PASHA

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Chapter 11
Protection facilities in PASHA

11.1 Introduction

This part of manual describes the protection coordination facilities and analysis of the behavior of the relays within the PASHA package. These facilities include the simulation of phase and earth overcurrent, phase and earth distance, and unit protection schemes. The algorithms provide coordinated settings of the protective devices and for checking their performance both under steady state and transient conditions.

11.2 Overview of data organization in PASHA

To find out about the place of protection facilities in PASHA, an overview of what described in this manual is represented in this section.

A particular system is entered to PASHA by drawing the network on the terminal screen. For all the components the corresponding data arrays are generated automatically (chapter 3). To input the system parameters the user selects the edit option from the main PASHA and this enables him to access the appropriate data tables for all the groups of components in the network diagram.

Once the required data table is displayed the user selects with the graphic cursor the data item to be entered or modified, and inputs the corresponding value using the keyboard (chapter 4).

By selecting the save option from the main menu the user can store the network entered and the associated data on disc storage so that it may be retrieved later at any further PASHA session (chapter 5).

The data base facility in PASHA allows data of standard types of equipment to be stored centrally for access at any time. Network data can therefore, be entered either explicitly or by referring to the standard data base types. All the data base entries are stored automatically at the end of each PASHA session (chapter 9).

The protection data related to a particular system, such as the relay or fuse specified at a given location, the current transformer data or the device settings, have been included with the network data in the form of new sections within the edit facility. PASHA will automatically generate the drawing symbols of the protection elements into the single-line diagram. Therefore, on the contrary to the other elements there is no need to draw these elements on single-line diagram.

The characteristics of the available protective devices, on the other hand, have been included in the data base facility.

11.3 Database: protective device characteristics

This section has been configured to provide input, editing and storage facilities for all the protective device data required for the calculations, namely the operating characteristics and setting restrictions for relays and fuses. Figure 11.1 (also included in figure 9.1) shows the data base menu which displays additional options to enable access to the protection data base pages.

11.3.1 Overcurrent relays

The data base facilities for overcurrent relays have been represented on the basis of Sachdev's modified representation for the time-current characteristics. This model is described in Appendix F.

It has been organized in five data pages, the first three for data input and the last two for the display of the coefficients of the calculated model. The coefficients of user model may also be entered directly in these pages.


USE THE CURSOR TO SELECT ONE OF THE OPTIONS, OR TYPE 'H' FOR HELP
PRESENT DIRECTORY :
c:\pasha\forcabuw
SELECT TO CHANGE DATA BASE DIRECTORY
DATA BASE OPTIONS:
LINE DATA BASE
TRANSFORMER DATA BASE 1,2
GENERATOR DATA BASE 1,2
AVR DATA BASE 1,2
GOVERNOR AND TURBINE DATA BASE
INDUCTION MOTOR DATA BASE 1,2
PROTECTION DATA BASE -RELAYS 1,2,3,4,5
PROTECTION DATA BASE -FUSES 1,2,3,4
PROTECTION DATA BASE -DISTANCE RELAYS
CIRCUIT BREAKER DATA BASE
RELIBILITY DATA BASE
RETURN TO MAIN OPTIONS
DATA 1 1
DATA 2 2
DATA 3 3
DATA 4 4
DATA 5 5
COPYRIGHT (C) TOM InC 1988 TIME : 03:02:54 28/08/2001

Figure 11.1

11.3.1.1 Relays 1: general parameters

The first data page, 'relays 1', is used to define the relay type number, and the associated general parameters (see figure 11.2). Also, a 'name' containing up to 20 characters may be specified for each relay type, to provide a convenient reference (of make, model, etc.) For the user. The general parameters to be defined for each relay are:

TYPE : Any positive integer (up to 7 digits) to be used as a unique identifier for a relay. Once a number is entered here, it will be automatically displayed on the rest of the pages.

MIN-TAP : Minimum plug setting, in (%) .

MAX-TAP : Maximum plug setting, in (%) .

TAP-STEP : Separation between taps, in (%) . A negative integer may be used to define a particular graded tap pattern: -1 corresponds to the pattern 25, 30, 37.5, 50, 60, 75 and 100 (%) of max-tap. Entering other negative integers reads file PASHAINT.FIL to find out the definition of tap steps. Description is available in PASHAINT.FIL. The steps may also be entered in Ampers.

MIN-IS : Minimum time dial setting.

MAX-TS : Maximum time dial setting**.**

RESET-TM : Resetting time in seconds, for the full disc travel (default value in analysis parameters 2).

RAT-AMPS : Relay rated current in amps (default value is 1.0).

Pressing key <G>, This option is shown on in-line green box. While the cursor is over the name of a relay pressing this key draws the characteristic of the relay in LOG-LOG axes. An example is shown in Figure 11.2(a).

PROTECTION DATA BASE -RELAYS 1: General parameters PAGE 1 OF 2

NAME	TYPE	PLUG SETTING MIN-TAP	MAX-TAP	TAP-STEP	TIME DIAL MIN-TS	MAX-TS	RESET-TM	RAT-AMPS	PASSWORD
IAC 51&52 O/C 0.5-2	1311	10.00	40.00	-3.00	0.50	10.00		5.00	
IAC 51&52 O/C 1.5-6	2311	30.00	120.00	-4.00	0.50	10.00		5.00	
IAC 51&52 O/C 4-16	3311	80.00	320.00	-5.00	0.50	10.00		5.00	
IAC 51&52 O/C 0.5-16	311	10.00	320.00	-2.00	0.50	10.00		5.00	
IBC 51&52 D/C 0.5-2	1411	10.00	40.00	-3.00	0.50	10.00		5.00	
IBC 51&52 D/C 1.5 6	2411	30.00	120.00	-4.00	0.50	10.00		5.00	
IBC 51&52 D/C 4-16	3411	80.00	320.00	-5.00	0.50	10.00		5.00	
IBC 51&52 D/C 0.5-16	411	10.00	320.00	-2.00	0.50	10.00		5.00	
IBC 53&54 D/C 0.5-2	1511	10.00	40.00	-3.00	0.50	10.00		5.00	
IBC 53&54 D/C 1.5-6	2511	30.00	120.00	-4.00	0.50	10.00		5.00	
IBC 53&54 D/C 4-16	3511	80.00	320.00	-5.00	0.50	10.00		5.00	
IBC 53&54 D/C 0.5-16	511	10.00	320.00	-2.00	0.50	10.00		5.00	
IBC 77&78 D/C .5-2	1611	10.00	40.00	-3.00	0.50	10.00		5.00	
IBC 77&78 D/C 1.5-6	2611	30.00	120.00	-4.00	0.50	10.00		5.00	
IBC 77&78 D/C 4-16	3611	80.00	320.00	-5.00	0.50	10.00		5.00	
IBC 77&78 D/C 0.5-16	611	10.00	320.00	-2.00	0.50	10.00		5.00	
PMR 410 MOTOR PROT.	4101	40.00	200.00	1.00	1.00	50.00		5.00	
PMR 410G MOTOR PROT	4100	10.00	50.00	10.00	0.05	0.60		1.00	
IO-L-B1 E/F PROT.	1711	10.00	100.00	0.50	0.50	10.00		2.00	
IOM-C-3B1 O/C PROT.	2711	10.00	100.00	1.00	0.50	10.00		5.00	
UHG-B1 D/C 0.25-2	4411	5.00	400.00	0.10	0.50	1.00		5.00	
CTMF-305 E/F MOT TOM	5100	10.00	50.00	2.00	0.10	0.60		1.00	
CTMF-305 O/C MOT TOM	5101	40.00	200.00	2.00	1.00	50.00		5.00	
IO-C-B1 O/C PROT.	2811	60.00	240.00	0.10	0.50	10.00		5.00	
ASEA RXPE D/C PROT.	6312	5.00	320.00	1.00	1.00	4.00		5.00	
DMX355CT E/F MOT PRO	3550	10.00	100.00	10.00	3.50	38.50		5.00	
DMX355CT MOT. PRO TH	3551	10.00	200.00	10.00	3.50	38.50		5.00	
ASEA RXIDF O/C PROT.	7311	10.00	400.00	5.00	0.30	6.60	0.08	5.00	
ASEA RXIG E/F PROT.	6313	2.00	6.00	0.20	0.20	3.00	0.05	5.00	
ASEA RXIDF E/F PROT.	7313	2.00	8.00	0.10	0.10	2.20	0.08	5.00	

OPTIONS:

REDISPLAY
NEXT PAGE

HELP
RETURN

Press:
G to see characteristic

Any other to enter data

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Figure 11.2

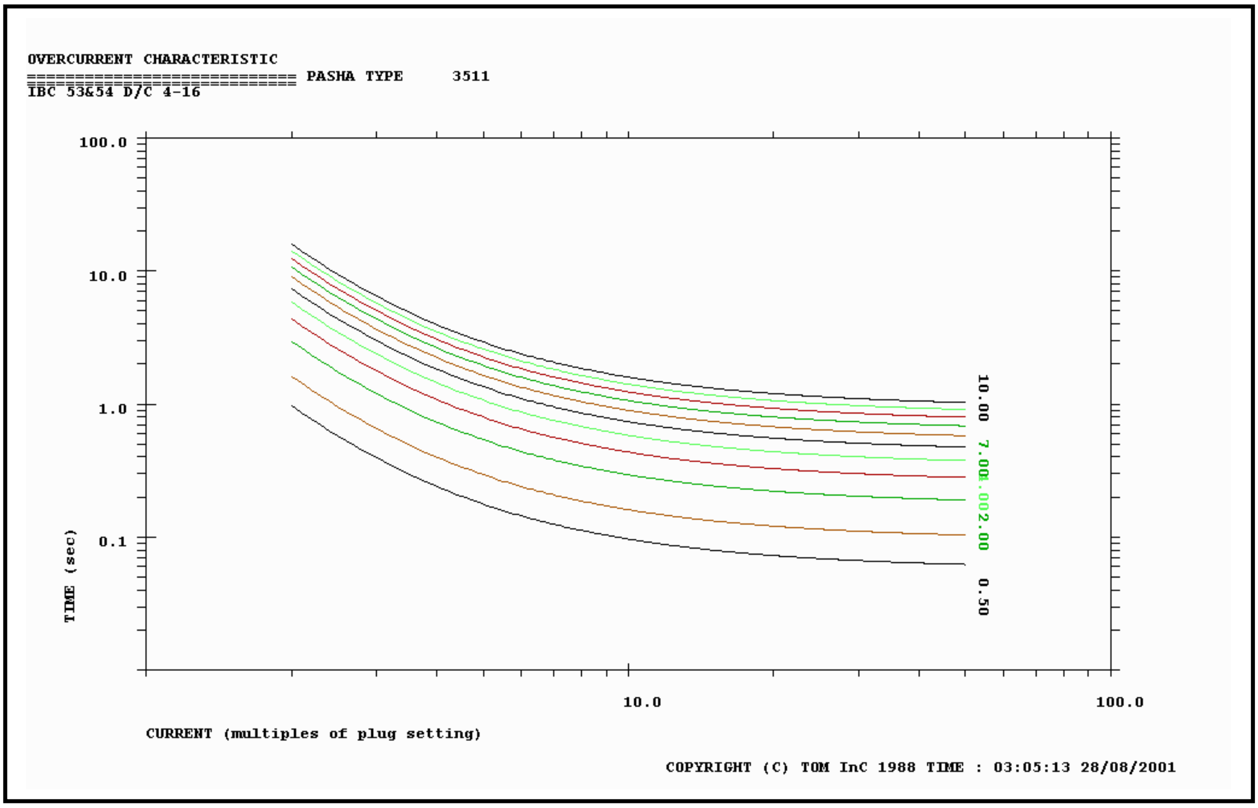

Figure 11.2(a)

11.3.1.2 Relays 2: manufacturer's time-current characteristic

This data page enables the user to enter the points for the time-current characteristic corresponding to the maximum time dial setting (MAX-IS) specified in relays 1. As shown in figure 11.3 two lines are used for each relay

Type: PASHA relay type as specified in relays 1 database page.
I-PSM , O-PSM : The first for the currents, in multiples of setting current (or pick-up) ; and the second for the corresponding operating times, in seconds. Immediately after the latter set of data has been entered a least squares curve fitting routine calculates the coefficients of equation F.1 (refer to Appendix F). These results are displayed in relays 4 (figure 11.4). The maximum error obtained in the curve fitting is also given, together with the value of current for it. This enables the user to check for any mistakes in the data and to gain some reassurance on the accuracy of the model.

Prior to this calculation the specified points are checked, and an appropriate error message is given whenever the calculation cannot proceed. At least 5 data pairs are required, and currents equal or less than 1.0 are not allowed.

To illustrate this, data for many relays (including IBC, and ASEA) are shown in figure 11.3 and the corresponding model parameters displayed in figure 11.4 .

PROTECTION DATA BASE -RELAYS 2: Manufac.op.time-m.pick up charac. PAGE 1 OF 4

TYPE	I-PSM-1 O-TIM-1	I-PSM-2 O-TIM-2	I-PSM-3 O-TIM-3	I-PSM-4 O-TIM-4	I-PSM-5 O-TIM-5	I-PSM-6 O-TIM-6	I-PSM-7 O-TIM-7	I-PSM-8 O-TIM-8	I-PSM-9 O-TIM-9	I-PSM10 O-TIM10	I-PSM11 O-TIM11	I-PSM12 O-TIM12	I-PSM13 O-TIM13	PASSWORD
1311	2.00	2.50	3.00	3.50	4.00	4.50	5.00	6.00	8.00	10.00	20.00	50.00		
	9.50	7.05	5.90	5.20	4.72	4.40	4.10	3.60	3.10	2.75	2.10	1.64		
2311	2.00	2.50	3.00	3.50	4.00	4.50	5.00	6.00	8.00	10.00	20.00	50.00		
	9.50	7.05	5.90	5.20	4.72	4.40	4.10	3.60	3.10	2.75	2.10	1.64		
3311	2.00	2.50	3.00	3.50	4.00	4.50	5.00	6.00	8.00	10.00	20.00	50.00		
	9.50	7.05	5.90	5.20	4.72	4.40	4.10	3.60	3.10	2.75	2.10	1.64		
311	2.00	2.50	3.00	3.50	4.00	4.50	5.00	6.00	8.00	10.00	20.00	50.00		
	9.50	7.05	5.90	5.20	4.72	4.40	4.10	3.60	3.10	2.75	2.10	1.64		
1411	2.00	2.50	3.00	4.00	5.00	6.00	7.00	8.00	10.00	20.00	30.00	40.00	50.00	
	0.75	0.60	0.53	0.44	0.39	0.36	0.33	0.32	0.30	0.25	0.23	0.22	0.20	
2411	2.00	2.50	3.00	4.00	5.00	6.00	7.00	8.00	10.00	20.00	30.00	40.00	50.00	
	0.75	0.60	0.53	0.44	0.39	0.36	0.33	0.32	0.30	0.25	0.23	0.22	0.20	
3411	2.00	2.50	3.00	4.00	5.00	6.00	7.00	8.00	10.00	20.00	30.00	40.00	50.00	
	0.75	0.60	0.53	0.44	0.39	0.36	0.33	0.32	0.30	0.25	0.23	0.22	0.20	
411	2.00	2.50	3.00	4.00	5.00	6.00	7.00	8.00	10.00	20.00	30.00	40.00	50.00	
	0.75	0.60	0.53	0.44	0.39	0.36	0.33	0.32	0.30	0.25	0.23	0.22	0.20	
1511	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00	15.00	20.00	30.00	50.00	
	16.00	6.50	4.00	2.90	2.40	2.10	1.80	1.70	1.60	1.35	1.25	1.10	1.00	
2511	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00	15.00	20.00	30.00	50.00	
	16.00	6.50	4.00	2.90	2.40	2.10	1.80	1.70	1.60	1.35	1.25	1.10	1.00	
3511	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00	15.00	20.00	30.00	50.00	
	16.00	6.50	4.00	2.90	2.40	2.10	1.80	1.70	1.60	1.35	1.25	1.10	1.00	
511	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00	15.00	20.00	30.00	50.00	
	16.00	6.50	4.00	2.90	2.40	2.10	1.80	1.70	1.60	1.35	1.25	1.10	1.00	
1611	2.00	3.00	4.00	5.00	6.00	7.00	8.00	10.00	15.00	20.00	30.00	40.00		
	16.00	6.00	3.40	2.20	1.50	1.15	0.88	0.60	0.30	0.26	0.22	0.20		
2611	2.00	3.00	4.00	5.00	6.00	7.00	8.00	10.00	15.00	20.00	30.00	40.00		
	16.00	6.00	3.40	2.20	1.50	1.15	0.88	0.60	0.30	0.26	0.22	0.20		
3611	2.00	3.00	4.00	5.00	6.00	7.00	8.00	10.00	15.00	20.00	30.00	40.00	1.00	
	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	

OPTIONS:

- REDISPLAY
- NEXT PAGE
- HELP
- RETURN

Figure 11.3

PROTECTION DATA BASE -RELAYS 4: Model op.time-mult.pick up param. PAGE 1 OF 2

NAME	TYPE	COEF-A0	COEF-A1	COEF-A2	COEF-A3	COEF-A4	MAX.ERROR O.TIME(S)	FOR I= (PSM)
IAC 51&52 O/C 0.5-2	1311	1.3679	14.3280	-18.2234	18.7526	-6.7250	0.044	6.000
IAC 51&52 O/C 1.5-6	2311	1.3679	14.3280	-18.2234	18.7526	-6.7250	0.044	6.000
IAC 51&52 O/C 4-16	3311	1.3679	14.3280	-18.2234	18.7526	-6.7250	0.044	6.000
IAC 51&52 O/C 0.5-16	311	1.3679	14.3280	-18.2234	18.7526	-6.7250	0.044	6.000
IBC 51&52 D/C 0.5-2	1411	0.1914	1.0474	-1.2333	1.1515	-.4071	0.044	6.000
IBC 51&52 D/C 1.5 6	2411	0.1914	1.0474	-1.2333	1.1515	-.4071	0.012	50.000
IBC 51&52 D/C 4-16	3411	0.1914	1.0474	-1.2333	1.1515	-.4071	0.012	50.000
IBC 51&52 D/C 0.5-16	411	0.1914	1.0474	-1.2333	1.1515	-.4071	0.012	50.000
IBC 53&54 D/C 0.5-2	1511	0.9416	4.1786	16.1640	-3.7755	-1.5089	0.012	50.000
IBC 53&54 D/C 1.5-6	2511	0.9416	4.1786	16.1640	-3.7755	-1.5089	0.057	8.000
IBC 53&54 D/C 4-16	3511	0.9416	4.1786	16.1640	-3.7755	-1.5089	0.057	8.000
IBC 53&54 D/C 0.5-16	511	0.9416	4.1786	16.1640	-3.7755	-1.5089	0.057	8.000
IBC 77&78 D/C .5-2	1611	0.2053	-1.7565	55.5842	-77.5660	39.5330	0.057	8.000
IBC 77&78 D/C 1.5-6	2611	0.2053	-1.7565	55.5842	-77.5660	39.5330	0.036	15.000
IBC 77&78 D/C 4-16	3611	3.0000	0.0000	-.0000	-.0000		0.000	2.000
IBC 77&78 D/C 0.5-16	611	0.2053	-1.7565	55.5842	-77.5660	39.5330	0.036	15.000
PMR 410 MOTOR PROT.	4101	50.0008	-.0021	0.0000	0.0001	-.0000	-.003	1.500
PMR 410G MOTOR PROT	4100	0.6000	0.0000	-.0000	0.0000		0.000	1.500
IO-L-B1 E/F PROT.	1711	2.1902	3.2825	-11.4461	28.7079	-11.7449	0.098	5.000
IOM-C-3B1 O/C PROT.	2711	-4.6606	240.5372	-332.6560	422.4702	-195.6910	0.519	5.000
UHG-B1 D/C 0.25-2	4411	2.5868	77.7185	-157.7386	164.6086	-64.1421	-.729	4.000
CTMF-305 E/F MOT TOM	5100	0.6000	-.0001	0.0000	0.0000	-.0000	-.000	1.450
CTMF-305 O/C MOT TOM	5101	50.0008	-.0021	0.0000	0.0001	-.0000	-.003	1.500
IO-C-B1 O/C PROT.	2811	1.8833	3.4480	-.1538	-.5924	0.1975	-.300	2.330
ASEA RXPE D/C PROT.	6312	0.0768	5.1439	-2.3134	0.7435	-.0895	-.202	3.000
IMX355CT E/F MOT PRO	3550	-13.2872	228.6735	912.4401	-571.3945	123.5835	-.139	2.000
IMX355CT MOT. PRO TH	3551	-13.2872	228.6735	912.4401	-571.3945	123.5835	0.572	6.000
ASEA RXIDF O/C PROT.	7311	6.6000	-.0002	0.0003	0.0000	-.0000	0.000	400.000
ASEA RXIG E/F PROT.	6313	3.0000	0.0002	-.0001	-.0000	0.0000	0.000	2.000
ASEA RXIDF E/F PROT.	7313	2.2000	-.0002	0.0001	-.0000	-.0000	-.000	2.000

OPTIONS:

- REDISPLAY
- NEXT PAGE
- HELP
- RETURN

Figure 11.4

11.3.1.3 Relays 3: operating time - time dial characteristic

This data page enables the user to specify the data required for generating the family of relay characteristics. This is achieved by specifying the spread of the curves for a constant current. Figure 11.5 shows the layout of this data page. For each relay type the time dial settings should be entered on the first line, and the corresponding operating times on the second. Following the entry of these values a curve fitting calculation determines the coefficients of equation F.2. These values, together with maximum error obtained can be displayed in relays 5 (figure 11.6).

Before this calculation, data checks are performed and an appropriate error message is given whenever it cannot proceed. At least 4 data pairs are required and one must include the maximum time dial setting (MAX-IS).

Figure 11.5 shows the data entered for the relays. For many cases a constant current of 3.0 was used, which is the value recommended in the literature. The corresponding results are presented in figure 11.6.

11.3.1.4 Relays 4,5: models coefficeients

These data pages show the values of the parameters of the curve fitting coefficients as described in Appendix F. The maximum errors of curve fittings are also shown. The user may alter the data entered in pages 1,2 and 3 more accurately to reduce the errors.

In new version of PASHA you may also enter these parameters for the relays. A formula specifies its characteristics. Please refer to in-line help for more information on this

PROTECTION DATA BASE -RELAYS 3: Manuf.op.time-time dial charac. PAGE 1 OF 4

TYPE	T-SET-1 O-TIM-1	T-SET-2 O-TIM-2	T-SET-3 O-TIM-3	T-SET-4 O-TIM-4	T-SET-5 O-TIM-5	T-SET-6 O-TIM-6	T-SET-7 O-TIM-7	T-SET-8 O-TIM-8	T-SET-9 O-TIM-9	T-SET10 O-TIM10	T-SET11 O-TIM11	T-SET12 O-TIM12	T-SET13 O-TIM13	PASSWORD
1311	0.50	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00			
	0.17	0.30	0.52	0.73	0.98	1.20	1.45	1.72	2.10	2.40	2.80			
2311	0.50	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00			
	0.17	0.30	0.52	0.73	0.98	1.20	1.45	1.72	2.10	2.40	2.80			
3311	0.50	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00			
	0.17	0.30	0.52	0.73	0.98	1.20	1.45	1.72	2.10	2.40	2.80			
311	0.50	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00			
	0.17	0.30	0.52	0.73	0.98	1.20	1.45	1.72	2.10	2.40	2.80			
1411	0.50	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00			
	0.18	0.30	0.54	0.74	0.98	1.30	1.50	1.70	2.10	2.50	2.70			
2411	0.50	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00			
	0.18	0.30	0.54	0.74	0.98	1.30	1.50	1.70	2.10	2.50	2.70			
3411	0.50	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00			
	0.18	0.30	0.54	0.74	0.98	1.30	1.50	1.70	2.10	2.50	2.70			
411	0.50	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00			
	0.18	0.30	0.54	0.74	0.98	1.30	1.50	1.70	2.10	2.50	2.70			
1511	0.50	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00			
	0.10	0.16	0.29	0.43	0.59	0.72	0.90	1.10	1.20	1.40	1.60			
2511	0.50	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00			
	0.10	0.16	0.29	0.43	0.59	0.72	0.90	1.10	1.20	1.40	1.60			
3511	0.50	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00			
	0.10	0.16	0.29	0.43	0.59	0.72	0.90	1.10	1.20	1.40	1.60			
511	0.50	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00			
	0.10	0.16	0.29	0.43	0.59	0.72	0.90	1.10	1.20	1.40	1.60			
1611	0.50	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00			
	0.05	0.08	0.14	0.17	0.24	0.27	0.35	0.40	0.45	0.50	0.60			
2611	0.50	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00			
	0.05	0.08	0.14	0.17	0.24	0.27	0.35	0.40	0.45	0.50	0.60			
3611	0.50	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00			
	0.05	0.08	0.14	0.17	0.24	0.27	0.35	0.40	0.45	0.50	0.60			

OPTIONS:

REDISPLAY
NEXT PAGE

HELP
RETURN

 TIME : 03:07:01 28/08/2001

Figure 11.5

PROTECTION DATA BASE -RELAYS 5: Model op.time-time dial param. PAGE 1 OF 2

NAME	TYPE	COEF-B0	COEF-B1	COEF-B2	COEF-B3	MAX.ERROR O.TIME(S)	FOR TS=
IAC 51&52 O/C 0.5-2	1311	0.0221	0.0844	-.0025	0.0004	-.042	8.000
IAC 51&52 O/C 1.5-6	2311	0.0221	0.0844	-.0025	0.0004	-.042	8.000
IAC 51&52 O/C 4-16	3311	0.0221	0.0844	-.0025	0.0004	-.042	8.000
IAC 51&52 O/C 0.5-16	311	0.0221	0.0844	-.0025	0.0004	-.042	8.000
IBC 51&52 D/C 0.5-2	1411	0.0297	0.0801	0.0006	0.0001	-.042	8.000
IBC 51&52 D/C 1.5 6	2411	0.0297	0.0801	0.0006	0.0001	-.093	9.000
IBC 51&52 D/C 4-16	3411	0.0297	0.0801	0.0006	0.0001	-.093	9.000
IBC 51&52 D/C 0.5-16	411	0.0297	0.0801	0.0006	0.0001	-.093	9.000
IBC 53&54 D/C 0.5-2	1511	0.0216	0.0764	0.0024	-.0000	-.093	9.000
IBC 53&54 D/C 1.5-6	2511	0.0216	0.0764	0.0024	-.0000	-.039	7.000
IBC 53&54 D/C 4-16	3511	0.0216	0.0764	0.0024	-.0000	-.039	7.000
IBC 53&54 D/C 0.5-16	511	0.0216	0.0764	0.0024	-.0000	-.039	7.000
IBC 77&78 D/C .5-2	1611	0.0369	0.0987	-.0042	0.0004	-.039	7.000
IBC 77&78 D/C 1.5-6	2611	0.0369	0.0987	-.0042	0.0004	0.018	9.000
IBC 77&78 D/C 4-16	3611	0.0369	0.0987	-.0042	0.0004	0.018	9.000
IBC 77&78 D/C 0.5-16	611	0.0369	0.0987	-.0042	0.0004	0.018	9.000
PMR 410 MOTOR PROT.	4101	0.0002	0.0200	-.0000		-.000	1.000
PMR 410G MOTOR PROT	4100	-.0000	1.6667	-.0000	0.0000	-.000	0.050
IO-L-B1 E/F PROT.	1711	-.0000	0.1000	-.0000	0.0000	0.000	10.000
IOM-C-3B1 O/C PROT.	2711	-.0000	0.1000	-.0000	0.0000	0.000	10.000
UHG-B1 D/C 0.25-2	4411	-2.4892	12.4251	-17.9907	9.0546	-.019	0.700
CTMF-305 E/F MOT TOM	5100	0.0000	1.6666	0.0004	-.0004	-.000	0.200
CTMF-305 O/C MOT TOM	5101	0.0002	0.0200	-.0000		-.000	1.000
IO-C-B1 O/C PROT.	2811	-.0001	0.1003	-.0001	0.0000	0.004	6.000
ASEA RXPE D/C PROT.	6312	-.4668	0.9669	-.5501	0.1000	-.038	0.400
IMX355CT E/F MOT PRO	3550	-.0248	0.0350	-.0007	0.0000	0.000	2.000
IMX355CT MOT. PRO TH	3551	-.0248	0.0350	-.0007	0.0000	0.059	6.000
ASEA RXIDF O/C PROT.	7311	0.0000	0.1515	0.0000	-.0000	0.059	6.000
ASEA RXIG E/F PROT.	6313	-.0000	0.3333	-.0000	0.0000	0.000	0.300
ASEA RXIDF E/F PROT.	7313	0.0000	0.4545	-.0000	0.0000	-.000	1.500

OPTIONS:

REDISPLAY
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HELP
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 TIME : 03:08:25 28/08/2001

Figure 11.6

11.3.2 Fuses

For the storage of the fuse data required by the protection algorithms a specific model for the manufacturers' characteristics is implemented. Briefly, this model uses up to three linear segments (on log-log scales) to represent the pre-arcing time-current characteristic for a given 'reference' fuse rating. This curve may be extrapolated to represent the characteristic for other ratings or to define the upper limit (highest operating T-C characteristic) for a given time-current zone. Hence, a family of similar fuse characteristics or a set of time-current zones can be generated.

