 are as follows -

- From bus number is the bus number to which the shunt impedance is connected.

- If the load power at the nominal voltage (base voltage) is known, then the impedance value in p.u is computed as the reciprocal of the conjugate of the complex power in p.u. Thus the p.u resistance and reactance values of 80 MW and 60 MVAR load are 0.8 and 0.6 respectively on 100 MVA base.

- Shunt status is interpreted as -
  0 : Shunt impedance does not exist.
  3 : Shunt impedance exists.

- Shunt location is interpreted as
  0 : Shunt impedance is connected to the bus.
  1 : Shunt impedance is connected to the from side of the series element.
  2 : Shunt impedance is connected to the to side of the series element.

Stream 10: Generator data

In this stream of data, generator impedances are given. Usually generator sub-transient reactance is considered for the fault study. While preparing the data file, either transient or sub-transient reactance value can be given. Even though negative sequence reactance values are close to sub-transient reactance value, negative sequence network is modeled separately to cater to greater flexibility. Total numbers of lines of data in this stream are equal to number of generators as given in specification stream. The data that appears in different columns of each line is given in table 3.12.

Table 3.12 - Generator Data

Col no.	Description	Type	Min	Max
1.	Generator bus number	int	1	1000
2.	Positive sequence resistance in pu	float	0.0	9999.9
3.	Positive sequence reactance in pu	float	0.0001	9999.9
4.	Negative sequence resistance in pu	float	0.00	9999.9
5.	Negative sequence reactance in pu	float	0.00	9999.9
6.	Zero sequence resistance in pu	float	0.00	9999.9
7.	Zero sequence reactance in pu	float	0.00	9999.9
8.	Breaker MVA rating	float	1.0	1.0e6
9.	Shunt status	int	0	3
10	Classification code	int	0	3

Explanations to entries given in Table 3.12 are as follows -

- Generator bus number is the bus number to which the generator is connected. This number should exist in the bus details stream.

- If the negative and zero sequence entries are 0.0, then the values are computed from the positive sequence values using the multiplication factors.

- For asynchronous motors, the initial ac short circuit current is obtained from the locked rotor current of the motor at the rated voltage. For motors, the impedance Z_m is computed as -

$$Z_m = R_m + jX_m = \frac{U_{nm}}{\sqrt{3}\, I_{an}} = \left(\frac{1}{I_{an}/I_{nm}}\right)\left(\frac{U^2}{S_{nm}}\right) \quad (2.1)$$

U_{nm} = rated voltage of motor
I_{an} = locked rotor current of motor
I_{nm} = rated motor current
S_{nm} = rated apparent power of motor

Hence for induction motors, Z_m as above is computed in p.u. and the values are given along with the generator data.

- Shunt status is interpreted as -
  0 : Generator does not exist.
  3 : Generator exists.

Stream 11: Load data

In this stream of data, load details are given. Total numbers of lines of data in this stream are equal to number of loads as given in specification stream. The data appearing in different columns of each line are given in table 3.13.

Table 3.13 - Load Data

Col No.	Description	Type	Min	Max
1.	Load bus number	int	0	2000
2.	Shunt status	int	0	3

Explanation to entries given in table 3.13 are as follows.
The load bus number is given in this column. The load given in the bus data stream is taken as the load value. At the specified bus voltage, load values are converted to equivalent impedances to model in the short circuit study. Negative and zero sequence values are obtained from the multiplication factors specified in system specification stream.

- Shunt status is interpreted as -
  0 : Load does not exist.
  3 : Load exists.

Stream 12: Filter data

In this stream of data filter details are given. For each filter, the bus number to which the filter is connected and the numbers of branch elements (Resistor, Inductor, and Capacitor) that constitute the filter are given followed by the actual filter data. Hence total numbers of lines of data in this stream are equal to sum of number of filters as given in the specification stream and sum of number of filter branches of each filter. The data that appears in different columns of each line for a filter branch is given in Table 3.14.

Table 3.14 - Filter data

Col no.	Description	Type	Min	Max
1.	Filter branch number	int	0	20
2.	From node	int	0	10
3.	To node	int	0	10
4.	Filter element type	int	1	3
5.	Element value	float	0.0	1.0e4

Explanations to entries in the Table 3.14 are as follows -

- Branch number is the serial number of the filter branch. Total number of branches per filter should be less than 20.
- Filter nodes are numbered in order considering the reference node (ground) as 0 and the bus to which the filter is connected as 1. From and to filter nodes refer to the node numbers of the filter, between which the basic filter element is connected.
- Filter element type is interpreted as -
  - 1 : Resistor, element value unit is in Ohm.
  - 2 : Inductor, element value unit is in Henry.
  - 3 : Capacitor, element value unit is in Farad.
- In the short circuit study, the equivalent shunt admittance in p.u., from the filter bus to the ground is computed at the specified system frequency, bus voltage and base MVA. If a filter at bus say 8, consists of resistor, inductor and capacitor connected as shown if figure 3.11, then the data appearing for the filter is as follows

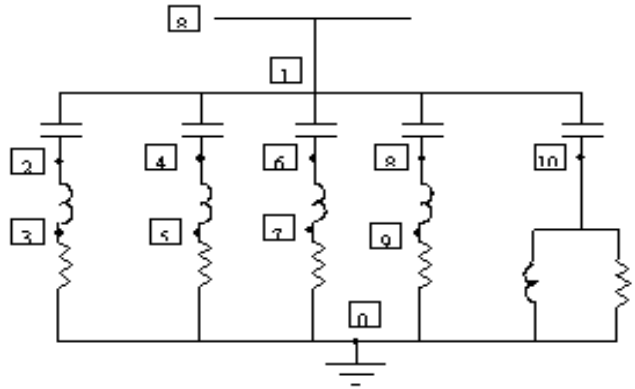


Figure 3.1: Example of a filter data

us = 8	Filter Branch Elements = 15			
Branch	From node	To node	Branch element type	Actual value
1	1	2	3	000.417e-6
2	2	3	2	000.974
3	3	0	1	037.000
4	1	4	3	000.417e-6
5	4	5	2	000.497
6	5	0	1	026.600
7	1	6	3	000.417e-6
8	6	7	2	000.201
9	7	0	1	016.900
10	1	8	3	000.417e-6
11	8	9	2	000.145
12	9	0	1	014.400
13	1	10	3	000.417e-6
14	10	0	2	0.085
15	10	0	1	452.000

Stream 13: HVDC converter data

One of the advantages of using HVDC system is that HVDC system will not contribute to AC system faults. If the AC system is relatively weak, i.e., low Short Circuit Ratio (SCR), then the AC fault level is comparable to HVDC rating. Because of the Voltage Dependent Current Order

Limiter (VDCOL), even the power is also reduced. A provision is provided to consider DC system in fault study. For each HVDC converting station, corresponding AC bus number, real power in MW and reactive power in Mvar are specified in this stream. At the specified bus voltage, load values are converted to equivalent impedances to model in the short circuit study.

- Shunt status is interpreted as -
  0 : HVDC converter does not exist.
  3 : HVDC converter exists.

Stream 14: Generator data for minimum generation condition

In this stream of data, generator impedances for minimum generation condition is given. Total numbers of lines of data in this stream are equal to number of generators as given in specification stream. The data that appears in different columns of each line is given in Table 3.15.

Table 3.15 - Generator Data For Minimum Generation Condition

Col no.	Description	Type	Min	Max
1.	Generator bus number	int	1	1000
2.	Positive sequence resistance in p.u..	float	0.0	9999.9
3.	Positive sequence reactance in p.u..	float	0.0001	9999.9
4.	Negative sequence resistance in p.u.	float	0.00	9999.9
5.	Negative sequence reactance in p.u..	float	0.00	9999.9
6.	Zero sequence resistance in p.u..	float	0.00	9999.9
7.	Zero sequence reactance in p.u..	float	0.00	9999.9
8.	Breaker MVA rating	float	1.0	1.0e6

Explanations to entries given in Table 3.15 are same as give in Table 3.12. Relay should operate and co-ordination should be ensured for faults during minimum generation condition. Relay pickup currents should be greater than the maximum load current but less than minimum fault current. Hence the minimum generation impedance is used to compute the minimum fault current seen by the relay. If at the infeed point of a distribution system, maximum generation 3 phase fault MVA is 2000 and minimum generation 3 phase fault MVA is 1600 then the equivalent generator impedance value on 100 MVA base is 0.05 p.u and 0.0625 p.u respectively for maximum and minimum generation condition.

Stream 15: Co-ordination Type

This stream of data consists of one line of data having an int field. The entry in this field is interpreted as -

- 1 : Overcurrent relay co-ordination.
- 0 : Distance relay co-ordination.

If overcurrent relay co-ordination is selected the following data is read.

Stream 16: Number of Overcurrent relays

This stream of data consists of one line of data having an int field. This field corresponds to number of overcurrent relays in the system.

Stream 17: Simulation type

This stream of data consists of one line of data having an int field. The entry in this field is interpreted as -

0-Only co-ordination and relay setting (Computed): Where fault is created at all the buses one at a time, the time dial setting and plug setting of each relay is determined.

1-Setting Verification (User given settings): Where the user defined plug setting and time dial setting is used to determine the operating time of all the relays.

2-Co-ordination and simulation (Computed): Where initially co-ordination of all the relays is done. Fault is created at the user-defined location. The operating time of each relay is determined.

3-Setting verification with simulation (User given settings): Where fault is created at user defined location. Operating time of each relay is determined. The time dial setting and the plug setting are to be given by the user.

4-Co-ordination, simulation with tripping (Computed): Where co-ordination of all the relays is done to determine the time dial setting and the plug setting. For each selected fault at the user defined location, the operating time of each relay is calculated and the sequence of relay operation is displayed until the fault is completely isolated.

5-Setting Verification, Simulation with tripping (user given settings): Where for each selected fault at the user defined location, the operating time of all the relays is calculated, where the plug setting and time dial setting are user specified. The sequence of relay operation is displayed until the fault is completely isolated.

6-Co-ordination verification (Existing settings): The coordination, verification is with "Existing settings" provided in the database

7-Setting verification with simulation (Existing settings): The coordination, verification and simulation of fault is with "Existing settings" provided in the database

Stream 18: Overcurrent Relay data

In this stream of data, overcurrent relay details are given. Total numbers of lines of data in this stream are equal to number of overcurrent relays.

The data that appears in different columns of each line is given in Table 3.16.

Table 3.16 - Overcurrent Relay Data

Col no.	Description	Type	Min	Max
1.	Relay name.	char	1	8
2.	Element number.	int	1	2000
3.	Element type.	int	0	1
4.	Relay type.	char	1	1
5.	Relay location.	char	1	1
6.	Connection sense of relay.	char	1	1
7.	Maximum load current.	float	0.0	10000.0
8.	Current transformer primary rating 1 in amps.	int	1	5000
9.	Current transformer primary rating 2 in amps.	int	1	5000
10.	Current transformer primary rating 3 in amps.	int	1	5000
11.	Current transformer primary rating 4 in amps.	int	1	5000
12.	Current transformer secondary rating in amps.	int	1	5000
13.	Relay choice.	int	1	3000
14.	Phase time dial setting.	float	0.05	10.0
15.	Earth time dial setting.	float	0.05	10.0
16.	Phase plug setting in amps (referred to primary).	float	1	12500
17.	Earth plug setting in amps (referred to primary).	float	1	2500
18.	Intact flag.	int	0	41
19.	Discrimination time.	float	0.1	1
20.	Phase Instantaneous setting factor	float	1.0	10000.0
21.	Earth Instantaneous setting factor	float	1.0	10000.0

Explanations to entries given in Table 3.16 are as follows -

- Relay name is a string of maximum 8 characters. Any alphanumeric characters can constitute the relay name. Relay name should be unique.
- Element number is the series/shunt element number to which the relay is connected. Series element number corresponds to the number counted starting from the first line in the series

element data. Transformers, transmission lines, series reactors, series capacitors, bus couplers and circuit breakers together are referred as series elements. Shunt element number corresponds to the number counted starting from the first line in the shunt element data. Shunt reactors, shunt capacitors, and shunt impedance, generator, load, filter and HVDC converters together are referred as shunt elements. Relay data for the series element is given in the beginning followed by the relay data for shunt elements.

- The element type is interpreted as -
  - 0: Relay corresponds to a series element.
  - 1: Relay corresponds to a shunt element.

- The relay type is interpreted as -
  - d/D: Directional relay.
  - n/N : Non directional relay.

- Relay location is interpreted as -
  - 1: Relay is located on from side of the series element.
  - 2: Relay is located on to side of the series element.

  The from side and to side is decided by the way in which data is given for the series elements.

  For example, consider a transmission line, whose from node is specified as 1 and to node as 2. If a relay is connected to node 1, the entry in this column should be 1. If in the transmission line data the from node is given as 2 and to node as 1 then for the same connection of the relay the entry in this column is 2.

- The entry in column 6 is significant only for a directional relay. If the relay is non-directional, data is read, but it is ignored.

  Connection sense of relay is interpreted as -

a/A: Relay is looking away from the bus to which it is connected.
t/T : Relay is looking towards the bus to which it is connected.

This is applicable only in case of directional relay.

Consider the following examples,

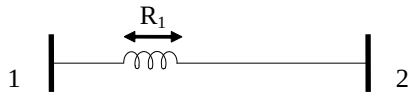


Figure 3.12 : Example 1

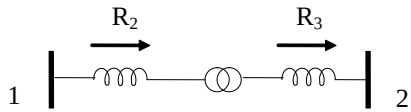


Figure 3.13 : Example 2

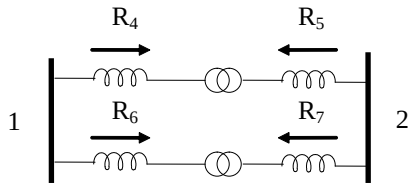


Figure 3.14 : Example 3

The entries made in columns 1, 3, 4, 5 and 6 for the relay in figure 3.12 are as shown in the table -

Relay name	Element type	Relay type	Relay location	Connection sense
R1	0	n	1	a

The entries in columns 1, 3, 4, 5 and 6 for the relays in figure 3.13 are as shown in the table

Relay name	Element type	Relay type	Relay location	Connection sense
R2	0	d	1	a
R3	0	d	2	t

The entries in columns 1, 3, 4, 5 and 6 for the relays in figure 3.14 are as shown in the table

Relay name	Element type	Relay type	Relay location	Connection sense
R4	0	d	1	a
R5	0	d	2	a
R6	0	d	1	a
R7	0	d	2	a

All entries are made assuming that the from node in the series element data is given as 1 and the to node as 2.

- The entry in column 7 specifies the maximum load current in amperes that will be carried by the element on which the relay is located. The CT primary rating is selected such that it is greater than the maximum load current multiplied by a factor (overload factor), which is usually in the range 1.0 to 1.3.

- The entries in column 8 to column 11 are different ratings for Current transformer primary. The CT primary rating is selected based upon
  1. Maximum load current
  2. Instantaneous setting
  The instantaneous setting decides the final selection of the CT primary rating. CT primary rating is selected such that it is capable of measuring the instantaneous setting. In case of dual rating CT ratio say 400/200/5 amps, the data should be given as 400, 200, 200, 200 in columns 8, 9, 10 and 11 respectively. The entries in columns 8 to 11 are significant only if relay type number is less than or equal to 1000 (relay). If relay type number is greater than 1000 (fuse), data is read, but it is ignored.

- The entry in column 13 refers to the relay type number. According to the number the relay is selected from the relay database. A relay type number identifies each relay in the database, which is unique. The relay type number is less than or equal to 1000 for an overcurrent relay and greater than 1000 for a fuse.

- Columns 14 to 17 are significant only if the intact flag option is greater the zero. If intact flag is selected as zero, though the fields are to be present the values are ignored. Phase time dial setting and earth time dial setting should be initialised to the minimum value. Though the user is allowed to specify TDS upto 10, usually the range is in between 0.05 to 1.0.

- Column 18 corresponds to intact flag. Intact flag is interpreted as -

  0: CT primary rating selection, plug setting and the time dial setting (TDS) are computed by the program.
  01: User defined TDS is selected, plug setting is computed by the program.
  10: User defined plug setting is selected with CT primary rating 1 and the TDS is computed

by the program.
11: User defined plug setting is selected with CT primary rating 1, and the TDS should be given by the user.
20: User defined plug setting is selected with CT primary rating 2 and the TDS is computed by the program.
21: User defined plug setting is selected with CT primary rating 2, and the TDS should be given by the user.
30: User defined plug setting is selected with CT primary rating 3 and the TDS is computed by the program.
31: User defined plug setting is selected with CT primary rating 3, and the TDS should be given by the user.
40: User defined plug setting is selected with CT primary rating 4 and the TDS is computed by the program.
41: User defined plug setting is selected with CT primary rating 4, and the TDS should be given by the user.
If the user wants to specify phase plug setting, earth plug setting, phase time dial setting and earth time dial setting which should not be altered during co-ordination, intact flag is selected suitably and required entries are made in columns 14 to 17
02: User defined close in operating time. The required operating time should be given in column 14 for phase relay and in column 15 for earth relay. Program computes the time dial setting

- Discrimination time in seconds is the time interval between the operation of this relay and the relay for which this provides backup protection.

- The entry in column 20 corresponds to phase instantaneous setting factor. This value is multiplied by the remote bus fault current to obtain phase instantaneous setting above, which the phase relay should operate instantaneously.
  For transformer protection relay the entry in this column is magnetising inrush current in amperes. The instantaneous setting is set such that the relay will not operate instantaneously for the magnetising inrush current.
  For motor protection relay the entry in this column is the starting current of the motor. The instantaneous setting is made such that the relay does not operate during motor starting.

- The entries in column 21 correspond to earth instantaneous setting factor. This value is multiplied by the remote bus earth fault current to obtain the earth instantaneous setting above, which the earth relay should operate instantaneously.
  For motor protection relay the entry in this column is the motor starting time in seconds.
  Even if phase and earth instantaneous settings are not present in the relays these fields has to be present. When the data file is created through integrated environment these values are 1.3 by default. To give user defined values the user has to change the relevant field in the data file and execute relay co-ordination with option 2.

Stream 19: Co-ordination details

In this stream of data the co-ordination details are given. This consists of one line of data. This has four fields of float type. The data that appears in different columns are

Table 3.17 - Co-ordination Details

Col no.	Description	Type	Min	Max
1.	Instantaneous setting factor	float	1.3	
2.	Time discrimination	float	0.0	
3.	Unbalance factor for earth fault	float	1.0	5.0
4.	Over load factor	float		

Explanations to entries given in Table 3.17 are as follows -

- The instantaneous setting is that value of current for which the overcurrent relay should operate instantaneously. The instantaneous setting is obtained by multiplying the remote bus fault current by the factor given in column 1. The typical value for instantaneous factor is 1.3
- Time discrimination is in seconds, which determines the time interval between the operating time of primary and back up relays. For example, consider a relay pair R1 (primary) and R2 (back up). If, for a close in fault R1 operates in tp seconds then according to the discrimination interval the operating time of the relay R2 is determined. If t is discrimination time interval operating time for back up relay = (tp + t) seconds.

  The usual time discrimination provided is 0.4 seconds. If the primary is a fuse, co-ordination interval between the fuse and the backup relay (t_b in seconds) is given by the formula,

$$t_b = 0.4t + 0.15 \quad (2.2)$$

  where t is the operating time of the fuse. The reduction in the time interval is due to the absence of circuit breaker operating time.
- The entry in column 3 corresponds to the unbalance factor for earth fault. The relay should not operate for slight unbalance. Hence certain percentage of tolerance is provided. The typical value for this unbalance factor for earth fault is 0.1
- The entry in column 4 is the over load factor. The relay should not operate for currents just above the maximum load current. Usually 30 percent of overload is permitted beyond which the relay should operate. The typical value of over load factor is 1.3

  If the entry in stream 17 is greater than 1, the following data is read.

Stream 20: Number of faults to be Simulated

This stream consists of one line of data having an int field. Total number of faults to be simulated is given in this field.

Stream 21: Partial Bus Bar Relay Data

In this Stream, the data for Partial bus bar relay is given. Total numbers of lines of data in this stream are equal to number of partial bus bar relays.
The data that appears in each column of each line is given in table 3.18

Table 3.18– Partial Bus Bar Relay Data

Col no.	Description	Type	Min	Max
1.	Bus Number	int	1	1E+009
2.	Incomer relay name	char	1	8
3.	Phase Instantaneous setting	float	0	10000
4.	Phase Instantaneous time delay	float	0	10
5.	Earth instantaneous setting	float	0	10000
6.	Earth instantaneous time delay	float	0	10
7.	Incomer relay name	char	1	8
8.	Series Element Id 1	Int	0	2500
9.	Series Element Id 2	Int	0	2500
10.	No. of outgoing feeders	Int		

Explanations to entries given in Table 3.19are as follows –

- Bus Number is the element number to which the relay is connected.
- Incomer relay name, this is the name of the relay which is placed on incomer of the bus
- Phase instantaneous setting is the instantaneous pickup setting of the incomer relay in ampere.
- Phase instantaneous time delay is the instantaneous relay operating time.
- Earth instantaneous setting is the instantaneous pickup setting of the incomer relay in ampere.
- Earth instantaneous time delay is the instantaneous relay operating time.
- Two winding transformers, three winding transformers, lines, series reactors (inductor), series capacitors and bus couplers are together referred as series elements (branches).

Note: If partial Bus Bar relay is not present, Stream 21 refers to Simulation data

Stream 22: Simulation data

In this stream of data, simulation details are given. The number of lines of data is equal to total number of faults. The data that appears in different columns of each line is given in Table 3.19.

Table 3.19 - Simulation data

Col no.	Description	Type	Min	Max
1 .	Element number	int	1	2000
2 .	Percent line	float	1.0	99.0
3 .	Fault type	int	1	4

Explanations to entries given in Table 3.19 are as follows -

- Element number in column 1 of Table 3.18 is the transmission line number (serial number counted starting from the first line in the transmission line data) on which fault is to be created. If fault is to be created on a bus, the entry in this column is bus number.

- Percent line is distance in percentage from the sending end of the element where the fault is simulated. For a fault on bus the entry in this column should be zero.

- Fault type is interpreted as -
  - 1 : Three phase fault.
  - 2 : Single line to ground fault at R phase.
  - 3 : Line to line fault between Y and B phases.
  - 4 : Double line (Y and B phases) to ground fault.

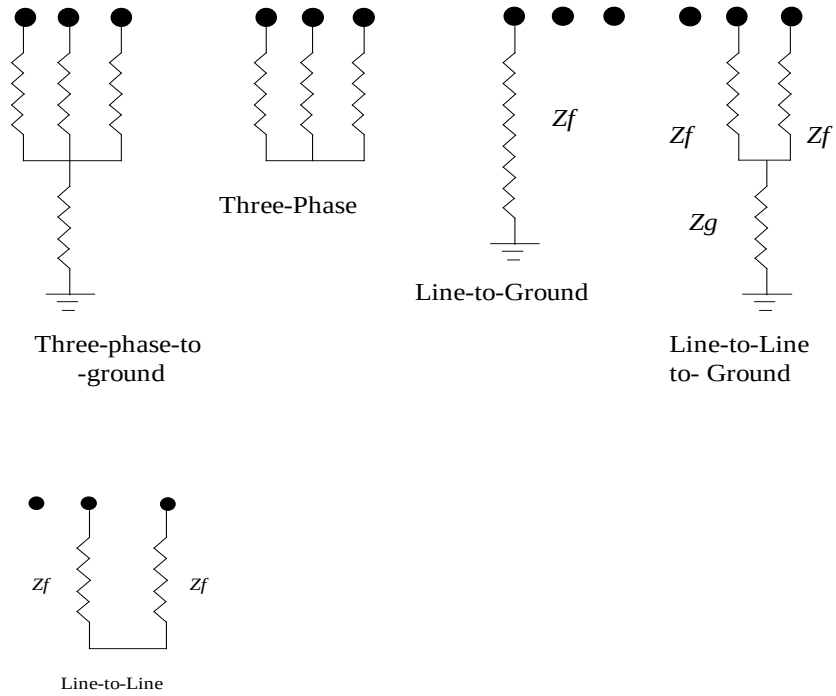


Figure 3.15 : Representation of various types of faults

File format for RCDBASE

The data present in this file depends upon the different types of relays available. If a relay is to be introduced with the characteristic, which does not exist in the database, this **RCDBASE** file should be updated.

