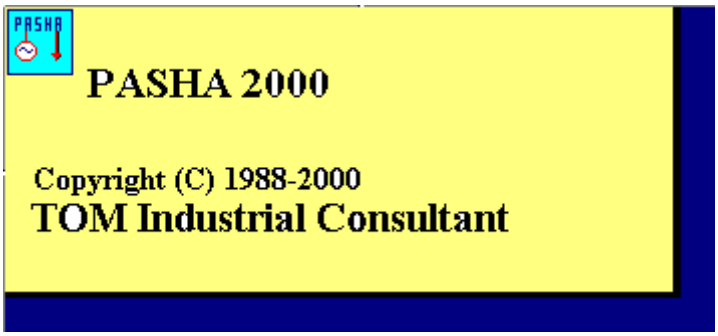


Chapter 7
The fault level section

The fault level section of PASHA calculates the fault current and has ability to define any kind of short circuit faults (LLL, LG, LL, LLG) or open circuit faults (one phase, two phases) and apply it anywhere in the network. The fault location and time can be defined and asymmetric RMS, asymmetric Peak, and symmetric RMS currents may be calculated.

The implementation of protection coordination facilities, which initiates from fault menu options, is described in chapter 11. Please refer to this chapter for more information about the protection coordination facility.

Circuit breaker automatic checking is also initiates from fault menu options. Please refer to chapter 15 for more information about this option.

7.1 Accessing the fault level section

The fault level section can be entered in two ways:

(i) By selecting the [FAULT LEVEL CALCULATION] option from the main menu

(ii) By selecting the [FAULTS] option from the Load Flow main menu (see 6.2.6)

Where fault level studies have been preceded by loadflow studies, the voltage profile will have been stored and will be used in the fault level calculations. Otherwise a flat, 1 pu voltage profile is used (with some adjustment for any generation or loads specified voltage entered in the data).

7.2 The initial phase

Entry to the fault level section initially performs some basic checks on the data entered in the LINE DATA 1 page which includes entries for all lines, transformers and shunts in the network. Depending on the type of plant and its connections in the network, it will be

necessary to have values available for the positive or the zero sequence impedance or both. A complete, automatic check on the data is, therefore, not possible and the checking procedure leaves some of the responsibility for correct entries on the user. The checks provided primarily establish whether a non-zero entry exists for either the positive or the zero sequence impedance in each circuit. If any branch has no impedance entries the fault level calculation is blocked. When positive sequence values have been entered for all circuits, but no zero sequence values exist at all, the calculation proceeds but the ground fault options are suppressed. Checks are also made for any unacceptable phase shifts occurs because of loops involving in parallel transformers. The user will be informed if such a loop found in the network. A line must also connect split networks, however, it can be on outage or disconnected.

No initial checks are made on generator or induction motor data as here, the amount of data provided determines the model used to calculate the short-circuit performance of each machine. However, minimum data required will be checked.

7.2.1 Modeling of synchronous machines

For synchronous machines the most detailed model requires the synchronous, transient and subtransient data to be entered. This permits peak, asymmetrical rms, or symmetrical rms values of the fault currents to be calculated. Machine contributions are calculated on the basis of:-

$$Yac = (1/X) + (1/X' - 1/X).\exp(-t/T') + (1/X'' - 1/X').\exp(-t/T'') \quad (1)$$

where

$$X = Xd + Xe \text{ , } X' = Xd' + Xe \text{ and } X'' = Xd'' + Xe \quad (2)$$

$$T' = Tdo'.(X'/X) \text{ and } T'' = Tdo''.(X''/X') \quad (3)$$

$$Ydc = (1/Xn).\exp(-t/T) \quad (4)$$

where Xe is the external reactance as described in the next section.

$$Xn = 2.(Xd''.Xq'')/(Xd'' + Xq'') + Xe \quad (5)$$

$$T = Xn/[w.(Ra + Re)] \quad (6)$$

If no entry is made for Xq", its value is assumed to be equal to Xd". The subtransient components are neglected when the subtransient data is not entered and, ultimately, a machine contribution with no time dependence is obtained when only a single machine reactance value is entered in the "positive sequence reactance" column of the GENERATOR DATA 1 page.

7.2.2 Modeling of induction motors

Fault level contributions by induction motors in the system are calculated either on a similar basis (by calculating the transient and subtransient parameters from the winding data) or by considering the running and starting characteristics of the motors. The approach used, is determined by the type of the rotor impedances entered. For the latter:

$$Yac = (1/X'').\exp(t/T'') \quad (7)$$

$$Ydc = (1/X'').\exp(t/Ta) \quad (8)$$

where

$$T'' = X''/(w.Rr) \quad (9)$$

$$Ta = X''/[w.(Rs + Re)] \quad (10)$$

$$X'' = Xe + Xs + (Xst.Xm)/(Xst + Xm) \quad (11)$$

$$Ze = Re + jXe \quad (12)$$

Where Ze is the external impedance between the machine terminals and the fault point. The external impedance is a function of the fault path and also the operating conditions and is calculated iteratively. Since this impedance has a significant effect on the decay of the d.c. components of fault currents, but affects the a.c. decay only marginally, a full correction for Ze is always made for the d.c. components, but only one iteration is performed for the a.c. components. If required, the number of iterations can be increased by pressing key <I> to reset the maximum number of iterations to be used in the external impedance calculation for the a.c. components. The default is one.

Iterative procedure of Ze is always included in calculations of the dc components.

7.3 The fault level main menu

The fault main menu is displayed automatically after the initial check was successfully passed, and can also be called up after the diagrammatic display of results by pressing the <O> key or just a click. The <O> key may also be used to interrupt the calculations. If an error is found in the initial check the error is highlighted and the user invited to investigate the cause of error by selecting the [FULL LIST] option. Figure 7.1 shows a successful check and the full list of options available.

These 'primary' fault level options offer the following facilities:

7.3.1 [L-G]

Selection of this option calculates the fault currents for a Line-to-ground fault on each busbar in turn, draws the system diagram and displays the fault MVA for each busbar on the diagram. This is shown in figure 7.2.

Three different current values can be calculated and displayed on the diagram by using the special keys <A>, <P> or <S>:

Press key <A> to display Asymmetric RMS currents

Press key <P> to display Asymmetric Peak currents

Press key <S> or any other key to display symmetric RMS currents

The options may be selected from green menu box too.

Note that in any ground involved calculation the magnitude of earth capacitance (C0), will be approximated automatically from the available data. This capacitance however will mostly influence on ungrounded systems currents and voltages.

7.3.2 [L-L]

Selection of this option calculates the fault currents for a Line-to-line fault on each busbar in turn, draws the system diagram and displays the fault MVA for each busbar on the diagram. This is shown in figure 7.3.

Three different current values can be calculated and displayed on the diagram by using the special keys <A>, <P> or <S>:

Press key <A> to display Asymmetric RMS currents

Press key <P> to display Asymmetric Peak currents

Press key <S> or any other key to display symmetric RMS currents

The options may be selected from green menu box too.

7.3.3 [L-L-G]

Selection of this option calculates the fault currents for a Line-to-line-to-ground fault on each busbar in turn, draws the system diagram and displays the fault MVA for each busbar on the diagram. This is shown in figure 7.4.

Three different current values can be calculated and displayed on the diagram by using the special keys <A>, <P> or <S>:

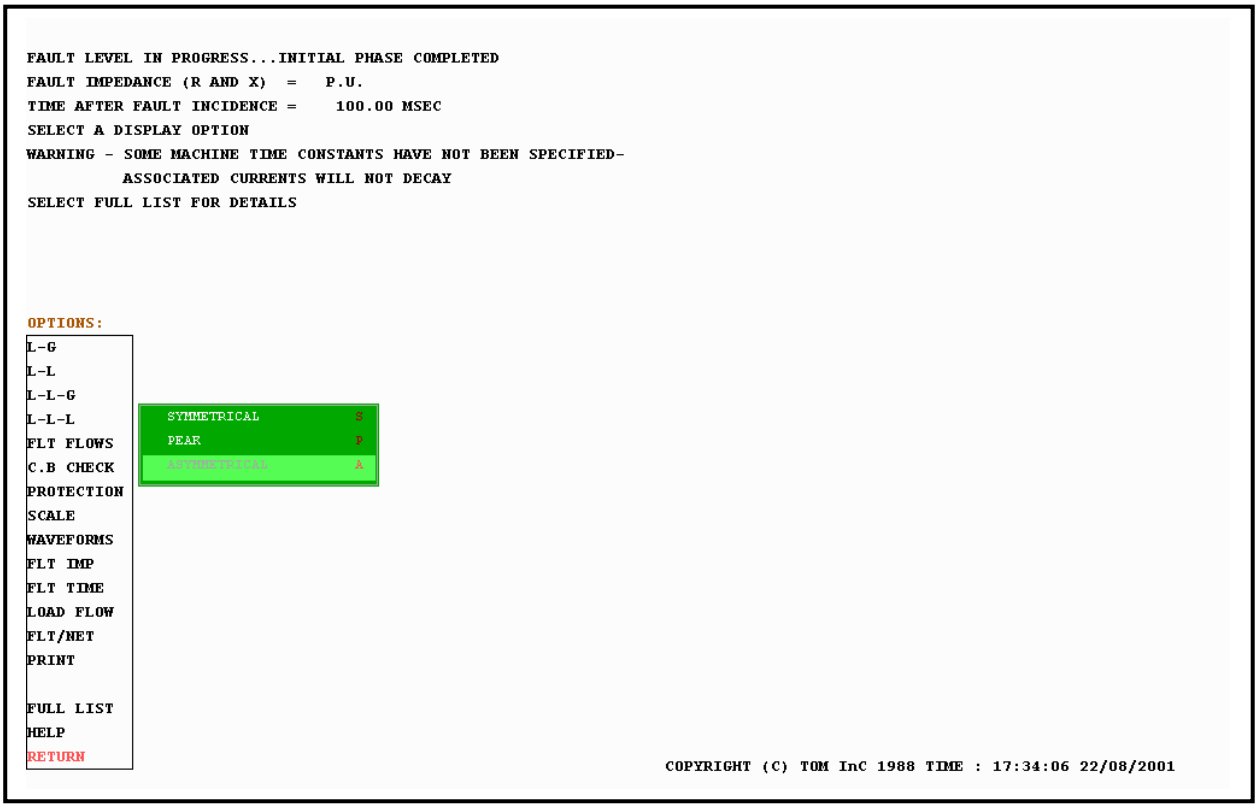


Figure 7.1

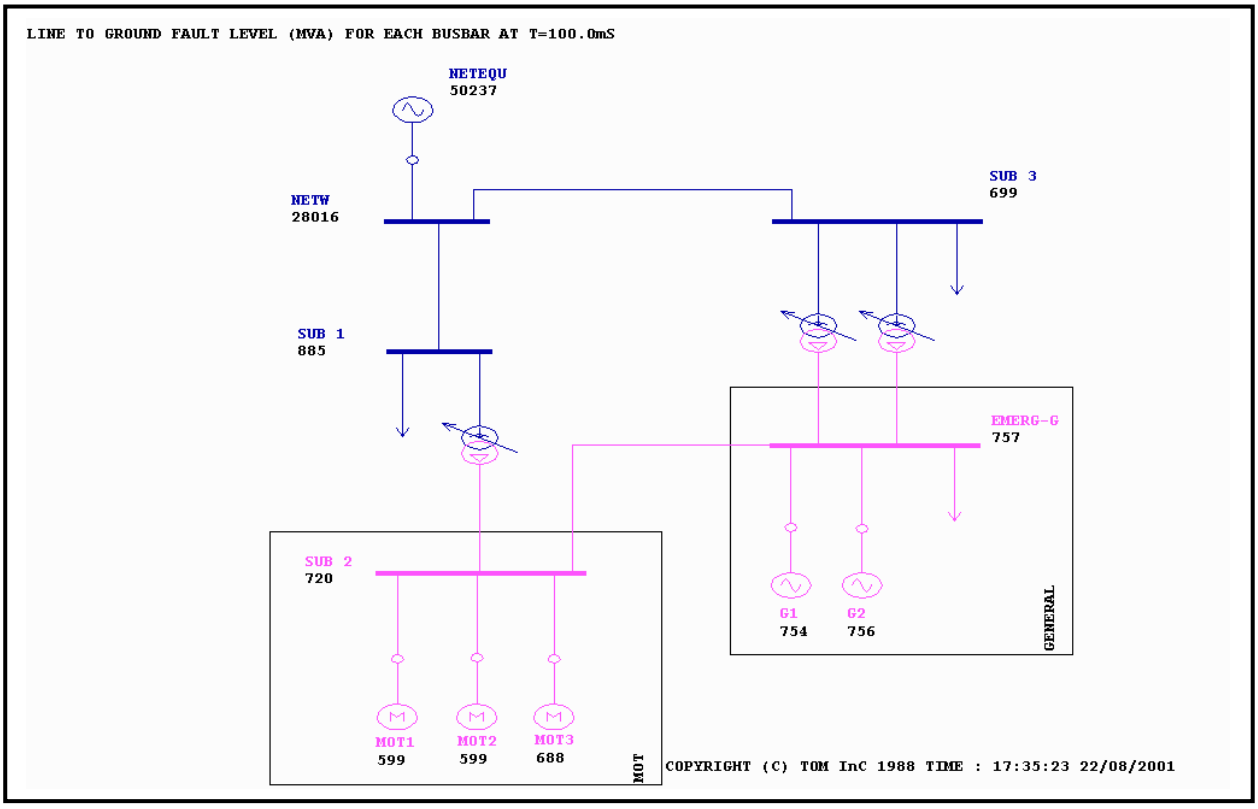


Figure 7.2

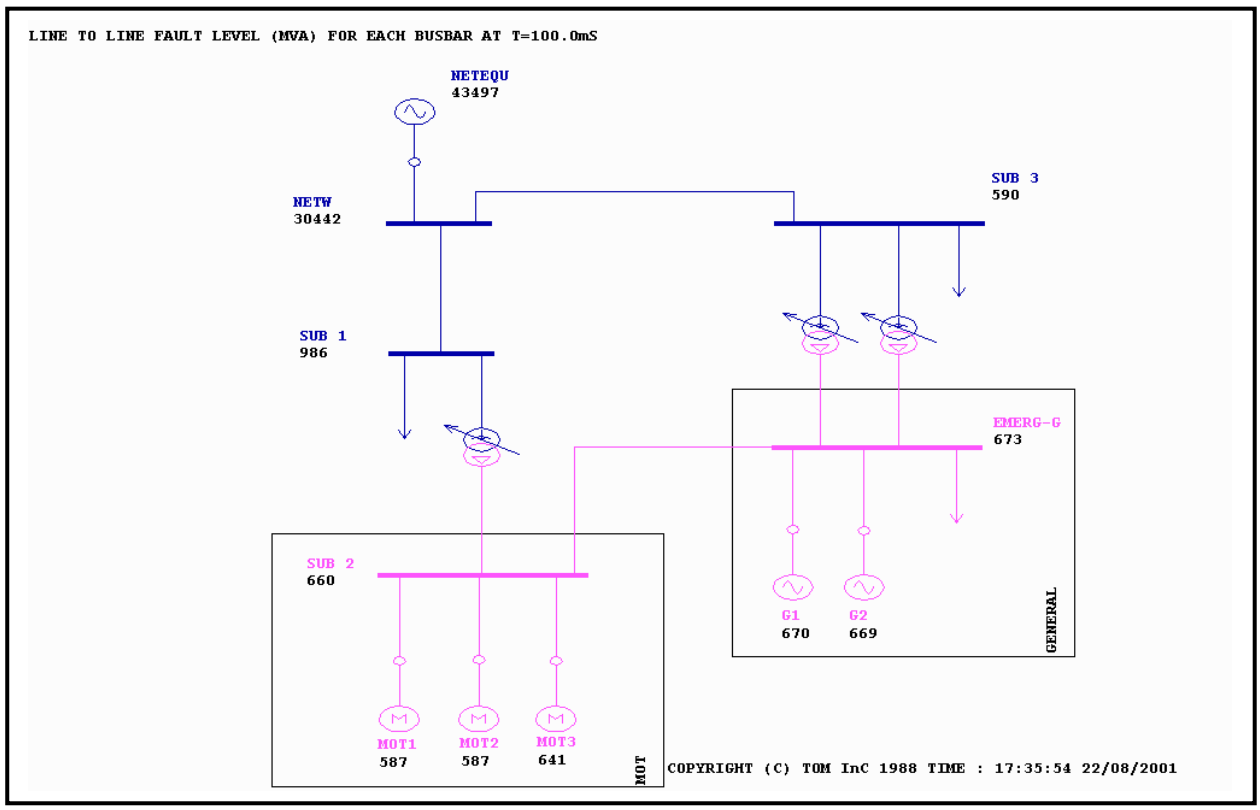


Figure 7.3

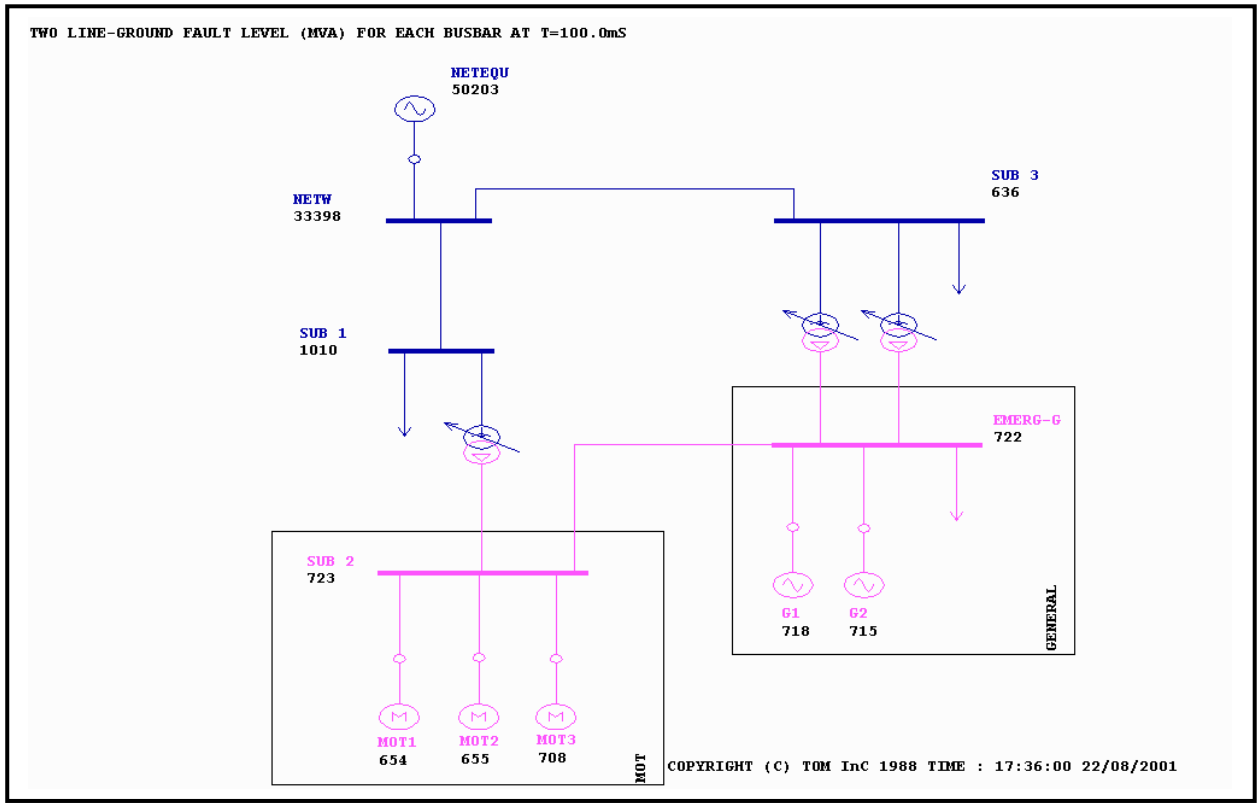


Figure 7.4

Press key <A> to display Asymmetric RMS currents

Press key <P> to display Asymmetric Peak currents

Press key <S> or any other key to display symmetric RMS currents

The options may be selected from green menu box too.

7.3.4 [L-L-L]

Selection of this option calculates the fault currents for a three phase fault on each busbar in turn, draws the system diagram and displays the fault MVA for each busbar on the diagram. This is shown in figure 7.5.

Three different current values can be calculated and displayed on the diagram by using the special keys <A>, <P> or <S>:

Press key <A> to display Asymmetric RMS currents

Press key <P> to display Asymmetric Peak currents

Press key <S> or any other key to display symmetric RMS currents

The options may be selected from green menu box too.

7.3.5 [FLT FLOWS]

The [FLT FLOWS] option is used to calculate and display the maximum MVA flows in each branch for a fault on any selected busbar or in a selected branch. The flows calculated will be for the last type of fault selected. If FLT FLOWS is selected before a fault type is selected, then a L-L-L symmetrical fault type is assumed.

Once the [FLT FLOWS] option has been selected, the user is invited to specify the busbar to be faulted, as shown in figure 7.6. To select a busbar the cross hair cursor is positioned over the required busbar and the <SP> key or a click is pressed. The diagram is then re-drawn with the flows displayed on it. Figure 7.7 shows the fault flows when busbar 'SUB 1' is faulted.

Alternatively, the fault can be located along any network branch. Just click on the required branch to candidate it for intermediate file. The user is then requested to enter the distance from the sending end busbar of the branch in P.U. You may also specify the required branch, by selecting its sending end busbar typing <B>, and the corresponding receiving end (or a 'knee point' on the branch) typing any key or a click. 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. This is shown in figure 7.8.

For all cases, the calculations start immediately after the fault location is defined and the result will be displayed on single-line diagram. The branch MVA flows shown in the single line diagram and in the result files. By default the sending end flows will be shown. If the

user wishes to have both sending end and receiving end results, he must set the option SINGLE/DOUBLE BRANCH FLOWS on double flows among the [SET COLOUR AND SYMBOLS] options. Please refer to chapter 2 section 2.5.16. Double flows mostly needed when you want to look at transformer flows in ground involving faults or when the transformer tap setting is in off nominal position. Figure 7.9 shows the results of previous fault when the option is on double and the tap of transformer between SUB 1 and SUB 2 is on -10%. In this figure S represents for sending end and R represents for receiving end.

Open circuit fault on a phase (required to do L-G fault before using the option) or on a double phase (required to do L-L-G fault before using the option) of a three phase system may also be asked for, by pressing key <O> while the cursor is located on this option or by selecting it from the available green box. Upon selection of this option the computer asks for the required branch. To specify the branch the same instruction as described above must be followed. The requested branch might be initially out or might be initially in. If it is initially out the computer will assume that a single phase or double phase closing has been occurred. Otherwise, single phase or double phase opening will be assumed (Figure 7.10).

7.3.6 [C.B CHECK]

Stands for circuit breakers automatic checking. Please refer to chapter 15 for circuit breakers data entry and facilities available upon selection of this option. Through this facility the entire power system plant circuit breakers duties can be checked. This is achieved by using PASHA circuit breakers automatic checking.

7.3.7 [PROTECTION]

Enters the protection coordination facilities. Please refer to chapter 11 for information about the protection coordination facilities and the data required.

Chapter 11 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.

7.3.8 [SCALE]

Selection of this option enables the user to re-scale and recentre the diagram. Different sections of a large system can thus be displayed on the screen, with the appropriate study results. This option functions in the same way as the [CHANGE SIZE AND RECENTRE] option in the drawing menu, for more details see section 3.4. However, the option may use less, considering that the zoom, padding, and scrolling facilities in Windows environment brought more efficiency in rescaling and recentring.

Therefore, by introducing zoom facility like those described in chapters 2 and 3, using mouse right click or using the key <Z>, an easier facility has been provided for scaling. However, there are certain uses of this facility, e.g. bringing a substation to the center of the screen by using its name.