Alternatively, a more accurate simulation of the arcing times can be achieved if the I2T data are available. This model is described in more detail in appendix G.

The input and storage facilities for fuse characterizations have been organized in four data base pages. The last only intended for displaying the calculated model parameters.

11.3.2.1 Fuses 1: general parameters

This section enables the user to input and store the general parameters required by the fuse model. Each data base entry can be associated to either one particular fuse, or to a family of fuses with similar characteristics. The layout of this data page is shown in figure 11.7. The general parameters are:

TYPE : An integer number that identifies each data base entry

REF-AMPS : Rating in amps of the 'reference' fuse i.e., That which provides the time-current characteristic entered on fuses.

I2T-P.A. : Pre-arcing I2T for the reference fuse

I2T-TOT. : Total I2T in $(\text{kamps})^2$-sec, for the reference fuse at nominal voltage.

FUSING FACTOR : Ratio of the minimum fusing current to the rated current for the reference fuse (default in analysis parameters 2).

A short description of each type can be entered by selecting the area name at the left of the screen. It may contain up to 20 characters.

The I2T quantities are generally available from manufacturers. Some standard requires them to state the minimum recorded value for the pre-arcing I2T. And the maximum for the operating (pre-arcing and arcing) I2T. Hence, the difference corresponds to the highest possible arcing 'energy'. The model determines the arcing time by assuming that this energy is constant for any given current.

Whenever the I2T values are not entered. A time-current zone representation is assumed and time operating time is 'read' from the next curve specified.

Pressing key <G> while the cursor is over the name of a fuse draws the characteristic of the fuse in LOG-LOG axes. An example is shown in Figure 11.7(a).

PROTECTION DATA BASE -FUSES 1: General parameters PAGE 1 OF 1

NAME	TYPE	REF-AMPS	I2T-P.A. (KA)2-S	I2T-TOT. (KA)2-S	FUSING FACTOR	PASSWORD
K81SVX-200A	636	200	0.136	0.990	1.330	
KJIIII	637	200	0.136	0.990		
PMR 410 THERMIC CHA.	4101	100	10.000	60.000	1.010	
CLF-H50	638	200	0.136	0.990		
LN 160-800 THERMAL	160800	250	10.000	65.000	1.050	
LONG DELAY B1-B4	8005000	2500	10.000	2000.000	1.050	
GEC 200 A FUSE	901	200	0.100	0.350	1.250	
GEC 300 A FUSE	902	300	0.100	0.350		
B.S.88 PT.2 *1975*	800	200				
B.S.88 PT.5 *1988*	882	200				
I2T DATA ENTERED	885	200	0.105	0.250	1.260	

OPTIONS:

REDISPLAY

HELP

RETURN

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Figure 11.7

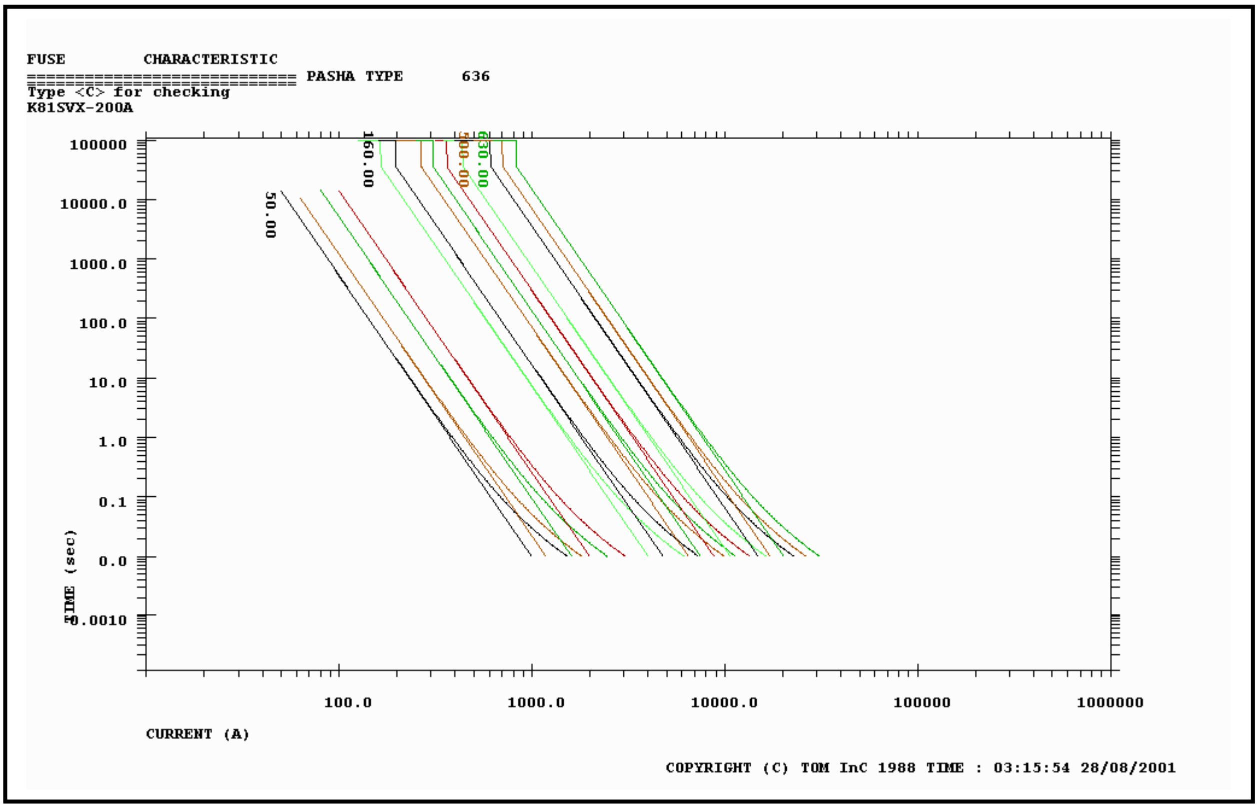


Figure 11.7(a)

11.3.2.2 Fuses 2: Ref. Fuse time-current characteristic

The pre-arcing time-current characteristic for the reference fuse must be entered on this page. As can be seen in figure 11.8 for each type two lines are used for the data pairs: the first one for the currents (in amps), and the other for the corresponding times (in sec). The curve fitting procedure may use either one, two or three lines (on log-log scales) to represent this characteristic. The user controls this choice by entering the data pairs as one set, or subdivided into two or three sets. A negative sign preceding any one of the elements of the pair indicates the beginning of a new set. This is illustrated in figure 11.8 which shows the points for types 800, 882 and 901 entered in 3 sets, and those for type 885 specified in one set.

The curve fitting calculation is performed every time the data is entered or modified and the results are displayed on fuses 4, together with the maximum error obtained (see figure 11.9). This enables the user to assess the accuracy of this calculation and to detect any errors in the data.

PROTECTION DATA BASE -FUSES 2: Manufac.op.time-current charact. PAGE 1 OF 1

TYPE	I(A)-01 T(S)-01	I(A)-02 T(S)-02	I(A)-03 T(S)-03	I(A)-04 T(S)-04	I(A)-05 T(S)-05	I(A)-06 T(S)-06	I(A)-07 T(S)-07	I(A)-08 T(S)-08	I(A)-09 T(S)-09	I(A)-10 T(S)-10	I(A)-11 T(S)-11	I(A)-12 T(S)-12	I(A)-13 T(S)-13	PASSWORD
636	600	800	-1000	2000	-3000	4000	5000							
	780.000	200.000	80.000	3.000	0.130	0.030	0.010							
637	600	800	-1000	2000	-3000	4000	5000							
	700.000	200.000	800.000	3.000	0.200	0.037	0.010							
4101	135	165	200	300	500	600	700	-800	850					
	1000.000	500.000	360.000	220.000	115.000	80.000	60.000	60.000	60.000					
638	600	800	-1000	2000	-3000	4000	5000							
	780.000	200.000	80.000	3.000	0.130	0.030	0.010							
160800	275	300	-375	500	750	1000	-1250	1500	1750	2000	2250	2500		
	2000.000	300.000	60.000	20.000	7.000	3.800	2.700	1.800	1.300	1.000	0.800	0.750		
8005000	2550	5000	7500	10000	12500	-15000	20000	25000	30000	50000				
	750.000	185.000	80.000	40.000	25.000	20.000	8.500	5.000	2.000	1.500				
901	590	800	-900	1300	2000	-3000	6000							
	100.000	10.000	5.400	1.000	0.230	0.070	0.010							
902	795	955	-1160	1270	-1590	2700	15000							
	40.000	13.000	6.000	3.000	0.900	0.100	0.010							
800	320	430	500	-640	740	890	1100	1370	1650	2070	-2600	3210	4400	
	100.000	20.000	10.000	4.000	2.000	1.000	0.400	0.200	0.100	0.040	0.020	0.010	0.004	
882	320	430	500	-640	740	890	1100	1370	1650	2070	-2600	3210	4400	
	100.000	20.000	10.000	4.000	2.000	1.000	0.400	0.200	0.100	0.040	0.020	0.010	0.004	
885	320	430	500	640	740	890	1100	1370	1650	2070	2600	3210	4400	
	100.000	20.000	10.000	4.000	2.000	1.000	0.400	0.200	0.100	0.040	0.020	0.010	0.004	

OPTIONS:

REDISPLAY

HELP

RETURN

 TIME : 03:17:25 28/08/2001

Figure 11.8

PROTECTION DATA BASE -FUSES 4 : Model TCC parameters -ref.fuse PAGE 1 OF 1

TYPE	COEF-A0	COEF-A1	COEF-B0	COEF-B1	COEF-C0	COEF-C1	MAX.ERROR TIME(%)	FOR I= (AMP)
636	11.8566	-4.7308	12.0059	-4.7370	11.5609	-5.0248	1.458	4000.0
637	11.3352	-4.3547	19.6549	-8.0589	14.2721	-5.8646	0.019	4000.0
4101	7.1255	-1.5435	4.0936	0.0003			-21.768	135.0
638	11.8566	-4.7308	12.0059	-4.7370	11.5609	-5.0248	1.458	4000.0
160800	9.6790	-21.8031	5.0838	-2.7806	4.0184	-1.9099	17.436	500.0
8005000	6.6859	-2.1425	6.7463	-2.2213			70.488	30000.0
901	12.7859	-7.5621	7.5245	-3.9371	4.9432	-2.8074	16.766	1300.0
902	9.6624	-6.1295	12.1389	-7.6509	2.4373	-1.8420	99.898	2700.0
800	7.0303	-5.1992	5.7665	-3.8481	3.8848	-3.0472	13.062	1100.0
882	7.0303	-5.1992	5.7665	-3.8481	3.8848	-3.0472	13.062	1100.0
885	5.8640	-3.8160					-41.420	320.0

OPTIONS:

REDISPLAY

HELP

RETURN

 TIME : 03:17:30 28/08/2001

Figure 11.9

11.3.2.3 Fuses 3: op.current-rated current data

The available ratings for a fuse type may be specified on this page, together with the corresponding operating currents related to a fixed pre-arcing time. This allows the extrapolation of the time-current characteristic specified on fuses 2 to other ratings. If no entries are made on this page only the reference fuse rating is assumed to be available.

As shown in figure 11.10, two lines are used for each type. The ratings (in amps) are entered on the first one. They must be sorted in increasing order (low to high) and the reference fuse rating (specified in -fuses 1) must be included. On the second line the corresponding operating currents (in amps) should be entered, for a fixed pre-arcing time T1. A second set of operating currents for another time T2 (T2 > T1) can be entered also, on the same line. A negative sign must precede the first quantity of this new set. The number of values must be the same for both sets and there is no need to repeat the fuse ratings for the second set. These two sets have been entered for type 800 (figure 11.10). For this type a time-current zone representation is used (i.e. No i2t values have been specified in fuses 1). Note that the entry for 800, has been repeated to define the upper limit for the last zone.

Whenever the second set of operating currents is specified, the extrapolation is performed differently in two time ranges:

- For T > T1 : A uniform converging (or diverging) trend is assumed

- For T< T1 : The characteristics are assumed parallel.

By the appropriate choice of the times T1 and T2 (related to the first and second sets of operating currents), a more realistic representation for a family of characteristics can be obtained. If only one set of operating currents has been entered, a parallel pattern is assumed (please also refer to Appendix G).

PROTECTION DATA BASE -FUSES 3 : Manuf.op.curr.-rated curr.char. PAGE 1 OF 1

TYPE	RT-I-01 OP-I-01	RT-I-02 OP-I-02	RT-I-03 OP-I-03	RT-I-04 OP-I-04	RT-I-05 OP-I-05	RT-I-06 OP-I-06	RT-I-07 OP-I-07	RT-I-08 OP-I-08	RT-I-09 OP-I-09	RT-I-10 OP-I-10	RT-I-11 OP-I-11	RT-I-12 OP-I-12	RT-I-13 OP-I-13	PASSWORD
636	50	63	80	100	125	160	200	250	315	350	400	500	630	
	260	310	420	520	1050	1250	1700	1950	2300	2800	3900	4500	5300	
637	50	63	80	100	125	160	200	250	315	350	400	500	630	
	180	230	305	380	650	790	970	1200	1300	1700	2200	2800	3100	
4101	50	63	80	100	125	160	200	250	315	350	400	500	630	
	350	420	610	780	1400	1800	2300	2900	3500	4500	6000	7000	8500	
638	50	63	80	100	125	160	200	250	315	350	400	500	630	
	260	310	420	520	1050	1250	1700	1950	2300	2800	3900	4500	5300	
160800	80	120	160	200	250	320	400	500	630	700	800			
	160	240	320	400	500	640	800	1000	1260	1400	1600			
8005000	800	1250	1600	2000	2500	3200	4000	5000						
	3200	5000	6400	8000	10000	12800	16000	20000						
901														
902														
800	50	100	200	400	800	800								
	160	420	890	2000	4200	12000	-85	200	430	950	2100	4900		
882	100	100	200	200	400	400								
	420	800	890	1800	2000	3780								
885	50	100	200	400	800									
	160	420	890	2000	4200									

OPTIONS:

REDISPLAY

HELP

RETURN

Figure 11.10

11.3.3 Distance relays

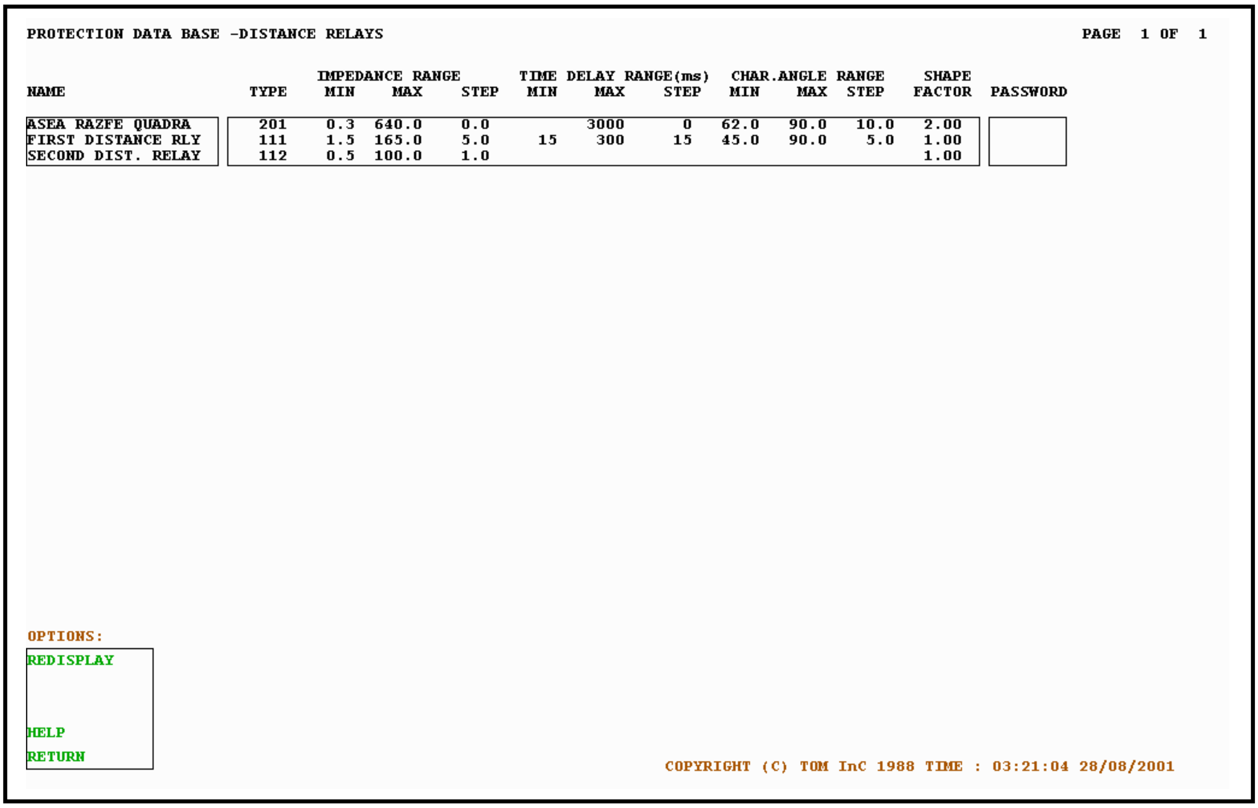
This section enables the user to store the basic parameters of impedance measuring elements. As shown in figure 11.11 these are the impedance setting range in ohms, the time delay setting range in milliseconds, the characteristic angle range in degrees, and the operating characteristic 'shape factor'.

The TYPE in this page has especial meanings. Types 100-199 are used for lenticular relays. Types 200 to 299 are used for quadratic relays. For other types please refer to on line help section.

The shape factor refers to the ratio A/B of lenticular shapes, where A and B are the dimensions indicated in figure 11.12. For quadratic the shape factor represents the length of trapezoidal base in real axes direction.

The lenticular shape described in this figure can be adjusted to represent the most frequently used characteristics, by the proper selection of the ratio A/B, the impedances ZE and ZB, and the characteristic angle '@'.

Pressing key <G> while the cursor is over the name of a distance relay draws the characteristic of the relay in R-X axes. This is shown in figure 11.12(a) and 11.12(b) for lenticular and quadratic shapes.



PROTECTION DATA BASE -DISTANCE RELAYS PAGE 1 OF 1

NAME	TYPE	IMPEDANCE RANGE MIN	MAX	STEP	TIME DELAY RANGE(ms) MIN	MAX	STEP	CHAR.ANGLE RANGE MIN	MAX	STEP	SHAPE FACTOR	PASSWORD
ASEA RAZFE QUADRA	201	0.3	640.0	0.0		3000	0	62.0	90.0	10.0	2.00	
FIRST DISTANCE RLY	111	1.5	165.0	5.0	15	300	15	45.0	90.0	5.0	1.00	
SECOND DIST. RELAY	112	0.5	100.0	1.0							1.00	

OPTIONS:
REDISPLAY
HELP
RETURN

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Figure 11.11

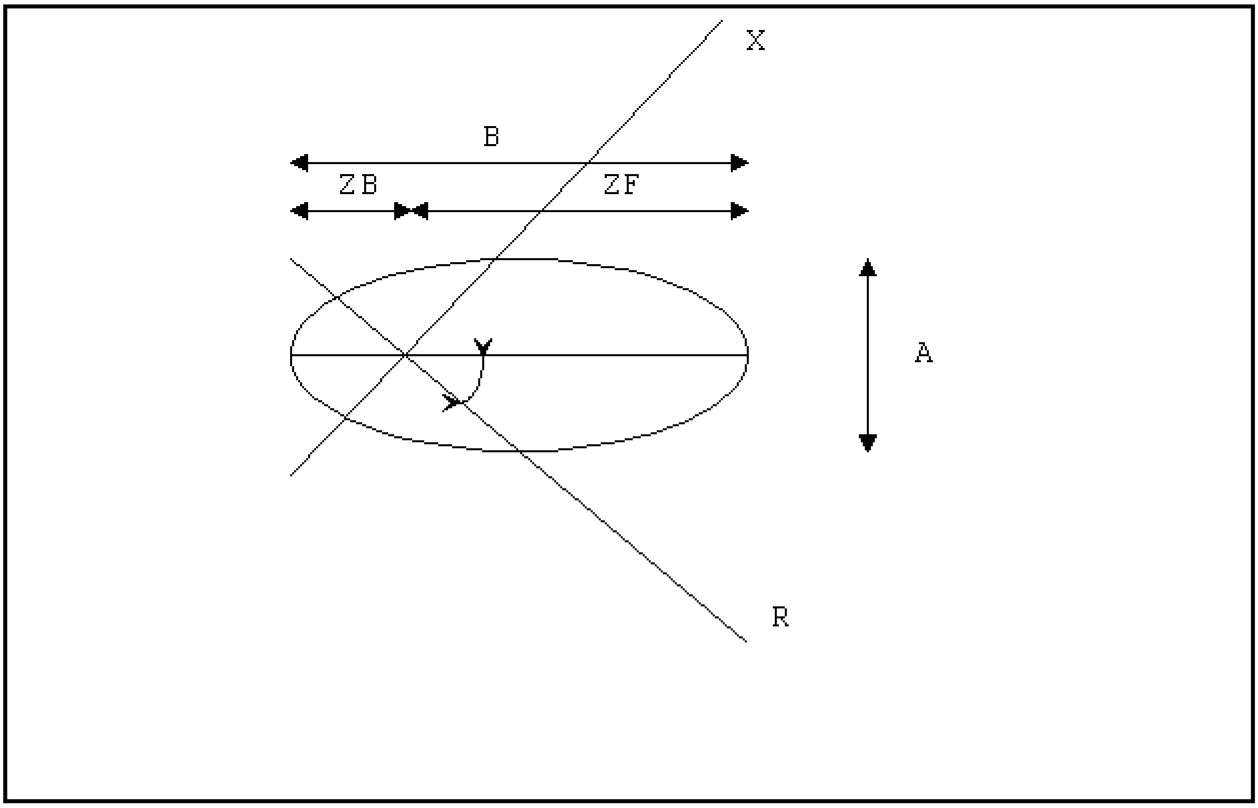


Figure 11.12

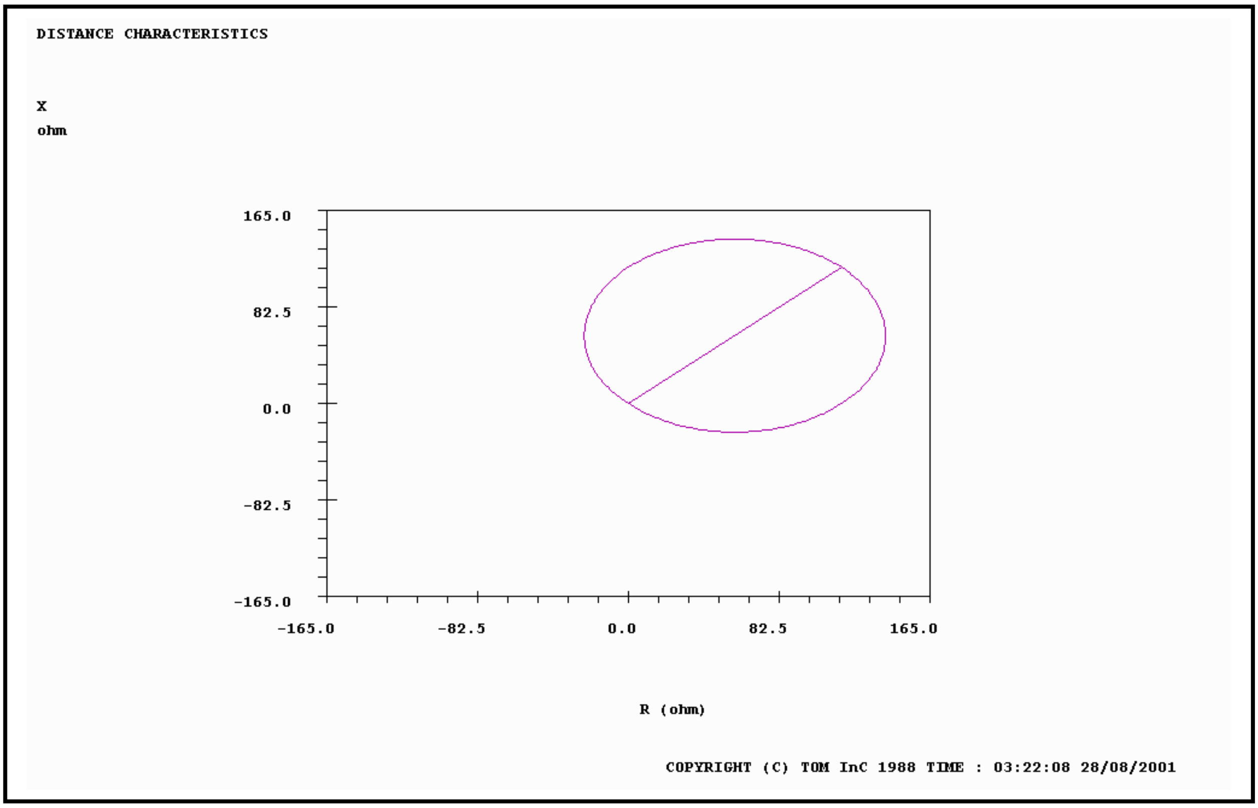


Figure 11.12(a)

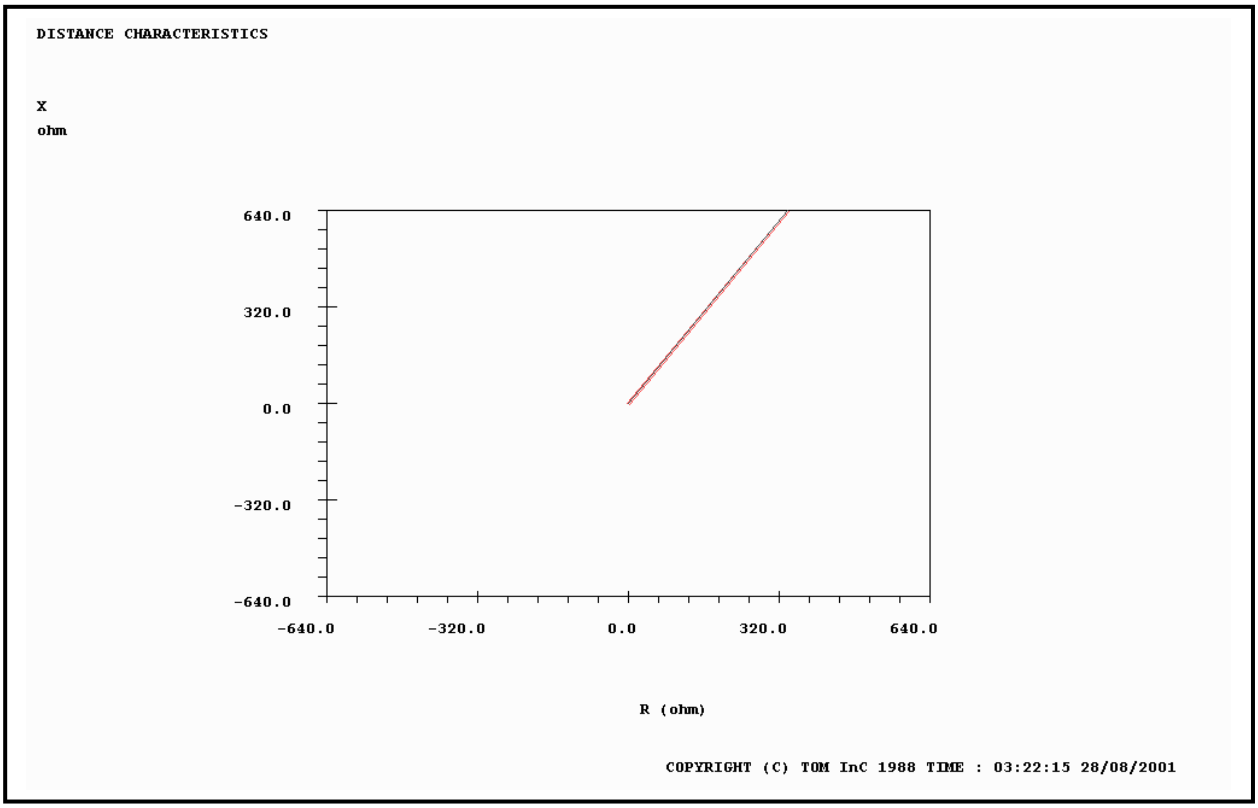
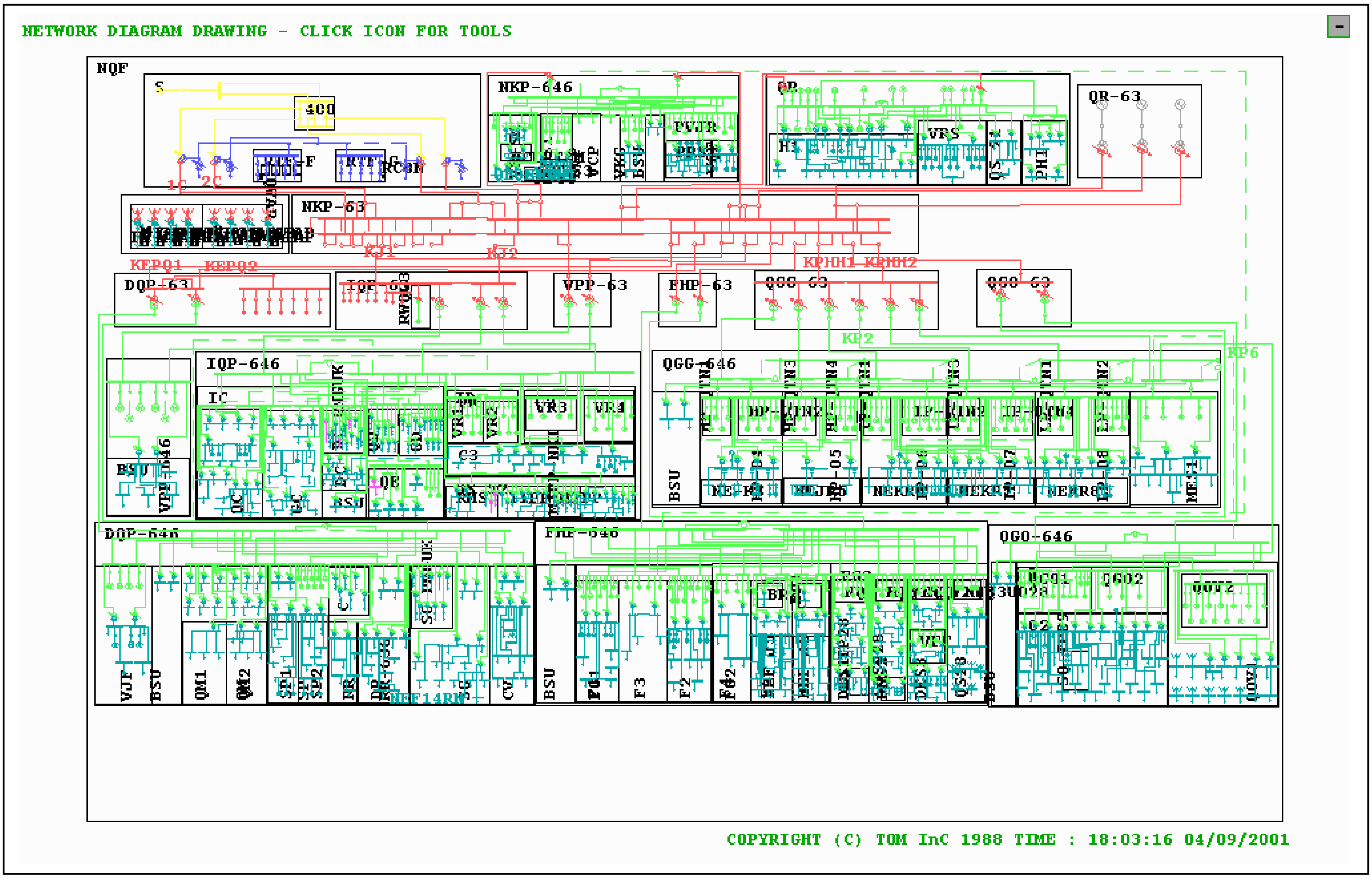


Figure 11.12(b)



The picture shows a large-scale steel mill plant. Just remind that in order to insert protection relays you need to represent the terminals of the motors as junctions, and put the relays in sending and receiving ends of the cables.