Stream 1: RCDBASE Data

This consists of one line of data having two int fields. First field tells the total number of relay types present in the database. If new relays are to be included in the database this number has to be changed accordingly.

The second field tells whether data should be written to the output file or not. If the entry in this

field is selected as one the over current relays used for the study is written to the output file. Each time while executing the relay co-ordination program the user may not want to print the relay database, in which case the user should select this field as zero.

Following this statement, for each relay, the details as per the manufacturer's technical specifications are entered. The data for each relay is as follows.

Stream 2: Relay type number

This consists of one line of data of int field indicating the relay type number. Relay type number refers to the number by which the relays are identified. Relay type numbers need not be continuous. Relay type number is unique. This number is

1. Less than or equal to 1000 for overcurrent relay
2. Greater than 1000 and less than 2000 for a fuse.
3. Greater than 2000 for a Voltage controlled relay

Stream 3: Manufacturer name

This consists of one line of data of char field indicating the relay make. Total number of characters should not exceed 30.

Stream 4: Relay name

This consists of one line of data of char field indicating the relay name. Total number of characters should not exceed 15. If it is a fuse, the name of the fuse is to be given in this field.

Stream 5: Number of Current Settings

This consists of one line of data of int field indicating the number of available current settings. For example, consider a case wherein the available ratings are 1 amps and 5 amps for phase fault relay, 0.03 amps, 0.2 amps, 1.0 amps and 5.0 amps for earth fault relay, then the total number of current settings is 6.

Stream 6: Current Settings Data

This stream of data consists of current setting details. Numbers of lines under this stream are equal to number of current settings as specified in the previous stream. The data that appears in different columns of each line are given in Table 3.20.

Table 3.20 - Current Settings

Col no.	Description	Type	Min	Max
1.	Maximum current	float	0.075	12.5
2.	Minimum current	float	0.003	0.5
3.	Rated current	float	0.03	5.0
4.	Flag	float	0	1

- The procedure for entering the values in different columns can be better understood with the help of an example. Consider the current rating of 5 amps. For phase plug setting selection, let the specified range be 50 to 250 percent of the rated current in steps of 25 percent.
- Maximum current in amps is the maximum available setting. In the example considered it is 12.5 amps (2.5 x 5.0).
- Minimum current in amps is the minimum available setting. In the example it is 2.5 amps (0.5 x 5.0)
- Flag is interpreted as -

⇒ 0: The entries in the columns 1 to 3 correspond to earth plug setting range.
⇒ 1: The entries in the columns 1 to 3 correspond to phase plug setting range.
⇒ 2: The entries in the columns 1 to 3 correspond to phase fault plug setting range

Stream 7: Number of plug Setting

This consists of one line of data of int field indicating the number of available steps of plug setting. The entry in this field depends on the type of plug setting data i.e., whether it is continuous, uniform or discrete variation. The number of plug setting data is significant only if the variation is in discrete steps. The number of discrete steps should not exceed 15. In case of plug setting having uniform step or which can be varied continuously this field should be zero.

Stream 8: Plug Setting Data

This stream of data consists of plug setting details. Number of lines in this stream is equal to the number of current settings for the relay. The type of variation of plug setting data is identified by the entry in the first column.

The character "D" in the first column indicates the variation is in discrete steps. This character is followed by a blank character and the plug setting values. This line consists as many fields as specified in the previous stream. The fields are all of float type separated by blanks.

Available plug settings are given in amps, from minimum to maximum value. Again considering the previous example, the plug setting data is given as follows. The plug setting should be given from minimum to maximum. Since 25 percent is step, the number of steps is 9 and the step value is 1.25. The entries in different columns of the line corresponding to CT secondary rating of 5 amps is

2.5 3.75 5.0 6.25 7.5 8.75 10.0 11.25 12.5

- The character "C" in the first column indicates the plug setting is continuously variable value between two limits.
- The character "U" in the first column indicates the plug setting data varies continuously between two limits with a uniform step. This character is followed by the uniform step value.

Stream 9: Time Dial Setting Data

This stream of data gives the time dial setting details. This consists of one line of data having three fields. The data that appears in different columns are given in Table 3.21.

Table 3.21 - Time Dial Setting Data

Col no.	Description	Type	Min	Max
1.	Minimum time dial setting	float	0.05	1.0
2.	Time dial setting step value	float	0.0005	1.0
3.	Maximum time dial setting	float	1.0	100.0

Time Dial Setting (TDS) is also referred as Time Multiplier Setting (TMS).

If minimum time dial setting is greater or equal to 100 then the step values and the setting is in seconds (Ex. Motor protection release (SR21)). Following this field the

Data that appears in different columns are

1. Minimum time in seconds
2. Number of steps
3. Maximum time setting in seconds
4. Step Values in seconds

Stream 10: Characteristic Specification

This stream gives the relay time current characteristic specification details. This consists of one line of data, having four fields. Relay's time current characteristic is stored using a look up table, taking intermediate x and y co-ordinates or curve fitting formula. The data that appears in different columns are given in Table 3.22.

Table 3.22 - Characteristic Specification

Col no.	Description	Type	Min	Max
1.	Characteristic type number	int	1	11
2.	Number of points	int	0	50
3.	Constant C_1	float		
4.	Constant C_2	float		

Explanations to entries given in Table 3.22 are as follows -

- Characteristic type number is interpreted as follows -
  1. The characteristic is represented by the formula,

$$t = \frac{C_1}{Log(M)}$$

at unity time dial setting, where t is the operating in seconds and M is the multiple of plug setting. Multiple of plug setting is computed as

$$M = \frac{\text{fault current in amps}}{\text{relay plug setting in amps}}$$

The relay characteristic is determined by the value of the constant. For example, if the constant is 3.0 the relay is a 3 seconds relay. For a plug setting multiplier of 10 the operating time is 3 seconds at unity TDS hence it is known as 3 seconds relay, 1.3 seconds relay can also be simulated by making the constant C_1 as 1.3.

Different types of relay characteristic can be simulated with a standard formula just by changing the constants. The empirical formula is given by

$$t \frac{C_1}{M^{C_2} - 1} \quad (2.3)$$

At unity time dial setting, where t is operating time in seconds and M is the multiple of plug setting.

The characteristics which can be simulated with this formula is

- Normal inverse characteristic i.e.,

$$t = \frac{0.14}{M^{0.02} - 1} \quad (2.4)$$

where $C_1 = 0.14$, $C_2 = 0.02$

- Very inverse characteristic i.e.,

$$t = \frac{13.5}{M - 1} \quad (2.5)$$

where $C_1 = 13.5$, $C_2 = 1.0$

– Extremely inverse characteristic i.e.,

$$t = \frac{80}{M^2 - 1} \quad (2.6)$$

where $C_1 = 80$, $C_2 = 2.0$

– Long time standby earth fault relay i.e.,

$$t = \frac{120}{M - 1} \quad (2.7)$$

where $C_1 = 120$, $C_2 = 1.0$

– RI-Curve characteristic relay i.e.,

$$t = \frac{1}{C_1 - \frac{C_2}{M}} \quad (2.8)$$

where $C_1 = 0.339$, $C_2 = 0.236$

at unity time dial setting, where t is operating time in seconds and M is the multiple of plug setting.

This curve type indicates the characteristics where the value I^2 is constant. This type of characteristic is best suited for fuses.

$$t = \frac{C_1}{I^2} \quad (2.9)$$

where C_1 is the constant I^{2t}.

Curve types 5, 6 and 7 are not used at present.

8. This curve type indicates that the relay characteristic is plotted, taking multiples of plug setting along X-axis and time in seconds along Y-axis.

9. This curve type indicates that the relay characteristic is plotted, taking multiples of plug setting (to the base 10) along X-axis and time in seconds (to the base 10) along Y-axis.

10. This curve type indicates that the relay characteristic is plotted, taking current in amps along X-axis and time in seconds along Y-axis.

11. This curve type indicates that the relay characteristic is plotted, taking current in amps (to the base 10) along X-axis and time in seconds (to the base 10) along Y-axis.

- Number of points given in field two refers to total number of discrete points given to construct the relay characteristic.
  This field is zero for characteristic curve types 1 to 4.

C_1 and C_2 should always be present, the values are interpreted depending upon the curve type.

Stream 11: Curve Table

This stream gives the curve details. This consists one line of data followed by the curve table. The data that appears in different columns of the first line are -

1. Number of Characteristic curves to be stored. In some of the relays the characteristic curves at different time dial settings are not parallel to unity time dial setting. Hence, option is provided to store the characteristic curves at different time dial settings. The number of characteristic curves should not exceed 15.
2. The entry in the subsequent columns specifies the time dial setting (or time in seconds for motor protection releases) values at which the characteristic curves are stored. The time dial setting (time) should be given from minimum to maximum.

The numbers of lines of data following this are equal to the number of curve points as given in the previous stream.
Each line consists as many numbers of fields as in the first line. If n number of curves is to be stored then each line consists (n+1) number of float fields separated by blanks. The data that appears in different columns are given in Table 3.23.

Table 3.23 - Curve table

Col no.	Description	Type	Min	Max
1	Plug setting multiplier	float	1.0	100
2.	Operating time at tds_1	float	1.0	1000
3.	Operating time at tds_2**	float	1.0	1000
4.	Operating time at tds_3**	float	1.0	1000
n+1	Operating time at tds_n**	float	1.0	1000

** : Time in seconds for motor protection releases (normally this is the time specified for 6 times the rated current). For these curves, no interpolation is done hence for each time setting the curve details must be given.

Explanations to entries given in Table 3.23 are as follows -

- Plug setting multiplier should be according to the selected scale.

- Operating time should be according to the selected scale. The entries in column 2 to (n+1) are the operating times at different time dial settings. The co-ordinates of the characteristics are stored at pre-selected intervals. The intervals need not be equal. The program selects data points adjacent to the required value of the plug setting multiple. If the plug setting and time curves have relatively small curvature, the intervals between adjacent points may be made relatively large. Otherwise, the intervals between the adjacent points must be decreased. If the time dial setting does not correspond to the time dial setting at which the curve is stored, linear interpolation is used to determine the operating times corresponding to that time dial setting. If tds_1 and tds_2 are the two time dial settings between which the required time dial setting tds_0 lies, for each plug setting multiplier the operating time is determined as follows -

Let Y_1 and Y_2 be the operating times at tds_1 and tds_2, the operating time corresponding to time dial setting tds_0 is -

$$Y_0 = Y_1 - \frac{(Y_1 - Y_2)(tds_2 - tds_n)}{(tds_2 - tds_1)}$$

The operating time corresponding to all the plug setting multiplier is determined. If the plug setting multiple does not correspond to a value stored, linear interpolation is used to determine the corresponding time.

If X_1 and X_2 are the two plug setting multipliers between which the required plug setting multiplier (X_0) lies, t_1 and t_2 are the corresponding times, then to determine the time for X_0 (t_0) , linear interpolation is used.
Therefore,

$$t_0 = t_1 - \frac{(t_1 - t_2)(X_2 - X_0)}{(X_2 - X_1)}$$

If the curve is stored, only at unity time dial setting suitable scaling should be done according to the TDS. The operating time for TDS other than unity is obtained by multiplying the TDS with the operating time at unity TDS.

For motor protection releases the earth relay characteristics is definite time. Hence, for such relays following the curve table the earth relay characteristics should be given if earth element exists. The data appearing in different columns are

Table 3.24 - Earth Characteristic Table

Col no.	Description	Type	Min	Max
1	Minimum time	float	1.0	100
2.	Maximum time	float	1.0	1000
3	Type of variation	float	1.0	1000
4	Step Values	Float	1.0	1000

Explanations to entries given in Table 3.24 are as follows -

- The minimum and maximum time correspond to the available definite time setting.
- The type of variation of time setting is identified by the entry in column 3.
- The character "D" in this column indicates the variation is in discrete steps. A blank character, number of discrete points and the discrete step values follow this character in seconds. The fields are all of float type separated by blanks.
- The character "C" in this column indicates the time setting is continuously variable value between two limits.
- The character "U" in this column indicates that the time varies continuously between two limits with a uniform step.

Stream 12: Instantaneous Data

This stream consists of one line of data. The line consists of two int. The data that appears in different columns are-

1. Phase instantaneous setting flag.
2. Earth instantaneous setting flag.

The phase instantaneous setting flag is interpreted as -

0 : Phase instantaneous setting does not exist.
1 : Phase instantaneous setting exists.
2 : Phase instantaneous setting with time delay
3 : Phase instantaneous setting with time delay and short circuit setting with time delay
4 : Different instantaneous setting for each CT rating

The earth instantaneous setting flag is interpreted as -

0 : Earth instantaneous setting does not exist.
1 : Earth instantaneous setting exists.
2 : Earth instantaneous setting with time delay

The possible options of phase and earth instantaneous setting flags are tabulated

Phase and Earth Instantaneous setting element flags		
Phase Inst Setting	Earth Inst Setting	Remarks
0	0	No phase instantaneous setting No earth instantaneous setting
0	1	No phase instantaneous setting Earth instantaneous setting without time delay
0	2	No phase instantaneous setting Earth instantaneous setting with time delay
1	0	Phase instantaneous setting without time delay No earth instantaneous setting
1	1	Phase instantaneous setting without time delay Earth instantaneous setting without time delay
1	2	Phase instantaneous setting without time delay Earth instantaneous setting with time delay
2	0	Phase instantaneous setting with time delay No earth instantaneous setting
2	1	Phase instantaneous setting with time delay Earth instantaneous setting without time delay
2	2	Phase instantaneous setting with time delay Earth instantaneous setting with time delay
3	0	Phase instantaneous setting with time delay and short circuit setting with time delay No earth instantaneous setting
3	1	Phase instantaneous setting with time delay and short circuit setting with time delay Earth instantaneous setting without time delay
3	2	Phase instantaneous setting with time delay and short circuit setting with time delay Earth instantaneous setting with time delay
4	0	Different instantaneous setting for each CT rating No earth instantaneous setting
4	1	Different instantaneous setting for each CT rating Earth instantaneous setting without time delay
4	2	Different instantaneous setting for each CT rating Earth instantaneous setting with time delay

Stream 13: Instantaneous Setting Data

In the previous stream, if either of the flag is set or both the flags are set this stream is

applicable (if both the flags are 0 data need not be given in this stream). If the phase instantaneous and earth instantaneous setting flags are set the number of lines depends on the flags set.

The data appearing in different columns of each line are -

1. Minimum instantaneous setting
2. Maximum instantaneous setting
3. Type of variation.
4. Step value.

- The minimum and maximum setting correspond to the available setting at which the relay should operate instantaneously. The values are in multiples of the relay rated current. This is usually in the range of 2 to 30.

The first line corresponds to phase instantaneous setting data. The data in the subsequent lines depends on the flags.
If only phase or earth instantaneous setting is available the only one line correspond to that setting.

- The type of variation of instantaneous setting is identified by the entry in column 3.

◊ The character "D" in this column indicates the variation is in discrete steps. This character is followed by a blank character, number of discrete points and the discrete step values in multiples of relay rated current. The fields are all of float type separated by blanks.

◊ The character "C" in this column indicates the instantaneous setting is continuously variable value between two limits.

◊ The character "U" in this column indicates the instantaneous setting data varies continuously between two limits with a uniform step.

If time delay is present, the data appearing in different columns of next line are

1. Minimum time delay in seconds
2. Maximum time delay in seconds
3. Type of variation of time.
4. Step value.

- The minimum and maximum time delay corresponds to the available time setting.
- The type of variation of time setting is identified by the entry in column 3.

∗ The character "D" in this column indicates the variation is in discrete steps. This character is followed by a blank character, number of discrete points and the discrete step values in seconds. The fields are all of float type separated by blanks.

∗ The character "C" in this column indicates the time setting is continuously variable value

∗ between two limits.

∗ The character "U" in this column indicates that the time varies continuously between two limits with a uniform step. This character is followed by the uniform step value (in seconds).

If short circuit setting is available then the data for the short circuit setting is given similar to instantaneous setting data with time delay.
For each CT tap if instantaneous setting are available then the data for each CT tap is given similar to instantaneous setting data with time delay.

Example for different cases of phase instantaneous flag

Phase Flag	Col 1	Col 2	Col3	Description for Col 1	Description for Col 2	Description for Col 3
Case 0	0	0		No Ph Iinst	No Earth Inst	
Case 1	1	0		Phase Inst without time	No Earth Inst	
	4	20	C	Min Inst Factor	Max Inst Factor	Type of variation
Case 2	2	0		Phase Inst with time delay	No Earth Inst	
	4	20	C	Min Inst Factor	Max Inst Factor	
	0.01	0.2	C	Min Time in seconds	Max Time in sec	Type of variation
Case 3	3	0		Phase Inst, Short Circuit setting with time delay	No Earth Inst	
	4	20	C	Phase Inst Min factor	Phase Inst Max factor	Type of variation
	0.01	0.2	C	Phase min time in sec	Phase max time in sec	Type of variation
	2	10	C	Short Circuit Min set	Short Circuit Max set	Type of variation
	0.02	0.4	C	Short Circuit Min time	Short Circuit Max time	Type of variation
Case 4	4	0		Phase inst for each CT tap	No Earth Inst	
	5.5	6.75**	C	Phase Inst Min factor for CT Tap 1	Phase Inst Max factor for CT Tap 1	Type of variation
	0.025	0.025	C	Phase Inst Min time for CT Tap 1	Phase Inst Max time for CT Tap 1	Type of variation
	5.7	7**	C	Phase Inst Min factor for CT Tap 2	Phase Inst Max factor for CT Tap 1	Type of variation
	0.025	0.025	C	Phase Inst Min time for CT Tap 2	Phase Inst Max time for CT Tap 2	Type of variation

*: If two CT taps are available

Stream 14: Overload capacity data

This consists of one line of data of float field indicating the maximum overload capacity of the relay.

Fuse Data

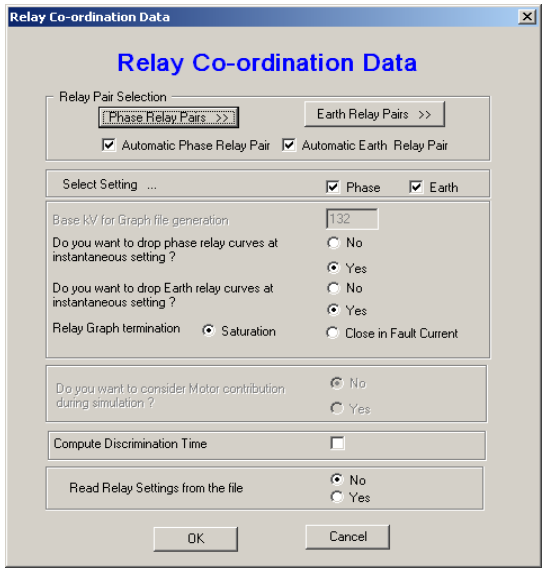
The fuse data streams differ from that of relay data i.e.,

- Stream 5 consists of one data of int field indicating the current rating of the fuse.
- Stream 6 consists of curve specification and number of points, and it is as explained for relay.
- Stream 7 consists of curve table as explained for relay.

File format for RCDPAIR.PHS and RCDPAIR.EAR

The relay pair is generated by the program and if the user desires it is written to the file RCDPAIR.PHS or RCDPAIR.EAR. If the file already exists the relay pairs can be directly read from the file for relay co-ordination.

If the user wants to co-ordinate for relay pairs of his choice the file RCDPAIR.PHS and RCDPAIR.EAR is to be modified accordingly. User can put comments as explained in **RCDIN**. The file format for RCDPAIR.PHS and RCDPAIR.EAR is as follows –



Stream 1: Number of Relay pairs

This consists of one line of data having an int field. This field corresponds to number of relay

pairs to be considered for relay co-ordination.

Stream 2: Relay pairs

This stream of data consists of relay pairs. Total number of lines of data in this stream is equal to number of relay pairs. Each line consists two columns of data, the primary and the backup relay array.

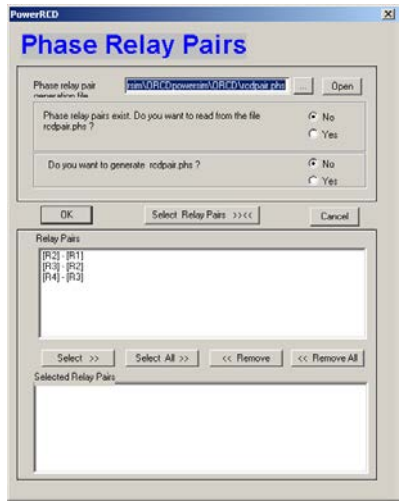
Interactive execution

When **POWERRCD** is invoked, following dialog box appears and the user is requested to provide some data during execution process -

The significance of each button and option is as follows -

Relay Pair Selection

POWERRCD program has 3 ways to select the primary backup relay pairs -



- Manual selection wherein user specifies the relay pairs in RCDPAIR.PHS and RCDPAIR.EAR files.
- Selection of primary backup relay pair from the automatically generated relay pairs
- Automatic generation of primary backup relay pairs.

The preferred steps to select the relay pairs are -

1. Automatic generation
2. Generate the relay pair files.
3. Manually edit the relay pair files to add/delete the relay pairs

Phase Relay Pair Selection

When the user clicks on this button the following dialog appears -

If the RCDPAIR.PHS file exists in the working directory, the following option is enabled.

Phase relay pairs exists do you want to read from the file rcdpair.phs?

The default option is NO. If relay pairs are to be used from the file, then option yes must be selected.

If the relay pairs are not to be read from the RCDPAIR.PHS file the relay pairs are generated by

the program. The generated relay pairs are displayed in the **Relay Pairs** list box. The relay pairs can be added to the S**elected relay pairs** by clicking on *Select* or *Select All.* Deselection of the selected pairs can be done by clicking *Remove* or *Remove All*

If the relay pairs considered for relay co-ordination is to be generated modify the below option.

Do you want to generate RCDPAIR.PHS?

The default option is NO. If RCDPAIR.PHS is to be generated select "yes", the phase relay pairs generated are written to the file. This is for phase relay pair generation.

On pressing OK the selections are updated and the previous screen appears. On cancel the selections are not updated.

Earth Relay Pair Selection

When this button is selected, the following dialog box appears

If the RCDPAIR.EAR file exists in the working directory, the following option is enabled

Earth relay pairs exists do you want to read from the file rcdpair.ear?

The default option is NO. If relay pairs are to be used from the file, then option "yes" must be selected.

If the relay pairs are not to be read from the RCDPAIR.EAR file the relay pairs are generated by the program. The generated relay pairs are displayed in the **Relay Pairs** list box. The relay pairs can be added to the **selected relay pairs** by clicking on *Select* or *Select All.* Clicking Remove or Remove All can do deselection of the selected pairs

If the relay pairs considered for relay co-ordination is to be generated, modify the below option -

Do you want to generate RCDPAIR.EAR ?

The default option is NO. If RCDPAIR.EAR is to be generated select "yes", the earth relay pairs generated is written to the file.

On pressing OK the selections are updated and the previous screen appears. On cancel the selections are not updated.

Select Settings

Selection of type of settings to be done,

By default both phase and earth relay co-ordination is done. If phase and earth relay co-ordination is to be done individually then appropriate option must be selected.