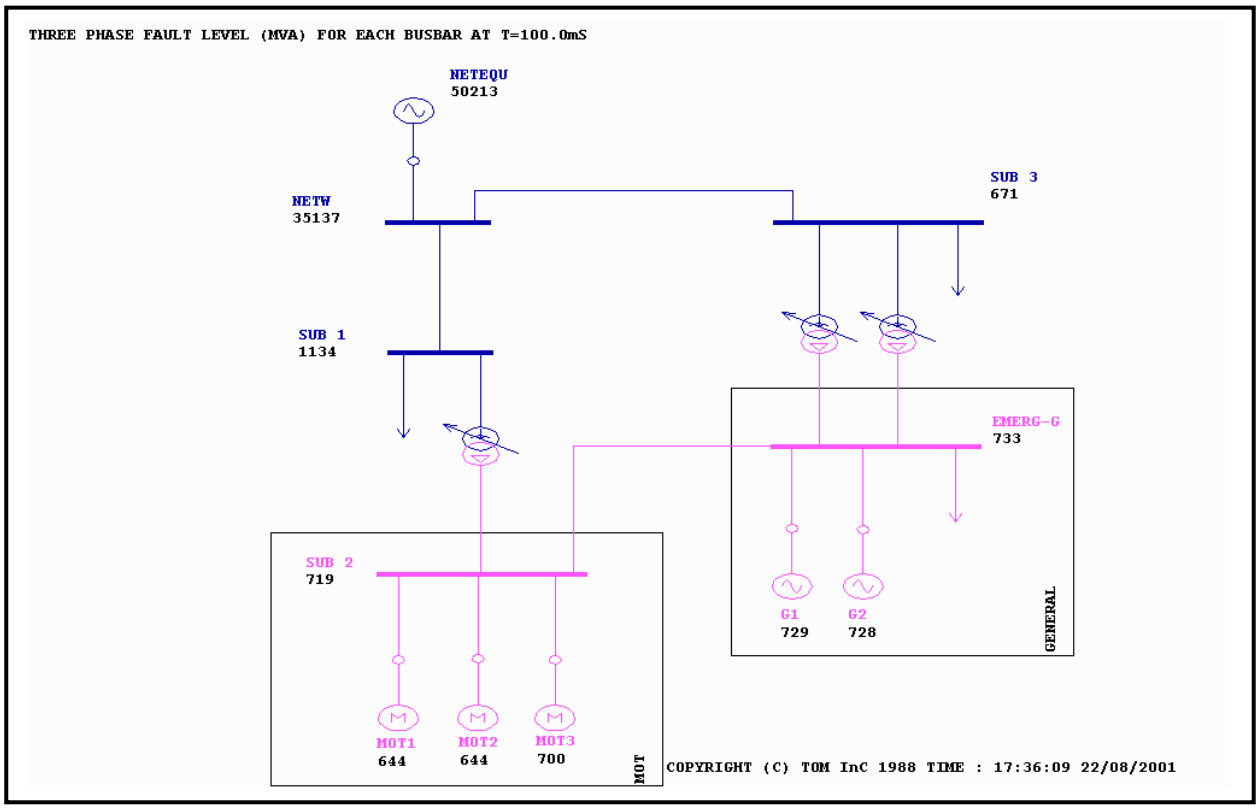


Figure 7.5

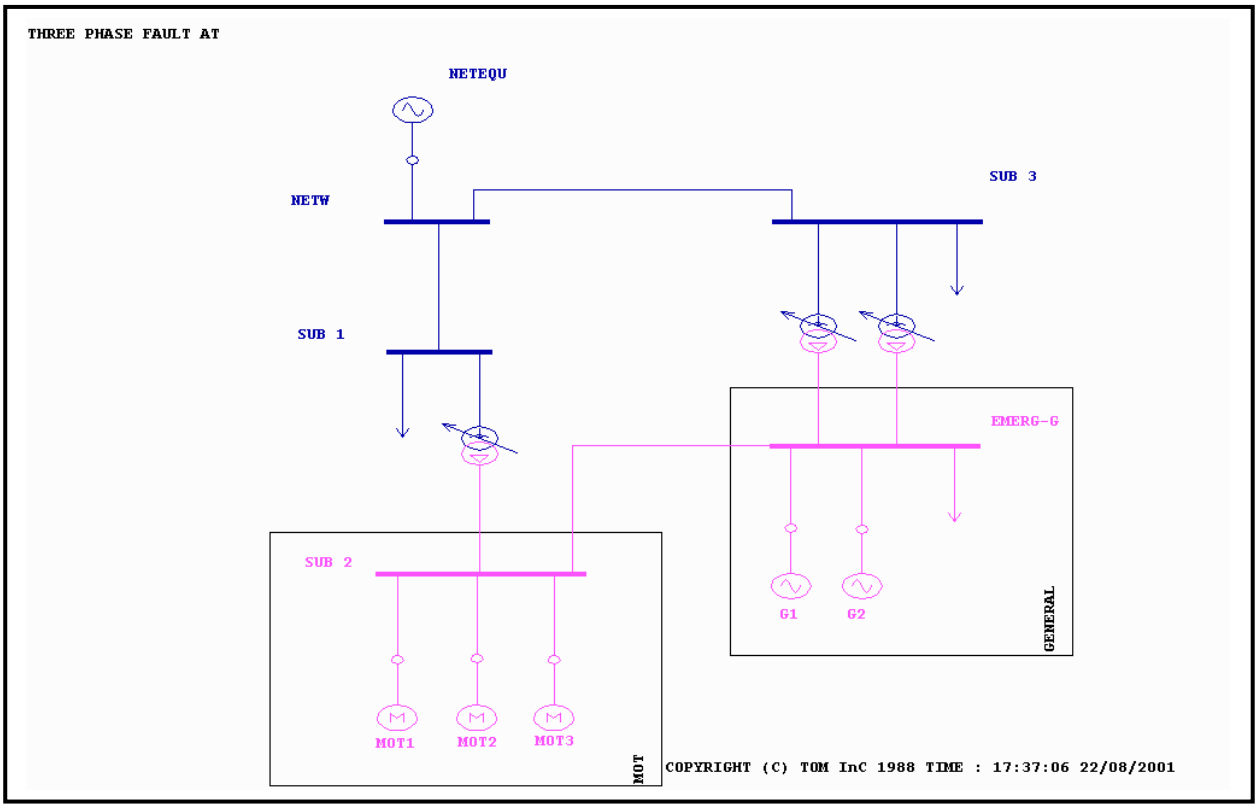


Figure 7.6

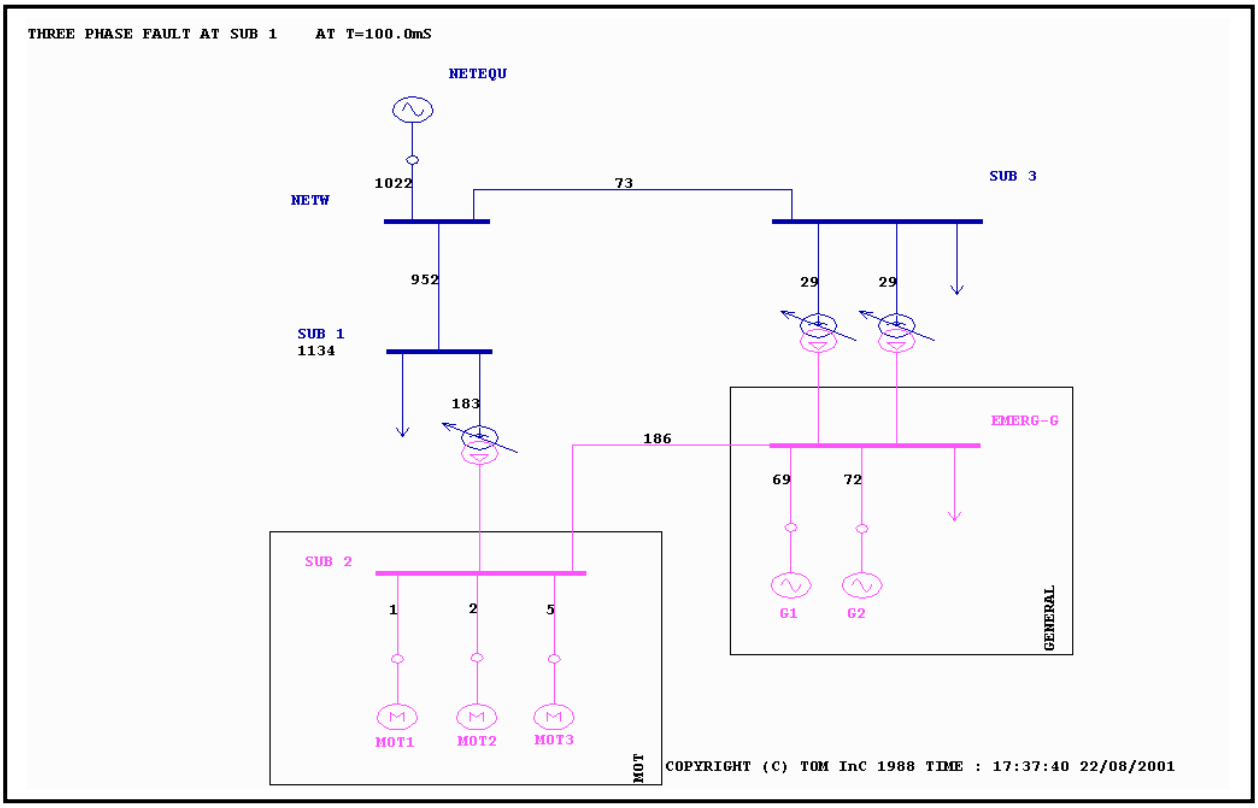


Figure 7.7

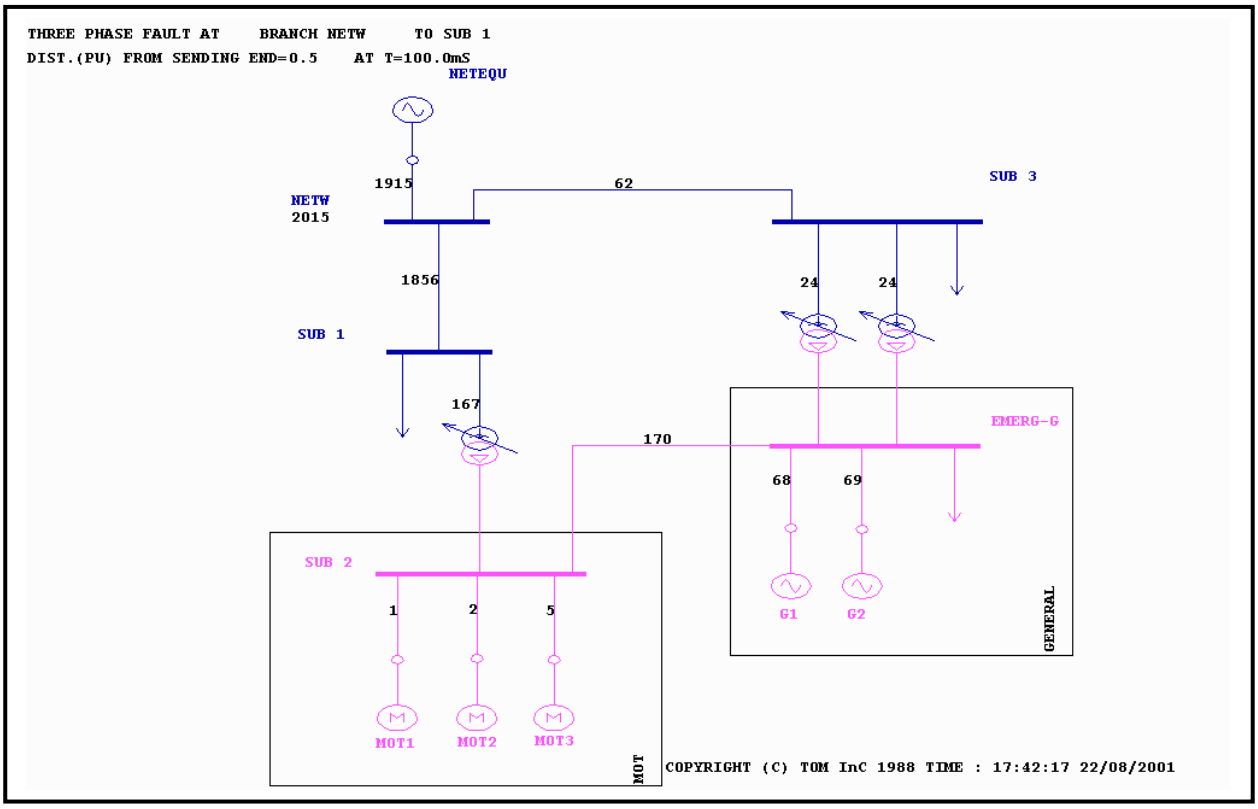


Figure 7.8

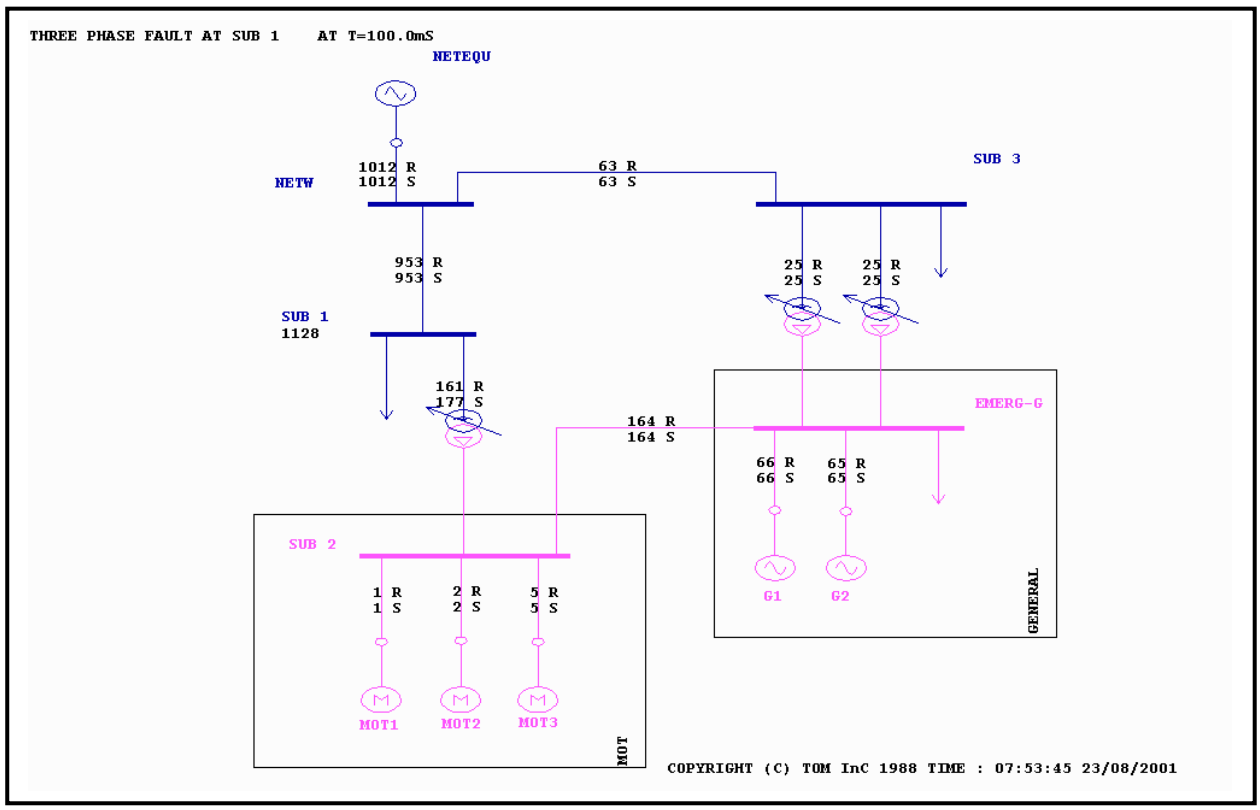


Figure 7.9

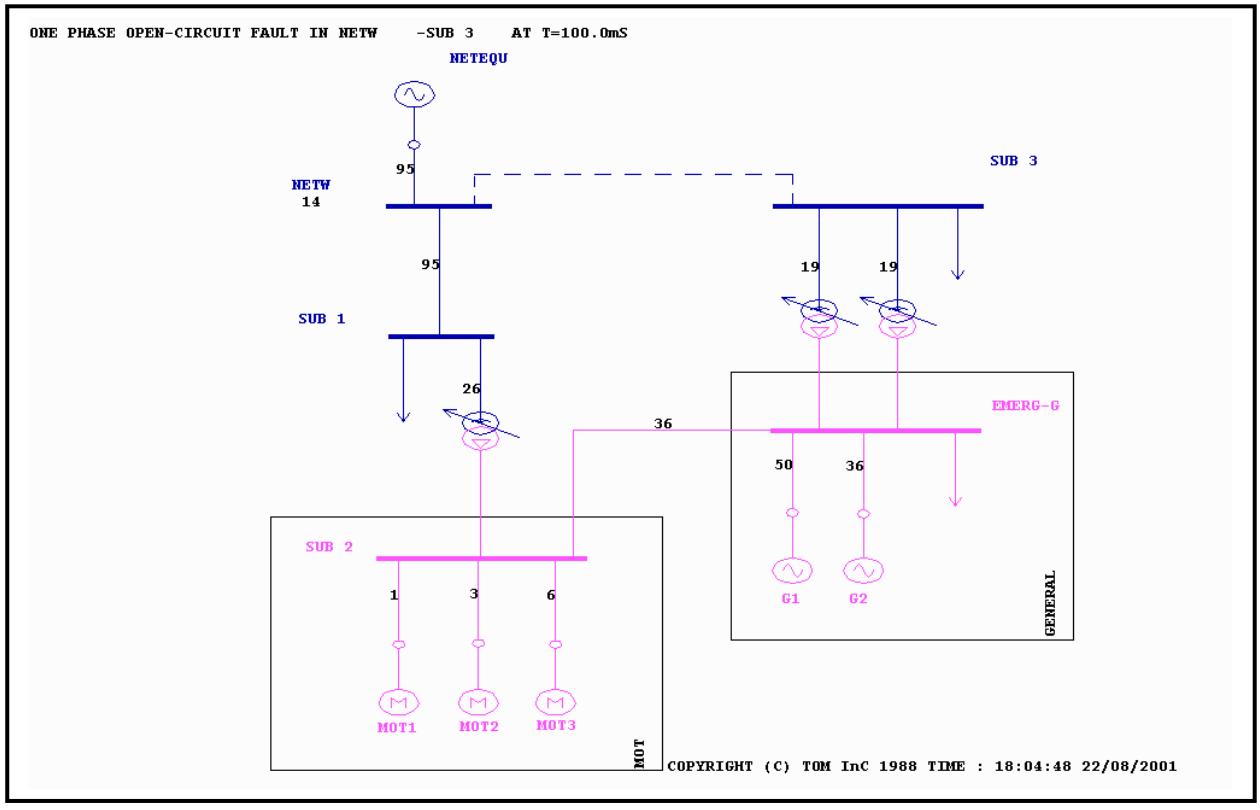
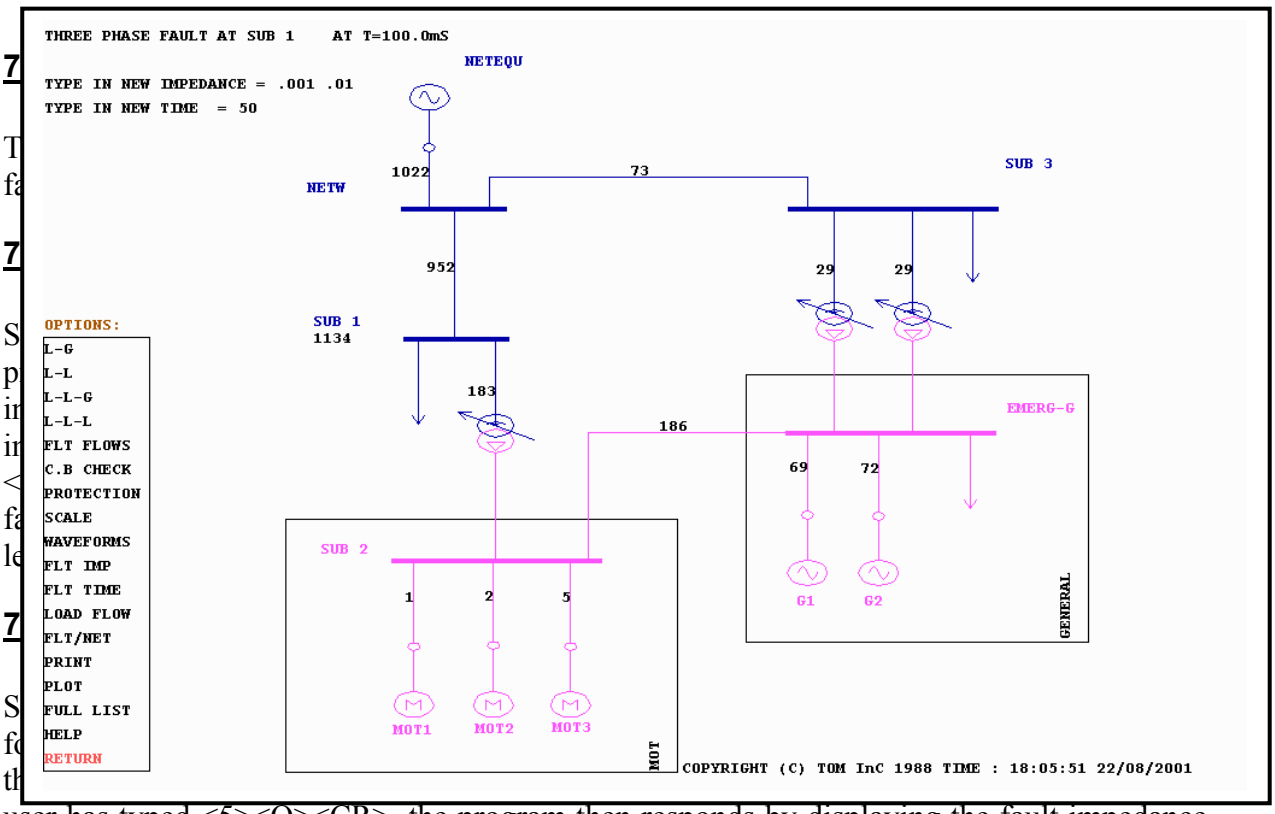


Figure 7.10



user has typed <5><O><CR>, the program then responds by displaying the fault impedance and new time. This new value is then used to calculate the new fault levels in any subsequent fault level studies. Figure 7.12 shows the new fault levels when the fault time has been changed to 50mS and the impedance set according to the previous section..

The default fault time is 100mS. This default can be changed, for a particular system, by entering a new value for FAULT TIME on the analysis parameters page in the edit section (see 4.5.9).

7.3.12 [LOAD FLOW]

Selection of this option provides the user with direct entry, or return, from the faults section to the loadflow section.

7.3.13 [FLT/NET]

Changes the area that the fault calculations are performed. By default the fault calculations will be performed for entire busbars of the system. By clicking on this option the option will be changed to FLT/WINDOW. While the option is in this location, selecting any faults calculations as described in sections 7.3.1, 7.3.2, 7.3.3, and 7.3.4 invites the user to specify the area for fault calculation. The user may then click inside the required area. The fault calculations will be performed for the busbars located inside the selected area. It is mostly required for large-scale systems, where the fault calculations take times.

7.3.14 [PRINT]

This option sends the results of the last fault calculation to the printer file for printing later. If [PRINT] is selected before any of the calculation options the system data will be appended to the printer file 'PRINTER.92'.