11.4 Edit : network protection data

Figure 11.13 shows the layout for the edit menu as shown in chapter 4, showing the pages for protection elements to accommodate the required protection data of the power system networks. These are line data 4 and 5, for overcurrent protection, and distance and unit protection 1, 2, and 3. Also analysis parameters 2 data page has been included to store the protection facilities analysis parameters. It contains all the new constants and default values associated with the protection facilities. To choose a particular data page, the user must now select the component using the cursor and press the required range number in the keyboard, or select the page from green box menu.

All the standard 'redisplay' facilities in PASHA as described in chapter 4 are included in these pages too. The 'transfer to (and from) database' operation are defined for the protection pages too. This facility allows the user to transfer directly from a network data page to the corresponding database and vice versa. If this operation is selected from a protection data page in edit, the first page of the relays database is displayed. Conversely, if this operation is performed from any protection data base page, the computer will transfer to the last protection page displayed.

Keys F4, and F5 may also be pressed where the cursor is over a line, whenever the single-line diagram is on the screen. In this way you can directly transfer to the corresponding edit pages for over current relays, while the selected line will be red highlighted.

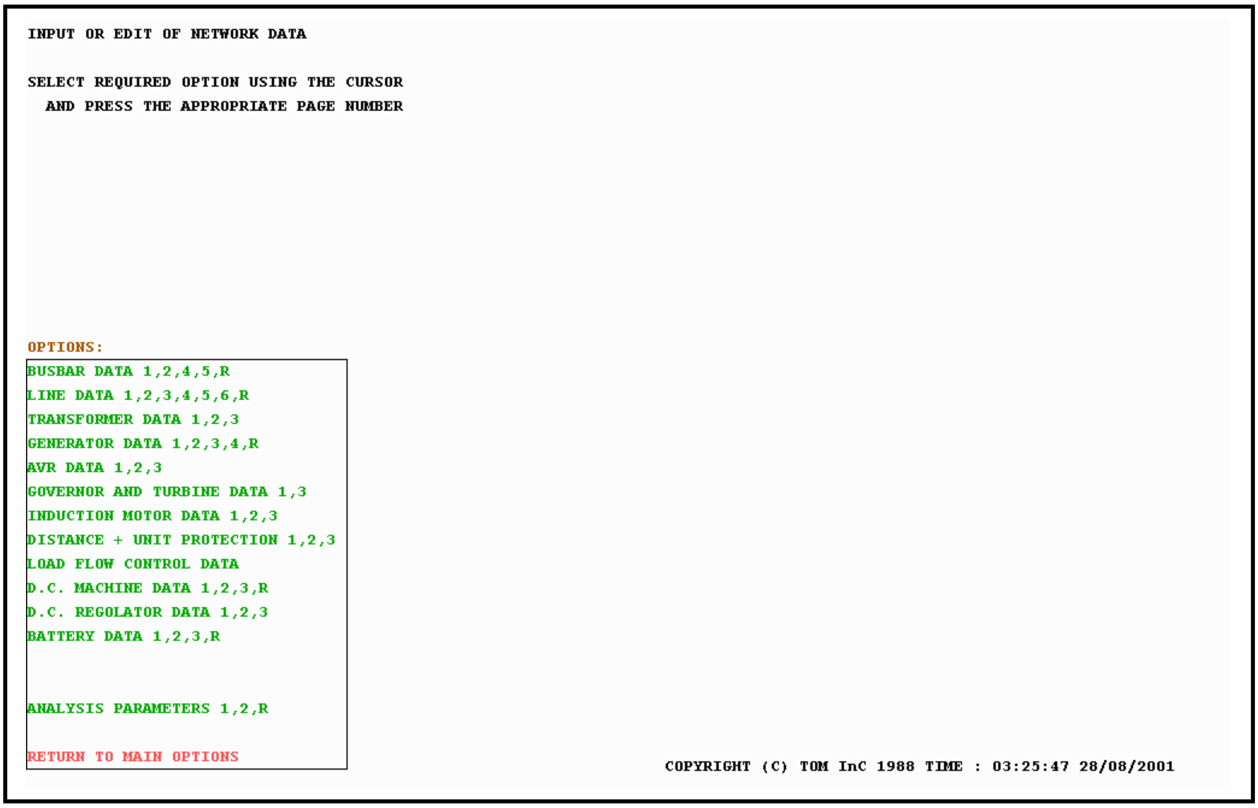

INPUT OR EDIT OF NETWORK DATA
SELECT REQUIRED OPTION USING THE CURSOR
AND PRESS THE APPROPRIATE PAGE NUMBER
OPTIONS:
BUSBAR DATA 1,2,4,5,R
LINE DATA 1,2,3,4,5,6,R
TRANSFORMER DATA 1,2,3
GENERATOR DATA 1,2,3,4,R
AVR DATA 1,2,3
GOVERNOR AND TURBINE DATA 1,3
INDUCTION MOTOR DATA 1,2,3
DISTANCE + UNIT PROTECTION 1,2,3
LOAD FLOW CONTROL DATA
D.C. MACHINE DATA 1,2,3,R
D.C. REGOLATOR DATA 1,2,3
BATTERY DATA 1,2,3,R
ANALYSIS PARAMETERS 1,2,R
RETURN TO MAIN OPTIONS
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Figure 11.13

11.4.1 Line data 4 - phase overcurrent protection

This data page enable the user to specify the overcurrent protection devices (relays or fuses) located at the sending and receiving ends of each line. Figure 11.14 shows the layout of this page. It can be seen here that two identical tables are displayed for the sending and the receiving ends respectively, and each row contains the data related to a particular line, designated by corresponding, sending and receiving busbar names. The protection data included on each table is defined as follows:

TYPE : The data base type number user to identify a particular protection device. A relay is specified with a positive entry; a fuse is specified with a negative entry.

CT-RAT : The C.T. Primary/secondary current ratio. For fuses: fuse rating in amps.

DIREC : The setting of the directional unit of the relay:
1 = sending to receiving end,
-1 = receiving to sending,
0 = no directional setting.

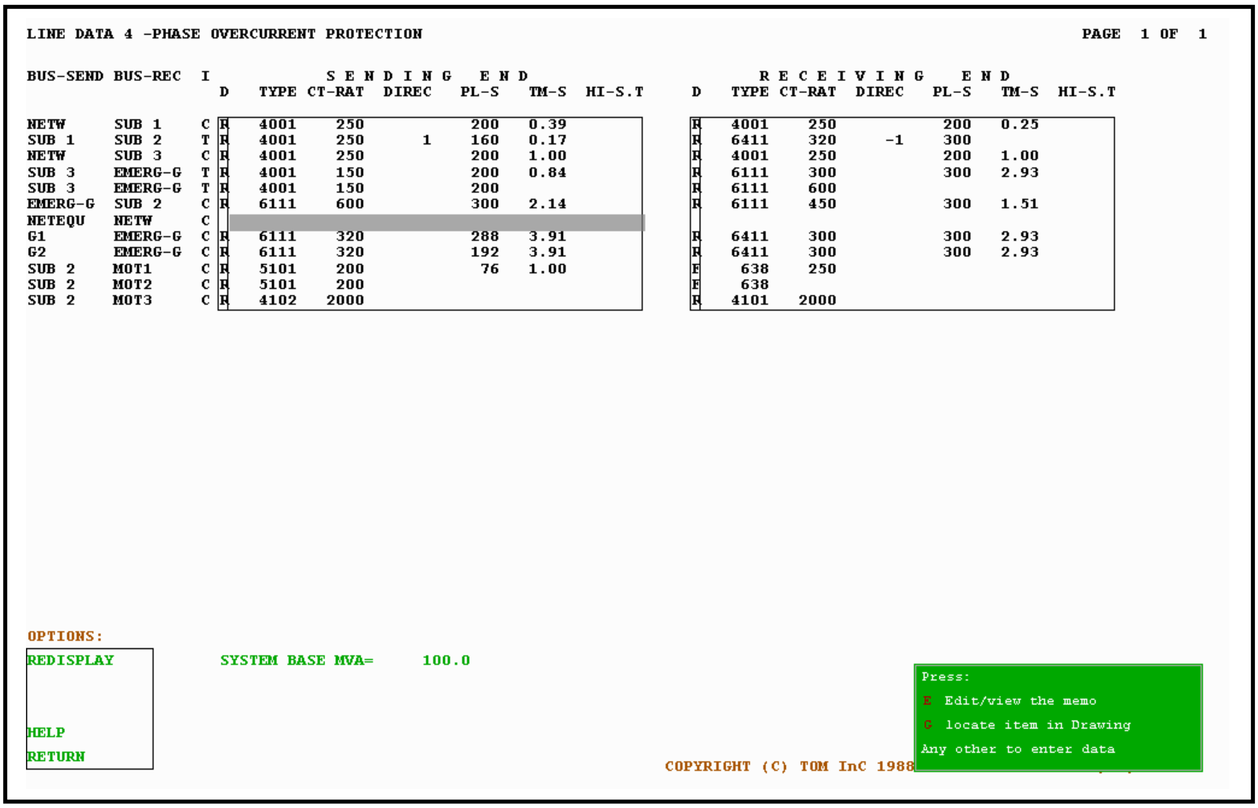
PL-S : Relay plug setting, in (%) .

TM-S : Relay time dial setting.

HI-S : (Integer part) Relay instantaneous unit (HI - SET) setting, in (%). (Real part) High set operation time in second.

These quantities can be entered or modified by the user whenever the data page is displayed, using the input/edit facilities of PASHA. The current values will be stored together with the rest of the system data if the network is 'saved', therefore the information will be available for further work after the PASHA session is finished.
After entering protection data, if the data page is redisplayed, the "d" column (figure 11.14) will contain either "R" or "F" to confirm the selection of a relay or fuse. Any setting value not compatible with the ranges of quantities available for the corresponding data base type, will not be accepted and an error message is given immediately after entry. If the value is out of range, it will be adjusted to the corresponding limit. Any nonexistent plug setting will be adjusted to the next one available. This case is illustrated by figures 11.15 and 11.14. It can be seen that the adjusted value is presented after the page is redisplayed.

The symbols of the relays or fuses, which are entered in this edit page, will be displayed on the single-line diagrams. The fuse symbol is standard symbol for the fuse but the existence of relays are shown by a small line crossed the circuit. A small orthogonal line on the right side of the line (looking from sending to receiving end of line) indicates the phase over current and if it appears on the left it shows there is an earth overcurrent relays. Examples are shown in the single-line diagrams of this chapter.
Note that if an MCCB as described in chapter 15 is entered in circuit breaker data, the TYPE will be filed automatically in this page.


LINE DATA 4 -PHASE OVERCURRENT PROTECTION PAGE 1 OF 1

BUS-SEND	BUS-REC	I	D	TYPE	CT-RAT	DIREC	PL-S	TM-S	HI-S.T	D	TYPE	CT-RAT	DIREC	PL-S	TM-S	HI-S.T
NETW	SUB 1	C	R	4001	250		200	0.39		R	4001	250		200	0.25	
SUB 1	SUB 2	T	R	4001	250	1	160	0.17		R	6411	320	-1	300		
NETW	SUB 3	C	R	4001	250		200	1.00		R	4001	250		200	1.00	
SUB 3	EMERG-G	T	R	4001	150		200	0.84		R	6111	300		300	2.93	
SUB 3	EMERG-G	T	R	4001	150		200			R	6111	600				
EMERG-G	SUB 2	C	R	6111	600		300	2.14		R	6111	450		300	1.51	
NETEQU	NETW	C														
G1	EMERG-G	C	R	6111	320		288	3.91		R	6411	300		300	2.93	
G2	EMERG-G	C	R	6111	320		192	3.91		R	6411	300		300	2.93	
SUB 2	MOT1	C	R	5101	200		76	1.00		F	638	250				
SUB 2	MOT2	C	R	5101	200					F	638					
SUB 2	MOT3	C	R	4102	2000					R	4101	2000				

OPTIONS:
REDISPLAY
HELP
RETURN

SYSTEM BASE MVA= 100.0

Press:
E Edit/view the memo
G locate item in Drawing
Any other to enter data

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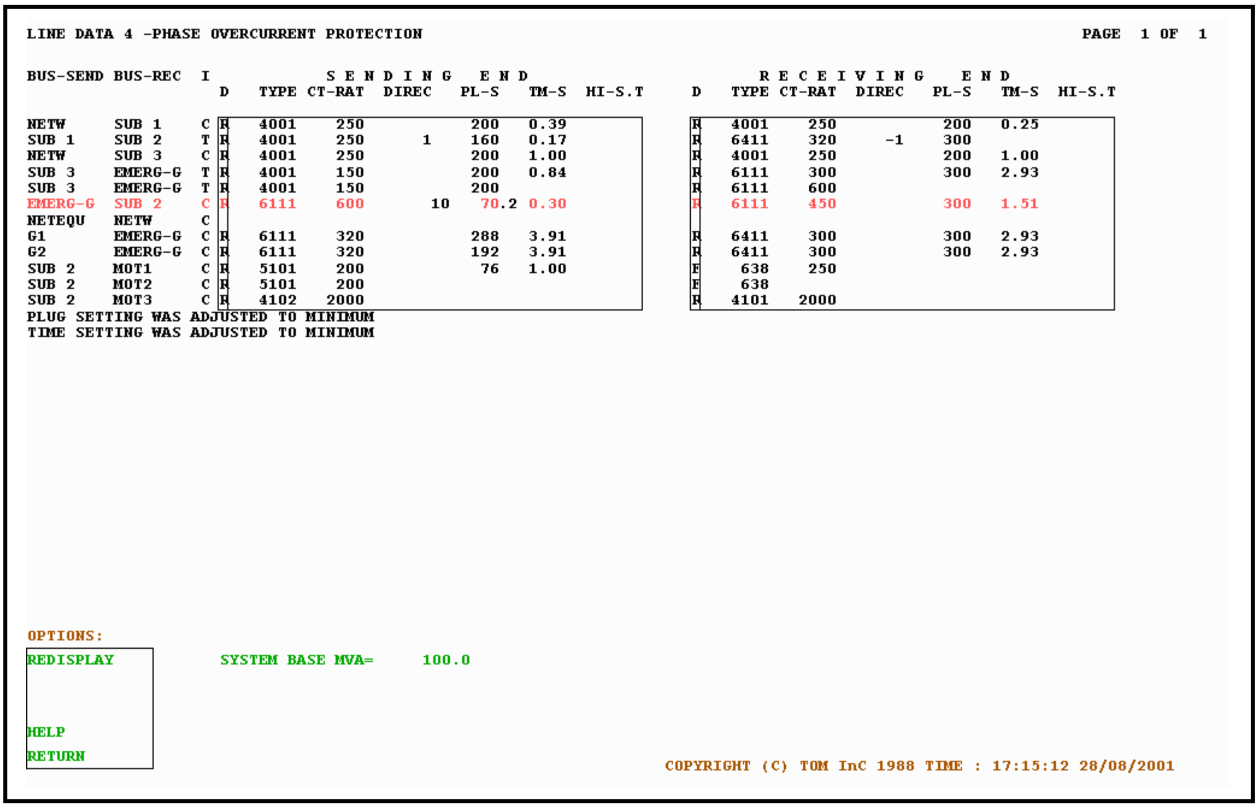
Figure 11.14


LINE DATA 4 -PHASE OVERCURRENT PROTECTION PAGE 1 OF 1

BUS-SEND	BUS-REC	I	D	TYPE	CT-RAT	DIREC	PL-S	TM-S	HI-S.T	D	TYPE	CT-RAT	DIREC	PL-S	TM-S	HI-S.T
NETW	SUB 1	C	R	4001	250		200	0.39		R	4001	250		200	0.25	
SUB 1	SUB 2	T	R	4001	250	1	160	0.17		R	6411	320	-1	300		
NETW	SUB 3	C	R	4001	250		200	1.00		R	4001	250		200	1.00	
SUB 3	EMERG-G	T	R	4001	150		200	0.84		R	6111	300		300	2.93	
SUB 3	EMERG-G	T	R	4001	150		200			R	6111	600				
EMERG-G	SUB 2	C	R	6111	600	10	70.2	0.30		R	6111	450		300	1.51	
NETEQU	NETW	C														
G1	EMERG-G	C	R	6111	320		288	3.91		R	6411	300		300	2.93	
G2	EMERG-G	C	R	6111	320		192	3.91		R	6411	300		300	2.93	
SUB 2	MOT1	C	R	5101	200		76	1.00		F	638	250				
SUB 2	MOT2	C	R	5101	200					F	638					
SUB 2	MOT3	C	R	4102	2000					R	4101	2000				

PLUG SETTING WAS ADJUSTED TO MINIMUM
TIME SETTING WAS ADJUSTED TO MINIMUM

OPTIONS:
REDISPLAY
HELP
RETURN

SYSTEM BASE MVA= 100.0

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Figure 11.15

11.4.2 Line data 5 - earth overcurrent protection

This data page (figure 11.16) enables the user to specify an earth fault relay at the sending and receiving end of each line or transformer. Its layout is identical to that already used in line data 4 for the specification of phase devices.

TYPE : The data base type number user to identify a particular protection device. A relay is specified with a positive entry; a fuse is specified with a negative entry.

CT-RAT : The C.T. Primary/secondary current ratio. For fuses: fuse rating in amps.

DIREC : The setting of the directional unit of the relay:
1 = sending to receiving end,
-1 = receiving to sending,
0 = no directional setting.

PL-S : Relay plug setting, in (%) .

TM-S : Relay time dial setting.

HI-S : (Integer part) Relay instantaneous unit (HI - SET) setting, in (%). (Real part) High set operation time in second.

The devices specified on this data page are assumed to be sensitive only to the residual current at their corresponding location. Hence. The specification of fuses is not allowed here. This must be done on line data 4 together with the phase overcurrent relays. In the calculation of the performance of phase devices for unbalanced faults the largest phase current is considered.

The symbols of the relays, which their types are entered in this edit page, will be displayed on the single-line diagrams. The existence of relays are shown by a small line crossed the circuit. A small orthogonal line on the right side of the line (looking from sending to receiving end of line) indicates the phase over current and if it appears on the left it shows there is an earth overcurrent relays. Examples are shown in chapter 3 figures 3-25 and 3-26 and on the single-line diagrams of this chapter.

LINE DATA 5 -EARTH OVERCURRENT PROTECTION PAGE 1 OF 1

			SENDING END							RECEIVING END						
BUS-SEND	BUS-REC	I	D	TYPE	CT-RAT	DIREC	PL-S	TM-S	HI-S.T	D	TYPE	CT-RAT	DIREC	PL-S	TM-S	HI-S.T
NETW	SUB 1	C	R	4002	400					R	4002	400				
SUB 1	SUB 2	T	R	4002	400					R	4002	400				
NETW	SUB 3	C	R	4002	400					R	4002	400				
SUB 3	EMERG-G	T	R	4002	400											
SUB 3	EMERG-G	T														
EMERG-G	SUB 2	C														
NETEQU	NETW	C	R	4002	400											
G1	EMERG-G	C														
G2	EMERG-G	C														
SUB 2	MOT1	C														
SUB 2	MOT2	C														
SUB 2	MOT3	C								R	4100	1000				

OPTIONS:

REDISPLAY

HELP

RETURN

SYSTEM BASE MVA= 100.0

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Figure 11.16

11.4.3 Distance and unit protection 1 (dup)

The layout of this data page is presented in figure 11.17. Since all the entries in this section are generated by the user, this page will be initially empty as shown in the figure. The user can create an entry by selecting the scheme code field with the cursor, and typing an appropriate code, according to the scheme being defined. The following codes are acceptable: **UNIT**, **DIS.PH**, and **DIS.G**, which correspond to unit, phase distance and ground-distance schemes respectively. After this order has been accepted the spaces in the corresponding data arrays are prepared, and the same entry is automatically made in the remaining distance and unit protection data pages.

Any existing scheme may be deleted by entering a '0' (zero) on the corresponding scheme code field. This removes all the related entries, and compacts the data arrays.

A new scheme can be entered by selecting the scheme code field on the line following the last entry, and repeating the same procedure. Figures 11.18 and 11.19 illustrate this sequence. It should be noted that the scheme no. Is automatically displayed, and provides a practical way of identifying any particular scheme.

The device location defines the position of the CT (and VT, for distance) in the network. It is specified by entering the busbar identifier number (displayed in busbar data). If a negative sing precedes the number, the location is assumed at the 'backward' side of the busbar; while a positive entry corresponds to the 'forward' side. The forward direction is given by the sequence of the busbars entered in the protected area data field. This convention also applies for the impedance measurement in distance protection schemes. When the data page is redisplayed the busbar name and either the letters 'F' or 'B' will be presented, to confirm the entry.

The protected area field is used to define the portion of the network protected by the scheme. By selecting this filed for a particular scheme with the cursor and typing <d> the network diagram is displayed to enable a graphic specification on of the protected area. This is achieved by selecting a set of interconnected branches of the network by positioning the cursor sequentially on the corresponding end busbars and pressing the space bar on each one. In unit schemes only, the key < - > can be used to include the circuit but not the busbar in the zone, or the key <g> to include the generator connected to the busbar. One branch can also be selected by pointing at one end busbar and at a knee point in it. This enables the user to choose between either one of two or more parallel branches. By pressing < X> the user exits from this procedure and the data page is displayed showing the busbar names selected, together with a "-" or a "G" if either of these keys were used in their selection.

For distance schemes only, the protected area can be specified by selecting this field in the conventional way (i.e., with the space bar) and typing the sequence of busbar identifiers corresponding to the set of branches to be specified. By redisplaying the data page, the names of the specified busbars are presented.

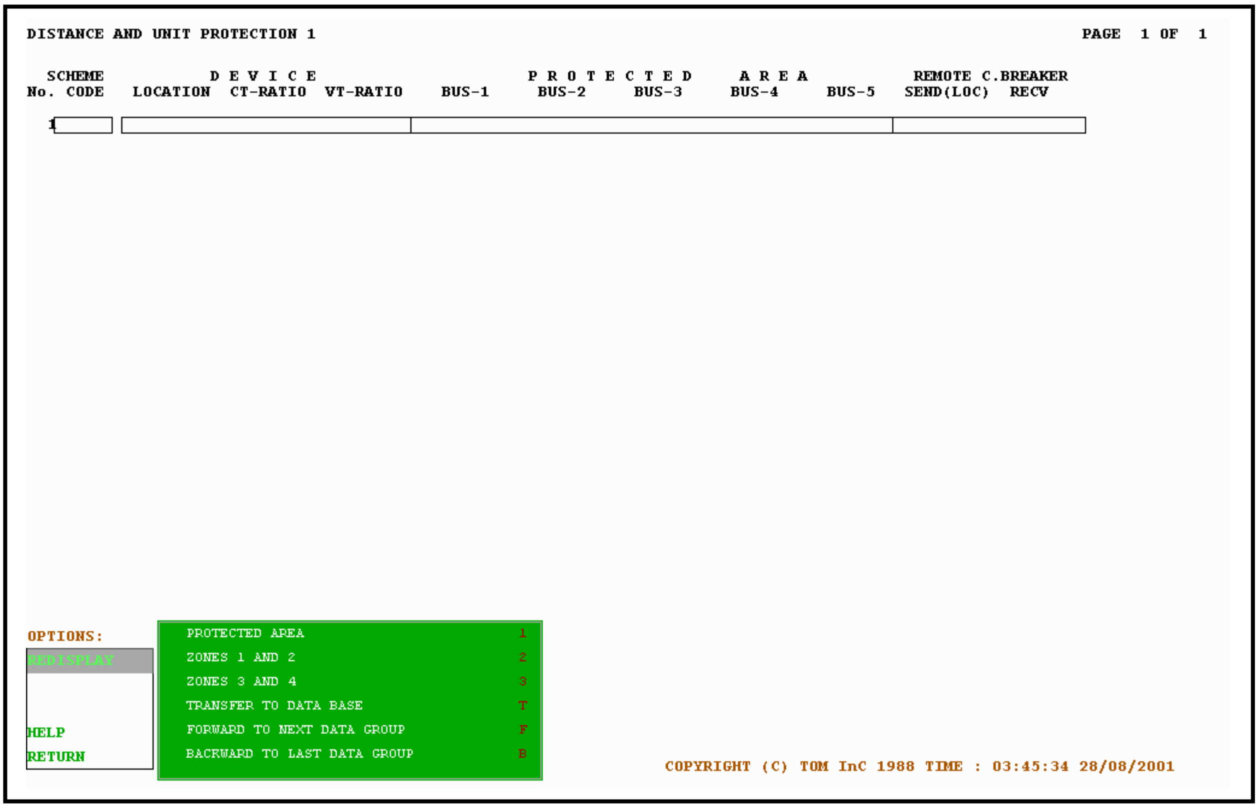


Figure 11.17

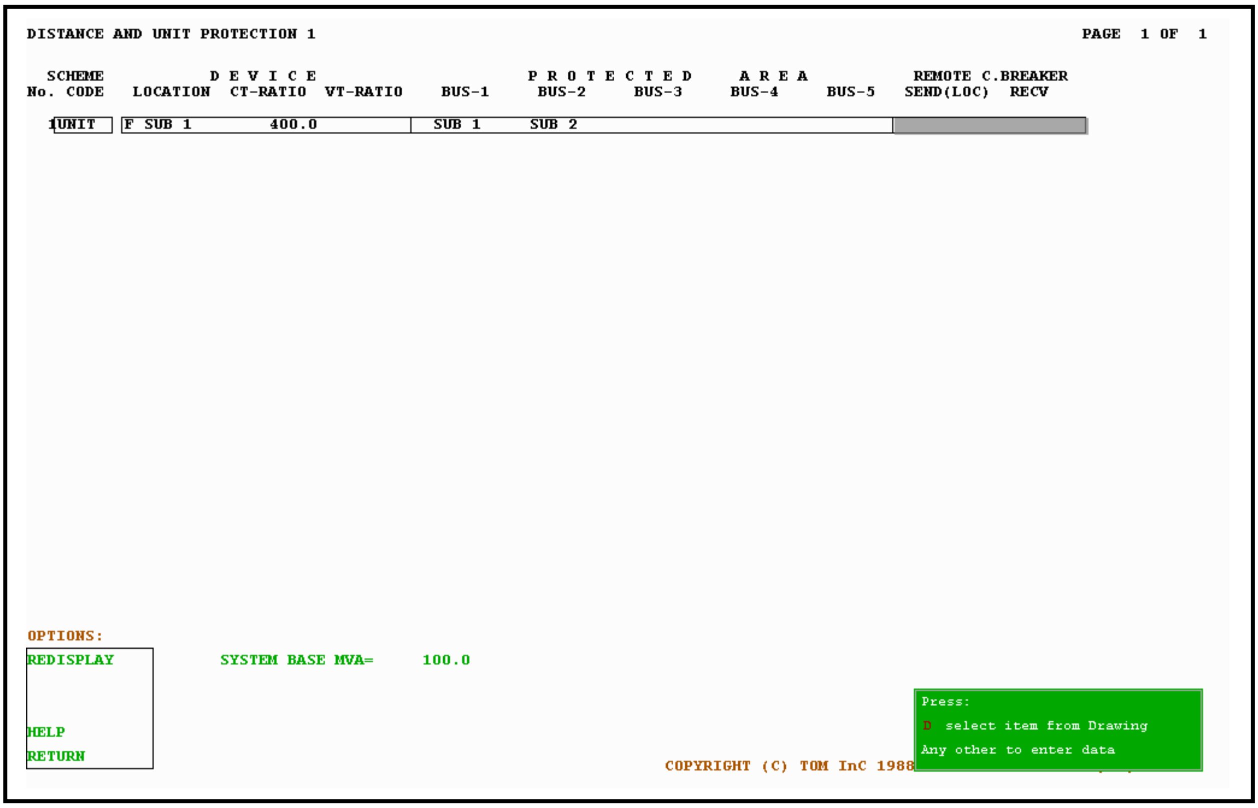


Figure 11.18

11.4.3.1 Examples: protected area entry for unit schemes.

Figure 11.20 shows the network diagram displayed after the user has selected this data field for scheme no. 1 and typed <D>. By selecting the junction G2 pressing <G> and the substation EMERG-G pressing <-> the user includes the generator and the line in the protected area, but not EMERG-G. The user then types <X> to terminate the selection and the data page is redisplayed as shown in figure 11.21, indicating the protected area specified.