Base kV

For graph files generation **enter base kV for graph file generation:**

The voltage kV base on which the relay graphs should be generated must be specified.

Option for graph generation

The relay co-ordination curves drop at the instantaneous setting. The user may want to view the graph beyond the instantaneous setting, in that case modify the below option

Do you want to drop the phase relay curves at inst. setting ?

The default option is YES. If the curve is to be viewed beyond phase instantaneous setting select "no", the curves will not drop at the instantaneous setting.

The following option should be modified to set whether to drop earth relay curves at instantaneous setting

Do you want to drop the earth relay curves at inst. setting y/n ? (y) :

The default option is YES. If the curve is to be viewed beyond earth instantaneous setting select "n", the curves will not drop at the instantaneous setting.

4. Input format for Distance Relay Co-ordination

Input data to **POWERRCD** for distance relay co-ordination is through an ASCII file. The file name is "**RCDIN**". Results are written to files "**RCDOUT**" and "**RCDTOETC**". If **POWERRCD** is run in the integrated environment of MiP-PSCT, "**RCDIN**" file is automatically generated.

The system specification data is read as explained in the previous chapter (upto co-ordination type).

Stream 16: Number of Distance relays

This stream of data consists of one line of data having an int field. This field corresponds to number of distance relays in the system.

Stream 17: Simulation type

This stream of data consists of one line of data having an int field. The entry in this field is interpreted as-

The various simulation options provided are -

0-Zone1 zone2 zone3 settings by length : Short line for zone2 is selected on length of the line and setting is considered by length

1-Fault creation and impedance determination (zone2 zone3) : Impedance determination and fault simulation by considering length of the lines

2-Zone1 zone2 zone3 settings by impedance : short line for zone2 is considered on impedance of the line and settings calculated by the program on considering impedance of the lines

3-Fault creation and impedance determination(Zone2 Zone3): Impedance determination and fault simulation by considering impedance of the lines

4-Zone2 zone3 settings(User selected element): Zone2 zone3 settings by considering the lines selected by the user

5-Zone2 zone3 user given element and fault simulation: Zone2 zone3 settings and fault simulation by considering the user selected element.

Stream 18: Distance Relay data

In this stream of data, distance relay details are given. Total number of lines of data in this stream is equal to number of distance relays.

The data that appears in different columns of each line is given in table 4.1.

Table 4.1 - Distance Relay Data

Col no.	Description	Type	Min	Max
1.	Relay name	char	1	8
2.	Series element number	int	1	2000
3.	Line length	int	1	1000
4.	Relay location	char	1	1
5.	Current transformer primary rating	int	1	5000
6.	Current transformer secondary rating	int	1	10
7.	Potential transformer primary rating	int	0.0	10000.0
8.	Potential transformer secondary rating	int	1	5000
9.	Load impedance (real)	float	0	1000

Table 4.1 - Distance Relay Data (cont.)

10.	Load impedance (imaginary)	float	1	1000
11.	Zone1 reach	int	50	90

12.	Zone2 reach	int	10	50
13.	Zone3 reach	int	50	100
14.	Zone 4 reach	Int	50	100
15.	Zone2 time discrimination	float	0.05	10.0
16.	Zone3 time discrimination	float	0.05	10.0
17.	Zone 4 time discrimination	float	0.05	10.0
18.	Relay library number	Int	0	7

Explanations to entries given in table 4.1 are as follows -

- Relay name is a string of maximum 8 characters. Any alphanumeric characters can constitute the relay name. Relay name should be unique.
- The series element number indicates the element to which the distance relay is connected. This should always be a transmission line. Series element number corresponds to the number counted starting from the first line in the series element data. Transformers, transmission lines, series reactors, series capacitors, bus couplers and circuit breakers together are referred as series elements.
- Line length is the length of the line on which the distance relay is present.
- Relay location is interpreted as -
  - 1: Relay is located on from side of the series element.
  - 2: Relay is located on to side of the series element.

  The from side and to side is decided by the way in which data is given for the series elements which is as explained for overcurrent relay data.
- The entry in column 9 corresponds to the real part (in pu) of the minimum apparent load impedance. The minimum apparent load impedance is determined by conducting load flow study with maximum generation condition with different contingencies.
- The entry in column 10 corresponds to the imaginary part (in pu) of the minimum apparent load impedance.
- Zone1 reach corresponds to certain percentage of the primary line impedance for which the relay should operate instantaneously.(Primary line is that line for which the relay provides primary protection). In case of two terminal lines, zone1 reach for both phase to phase and phase to ground faults are done to cover a fraction (usually 80 percent to 85 percent) of the primary line. In case of multi-terminal lines, a fraction times (usually 80 percent) the minimum apparent impedance for the fault on one of the remote relaying bus is considered.
- Zone2 reach corresponds to certain percentage (usually 40 to 50 percent) of the impedance of shortest line in the adjacent section for which the relay provides backup protection.

- Zone3 reach corresponds to certain percentage of the impedance of longest line connected to the remote bus of the shortest adjacent section.
- Zone4 reach corresponds to certain percentage of the primary line impedance measured in reverse direction for which the relay should operate with certain time delay.
- Zone2 discrimination time corresponds to the co-ordination interval between zone1 and zone2 operating times.
- Zone3 discrimination time is the co-ordination interval between zone2 and zone3 operating time.
- Zone 4 discrimination time is the zone 4 operating time.
- Relay library number refers to the standard available relay library types. The zone settings in the output file are given in the format of the selected relay library. The following libraries are available.

  0 – RED 670
  1 – Micom P543
  2 – REL 521
  3 – REL 561
  4 – Micom P441
  5 – REL 511
  6 – 7SD5
  7 – RAZOA

Stream 19: Discrimination time

This stream of data consists of one line of data having a float field. Discrimination time in seconds is co-ordination interval between two distance relays.

If the entry in stream 17 is 1, the following data is read.

Stream 20: Number of faults to be simulated

This stream consists of one line of data having an int field. Total number of faults to be simulated is given in this field.

Stream 21: Simulation data

In this stream of data, simulation details are given. The number of lines of data is equal to total number of faults. The data that appears in different columns of each line is given in table 4.2.

Table 4.2 - Simulation data

Col no.	Description	Type	Min	Max

1 .	Element number	int	1	2000
2 .	Percent line	float	1.0	99.0
3 .	Fault type	int	1	4

Explanations to entries given in table 4.2 are as follows -

- Element number corresponds to the series/shunt element number on which the fault is to be simulated. If fault is to be created on a bus, the entry in this column is bus number.

- Percent line is distance in percentage from the sending end of the element where the fault is simulated. For a fault on bus the entry in this column should be zero.

- Fault type is interpreted as -
  1 : Three phase to ground fault.
  2 : Single line to ground fault at R phase.
  3 : Line to line fault between Y and B phases.
  4 : Double line (Y and B phases) to ground fault

  Distance Relay Library

5. INPUT/OUTPUT FILES

Table 5.1 gives names of different input and output files used by **POWERRCD** for overcurrent relay co-ordination.

Table 5.1 - Input and Output Files of POWERRCD

Sl. No.	File Name	Mode	Description
1.	"RCDIN"	input	Program input file
2.	"RCDOUT"	output	Program output (general report) file
3.	"RCDBASE"	input	Overcurrent relay database file consisting of relay characteristics
4.	"RCDPAIR.PHS" and "RCDPAIR.EAR"	input/output	File containing primary backup relay pairs
5	"Rcdph.bin" and "rcder.bin"	Output file	Binary files compatible to Migraph, for plotting phase and earth relay co-ordination curves

Table 5.2 gives names of different input and output files used by **POWERRCD** for distance relay co-ordination.

Table 5.2 - Input and Output Files of POWERRCD

Sl. No.	File Name	Mode	Description
1.	"RCDIN"	input	Program input file
2.	"RCDOUT"	output	Program output (general report) file
3.	"RCDPAIR.PHS" and "RCDPAIR.EAR"	input/output	File containing primary backup relay pairs

"RCDOUT" file for overcurrent relay co-ordination contains -

- Input data to the program, in the order the data is read.
- Relay database contents of the relays used in the system, if rdbflag option is 1.
- New order for the buses, if the report option is 4.
- Ybus element values for the system, if the report option is 4.
- Zbus element values if the report option is 4.
- Current transformer primary rating selected.
- Relay settings for phase faults.
- Instantaneous setting for phase faults.
- Relay settings for earth faults.
- Operating time of all the relays for a fault at user defined location if simulation option is greater than 1.

- Sequence of operation of the relays for a fault at user defined location if simulation option is 4 or 5.

"RCDOUT" file for distance relay co-ordination contains -

- Input data to the program, in the order the data is read.
- New order for the buses, if the report option is 4.
- Ybus element values for the system, if the report option is 4.
- Zbus element values if the report option is 4.
- Impedance setting of all the three zones. Time settings for zone 2 and zone 3.
- Impedance sensed by the relay for a fault at the user-defined location if the simulation option is 1.

Error Messages

If any error is traced by the program while execution, an error message is written to the report file and further execution of the program is terminated. The error messages, which are traced by the program, are printed in the following format -

Error Number Error Message Error Description

Error number is a number by which the error is identified. The nature of error is given in the error message. An error description specific to user/application is also given. The errors identified by the program are -

- [**Error no 0**] *Parameter passing error:* If there is an error in passing parameters to the program, then an error is reported. In the description, the missing parameter is named. {\bf[Error no 1] Input file opening error : If the input data file name specified by the user is not found or if an error occurs while the input file is opened, this message is generated. If there is more than one input file for the program then, the description specifies missing input file.
- [**Error no 2**] *Output file opening error:* If an error occurs while opening the output file, this message is generated.

- [**Error no 3**] *Too less parameters to read:* If the data provided is insufficient then, this error is displayed. The input data 'stream' for which data is insufficient is also described in the error message.

- [**Error no 4**] *Memory allocation error:* If memory is not allocated for a variable for which dynamic memory allocation is done, this error message is given. The variable for which memory allocation is not successfully done is mentioned in the error description.

- [**Error no 5**] *Invalid character:* If an invalid character data is present in the input data file then this message is generated. The data item for which invalid character is entered is also mentioned in the error message.
- [**Error no 6**] *Invalid number:* If an invalid integer data is present in the input data file then this message is displayed. The data item for which invalid integer data is given is also mentioned in the error message.
- [**Error no** 7] *Invalid value:* If the data given exceeds the limits mentioned for each item mentioned under different streams, an error message is given along with a description of the data item.
- [**Error no 8**] *Division by zero:* During a mathematical operation, if division by zero occurs, then this error is generated. The variable which may have caused this condition is mentioned in the error description.
- [**Error no 9**] *Diverging error:* This message is generated if no convergence is observed after a specified number of iterations.
- [**Error no 10**] *Error in data, Results not okay* : If an erroneous input data is present which doesn't come under any of the above mentioned categories as a result of which wrong results are obtained, then this message is generated.

These errors are displayed in the output file mentioned by the user. Some of the common error messages and their probable reasons for occurrence are -

For example, the command line arguments passed to the program are - **myin** as input file and **myout** as output (report) file. If input file **myin** is not found in the current working directory, or error while opening the file, message -

ERROR [1]: *Input file opening error - Input file not opened for reading*. is written to the report file. If the program expects data to be read from input file, but has not provided data and end of file is reached, then this error message.

ERROR [3]: *Too less parameters to read - Insufficient data provided for Stream* is written to the report file. If the from/to bus of a transformer specified by the user doesn't exist in the bus data stream, then an error message

ERROR [6]: *Invalid number - Invalid bus id specified* is written to the report file.

6. Case Study

In this section, three sample power systems are considered with most of the data and element types to explain the execution of **POWERRCD** and analysis of results. Different cases are studied with the help of the network. The single line diagram of the test system is shown in figure 6.1, 6.2 and 6.3. Listing of files "rcdin" are given in tables 6.1, 6.3 and 6.5, and listing of files "rcdout" are given in tables 6.2, 6.4 and 6.6 for the three sample systems and "rcdtoetc" in table 6.7 for case 3.

Case 1 : 6 Bus Radial System Overcurrent Relay co-ordination

The system considered is a six bus radial system. The one line diagram of the system considered is as shown in Fig 6.1. Listing of files "rcdin" and "rcdout" are given in tables 6.1 and 6.2 respectively.

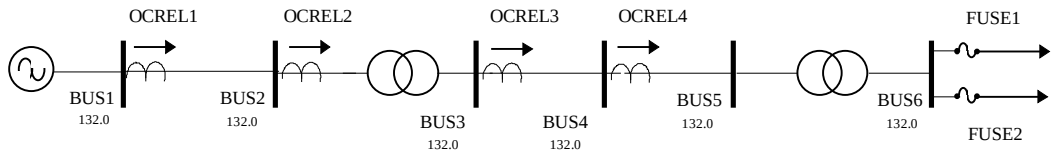


Figure 6.1 : Radial Distribution Sample System

Table 6.1 : "rcdin" file listing for Case 1.

```
CASE NO :  1     CONTINGENCY  : 0    SCHEDULE NO : 0
CONTINGENCY NAME : Base Case
VERSION 7
%% First Power System Network
%Release Notes
%Phase and Earth Intact flag
%Phase and Earth Instantaneous time delay setting
%Phase and Earth Instantaneous factor(remote or on the CT Rating
% COMMON SYSTEM SPECIFICATIONS

%  (1)Maximum Bus Id (2)       No of Buses    (3) No of 2WdgTr
%  (4)No of 3WdgTr   (5)       No of Lines    (6) No of SerReac
%  (7)No of SerCap   (8)       No of CBs      (9) No of ShReac
% (10)No of ShCap   (11)    No of Sh Imp  (12) No of Gen
% (13)No of Loads   (14)       No of Filters (15) No of HVDC
   6    6    2    0    3    0    0    0    0    0
0     1    0   1    0    0
% Number of Partial Bus Bar relays
0
% CONTROL INPUTS
```

```
% NoOfZones   PrintOpt  GraphOpt  BaseMVA NomFreq  PreFaultVoltOpt
  1     3     1    10.000   50.000     0
% FAULT IMPEDANCE
% FaultR  FaultX  GndFaultR  GndFaultX
0.000e+000  0.000e+000  0.000e+000  0.000e+000

% MULTIPLICATION FACTORS
% CB R   CB X   Trans R/X
0.000000e+000  1.000000e-004   0.050000
% TranZeroSeqZFactor   No of TLine levels
 0.90000   3

% LineVolt ZeroSeqZFact   ZeroSeqAFact
 132.0000      2.5000      0.8000
  11.0000      2.5000      0.0250
   3.3000      2.5000      0.0250
% Gen-veSeqRFact Gen-veSeqXFact  GenZerSeqRFact GenZerSeqXFact

 0.1750      0.1750      0.0375      0.0375

% Load-veSeqZFact              LoadZerSeqZFact    SerZerSeqZFact  ShZerSeqZFact
   0.8100      1.6000      1.0000      0.6250

% BUS DATA
% BusId  Status  Area No  Base Volt  BusName
% VMag   VAng    PGen     QGen            PLd     QLd  QComp

   1 1   1 132.000     Bus1
     1.000000000000e+000 0.000000000000e+000     0.00     0.00     0.00     0.00   0.00
   2 1   1 132.000     Bus2
     1.000000000000e+000 0.000000000000e+000     0.00     0.00     0.00     0.00   0.00
   3 1   1  11.000     Bus3
     1.000000000000e+000 0.000000000000e+000     0.00     0.00     0.00     0.00   0.00
   4 1   1  11.000     Bus4
     1.000000000000e+000 0.000000000000e+000     0.00     0.00     0.00     0.00   0.00
   5 1   1  11.000     Bus5
     1.000000000000e+000 0.000000000000e+000     0.00     0.00     0.00     0.00   0.00
   6 1   1   3.300     Bus6
     1.000000000000e+000 0.000000000000e+000     0.00     0.00     0.00     0.00   0.00

% 2 WDG TRANSFORMER DATA
% Status  Units   FromBus   ToBus    +veR     +veX  ZeroR  ZeroX
% NomTap  PhShift FromCBMVA ToCBMVA  FromWdg  ToWdg

3   1     2     3  7.500751e-006 7.500000e-002    6.750675e-006 6.750000e-002
    1.00000      0.0  50.00000  50.00000  G  G
3   1     5     6  1.750175e-005 1.750000e-001    1.574157e-005 1.574000e-001
    1.00000      0.0  50.00000  50.00000  G  G

% TRANSMISSION LINE DATA
% Status  Units   FromBus  ToBus  +veR  +veX  +ve B  ZeroR  ZeroX ZeroB
%         FromCBMVA ToCBMVA
```

3 1 1 2 0.000000e+000 3.600000e-003 0.000000e+000 0.000000e+000 1.080000e-002 0.000000e+000
100.000 100.000
3 1 3 4 0.000000e+000 1.980000e-002 0.000000e+000 0.000000e+000 4.950000e-002 0.000000e+000
50.000 50.000
3 1 4 5 0.000000e+000 3.300000e-003 0.000000e+000 0.000000e+000 8.250000e-003 0.000000e+000
50.000 50.000

% GENERATOR DATA
%FromBus +veR +veX -veR -veX ZeroR ZeroX CBMVA

1 0.000000e+000 2.900000e-003 0.000000e+000 2.900000e-003 0.000000e+000 2.900000e-003 100.000
3

% LOAD DATA
% FromBus

6 3

% GENERATOR DATA FOR MINIMUM GENERATION CONDITION
%FromBus +veR +veX -veR -veX ZeroR ZeroX CBMVA

1 0.000000e+000 2.900000e-003 0.000000e+000 2.900000e-003 0.000000e+000 2.900000e-003 100.000
3

% CO-ORDINATION TYPE (1-Overcurrent 0-Distance)

1

% NO of OVERCURRENT RELAYS

6
% SIMULATION TYPE
% 0 - Only co-ordination
% 1 - Co-ordination Checking
% 2 - Co-ordination and Simulation
% 3 - Simulation Checking
% 4 - Co-ordination and Simulation with Tripping
% 5 - Simulation and Trip Checking

% 6 - Co-ordination Checking (Existing Settings)

% 7 - Co-ordination, Simulation verification (Existing Settings)

% 8 - Co-ordination, Simulation and Trip verification (Existing Settings)

3

% OVERCURRENT RELAY DATA

% RelayName EleNo EleType RelayType RelayLoc ConnSense MaxLdCurrent
% CT Primary Ratings in amps (4 ratings)
% CT Secondary rating in amps
% Relay/Fuse Data Base Number

```
% Id <1000 - Relay
% Id > 1000 and < 2000 - Fuse
% Id > 2000 - CDV relays% PhaseTDS  EarthTDS   PlugSet( amps )  EarthPlugSet( amps )
% Intact flag  DiscriminationTime   PhaseInstSetFactor  EarthInstSetFactor

R1    3   0  D   1  A  450.000  500.000   500.000   500.000   500.000     1.000
          104    0.290     0.430   500.000   175.000
            0     0.400     1.300     1.300    1.000    0.100
 11  11 1 0 0 0.000000 0.000000 0 1 1
R2    1   0  D   1  A  150.000  150.000   150.000   150.000   150.000     1.000
          104    0.210     0.300   112.500    52.500
            0     0.400     1.300     1.300    1.000    0.100
 11  01 1 0 0 0.000000 0.000000 0 1 1
R3    4   0  D   1  A  450.000  500.000   500.000   500.000   500.000     1.000
          104    0.180     0.320   500.000    75.000
            0     0.400     1.300     1.300    1.000    0.100
 11  11 1 0 0 0.000000 0.000000 0 1 1
R4    5   0  D   1  A  250.000  250.000   250.000   250.000   250.000     1.000
          104    0.050     0.080   250.000    50.000
            0     0.400     1.300     1.300    1.000    0.100
 11  11 1 0 0 0.000000 0.000000 0 1 1
R5    2   1  D   1  A  250.000  200.000   200.000   200.000   200.000     1.000
         1001    0.210     0.000     2.500     2.500
            0     0.400     1.300     1.300    1.300    0.100
 00  00 1 0 0 0.000000 0.000000 0 1 1
R6    2   1  D   1  A  250.000  200.000   200.000   200.000   200.000     1.000
         1001    0.210     0.000     2.500     2.500
            0     0.400     1.300     1.300    1.300    0.100
 00  00 1 0 0 0.000000 0.000000 0 1 1

% CO-ORDINATION DETAILS
% InstSetFactor  TimeDisc  UnbalanceFact   OverloadFact
%                    for earth flt

  1.300     0.400      0.100     1.300
% NO OF FAULTS TO BE SIMULATED
  1
% SIMULATION DATA
  4  0.0     1
```

Table 6.2 : " rcdout " file listing for Case 1.

```
--------------------------------------------------------------------------------
            RESULTS OF IDMT  RELAY COORDINATION
               Contingency : BASE CASE
               Schedule    : SCHEDULE 0
--------------------------------------------------------------------------------
        OVER CURRENT RELAY CO-ORDINATION
CASE NO :  1     CONTINGENCY  : 0    SCHEDULE NO : 0
CONTINGENCY NAME : Base Case
--
```

```
VERSION NUMBER :  7.0
%% First Power System Network
LARGEST BUS NUMBER USED        :    6    ACTUAL NUMBER OF BUSES         :    6
NUMBER OF 2 WIND. TRANSFORMERS :    2    NUMBER OF 3 WIND. TRANSFORMERS :    0
NUMBER OF TRANSMISSION LINES   :    3
NUMBER OF SERIES REACTORS      :    0    NUMBER OF SERIES CAPACITORS    :    0
NUMBER OF BUS COUPLERS         :    0
NUMBER OF SHUNT REACTORS       :    0    NUMBER OF SHUNT CAPACITORS     :    0
NUMBER OF SHUNT IMPEDANCES     :    0    NUMBER OF GENERATORS           :    1
NUMBER OF MOTORS               :    0    NUMBER OF LOADS                :    1
NUMBER OF FILTERS              :    0
NUMBER OF HVDC CONVERTORS      :    0
NUMBER OF PARTIAL BUS BAR DIFFERENTIAL RELAYS :    0
--------------------------------------------------------------------------------
NUMBER OF ZONES                :    1
PRINT OPTION                   :    3 (BOTH DATA AND RESULTS PRINT)
GRAPH OPTION                   :    1 (GRAPH FILE FOR ALL THE RELAYS
                                     IS GENERATED)
BASE MVA                       :   10.000
NOMINAL SYSTEM FREQUENCY       :   50.000
PREFAULT VOLTAGE OPTION        :    0 (VOLTAGE OF 1.0 PU IS ASSUMED)
--------------------------------------------------------------------------------
FAULT RESISTANCE - PHASE       :   0.000000 (PU)
FAULT REACTANCE  - PHASE       :   0.000000 (PU)
FAULT RESISTANCE - GROUND      :   0.000000 (PU)
FAULT REACTANCE  - GROUND      :   0.000000 (PU)
--------------------------------------------------------------------------------
CIRCUIT BREAKER RESISTANCE (PU)                    : 0.000000e+000
CIRCUIT BREAKER REACTANCE  (PU)                    : 1.000000e-004
TRANSFORMER R/X RATIO                              :   0.050000
TRANSFORMER ZERO SEQUENCE IMPEDANCE MULT FACTOR    :   0.900000

NUMBER OF TRANSMISSION VOLTAGE LEVELS              :   3
TRANSMISSION LINE VOLTAGE - KV                     : 132.000000
TRANSMISSION LINE ZERO SEQUENCE IMP. MULT. FACTOR  :   2.500000
TRANSMISSION LINE ZERO SEQUENCE ADM. MULT. FACTOR  :   0.800000
TRANSMISSION LINE VOLTAGE - KV                     :  11.000000
TRANSMISSION LINE ZERO SEQUENCE IMP. MULT. FACTOR  :   2.500000
TRANSMISSION LINE ZERO SEQUENCE ADM. MULT. FACTOR  :   0.025000
TRANSMISSION LINE VOLTAGE - KV                     :   3.300000
TRANSMISSION LINE ZERO SEQUENCE IMP. MULT. FACTOR  :   2.500000
TRANSMISSION LINE ZERO SEQUENCE ADM. MULT. FACTOR  :   0.025000

GENERATOR NEGATIVE SEQUENCE RESISTANCE MULT. FACTOR  :   0.175000
GENERATOR NEGATIVE SEQUENCE REACTANCE  MULT. FACTOR  :   0.175000
GENERATOR ZERO SEQUENCE RESISTANCE MULT. FACTOR      :   0.037500
GENERATOR ZERO SEQUENCE REACTANCE MULT. FACTOR       :   0.037500
LOAD      NEGATIVE SEQUENCE IMPEDANCE  MULT. FACTOR  :   0.810000
LOAD      ZERO SEQUENCE IMPEDANCE  MULT. FACTOR      :   1.600000
SERIES REACTOR ZERO SEQUENCE IMPEDANCE MULT. FACTOR  :   1.000000
SHUNT  REACTOR ZERO SEQUENCE IMPEDANCE MULT. FACTOR  :   0.625000
```