Figure 7.11

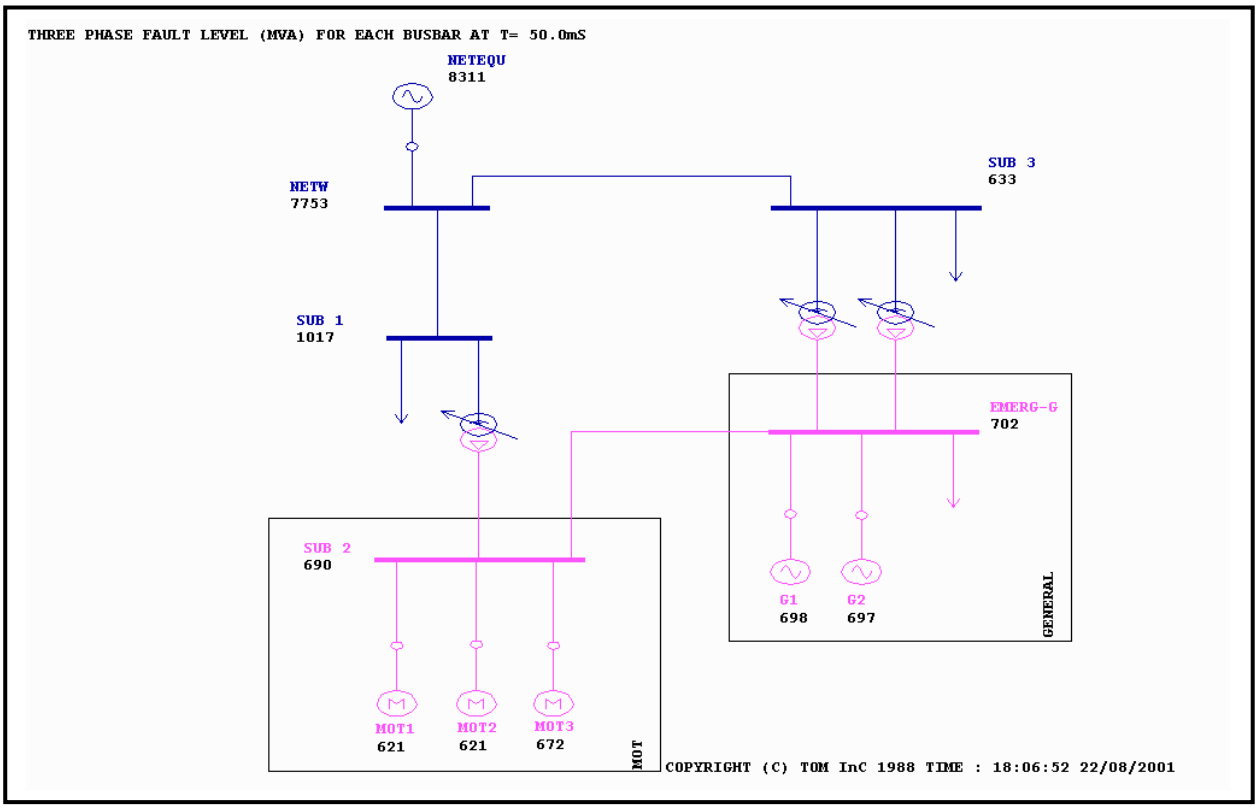


Figure 7.12

7.3.15 [PLOT]

Sends the entire diagram (on the screen and out of the screen) together with the latest fault calculations results to a plotting file. The plotting diagrams can then be plotted on a plotter device by running PLOT.EXE under the DOS command or its counterpart in Windows or Linux. Please refer to chapter 20 to find out about the plot files

7.3.16 [FULL LIST]

This option displays the results of the last fault calculation on the terminal. If [FULL LIST] is selected before any of the calculation options, the system data will be displayed on the screen.

Figure 7.13 shows an example of the full list results. It should be noted that the [FULL LIST] results are formatted in the same way as the printer file, i.e. they look the same.

7.3.17 [HELP]

This option displays the on-line HELP information on the terminal screen.

7.3.18 [RETURN]

Selection of this option exits from the fault level section and returns to the PASHA main menu.

7.4 The waveform section

This option on the fault level main menu, allows the user to simulate a fault on a single busbar and examine the current waveforms.

When the option is selected, the user is prompted for the busbar to be faulted. Figure 7.14 shows the prompt message, in this case the busbar name has been entered as 'SUB 1'. The waveform menu is then displayed, as shown in figure 7.14. The action of each option is described below.

7.4.1 [L-G-W]

Selection of this option calculates and displays the current waveforms for a line-to-ground fault with maximum asymmetry on the faulted red phase. Figure 7.15 shows the resulting waveforms.

7.4.2 [L-L-W]

Selection of this option calculates and displays the current waveforms for a line-to-line fault, with equal- opposite asymmetry in the two faulted phases (yellow and blue). Figure 7.16 shows the resulting waveforms.

```
UNBALANCED FAULT STUDY RESULTS
==============================

SYSTEM TITLE : PASHA MANUAL 2000 WITH DATA WITH AREA
STUDY  TITLE :
FAULT IMPEDANCE (R AND X) =     0.0010    0.0100 PU


TIME AFTER FAULT INCIDENCE =      50.00 MSEC



LINE  TO  GROUND FAULT AT SUB 1    ,FAULT CURRENT =   8.107PU (   3.546 KA)          ITS = 1
-------------------------------------------------------------------------
X1=   0.0783 R1=   0.0292 X2=   0.0779 R2=   0.0289 X0=   0.1522 R0=   0.0328    PU

   RED PHASE FAULT CURRENT =    8.10737(PU) AT   -79.085(DEG) (   3.546 KA)
YELLOW PHASE FAULT CURRENT =    0.00000(PU) AT     0.000(DEG) (   0.000 KA)
  BLUE PHASE FAULT CURRENT =    0.00000(PU) AT     0.000(DEG) (   0.000 KA)


B U S B A R   AC   V O L T A G E S
----------------------------------

BUSBAR          RED  PHASE        YELLOW  PHASE          BLUE  PHASE     AREA
             MAG(PU)  ANG(DEG)    MAG(PU)  ANG(DEG)    MAG(PU)  ANG(DEG)

NETW           0.979    -0.118      1.001  -120.038      0.999   120.021
SUB 1          0.081     5.205      1.093  -132.366      1.026   126.193
SUB 2          0.928    36.168      1.011   -89.360      0.891   148.637   MOT
SUB 3          0.903    -0.046      0.976  -119.494      0.950   116.634
EMERG-G        0.931    35.811      1.015   -89.373      0.898   148.456   GEN

NETEQU         0.988    -0.108      0.999  -119.884      0.999   119.930
MOT1           0.928    36.167      1.011   -89.357      0.891   148.635   MOT
MOT2           0.928    36.167      1.011   -89.355      0.890   148.634   MOT
MOT3           0.928    36.164      1.011   -89.359      0.891   148.633   MOT
G1             0.931    35.789      1.015   -89.376      0.899   148.445   GEN

G2             0.931    35.772      1.015   -89.373      0.900   148.436   GEN

Continue listing? (Y or N or S)   Yes
                                  No
                                  Search
                                                  COPYRIGHT (C) TOM InC 1988 TIME : 18:08:25 22/08/2001
```

Figure 7.13

```
FAULT LOCATED AT SUB 1
FAULT IMPEDANCE (R AND X)  =   P.U.
PRESENT CURRENT SCALE =     25.00 PU
PRESENT TIME SCALE =    100.00 MSEC
PRESENT CALCULATION INTERVAL =      0.01 MSEC
TYPE IN NEW CURRENT SCALE = 25      PU
BASE STEP =      1.67
TYPE IN NUMBER OF INTERVALS PER STEP = 0.835









OPTIONS:
L-G W
L-L W
L-L-G W
L-L-L W
CUR SCALE
TIME SCALE
TIME STEP
FAULT LOC
PRINT
FULL LIST
HELP
RETURN
                                                  COPYRIGHT (C) TOM InC 1988 TIME : 18:14:26 22/08/2001
```