Figure 11.22 shows the data page after the protected areas for two more unit schemes were selected. Scheme no. 3 contains the line NETEQU to NETW, the busbar NETW and the branches NETW – SUB1 and NETW - SUB3. Scheme no.4 contains only the busbar NETW. Note that the device location was specified at the "backward" side of this busbar (by entering –1 where 1 is the busbar number specified in BUSBAR DATA 1) in order to exclude the branch NETEQU to NETW from the protected area.

11.4.3.2 Examples : protected area entry for distance schemes.

Figure 11.23 displays the data page with the protected areas for two distance schemes specified for network of figure 11.24 (two junctions J1 and J2 together with two associated lines are added to the previous network, also a parallel line is added between SUB 1 and NETW). For scheme no.2 the busbars NETW, SUB3, J1 and J2 were selected by pressing the space bar. For scheme no. 5 the selection sequence is indicated in figure 11.24. Here a knee point was used to discriminate between the parallel lines. Note that the selection of this point enters automatically the other end busbar NETW.

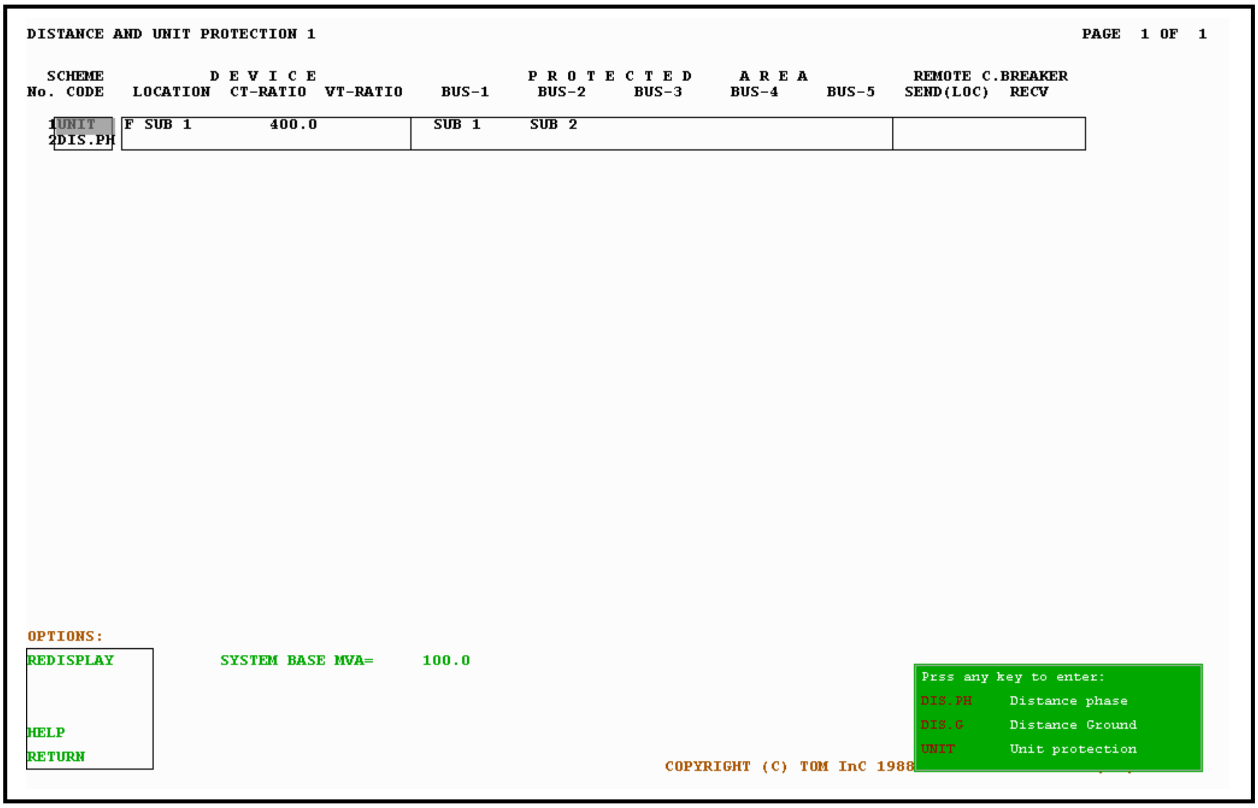


Figure 11.19

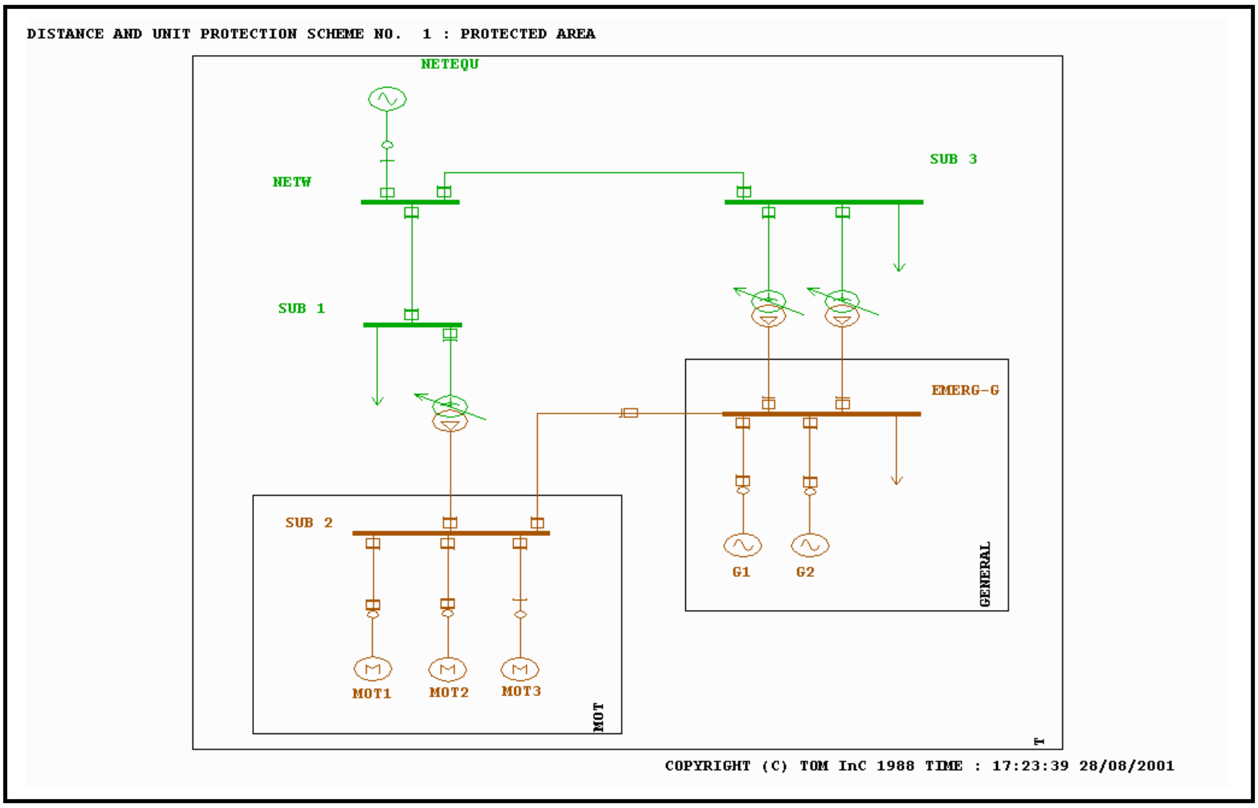


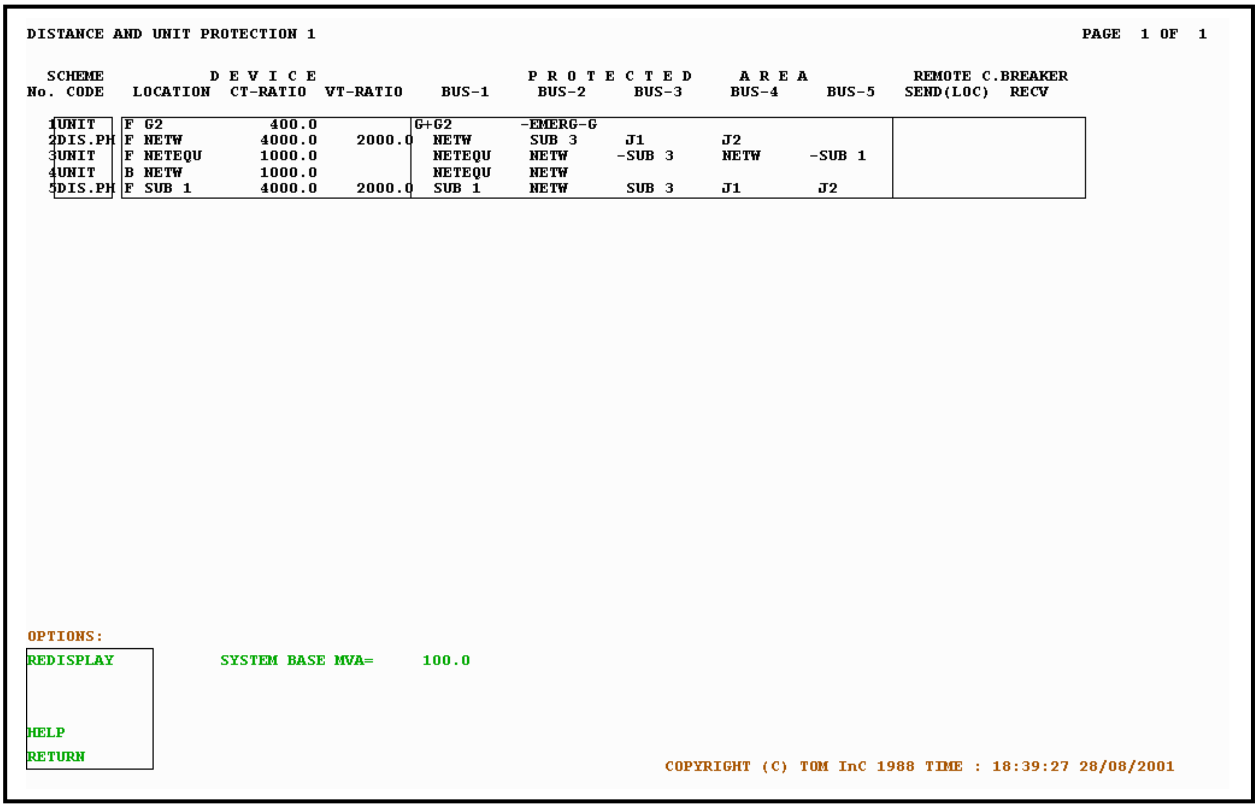
Figure 11.20

```
DISTANCE AND UNIT PROTECTION 1                                                                  PAGE  1 OF  1

  SCHEME          D E V I C E                        P R O T E C T E D     A R E A          REMOTE C.BREAKER
No. CODE    LOCATION  CT-RATIO  VT-RATIO     BUS-1     BUS-2     BUS-3     BUS-4     BUS-5    SEND(LOC)  RECV

  1UNIT     F G2           400.0            G+G2          -EMERG-G
  2DIS.PH

OPTIONS:
REDISPLAY           SYSTEM BASE MVA=      100.0

HELP
RETURN                                                         COPYRIGHT (C) TOM InC 1988 TIME : 17:24:32 28/08/2001
```

Figure 11.21

```
DISTANCE AND UNIT PROTECTION 1                                                                  PAGE  1 OF  1

  SCHEME          D E V I C E                        P R O T E C T E D     A R E A          REMOTE C.BREAKER
No. CODE    LOCATION  CT-RATIO  VT-RATIO     BUS-1     BUS-2     BUS-3     BUS-4     BUS-5    SEND(LOC)  RECV

  1UNIT     F G2           400.0            G+G2          -EMERG-G
  2DIS.PH   F NETW        4000.0    2000.0    NETW      SUB 3       J1        J2
  3UNIT     F NETEQU      1000.0              NETEQU    NETW      -SUB 3      NETW      -SUB 1
  4UNIT     B NETW        1000.0              NETEQU    NETW

OPTIONS:
REDISPLAY           SYSTEM BASE MVA=      100.0

HELP
RETURN                                                         COPYRIGHT (C) TOM InC 1988 TIME : 18:45:01 28/08/2001
```

Figure 11.22



DISTANCE AND UNIT PROTECTION 1 PAGE 1 OF 1

SCHEME No.	CODE	DEVICE LOCATION	CT-RATIO	VT-RATIO	PROTECTED AREA BUS-1	BUS-2	BUS-3	BUS-4	BUS-5	REMOTE C.BREAKER SEND(LOC)	RECV
1	UNIT	F G2	400.0		G+G2	-EMERG-G					
2	DIS.PH	F NETW	4000.0	2000.0	NETW	SUB 3	J1	J2			
3	UNIT	F NETEQU	1000.0		NETEQU	NETW	-SUB 3	NETW	-SUB 1		
4	UNIT	B NETW	1000.0		NETEQU	NETW					
5	DIS.PH	F SUB 1	4000.0	2000.0	SUB 1	NETW	SUB 3	J1	J2		

OPTIONS:
REDISPLAY
HELP
RETURN

SYSTEM BASE MVA= 100.0

COPYRIGHT (C) TOM InC 1988 TIME : 18:39:27 28/08/2001

Figure 11.23

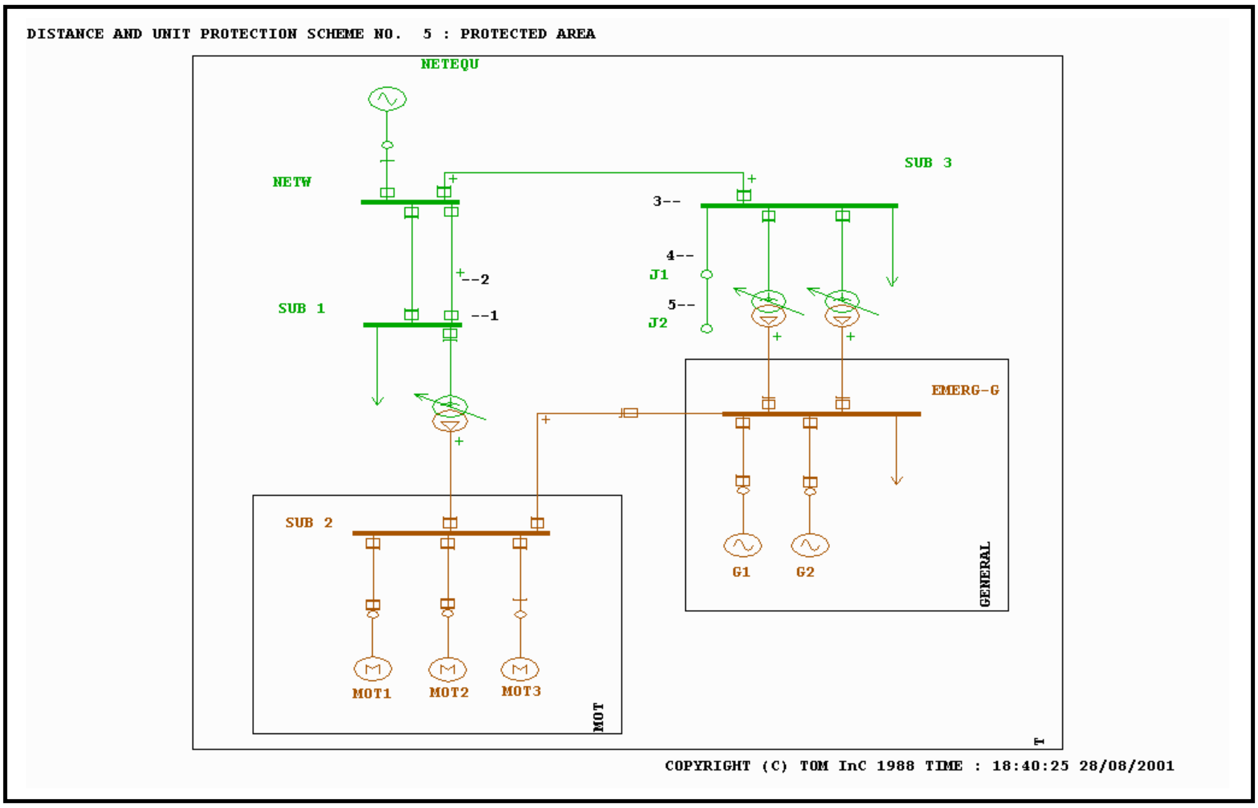


Figure 11.24

11.4.4 Distance and unit protection 2 and 3

These two data pages enable the user to specify distance relay types and settings for 4 distance protection zones. Likewise, the settings required for unit protection can be entered.

The layout of data page 2 is shown in figure 11.25. The data contained in the table for zone 1 can be defined as follows.

TYPE: Data base type number for the distance relays section

% PROT : Percentage of the protected area covered by relay:
(% sett) eg., 125% indicates that the relay reaches up to 25 % of the second branch.
(for unit schemes, differential relay setting as a % of the CT-ratio entry).

Z-FWD : Operating characteristic forward impedance
(% bias) setting (ZF in figure 11.12), in secondary ohms. For unit schemes: differential relay bias, in %.

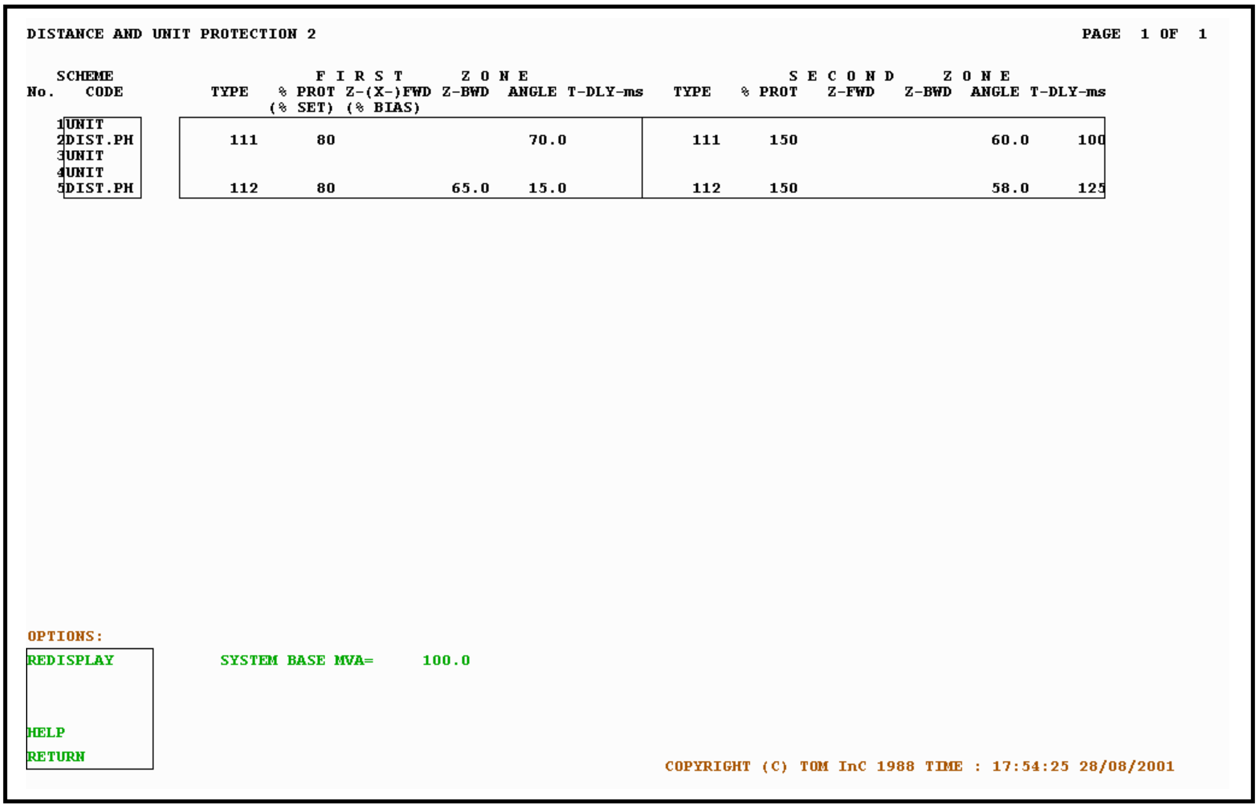
Z-BWD : operating characteristic backward impedance setting (ZB in figure 11.12), in secondary ohms.

ANGLE : Operating characteristic angle in degrees.

T-DLT-MS: Time delay between fault detection and tripping, in ms. For unit schemes the same definition applies.

The data tables for the remaining zones contain the same data entries for distance schemes.

Unit protection settings are only specified in the first zone table, as indicated above. This arrangement allows the specification of different relay characteristics for each distance protection zone.



DISTANCE AND UNIT PROTECTION 2 PAGE 1 OF 1

No.	SCHEME CODE	FIRST ZONE TYPE	% PROT (% SET)	Z-(X-)FWD (% BIAS)	Z-BWD	ANGLE	T-DLY-ms	SECOND ZONE TYPE	% PROT	Z-FWD	Z-BWD	ANGLE	T-DLY-ms
1	UNIT												
2	DIST.PH	111	80			70.0		111	150			60.0	100
3	UNIT												
4	UNIT												
5	DIST.PH	112	80		65.0	15.0		112	150			58.0	125

OPTIONS:
REDISPLAY SYSTEM BASE MVA= 100.0
HELP
RETURN

COPYRIGHT (C) TOM InC 1988 TIME : 17:54:25 28/08/2001

Figure 11.25

11.4.5 Analysis parameters 2

As it can be seen in figure 11.26, this data page contains all the default parameters used by the protection facilities. The grading constants A and B are used to define the coordination time interval (CTI), as

$$CTI= A + B * t$$

Where CTI is the interval in seconds and t the operating time (in seconds) of the minor or primary device. The grading constant C is the minimum ratio between the current (pick-up) settings of the major and minor devices, (refer to section 11.5.2 for details).

The user may change these values at any time, and they are saved together with the network data.

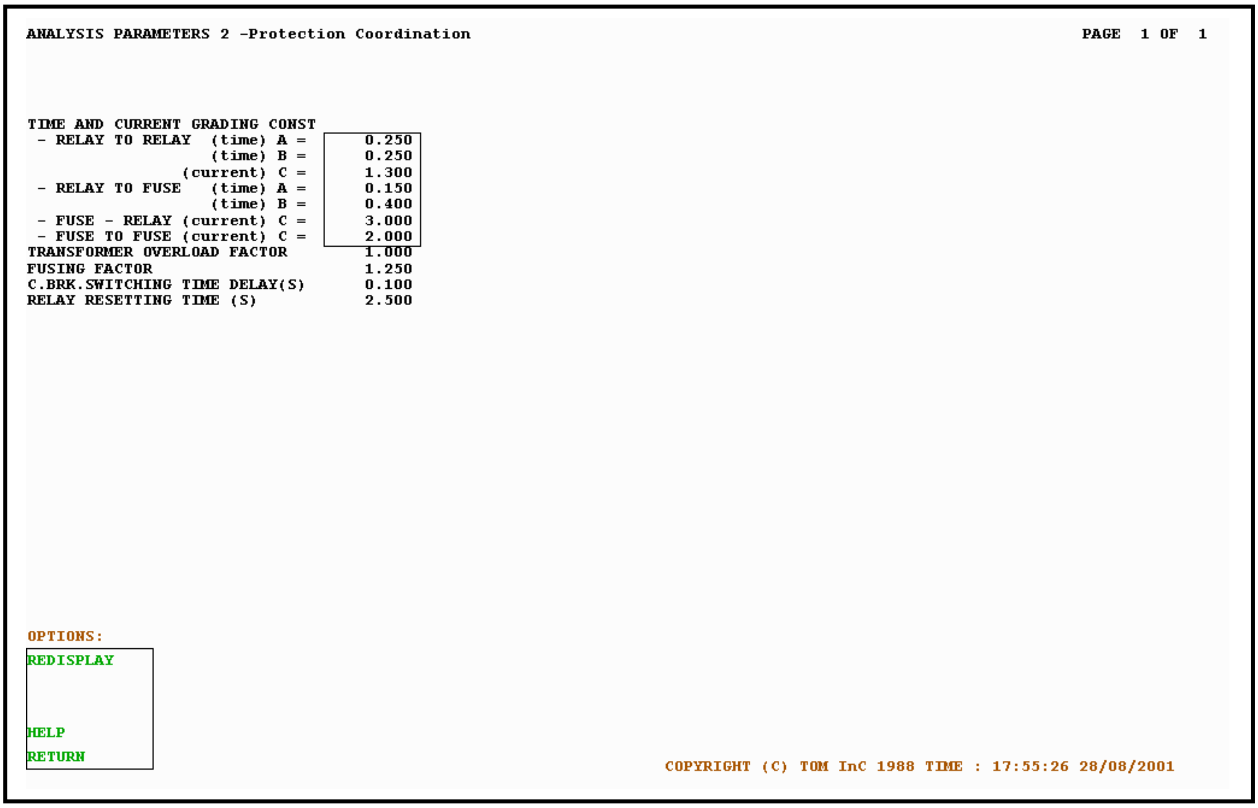

ANALYSIS PARAMETERS 2 -Protection Coordination
PAGE 1 OF 1
TIME AND CURRENT GRADING CONST
- RELAY TO RELAY (time) A = 0.250
(time) B = 0.250
(current) C = 1.300
- RELAY TO FUSE (time) A = 0.150
(time) B = 0.400
- FUSE - RELAY (current) C = 3.000
- FUSE TO FUSE (current) C = 2.000
TRANSFORMER OVERLOAD FACTOR 1.000
FUSING FACTOR 1.250
C.BRK.SWITCHING TIME DELAY(S) 0.100
RELAY RESETTING TIME (S) 2.500
OPTIONS:
REDISPLAY
HELP
RETURN
COPYRIGHT (C) TOM InC 1988 TIME : 17:55:26 28/08/2001

Figure 11.26

11.5 Protection coordination

Access to these facilities is gained by selecting the protection option from the fault analysis menu, shown in figure 11.27. This ensures that the network data are checked and prepared for fault calculations before running the coordination routines. The fault level section may be accessed either directly from PASHA main options, or passing through load flow. For the latter case the load currents are included in the fault calculations.

Furthermore, the outages facility in the load flow section enables the user to simulate the temporary removal of network components to obtain the most onerous conditions for the protection coordinating. All the removed components are restored by selecting outages again, or by returning to PASHA main options.

The organization of the program allows the user to 'move' freely from protection coordination to edit or load flow outages facilities, perform any change and return to protection coordination to continue the design without any unwanted disturbance.

11.5.1 Protection coordination menu

The layout of the protection menu is shown in figure 11.28. The first four options refer to overcurrent protection and allow access to the coordination and grading curve plotting routines, for phase and earth devices. The next two subsequent options enable the calculation of distance protection settings.

Additionally, a set of options provide access to the tripping times algorithms, which enable the user to check the coordination of overcurrent and distance protection for different fault types and fault locations.

The print and full list options provide the standard facilities for the display and printing of the most recent calculation results.

Selection of the return option enables the user to exit to the fault analysis section. However, it also provides a direct access to some protection-related pages in edit:

- To line data 4 by typing <E>
- To distance and unit protection 1 by typing <D>, and
- To analysis parameters 2, by typing <P>.

Other non-explicit options in this menu are:

- Repeat last coordination, by selecting any coordination option pressing <R>
- Faulted busbar name entry, by selecting any of the tripping times option pressing <N>.

SET Mode option is illustrated in the next section while the other options are described throughout this chapter.