BUS DATA

NODE	STAT	ZONE	BUS-KV	NAME	VMAG-PU	VANG-DEG	PGEN-MW	QGEN-MR
						PLOAD-MW	QLOAD-MR	QCOMP-MR
1	1	1	132.000	Bus1	1.0000	0.000	0.000	0.000
						0.000	0.000	0.000
2	1	1	132.000	Bus2	1.0000	0.000	0.000	0.000
						0.000	0.000	0.000
3	1	1	11.000	Bus3	1.0000	0.000	0.000	0.000
						0.000	0.000	0.000
4	1	1	11.000	Bus4	1.0000	0.000	0.000	0.000
						0.000	0.000	0.000
5	1	1	11.000	Bus5	1.0000	0.000	0.000	0.000
						0.000	0.000	0.000
6	1	1	3.300	Bus6	1.0000	0.000	0.000	0.000
						0.000	0.000	0.000

TRANSFORMER DATA

STAT	CKTS	FROM NODE	FROM NAME	TO NODE	TO NAME	POSITIVE R(P.U)	POSITIVE X(P.U.)	ZERO R(P.U.)	ZERO X(P.U.)
						TAP	PHASE	RATED MVA	PRI SEC
3	1	2	Bus2	3	Bus3	0.00001	0.07500	0.00001	0.06750
						1.00000	0.000	50.00	G G
3	1	5	Bus5	6	Bus6	0.00002	0.17500	0.00002	0.15740
						1.00000	0.000	50.00	G G

TRANSMISSION LINE DATA

STAT	CKTS	FROM NODE	FROM NAME	TO NODE	TO NAME	RP(P.U)	XP(P.U)	BP/2(PU)	THERMAL
						RZ(P.U)	XZ(P.U)	BZ/2(PU)	RATING
3	1	1	Bus1	2	Bus2	0.00000	0.00360	0.00000	
						0.00000	0.01080	0.00000	100.00
3	1	3	Bus3	4	Bus4	0.00000	0.01980	0.00000	
						0.00000	0.04950	0.00000	50.00
3	1	4	Bus4	5	Bus5	0.00000	0.00330	0.00000	
						0.00000	0.00825	0.00000	50.00

GENERATOR DATA

FROM NODE	FROM NAME	POSITIVE R(P.U)	POSITIVE X(P.U.)	NEGATIVE R(P.U.)	NEGATIVE X(P.U.)	ZERO R(P.U.)	ZERO X(P.U.)	MVA RATING	STAT
1	Bus1	0.00000	0.00290	0.00000	0.00290	0.00000	0.00290	100	3

LOAD DATA

NODE	NAME	STATUS

```
   6     Bus6      3
--------------------------------------------------------------------------------
GENERATOR DATA FOR MINIMUM GENERATION
FROM FROM           POSITIVE         NEGATIVE          ZERO          MVA
NODE NAME       R(P.U)  X(P.U.)  R(P.U.)  X(P.U.)  R(P.U.)  X(P.U.) RATING STAT
---- -------- -------- -------- -------- -------- -------- -------- ------ ----
   1     Bus1  0.00000  0.00290  0.00000  0.00290  0.00000  0.00290    100    3
--------------------------------------------------------------------------------
CO-ORDINATION TYPE                      :    1 (OVER CURRENT RELAY CO-ORDIN)
--------------------------------------------------------------------------------
NUMBER OF OVERCURRENT RELAYS            :    6
--------------------------------------------------------------------------------
SIMULATION STATUS                       :    3 (SIMULATION CHECKING WITH USER
DEFINED SETTINGS)
--------------------------------------------------------------------------------
  The entries in different columns of Overcurrent relay data
  are as follows -

RELAY NAME  : Name of the relay, the size should not exceed 8 characters.
EL-NO       : Series/Shunt element number on which the relay is located.
EL-TYP      : 0 if relay is on series element.
              1 if relay is on shunt element.
DR ST       : d/D for a directional relay.
              n/N for a nondirectional relay.
FOR/REV     : 1 if relay is located on from side of the series element.
              2 if relay is located on to side of the series element.
CON SEN     : a/A if it is looking away from the bus to which it is connected.
              t/T if it is looking towards the bus to which it is connected.
MAXI LOAD   : Maximum load current in amperes.
CTPR1       : Current transformer primary rating 1 in amperes.
CTPR2       : Current transformer primary rating 2 in amperes.
CTPR3       : Current transformer primary rating 3 in amperes.
CTPR4       : Current transformer primary rating 4 in amperes.
CTSEC       : Current transformer secondary rating in amperes.
RELAY DBASE : The relay type number (less than or equal to 1000 if
              it is relay, than 1000 and less than 2000 for fuse).
              greater than 2000 for a Voltage Controlled relay).
PHTD SET    : Phase fault time dial setting.
ERTD SET    : Earth fault time dial setting.
PHPS        : Phase fault plug setting in amperes.
ERPS        : Earth fault plug setting in amperes.
INT FLG

   0 : CT selection, plug setting and the time dial setting (TDS) are
       computed by the program.
  01 : User defined TDS is selected and the plug setting is computed by the
       program.
  10 : User defined plug setting is selected with CT primary 1, and the TDS
       is computed by the program.
  11 : User defined plug setting is selected with CT primary 1, and the TDS
       is given by the user.
```

```
  20 : User defined plug setting is selected with CT primary 2, and the TDS
       is computed by the program.
  21 : User defined plug setting is selected with CT primary 2, and the TDS
       is given by the user.
  30 : User defined plug setting is selected with CT primary 3, and the TDS
       is computed by the program.
  31 : User defined plug setting is selected with CT primary 3, and the TDS
       is given by the user.
  40 : User defined plug setting is selected with CT primary 4, and the TDS
       is computed by the program.
  41 : User defined plug setting is selected with CT primary 4, and the TDS
       is given by the user.

   2  : User defined Close in operating time, TDS
DISC TIME    : Discrimination time in seconds.
PH INS FCT    : Phase fault Instantaneous setting factor.

ER INS FCT    : Earth fault Instantaneous setting factor.
OVLD FACT     : Overload factor.
UNBL FACT     : Unbalance factor.
PHAS INTCT    : PHASE INTACT FLAG.
EARTH INTCT   : EARTH INTACT FLAG.
CT SEL        : SELECTED CT.
PH INS FLAG   : PHASE INSTANTANEOUS SETTING FLAG.
ER INS FLAG   : EARTH INSTANTANEOUS SETTING FLAG.
PH INST TIME  : SET PHASE INSTANTANEOUS TIME.
ER INST TIME  : SET EARTH INSTANTANEOUS TIME
--------------------------------------------------------------------------------
OVERCURRENT\SBEF RELAY DATA

               RELAY  EL ELM DIR  FOR/  CON  MAXIM  CTPR1  CTPR2  CTPR3  CTPR4
CTSEC   RELAY
                NAME  NUM TYP SEN REV   SEN   LOAD   AMPS   AMPS   AMPS   AMPS
AMPS   DBASE
                                        PHTD  ERTD   PHPS   ERPS  INTCT   DISC PH
INS  ER INS OVERLOAD UNBALANCE
                                        SET   SET                 FLAG   TIME    FCT
FCT    FACT     FACT
                                        PHAS  EARTH    CT  PH INS  ER INS  PH INST
ERTH INST
                                        INTCT  INTCT    SEL FLAG     FLAG    TIME
TIME
------------------- --- --- --- ---- ----- ------ ------ ------ ------ ------ -----
- ------- ------- --------
                  R1   3   0   D    1     A  450.0  500.0  500.0  500.0  500.0
1.000     104
                                       0.29   0.43  500.0  175.0      0  0.400
1.30    1.30    1.00    0.100
                                            11     11      1      0       0
0.00    0.000
0 1 1
```

```
                  R2   1   0   D    1     A  150.0  150.0  150.0  150.0  150.0
1.000     104
                                          0.21   0.30  112.5   52.5      0  0.400
1.30    1.30    1.00    0.100
                                              11      1      1      0       0
0.00    0.000
0 1 1
                  R3   4   0   D    1     A  450.0  500.0  500.0  500.0  500.0
1.000     104
                                          0.18   0.32  500.0   75.0      0  0.400
1.30    1.30    1.00    0.100
                                              11     11      1      0       0
0.00    0.000
0 1 1
                  R4   5   0   D    1     A  250.0  250.0  250.0  250.0  250.0
1.000     104
                                          0.05   0.08  250.0   50.0      0  0.400
1.30    1.30    1.00    0.100
                                              11     11      1      0       0
0.00    0.000
0 1 1
                  R5   2   1   D    1     A  250.0    ***    ***    ***    ***
***     1001
                                           ***    ***    ***    ***    ***    ***
1.30     0.10
                                                0      0      1      0       0
0.00    0.000
0 1 1
                  R6   2   1   D    1     A  250.0    ***    ***    ***    ***
***     1001
                                           ***    ***    ***    ***    ***    ***
1.30     0.10
                                                0      0      1      0       0
0.00    0.000
0 1 1
--------------------------------------------------------------------------------
------
STAND BY EARTH FAULT RELAY DATA

                RELAY  EL  ELM DIR  FOR/  CON  MAXIM  CTPR1  CTPR2  CTPR3  CTPR4
CTSEC   RELAY       STAGE 1      STAGE 2
                 NAME  NUM TYP SEN  REV   SEN   LOAD
DBASE   CURRENT TIME  CURRENT TIME
                                                (A)    (A)    (A)    (A)    (A)    (A)
(A)    (s)     (A)    (s)
------------------- --- --- --- ---- ----- ------ ------ ------ ------ ------ ---
NUMBER OF FAULTS SIMULATED              :    1
--------------------------------------------------------------------------------
BUS NUMBER FAULTTYPE
---------- ---------
         4         1 (3 PHASE TO GROUND FAULT)
--
```

```
Number of phase relays 6 Number of earth relays 6
--------------------------------------------------------------------------------
               RELAY ELMT ELEMNT FROM     FROM TO         TO    RELAY PHASE EARTH
                NAME NMBR   TYPE BUS      NAME BUS      NAME LOCATION
------------------- ---- ------ ---- -------- ---- -------- -------- ----- -----
                  R1    3 Series    1     Bus1    2     Bus2     Bus1   YES   YES
                  R2    1 Series    2     Bus2    3     Bus3     Bus2   YES   YES
                  R3    4 Series    3     Bus3    4     Bus4     Bus3   YES   YES
                  R4    5 Series    4     Bus4    5     Bus5     Bus4   YES   YES
                  R5    2  Shunt    6     Bus6                   Bus6   YES   YES
                  R6    2  Shunt    6     Bus6                   Bus6   YES   YES
--------------------------------------------------------------------------------
************************************************
Thermal Curves will not be generated
Check and rerun to obtain Thermal Curves
************************************************
--------------------------------------------------------------------------------
User Given Discrimination Time
Phase Relay Co-ordination Checking
--------------------------------------------------------------------------------
             Primary               Backup Pri. Current Pri Psm Pri Tds  Pri time
BackCurrnt Back Psm Back Tds Backtime Disc time  Remarks
------------------- ------------------- ------------ ------- -------- -------- ---
------- -------- -------- -------- --------- --------
                  R2                    R1    6729.0241 112.500    0.2100    0.4842
6729.0241 500.000   0.2900   0.7706    0.2864 << NA
                  R3                    R2    6440.0476 500.000    0.1800    0.4865
536.6706 112.500   0.2100   0.9284    0.4419 >> OK
                  R4                    R3    5181.2821 250.000    0.0500    0.1153
5181.2821 500.000   0.1800   0.5318    0.4165 >> OK
                  R5                    R4    6257.3185 200.000    1.0000  No Opert.
1877.1956 250.000   0.0500   0.1713    0.1713 >> OK!!
                  R6                    R4    6257.3185 200.000    1.0000  No Opert.
1877.1956 250.000   0.0500   0.1713    0.1713 >> OK!!
--------------------------------------------------------------------------------
User Given Discrimination Time
Earth Relay Co-ordination Checking
--------------------------------------------------------------------------------
             Primary               Backup Pri. Current Pri Psm Pri Tds  Pri time
BackCurrnt Back Psm Back Tds Backtime Disc time  Remarks
------------------- ------------------- ------------ ------- -------- --------
R2                   R1    4914.4558  52.500    0.3000    0.6918  4914.4558 175.000
0.4300   0.9915    0.2998 << NA
                  R3                    R2    6447.9592  75.000    0.3200    0.7379
537.3299  52.500   0.3000   0.8910    0.1531 << NA
                  R4                    R3    4724.2473  50.000    0.0800    0.1845
4724.2473  75.000   0.3200   0.7379    0.5534 >> OK
                  R5                    R4    6134.8125 200.000    1.0000  No Opert.
1840.4437  50.000   0.0800   0.1845    0.1845 >> OK!!
                  R6                    R4    6134.8125 200.000    1.0000  No Opert.
1840.4437  50.000   0.0800   0.1845    0.1845 >> OK!!
--
```

RELAY SETTINGS FOR PHASE FAULTS

RELAY NAME	CLOSE IN FAULT CURRENT (Amps)	PLUG SETTING RATIO (Amps)		RELAY CAPACITY	REMARKS
R1	15082.2954	500.0000	30.165	100.00	Within Limit
R2	6729.0241	112.5000	59.814	100.00	Within Limit
R3	6440.0476	500.0000	12.880	100.00	Within Limit
R4	5181.2821	250.0000	20.725	100.00	Within Limit
R5	6257.3185	200.0000	31.287	0.00	Exceeds Limit
R6	6257.3185	200.0000	31.287	0.00	Exceeds Limit

SL. NO.	RELAY NAME	From Bus FAULT	To Bus REMOTE	CT PRIM OP.TIME	CT SEC CHOSEN RELAY	PLUG SETTING (%)	PLUG SETTING (PRIM) (A)	PLUG INSTANT SETTING NAME (SEC) (A)	RELAY T.D.S CLOSE IN FAULT CURRENT (Amps)	OP. TIME FOR CLOSE FAULT CURRENT (Secs)	DB CURVE NAME BUS FAULT CURRENT (Amps)	REMOTE (Secs)
1	R1	1	2	500	1	100.00	500.00	1.00	0.29	15082.30	0.6687	6729.02
2	R2	2	3	150	1	75.00	112.50	0.75	0.21	6729.02	0.4842	536.67
3	R3	3	4	500	1	100.00	500.00	1.00	0.18	6440.05	0.4865	5181.28
4	R4	4	5	250	1	100.00	250.00	1.00	0.05	5181.28	0.1153	1877.20
5	R5	6	0	****	****	****	6257.32	-1.#INF	DOES NOT BACK-UP	****	*****	Fs1
6	R6	6	0	****	****	****	6257.32	-1.#INF	DOES NOT BACK-UP	****	*****	Fs1

0.1713 R6 ***** CDG-11P(3) 3S-RELAY

0.1713 R5 CDG-11P(3) 3S-RELAY

0.1713 R4 CDG-11P(3) 3S-RELAY

0.1713 R3 CDG-11P(3) 3S-RELAY

0.1713 R2 CDG-11P(3) 3S-RELAY

0.1713 R1 CDG-11P(3) 3S-RELAY

PHASE RELAY SETTINGS

RELAY NAME	PLUG SETTING (PRIM) (A)	PLUG SETTING (SEC) (A)	TIME MULTIPLIER SETTING	INST. SETTING (A)
R1	500.000		0.290	******
R2	112.500		0.210	******
R3	500.000		0.180	******
R4	250.000		0.050	******
R5	200.000		1.000	******

```
                R6      200.000                  1.000        ******
--------------------------------------------------------------------------------
NOTE : For motor relays, TDS refers to time in seconds. If the manufacturer
 specification is say t seconds at 'X' times Ith, then TDS refer to t seconds
--------------------------------------------------------------------------------
RELAY SETTINGS FOR EARTH FAULTS
--------------------------------------------------------------------------------
               RELAY  CLOSE IN FAULT  PLUG SETTING RATIO    RELAY    REMARKS
                NAME   CURRENT (Amps)  (Amps)              CAPACITY
------------------- ---------------  ------------ -------- -------- -------------
                R1      15082.2954     175.0000   86.185   100.00 Within Limit
                R2       4914.4558      52.5000   93.609   100.00 Within Limit
                R3       6447.9592      75.0000   85.973   100.00 Within Limit
                R4       4724.2473      50.0000   94.485   100.00 Within Limit
                R5       6134.8125     200.0000   30.674     0.00 Exceeds Limit
                R6       6134.8125     200.0000   30.674     0.00 Exceeds Limit
--------------------------------------------------------------------------------
SL.             RELAY  From Bus  To Bus   CT PRIM CT SEC  PLUG    PLUG    PLUG
T.D.S CLOSE IN  OP. TIME      REMOTE   OP.TIME              PRIMARY  INSTANT  RELAY
DB CURVE NAME
NO.             NAME                         CHOSEN         SETTING SETTING SETTING
FAULT  FOR CLOSE  BUS FAULT    REMOTE                 RELAY  SETTING  NAME
                                                      (Amps)         (%)    (PRIM)  (SEC)
CURRENT IN FAULT     CURRENT BUS FAULT                                          (A)     (A)
(Amps)    Secs)     (Amps)    (Secs)                          (%)
--- ------------------- --------- --------- ------- ------ ------- ------- ------
  1                   R1         1         2     500       1  35.00  175.00    0.35
0.43  15082.30    0.9915    4914.46    0.9915                   R2    ***** CDG-
11P(3) 3S-RELAY
  2                   R2         2         3     150       1  35.00   52.50    0.35
0.30   4914.46    0.6918     537.33    0.8910                   R3    ***** CDG-
11P(3) 3S-RELAY
  3                   R3         3         4     500       1  15.00   75.00    0.15
0.32   6447.96    0.7379    4724.25    0.7379                   R4    ***** CDG-
11P(3) 3S-RELAY
  4                   R4         4         5     250       1  20.00   50.00    0.20
0.08   4724.25    0.1845    1840.44    0.1845                   R5

1840.44    0.1845                   R6    ***** CDG-11P(3) 3S-RELAY
  5                   R5        6      0 ****    ****  ****   6134.81   -1.#INF
DOES NOT BACK-UP                 ****        *****      Fs1     User   Points
  6                   R6        6      0 ****    ****  ****   6134.81   -1.#INF
DOES NOT BACK-UP                 ****        *****      Fs1     User   Points
--------------------------------------------------------------------------------
EARTH RELAY SETTINGS
--------------------------------------------------------------------------------
RELAY NAME           PLUG SETTING PLUG SETTING TIME MULTIPLIER SETTING INST. SETTING
                        (PRIM)       (SEC)                                  (A)
                        (A)           (A)
------------------- ------------ ------------ ---------------------- -----------
```

```
                  R1      175.000                  0.430        ******
                  R2       52.500                  0.300        ******
                  R3       75.000                  0.320        ******
                  R4       50.000                  0.080        ******
                  R5      200.000                  1.000        ******
                  R6      200.000                  1.000        ******
-------------------------------------------------------------------------------
               RELAY PH INSTANT OPER TIME SHORT CIRCUIT OPER TIME ER INSTANT OPER
TIME
                NAME    SETTING              SETTING                 SETTING
                         (Amps)    (Secs)    (Amps)        (Secs)     (Amps)
(Secs)
------------------- ---------- --------- ------------ --------- ---------- -----
                  R1    No Inst      ****         No SC      ****  No Er Inst
****
                  R2    No Inst      ****         No SC      ****  No Er Inst
****
                  R3    No Inst      ****         No SC      ****  No Er Inst
****
                  R4    No Inst      ****         No SC      ****  No Er Inst
****
                  R5    No Inst      ****         No SC      ****  No Er Inst
****
                  R6    No Inst      ****         No SC      ****  No Er Inst
****
-------------------------------------------------------------------------------
 3 Phase to ground fault is created at bus Bus4 (4).
-------------------------------------------------------------------------------
               RELAY PH A FAULT OPERT TIME FOR ZER SEQ FAULT  OPERATING TIME
                NAME  CURRENT      PH A CURRENT CURRENT (3*I0) FOR ZS FALTCUR
                     (Amps)        (Secs)          (Amps)        (Secs)
------------------- ---------- -------------- -------------- --------------
                  R1     431.77      No pickup           0.00      No pickup
                  R2     431.77    1.0786                0.00      No pickup
                  R3    5181.28    0.5318                0.00      No pickup
-------------------------------------------------------------------------------
Date and Time : Wed Apr 23 10:28:23 2014
```

Case 2 : 6 Bus Ring System Overcurrent Relay co-ordination

The system considered is a six bus ring main distribution system. The one line diagram of the system considered is as shown in Fig 6.2. Listing of files "rcdin" and "rcdout" are given in tables 6.3 and 6.4 respectively.