Figure 7.14

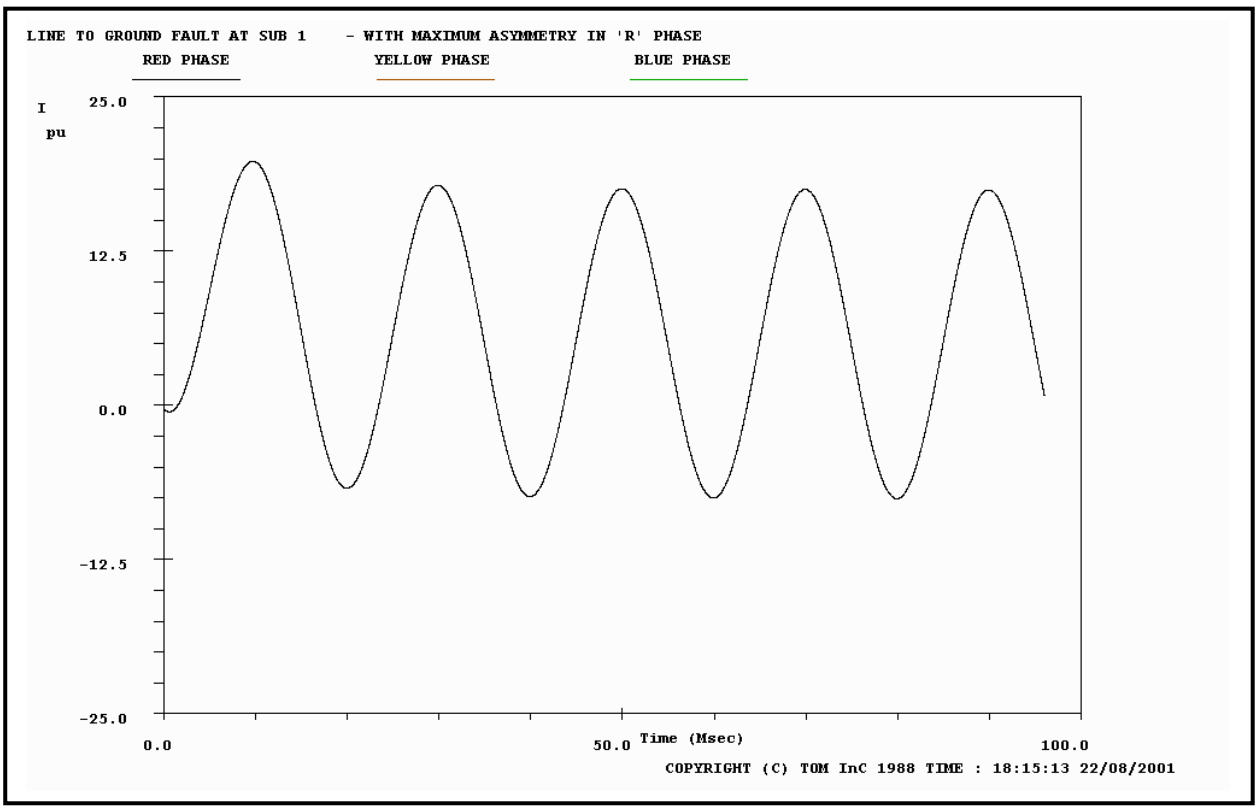


Figure 7.15

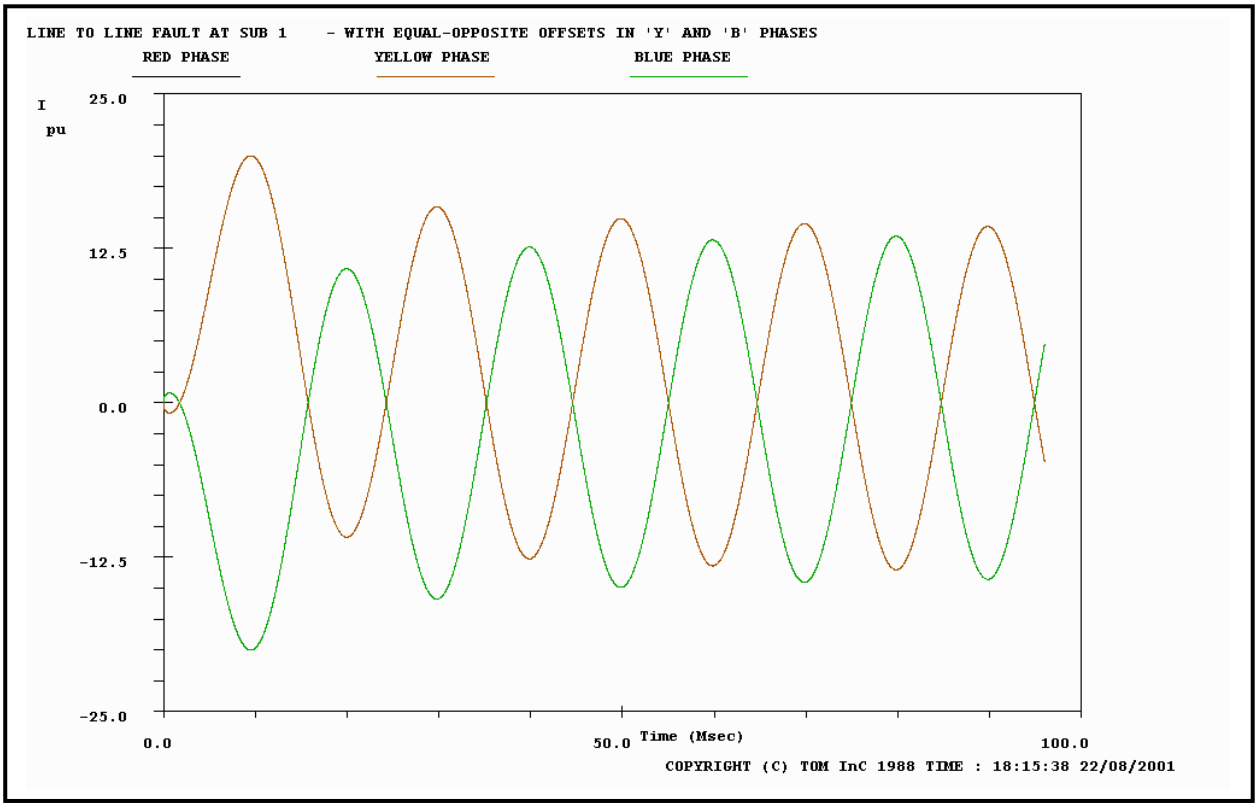
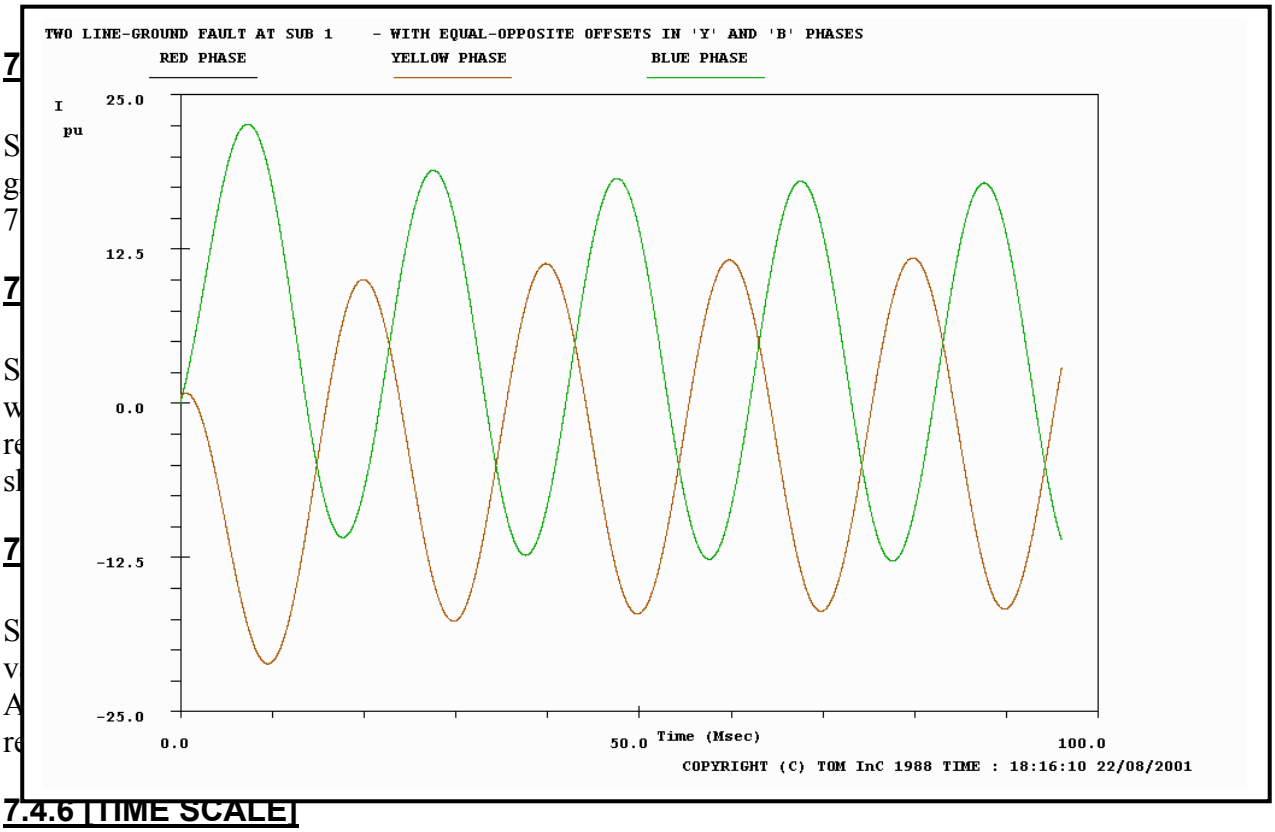


Figure 7.16



7.4.6 [TIME SCALE]

Selection of this option changes the overall fault study time duration and the horizontal time axis scale. The default value is 100 msec. Figure 7.21 shows the time scale being changed to 200 msec.

Figure 7.22, shows the new waveforms plot with the new vertical and horizontal scales (150), chosen as in 7.4.5 and this section.

7.4.7 [TIME STEP]

Selection of this option enables the user to set the time interval at which the instantaneous values of the fault currents are calculated and plotted. Satisfactory waveform displays can be obtained by calculating currents at steps of 30 degrees or less. The default value of 30 degrees is treated as a base, which can be subdivided into any integral number of steps. Decreasing the time step produces smoother waveform displays.

7.4.8 [FAULT LOC]

Selection of this option allows a new fault location to be entered. (This is done as described in 7.4, by simply typing the substation name.)

7.4.9 [PRINT]

Selection of this option stores the tabulated results in the printer file, which can be printed later.