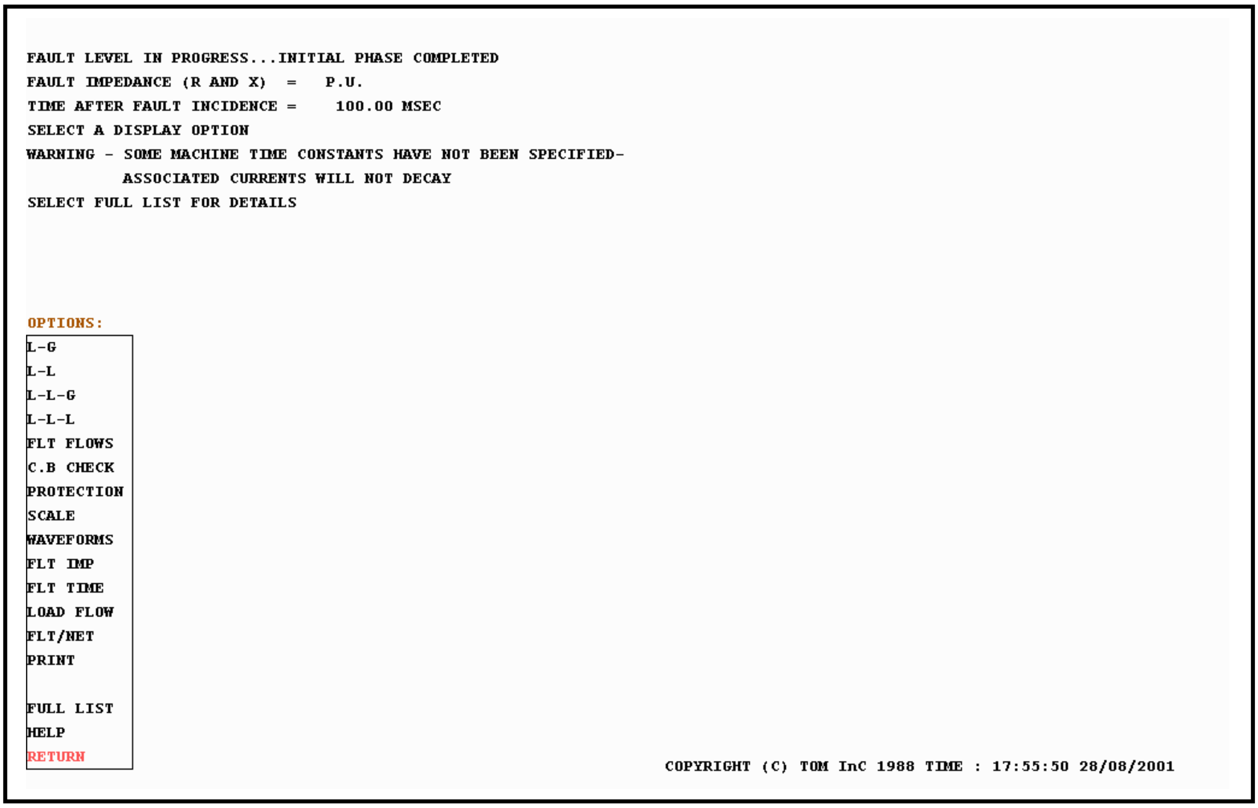


Figure 11.27

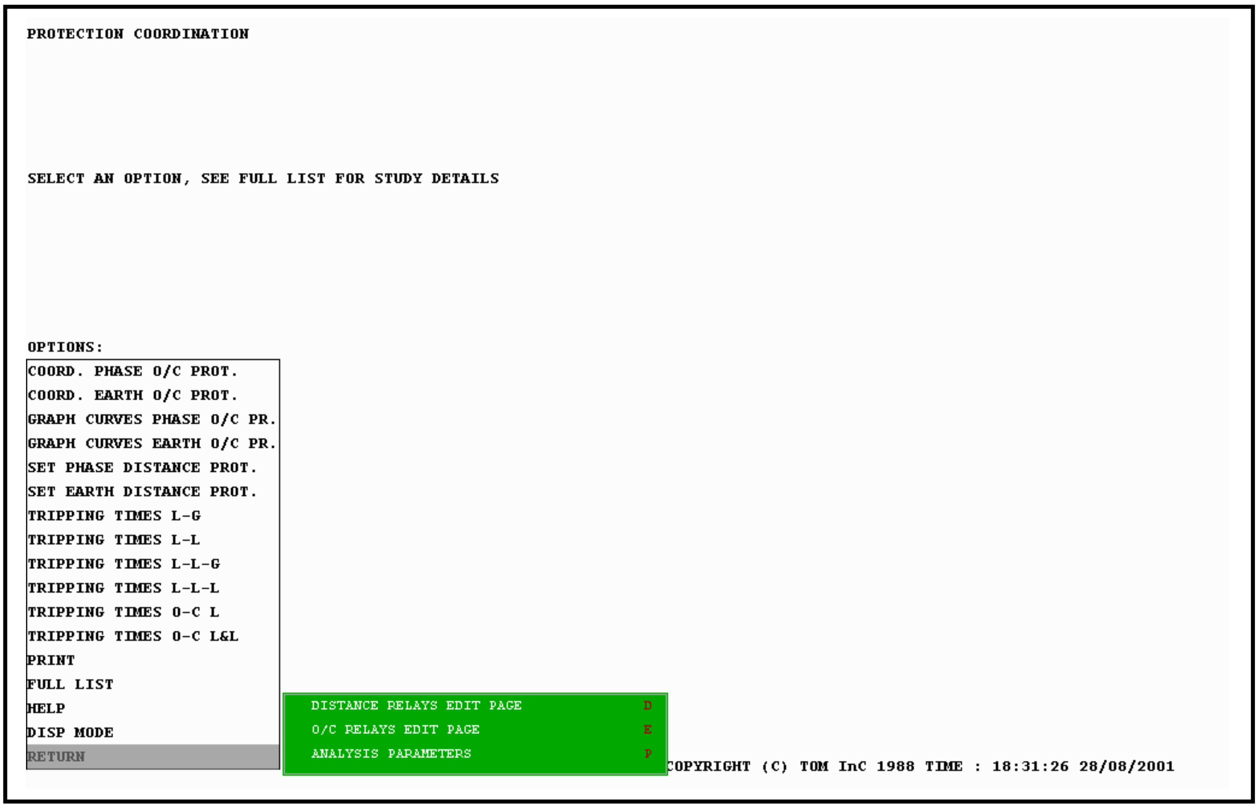


Figure 11.28

11.5.1.1 [SET MODE]

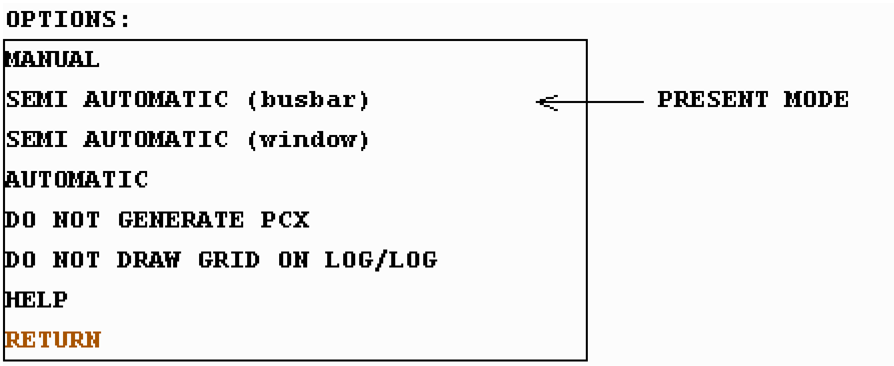
The set mode option enables to choose between manual and automatic path selection. A path is defined as a minimal set of components that connect a selected node to the generation nodes, which the selected node is supplying from. This is a familiar definition in reliability analysis.

In PASHA protection routines described in the next sections of this manual, the user may select the paths manually or leave the computer to find the paths automatically. There are a number of options associated with set mode option. If the [SET MODE] option is selected by pressing the <SP> key or a click, another the display subsection is entered. Figure 11.29 shows the display menu, after initial entry. The main options also shown in the following figure.

To select a particular mode position the horizontal cursor over the required option title and:

Press the <SP> key or a click to change the display mode or Press <X> to select the mode and come back to the protection main menu options.

For example, if the cursor is positioned over the [MANUAL] option and the <SP> key or a click is pressed, then set mode is changed, and this is indicated by an arrow, as shown in the following figure as well as in figure 11.30. The meanings of the options are as following:



MANUAL
The user will be invited to select the path manually. The process described in section 11.5.2.2.

SEMI AUTOMATIC (busbar)
This is protection routine default option. When selected, the user just needs to click on the start node (busbar) and the computer finds the paths automatically in protection routines.

SEMI AUTOMATIC (window)
When selected the computer draws the single-line diagram of the network and asks the user to select his desired window (area). The user specifies his desired area by clicking the mouse in any point inside the area. The name of the window selected will be written in front of this option.

The selection of this option causes that the start nodes of the paths will be selected by protection routines automatically and will be chosen from the nodes inside this area. The nodes with minimum fault level will be candidates. Among the candidate nodes the paths which its busbars have maximum least square fault level will be selected from. Therefore, selection of this option needs the user to have been performed a fault level calculation before.

AUTOMATIC
This acts as the previous option, but instead of an area the entire network will be considered. The selection of this option causes that the start nodes of the paths will be selected by protection routines automatically and will be chosen from the nodes of the networks. The nodes with minimum fault level will be the candidates for start node. Among the candidate nodes the paths which its busbars have maximum least square fault level will be selected from. Therefore, selection of this option needs the user to have been performed a fault level calculation before.

DO NOT GENERATE gif / DO GENERATE gif
Generates gif copy of LOG-LOG graphs for each path where automatic checking of the protection relays displays on screen. The gif files will store in gif format with the name of PASH*.gif. The user can implement a graphic package in order to print these files latter.

DO NOT DRAW GRID / DO DRAW GRID
Generates a horizontal and vertical lines for grinding the LOG-LOG graphs.

HELP
Provides help information.

RETURN
Returns back to the previous main menu of protection facilities.

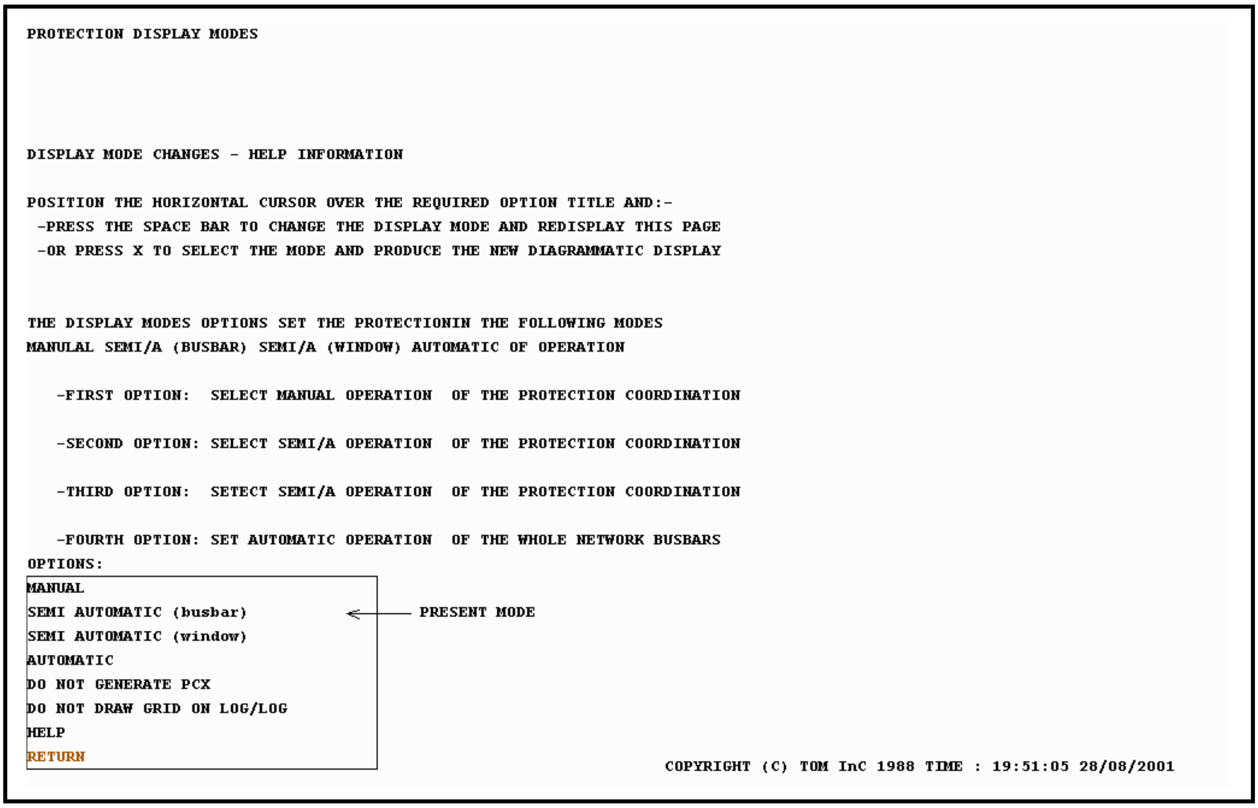


Figure 11.29

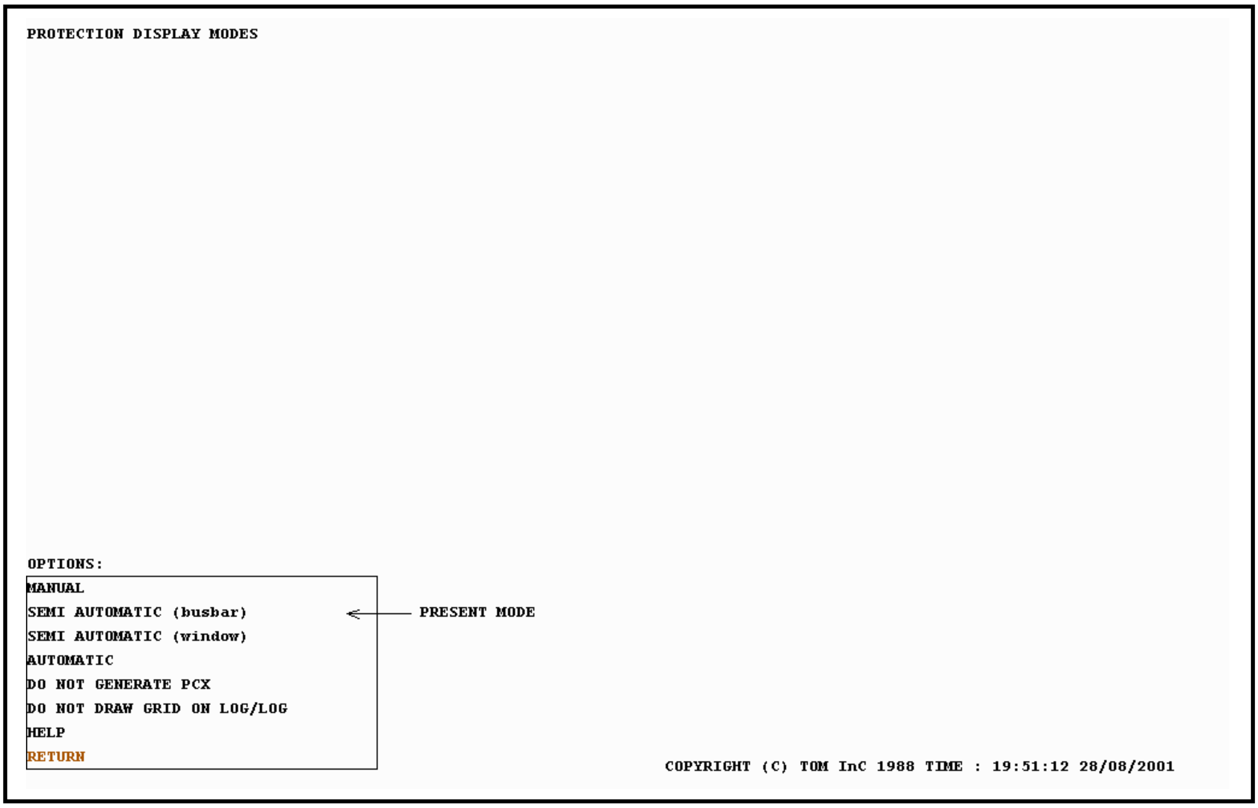


Figure 11.30

11.5.2 Overcurrent protection coordination routines

11.5.2.1 General considerations

The grading criteria implemented in the coordination routines can be summarized as follows:

- The current (pick-up) levels of each "minor" (or primary) device and its "major" (or back-up) should be such that:

IPM > C*IPN

Where:

IPM = pick-up level of major device.
IPN = pick-up level of minor device.
C = 1.3, if relay-to-fuse; 2.0, if fuse-to-fuse; and 3.0, if fuse-to-relay, or relay-to-fuse.

- the coordination time interval between the operation of the major and the minor devices, given the worst possible fault for the latter, should be:

CTI = A + B*t

Where:

A = 0.25,B = 0.25, if relay to relay:
A = 0.15, B = 0.4, if relay to fuse,
T = time for the minor device to operate (sec). (if it is a fuse, the clearing time is assumed)
CTI = coordination time interval, in sec.

The magnitudes given above for the grading constants A, B, and C are the default values, the user may change them in edit - analysis parameters 2, and the updated values are stored with the network data whenever the system is filed.

In addition to the network and machine impedances required by the fault calculation in PASHA, the essential data required for the protection coordination facilities are:

- The busbar rated (or BASE) voltages, VNOM-KV in busbar data 1;
- The line load ratings, RAT-MVA in line data 2:
- The relay type and current transformer ratio (CT-RAT), or only the type for fuses, in line data 4 and 5;
- The transformer winding connections for earth relay coordination only.

Any relay settings (or fuse rated amps) entered in line data 4 or 5 are assumed to be 'pre-settings': they can only be updated by the user's decision. For relays, any time setting specified without the corresponding plug setting is ignored in the calculations.

The program allows for the simultaneous storage of three different values for the device settings:

- 'pre-setting' value, specified in line data 4, or 5

-'calculated' value, determined by the computer using the grading criteria described above. Whenever this value exceeds the pre-setting (if specified) a conflict arises, which has to be solved by the user.

-'present' value, which is the result of the last updating of the setting. All the 'present' settings represent the current state of the design, and they are stored with the network data when the system is filed.

The general updating procedure considers two cases:

- if no pre-setting has been specified, any 'present' setting is overwritten by the calculated' value only if the latter is higher.

- if, on the other hand, a pre-setting exists it will be adopted as the 'present' setting, as long as the calculated value does not exceed the pre-setting. Otherwise, the user must choose which one should become the 'present' setting.

11.5.2.2 Coordination of phase devices

Access to this facility is achieved by selecting [**COORD PHASE O/C PROTECTION**] from the protection coordination options. Immediately after doing so, the network diagram is displayed on the screen and the user is requested to enter the coordination path. The selection of the coordination path depends to the mode selection (section11.5.1.2).

If mode is in MANUAL

Selection of the coordination path is done by selecting the substations (or junctions) that define the path using the cursors and pressing the space bar or a click for each selected location. The data corresponding to each branch are checked simultaneously with the path entry, and an appropriate error message is given if any essential specification is missing. The sequence in which the protection devices are graded is determined by the direction of the coordination path entry. Hence, this direction should be opposite to the likely fault current flow. After the coordination path entry is completed the user starts the calculation of the settings by pressing 'X'.

If mode is in SEMI AUTOMATIC (busbar)

Selecting a single substation (or junction) that you would like the coordination starts from determines the coordination paths. Computer finds the paths, which supply this substation, and shows the paths single-line diagrams one by one automatically. An example is shown in figure 11.31 and 11.32.

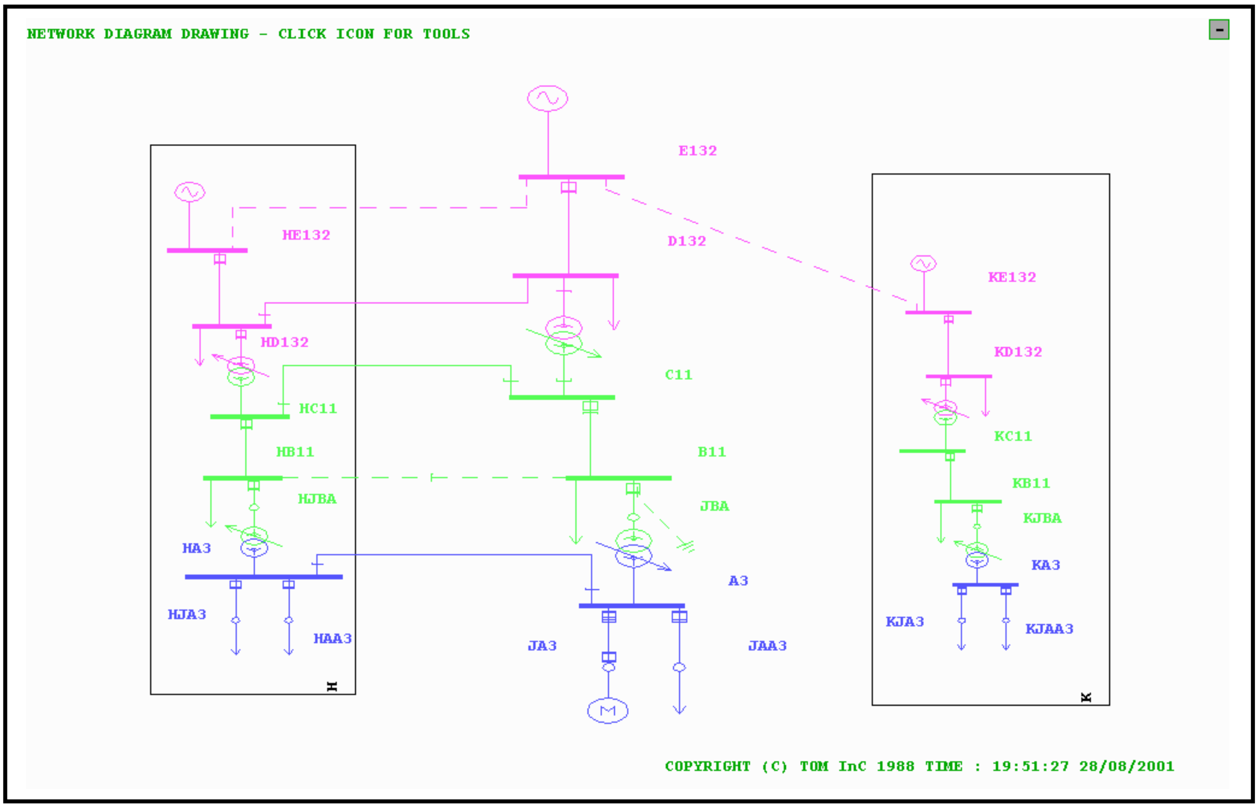


Figure 11.31

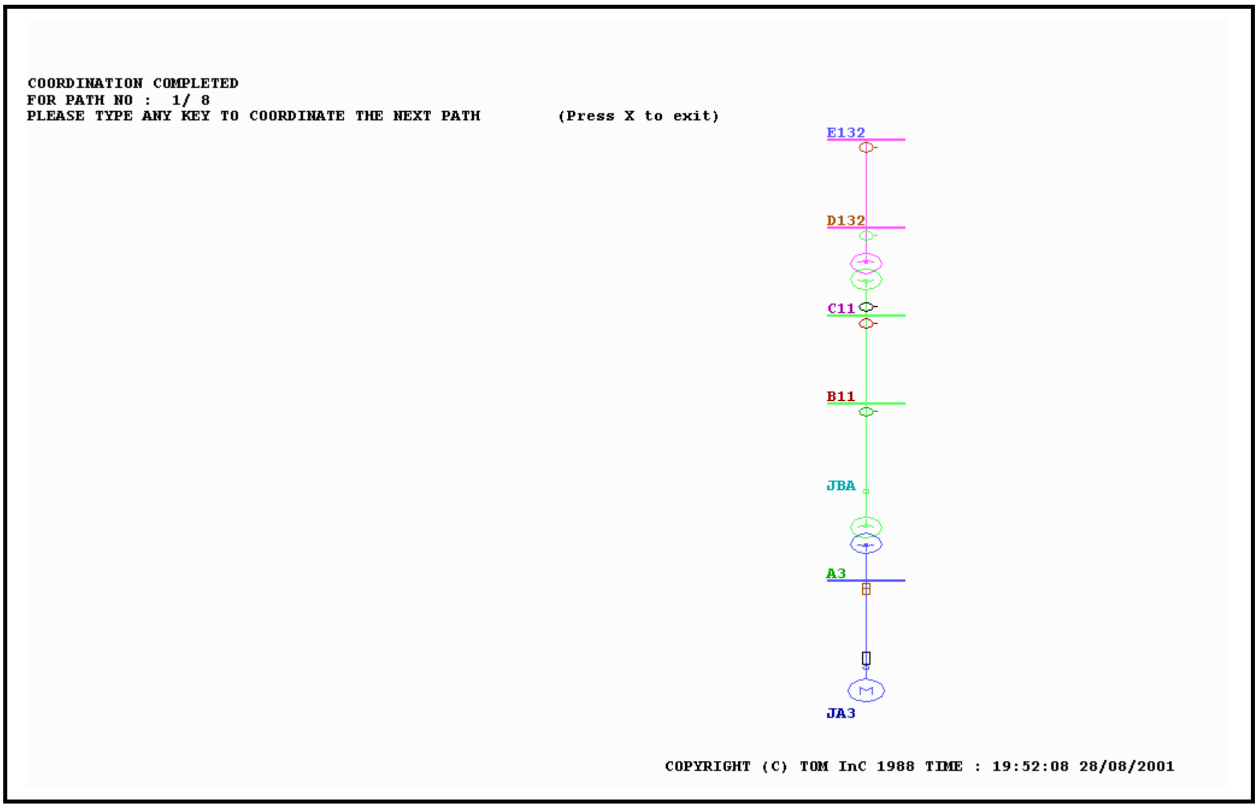


Figure 11.32

The sequence in which the protection devices are graded is determined by the direction of the coordination path selected. Hence, this direction should be opposite to the likely fault current flow. Therefore, the busbar selected by the user should be in the far end of the paths. For example, junction of an induction motor supplied in an industrial plants or substation at the end of a radial system. After the coordination for the first path is completed the user continue the coordination by a click. The process can be ended or interrupted by pressing <X> or <O>.

If mode is in SEMI AUTOMATIC (window) or in AUTOMATIC

The starting substation and the paths and the reports will be done automatically. The user just need to answer to the computer questions and press a key or a click after computer finishes a path. If [**DO GENERATE gif**] is active the gif files are also created and stored.

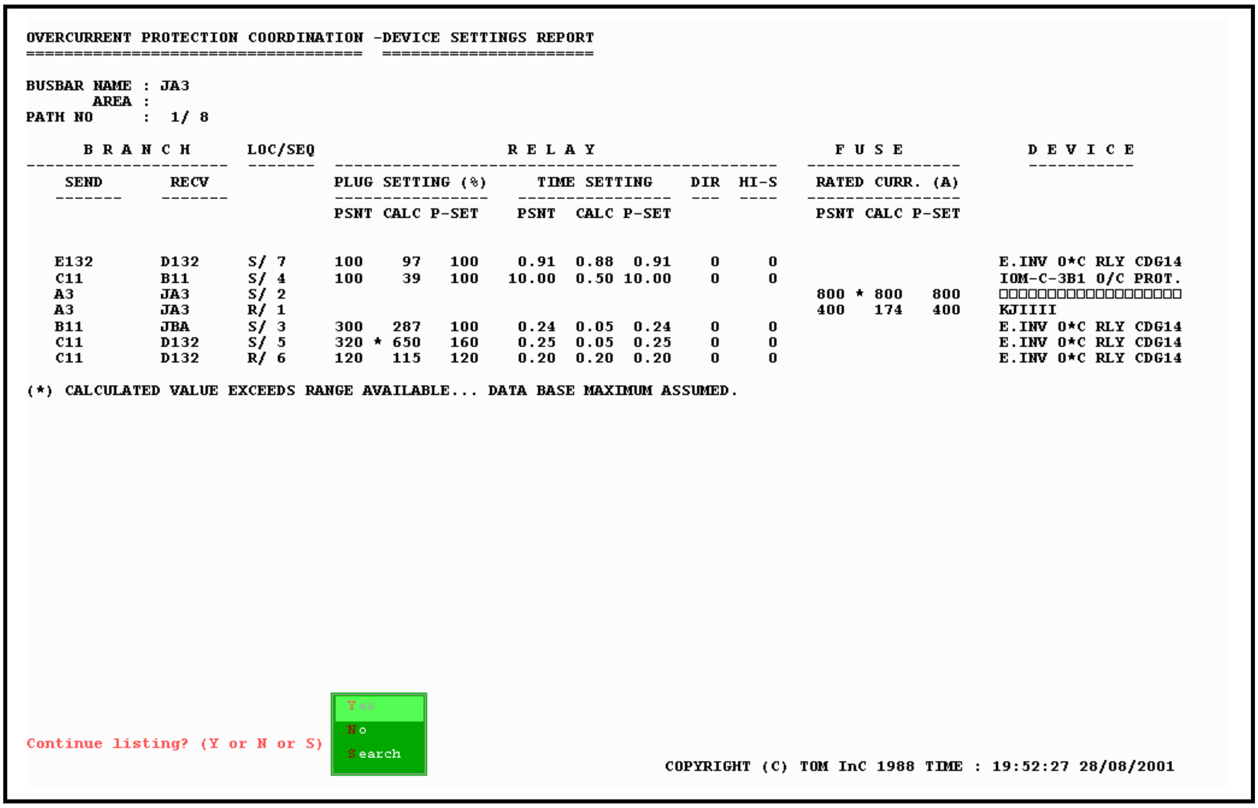
In all the cases, the rated load currents are first calculated for the sending and receiving ends of each branch in the coordination path, from the corresponding rated load (RAT-MVA) and rated voltage (VNOM-KV). These currents are then used to set the current (pick-up) levels of the devices, to ensure no operation for nominal load conditions. An overload factor (defined in analysis parameters 2) is considered for the transformers. These current (pick-up) settings are selected from the relay plug settings (or fuse rated currents) available for the corresponding type in the data base, and are later checked (and modified, if required) according to the current grading to the current grading criteria.