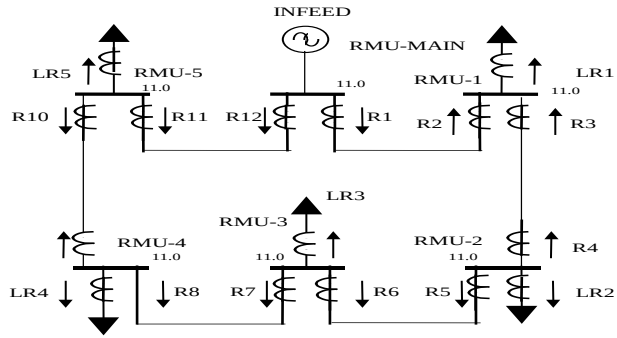


Figure 6.2 : Ring Main Distribution Sample System

Table 6.3 : "rcdin" file listing for Case 2.

```
CASE NO :  1     CONTINGENCY  : 0    SCHEDULE NO : 0
CONTINGENCY NAME : Base Case
VERSION 7
%% First Power System Network
%Release Notes
%Phase and Earth Intact flag
%Phase and Earth Instantaneous time delay setting
%Phase and Earth Instantaneous factor(remote or on the CT Rating
% COMMON SYSTEM SPECIFICATIONS
%  (1)Maximum Bus Id (2)      No of Buses    (3) No of 2WdgTr
%  (4)No of 3WdgTr   (5)      No of Lines    (6) No of SerReac
%  (7)No of SerCap   (8)      No of CBs      (9) No of ShReac
% (10)No of ShCap   (11)    No of Sh Imp  (12) No of Gen
% (13)No of Loads   (14)      No of Filters (15) No of HVDC
   6     6     0     0     6     0     0     0     0     0
0      1     0    5     0     0
% Number of Partial Bus Bar relays
0
% CONTROL INPUTS
% NoOfZones   PrintOpt  GraphOpt  BaseMVA NomFreq  PreFaultVoltOpt
   1     3     1    10.000   50.000     0
% FAULT IMPEDANCE
% FaultR  FaultX  GndFaultR  GndFaultX
0.000e+000  0.000e+000  0.000e+000  0.000e+000
% MULTIPLICATION FACTORS
% CB R   CB X   Trans R/X
0.000000e+000  1.000000e-004   0.050000
% TranZeroSeqZFactor   No of TLine levels
 0.90000   1
```

```
% LineVolt ZeroSeqZFact   ZeroSeqAFact
  11.0000      2.5000      0.0250
% Gen-veSeqRFact Gen-veSeqXFact  GenZerSeqRFact GenZerSeqXFact
   0.1750      0.1750      0.0375      0.0375
% Load-veSeqZFact      LoadZerSeqZFact         SerZerSeqZFact  ShZerSeqZFact
   0.8100      1.6000      1.0000      0.6250
% BUS DATA
% BusId  Status  Area No  Base Volt  BusName
% VMag   VAng    PGen     QGen          PLd     QLd  QComp
   1 1   1  11.000  RMUMAIN
      1.000000000000e+000 0.000000000000e+000     0.00     0.00     0.00     0.00
0.00
   2 1   1  11.000    RMU-1
      1.000000000000e+000 0.000000000000e+000     0.00     0.00     0.00     0.00
0.00
   3 1   1  11.000    RMU-2
      1.000000000000e+000 0.000000000000e+000     0.00     0.00     0.00     0.00
0.00
   4 1   1  11.000    RMU-3
      1.000000000000e+000 0.000000000000e+000     0.00     0.00     0.00     0.00
0.00
   5 1   1  11.000    RMU-4
      1.000000000000e+000 0.000000000000e+000     0.00     0.00     0.00     0.00
0.00
   6 1   1  11.000    RMU-5
      1.000000000000e+000 0.000000000000e+000     0.00     0.00     0.00     0.00
0.00
% 2 WDG TRANSFORMER DATA
% Status  Units   FromBus   ToBus    +veR     +veX  ZeroR  ZeroX
% NomTap  PhShift FromCBMVA ToCBMVA  FromWdg  ToWdg
% TRANSMISSION LINE DATA
% Status  Units   FromBus  ToBus  +veR  +veX  +ve B  ZeroR  ZeroX ZeroB
%         FromCBMVA ToCBMVA
3  1     1    2 3.579000e-002 6.450000e-003 0.000000e+000  8.947500e-002 1.612500e-
002 0.000000e+000   10.000   10.000
3  1     2    3 7.157000e-002 1.289000e-002 0.000000e+000  1.789250e-001 3.222500e-
002 0.000000e+000   10.000   10.000
3  1     3    4 5.368000e-002 9.670000e-003 0.000000e+000  1.342000e-001 2.417500e-
002 0.000000e+000   10.000   10.000
3  1     4    5 3.579000e-002 6.450000e-003 0.000000e+000  8.947500e-002 1.612500e-
002 0.000000e+000   10.000   10.000
3  1     5    6 5.368000e-002 9.670000e-003 0.000000e+000  1.342000e-001 2.417500e-
002 0.000000e+000   10.000   10.000
3  1     6    1 3.579000e-002 6.450000e-003 0.000000e+000  8.947500e-002 1.612500e-
002 0.000000e+000   10.000   10.000


% GENERATOR DATA
%FromBus +veR  +veX  -veR  -veX  ZeroR  ZeroX  CBMVA

   1 0.000000e+000  2.000000e-002  0.000000e+000  2.000000e-002 0.000000e+000
```

```
2.000000e-002  100.000    3
% LOAD DATA
% FromBus

   6     3
   5     3
   4     3
   3     3
   2     3
% GENERATOR DATA FOR MINIMUM GENERATION CONDITION
%FromBus +veR  +veX  -veR  -veX  ZeroR  ZeroX  CBMVA
   1 0.000000e+000  2.000000e-002  0.000000e+000  2.000000e-002 0.000000e+000
2.000000e-002  100.000    3
% CO-ORDINATION TYPE (1-Overcurrent  0-Distance)
1
% NO of OVERCURRENT RELAYS
17
% SIMULATION TYPE
% 0 - Only co-ordination
% 1 - Co-ordination Checking
% 2 - Co-ordination and Simulation
% 3 - Simulation Checking
% 4 - Co-ordination and Simulation with Tripping
% 5 - Simulation and Trip Checking
% 6 - Co-ordination Checking (Existing Settings)
% 7 - Co-ordination, Simulation verification (Existing Settings)
% 8 - Co-ordination, Simulation and Trip verification (Existing Settings)
 4
% OVERCURRENT RELAY DATA
% RelayName  EleNo  EleType  RelayType RelayLoc  ConnSense MaxLdCurrent
% CT Primary Ratings in amps (4 ratings)
% CT Secondary rating in amps
% Relay/Fuse Data Base Number
% Id <1000 - Relay
% Id > 1000 and < 2000 - Fuse
% Id > 2000 - CDV relays% PhaseTDS  EarthTDS   PlugSet( amps )  EarthPlugSet( amps )
% Intact flag  DiscriminationTime   PhaseInstSetFactor  EarthInstSetFactor

R1     1   0  N   1  A  200.000  200.000   400.000   600.000  1200.000     5.000
               1    0.180     0.300   300.000   100.000
               0     0.400     1.300     1.300    1.000    0.200
  11  11 1 0 0 0.000000 0.000000 0 1 1
R2     1   0  D   2  A  200.000  300.000   300.000   300.000   300.000     5.000
               1    0.050     0.300   300.000    30.000
               0     0.400     1.300     1.300    1.000    0.200
  01  11 1 0 0 0.000000 0.000000 0 1 1
R3     2   0  D   1  A  200.000  300.000   300.000   300.000   300.000     5.000
               1    0.640     0.790   300.000    90.000
               0     0.400     1.300     1.300    1.000    0.200
  01  11 1 0 0 0.000000 0.000000 0 1 1
R4     2   0  D   2  A  200.000  300.000   300.000   300.000   300.000     5.000
```

```
                1    0.170     0.270   300.000    90.000
                0     0.400     1.300     1.300    1.000    0.200
  01  11 1 0 0 0.000000 0.000000 0 1 1
R5     3   0  D   1  A  200.000  300.000   300.000   300.000   300.000     5.000
                1    0.460     0.690   300.000    45.000
                0     0.400     1.300     1.300    1.000    0.200
  01  11 1 0 0 0.000000 0.000000 0 1 1
R6     3   0  D   2  A  200.000  300.000   300.000   300.000   300.000     5.000
                1    0.320     0.500   300.000    30.000
                0     0.400     1.300     1.300    1.000    0.200
  01  11 1 0 0 0.000000 0.000000 0 1 1
R7     4   0  D   1  A  200.000  300.000   300.000   300.000   300.000     5.000
                1    0.300     0.500   300.000    30.000
                0     0.400     1.300     1.300    1.000    0.200
  01  11 1 0 0 0.000000 0.000000 0 1 1
R8     4   0  D   2  A  200.000  300.000   300.000   300.000   300.000     5.000
                1    0.490     0.700   300.000    45.000
                0     0.400     1.300     1.300    1.000    0.200
  01  11 1 0 0 0.000000 0.000000 0 1 1
R9     5   0  D   1  A  200.000  300.000   300.000   300.000   300.000     5.000
                1    0.170     0.270   300.000    30.000
                0     0.400     1.300     1.300    1.000    0.200
  01  11 1 0 0 0.000000 0.000000 0 1 1
R10    5   0  D   2  A  200.000  300.000   300.000   300.000   300.000     5.000
                1    0.680     0.800   300.000    90.000
                0     0.400     1.300     1.300    1.000    0.200
  01  11 1 0 0 0.000000 0.000000 0 1 1
R11    6   0  D   1  A  200.000  300.000   300.000   300.000   300.000     5.000
                1    0.050     0.300   300.000    30.000
                0     0.400     1.300     1.300    1.000    0.200
  01  10 1 0 0 0.000000 0.000000 0 1 1
R12    6   0  N   2  A  200.000  300.000   400.000   600.000  1200.000     5.000
                1    0.690     0.790   300.000   300.000
                0     0.400     1.300     1.300    1.000    0.200
  01  11 4 0 0 0.000000 0.000000 0 1 1
LR13    2   1  D   1  A  200.000  300.000   300.000   300.000   300.000     5.000
                1    0.050     0.300   300.000   105.000
                0     0.400     1.300     1.300    1.000    0.200
  01  10 1 0 0 0.000000 0.000000 0 1 1
LR14    3   1  D   1  A  200.000  300.000   300.000   300.000   300.000     5.000
                1    0.050     0.300   300.000    60.000
                0     0.400     1.300     1.300    1.000    0.200
  01  10 1 0 0 0.000000 0.000000 0 1 1
LR15    4   1  D   1  A  200.000  300.000   300.000   300.000   300.000     5.000
                1    0.050     0.300   300.000    60.000
                0     0.400     1.300     1.300    1.000    0.200
  01  10 1 0 0 0.000000 0.000000 0 1 1
LR16    5   1  D   1  A  200.000  300.000   300.000   300.000   300.000     5.000
                1    0.050     0.300   300.000    60.000
                0     0.400     1.300     1.300    1.000    0.200
  01  10 1 0 0 0.000000 0.000000 0 1 1
```

```
LR17     6   1  D   1  A  200.000  300.000   300.000   300.000   300.000     5.000
               1    0.050     0.300   300.000   105.000
               0     0.400     1.300     1.300    1.000    0.200
  01  10 1 0 0 0.000000 0.000000 0 1 1
% CO-ORDINATION DETAILS
% InstSetFactor  TimeDisc  UnbalanceFact   OverloadFact
%                          for earth flt
   1.300     0.400      0.100     1.300
% NO OF FAULTS TO BE SIMULATED
   1
% SIMULATION DATA
   1    20.000      1
```

