CheatSheets

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Chapter 1
SUB/MON/CON File Descriptions

1.1. Overview

This section contains details on the formats of the data input files used by activity DFAX. File Notational Conventions defines the notational conventions used in the data record descriptions defined below. Special Data Records describes those records that are common to all of the Linear Network Analysis Data Files. Section 1.2, "Subsystem Definition Data File" gives the record formats used in the Subsystem Definition data file, Monitored Element Data File describes the Monitored Element data file, and Contingency Definition Data File defines the Contingency Definition data file.

1.1.1. File Notational Conventions

In describing the input file syntax, the following notational conventions are used:

CAPITALS	Keyword that must be specified exactly as shown. No keyword abbreviations are allowed.
[...]	Items enclosed in square brackets are optional keywords and/or values.
|A| or A|B |B|	Specify one from the list separated by, or enclosed in, the vertical bars.
bsid	Bus identifier; this data value *must* be a bus number when the *numbers* input option is in effect, and an extended bus name (twelve character name plus bus base voltage) when the *names* input option is in effect (refer to Section 3.3.3, "Program Run-Time Option Settings" and activity OPTN). If an extended bus name contains blanks or special characters, it must be enclosed in single quotes.
bsid1 bsid2	A range of bus identifiers.
staid	Substation identifier; this data value *must* be a substation number.
ndid	Substation node identifier; this data value *must* be a valid substation node number for the substation specified in the same context.
ckid	One-or two-character circuit identifier.
mcid, ldid, shid, swid, imid	One- or two-character equipment identifier for a machine, load, shunt, switched shunt, or induction machine, respectively.
devid	FACTS device or dc line name; up to twelve characters. If a device name contains blanks or special characters, it must be enclosed in single quotes.
i	An integer value.
i j	An range of integer values.
r	A floating point value; the decimal point is optional when specifying a whole number (e.g., 10, 10., and 10.0 all specify the floating point number ten).
r1 r2, or rlow rhigh	A range of floating point values.
filename	A filename. Up to 260 characters is allowed.

label	A 32-character label identifier. If a label contains blanks or special characters, it must be enclosed in single quotes.
category-string	Up to 160 characters are allowed. If the string contains blanks or special characters, it must be enclosed in single quotes. The total size of all the category-strings in a CATEGORY structure combined is limited. The limit depends on a number of things, but is certainly less than 300 characters

Keywords and data values must be separated by one or more blanks.

1.1.2. Bus Input/Output Using Bus Numbers and Names

PSS®E allows users to specify buses by using either bus numbers or names. PSS®E's bus input/output mode is set to bus numbers by default.

PSS®E will automatically accept bus names of the format 'nnnnnnnnnnnnvvvv' (12-character name plus 4-character voltage); where nnnnnnnnnnnn is the name portion and vvvv the voltage portion of the bus name.

Bus names have to be specified via a name and voltage level as shown below:

```
BUS 'ALPHABETA 345' / Bus name
BUS 'GAMMAALPHAXX 169' 11.000 / Bus name with participation factor
```

There are two ways to tell PSS®E to use the bus name. It can be done by changing the BUS Input/Output option or by directly using the BUSNAMES command in the input file.

Inputting by bus names provides independence from bus numbering, and allows bus renumbering, which is done by some companies in the United States on a consistent basis when creating combined load flow cases. It is quite common to use bus names in various transfer analysis/assessment reports.

To accommodate the advantages of both types of bus input, PSS®E allows the user to alternate between the two modes of bus input within the same input files. For example, one subsystem may be defined using a bus name, the next one using bus numbers; or, define a subsystem file by using bus names, and then use input by bus number to define monitored elements.

Changing bus input mode can be done anywhere in the subsystem, contingent, monitored, and/or exclude data input files via BUSNAMES and BUSNUMBERS keywords. BUSNAMES and BUSNUMBERS records are specified on separate input lines.

```
BUSNAMES / will switch input to read by bus names
BUSNUMBERS / will switch input to read by bus number
```

The default mode for specifying the use of bus names or bus numbers can be set by selecting the BUS Input/Output option. If a user has redefined the input mode to bus name, this redefinition will propagate to other input functions. For example, if a user used bus input by names to read in the subsystem file, then PSS®E will use bus names input mode when reading monitored element and contingency files. Only the explicit record BUSNUMBERS will switch the bus input mode to bus numbers.

1.1.3. Special Data Records

The following record types are allowed in each of the Linear Network Analysis data files:

TRACE	Enable or disable input tracing. When enabled, each line read from the input file is written to the *Progress* tab or the user's designated output file; refer to Section 4.4, "Virtual Output Devices". Tracing is initially disabled.
ECHO filename	Write each input line to the designated file; if the filename specification contains any blanks or slashes (/), it must be enclosed in single quotes. Echoing of input records is useful when data records are being entered interactively and the same set of input records will be used in subsequent executions of activity DFAX. The file specified here is completely independent of any file specified to the PSS®E activity ECHO (refer to Section 19.12, "Running a Response File" and Section 19.13, "Recording User Actions"). Refer to Section 2.4.1, "File Usage " for the file specification conventions used by activity DFAX.
COM	Comment line that is ignored during input processing. Any meaningful comments may be placed on a comment line following the COM keyword.
END	End of block structure or end of data input, as appropriate.

In addition, blank lines may be included anywhere in the file. These are ignored during the input file processing.