The grading procedure includes all non-directional relays and fuses specified in the coordination path, and also the directional relays set to operate for the 'downstream' fault current direction. When defining the coordination path, the user is in fact assuming the 'downstream' direction to be opposite to the path entry direction.

For both time and current grading the devices are considered to form 'minor-major' pairs; the 'major' device graded to back-up the 'minor'. The process starts by assuming the first device as 'minor' and settings for the second device (i.e., The 'major') are calculated to provide an adequate back-up; then the second device becomes the 'minor' and the third is assumed as the 'major', etc.

For time grading a three phase fault is assumed to be located immediately adjacent to the 'minor' device, on the downstream side. If no grading conflicts arise during the calculations (i.e., No calculated setting exceeds the pre-setting), all the 'present' settings are updated as described above (section 11.5.2.1), and the program displays the protection coordination options page on the screen with the message 'coordination completed'. The results can be listed on the screen by selecting full list and/or appended to a printer file (PRINTER.92) by choosing print which are standard procedures in PASHA. Figure 11.33 shows an example of these results. Note here that the device location in the branch and its sequence number within the coordination path are indicated under the heading LOC/SEC.

However, if grading conflicts do arise, the computer stops and displays a table with the results, after having completed the calculations for that grading stage (time or current). As can be seen in figure 11.34, the alphanumeric cursor is positioned on the line corresponding to the conflictive device, and the user is required to type 'C' or 'P' to select either the calculated or the pre-set value.



OVERCURRENT PROTECTION COORDINATION -DEVICE SETTINGS REPORT

BUSBAR NAME : JA3
AREA :
PATH NO : 1/ 8

BRANCH SEND	BRANCH RECV	LOC/SEQ	RELAY PLUG SETTING (%) PSNT	CALC	P-SET	RELAY TIME SETTING PSNT	CALC	P-SET	DIR	HI-S	FUSE RATED CURR. (A) PSNT	CALC	P-SET	DEVICE
E132	D132	S/ 7	100	97	100	0.91	0.88	0.91	0	0				E.INV O*C RLY CDG14
C11	B11	S/ 4	100	39	100	10.00	0.50	10.00	0	0				IOM-C-3B1 O/C PROT.
A3	JA3	S/ 2									800	* 800	800	□□□□□□□□□□□□□□□□□□□□
A3	JA3	R/ 1									400	174	400	KJIIII
B11	JBA	S/ 3	300	287	100	0.24	0.05	0.24	0	0				E.INV O*C RLY CDG14
C11	D132	S/ 5	320	* 650	160	0.25	0.05	0.25	0	0				E.INV O*C RLY CDG14
C11	D132	R/ 6	120	115	120	0.20	0.20	0.20	0	0				E.INV O*C RLY CDG14

(*) CALCULATED VALUE EXCEEDS RANGE AVAILABLE... DATA BASE MAXIMUM ASSUMED.

Continue listing? (Y or N or S) Yes No Search

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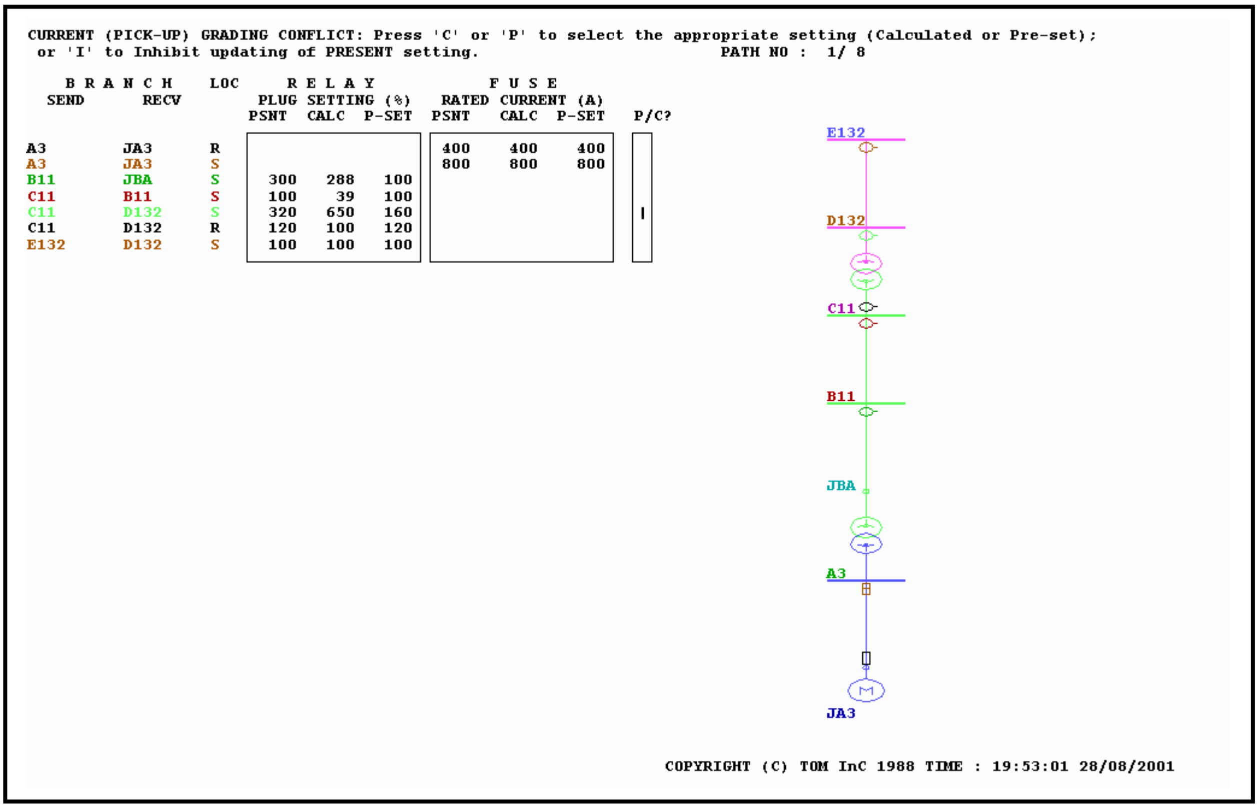
Figure 11.33



CURRENT (PICK-UP) GRADING CONFLICT: Press 'C' or 'P' to select the appropriate setting (Calculated or Pre-set);
or 'I' to Inhibit updating of PRESENT setting. PATH NO : 1/ 8

BRANCH SEND	BRANCH RECV	LOC	RELAY PLUG SETTING (%) PSNT	CALC	P-SET	FUSE RATED CURRENT (A) PSNT	CALC	P-SET	P/C?
A3	JA3	R				400	400	400	
A3	JA3	S				800	800	800	
B11	JBA	S	300	288	100				
C11	B11	S	100	39	100				
C11	D132	S	320	650	160				I
C11	D132	R	120	100	120				
E132	D132	S	100	100	100				

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Figure 11.34

It should be noted that the calculated settings given in the table for the devices located after the conflictive one are based on the assumption that the pre-setting will be chosen. Hence, if the user selects the calculated setting, these devices have to be re-graded. This procedure enables the user's direct intervention to solve the grading conflicts, providing him at the same time with enough information to assess the state of the calculations and to decide how to continue.

11.5.2.3 Coordination of earth devices

This coordination facility follows the same guidelines defined previously for phase devices. However, a number of particular aspects concerning the zero sequence network configuration and the device grading criteria need to be considered.

The earth overcurrent protection coordination facility requires essentially the same network data as the phase coordination routine, but additionally all the relevant zero sequence impedances must be specified. For transformers and machines with neutrals connected to ground, these values must include three times the magnitude of the grounding impedance. The impedance of the ground return path may also be considered here. Transformer winding connections are also required (transformer data 2).

The coordination path is specified in the same way as in phase device coordination, by selecting the corresponding substations or junctions with the cursors in manual mode and automatically by computer in automatic mode. Every time a new branch is included in the path a number of checks for essential data are performed. For earth-fault protection this procedure includes also the zero sequence impedance and the transformer winding connection (if the branch includes one). Whenever any essential data is missing an error message is written on the screen, the coordination calculations are blocked and control is returned to the user at the protection menu page.

A particular feature of this coordination routine is that the path selected may include devices belonging to non-connected areas of the zero sequence networks. The user is allowed to include any number of these areas in the coordination path. Whenever a transformer whose winding connection splits the zero sequence networks is entered, a warning message is given. The coordination routine will grade the devices on each area independently, i.e., The first device found on each one will be assumed as the reference device and the next earth-fault relay is graded against it. Also, the coordination routine will ignore any earth-fault device specified in an ungrounded area (where no path is available for the residual current).

The possibility of grading an earth relay against a phase device has also been considered. If the first device found in the coordination path is a phase device, and no earth-fault protection has been specified on that location, then the phase device (relay or fuse) is assumed as the 'reference' device. Hence, this matter is determined by the user's choice of the path and the specification of the protection devices.

The calculation of the settings in these routine follows the same structure used for phase device coordination. However the initial plug settings are not based on the rated load conditions, but on the line-to ground fault levels for faults occurring at the downstream side of each earth-fault device. The plug settings are chosen to give a setting current equivalent to 10 % of this fault current.

After the initial values for the plug settings have been defined. The procedure for checking (and adjusting) these values for current grading and for calculating the time settings is essentially the same as that previously described for phase protection. However, in the time grading stage a line-to-ground fault adjacent to the minor device is assumed for calculating the time setting of the corresponding major device. Also, the independent grading for devices at different earth-fault protection zones has been considered.

Figure 11.35 presents an example of the device settings report for a path involving two of these zones. Note that the coordination sequence numbers are set to indicate this.

11.5.2.4 Repeat/Empty the last coordination facility

During a protection coordination study it is frequently necessary to repeat the same coordination path. This facility enables the user to do it simply by pressing <R> when selecting any of the coordination options (phase or earth). The option may also be selected from green box available when the cursor is located on coordination options.

This avoids the need to enter the path again, which is unnecessary and time-consuming. In automatic mode however the routines are fast enough to avoid using this option.

Before executing the selected coordination routine the user may decide to cancel the 'present' settings updated during the last coordination (figure 11.36). Pressing <E> will do this job. By doing so the user clears these 'present' values, hence allowing the new values to be calculated only on the basis of the new conditions imposed.

EARTH-OVERCURRENT PROTECTION COORDINATION -DEVICE SETTINGS REPORT

BUSBAR NAME : 160P32
AREA : P2 /P /PEL-6.6 /MSC
PATH NO : 1/ 2

BRANCH		LOC/SEQ	RELAY								FUSE			DEVICE
SEND	RECV		PLUG SETTING (%)			TIME SETTING			DIR	HI-S	RATED CURR. (A)			
			PSNT	CALC	P-SET	PSNT	CALC	P-SET			PSNT	CALC	P-SET	
PEL-A	PEL-B	S/ 5	10	13	10	7.00	10.67	*7.00	0	0				IAC 51&52 O/C 0.5-2
PEL-A	PEL-B	R/ 4	10	4	10	7.00	7.00	7.00	0	0				IAC 51&52 O/C 0.5-2
PEL-B	MC-PEL1B	S/ 3	10	13	10	3.00	3.62	3.00	0	0				IAC 51&52 O/C 0.5-2
PEL-B	MC-PEL1B	R/ 2	10	5	10	3.00	0.69	3.00	0	0				IAC 51&52 O/C 0.5-2
PEL	T1B-P	S/ 1	0		300	0.00		2.00	0	800				ASEA RACIC DEFIN 1A
PC-PEL3A	160P32	S/ 1	1000	*27440	1000	0.20	0.20	0.20	0	0				M1AM02B (.3-3.6)E/F
T1B-P	PEL-A	S/ 7	6	* 12	6	2.00	1.67	2.00	0	0				ASEA RXIG E/F PROT.
T1B-P	PEL-A	R/ 6	10	7	10	4.00	4.00	4.00	0	0				IAC 51&52 O/C 0.5-2
MC-PEL1B	PC-PEL3A	S/ 1	10	* 61	10	0.50	0.50	0.50	0	0				IAC 51&52 O/C 0.5-2
MC-PEL1B	PC-PEL3A	R/ 2	500	*2716	500	0.50	0.50	0.50	0	0				M1AM04B (.2-2.4)EF

(*) CALCULATED VALUE EXCEEDS RANGE AVAILABLE... DATA BASE MAXIMUM ASSUMED.

Continue listing? (Y or N or S)

Yes
No
Search

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Figure 11.35

PROTECTION COORDINATION

SELECT AN OPTION, SEE FULL LIST FOR STUDY DETAILS

OPTIONS:

COORD. PHASE O/C PROT.
COORD. EARTH O/C PROT.
GRAPH CURVES PHASE O/C PR.
GRAPH CURVES EARTH O/C PR.
SET PHASE DISTANCE PROT.
SET EARTH DISTANCE PROT.
TRIPPING TIMES L-G
TRIPPING TIMES L-L
TRIPPING TIMES L-L-G
TRIPPING TIMES L-L-L
TRIPPING TIMES O-C L
TRIPPING TIMES O-C L&L
PRINT
FULL LIST
HELP
DISP MODE
RETURN

REPEAT THE LAST PATH R
EMPTY PREVIOUS SETTINGS E

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Figure 11.36

11.5.3 Coordination curve plotting routines

These facilities enable the user to assess the coordination of overcurrent devices by displaying their time-current characteristics and reporting their response to the faults. This may be achieved for any device specified in the network if the corresponding settings are available. The 'present' settings are normally assumed, to enable the assessment of the current design. However, if these have not been defined, the settings specified in line data 4 or 5 (pre-settings) are used. Hence, these facilities can be used immediately after retrieving a network form file, allowing the user to redefine any setting and plot the curves to check the effect on the coordination. After running the corresponding coordination routine the 'present' settings are defined and these values will be used subsequently.

A report will be generated automatically. Giving the response of the relays to all kinds of the faults (LLL, LG, LL, and LLG) located at appropriate points of the path in a table. Therefore, the effectiveness of each coordination path will be automatically assessed. The user just needs to look at the reports and finds out the grading conflicts which are specified by an asterisk (*) in the report (see figure 11.37).

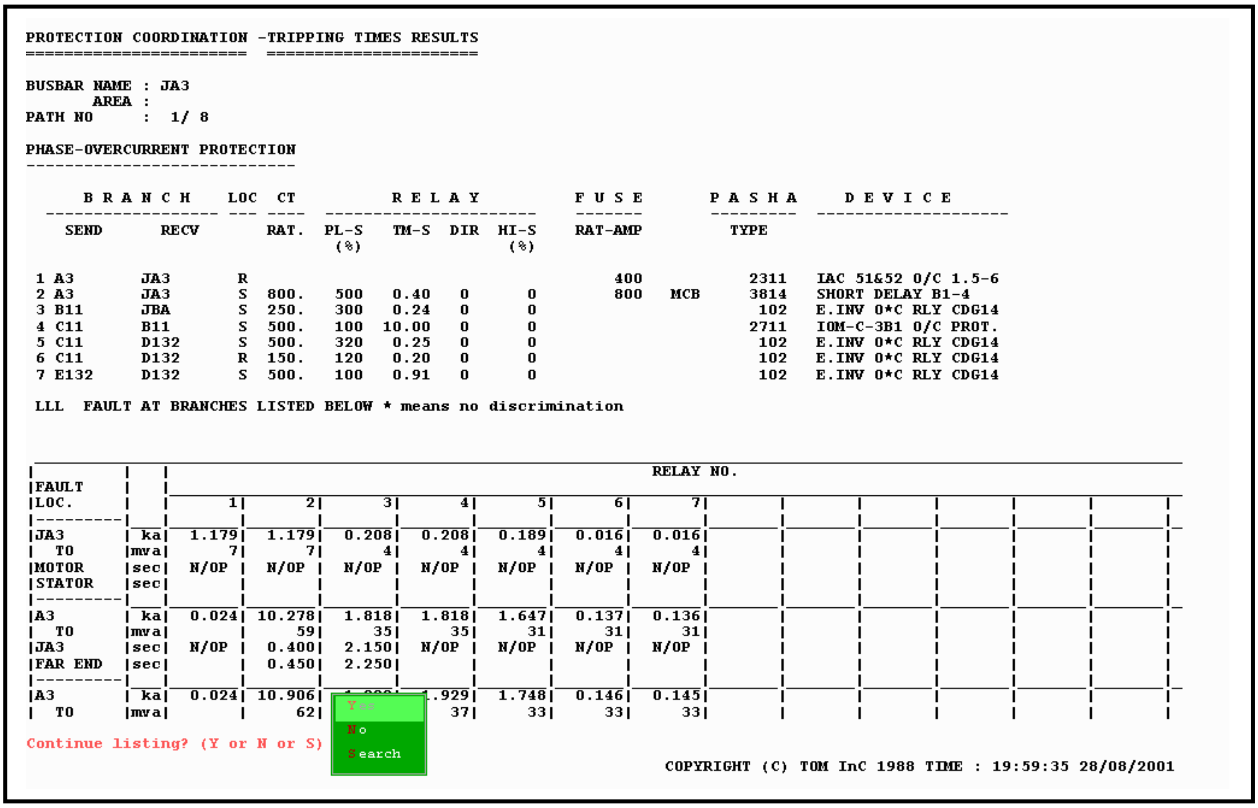
The name of the circuits which the relays and fuses are located will be written at the top of the plotting area. If the mouse cursor moves over any one of these names, a green box appears which shows all the information of that particular device. The user may change the device settings and APPLY it. The computer will do calculations for the same path and shows the results considering the new conditions. Therefore, the user may apply his view and check the new situation interactively (see figure 11.38).

At the right side of the screen a network consisting of the elements of the path and their connection together with the protection device symbols will be drawn. If the mouse cursor moves over the elements of this symbolic network, a green box will be appeared. By using these green boxes the user can for example start a motor and the TIME MVA characteristics of the motor starting will be calculated in transient stability routines while considering the entire plants, i.e. motor starts as being in the plant. The results will be shown on the graph.

Using the green boxes, through fault protection curves or the damage curves of transformers, cables and lines may be plotted inside the protection graphs and it is in user choice.

11.5.3.1 Graph curves option for phase devices (Automatic mode)

In automatic mode, the user just needs to specify the busbar (if you are in full automatic mode for windows or the entire plants the computer selects the busbar by its own). This is usually the busbar or junction that is located in the far end of a network, i.e. the junction that a motor is supplying from. The computer finds the paths and displays them one by one as shown in figure 11.39 (path no 1), and 11.40 (path no 2). A click will display the next path if it exists. Please refer to section 11.5.3.3 to find out more about the facilities available in this regard.



PROTECTION COORDINATION -TRIPPING TIMES RESULTS

BUSBAR NAME : JA3
AREA :
PATH NO : 1/ 8

PHASE-OVERCURRENT PROTECTION

	BRANCH SEND	BRANCH RECV	LOC	CT RAT.	RELAY PL-S (%)	RELAY TM-S	RELAY DIR	RELAY HI-S (%)	FUSE RAT-AMP		PASHA TYPE	DEVICE
1	A3	JA3	R						400		2311	IAC 51&52 O/C 1.5-6
2	A3	JA3	S	800.	500	0.40	0	0	800	MCB	3814	SHORT DELAY B1-4
3	B11	JBA	S	250.	300	0.24	0	0			102	E.INV O*C RLY CDG14
4	C11	B11	S	500.	100	10.00	0	0			2711	IOM-C-3B1 O/C PROT.
5	C11	D132	S	500.	320	0.25	0	0			102	E.INV O*C RLY CDG14
6	C11	D132	R	150.	120	0.20	0	0			102	E.INV O*C RLY CDG14
7	E132	D132	S	500.	100	0.91	0	0			102	E.INV O*C RLY CDG14

LLL FAULT AT BRANCHES LISTED BELOW * means no discrimination

FAULT LOC.		RELAY NO. 1	2	3	4	5	6	7
JA3 TO MOTOR STATOR	ka	1.179	1.179	0.208	0.208	0.189	0.016	0.016
	mva	7	7	4	4	4	4	4
	sec	N/OP	N/OP	N/OP	N/OP	N/OP	N/OP	N/OP
	sec							
A3 TO JA3 FAR END	ka	0.024	10.278	1.818	1.818	1.647	0.137	0.136
	mva		59	35	35	31	31	31
	sec	N/OP	0.400	2.150	N/OP	N/OP	N/OP	N/OP
	sec		0.450	2.250				
A3 TO	ka	0.024	10.906	[illegible]	.929	1.748	0.146	0.145
	mva		62		37	33	33	33

Continue listing? (Y or N or S)

Yes
No
Search

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Figure 11.37

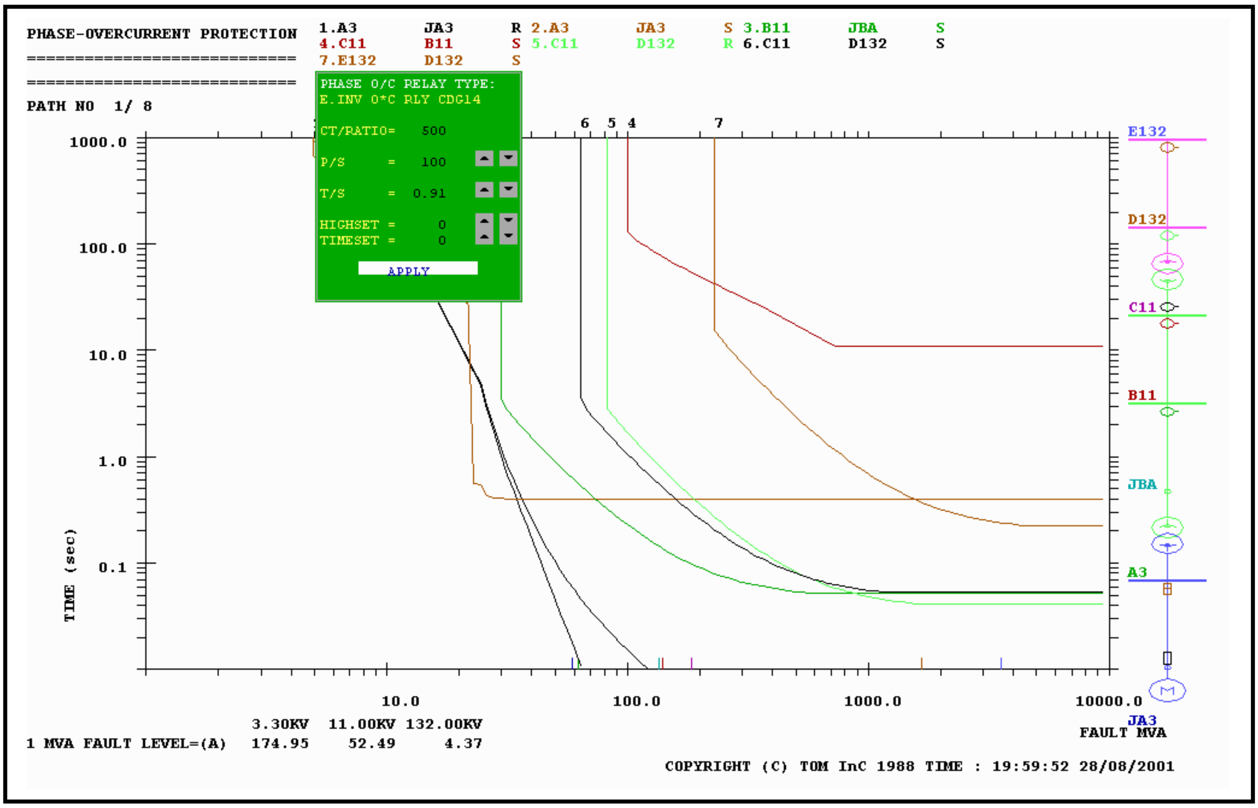


Figure 11.38

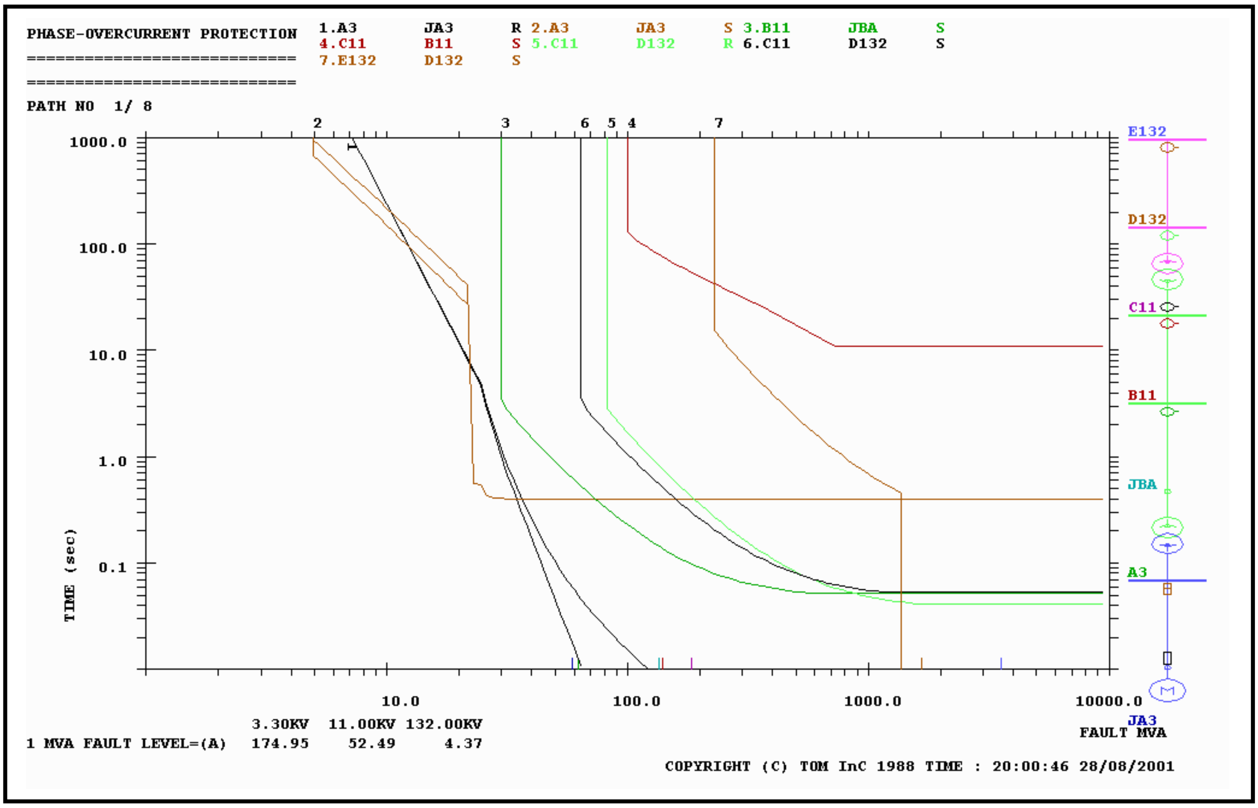


Figure 11.39

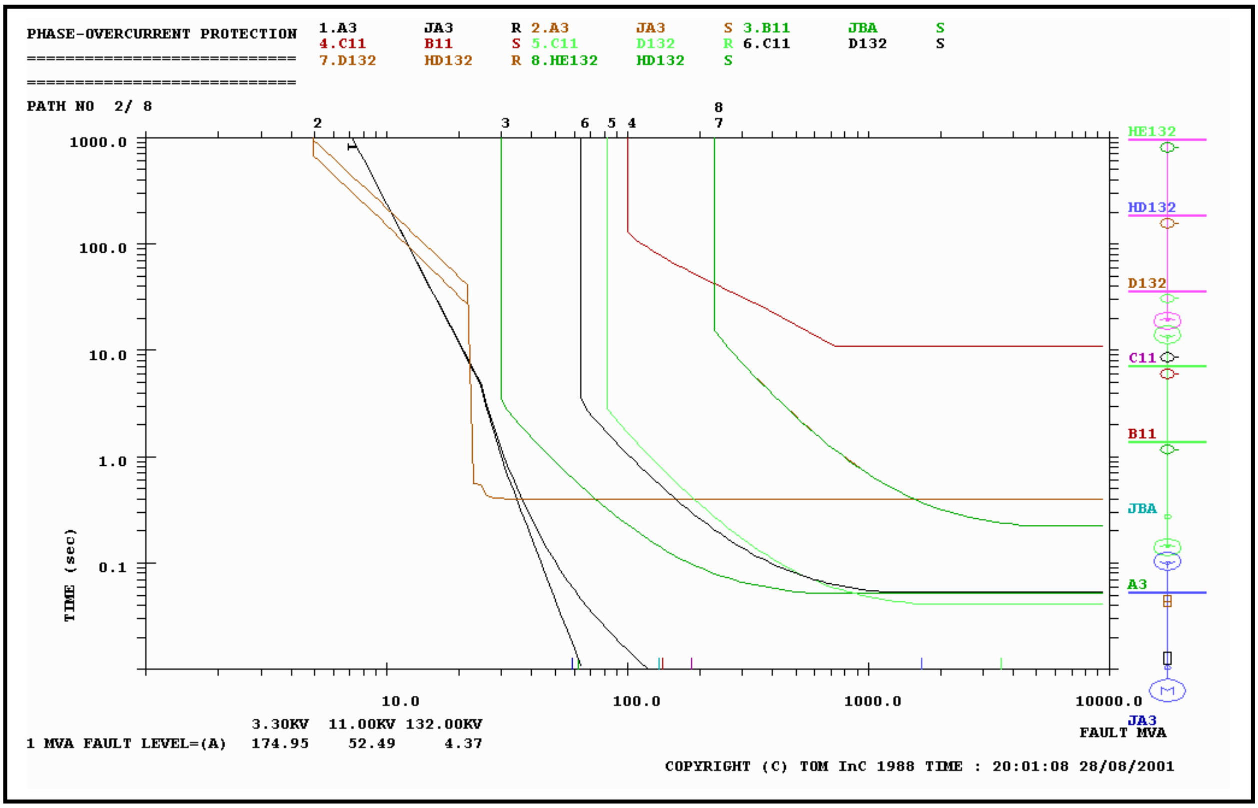


Figure 11.40

11.5.3.2 Graph curves option for phase devices (Manual mode)

Figure 11.41 shows the page displayed on the screen when this option is selected. It allows the user to define a protective device location for each one of the traces available. This is achieved by entering the sending and receiving busbar names for the branch, and 'S' or 'R' (to indicate sending or receiving end location) on the table provided. The devices included in the most recent coordination path can be automatically filled-in by pressing <F> with the cursors placed on this table. The entries shown in figure 11.41 correspond to the coordination report of figure 11.33.