Table 6.4 :" rcdout " file listing for Case 2.

```
        OVER CURRENT RELAY CO-ORDINATION
CASE NO :  1     CONTINGENCY  : 0    SCHEDULE NO : 0
CONTINGENCY NAME : Base Case

VERSION NUMBER :  7.0
%% First Power System Network
LARGEST BUS NUMBER USED        :    6    ACTUAL NUMBER OF BUSES         :    6
NUMBER OF 2 WIND. TRANSFORMERS :    0    NUMBER OF 3 WIND. TRANSFORMERS :    0
NUMBER OF TRANSMISSION LINES   :    6
NUMBER OF SERIES REACTORS      :    0    NUMBER OF SERIES CAPACITORS    :    0
NUMBER OF BUS COUPLERS         :    0
NUMBER OF SHUNT REACTORS       :    0    NUMBER OF SHUNT CAPACITORS     :    0
NUMBER OF SHUNT IMPEDANCES     :    0    NUMBER OF GENERATORS           :    1
NUMBER OF MOTORS               :    0    NUMBER OF LOADS                :    5
NUMBER OF FILTERS              :    0
NUMBER OF HVDC CONVERTORS      :    0
NUMBER OF PARTIAL BUS BAR DIFFERENTIAL RELAYS :    0

NUMBER OF ZONES                :    1
PRINT OPTION                   :    3 (BOTH DATA AND RESULTS PRINT)
GRAPH OPTION                   :    1 (GRAPH FILE FOR ALL THE RELAYS
                                     IS GENERATED)
BASE MVA                       :   10.000
NOMINAL SYSTEM FREQUENCY       :   50.000
PREFAULT VOLTAGE OPTION        :    0 (VOLTAGE OF 1.0 PU IS ASSUMED)
FAULT RESISTANCE - PHASE       :   0.000000 (PU)
FAULT REACTANCE  - PHASE       :   0.000000 (PU)
FAULT RESISTANCE - GROUND      :   0.000000 (PU)
FAULT REACTANCE  - GROUND      :   0.000000 (PU)
CIRCUIT BREAKER RESISTANCE (PU)                    : 0.000000e+000
CIRCUIT BREAKER REACTANCE  (PU)                    : 1.000000e-004
TRANSFORMER R/X RATIO                              :   0.050000
```

```
TRANSFORMER ZERO SEQUENCE IMPEDANCE MULT FACTOR      :   0.900000

NUMBER OF TRANSMISSION VOLTAGE LEVELS                :   1
TRANSMISSION LINE VOLTAGE - KV                       :  11.000000
TRANSMISSION LINE ZERO SEQUENCE IMP. MULT. FACTOR    :   2.500000
TRANSMISSION LINE ZERO SEQUENCE ADM. MULT. FACTOR    :   0.025000
GENERATOR NEGATIVE SEQUENCE RESISTANCE MULT. FACTOR  :   0.175000
GENERATOR NEGATIVE SEQUENCE REACTANCE  MULT. FACTOR  :   0.175000
GENERATOR ZERO SEQUENCE RESISTANCE MULT. FACTOR      :   0.037500
GENERATOR ZERO SEQUENCE REACTANCE MULT. FACTOR       :   0.037500
LOAD      NEGATIVE SEQUENCE IMPEDANCE  MULT. FACTOR  :   0.810000
LOAD      ZERO SEQUENCE IMPEDANCE  MULT. FACTOR      :   1.600000
SERIES REACTOR ZERO SEQUENCE IMPEDANCE MULT. FACTOR  :   1.000000
SHUNT  REACTOR ZERO SEQUENCE IMPEDANCE MULT. FACTOR  :   0.625000
--------------------------------------------------------------------------------
BUS DATA
NODE STAT ZONE BUS-KV   NAME     VMAG-PU  VANG-DEG  PGEN-MW  QGEN-MR
                                           PLOAD-MW QLOAD-MR QCOMP-MR
---- ---- ---- -------- -------- -------- -------- -------- --------
   1    1    1   11.000  RMUMAIN   1.0000    0.000    0.000    0.000
                                              0.000    0.000    0.000
   2    1    1   11.000    RMU-1   1.0000    0.000    0.000    0.000
                                              0.000    0.000    0.000
   3    1    1   11.000    RMU-2   1.0000    0.000    0.000    0.000
                                              0.000    0.000    0.000
   4    1    1   11.000    RMU-3   1.0000    0.000    0.000    0.000
                                              0.000    0.000    0.000
   5    1    1   11.000    RMU-4   1.0000    0.000    0.000    0.000
                                              0.000    0.000    0.000
   6    1    1   11.000    RMU-5   1.0000    0.000    0.000    0.000
                                              0.000    0.000    0.000
--------------------------------------------------------------------------------
TRANSMISSION LINE DATA
STAT CKTS FROM FROM       TO TO
          NODE NAME     NODE NAME      RP(P.U)  XP(P.U) BP/2(PU) THERMAL
                                       RZ(P.U)  XZ(P.U) BZ/2(PU) RATING
---- ---- ---- -------- ---- -------- -------- -------- -------- -------
   3    1    1  RMUMAIN    2    RMU-1  0.03579  0.00645  0.00000
                                       0.08947  0.01613  0.00000   10.00
   3    1    2    RMU-1    3    RMU-2  0.07157  0.01289  0.00000
                                       0.17893  0.03222  0.00000   10.00
   3    1    3    RMU-2    4    RMU-3  0.05368  0.00967  0.00000
                                       0.13420  0.02417  0.00000   10.00
   3    1    4    RMU-3    5    RMU-4  0.03579  0.00645  0.00000
                                       0.08947  0.01613  0.00000   10.00
   3    1    5    RMU-4    6    RMU-5  0.05368  0.00967  0.00000
                                       0.13420  0.02417  0.00000   10.00
   3    1    6    RMU-5    1  RMUMAIN  0.03579  0.00645  0.00000
                                       0.08947  0.01613  0.00000   10.00
```

```
--------------------------------------------------------------------------------
GENERATOR DATA

FROM FROM           POSITIVE          NEGATIVE           ZERO          MVA
NODE NAME       R(P.U)  X(P.U.)  R(P.U.)  X(P.U.)  R(P.U.)  X(P.U.) RATING STAT
---- -------- -------- -------- -------- -------- -------- -------- ------ ----
   1  RMUMAIN  0.00000  0.02000  0.00000  0.02000  0.00000  0.02000    100    3

--------------------------------------------------------------------------------
LOAD DATA
NODE NAME     STATUS
---- -------- ------
   6    RMU-5      3
   5    RMU-4      3
   4    RMU-3      3
   3    RMU-2      3
   2    RMU-1      3
--------------------------------------------------------------------------------
GENERATOR DATA FOR MINIMUM GENERATION

FROM FROM           POSITIVE          NEGATIVE           ZERO          MVA
NODE NAME       R(P.U)  X(P.U.)  R(P.U.)  X(P.U.)  R(P.U.)  X(P.U.) RATING STAT
---- -------- -------- -------- -------- -------- -------- -------- ------ ----
   1  RMUMAIN  0.00000  0.02000  0.00000  0.02000  0.00000  0.02000    100    3
--------------------------------------------------------------------------------
CO-ORDINATION TYPE                        :    1 (OVER CURRENT RELAY CO-ORDIN)
--------------------------------------------------------------------------------
NUMBER OF OVERCURRENT RELAYS              :   17
--------------------------------------------------------------------------------
SIMULATION STATUS                         :    4 (CO-ORDINATION, SIMULATION WITH
TRIPPING)
 --------------------------------------------------------------------------------
  The entries in different columns of Overcurrent relay data
  are as follows -

RELAY NAME  : Name of the relay, the size should not exceed 8 characters.
EL-NO       : Series/Shunt element number on which the relay is located.
EL-TYP      : 0 if relay is on series element.
              1 if relay is on shunt element.
DR ST       : d/D for a directional relay.
              n/N for a nondirectional relay.
FOR/REV     : 1 if relay is located on from side of the series element.
              2 if relay is located on to side of the series element.
CON SEN     : a/A if it is looking away from the bus to which it is connected.
              t/T if it is looking towards the bus to which it is connected.
MAXI LOAD   : Maximum load current in amperes.
CTPR1       : Current transformer primary rating 1 in amperes.
CTPR2       : Current transformer primary rating 2 in amperes.
CTPR3       : Current transformer primary rating 3 in amperes.
CTPR4       : Current transformer primary rating 4 in amperes.
CTSEC       : Current transformer secondary rating in amperes.
```

```
RELAY DBASE : The relay type number (less than or equal to 1000 if
              it is relay, than 1000 and less than 2000 for fuse).
              greater than 2000 for a Voltage Controlled relay).
PHTD SET    : Phase fault time dial setting.
ERTD SET    : Earth fault time dial setting.
PHPS        : Phase fault plug setting in amperes.
ERPS        : Earth fault plug setting in amperes.
INT FLG

   0 : CT selection, plug setting and the time dial setting (TDS) are
       computed by the program.
  01 : User defined TDS is selected and the plug setting is computed by the
       program.
  10 : User defined plug setting is selected with CT primary 1, and the TDS
       is computed by the program.
  11 : User defined plug setting is selected with CT primary 1, and the TDS
       is given by the user.
  20 : User defined plug setting is selected with CT primary 2, and the TDS
       is computed by the program.
  21 : User defined plug setting is selected with CT primary 2, and the TDS
       is given by the user.
  30 : User defined plug setting is selected with CT primary 3, and the TDS
       is computed by the program.
  31 : User defined plug setting is selected with CT primary 3, and the TDS
       is given by the user.
  40 : User defined plug setting is selected with CT primary 4, and the TDS
       is computed by the program.
  41 : User defined plug setting is selected with CT primary 4, and the TDS
       is given by the user.

   2  : User defined Close in operating time, TDS
DISC TIME    : Discrimination time in seconds.

PH INS FCT    : Phase fault Instantaneous setting factor.

ER INS FCT    : Earth fault Instantaneous setting factor.
OVLD FACT     : Overload factor.
UNBL FACT     : Unbalance factor.
PHAS INTCT    : PHASE INTACT FLAG.
EARTH INTCT   : EARTH INTACT FLAG.
CT SEL        : SELECTED CT.
PH INS FLAG   : PHASE INSTANTANEOUS SETTING FLAG.
ER INS FLAG   : EARTH INSTANTANEOUS SETTING FLAG.
PH INST TIME  : SET PHASE INSTANTANEOUS TIME.
ER INST TIME  : SET EARTH INSTANTANEOUS TIME
--------------------------------------------------------------------------------
OVERCURRENT\SBEF RELAY DATA

               RELAY  EL ELM DIR  FOR/  CON  MAXIM  CTPR1  CTPR2  CTPR3  CTPR4
CTSEC   RELAY
                NAME  NUM TYP SEN REV   SEN   LOAD   AMPS   AMPS   AMPS   AMPS
```

```
   AMPS    DBASE                                                PHTD  ERTD   PHPS   ERPS  INTCT   DISC PH
INS  ER INS OVERLOAD UNBALANCE                                  SET   SET                 FLAG   TIME    FCT
FCT    FACT     FACT                                           PHAS  EARTH    CT  PH INS  ER INS  PH INST
ERTH INST                                                      INTCT  INTCT    SEL FLAG     FLAG    TIME
TIME
------------------- --- --- --- ---- ----- ------ ------ ------ ------ ------
                  R1   1   0   N    1     A  200.0  200.0  400.0  600.0 1200.0
5.000       1
                                          0.18   0.30  300.0  100.0      0  0.400
1.30    1.30    1.00    0.200
                                              11     11      1      0       0
0.00    0.000
0 1 1
                  R2   1   0   D    2     A  200.0  300.0  300.0  300.0  300.0
5.000       1
                                          0.05   0.30  300.0   30.0      0  0.400
1.30    1.30    1.00    0.200
                                               1     11      1      0       0
0.00    0.000
0 1 1
                  R3   2   0   D    1     A  200.0  300.0  300.0  300.0  300.0
5.000       1
                                          0.64   0.79  300.0   90.0      0  0.400
1.30    1.30    1.00    0.200
                                               1     11      1      0       0
0.00    0.000
0 1 1
                  R4   2   0   D    2     A  200.0  300.0  300.0  300.0  300.0
5.000       1
                                          0.17   0.27  300.0   90.0      0  0.400
1.30    1.30    1.00    0.200
                                               1     11      1      0       0
0.00    0.000
0 1 1
                  R5   3   0   D    1     A  200.0  300.0  300.0  300.0  300.0
5.000       1
                                          0.46   0.69  300.0   45.0      0  0.400
1.30    1.30    1.00    0.200
                                               1     11      1      0       0
0.00    0.000
0 1 1
                  R6   3   0   D    2     A  200.0  300.0  300.0  300.0  300.0
5.000       1
                                          0.32   0.50  300.0   30.0      0  0.400
1.30    1.30    1.00    0.200
                                               1     11      1      0       0
0.00    0.000
```

```
0 1 1
                R7   4   0   D    1     A  200.0  300.0  300.0  300.0  300.0
5.000       1
                                        0.30   0.50  300.0   30.0      0  0.400
1.30    1.30    1.00    0.200
                                                1     11      1      0       0
0.00    0.000
0 1 1
                R8   4   0   D    2     A  200.0  300.0  300.0  300.0  300.0
5.000       1
                                        0.49   0.70  300.0   45.0      0  0.400
1.30    1.30    1.00    0.200
                                                1     11      1      0       0
0.00    0.000
0 1 1
                R9   5   0   D    1     A  200.0  300.0  300.0  300.0  300.0
5.000       1
                                        0.17   0.27  300.0   30.0      0  0.400
1.30    1.30    1.00    0.200
                                                1     11      1      0       0
0.00    0.000
0 1 1
               R10   5   0   D    2     A  200.0  300.0  300.0  300.0  300.0
5.000       1
                                        0.68   0.80  300.0   90.0      0  0.400
1.30    1.30    1.00    0.200
                                                1     11      1      0       0
0.00    0.000
0 1 1
               R11   6   0   D    1     A  200.0  300.0  300.0  300.0  300.0
5.000       1
                                        0.05   0.30  300.0   30.0      0  0.400
1.30    1.30    1.00    0.200
                                                1     10      1      0       0
0.00    0.000
0 1 1
               R12   6   0   N    2     A  200.0  300.0  400.0  600.0 1200.0
5.000       1
                                        0.69   0.79  300.0  300.0      0  0.400
1.30    1.30    1.00    0.200
                                                1     11      4      0       0
0.00    0.000
0 1 1
              LR13   2   1   D    1     A  200.0  300.0  300.0  300.0  300.0
5.000       1
                                        0.05   0.30  300.0  105.0      0  0.400
1.30    1.30    1.00    0.200
                                                1     10      1      0       0
0.00    0.000
0 1 1
```

```
                LR14   3   1   D    1     A  200.0  300.0  300.0  300.0  300.0
5.000       1
                                          0.05   0.30  300.0   60.0      0  0.400
1.30    1.30    1.00    0.200
                                               1     10      1      0       0
0.00    0.000
0 1 1
                LR15   4   1   D    1     A  200.0  300.0  300.0  300.0  300.0
5.000       1
                                          0.05   0.30  300.0   60.0      0  0.400
1.30    1.30    1.00    0.200
                                               1     10      1      0       0
0.00    0.000
0 1 1
                LR16   5   1   D    1     A  200.0  300.0  300.0  300.0  300.0
5.000       1
                                          0.05   0.30  300.0   60.0      0  0.400
1.30    1.30    1.00    0.200
                                               1     10      1      0       0
0.00    0.000
0 1 1
                LR17   6   1   D    1     A  200.0  300.0  300.0  300.0  300.0
5.000       1
                                          0.05   0.30  300.0  105.0      0  0.400
1.30    1.30    1.00    0.200
                                               1     10      1      0       0
0.00    0.000
0 1 1
--------------------------------------------------------------------------------
STAND BY EARTH FAULT RELAY DATA

               RELAY  EL  ELM DIR  FOR/  CON  MAXIM  CTPR1  CTPR2  CTPR3  CTPR4
CTSEC   RELAY       STAGE 1      STAGE 2
                NAME  NUM TYP SEN  REV   SEN   LOAD
DBASE   CURRENT TIME  CURRENT TIME
                                             (A)    (A)    (A)    (A)    (A)    (A)
(A)    (s)     (A)    (s)
------------------- --- --- --- ---- ----- ------ ------ ------ ------ ------ ------
--------------------------------------------------------------------------------
NUMBER OF FAULTS SIMULATED              :    1
SERIES ELEMENT PERCENT FAULTTYPE
    NUMBER     LINE
-------------- ------- ---------
             1   20.00         1 (3 PHASE TO GROUND FAULT)
--------------------------------------------------------------------------------
Number of phase relays 17 Number of earth relays 17
--------------------------------------------------------------------------------
               RELAY ELMT ELEMNT FROM     FROM TO         TO    RELAY PHASE EARTH
                NAME NMBR   TYPE BUS      NAME BUS      NAME LOCATION
------------------- ---- ------ ---- -------- ---- -------- -------- ----- -----
                 R1    1 Series    1  RMUMAIN    2    RMU-1  RMUMAIN   YES   YES
```

```
                R2    1 Series    1  RMUMAIN    2    RMU-1    RMU-1   YES   YES
                R3    2 Series    2    RMU-1    3    RMU-2    RMU-1   YES   YES
                R4    2 Series    2    RMU-1    3    RMU-2    RMU-2   YES   YES
                R5    3 Series    3    RMU-2    4    RMU-3    RMU-2   YES   YES
                R6    3 Series    3    RMU-2    4    RMU-3    RMU-3   YES   YES
                R7    4 Series    4    RMU-3    5    RMU-4    RMU-3   YES   YES
                R8    4 Series    4    RMU-3    5    RMU-4    RMU-4   YES   YES
                R9    5 Series    5    RMU-4    6    RMU-5    RMU-4   YES   YES
               R10    5 Series    5    RMU-4    6    RMU-5    RMU-5   YES   YES
               R11    6 Series    6    RMU-5    1  RMUMAIN    RMU-5   YES   YES
               R12    6 Series    6    RMU-5    1  RMUMAIN  RMUMAIN   YES   YES
              LR13    2  Shunt    6    RMU-5                 RMU-5   YES   YES
              LR14    3  Shunt    5    RMU-4                 RMU-4   YES   YES
              LR15    4  Shunt    4    RMU-3                 RMU-3   YES   YES
              LR16    5  Shunt    3    RMU-2                 RMU-2   YES   YES
              LR17    6  Shunt    2    RMU-1                 RMU-1   YES   YES
--------------------------------------------------------------------------------
************************************************
Thermal Curves will not be generated
Unable to find the file D:\Padmaja\PS_problems\RElay_Manual\Relay-
ring\ORCD\1RELAY0I.Thm
Check and rerun to obtain Thermal Curves
************************************************
--------------------------------------------------------------------------------
User Given Discrimination Time
Phase Relay Co-ordination Checking
--------------------------------------------------------------------------------
            Primary               Backup Pri. Current Pri Psm Pri Tds  Pri time
BackCurrnt Back Psm Back Tds Backtime Disc time  Remarks
------------------- ------------------- ------------ ------- -------- --------
R1                  R11   26243.1941 300.000    0.1800    0.2781     0.0000 225.000
0.0500 No Opert *********
                    R2                   R4    1621.0564 225.000    0.0500    0.1749
1621.0564 225.000   0.1700   0.5947    0.4198 >> OK
                    R3                   R1   11346.3595 225.000    0.6400    1.1276
11346.3595 300.000   0.1800   0.3423   -0.7854 << NA
                    R4                   R6    2646.1674 225.000    0.1700    0.4764
2646.1674 225.000   0.3200   0.8968    0.4204 >> OK
                    R5                   R3    4410.4668 225.000    0.4600    1.0679
4410.4668 225.000   0.6400   1.4857    0.4179 >> OK
                    R6                   R8    3800.9080 225.000    0.3200    0.7819
3800.9080 225.000   0.4900   1.1974    0.4154 >> OK
                    R7                   R5    2956.4417 225.000    0.3000    0.8046
2956.4417 225.000   0.4600   1.2337    0.4291 >> OK
                    R8                  R10    5235.8528 225.000    0.4900    1.0755
5235.8528 225.000   0.6800   1.4925    0.4170 >> OK
                    R9                   R7    2379.9884 225.000    0.1700    0.4979
2379.9884 225.000   0.3000   0.8786    0.3807 << NA
                   R10                  R12   11346.3595 225.000    0.6800    1.1981
11346.3595 600.000   0.6900   1.6214    0.4232 >> OK
                   R11                   R9    1621.0564 225.000    0.0500    0.1749
```

```
1621.0564 225.000   0.1700   0.5947    0.4198 >> OK
                R12                   R2   26243.1941 600.000    0.6900    1.2615
0.0000 225.000   0.0500 No Opert *********
               LR13                   R9   12967.4159 225.000    0.0500    0.0852
1621.0564 225.000   0.1700   0.5947    0.5095 >> OK
               LR13                  R12   12967.4159 225.000    0.0500    0.0852
11346.3595 600.000   0.6900   1.6214    1.5362 >> OK!!
               LR14                   R7    7615.8411 225.000    0.0500    0.0981
2379.9884 225.000   0.3000   0.8786    0.7805 >> OK
               LR14                  R10    7615.8411 225.000    0.0500    0.0981
5235.8528 225.000   0.6800   1.4925    1.3945 >> OK!!
               LR15                   R8    6757.3497 225.000    0.0500    0.1015
3800.9080 225.000   0.4900   1.1974    1.0958 >> OK!!
               LR15                   R5    6757.3497 225.000    0.0500    0.1015
2956.4417 225.000   0.4600   1.2337    1.1322 >> OK!!
               LR16                   R3    7056.6343 225.000    0.0500    0.1002
4410.4668 225.000   0.6400   1.4857    1.3855 >> OK!!
               LR16                   R6    7056.6343 225.000    0.0500    0.1002
2646.1674 225.000   0.3200   0.8968    0.7966 >> OK
               LR17                   R1   12967.4159 225.000    0.0500    0.0852
11346.3595 300.000   0.1800   0.3423    0.2571 << NA
               LR17                   R4   12967.4159 225.000    0.0500    0.0852
1621.0564 225.000   0.1700   0.5947    0.5095 >> OK
--------------------------------------------------------------------------------
User Given Discrimination Time
Earth Relay Co-ordination Checking
--------------------------------------------------------------------------------
            Primary               Backup Pri. Current Pri Psm Pri Tds  Pri time
BackCurrnt Back Psm Back Tds Backtime Disc time  Remarks
------------------- ------------------- ------------ ------- -------- --------
R1                  R11   26243.1941 100.000    0.3000    0.3911     0.0000  30.000
0.0500 No Opert *********
                R2                    R4    1194.5853  30.000    0.3000    0.5625
1194.5853  90.000   0.2700   0.7213    0.1588 << NA
                R3                    R1    8361.3344  90.000    0.7900    1.2042
8361.3344 100.000   0.3000   0.4682   -0.7361 << NA
                R4                    R6    1828.6140  90.000    0.2700    0.6193
1828.6140  30.000   0.5000   0.8403    0.2210 << NA
                R5                    R3    3047.8197  45.000    0.6900    1.1307
3047.8197  90.000   0.7900   1.5493    0.4186 >> OK
                R6                    R8    2620.3800  30.000    0.5000    0.7727
2620.3800  45.000   0.7000   1.1897    0.4170 >> OK
                R7                    R5    2038.1973  30.000    0.5000    0.8187
2038.1973  45.000   0.6900   1.2500    0.4313 >> OK
                R8                   R10    3635.0185  45.000    0.7000    1.1010
3635.0185  90.000   0.8000   1.4942    0.3931 << NA
                R9                    R7    1652.3195  30.000    0.2700    0.4653
1652.3195  30.000   0.5000   0.8616    0.3963 << NA
               R10                   R12    8361.3344  90.000    0.8000    1.2195
8361.3344 300.000   0.7900   1.6400    0.4205 >> OK
               R11                    R9    1194.5853  30.000    0.0500    0.0937
```

```
1194.5853  30.000   0.2700   0.5062    0.4125 >> OK
                R12                   R2   26243.1941 300.000    0.7900    1.2205
0.0000  30.000   0.3000 No Opert *********
               LR13                   R9    9555.9197 105.000    0.0500    0.0766
1194.5853  30.000   0.2700   0.5062    0.4297 >> OK
               LR13                  R12    9555.9197 105.000    0.0500    0.0766
8361.3344 300.000   0.7900   1.6400    1.5634 >> OK!!
               LR14                   R7    5287.3380  60.000    0.0500    0.0771
1652.3195  30.000   0.5000   0.8616    0.7845 >> OK
               LR14                  R10    5287.3380  60.000    0.0500    0.0771
3635.0185  90.000   0.8000   1.4942    1.4170 >> OK!!
               LR15                   R8    4658.5772  60.000    0.0500    0.0794
2620.3800  45.000   0.7000   1.1897    1.1103 >> OK!!
               LR15                   R5    4658.5772  60.000    0.0500    0.0794
2038.1973  45.000   0.6900   1.2500    1.1706 >> OK!!
               LR16                   R3    4876.4337  60.000    0.0500    0.0785
3047.8197  90.000   0.7900   1.5493    1.4707 >> OK!!
               LR16                   R6    4876.4337  60.000    0.0500    0.0785
1828.6140  30.000   0.5000   0.8403    0.7618 >> OK
               LR17                   R1    9555.9197 105.000    0.0500    0.0766
8361.3344 100.000   0.3000   0.4682    0.3916 << NA
               LR17                   R4    9555.9197 105.000    0.0500    0.0766
1194.5853  90.000   0.2700   0.7213    0.6447 >> OK
--------------------------------------------------------------------------------
RELAY SETTINGS FOR PHASE FAULTS
--------------------------------------------------------------------------------
              RELAY  CLOSE IN FAULT  PLUG SETTING RATIO    RELAY    REMARKS
               NAME   CURRENT (Amps)  (Amps)                CAPACITY
------------------ --------------  ------------ -------- -------- -------------
                R1      26243.1941     300.0000   87.477   100.00 Within Limit
                R2       1621.0564     225.0000    7.205   100.00 Within Limit
                R3      11346.3595     225.0000   50.428   100.00 Within Limit
                R4       2646.1674     225.0000   11.761   100.00 Within Limit
                R5       4410.4668     225.0000   19.602   100.00 Within Limit
                R6       3800.9080     225.0000   16.893   100.00 Within Limit
                R7       2956.4417     225.0000   13.140   100.00 Within Limit
                R8       5235.8528     225.0000   23.270   100.00 Within Limit
                R9       2379.9884     225.0000   10.578   100.00 Within Limit
               R10      11346.3595     225.0000   50.428   100.00 Within Limit
               R11       1621.0564     225.0000    7.205   100.00 Within Limit
               R12      26243.1941     600.0000   43.739   100.00 Within Limit
              LR13      12967.4159     225.0000   57.633   100.00 Within Limit
              LR14       7615.8411     225.0000   33.848   100.00 Within Limit
              LR15       6757.3497     225.0000   30.033   100.00 Within Limit
              LR16       7056.6343     225.0000   31.363   100.00 Within Limit
              LR17      12967.4159     225.0000   57.633   100.00 Within Limit
--------------------------------------------------------------------------------
SL.              RELAY  From Bus  To Bus   CT PRIM CT SEC  PLUG    PLUG    PLUG
T.D.S CLOSE IN  OP. TIME      REMOTE   OP.TIME              PRIMARY  INSTANT  RELAY
```

```
DB CURVE NAME
NO.                NAME                          CHOSEN          SETTING SETTING SETTING
FAULT  FOR CLOSE  BUS FAULT    REMOTE                    RELAY  SETTING  NAME
                                                        (Amps)          (%)    (PRIM)  (SEC)
CURRENT IN FAULT     CURRENT BUS FAULT                                                 (A)     (A)
(Amps)    Secs)     (Amps)    (Secs)                                    (%)
--- -------------------- --------- --------- ------- ------ ------- ------- -------
----- --------- --------- ---------- --------- -------------------- -------- -------
- ----------
  1                  R1         1         2     200       5 150.00  300.00    7.50
0.18  26243.19    0.2781   11346.36    0.3423                   R3

11346.36    0.3423                LR17    *****   Relay1 3S-RELAY
  2                  R2         1         2     300       5  75.00  225.00    3.75
0.05   1621.06    0.1749       0.00  NO OPERT                  R12    *****   Relay1
3S-RELAY
  3                  R3         2         3     300       5  75.00  225.00    3.75
0.64  11346.36    1.1276    4410.47    1.4857                  LR16

4410.47    1.4857                   R5    *****   Relay1 3S-RELAY
  4                  R4         2         3     300       5  75.00  225.00    3.75
0.17   2646.17    0.4764    1621.06    0.5947                   R2

1621.06    0.5947                LR17    *****   Relay1 3S-RELAY
  5                  R5         3         4     300       5  75.00  225.00    3.75
0.46   4410.47    1.0679    2956.44    1.2337                   R7

2956.44    1.2337                LR15    *****   Relay1 3S-RELAY
  6                  R6         3         4     300       5  75.00  225.00    3.75
0.32   3800.91    0.7819    2646.17    0.8968                   R4

2646.17    0.8968                LR16    *****   Relay1 3S-RELAY
  7                  R7         4         5     300       5  75.00  225.00    3.75
0.30   2956.44    0.8046    2379.99    0.8786                   R9

2379.99    0.8786                LR14    *****   Relay1 3S-RELAY
  8                  R8         4         5     300       5  75.00  225.00    3.75
0.49   5235.85    1.0755    3800.91    1.1974                  LR15

3800.91    1.1974                   R6    *****   Relay1 3S-RELAY
  9                  R9         5         6     300       5  75.00  225.00    3.75
0.17   2379.99    0.4979    1621.06    0.5947                  LR13

1621.06    0.5947                  R11    *****   Relay1 3S-RELAY
 10                 R10         5         6     300       5  75.00  225.00    3.75
0.68  11346.36    1.1981    5235.85    1.4925                   R8

5235.85    1.4925                LR14    *****   Relay1 3S-RELAY
 11                 R11         6         1     300       5  75.00  225.00    3.75
0.05   1621.06    0.1749       0.00  NO OPERT                   R1    *****   Relay1
```

```
3S-RELAY
 12                  R12         6         1    1200       5  50.00  600.00    2.50
0.69  26243.19    1.2615   11346.36    1.6214                 LR13

11346.36    1.6214                  R10    *****   Relay1 3S-RELAY
 13                 LR13         6         0     300       5  75.00  225.00    3.75
0.05  12967.42    0.0852     DOES NOT BACK-UP                 ****        *****
Relay1 3S-RELAY
 14                 LR14         5         0     300       5  75.00  225.00    3.75
0.05   7615.84    0.0981     DOES NOT BACK-UP                 ****        *****
Relay1 3S-RELAY
 15                 LR15         4         0     300       5  75.00  225.00    3.75
0.05   6757.35    0.1015     DOES NOT BACK-UP                 ****        *****
Relay1 3S-RELAY
 16                 LR16         3         0     300       5  75.00  225.00    3.75
0.05   7056.63    0.1002     DOES NOT BACK-UP                 ****        *****
Relay1 3S-RELAY
 17                 LR17         2         0     300       5  75.00  225.00    3.75
0.05  12967.42    0.0852     DOES NOT BACK-UP                 ****        *****
Relay1 3S-RELAY
--------------------------------------------------------------------------------
PHASE RELAY SETTINGS
--------------------------------------------------------------------------------
RELAY NAME           PLUG SETTING PLUG SETTING TIME MULTIPLIER SETTING INST. SETTING
                        (PRIM)       (SEC)                                   (A)
                        (A)           (A)
-------------------- ------------ ------------ ---------------------- -------------
                  R1      300.000                  0.180        ******
                  R2      225.000                  0.050        ******
                  R3      225.000                  0.640        ******
                  R4      225.000                  0.170        ******
                  R5      225.000                  0.460        ******
                  R6      225.000                  0.320        ******
                  R7      225.000                  0.300        ******
                  R8      225.000                  0.490        ******
                  R9      225.000                  0.170        ******
                 R10      225.000                  0.680        ******
                 R11      225.000                  0.050        ******
                 R12      600.000                  0.690        ******
                LR13      225.000                  0.050        ******
                LR14      225.000                  0.050        ******
                LR15      225.000                  0.050        ******
                LR16      225.000                  0.050        ******
                LR17      225.000                  0.050        ******
--------------------------------------------------------------------------------
NOTE : For motor relays, TDS refers to time in seconds. If the manufacturer
 specification is say t seconds at 'X' times Ith, then TDS refer to t seconds
```

RELAY SETTINGS FOR EARTH FAULTS

RELAY NAME	CLOSE IN FAULT CURRENT (Amps)	PLUG SETTING (Amps)	RATIO	RELAY CAPACITY	REMARKS
R1	26243.1941	100.0000	262.432	100.00	Exceeds Limit
R2	1194.5853	30.0000	39.820	100.00	Within Limit
R3	8361.3344	90.0000	92.904	100.00	Within Limit
R4	1828.6140	90.0000	20.318	100.00	Within Limit
R5	3047.8197	45.0000	67.729	100.00	Within Limit
R6	2620.3800	30.0000	87.346	100.00	Within Limit
R7	2038.1973	30.0000	67.940	100.00	Within Limit
R8	3635.0185	45.0000	80.778	100.00	Within Limit
R9	1652.3195	30.0000	55.077	100.00	Within Limit
R10	8361.3344	90.0000	92.904	100.00	Within Limit
R11	1194.5853	30.0000	39.820	100.00	Within Limit
R12	26243.1941	300.0000	87.477	100.00	Within Limit
LR13	9555.9197	105.0000	91.009	100.00	Within Limit
LR14	5287.3380	60.0000	88.122	100.00	Within Limit
LR15	4658.5772	60.0000	77.643	100.00	Within Limit
LR16	4876.4337	60.0000	81.274	100.00	Within Limit
LR17	9555.9197	105.0000	91.009	100.00	Within Limit

SL. NO.	RELAY NAME	From Bus	To Bus	CT PRIM CHOSEN (Amps)	CT SEC RELAY	PLUG SETTING PRIMARY (%)	PLUG SETTING INSTANT (PRIM) (A)	PLUG SETTING RELAY (SEC) (A)	T.D.S	CLOSE IN FAULT CURRENT IN FAULT (Amps)	OP. TIME FOR CLOSE Secs)	DB CURVE NAME	REMOTE BUS FAULT (Amps)	OP.TIME REMOTE FAULT (Secs)	NAME	CURRENT BUS FAULT (Amps)	(%)
1	R1	1	2	200	5	50.00	100.00	2.50	0.30	26243.19	0.3911		8361.33	0.4682	R3		
										8361.33	0.4682		LR17	*****	Relay1 3S-RELAY		
2	R2	1	2	300	5	10.00	30.00	0.50	0.30	1194.59	0.5625		0.00	NO OPERT	R12	*****	Relay1 3S-RELAY
3	R3	2	3	300	5	30.00	90.00	1.50	0.79	8361.33	1.2042		3047.82	1.5493	LR16		
										3047.82	1.5493		R5	*****	Relay1 3S-RELAY		
4	R4	2	3	300	5	30.00	90.00	1.50	0.27	1828.61	0.6193		1194.59	0.7213	R2		
										1194.59	0.7213		LR17	*****	Relay1 3S-RELAY		

```
  5                  R5         3         4     300       5  15.00   45.00    0.75
0.69   3047.82    1.1307    2038.20    1.2500                 R7

2038.20    1.2500                LR15    *****   Relay1 3S-RELAY
  6                  R6         3         4     300       5  10.00   30.00    0.50
0.50   2620.38    0.7727    1828.61    0.8403                 R4

1828.61    0.8403                LR16    *****   Relay1 3S-RELAY
  7                  R7         4         5     300       5  10.00   30.00    0.50
0.50   2038.20    0.8187    1652.32    0.8616                 R9

1652.32    0.8616                LR14    *****   Relay1 3S-RELAY
  8                  R8         4         5     300       5  15.00   45.00    0.75
0.70   3635.02    1.1010    2620.38    1.1897                 LR15

2620.38    1.1897                   R6    *****   Relay1 3S-RELAY
  9                  R9         5         6     300       5  10.00   30.00    0.50
0.27   1652.32    0.4653    1194.59    0.5062                 LR13

1194.59    0.5062                  R11    *****   Relay1 3S-RELAY
 10                 R10         5         6     300       5  30.00   90.00    1.50
0.80   8361.33    1.2195    3635.02    1.4942                 R8

3635.02    1.4942                LR14    *****   Relay1 3S-RELAY
 11                 R11         6         1     300       5  10.00   30.00    0.50
0.05   1194.59    0.0937      0.00  NO OPERT                  R1     *****   Relay1
3S-RELAY
 12                 R12         6         1    1200       5  25.00  300.00    1.25
0.79  26243.19    1.2205    8361.33    1.6400                 LR13

8361.33    1.6400                  R10    *****   Relay1 3S-RELAY
 13                LR13         6         0     300       5  35.00  105.00    1.75
0.05   9555.92    0.0766     DOES NOT BACK-UP                  ****        *****
Relay1 3S-RELAY
 14                LR14         5         0     300       5  20.00   60.00    1.00
0.05   5287.34    0.0771     DOES NOT BACK-UP                  ****        *****
Relay1 3S-RELAY
 15                LR15         4         0     300       5  20.00   60.00    1.00
0.05   4658.58    0.0794     DOES NOT BACK-UP                  ****        *****
Relay1 3S-RELAY
 16                LR16         3         0     300       5  20.00   60.00    1.00
0.05   4876.43    0.0785     DOES NOT BACK-UP                  ****        *****
Relay1 3S-RELAY
 17                LR17         2         0     300       5  35.00  105.00    1.75
0.05   9555.92    0.0766     DOES NOT BACK-UP                  ****        *****
Relay1 3S-RELAY
```