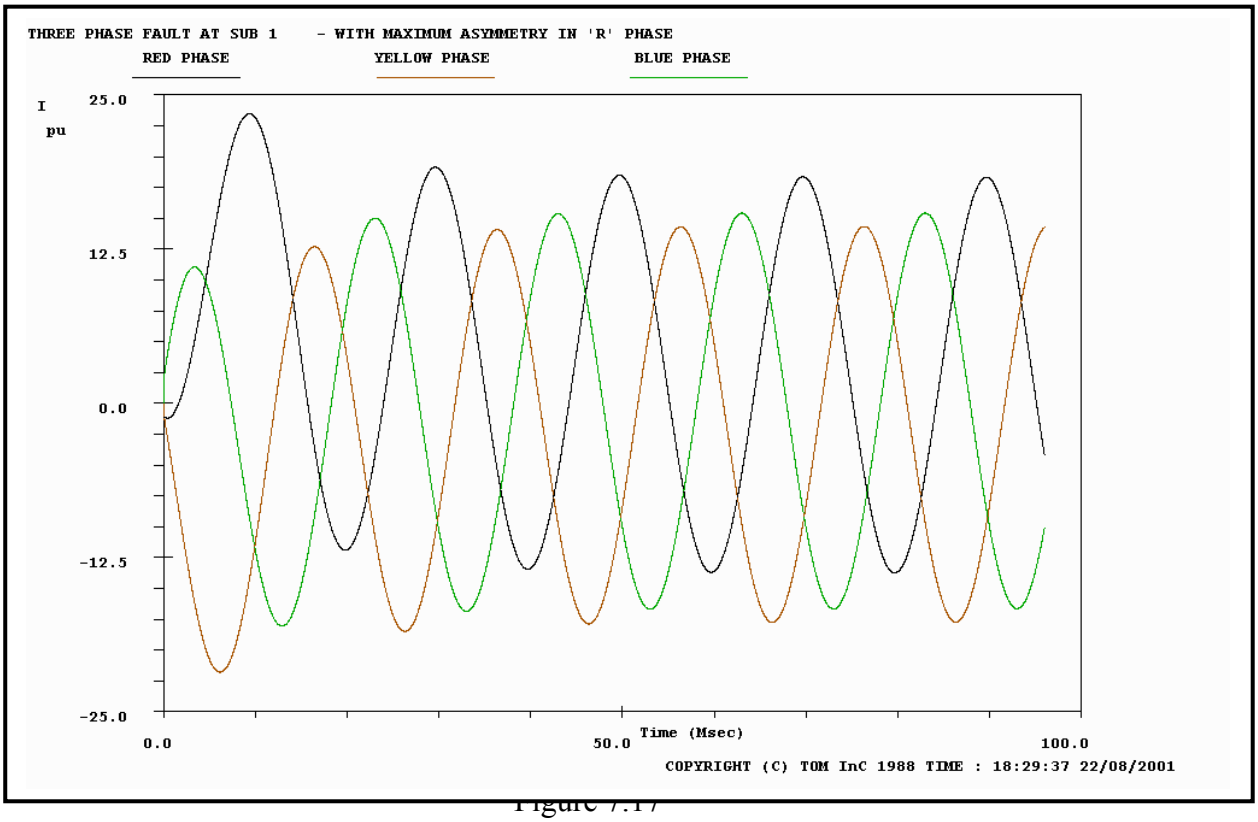


Figure 7.17

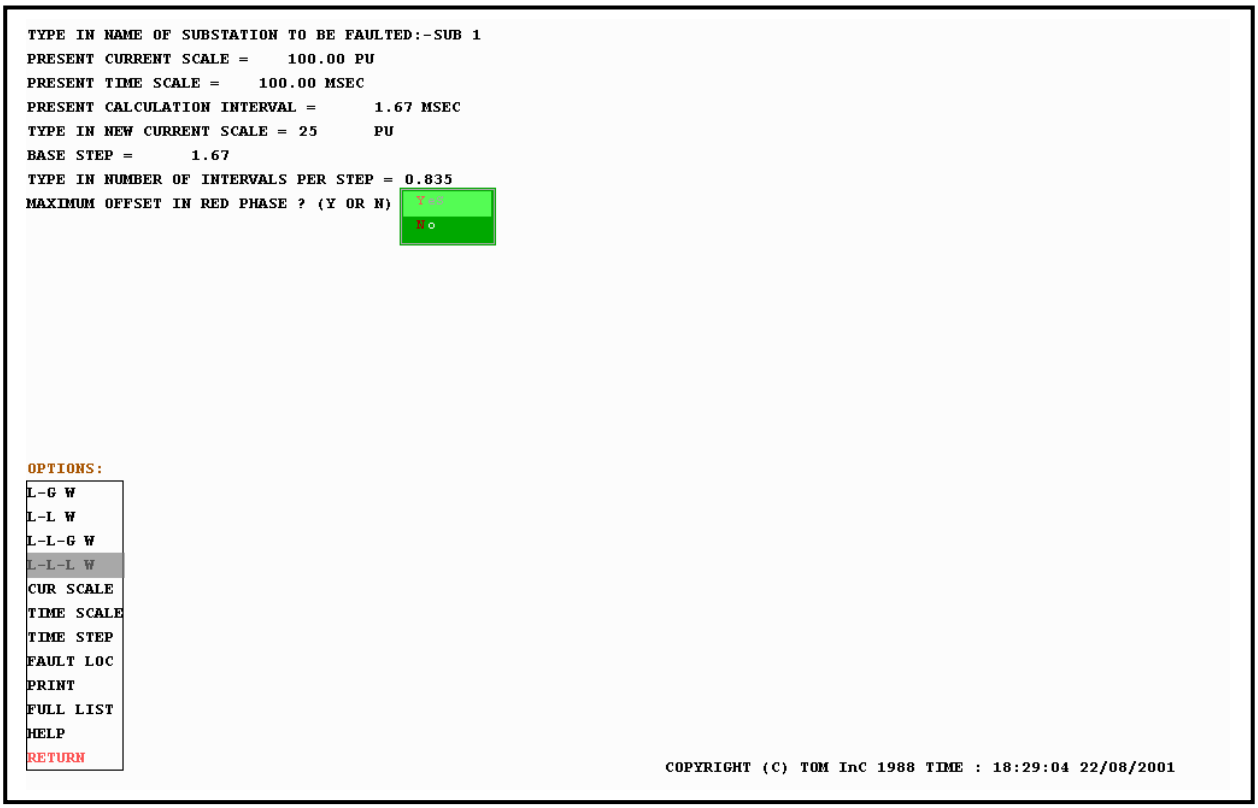


Figure 7.18

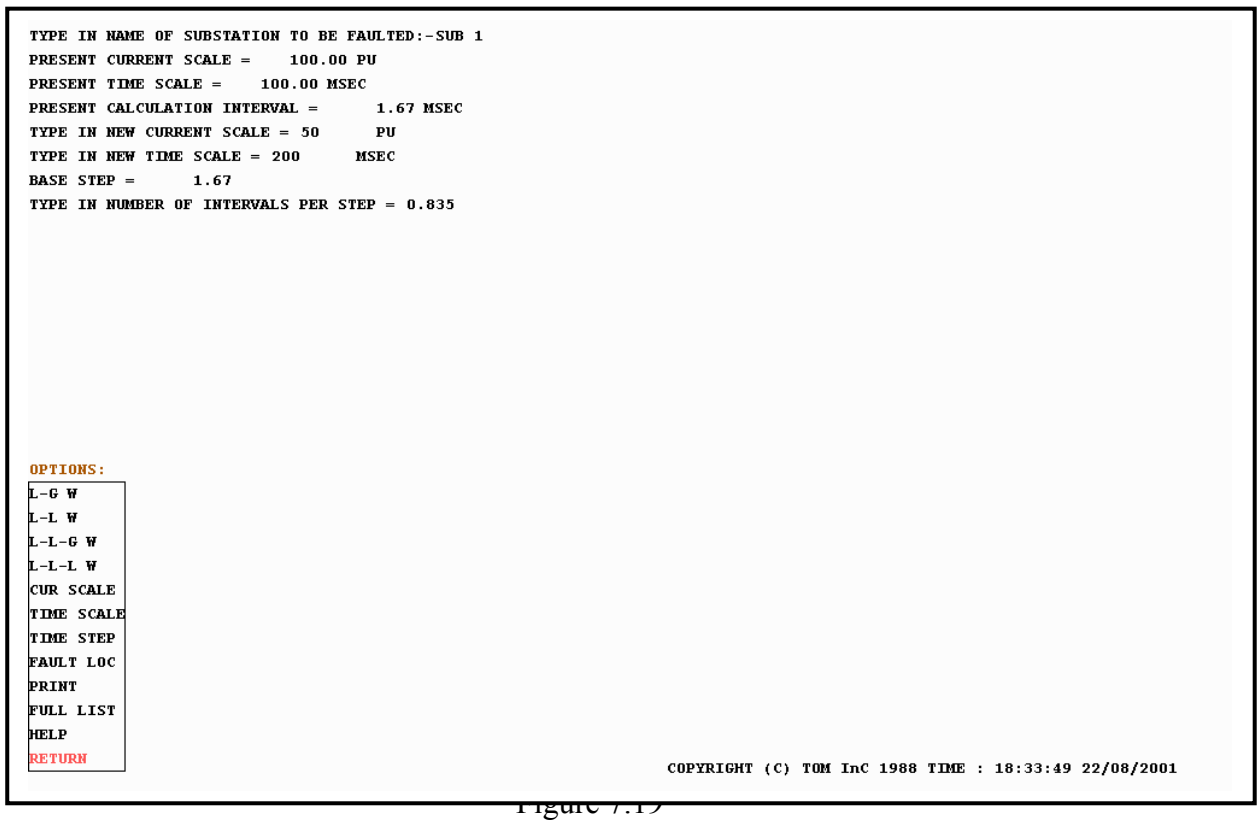


Figure 7.19

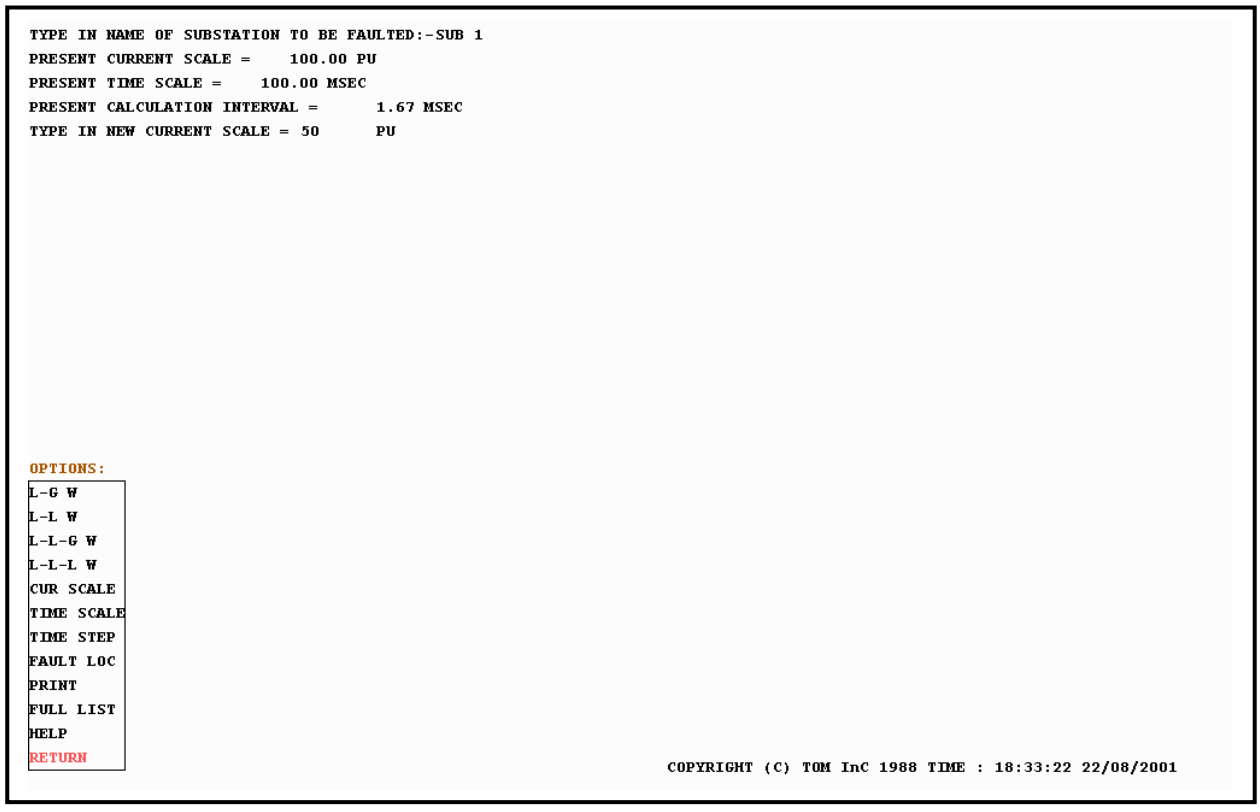


Figure 7.20

Figure 7.21

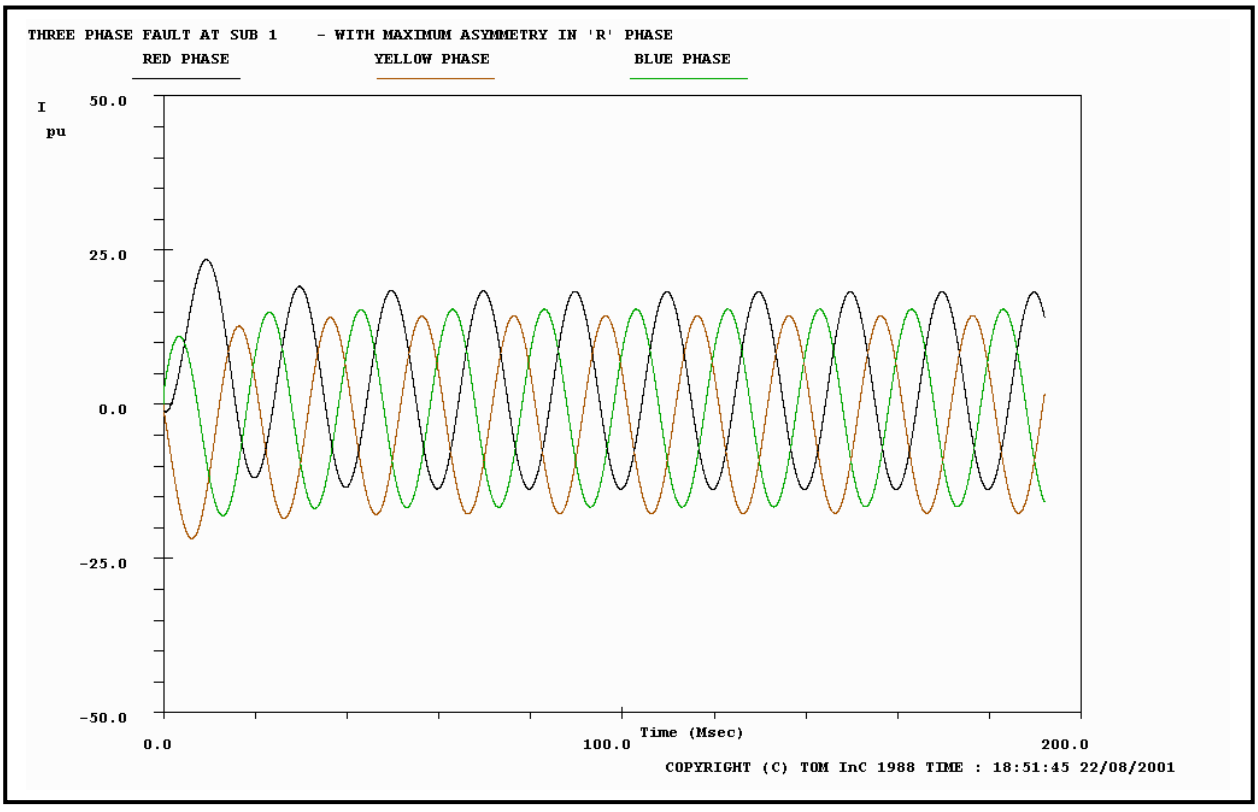


Figure 7.22

7.4.10 [FULL LIST]

Selection of this option enables the user to display the tabulated results on the terminal. Figure 7.23 shows a sample of the listing.

7.4.11 [HELP]

This option displays the on line HELP information on the terminal screen.

7.4.12 [RETURN]

Selection of this option returns the user to the fault level main menu. Typing an <X> when selecting this option returns directly to the PASHA main menu. You may select exit from right click menu too.

7.5 Error and warning messages

When insufficient data is specified to run the fault level section the initial phase detects this and displays an error or warning message.

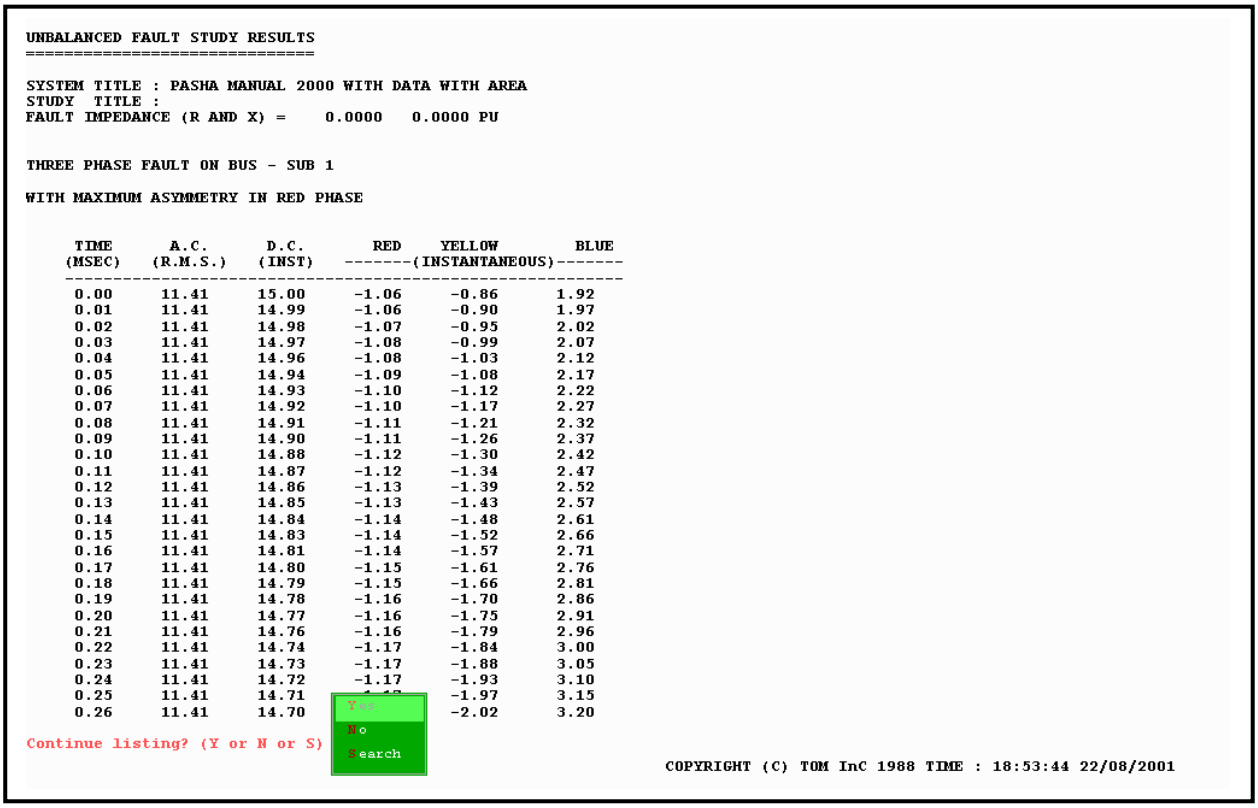
7.5.1 Error messages

When a vital piece of system data is missing the fault level section displays the error message shown in figure 7.24, and invites the user to look at the tabulated results to identify the problem. Figure 7.25 shows the second page of the tabulated results (seen by selecting the [FULL LIST] option 7.3.12). The missing data in this case is the line impedance of a particular branch. The branch data error will also be written for split network. If you wish to do fault for split network, do connect the split parts by a circuit together, but initially switch the connection element disconnected by specifying its STATUS minus one (see 4.5.2).