Two ranges are provided for the time and current scales. An asterisk (*) indicates the selected range which can be changed using the horizontal cursor and pressing any key.

Figure 11.42 shows the curves displayed on the screen by selecting the plot option. A HI-SET of 1200 % has been specified for the relay at C11, for the sake of illustration.

It should be noted that for a fuse, the pre-arcing time-current characteristic is always plotted. The clearing (i.e., Pre-arcing+arcing) characteristic can also be plotted by entering the fuse location manually. As indicated above, and typing <Y> in reply to the prompt both fuse TCCs? (Y/N).

The facilities described in section 11.5.3.3 are available too. Please refer to this section for more information.

11.5.3.2.1 Graph curves option for earth devices

This option enables the user to display the time-current characteristics for earth-fault devices whose settings have been already defined. The selection of the scales, traces and devices is performed as described above.

However, the specification of phase-overcurrent devices is allowed here, as long as no earth device exists on the same location. This enables the user to plot also the characteristics for phase devices involved in the coordination. Figure 11.42 also presents the curves obtained for the earth device coordination results of figure 11.35.

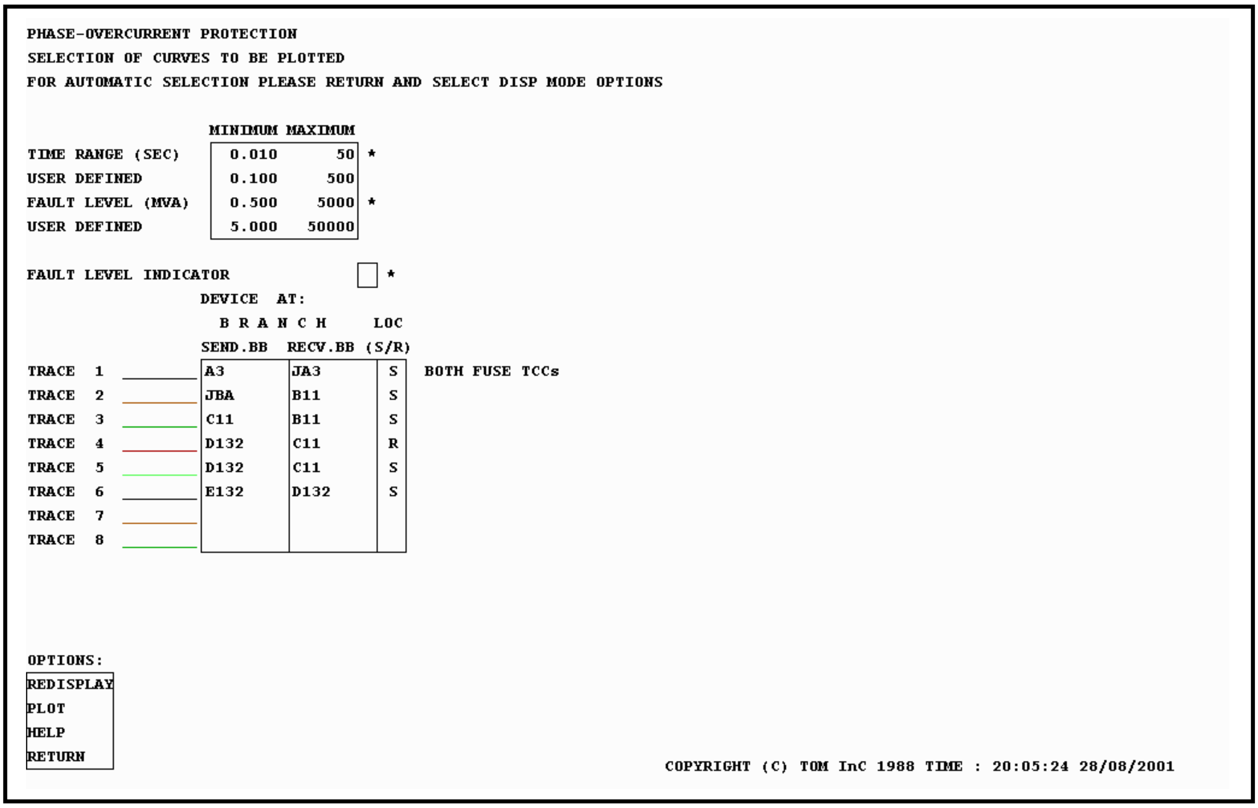


Figure 11.41

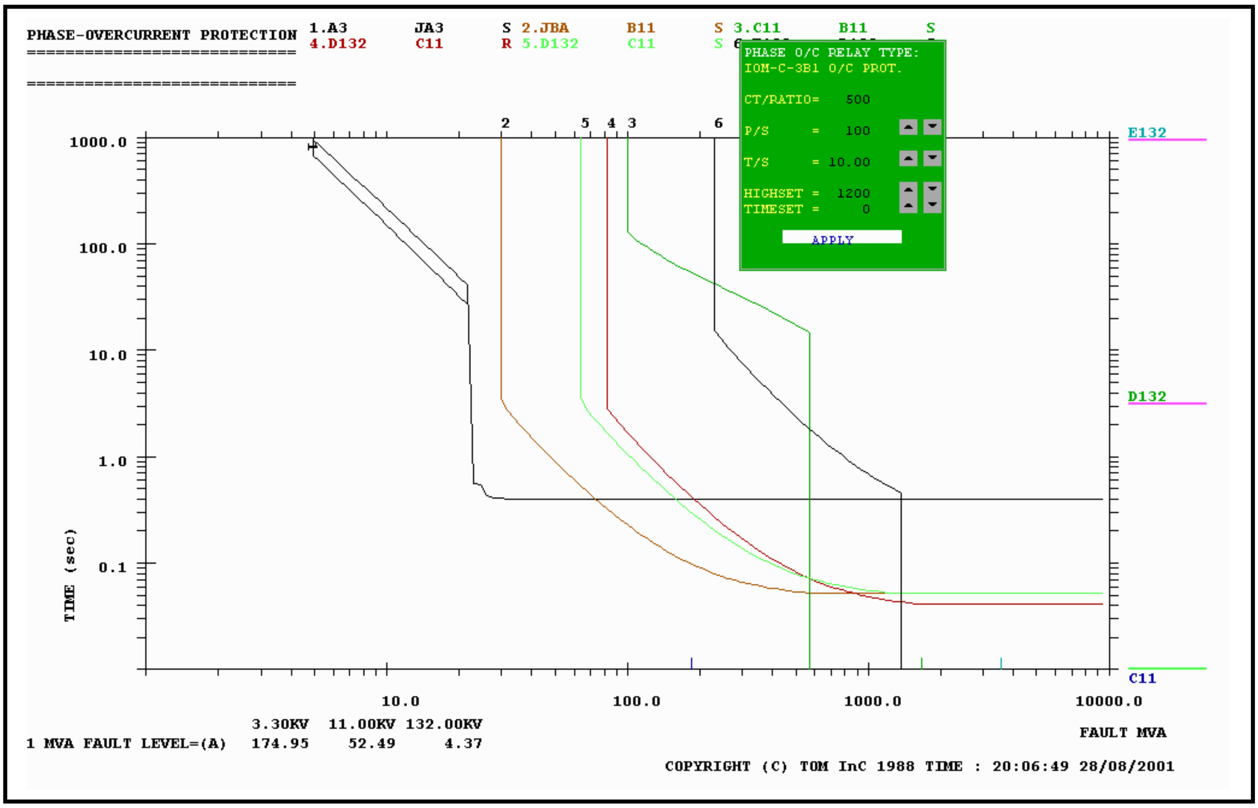
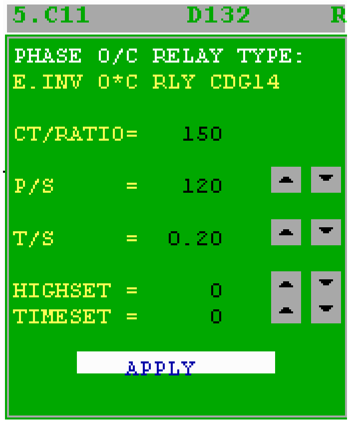
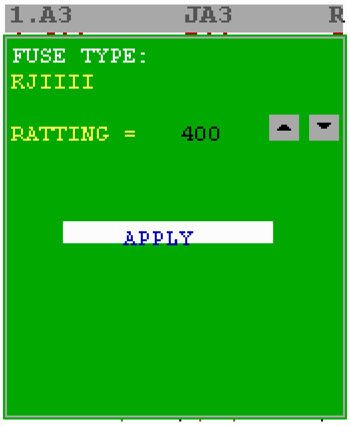


Figure 11.42

11.5.3.3 In line facilities

The user can locate mouse on top of the page over a relay name. A green box will be appearing which shows the information about that particular device. Examples are shown in the following figures.

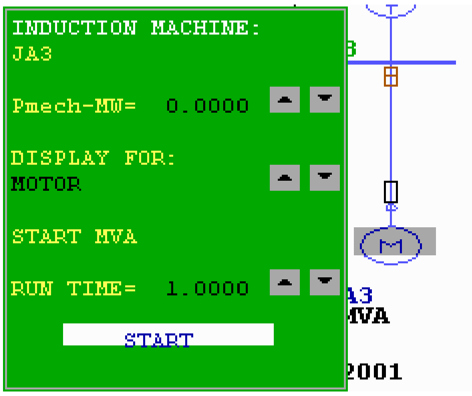




You can change the value of the variables shown in black by clicking on the small arrows. Click on the [APPLY] button to apply your changes. This will redisplays the graphics and will produce the new results.

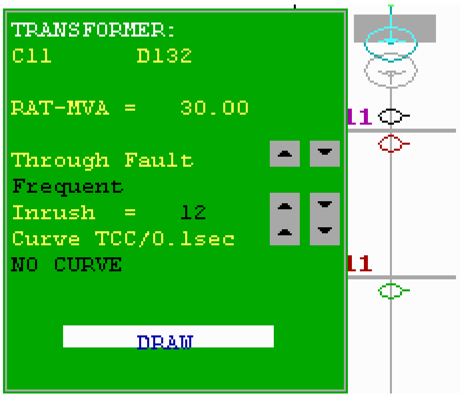
You can locate mouse on right of the page over an element of the symbolic graphs. A green box will be appearing which shows the information about that particular device. The following green boxes are available.

INDUCTION MOTOR



You can set **RUN TIME** and the mechanical power during start up (please also see chapter 4 section 4, in order to find out about the characteristic of the mechanical loads) and click on [**START**] button. You can also change the **DISPLAY FOR** in order to draw your desired line current instead of motor current.

TRANFORMER



Draws the damage curve for a transformer, based on information you enter through the dialog box shown and in the edit pages of that particular transformer. Click on the Draw button to draw the curve. According to ANSI/IEEE Standard C57.109 (and C37.91), the curve may take into account both thermal and mechanical stresses. The curves are dependent to the following:

Primary voltage:

Rated Primary Line to Line transformer voltage (in kV) entered in busbar data page 1.

Impedance:

The impedance entered in line data 1 for transformer.

RAT-MVA:

Three-phase base power rating of the transformer in MVA entered in line data 2 edit page.

Connection:

The transformer connection type entered in transformer data page 2.

Inrush:

Draws a circle at 0.1 second to indicate the transformer inrush current. You may change the inrush value by clicking on the arrows in front of the Inrush Multiplier field.

CURVE/TCC 0.1 sec:

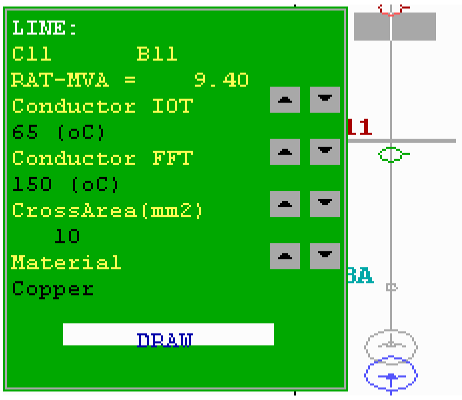
You may change this option to choose the inrush representation. Draw it or not to draw it. You may also select to represent the inrush, as a curve (is not active when writing this manual). An Identification Tag identifies the inrush in relays graph. Click on the arrows marked in front of this option to change the option.

Through Fault:
Select the type of curve to be displayed by clicking on it. Frequent through-fault accounts for cumulative mechanical damage due to winding stresses in addition to the thermal damage due to temperature rise. Infrequent through-fault accounts for thermal damage only. (« Frequent» means typically 10 or more through-faults during the life of the transformer.)
An alternative defined by the 1975 version of the IEEE Buff Book (IEEE Std. 242-1975) is to plot a Damage Point at coordinates (A,T) given by:

A = (100 / Z%) Full Load Amps
T = (Z% – 2) seconds

Where Z is the impedance of transformer as entered in line data 2 page.

LINES and CABLES



An important consideration in protection coordination studies is whether the feeder cables are able to withstand the thermal effects of fault currents until protective devices clear the fault. Taking into account the conductor size and material as well as the insulation type, it is possible to arrive at curves specifying the maximum permissible exposure time of a given cable to a certain fault current. These curves are commonly known as "cable damage" curves. The curves drawn by PASHA adhere to the IEEE standard 242-1986.

Conductor IOT Initial operating temperature of the conductor in degree.

Conductor FFT Final faulted temperature of the conductor in degree.

CrossArea (mm2) cross section area of conductor in mm2.

Material allows you to select Aluminum or Copper conductors. Click on arrows for your choice.

11.5.4 Atomatic checking of the relays

Whenever, you choose the options described in section 11.5.3 a report will be generated. An example is shown in figure 11.44. This report will be generated automatically. Giving the response of the relays to all kinds of the faults (LLL, LG, LL, and LLG) located at appropriate points of the path in a table. Therefore, the effectiveness of each coordination path will be automatically assessed. The user just needs to look at the reports and finds out the grading conflicts which are specified by an asterisk (*) in the report (see figure 11.37).

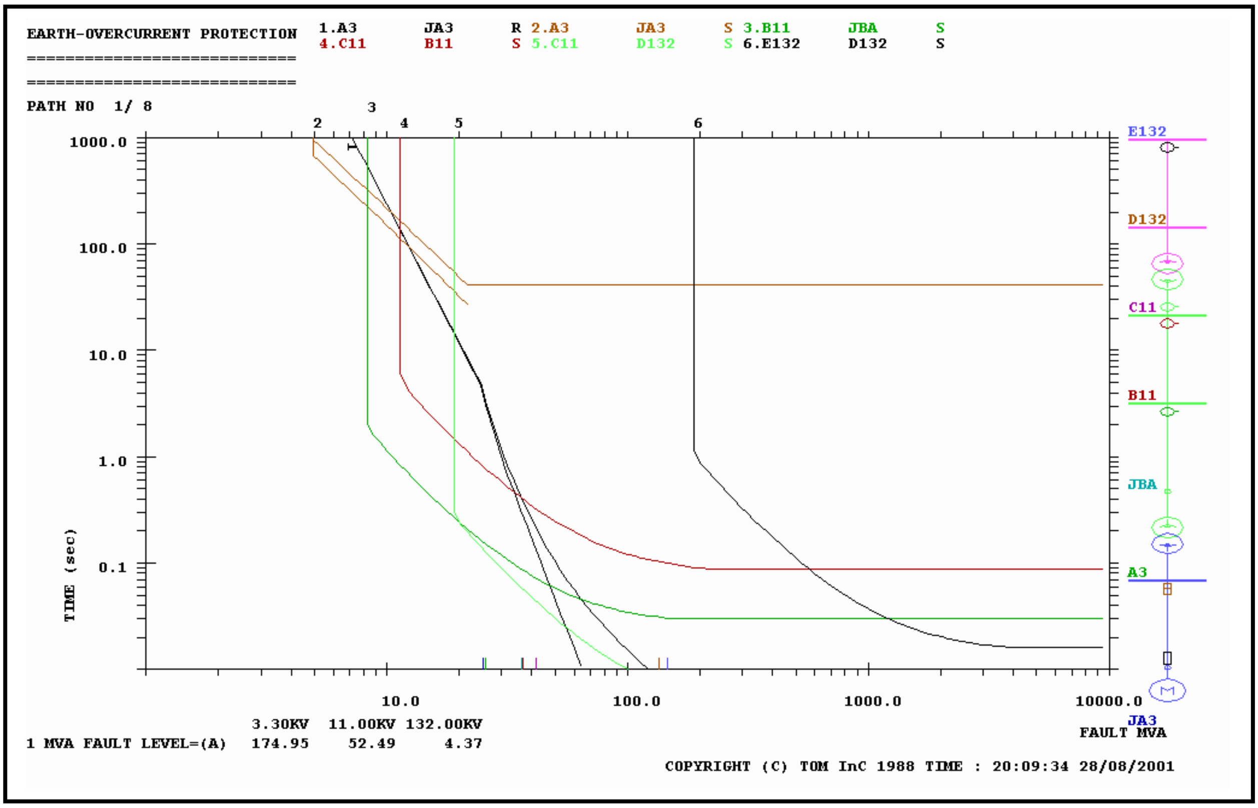


Figure 11.43

PROTECTION COORDINATION -TRIPPING TIMES RESULTS

BUSBAR NAME : JA3
AREA :
PATH NO : 1/ 8

EARTH-OVERCURRENT PROTECTION

	BRANCH SEND	BRANCH RECV	LOC	CT RAT.	RELAY PL-S (%)	RELAY TM-S	RELAY DIR	RELAY HI-S (%)	FUSE RAT-AMP	PASHA TYPE	DEVICE
1	B11	JBA	S	150.	140	0.16	0	0	800	102	E.INV O*C RLY CDG14
2	C11	B11	S	200.	140	0.39	0	0	800	102	E.INV O*C RLY CDG14
3	C11	D132	S	150.	320	0.05	0	0	800	102	E.INV O*C RLY CDG14
4	E132	D132	S	500.	80	0.10	0	0	800	102	E.INV O*C RLY CDG14

L-G FAULT AT BRANCHES LISTED BELOW * means no discrimination

FAULT LOC.		RELAY NO. 1	2	3	4										
JA3	ka	0.299	0.299	0.299	0.025										
TO	mva	6	6	6	6										
MOTOR	sec	N/OP	N/OP	N/OP	N/OP										
STATOR	sec														
A3	ka	1.311	1.311	1.311	0.109										
TO	mva	25	25	25	25										
JA3	sec	0.159	0.822	* 0.136	N/OP										
FAR END	sec	0.259	0.922	0.236											
A3	ka	1.343	1.343	1.343	0.112										
TO	mva	26	26	26	26										
JA3	sec	0.152	0.783	* 0.128	N/OP										
NEAR END	sec	0.252	0.883	[illegible]											

Continue listing? (Y or N or S)

Yes
No
Search

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Figure 11.44

11.5.4 Distance protection settings calculation

These routines calculate the distance protection settings corresponding to any specified reach point, for a given set of system conditions, such as network configuration, fault impedance and generation level. The reach point is specified in the distance and unit protection data pages in the edit section.

Two options in the protection coordination menu provide access to the phase and earth distance setting algorithms.

The selection of either of these defines the schemes to be considered for the calculations.

For phase distance schemes a three-phase fault is assumed at each specified reach point and the impedance 'seen' by the relay is used to determine the settings. The typical phase compensation arrangement is simulated by calculating the impedance on the basis of the delta voltage and the delta current; say, for phases R and Y:

$Zry = (Vr - Vy) / (Ir - Iy)$

Where Vr and Vy are the phase voltages, Ir and Iy the phase currents.

The impedances for the three phase pairs are determined, and the lowest one is used in the calculations.

Likewise, for earth distance schemes the residual compensation arrangement is assumed:

$$Zr = Vr / (Ir - I0*k)$$

Where

Zr is the measured impedance for phase 'R'
Vr,Ir are the phase 'R' voltage and current

$I0 = Ir + Iy + Is$
$K = (Z0/Z - 1)/3$

Z0 is the zero sequence impedance of protected line
Z is the positive sequence impedance.

Again, the three impedances are determined and the lowest one is used.

For both cases the zone relays with a non-zero entry in the **% PROT** fields in distance and unit protection 2 and 3 zone tables are considered. The settings calculation determines the forward impedance (**ZF**) for the general lenticular characteristic of figure 11.12, such that its threshold of operation passes through the measured impedance point, for any given backward impedance (**ZB**) and characteristic angle (a).

11.5.4.1 Data required

The essential data required specifically for distance protection settings calculation are:

CT and VT ratios (DUP 1 data page)
Protected area: at least 1 branch (DUP 1 data page)
Type of distance relay element (DUP 1 data page)
% protected (DUP 2,3 data pages)

The busbar rated voltages (VNOM-KV in busbar data) are a general requirement for all protection routines.

The following default conditions have been assumed:

- device location at first end of the first branch entered in protected area.
- backward impedance = 0 .
- characteristic angle equal to the impedance angle of the branch where the device is located.

Whenever any essential information is missing. The corresponding case (i.e., Scheme or zone) is excluded from the calculations and error message is given in the device settings report.

11.5.4.2 Examples

Figures 11.45 and 11.46 show the device settings report for phase and earth distance protection respectively. The usual 'present', 'calculated' and 'preset' values are listed for the forward impedance, in secondary ohms. However, the pre-set value is presented here only for reference, since it is not used in the calculations.

11.5.5 Tripping times options

These facilities allow the user to check the coordination by simulating the performance of the protective devices specified in the network for any fault occurring at any given location. The effects of directional and instantaneous (hi-set) elements in overcurrent relays are taken into account.

As it can be seen in figure 11.27, a separate tripping times option has been provided for each of the six fault types (four short circuits and two open circuits) considered in PASHA. This enables the selection of the fault type.

The fault location can be specified in two ways:

1) If the user selects one of these options with the cursor and types <N>, the computer requests the faulted busbar name. After a valid name is entered the calculations are performed and the results can be displayed using the full list option.

2) If, on the other hand, the selection is made pressing the space bar or a click (or any key other than 'n') the network diagram is displayed for the graphic specification of the fault location.

Using the graphic procedure the fault can be located at any busbar or junction by selecting it with the cursor and pressing the space bar.

Alternatively, the fault can be located along any network branch, by selecting the branch (circuit or transformer) by a click. You may also select the branch by locating its sending end busbar typing <B>, and the corresponding receiving end (or a 'knee point' on the branch) typing any key. The user is then requested to enter the distance from the first end busbar selected to the fault (in p.u.) to complete the specification.

For both cases, the calculations start immediately after the fault location is defined.

Whenever a coordination path is available, the tripping times (or the pre-arcing times for fuses) are displayed on the network diagram, for the devices included in the path, as shown in figure 11.28. Subsequently, the user returns to the protection options by typing any key, and the selection of [FULL LIST] displays the results in detail. Figures 11.47 and 11.48 give and example of the results for a busbar fault, whilst figures 11.49 and 11.50 present the results for a mid-branch fault. Note that both the tripping time and the operating time are given for each device. For relays the latter value is obtained by considering the circuit breaker delay time specified in LINE DATA 6 (in edit, see chapter 15) for the corresponding location. A default value in analysis parameters 2 is used whenever this specification is omitted. In the case of fuses the arcing time provided by the corresponding model is taken into account.

The tripping times and operating times are calculated for all the distance and overcurrent devices fully specified in the network. Being the main purpose to check the performance of the current design, the 'present' settings are used, for the calculations. However, if these settings are not available (i.e., Not yet defined) for a device, the 'pre-settings' entered in edit (line data 4 and 5, or distance and unit protection 2 and 3) are assumed. This allows the user to check the performance for any design immediately after retrieving the system form file.