EARTH RELAY SETTINGS

RELAY NAME	PLUG SETTING (PRIM) (A)	PLUG SETTING (SEC) (A)	TIME MULTIPLIER SETTING	INST. SETTING (A)
R1	100.000		0.300	******
R2	30.000		0.300	******
R3	90.000		0.790	******
R4	90.000		0.270	******
R5	45.000		0.690	******
R6	30.000		0.500	******
R7	30.000		0.500	******
R8	45.000		0.700	******
R9	30.000		0.270	******
R10	90.000		0.800	******
R11	30.000		0.050	******
R12	300.000		0.790	******
LR13	105.000		0.050	******
LR14	60.000		0.050	******
LR15	60.000		0.050	******
LR16	60.000		0.050	******
LR17	105.000		0.050	******

RELAY NAME	PH INSTANT OPER SETTING (Amps)	TIME (Secs)	SHORT CIRCUIT OPER SETTING (Amps)	TIME (Secs)	ER INSTANT OPER SETTING (Amps)	TIME (Secs)
R1	No Inst	****	No SC	****	No Er Inst	****
R2	No Inst	****	No SC	****	No Er Inst	****
R3	No Inst	****	No SC	****	No Er Inst	****
R4	No Inst	****	No SC	****	No Er Inst	****
R5	No Inst	****	No SC	****	No Er Inst	****
R6	No Inst	****	No SC	****	No Er Inst	****
R7	No Inst	****	No SC	****	No Er Inst	****
R8	No Inst	****	No SC	****	No Er Inst	****
R9	No Inst	****	No SC	****	No Er Inst	****
R10	No Inst	****	No SC	****	No Er Inst	

```
****
                R11    No Inst      ****         No SC      ****  No Er Inst
****
                R12    No Inst      ****         No SC      ****  No Er Inst
****
               LR13    No Inst      ****         No SC      ****  No Er Inst
****
               LR14    No Inst      ****         No SC      ****  No Er Inst
****
               LR15    No Inst      ****         No SC      ****  No Er Inst
****
               LR16    No Inst      ****         No SC      ****  No Er Inst
****
               LR17    No Inst      ****         No SC      ****  No Er Inst
****
--------------------------------------------------------------------------------
 3 Phase to ground fault is created at 20.00 percent of line 1
 whose from node is RMUMAIN (1) and to node is RMU-1 (2).
--------------------------------------------------------------------------------
              RELAY PH A FAULT OPERT TIME FOR ZER SEQ FAULT  OPERATING TIME
               NAME  CURRENT      PH A CURRENT CURRENT (3*I0) FOR ZS FALTCUR
                    (Amps)        (Secs)          (Amps)        (Secs)
------------------- ---------- ------------- ------------- -------------
                 R1   23214.31    0.2859               0.00      No pickup
                 R2     595.29    0.3550               0.00      No pickup
                 R4     595.29    1.2070               0.00      No pickup
                 R6     595.29    2.2720               0.00      No pickup
                 R8     595.29    3.4789               0.00      No pickup
                R10     595.29    4.8279               0.00      No pickup
                R12     595.29      No pickup          0.00      No pickup
--------------------------------------------------------------------------------
              RELAY RELAY    RELAY    LINE END LINE END  OP.TIME FROM  SENSED
              NAME  LOCATION LOCATION NODE     NODE NAME INST OF FAULT FAULT
                             NAME                (Secs)
------------------- -------- -------- -------- --------- ------------- ------
                 R1        1  RMUMAIN        2     RMU-1        0.2859  Phase
                 R2        2    RMU-1        1   RMUMAIN        0.4507 Phase
--------------------------------------------------------------------------------
Date and Time : Wed Apr 23 10:39:57 2014
```

Case 3 : 5 Bus Ring System Distance Relay Co-ordination

In this section, a sample power system is considered with most of the data and element types to explain the distance relay co-ordination. The system considered is as shown in Fig. 6.3. Listing of files “rcdin”, “rcdout” and “rcdtoetc” are given in tables 6.5, 6.6 and 6.7 respectively.

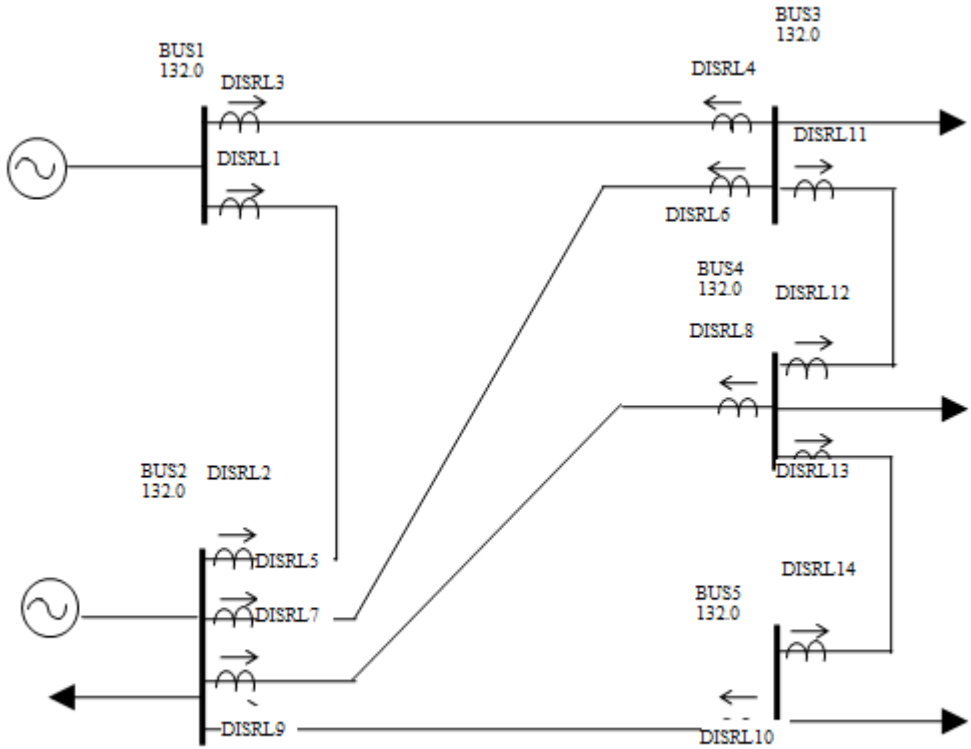


Figure 6.3 : 5 Bus Ring System

Table 6.6 : “rcdin” file listing for case 3

```
      DISTANCE RELAY CO-ORDINATION
       CASE NO  :   1               SCHEDULE NO : 0
CONTINGENCY NAME : Base Case
VERSION 8
%% First Power System Network
% COMMON SYSTEM SPECIFICATIONS

%  (1)Maximum Bus Id (2)      No of Buses    (3) No of 2WdgTr
%  (4)No of 3WdgTr   (5)      No of Lines    (6) No of SerReac
%  (7)No of SerCap   (8)      No of CBs      (9) No of ShReac
% (10)No of ShCap   (11)    No of Sh Imp  (12) No of Gen
% (13)No of Loads   (14)      No of Filters (15) No of HVDC
   5     5     0     0     7     0     0     0     0     0
0      2     0    4     0     0
% Number of Partial Bus Bar relays
0
% CONTROL INPUTS
% NoOfZones   PrintOpt  GraphOpt  BaseMVA NomFreq  PreFaultVoltOpt

   1     3     0   100.000   50.000     0
% FAULT IMPEDANCE
% FaultR  FaultX  GndFaultR  GndFaultX
0.000e+000  0.000e+000  0.000e+000  0.000e+000

% MULTIPLICATION FACTORS
% CB R   CB X   Trans R/X
0.000000e+000  1.000000e-004   0.050000
% TranZeroSeqZFactor   No of TLine levels
 0.90000   1

% LineVolt ZeroSeqZFact   ZeroSeqAFact
 132.0000      2.5000      0.8000
% Gen-veSeqRFact Gen-veSeqXFact  GenZerSeqRFact GenZerSeqXFact
   0.1750      0.1750      0.0375      0.0375
% Load-veSeqZFact      LoadZerSeqZFact         SerZerSeqZFact  ShZerSeqZFact
   0.8100      1.6000      1.0000      0.6250

% BUS DATA
% BusId  Status  Area No  Base Volt  BusName
% VMag   VAng    PGen     QGen          PLd     QLd  QComp

   1 1   1 132.000     Bus1
      1.000000000000e+000 0.000000000000e+000     0.00     0.00     0.00     0.00
0.00
   2 1   1 132.000     Bus2
      1.000000000000e+000 0.000000000000e+000     0.00     0.00     0.00     0.00
0.00
```

```
   3 1   1 132.000     Bus3
      1.000000000000e+000 0.000000000000e+000     0.00     0.00     0.00     0.00
0.00
   4 1   1 132.000     Bus4
      1.000000000000e+000 0.000000000000e+000     0.00     0.00     0.00     0.00
0.00
   5 1   1 132.000     Bus5
      1.000000000000e+000 0.000000000000e+000     0.00     0.00     0.00     0.00
0.00

% 2 WDG TRANSFORMER DATA
% Status  Units   FromBus   ToBus    +veR     +veX  ZeroR  ZeroX
% NomTap  PhShift FromCBMVA ToCBMVA  FromWdg  ToWdg

% TRANSMISSION LINE DATA
% Status  Units   FromBus  ToBus  +veR  +veX  +ve B  ZeroR  ZeroX ZeroB
%         FromCBMVA ToCBMVA

3  1     1    2 2.009000e-002 5.997000e-002 0.000000e+000  4.017000e-002 1.199500e-
001 0.000000e+000  100.000  100.000
100.000000 0.700000 1.000000 2500.000000 6.000000 20.000000 1.500000 5.000000
0.600000 2.500000 7.000000
3  1     1    3 8.000000e-002 2.399600e-001 0.000000e+000  1.549600e-001 4.820900e-
001 0.000000e+000  100.000  100.000
100.000000 0.700000 1.000000 2500.000000 6.000000 20.000000 1.500000 5.000000
0.600000 2.500000 7.000000
3  1     2    3 5.997000e-002 1.799800e-001 0.000000e+000  1.199500e-001 3.673100e-
001 0.000000e+000  100.000  100.000
100.000000 0.700000 1.000000 2500.000000 6.000000 20.000000 1.500000 5.000000
0.600000 2.500000 7.000000
3  1     2    4 5.997000e-002 1.799800e-001 0.000000e+000  1.199500e-001 3.673100e-
001 0.000000e+000  100.000  100.000
100.000000 0.700000 1.000000 2500.000000 6.000000 20.000000 1.500000 5.000000
0.600000 2.500000 7.000000
3  1     2    5 3.994000e-002 1.200100e-001 0.000000e+000  8.035000e-002 2.410500e-
001 0.000000e+000  100.000  100.000
100.000000 0.700000 1.000000 2500.000000 6.000000 20.000000 1.500000 5.000000
0.600000 2.500000 7.000000
3  1     3    4 9.990000e-003 2.996000e-002 0.000000e+000  2.009000e-002 5.992000e-
002 0.000000e+000  100.000  100.000
100.000000 0.700000 1.000000 2500.000000 6.000000 20.000000 1.500000 5.000000
0.600000 2.500000 7.000000
3  1     4    5 8.000000e-002 2.399600e-001 0.000000e+000  1.549600e-001 4.820900e-
001 0.000000e+000  100.000  100.000
100.000000 0.700000 1.000000 2500.000000 6.000000 20.000000 1.500000 5.000000
0.600000 2.500000 7.000000
```

```
% GENERATOR DATA
%FromBus +veR  +veX  -veR  -veX  ZeroR  ZeroX  CBMVA

   1 0.000000e+000  2.500000e-001  0.000000e+000  1.000000e-002 0.000000e+000
1.000000e-002  100.000    3
   2 0.000000e+000  2.500000e-001  0.000000e+000  1.000000e-002 0.000000e+000
1.000000e-002  100.000    3

% LOAD DATA
% FromBus
   2     3
   3     3
   4     3
   5     3

% GENERATOR DATA FOR MINIMUM GENERATION CONDITION
%FromBus +veR  +veX  -veR  -veX  ZeroR  ZeroX  CBMVA

   1 0.000000e+000  2.500000e-001  0.000000e+000  1.000000e-002 0.000000e+000
1.000000e-002  100.000    3
   2 0.000000e+000  2.500000e-001  0.000000e+000  1.000000e-002 0.000000e+000
1.000000e-002  100.000    3

% CO-ORDINATION TYPE (1-Overcurrent  0-Distance)

0

% Number of Distance Relays
  14

% Simulation Type
% 0 - Only Co-ordination
% 1 - Co-ordination and Simulation
% Distance Relay Data
1 1

% Relay Ser   Line   Loc.       CT       PT    Load   DistanceRelayReach
Discrimination  RDBNo
% Name  EleNo Length (0/1/2)  Pri Sec Pri Sec  P    Q  Zone1 Zone2  Zone3  Zone2
Zone3
        Dr1     1     1     1         400      5          132    110 999.99 999.99
80    40   100    20     0.500     0.800     1.000     0
        Dr2     1     1     2         400      5          132    110 999.99 999.99
80    40   100    20     0.500     0.800     1.000     0
        Dr3     2     1     1         400      5          132    110 999.99 999.99
80    40   100    29     0.500     0.800     1.000     0
        Dr4     2     1     2         400      5          132    110 999.99 999.99
80    40   100    20     0.500     0.800     1.000     0
        Dr5     3     1     1         400      5          132    110 999.99 999.99
80    40   100    20     0.500     0.800     1.000     0
```

```
        Dr6     3     1     2         400      5          132    110 999.99 999.99
80    40   100    20     0.500     0.800     1.000     0
        Dr7     4     1     1         400      5          132    110 999.99 999.99
80    40   100    20     0.500     0.800     1.000     0
        Dr8     4     1     2         400      5          132    110 999.99 999.99
80    40   100    20     0.500     0.800     1.000     0
        Dr9     5     1     1         400      5          132    110 999.99 999.99
80    40   100    20     0.500     0.800     1.000     0
       Dr10     6     1     1         400      5          132    110 999.99 999.99
80    40   100    20     0.500     0.800     1.000     0
       Dr11     6     1     2         400      5          132    110 999.99 999.99
80    40   100    20     0.500     0.800     1.000     0
       Dr12     7     1     1         400      5          132    110 999.99 999.99
80    40   100    20     0.500     0.800     1.000     0
       Dr13     7     1     2         400      5          132    110 999.99 999.99
80    40   100    20     0.500     0.800     1.000     0
       Dr14     5     1     2         400      5          132    110 999.99 999.99
80    40   100    20     0.500     0.800     1.000     2


% Discrimination Time
   0.400
% No of faults to be simulated
   1
% Simulation Data
   1    50.000      1
```

Table 6.6: “rcdout” file listing for Case 3

```
--------------------------------------------------------------------------------
        DISTANCE RELAY CO-ORDINATION
       CASE NO :   1               SCHEDULE NO : 0
CONTINGENCY NAME : Base Case
--------------------------------------------------------------------------------

VERSION NUMBER :  8.0
%% First Power System Network
LARGEST BUS NUMBER USED        :    5    ACTUAL NUMBER OF BUSES         :    5
NUMBER OF 2 WIND. TRANSFORMERS :    0    NUMBER OF 3 WIND. TRANSFORMERS :    0
NUMBER OF TRANSMISSION LINES   :    7
NUMBER OF SERIES REACTORS      :    0    NUMBER OF SERIES CAPACITORS    :    0
NUMBER OF BUS COUPLERS         :    0
NUMBER OF SHUNT REACTORS       :    0    NUMBER OF SHUNT CAPACITORS     :    0
NUMBER OF SHUNT IMPEDANCES     :    0    NUMBER OF GENERATORS           :    2
NUMBER OF MOTORS               :    0    NUMBER OF LOADS                :    4
NUMBER OF FILTERS              :    0
NUMBER OF HVDC CONVERTORS      :    0
NUMBER OF PARTIAL BUS BAR DIFFERENTIAL RELAYS :    0
```

```
--------------------------------------------------------------------------------
NUMBER OF ZONES                 :    1
PRINT OPTION                    :    3 (BOTH DATA AND RESULTS PRINT)
GRAPH OPTION                    :    0 (NO GRAPH FILE GENERATION)
BASE MVA                        :  100.000
NOMINAL SYSTEM FREQUENCY        :   50.000
PREFAULT VOLTAGE OPTION         :    0 (VOLTAGE OF 1.0 PU IS ASSUMED)
--------------------------------------------------------------------------------
FAULT RESISTANCE - PHASE        :   0.000000 (PU)
FAULT REACTANCE  - PHASE        :   0.000000 (PU)
FAULT RESISTANCE - GROUND       :   0.000000 (PU)
FAULT REACTANCE  - GROUND       :   0.000000 (PU)
--------------------------------------------------------------------------------
CIRCUIT BREAKER RESISTANCE (PU)                      : 0.000000e+000
CIRCUIT BREAKER REACTANCE  (PU)                      : 1.000000e-004
TRANSFORMER R/X RATIO                                :   0.050000
TRANSFORMER ZERO SEQUENCE IMPEDANCE MULT FACTOR      :   0.900000

NUMBER OF TRANSMISSION VOLTAGE LEVELS                :   1
TRANSMISSION LINE VOLTAGE - KV                       : 132.000000
TRANSMISSION LINE ZERO SEQUENCE IMP. MULT. FACTOR    :   2.500000
TRANSMISSION LINE ZERO SEQUENCE ADM. MULT. FACTOR    :   0.800000

GENERATOR NEGATIVE SEQUENCE RESISTANCE MULT. FACTOR  :   0.175000
GENERATOR NEGATIVE SEQUENCE REACTANCE  MULT. FACTOR  :   0.175000
GENERATOR ZERO SEQUENCE RESISTANCE MULT. FACTOR      :   0.037500
GENERATOR ZERO SEQUENCE REACTANCE MULT. FACTOR       :   0.037500
LOAD      NEGATIVE SEQUENCE IMPEDANCE  MULT. FACTOR  :   0.810000
LOAD      ZERO SEQUENCE IMPEDANCE  MULT. FACTOR      :   1.600000
SERIES REACTOR ZERO SEQUENCE IMPEDANCE MULT. FACTOR  :   1.000000
SHUNT  REACTOR ZERO SEQUENCE IMPEDANCE MULT. FACTOR  :   0.625000
--------------------------------------------------------------------------------
BUS DATA
NODE STAT ZONE BUS-KV   NAME     VMAG-PU  VANG-DEG  PGEN-MW  QGEN-MR
                                           PLOAD-MW QLOAD-MR QCOMP-MR
---- ---- ---- -------- -------- -------- -------- -------- --------
   1    1    1  132.000     Bus1   1.0000    0.000    0.000    0.000
                                             0.000    0.000    0.000
   2    1    1  132.000     Bus2   1.0000    0.000    0.000    0.000
                                             0.000    0.000    0.000
   3    1    1  132.000     Bus3   1.0000    0.000    0.000    0.000
                                             0.000    0.000    0.000
   4    1    1  132.000     Bus4   1.0000    0.000    0.000    0.000
                                             0.000    0.000    0.000
   5    1    1  132.000     Bus5   1.0000    0.000    0.000    0.000
                                             0.000    0.000    0.000
```

TRANSMISSION LINE DATA

STAT	CKTS	FROM NODE	FROM NAME	TO NODE	TO NAME	RP(P.U) / RZ(P.U)	XP(P.U) / XZ(P.U)	BP/2(PU) / BZ/2(PU)	THERMAL RATING
3	1	1	Bus1	2	Bus2	0.02009	0.05997	0.00000	
						0.04017	0.11995	0.00000	100.00
3	1	1	Bus1	3	Bus3	0.08000	0.23996	0.00000	
						0.15496	0.48209	0.00000	100.00
3	1	2	Bus2	3	Bus3	0.05997	0.17998	0.00000	
						0.11995	0.36731	0.00000	100.00
3	1	2	Bus2	4	Bus4	0.05997	0.17998	0.00000	
						0.11995	0.36731	0.00000	100.00
3	1	2	Bus2	5	Bus5	0.03994	0.12001	0.00000	
						0.08035	0.24105	0.00000	100.00
3	1	3	Bus3	4	Bus4	0.00999	0.02996	0.00000	
						0.02009	0.05992	0.00000	100.00
3	1	4	Bus4	5	Bus5	0.08000	0.23996	0.00000	
						0.15496	0.48209	0.00000	100.00

GENERATOR DATA

FROM NODE	FROM NAME	POSITIVE R(P.U)	POSITIVE X(P.U.)	NEGATIVE R(P.U.)	NEGATIVE X(P.U.)	ZERO R(P.U.)	ZERO X(P.U.)	MVA RATING	STAT
1	Bus1	0.00000	0.25000	0.00000	0.01000	0.00000	0.01000	100	3
2	Bus2	0.00000	0.25000	0.00000	0.01000	0.00000	0.01000	100	3