7.5.2 Warning messages

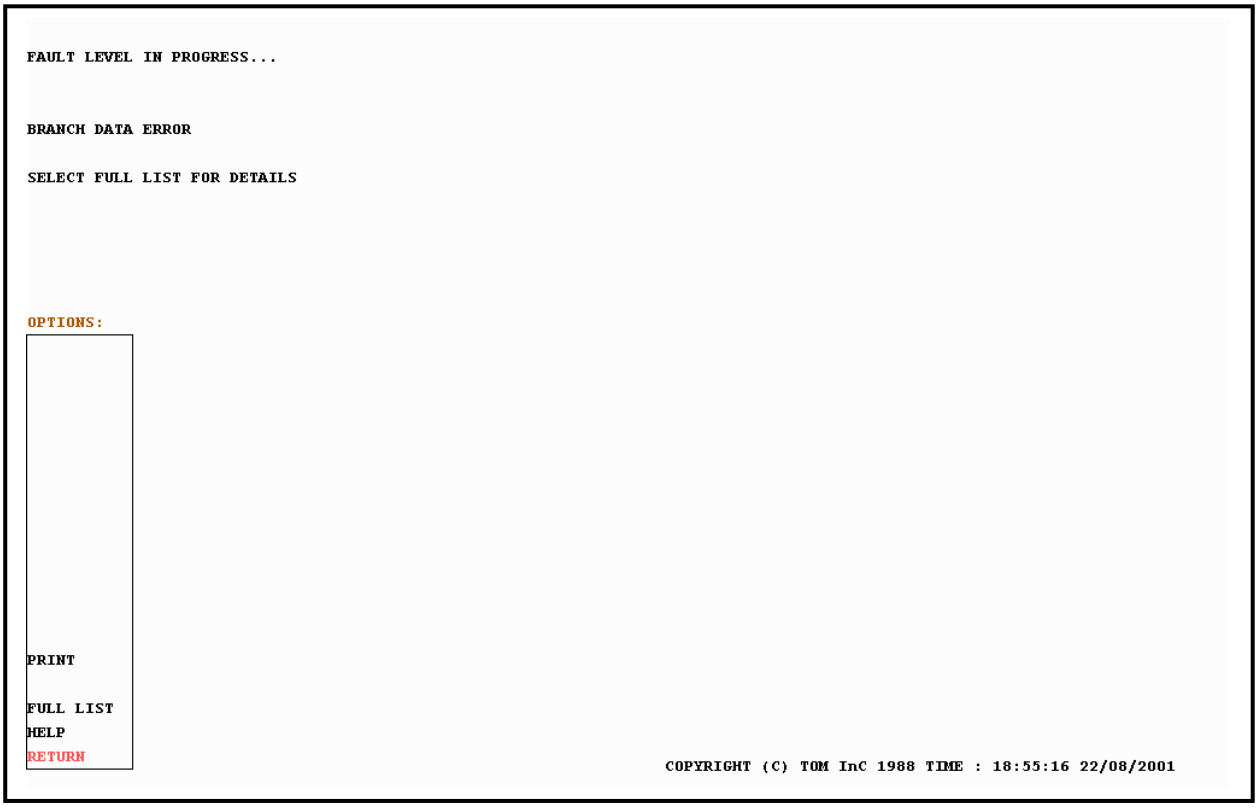
When the time constants on a machine are not specified a warning message is displayed to remind the user that the associated currents will not decay during the simulation. The warning message is shown in figure 7.1 and figure 7.26 shows this warning message in the listing.

There are some other warnings that will be written in the list files. These are mostly for awarding the user about some future actions in the actual plant that will damage the plant. For example out of phase (those stems from transformer phase shifts) switching of a line will be warned.



```
UNBALANCED FAULT STUDY RESULTS
==============================

SYSTEM TITLE : PASHA MANUAL 2000 WITH DATA WITH AREA
STUDY  TITLE :
FAULT IMPEDANCE (R AND X) =    0.0000   0.0000 PU


THREE PHASE FAULT ON BUS - SUB 1

WITH MAXIMUM ASYMMETRY IN RED PHASE

     TIME      A.C.      D.C.       RED     YELLOW        BLUE
    (MSEC)   (R.M.S.)   (INST)   -------(INSTANTANEOUS)-------
    ------------------------------------------------------------
     0.00     11.41     15.00     -1.06     -0.86      1.92
     0.01     11.41     14.99     -1.06     -0.90      1.97
     0.02     11.41     14.98     -1.07     -0.95      2.02
     0.03     11.41     14.97     -1.08     -0.99      2.07
     0.04     11.41     14.96     -1.08     -1.03      2.12
     0.05     11.41     14.94     -1.09     -1.08      2.17
     0.06     11.41     14.93     -1.10     -1.12      2.22
     0.07     11.41     14.92     -1.10     -1.17      2.27
     0.08     11.41     14.91     -1.11     -1.21      2.32
     0.09     11.41     14.90     -1.11     -1.26      2.37
     0.10     11.41     14.88     -1.12     -1.30      2.42
     0.11     11.41     14.87     -1.12     -1.34      2.47
     0.12     11.41     14.86     -1.13     -1.39      2.52
     0.13     11.41     14.85     -1.13     -1.43      2.57
     0.14     11.41     14.84     -1.14     -1.48      2.61
     0.15     11.41     14.83     -1.14     -1.52      2.66
     0.16     11.41     14.81     -1.14     -1.57      2.71
     0.17     11.41     14.80     -1.15     -1.61      2.76
     0.18     11.41     14.79     -1.15     -1.66      2.81
     0.19     11.41     14.78     -1.16     -1.70      2.86
     0.20     11.41     14.77     -1.16     -1.75      2.91
     0.21     11.41     14.76     -1.16     -1.79      2.96
     0.22     11.41     14.74     -1.17     -1.84      3.00
     0.23     11.41     14.73     -1.17     -1.88      3.05
     0.24     11.41     14.72     -1.17     -1.93      3.10
     0.25     11.41     14.71     -1.17     -1.97      3.15
     0.26     11.41     14.70     -1.17     -2.02      3.20

Continue listing? (Y or N or S)
                                                  Yes
                                                  No
                                                  Search
                                  COPYRIGHT (C) TOM InC 1988 TIME : 18:53:44 22/08/2001
```

Figure 7.23



```
FAULT LEVEL IN PROGRESS...


BRANCH DATA ERROR

SELECT FULL LIST FOR DETAILS




OPTIONS:
                    PRINT

                    FULL LIST
                    HELP
                    RETURN
                                  COPYRIGHT (C) TOM InC 1988 TIME : 18:55:16 22/08/2001
```

Figure 7.24

```
G2          0.00    0.00     1.0000   0.000   GEN

END OF STATIC LOAD DATA


I N D U C T I O N     M O T O R S

              LOAD                        MOTOR IMPEDANCES PU
 BUSBAR       P        Q         STATOR          ROTOR 1          ROTOR 2     MAGNETISING  AREA
  NAME     (MW)    (MVAR)     RES     REACT     RES     REACT    RES     REACT     REACT

MOT1         1.06     0.77  2.5902 16.6048  1.2951 16.6048  0.0000  0.0000   313.8276   MOT
MOT2         2.13     1.54  1.2951  8.3024  0.6476  8.3024  0.0000  0.0000   156.9138   MOT
MOT3         4.92     3.04  0.2172  4.9702  0.1546  2.7612  0.4676  1.2481   153.1914   MOT

END OF INDUCTION MACHINE DATA

END OF BUSBAR DATA


B R A N C H     D A T A     I N P U T
-------------------------------------

     BUSBAR                  BRANCH IMPEDANCES (PU)           TRANSFORMER  AREA-TO-AREA
 FROM       TO         PPS AND NPS          ZPS        SUSC    TAP WINDING
                         R       X       R       X       B      (%)   CODE

NETW      SUB 1       0.0308  0.0973  0.1039  0.2717  0.0211
SUB 1     SUB 2       0.0187  0.3750  0.0159  0.3190  0.0000   0.0   XD11          MOT
NETW      SUB 3       0.0990  0.2187  0.3051  0.8109  0.0450
SUB 3     EMERG-G     0.0187  0.3750  0.0159  0.3190  0.0000   0.0   XD11          GEN
SUB 3     EMERG-G     0.0187  0.3750  0.0159  0.3190  0.0000   0.0   XD11          GEN
     DATA ERROR - IMPEDANCE OF FOLLOWING BRANCH MISSING
EMERG-G   SUB 2       0.0000  0.0000  0.0000  0.0000  0.0000                GEN    MOT
NETEQU    NETW        0.0003  0.0009  0.0010  0.0030  0.0003
MOT1      SUB 2       0.0202  0.0124  0.0607  0.0372  0.0001                MOT    MOT
MOT2      SUB 2       0.0202  0.0124  0.0607  0.0372  0.0001                MOT    MOT
MOT3      SUB 2       0.0051  0.0031  0.0152  0.0093  0.0002                MOT    MOT
G1        EMERG-G     0.0013  0.0008  0.0040  0.0025  0.0008                GEN    GEN
G2        EMERG-G     0.0020  0.0012  0.0061  0.0037  0.0005                GEN    GEN

Continue listing? (Y or N or S)   Yes
                                  No
                                  Search
                                                  COPYRIGHT (C) TOM InC 1988 TIME : 18:55:29 22/08/2001
```

Figure 7.25

```
UNBALANCED FAULT STUDY DATA
===========================

SYSTEM TITLE: PASHA MANUAL 2000 WITH DATA WITH AREA

STUDY TITLE:

SYSTEM MVA BASE = 100.000


B U S B A R     D A T A     I N P U T
-------------------------------------

S Y N C H R O N O U S     G E N E R A T O R S

            GENERATION        GENERATOR IMPEDANCES PU      O-C TIME CONST
 BUSBAR       P        Q      RES     SYN-X  DA-TR-X DA-ST-X  TDO'     TDO"     AREA
  NAME      (MW)    (MVAR)     R        XD      XD'      XD"   (MSEC)   (MSEC)

     WARNING - TDO' OF FOLLOWING MACHINE MISSING
NETEQU     112.06    30.87  0.0000  0.0020  0.0020  0.0000     0.00     0.00
G1          40.00    30.00  0.0010  0.1000  1.1032  0.7890 4600.00    70.00  GEN
G2          30.00    19.10  0.0010  0.1000  0.6758  0.5097 6790.00    45.00  GEN

END OF SYNCHRONOUS MACHINE DATA


S T A T I C     L O A D S

 BUSBAR         LOAD          INITIAL VOLTAGES  AREA
  NAME      P(MW) Q(MVAR)     MAG(PU) ANG(DEG)

NETW          0.00    0.00      1.0000   0.000
SUB 1       120.00   40.00      1.0000   0.000
SUB 2         0.00    0.00      1.0000   0.000   MOT
SUB 3        40.00   20.00      1.0000   0.000
EMERG-G      10.00    5.00      1.0000   0.000   GEN
NETEQU        0.00    0.00      1.0000   0.000
MOT1          0.00    0.00      1.0000   0.000   MOT
MOT2          0.00    0.00      1.0000   0.000   MOT
MOT3          0.00    0.00      1.0000   0.000   MOT
G1            0.00    0.00      1.0000   0.000   GEN

Continue listing? (Y or N or S)   Yes
                                  No
                                  Search
                                                  COPYRIGHT (C) TOM InC 1988 TIME : 18:56:47 22/08/2001
```

Figure 7.26

7.6 Summary

The fault level section of PASHA enables the user to calculate the fault level currents for a full range of fault types at each busbar in the system at user selectable times. The fault impedance and reactance can be changed at will. The fault current flows can be displayed to show the current contribution of each branch in the system.

It is also possible to do a time simulation of a fault at a particular busbar, and plot the current waveforms.

Symmetrical and asymmetrical busbar and branch faults will also be calculated, and all the branch flows will be reported on single-line diagram or in the list files.