PHASE-DISTANCE PROTECTION DEVICE SETTINGS REPORT

SCH. NO.	B R A N C H		LOC	ZONE	FWD-Z(-X) SETTINGS %PROT	PSNT	CALC	P-SET	BWD-Z	ANGLE (DEG)	TM-DLY (ms)	D E V I C E
1	E132	D132	S/	1	80	11.59	11.59	2.03	0.00	60.00	15	FIRST DISTANCE RLY
				2	150	100.00	195.04	27.27	0.00	50.00	150	SECOND DIST. RELAY
				3	150	165.00	182.40	30.31	0.00	55.00	66	FIRST DISTANCE RLY
				4	220	165.00	302.80	50.05	0.00	85.00	222	FIRST DISTANCE RLY
3	E132	D132	S/	1	80	11.59	11.59	2.03	0.00	60.00	15	FIRST DISTANCE RLY
				2	150	100.00	195.04	27.27	0.00	50.00	150	SECOND DIST. RELAY
				3	150	165.00	182.40	30.31	0.00	55.00	66	FIRST DISTANCE RLY
				4	220	165.00	302.80	50.05	0.00	85.00	222	FIRST DISTANCE RLY
5	E132	D132	S/	1	80	11.59	11.59	2.03	0.00	60.00	15	FIRST DISTANCE RLY
				2	150	100.00	195.04	27.27	0.00	50.00	150	SECOND DIST. RELAY
				3	150	165.00	182.40	30.31	0.00	55.00	66	FIRST DISTANCE RLY
				4	220	165.00	302.80	50.05	0.00	85.00	222	FIRST DISTANCE RLY

Continue listing? (Y or N or S)

Yes
No
Search

 TIME : 20:11:11 28/08/2001

Figure 11.45

EARTH-DISTANCE PROTECTION DEVICE SETTINGS REPORT

SCH. NO.	B R A N C H		LOC	ZONE	FWD-Z(-X) SETTINGS %PROT	PSNT	CALC	P-SET	BWD-Z	ANGLE (DEG)	TM-DLY (ms)	D E V I C E
2	E132	D132	S/	1	85	11.77	11.77	1.86	0.00	65.00	15	SECOND DIST. RELAY
				2	150	100.00	258.84	5.39	0.00	55.00	135	SECOND DIST. RELAY
4	E132	D132	S/	1	85	11.77	11.77	1.86	0.00	65.00	15	SECOND DIST. RELAY
				2	150	100.00	258.84	5.39	0.00	55.00	135	SECOND DIST. RELAY
6	E132	D132	S/	1	85	11.77	11.77	1.86	0.00	65.00	15	SECOND DIST. RELAY
				2	150	100.00	258.84	5.39	0.00	55.00	135	SECOND DIST. RELAY

Continue listing? (Y or N or S)

Yes
No
Search

 TIME : 20:11:27 28/08/2001

Figure 11.46

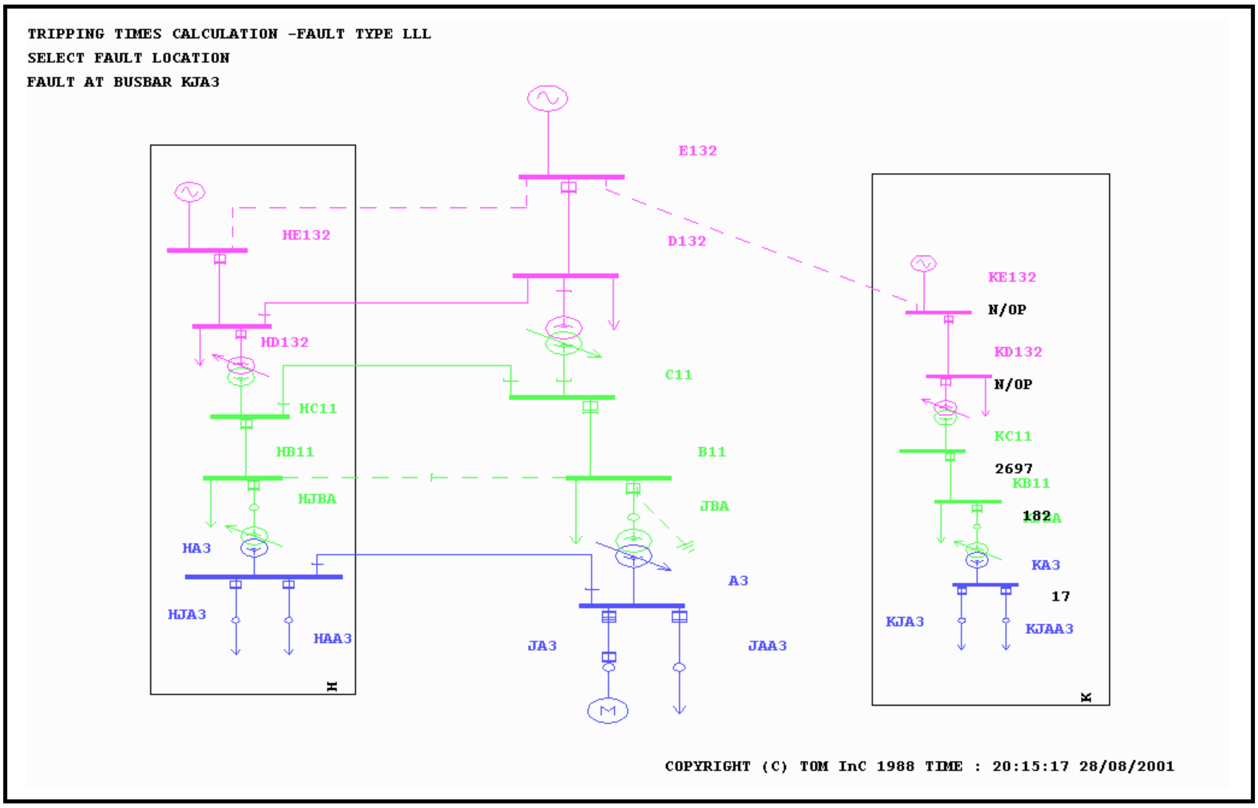

Figure 11.47

PROTECTION COORDINATION -TRIPPING TIMES RESULTS

LLL FAULT AT SUBSTATION KJA3 FAULT IMPEDANCE (R AND X) = 0.0000 0.0000 PU

PHASE-OVERCURRENT PROTECTION

BRANCH SEND	BRANCH RECV	LOC/SEQ	RELAY PL-S (%)	RELAY TM-S	RELAY DIR	RELAY HI-S (%)	FUSE RAT-AMP	FAULT (KA)	FAULT (MVA)	FAULT MAX FOR	TRIPPING TIME (S)	OPERAT. TIME(S)	
E132	D132	S/	100	0.91	0	0		0.000	0		NO OPERATION		
C11	B11	S/	100	10.00	0	0		0.006	0		NO OPERATION		
A3	JA3	S/	500	0.40	0	0	800	0.033	0		NO OPERATION		MCB
A3	JA3	R/					400	0.033	0		NO OPERATION		
A3	JAA3	S/					150	0.000	0		NO OPERATION		
B11	JBA	S/	300	0.24	0	0		0.006	0		NO OPERATION		
HE132	HD132	S/	100	0.91	0	0		0.000	0		NO OPERATION		
HD132	HC11	S/	100	0.20	0	0		0.000	0		NO OPERATION		
HC11	HB11	S/	100	0.69	0	0		0.004	0		NO OPERATION		
HA3	HJA3	S/					200	0.000	0		NO OPERATION		
HA3	HAA3	S/					150	0.000	0		NO OPERATION		
HB11	HJBA	S/	100	0.20	0	0		0.004	0		NO OPERATION		
KE132	KD132	S/ 5	100	0.91	0	0		0.151	35		NO OPERATION		
KD132	KC11	S/ 4	100	0.20	0	0		0.151	35		NO OPERATION		
KC11	KB11	S/ 3	100	0.69	0	0		1.812	35		2.697	2.797	
KA3	KJA3	S/ 1					200	6.041	35		0.010	0.017	
KA3	KJAA3	S/					150	0.000	0		NO OPERATION		
KB11	KJBA	S/ 2	100	0.21	0	0		1.812	35		0.182	0.282	
HB11	B11	S/	100	0.69	0	0		0.000	0		NO OPERATION		
C11	D132	S/	320	0.25	0	0		0.005	0		NO OPERATION		
C11	D132	R/	120	0.20	0	0		0.000	0		NO OPERATION		
D132	HD132	R/	100	0.91	0	0		0.000	0		NO OPERATION		
C11	HC11	S/	100	0.60	0	0		0.001	0		NO OPERATION		
C11	HC11	R/	100	0.80	0	0		0.001	0		NO OPERATION		
A3	HA3	S/	[illegible]	[illegible]	0	0		0.014	0		NO OPERATION		

Continue listing? (Y or N or S)

Yes
No
Search

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Figure 11.48

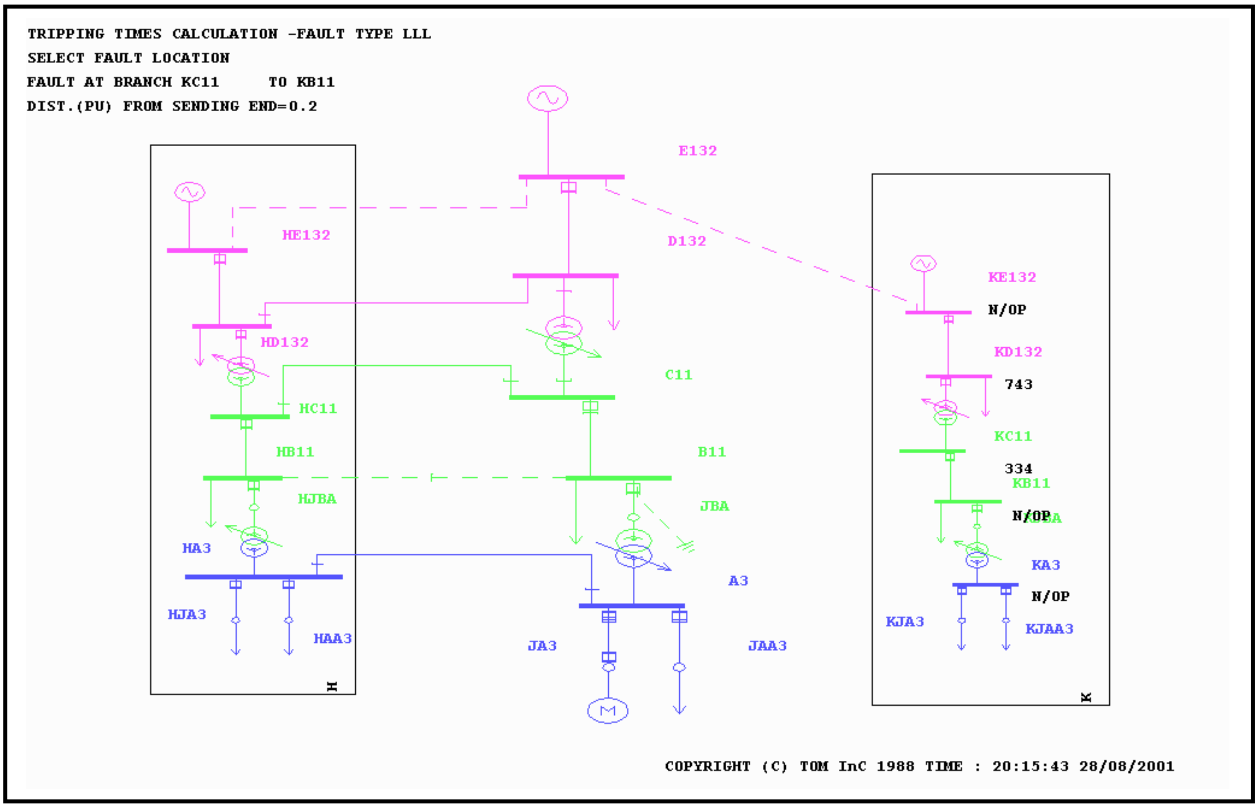

Figure 11.49

PROTECTION COORDINATION -TRIPPING TIMES RESULTS

LLL FAULT AT 20 % OF BRANCH FROM KC11 TO KB11 FAULT IMPEDANCE (R AND X) = 0.0000 0.0000 PU

PHASE-OVERCURRENT PROTECTION

BRANCH SEND	BRANCH RECV	LOC/SEQ	RELAY PL-S (%)	RELAY TM-S	RELAY DIR	RELAY HI-S (%)	FUSE RAT-AMP	FAULT (KA)	FAULT (MVA)	FAULT MAX FOR	TRIPPING TIME (S)	OPERAT. TIME(S)
E132	D132	S/	100	0.91	0	0		0.000	0		NO OPERATION	
C11	B11	S/	100	10.00	0	0		0.006	0		NO OPERATION	
A3	JA3	S/	500	0.40	0	0	800	0.033	0		NO OPERATION	MCB
A3	JA3	R/					400	0.033	0		NO OPERATION	
A3	JAA3	S/					150	0.000	0		NO OPERATION	
B11	JBA	S/	300	0.24	0	0		0.006	0		NO OPERATION	
HE132	HD132	S/	100	0.91	0	0		0.000	0		NO OPERATION	
HD132	HC11	S/	100	0.20	0	0		0.000	0		NO OPERATION	
HC11	HB11	S/	100	0.69	0	0		0.004	0		NO OPERATION	
HA3	HJA3	S/					200	0.000	0		NO OPERATION	
HA3	HAA3	S/					150	0.000	0		NO OPERATION	
HB11	HJBA	S/	100	0.20	0	0		0.004	0		NO OPERATION	
KE132	KD132	S/ 5	100	0.91	0	0		0.512	117		NO OPERATION	
KD132	KC11	S/ 4	100	0.20	0	0		0.512	117		0.743	0.843
KC11	KB11	S/ 3	100	0.69	0	0		6.142	117		0.334	0.434
KA3	KJA3	S/ 1					200	0.000	0		NO OPERATION	
KA3	KJAA3	S/					150	0.000	0		NO OPERATION	
KB11	KJBA	S/ 2	100	0.21	0	0		0.000	0		NO OPERATION	
HB11	B11	S/	100	0.69	0	0		0.000	0		NO OPERATION	
C11	D132	S/	320	0.25	0	0		0.005	0		NO OPERATION	
C11	D132	R/	120	0.20	0	0		0.000	0		NO OPERATION	
D132	HD132	R/	100	0.91	0	0		0.000	0		NO OPERATION	
C11	HC11	S/	100	0.60	0	0		0.001	0		NO OPERATION	
C11	HC11	R/	100	0.80	0	0		0.001	0		NO OPERATION	
A3	HA3	S/	[illegible]	[illegible]	0	0		0.014	0		NO OPERATION	

Continue listing? (Y or N or S)

Yes
No
Search

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Figure 11.50

11.6 Dynamic simulation of protection performance

The dynamic performance of overcurrent, distance and unit protection can be simulated within a transient stability study. Both the protective device response to the system transient conditions and the corresponding switching action are represented. Hence, the user needs only to specify the fault condition and the protection systems will automatically perform the appropriate switching operations. Only three-phase faults can be simulated due to the system modeling restrictions in the transient stability algorithms, therefore earth protection schemes are not included at this version of PASHA.

11.6.1 overcurrent protection

The simulation of overcurrent protective device operation includes the action of all the devices with the required settings available, either directly specified in line data 4 (pre-settings), or from the last updating of the 'present' settings using the coordination routine. It should be noted that whenever both types of settings exist the 'present' settings are used for the calculations. This follows the criteria previously defined for the tripping times and graph curves sections. Relay hi-set and directional units are also considered.

The dynamic response of the relays is represented by a quasi steady state model based on information generally provided by the manufacturers, namely the time-current characteristics and resetting times, (refer to appendix h for details)

In the simulation of fuse operation the same quasi-steady state model has been used. However, for this device the concept of 'travel angle' should be replaced by an equivalent one, such as 'melting progress' or 'pre-arcing progress'. For generality the term 'p.u. Protection state' has been used in the output.

The tripping time (or arcing initiation time, for fuses) is determined by the instant when the device state reaches 1.0 P.U. between tripping time of a relay and the corresponding switching operation time. A delay has been considered to allow for circuit breaker operation and arc clearing time.

The circuit breaker delay times are selected from circuit breaker data base as selected in LINE DATA 6 (please refer to chapter 15) if a particular value needs to be considered. Otherwise, the default value in analysis parameters 2 is assumed.

In the case of a fuse, this time delay is only due to the arcing time. In the program this quantity is calculated form the information entered in fuse data base (see sec. 11.3.2).

It has been assumed also that the lower limit of the relay operation 'dead band' is 0.9 of the plug setting current: and the upper limit, the lowest value of current entered to define the curves in relay data base 2.

Figures 11.51 and 11.52 give an example of the output for the transient stability results. It can be seen that a new section, line flows gives the protection state and other line conditions. The entries to this section are made automatically if the state of an overcurrent device exceeds

0.1. Alternatively, the user can enter any network branch manually by setting the flag (monit?) to 1 in line data 2. The switching messages give the protection details whenever the switching is caused by the operation of a protective device.

These figures present the conditions immediately before and after a switching operation. Note that the state for the relay causing the switching changes from 1.00000 to 1.00001 . This indicates that the breaker has operated. A state of 1.0000 shows that the relay has tripped, but the switching mechanism is still in progress. Also, a state of 0.99999 indicates that the relay has completed its travel, but the tripping has been inhibited by the directional unit.

The switching operation messages will also be written in PASHA message box during the transient run and a beep will be heard.

```
STEP NUMBER =   67     TIME = 0.5635      MAXIMUM ITERATIONS PER STEP =  1     STEP LENGTH = 0.0035     ITS/PRINT =   1
----------------------------------

SYNCHRONOUS MACHINES

 BUSBAR   M/C   ROTOR   POLE   ROTOR      MECH.       POWER OUTPUT       TERM.     TERM.     FIELD     FIELD     POWER
  NAME    NO.   ANGLE   PRS    SLIP       POWER    ACTIVE    REACTIVE   VOLTAGE   CURRENT   VOLTAGE   CURRENT   FACTOR
                DEGREES SLPD   P.U.        MW        MW        MVAR       P.U.      P.U.      P.U.      P.U.

E132        *     0.43*   0   0.0001      0.001     -.007     87.124     0.974     8.944     1.000     1.000     -.0001
HE132             0.00    0   0.0001      0.000     0.007     49.910     0.985     5.065     1.000     1.000     0.0001
KE132             -.43    0   0.0000      0.000     0.000      0.000     1.000     0.000     1.000     1.000     0.0000

BUSBAR VOLTAGES
                              *                             *                             *
  BUSBAR  VOLTAGE   ANGLE        BUSBAR  VOLTAGE   ANGLE        BUSBAR  VOLTAGE   ANGLE        BUSBAR  VOLTAGE   ANGLE
 E132       0.974    0.43       D132       0.942    0.43       C11        0.252    0.43       B11        0.000    0.43
 A3         0.226    0.43       JA3        0.226    0.43       JAA3       0.226    0.43       JBA        0.004    0.43
 HE132      0.985    0.44       HD132      0.967    0.44       HC11       0.606    0.43       HB11       0.581    0.43
 HA3        0.354    0.43       HJA3       0.354    0.43       HAA3       0.354    0.43       HJBA       0.577    0.43
 KE132      1.000    0.00       KD132      1.000    0.00       KC11       1.000    0.00       KB11       1.000    0.00
 KA3        1.000    0.00       KJA3       1.000    0.00       KJAA3      1.000    0.00       KJBA       1.000    0.00

LINE-FLOWS
                                      (------------ SENDING-END ------------) (----------- RECEIVING-END -----------)
 SENDING  RECEIVING O/C.PROT.STATE,PU    VOLTAGE     CURRENT      POWER          VOLTAGE     CURRENT      POWER
  BUSBAR   BUSBAR   SEND.DEV REC.DEV   P.U.  ANGLE   P.U.    P(MW)   Q(MVAR)   P.U.  ANGLE   P.U.    P(MW)   Q(MVAR)

 HB11     HJBA      0.34878  0.00000  0.581    0.4  1.274     0.00     7.40   0.577    0.4  1.274     0.00     7.35
 C11      D132      0.36184  0.22133  0.252    0.4  9.196     0.00   -23.19   0.942    0.4  9.196     0.00   -86.62
 C11      HC11      0.81007  0.43557  0.252    0.4  3.539     -.00    -8.93   0.606    0.4  3.539     -.00   -21.45
 A3       HA3       0.90459  1.00000  0.226    0.4  1.274     -.00    -2.88   0.354    0.4  1.274     -.00    -4.51

-----------------------------------------------------------------------------------------------------------------------

LINE OF IMPEDANCE  0.00000 +J  0.10000 P.U. SWITCHED OUT BETWEEN BUSES A3      AND HA3      AT TIME 0.5635 SECONDS
DUE TO RECV. END O/C RELAY OPERATION (TRIPPING TIME = 0.4635 SEC)

-----------------------------------------------------------------------------------------------------------------------

PAGE   22; Type X to exit, any other for next page  or step number=
                                                                 COPYRIGHT (C) TOM InC 1988 TIME : 20:18:26 28/08/2001
```

Figure 11.51

```
STEP NUMBER =   67     TIME = 0.5635      MAXIMUM ITERATIONS PER STEP =  1     STEP LENGTH = 0.0000     ITS/PRINT =   0
----------------------------------

SYNCHRONOUS MACHINES

 BUSBAR   M/C   ROTOR   POLE   ROTOR      MECH.       POWER OUTPUT       TERM.     TERM.     FIELD     FIELD     POWER
  NAME    NO.   ANGLE   PRS    SLIP       POWER    ACTIVE    REACTIVE   VOLTAGE   CURRENT   VOLTAGE   CURRENT   FACTOR
                DEGREES SLPD   P.U.        MW        MW        MVAR       P.U.      P.U.      P.U.      P.U.

E132        *     0.43*   0   0.0001      0.001     -.007     85.820     0.974     8.807     1.000     1.000     -.0001
HE132             0.00    0   0.0001      0.000     0.007     42.983     0.987     4.353     1.000     1.000     0.0002
KE132             -.43    0   0.0000      0.000     0.000      0.000     1.000     0.000     1.000     1.000     0.0000

BUSBAR VOLTAGES
                              *                             *                             *
  BUSBAR  VOLTAGE   ANGLE        BUSBAR  VOLTAGE   ANGLE        BUSBAR  VOLTAGE   ANGLE        BUSBAR  VOLTAGE   ANGLE
 E132       0.974    0.43       D132       0.943    0.43       C11        0.261    0.43       B11        0.000    0.45
 A3         0.011    3.44       JA3        0.012    3.44       JAA3       0.011    3.44       JBA        0.000    3.26
 HE132      0.987    0.44       HD132      0.972    0.44       HC11       0.667    0.43       HB11       0.667    0.43
 HA3        0.667    0.43       HJA3       0.667    0.43       HAA3       0.667    0.43       HJBA       0.667    0.43
 KE132      1.000    0.00       KD132      1.000    0.00       KC11       1.000    0.00       KB11       1.000    0.00
 KA3        1.000    0.00       KJA3       1.000    0.00       KJAA3      1.000    0.00       KJBA       1.000    0.00

LINE-FLOWS
                                      (------------ SENDING-END ------------) (----------- RECEIVING-END -----------)
 SENDING  RECEIVING O/C.PROT.STATE,PU    VOLTAGE     CURRENT      POWER          VOLTAGE     CURRENT      POWER
  BUSBAR   BUSBAR   SEND.DEV REC.DEV   P.U.  ANGLE   P.U.    P(MW)   Q(MVAR)   P.U.  ANGLE   P.U.    P(MW)   Q(MVAR)

 HB11     HJBA      0.34878  0.00000  0.667    0.4  0.000     0.00     -.00   0.667    0.4  0.000     0.00     -.00
 C11      D132      0.36184  0.22133  0.261    0.4  9.096     0.00   -23.70   0.943    0.4  9.096     0.00   -85.76
 C11      HC11      0.81007  0.43557  0.261    0.4  4.064     -.00   -10.59   0.667    0.4  4.064     -.00   -27.10
 A3       HA3       0.90459  1.00001  0.011    3.4  0.000     0.00     0.00   0.667    0.4  0.000     0.00     0.00

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PAGE   23; Type X to exit, any other for next page  or step number=
                                                                 COPYRIGHT (C) TOM InC 1988 TIME : 20:19:08 28/08/2001
```

Figure 11.52

11.6.2 Distance protection

The performance of phase distance protection schemes is simulated by monitoring the currents and voltages at the relay location throughout the transient stability study. Whenever the impedance seen by the relay enters the operating region defined by the relay characteristic, the corresponding timer is started. If this condition persists long enough and the timer reaches its setting value T-DLY-MS, specified in distance and unit protection (DUP 2 and 3 in edit), the tripping order is issued and the switching operation is performed after the circuit breaker delay time has elapsed.

Otherwise, if the impedance leaves the region before this occurs the timer is reset to zero.
The distance protection data required by the simulation are:

CT and VT ratios (DUP 1 data page)
Protected area: at least 1 branch (DUP 1 data page)
Type of distance relay element (DUP 1 data page)
Type of distance relay element (DUP 2,3 data pages)
Characteristic angle (DUP 2,3 data pages)
Time delay (T-DLY-MS in DUP 2,3)

The busbar rated voltages (VNOM in busbar data) are a general requirement for all protection routines.

The following default conditions have been assumed:

- device location at the first busbar of the first branch entered in protected area.
- backward impedance = 0 .

Any phase distance scheme whose settings have been calculated by the routine available in the protection coordination section will have all the data required by the transient stability simulation.

Whenever a study is attempted with essential data missing an error message is given on the screen and the calculations are blocked.

Figure 11.53 shows an example of the full list output containing a switching operation message caused by distance protection action. The switching operation messages will also be written in PASHA message box during the transient run and a beep will be heard.

11.6.3 Unit protection

The performance of unit protection schemes is simulated by monitoring the current flowing in and out of each unit protection zone. The boundaries of the zone are determined by the protected area specified in the edit section (distance and unit protection 1). From these currents a differential current (Id) and a through current (Ith) are calculated at each integration step during the study. The relay operation condition is defined by:

Id > (%bias/100) * (Ith) + Is
Where
Is = (%set/100) * (CTR) = setting current
CTR = CT ratio entry
% bias = entry in edit (DUP 2 data page)
% set = entry in edit (DUP 2 data page)

Whenever this operation condition is satisfied and for a time greater than the time delay setting, the tripping order is given to all the breakers at the boundary points. After allowing for the circuit breakers at the boundary points.

After allowing for the circuit breaker operation time (entered in line data 6 or default in analysis parameters 2), the corresponding switchings are performed.

The essential data required for the simulation of unit protection are:

- protected area (at least one branch)
- ct-ratio in edit (DUP 1 data page)
- % setting (DUP 2 data page)
- time delay (DUP 2 data page)

The switching operation messages can also be produced by the action of a unit protection scheme. These messages will be written in message box and a beep will also be heard.

Figure 11.54 shows an example of transient stability graphic curves. The small vertical lines on this graph show the switching operations, which may occur due to the following events:

1- Any switching e.g. Fault initiation
2- Overcurrent relays operation
3- Fuses operation
4- Distance relays operation
5- Unit protections operation
6- Induction motor under voltage relays operation as entered in induction motor data 2
7- Under/over frequency relays operation as entered in busbar data 2,3,4
8- Busbar under/over voltage relays operation as entered in busbar data 3,4
9- Busbar overflux operation as entered in busbar data 3,4

```
STEP NUMBER =  21    TIME = 0.3000      MAXIMUM ITERATIONS PER STEP =  1     STEP LENGTH = 0.0200      ITS/PRINT =   1
----------------------------------

SYNCHRONOUS MACHINES

 BUSBAR   M/C   ROTOR    POLE   ROTOR     MECH.       POWER OUTPUT       TERM.     TERM.     FIELD     FIELD     POWER
  NAME    NO.   ANGLE    PRS    SLIP      POWER    ACTIVE     REACTIVE   VOLTAGE   CURRENT   VOLTAGE   CURRENT   FACTOR
                DEGREES  SLPD   P.U.       MW        MW         MVAR       P.U.      P.U.      P.U.      P.U.

SYSTEM66    *      -.00*   0   -.0000      0.000     22.076     76.296     0.810     0.090     1.000     1.000     0.2780

BUSBAR VOLTAGES
                              *                              *                              *
  BUSBAR  VOLTAGE   ANGLE        BUSBAR  VOLTAGE   ANGLE        BUSBAR  VOLTAGE   ANGLE        BUSBAR  VOLTAGE   ANGLE
 SYSTEM66   0.810   -3.13       A          0.503  -13.56       B          0.000   13.01       R1          0.000   13.01
 R2         0.000   13.01       11KV       0.000   13.01       RR1        0.000   13.01

LINE-FLOWS

                                       (------------ SENDING-END ------------) (----------- RECEIVING-END -----------)
 SENDING  RECEIVING O/C.PROT.STATE,PU    VOLTAGE     CURRENT     POWER          VOLTAGE     CURRENT     POWER
  BUSBAR    BUSBAR   SEND.DEV REC.DEV   P.U.  ANGLE   P.U.   P(MW)   Q(MVAR)   P.U.  ANGLE   P.U.   P(MW)   Q(MVAR)

---------------------------------------------------------------------------------------------------------------------
NORMAL STEP LENGTH REDUCED TO 0.01000 S. BECAUSE OF SWITCHING

LINE OF IMPEDANCE  2.50000 +J  5.00000 P.U. SWITCHED OUT BETWEEN BUSES A        AND B        AT TIME 0.3000 SECONDS
DUE TO SEND. END DISTANCE RELAY OPERATION, ZONE 2 SCH. NO.  1: (TRIPPING TIME = 0.2000 SEC)

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PAGE  14; Type X to exit, any other for next page  or step number=
                                                              COPYRIGHT (C) TOM InC 1988 TIME : 20:21:03 28/08/2001
```

Figure 11.53

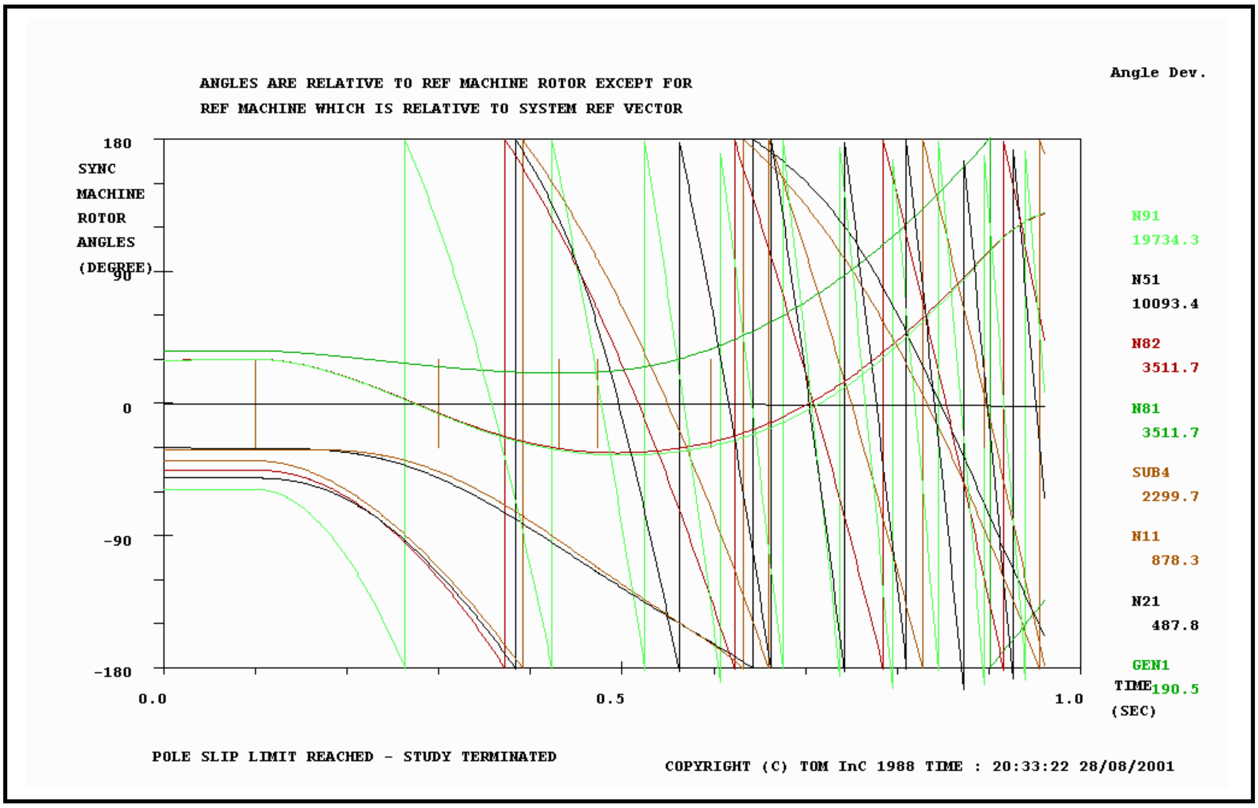

Figure 11.54

11.7 Summary

The implementation of protection coordination and analysis facilities within the PASHA package is described. These facilities include the simulation of phase and earth overcurrent, phase and earth distance, and unit protection schemes. The algorithms implemented provide a user friendly coordinated settings of the protective devices and for checking their performance both under steady state and transient conditions.