LOAD DATA

NODE	NAME	STATUS
2	Bus2	3
3	Bus3	3
4	Bus4	3
5	Bus5	3

GENERATOR DATA FOR MINIMUM GENERATION

FROM NODE	FROM NAME	POSITIVE R(P.U)	POSITIVE X(P.U.)	NEGATIVE R(P.U.)	NEGATIVE X(P.U.)	ZERO R(P.U.)	ZERO X(P.U.)	MVA RATING	STAT
1	Bus1	0.00000	0.25000	0.00000	0.01000	0.00000	0.01000	100	3
2	Bus2	0.00000	0.25000	0.00000	0.01000	0.00000	0.01000	100	3

```
--------------------------------------------------------------------------------
CO-ORDINATION TYPE                    :    0 (DISTANCE RELAY CO-ORDIN)
--------------------------------------------------------------------------------
NUMBER OF DISTANCE RELAYS             :   14
--------------------------------------------------------------------------------
SIMULATION STATUS                     :    1 (SIMULATION)
--------------------------------------------------------------------------------

  The entries in different columns of Distance relay data
  are as follows -

RELAY NAME  : Name of the relay, the size should not exceed 8 characters.
ELMN-NUMB   : Series element number on which the relay is located.
LINE-LNTH   : The length of the transmission line on which the relay is
              located.
FOR/REV     : 1 if relay is located on from side of the series element.
              2 if relay is located on to side of the series element.
CTPRI       : Current transformer primary rating in amperes.
CTSE        : Current transformer secondary rating in amperes.
PTPR        : Potential transformer primary rating in Kv.
PTSE        : Potential transformer secondary rating in volts.
LOAD IMP
R (P.U)     : Apparent load resistance in p.u determined using load flow
              results.
X (P.U)     : Apparent load reactance in p.u determined using load flow
              results.
Z1 REACH    : Percentage of the primary line impedance for which the
              relay should operate instantaneously.
Z2 REACH    : Percentage of shortest line impedance in the adjacent section
              for which the relay provides backup protection.
Z3 REACH    : Percentage of the longest line impedance connected to the
              remote bus of the shortest adjacent section for which the
              relay provides backup protection.
Z2 DIS TIME : The co-ordination time interval between zone1 and zone2
              in seconds.
Z3 DIS TIME : The co-ordination time interval between zone2 and zone3
              in seconds.
RELAY DBASE : The relay type number.

--------------------------------------------------------------------------------
DISTANCE RELAY DATA

               RELAY      ELMN LINE  FOR/ CTPR CTSE PTPR PTSE   LOAD IMP      Z1
REACH Z2 REACH
                NAME      NUMB LNTH  REV  AMPS  AMP   KV VOLT   R(P.U) X(P.U)
PERCENT  PERCENT
                                              Z3 REACH Z2 DIS   Z3 DIS    Z4 REACH
Z4     RELAY
                                                PERCENT   TIME     TIME    PERCENT
TIME   DBASE
```

```
------------------- ---- ----- ---- ---- ---- ---- ---- -------- ------ --------
                Dr1    1  1.00    1  400    5  132  110  999.990 999.99       80
40
                                                100  0.500    0.800       20
1.000        0
                Dr2    1  1.00    2  400    5  132  110  999.990 999.99       80
40
                                                100  0.500    0.800       20
1.000        0
                Dr3    2  1.00    1  400    5  132  110  999.990 999.99       80
40
                                                100  0.500    0.800       29
1.000        0
                Dr4    2  1.00    2  400    5  132  110  999.990 999.99       80
40
                                                100  0.500    0.800       20
1.000        0
                Dr5    3  1.00    1  400    5  132  110  999.990 999.99       80
40
                                                100  0.500    0.800       20
1.000        0
                Dr6    3  1.00    2  400    5  132  110  999.990 999.99       80
40
                                                100  0.500    0.800       20
1.000        0
                Dr7    4  1.00    1  400    5  132  110  999.990 999.99       80
40
                                                100  0.500    0.800       20
1.000        0
                Dr8    4  1.00    2  400    5  132  110  999.990 999.99       80
40
                                                100  0.500    0.800       20
1.000        0
                Dr9    5  1.00    1  400    5  132  110  999.990 999.99       80
40
                                                100  0.500    0.800       20
1.000        0
               Dr10    6  1.00    1  400    5  132  110  999.990 999.99       80
40
                                                100  0.500    0.800       20
1.000        0
               Dr11    6  1.00    2  400    5  132  110  999.990 999.99       80
40
                                                100  0.500    0.800       20
1.000        0
               Dr12    7  1.00    1  400    5  132  110  999.990 999.99       80
40
                                                100  0.500    0.800       20
1.000        0
               Dr13    7  1.00    2  400    5  132  110  999.990 999.99       80
```

```
40
                                                  100  0.500    0.800       20
1.000        0
                Dr14    5  1.00    2  400    5  132  110  999.990 999.99       80
40
                                                  100  0.500    0.800       20
1.000        2
-------------------------------------------------------------------------------
DISCRIMINATION TIME                    :    0.40
-------------------------------------------------------------------------------
NUMBER OF FAULTS SIMULATED             :    1
-------------------------------------------------------------------------------
SERIES ELEMENT PERCENT FAULTTYPE
    NUMBER     LINE
-------------- ------- ---------
             1   50.00         1 (3 PHASE TO GROUND FAULT)
-------------------------------------------------------------------------------
              RELAY ELEMENT FROM BUS FROM BUS TO BUS   TO BUS RELAY LOCATION
                NAME  NUMBER   NUMBER     NAME NUMBER     NAME      (FROM/TO)
                                                        BUS NAME
------------------- ------- -------- -------- ------ -------- --------------
                Dr1       1        1     Bus1      2     Bus2           Bus1
                Dr2       1        1     Bus1      2     Bus2           Bus2
                Dr3       2        1     Bus1      3     Bus3           Bus1
                Dr4       2        1     Bus1      3     Bus3           Bus3
                Dr5       3        2     Bus2      3     Bus3           Bus2
                Dr6       3        2     Bus2      3     Bus3           Bus3
                Dr7       4        2     Bus2      4     Bus4           Bus2
                Dr8       4        2     Bus2      4     Bus4           Bus4
                Dr9       5        2     Bus2      5     Bus5           Bus2
               Dr10       6        3     Bus3      4     Bus4           Bus3
               Dr11       6        3     Bus3      4     Bus4           Bus4
               Dr12       7        4     Bus4      5     Bus5           Bus4
               Dr13       7        4     Bus4      5     Bus5           Bus5
               Dr14       5        2     Bus2      5     Bus5           Bus5
-------------------------------------------------------------------------------
Number of phase relays 14 Number of earth relays 0
-------------------------------------------------------------------------------
DISTANCE RELAY PAIRS
--------------------
PRIMARY           RELAY NAME BACK UP           RELAY NAME
------- -------------------- ------- --------------------
      5                  Dr5       1                  Dr1
      7                  Dr7       1                  Dr1
      9                  Dr9       1                  Dr1
      3                  Dr3       2                  Dr2
      6                  Dr6       3                  Dr3
     10                 Dr10       3                  Dr3
      1                  Dr1       4                  Dr4
      4                  Dr4       5                  Dr5
     10                 Dr10       5                  Dr5
```

2	Dr2	6	Dr6
7	Dr7	6	Dr6
9	Dr9	6	Dr6
11	Dr11	7	Dr7
12	Dr12	7	Dr7
2	Dr2	8	Dr8
5	Dr5	8	Dr8
9	Dr9	8	Dr8
13	Dr13	9	Dr9
8	Dr8	10	Dr10
12	Dr12	10	Dr10
4	Dr4	11	Dr11
6	Dr6	11	Dr11
14	Dr14	12	Dr12
8	Dr8	13	Dr13
11	Dr11	13	Dr13
2	Dr2	14	Dr14
5	Dr5	14	Dr14
7	Dr7	14	Dr14

PHASE/ZERO ZONE REACH (COMPUTED)

RELAY NAME	ZONE1 SETTING PH-PH	ZONE2 SETTING IN DEG PH-PH	ZONE3 SETTING PH-PH	ZONE4 SETTING (msecs) PH-PH	ZONE1 SETTING PH-E	ZONE2 SETTING PH-E	ZONE3 SETTING PH-E	ZONE4 SETTING PH-E	ZONE2 TIME (s)	ZONE3 TIME (s)	ZONE4 TIME (s)	APP.IMP BUS RM	FAR BUS	CH ANG	Z0 COMP L/R
Dr1	0.5877	1.3223	5.1421	-0.147	1.1755	2.6500	10.3030	-0.294	0.500	1.300	2.300		3.9864	71	0.333
Dr2	0.5877	1.9099	5.8765	-0.147	1.1755	3.8222	11.8398	-0.294	0.500	1.300	2.300		3.2520	71	0.333
Dr3	2.3506	3.0849	6.2433	-0.852	4.7057	6.1758	12.4983	-1.706	0.500	1.300	2.300		3.6813	72	0.336
Dr4	2.3506	3.2321	5.8765	-0.588	4.7057	6.4699	11.8399	-1.176	0.500	1.300	2.300	NO RM	BUS	72	0.336
Dr5	1.7629	2.3504	5.5087	-0.441	3.5907	4.7821	11.1046	-0.898	0.500	1.300	2.300		2.9282	72	0.347
Dr6	1.7629	2.4975	5.8765	-0.441	3.5907	5.0762	11.8399	-0.898	0.500	1.300	2.300	NO RM	BUS	72	0.347
Dr7	1.7629	2.3504	5.5087	-0.441	3.5907	4.7821	11.1046	-0.898	0.500	1.300	2.300		2.2037	72	0.347
Dr8	1.7629	2.4975	5.8765	-0.441	3.5907	5.0762	11.8399	-0.898	0.500	1.300	2.300	NO RM	BUS	72	0.347
Dr9	1.1754	2.6445	6.6111	-0.294	2.3612	5.3043	13.3219	-0.590	0.500	1.300	2.300		4.4074	72	0.336
Dr10	0.2935	1.2483	4.7742	-0.073	0.5873	2.5295	9.7109	-0.147	0.500	1.300	2.300		0.3669	72	0.333
Dr11	0.2935	1.2483	4.7742	-0.073	0.5873	2.5295	9.7109	-0.147	0.500	1.300	2.300	NO RM	BUS	72	0.333
Dr12	2.3506	3.5259	6.6111	-0.588	4.7057	7.0627	13.3219	-1.176							

```
0.500 1.300 2.300  NO RM BUS     72   0.336   9.548
                Dr13  2.3506  3.0849  6.2433  -0.588  4.7057  6.1758 12.4983  -1.176
0.500 1.300 2.300     2.9382     72   0.336   9.548
                Dr14  1.1754  1.7631  5.1421  -0.294  2.3612  3.5393 10.3030  -0.590
0.500 1.300 2.300     2.9382     72   0.336   9.564
--------------------------------------------------------------------------------
PHASE/ZERO ZONE REACH (SET VALUES)
--------------------------------------------------------------------------------
               RELAY RELAY    QUANTITY          ZONE1                ZONE2
ZONE3                  ZONE4             ZONE1                ZONE2
ZONE3                  ZONE4           REMARKS
                NAME TYPE                 PHASE SETTING        PHASE SETTING
PHASE SETTING          PHASE SETTING     EARTH SETTING        EARTH SETTING
EARTH SETTING          EARTH SETTING
-------------------- -------- --------- ---------- --------- ---------- ---------
                 Dr1   RED670 RES\REACT     0.1900    0.5600     0.4200     1.260
1.6300    4.8800     0.0500     0.150     0.3800     1.120     0.8400     2.520
3.2100    9.8000     0.1000     0.290 RES\REACT
                 Dr2   RED670 RES\REACT     0.1900    0.5600     0.6100     1.820
1.8700    5.5800     0.0500     0.150     0.3800     1.120     1.1900     3.640
3.6900   11.2600     0.1000     0.290 RES\REACT
                 Dr3   RED670 RES\REACT     0.7500    2.2300     0.9800     2.930
1.9800    5.9300     0.2800     0.810     1.4500     4.480     1.9000     5.880
3.8300   11.9000     0.5300     1.630 RES\REACT
                 Dr4   RED670 RES\REACT     0.7500    2.2300     1.0300     3.070
1.8600    5.5800     0.1900     0.560     1.4500     4.480     1.9900     6.160
3.6500   11.2700     0.3700     1.120 RES\REACT
                 Dr5   RED670 RES\REACT     0.5600    1.6800     0.7500     2.230
1.7500    5.2300     0.1500     0.430     1.1200     3.420     1.4900     4.550
3.4300   10.5700     0.2900     0.860 RES\REACT
                 Dr6   RED670 RES\REACT     0.5600    1.6800     0.7900     2.370
1.8600    5.5800     0.1500     0.430     1.1200     3.420     1.5800     4.830
3.6600   11.2700     0.2900     0.860 RES\REACT
                 Dr7   RED670 RES\REACT     0.5600    1.6800     0.7500     2.230
1.7500    5.2300     0.1500     0.430     1.1200     3.420     1.4900     4.550
3.4300   10.5700     0.2900     0.860 RES\REACT
                 Dr8   RED670 RES\REACT     0.5600    1.6800     0.7900     2.370
1.8600    5.5800     0.1500     0.430     1.1200     3.420     1.5800     4.830
3.6600   11.2700     0.2900     0.860 RES\REACT
                 Dr9   RED670 RES\REACT     0.3800    1.1200     0.8400     2.510
2.0900    6.2800     0.1000     0.290     0.7500     2.250     1.6600     5.050
4.1700   12.6600     0.1900     0.570 RES\REACT
                Dr10   RED670 RES\REACT     0.1000    0.2800     0.4000     1.190
1.5100    4.5300     0.0300     0.100     0.1900     0.560     0.8000     2.410
3.0300    9.2300     0.0500     0.150 RES\REACT
                Dr11   RED670 RES\REACT     0.1000    0.2800     0.4000     1.190
1.5100    4.5300     0.0300     0.100     0.1900     0.560     0.8000     2.410
3.0300    9.2300     0.0500     0.150 RES\REACT
                Dr12   RED670 RES\REACT     0.7500    2.2300     1.1200     3.350
2.1000    6.2800     0.1900     0.560     1.4500     4.480     2.1800     6.720
4.1100   12.6800     0.3700     1.120 RES\REACT
```

```
                Dr13   RED670 RES\REACT     0.7500    2.2300     0.9800     2.930
1.9800    5.9300     0.1900     0.560     1.4500     4.480     1.9000     5.880
3.8300   11.9000     0.3700     1.120 RES\REACT
                Dr14   REL521 RES\REACT     0.3800    1.1200     0.5600     1.680
1.6300    4.8800     0.1000     0.290     0.7500     2.250     1.1200     3.360
3.2000    9.8000     0.1900     0.570 RES\REACT
-------------------------------------------------------------------------------
LOAD IMPEDANCE
-------------------------------------------------------------------------------
RELAY NAME           EMERGENCY LOAD  EMERGENCY IMP
                     IMPEDANCE                ANGLE
-------------------- --------------- -------------
                 Dr1          8.4681         45.57
                 Dr2          8.4681         45.57
                 Dr3          8.4681         45.57
                 Dr4          8.4681         45.57
                 Dr5          8.4681         45.57
                 Dr6          8.4681         45.57
                 Dr7          8.4681         45.57
                 Dr8          8.4681         45.57
                 Dr9          8.4681         45.57
                Dr10          8.4681         45.57
                Dr11          8.4681         45.57
                Dr12          8.4681         45.57
                Dr13          8.4681         45.57
                Dr14          8.4681         45.57
-------------------------------------------------------------------------------
RESISTIVE REACH (COMPUTED\SET VALUE)
-------------------------------------------------------------------------------
RELAY NAME           PH-PH ZONE 1 PH-PH ZONE 2 PH-PH ZONE 3 PH-ER ZONE 1 PH-ER ZONE
2 PH-ER ZONE 3
-------------------- ------------ ------------ ------------ ------------ ---------
                 Dr1  1.115\ 1.12  2.508\ 2.51  7.621\ 7.63  1.672\ 1.68  3.763\
3.77  7.621\ 7.63
                 Dr2  1.115\ 1.12  3.623\ 3.63  7.621\ 7.63  1.672\ 1.68  5.435\
5.44  7.621\ 7.63
                 Dr3  4.460\ 4.46  5.853\ 5.86  7.621\ 7.63  6.690\ 6.69  7.621\
7.63  7.621\ 7.63
                 Dr4  4.460\ 4.46  6.132\ 6.14  7.621\ 7.63  6.690\ 6.69  7.621\
7.63  7.621\ 7.63
                 Dr5  3.345\ 3.35  4.460\ 4.46  7.621\ 7.63  5.018\ 5.02  6.690\
6.69  7.621\ 7.63
                 Dr6  3.345\ 3.35  4.739\ 4.74  7.621\ 7.63  5.018\ 5.02  7.108\
7.11  7.621\ 7.63
                 Dr7  3.345\ 3.35  4.460\ 4.46  7.621\ 7.63  5.018\ 5.02  6.690\
6.69  7.621\ 7.63
                 Dr8  3.345\ 3.35  4.739\ 4.74  7.621\ 7.63  5.018\ 5.02  7.108\
7.11  7.621\ 7.63
                 Dr9  2.230\ 2.24  5.018\ 5.02  7.621\ 7.63  3.346\ 3.35  7.527\
7.53  7.621\ 7.63
                Dr10  0.557\ 0.56  2.369\ 2.37  7.621\ 7.63  0.835\ 0.84  3.553\
```

```
3.56  7.621\ 7.63
                Dr11  0.557\ 0.56  2.369\ 2.37  7.621\ 7.63  0.835\ 0.84  3.553\
3.56  7.621\ 7.63
                Dr12  4.460\ 4.46  6.690\ 6.69  7.621\ 7.63  6.690\ 6.69  7.621\
7.63  7.621\ 7.63
                Dr13  4.460\ 4.46  5.853\ 5.86  7.621\ 7.63  6.690\ 6.69  7.621\
7.63  7.621\ 7.63
                Dr14  3.346\ 3.35  5.019\ 5.02  5.019\ 5.02  5.019\ 5.02  7.528\
7.53  7.528\ 7.53
-------------------------------------------------------------------------------
RAZOA RELAY SETTINGS
-------------------------------------------------------------------------------
RELAY NAME           a      b      P1     P2     P3     START RELAY ZMAX ZONE3
OVERREACH A     B
-------------------- ------ ------ ------ ------ ------ ---------------- ---------
RESIDUAL COMPENSATION SET VALUE
-------------------------------------------------------------------------------
RELAY NAME           ZONE 1                    ZONE 2                    ZONE 3
REMARKS
-------------------- ------------ ------------ ------------ ------------ ---------
                 Dr1  0.333\ 0.34  0.333\ 0.34  0.335\ 0.34  0.335\ 0.34  0.322\
0.33  0.336\ 0.34 RESISTIVE/REACTIVE
                 Dr2  0.333\ 0.34  0.333\ 0.34  0.320\ 0.33  0.335\ 0.34  0.327\
0.33  0.340\ 0.34 RESISTIVE/REACTIVE
                 Dr3  0.312\ 0.32  0.336\ 0.34  0.314\ 0.32  0.336\ 0.34  0.312\
0.32  0.336\ 0.34 RESISTIVE/REACTIVE
                 Dr4  0.312\ 0.32  0.336\ 0.34  0.314\ 0.32  0.336\ 0.34  0.320\
0.33  0.340\ 0.35 RESISTIVE/REACTIVE
                 Dr5  0.333\ 0.34  0.347\ 0.35  0.334\ 0.34  0.346\ 0.35  0.321\
0.33  0.340\ 0.35 RESISTIVE/REACTIVE
                 Dr6  0.333\ 0.34  0.347\ 0.35  0.333\ 0.34  0.345\ 0.35  0.322\
0.33  0.340\ 0.35 RESISTIVE/REACTIVE
                 Dr7  0.333\ 0.34  0.347\ 0.35  0.334\ 0.34  0.346\ 0.35  0.321\
0.33  0.340\ 0.35 RESISTIVE/REACTIVE
                 Dr8  0.333\ 0.34  0.347\ 0.35  0.333\ 0.34  0.345\ 0.35  0.322\
0.33  0.340\ 0.35 RESISTIVE/REACTIVE
                 Dr9  0.337\ 0.34  0.336\ 0.34  0.326\ 0.33  0.336\ 0.34  0.330\
0.34  0.339\ 0.34 RESISTIVE/REACTIVE
                Dr10  0.337\ 0.34  0.333\ 0.34  0.334\ 0.34  0.343\ 0.35  0.336\
0.34  0.346\ 0.35 RESISTIVE/REACTIVE
                Dr11  0.337\ 0.34  0.333\ 0.34  0.334\ 0.34  0.343\ 0.35  0.336\
0.34  0.346\ 0.35 RESISTIVE/REACTIVE
                Dr12  0.312\ 0.32  0.336\ 0.34  0.316\ 0.32  0.336\ 0.34  0.321\
0.33  0.340\ 0.35 RESISTIVE/REACTIVE
                Dr13  0.312\ 0.32  0.336\ 0.34  0.314\ 0.32  0.336\ 0.34  0.312\
0.32  0.336\ 0.34 RESISTIVE/REACTIVE
                Dr14
```

```
--------------------------------------------------------------------------------
ARC AND TOWER FOOTING RESISTANCE
--------------------------------------------------------------------------------
RELAY NAME           PH-PH ZONE 1 PH-PH ZONE 2 PH-PH ZONE 3 PH-E ZONE 1 PH-E ZONE 2
PH-E ZONE 3
-------------------- ------------ ------------ ------------ ----------- ----------
                Dr1       0.2411       0.2411       0.2411       0.7987
0.7980       0.7987
                Dr2       0.2411       0.2411       0.2411       0.7987
0.7980       0.7987
                Dr3       0.2411       0.2411       0.2411       0.7987
0.7980       0.7987
                Dr4       0.2411       0.2411       0.2411       0.7987
0.7980       0.7987
                Dr5       0.2411       0.2411       0.2411       0.7987
0.7980       0.7987
                Dr6       0.2411       0.2411       0.2411       0.7987
0.7980       0.7987
                Dr7       0.2411       0.2411       0.2411       0.7987
0.7980       0.7987
                Dr8       0.2411       0.2411       0.2411       0.7987
0.7980       0.7987
                Dr9       0.2411       0.2411       0.2411       0.7987
0.7980       0.7987
               Dr10       0.2411       0.2411       0.2411       0.7987
0.7980       0.7987
               Dr11       0.2411       0.2411       0.2411       0.7987
0.7980       0.7987
               Dr12       0.2411       0.2411       0.2411       0.7987
0.7980       0.7987
               Dr13       0.2411       0.2411       0.2411       0.7987
0.7980       0.7987
               Dr14       0.2411       0.2411       0.2411       0.7987
0.7980       0.7987
--------------------------------------------------------------------------------
PHASE SELECTION SETTINGS
--------------------------------------------------------------------------------
RELAY NAME           PH-PH ZONE 1 PH-PH ZONE 2 PH-EE ZONE 1 PH-ER ZONE 2
-------------------- ------------ ------------ ------------ ------------
                Dr1        5.370        5.370       10.780        8.390
10.760
                Dr2        6.140        6.140       12.380        8.390
11.100
                Dr3        6.520        6.520       13.090        8.390
11.240
                Dr4        6.140        6.140       12.400        8.390
11.090
                Dr5        5.750        5.750       11.630        8.390
10.920
                Dr6        6.140        6.140       12.390        8.390
```

11.090

Dr7	5.750	5.750	11.630	8.390

10.920

Dr8	6.140	6.140	12.390	8.390

11.090

Dr9	6.900	6.900	13.930	8.390

11.450

Dr10	4.990	4.990	10.150	8.390

10.610

Dr11	4.990	4.990	10.150	8.390

10.610

Dr12	6.900	6.900	13.950	8.390

11.430

Dr13	6.520	6.520	13.090	8.390

11.240

Dr14	1.7900	5.3700	8.9000	10.7800

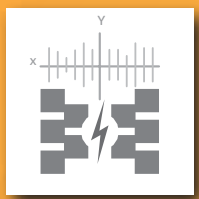
POWER SWING BLOCKING

RELAY NAME	R1-IN	X1-IN	R1-OUT	X1-OUT
Dr1	6.780	6.780	8.130	8.130
Dr1	6.780	6.780	8.130	8.130
Dr2	6.780	6.780	8.130	8.130
Dr2	6.780	6.780	8.130	8.130
Dr3	6.780	6.780	8.130	8.130
Dr3	6.780	6.780	8.130	8.130
Dr4	6.780	6.780	8.130	8.130
Dr4	6.780	6.780	8.130	8.130
Dr5	6.780	6.780	8.130	8.130
Dr5	6.780	6.780	8.130	8.130
Dr6	6.780	6.780	8.130	8.130
Dr6	6.780	6.780	8.130	8.130
Dr7	6.780	6.780	8.130	8.130
Dr7	6.780	6.780	8.130	8.130
Dr8	6.780	6.780	8.130	8.130
Dr8	6.780	6.780	8.130	8.130
Dr9	6.780	6.780	8.130	8.130
Dr9	6.780	6.780	8.130	8.130
Dr10	6.780	6.780	8.130	8.130
Dr10	6.780	6.780	8.130	8.130
Dr11	6.780	6.780	8.130	8.130
Dr11	6.780	6.780	8.130	8.130
Dr12	6.780	6.780	8.130	8.130
Dr12	6.780	6.780	8.130	8.130
Dr13	6.780	6.780	8.130	8.130
Dr13	6.780	6.780	8.130	8.130
Dr14	7.310	5.370	8.130	8.130

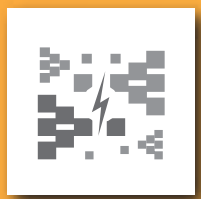
Protection Suite

PSCT | *Protection Analytic tool*

Power System Network Editor

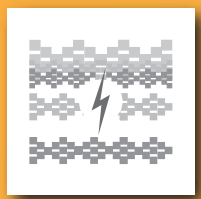


Graph Utility



Free Programmable Block

Database Manager



COMTRADE Viewer

LPC/CPC

Power Research & Development Consultants Pvt. Ltd.

5, 11th Cross, 2nd Stage, West of Chord Road, Bengaluru India - 560086.

Tel: +91-80-4245 5555 / 23192209, Fax: +91-80-4245 5556 / 23192210

Email: Info@prdcinfotech.com website: www.prdcinfotech.com