1.2. Subsystem Definition Data File

Subsystems of the working case are defined via the Subsystem Definition data file. While format details differ, the subsystem definition provided is functionally identical to the specification of subsystems via the bus subsystem selector dialog and the optional suffixes of many PSS®E reporting and processing activities (refer to Section 4.8, "Subsystem Selection").

The portion of the working case to be contained in each subsystem being defined is specified in the following block structure:

```
SUBSYSTEM|SYSTEM [label]
(subsystem specification data record)
.
.
(subsystem specification data record)
END
```

The subsystem specification data records allowed are as described below.

The optional subsystem labels are used on several record types in the Monitored Element and Contingency Definition data files; they are also printed in the line mode dialog of activity TLTG, SPIL, and POLY, which summarizes the subsystems defined and allows the user to select the study and opposing systems. If no label is specified on a SUBSYSTEM record, the label UNNAMED n is assigned to the subsystem, where < n > is a unique integer. Up to 100 subsystems may be specified in a Subsystem Definition data file, and each subsystem must be defined within a single SUBSYSTEM block structure.

Buses can be selected to be in included in a SUBSYSTEM or SYSTEM using a series of criteria; that is selecting by BUS, AREA, ZONE, OWNER, and KV. Furthermore, buses can be selected on an individual basis or in groups.

Selecting buses by number requires data records of the following form:

```
BUS bsid
BUSES bsid bsid
```

The BUSES record is valid only when the *numbers* input option is in effect (refer to Section 3.3.3, "Program Run-Time Option Settings" and activity OPTN), and assigns the designated buses, as well as all buses where bus numbers fall between the two bus numbers specified, to the subsystem being defined. For example, the data record BUSES 15 77 may be used to select all buses with numbers from 16 to 76, inclusive.

All buses in selected areas may be assigned to a subsystem with data records in the following format:

```
AREA i
AREAS i j
```

where `i` is an area number. The AREAS record type assigns all buses in a range of area numbers to the subsystem being defined. For example, the data record AREAS 5 7 may be used to assign all buses in areas five, six, and seven to the subsystem.

Similarly, all buses in selected zones and owners may be assigned to a subsystem with data records of the following form:

```
ZONE i
ZONES i j
OWNER i
OWNERS i j
```

Buses at designated voltage levels may be assigned to a subsystem with records of the following form, where, as above, the KVRANGE record defines a range of voltage levels:

```
KV r
KVRANGE r1 r2
```

Note that, in specifying ranges of bus numbers, areas, zones, owners, and voltage levels, the second value specified *must not* be preceded with a minus sign. The second number specified *must* be greater than the first.

In addition, a join group block structure provides for the specification of a group of buses through the logical anding of two or more of the five selection criteria described above. A join group has the following block structure:

```
JOIN [label]
(subsystem specification data record)
.
.
(subsystem specification data record)
END
```

where each subsystem specification data record is one of the simple record types (BUS, AREA, ZONE, OWNER, KV, or the corresponding range of records) described above. The optional JOIN group label is for the user's convenience and is neither used by activity DFAX nor preserved in the Distribution Factor data file.

Each join group block structure must appear within the subsystem block structure described above. Both join group block structures and the simple record types may be included within a subsystem block structure.

The following example defines the subsystem MY COMPANY, which consists of all buses in Area 5, along with all buses in Area 6, which are in Zones 8 through 10:

```
SUBSYSTEM 'MY COMPANY'
AREA 5
JOIN 'GROUP 1'
  AREA 6
  ZONES 8 10
  END
END
```

A single bus or a set of buses can be excluded from a subsystem with the SKIP commands as described below. The commands must follow the simple subsystem specification records and/or join group block structures; in other words they must be the last records or only appear before the participation block within the subsystem specification block.

A single bus may be excluded from a subsystem with the data record in the form of:

```
SKIP BUS bsid
```

A set of buses may be excluded form a subsystem with the following data records:

```
SKIP BUS WITH [IN-SERVICE] |LOAD        | |LESS    | r   |MW  |
                           |GENERATION  | |GREATER|      |MVAR|
                           |GENUPLIMIT  |                |MVA |
                           |GENLOWLIMIT|
                           |SHUNT       |
```

When the optional IN-SERVICE keyword is present, only in-service components are considered in summation, otherwise both in-service and out-of-service components are counted. The 'r' value is the threshold in the specified unit of one of keywords MW, MVAR, or MVA. In using the LESS keyword, a bus is skipped from a subsystem if the corresponding data quantity of the bus is less than the 'r' value. In using the GREATER keyword, a bus is skipped from a subsystem if its data quantity is greater than the 'r' value.

At each bus that is assigned to the subsystem, in using LOAD keyword the total nominal load of loads is compared against the 'r' value. When the GENERATION keyword is used, the total generation of the machines is compared against the 'r' value. In using GENUPLIMIT or GENLOWLIMIT keyword, the corresponding total upper or lower limit of machines is considered in the summation. When the SHUNT keyword is present, the total nominal output of bus fixed shunts is used for comparing against the 'r' value.

The following data record can be used to exclude buses from a subsystem by comparing the current nominal reactive power output from the switched shunt at the buses against the 'r' value.

```
SKIP BUS WITH [IN-SERVICE] SWSHUNT |LESS    | r   MWAR
                                   |GREATER|
```

The following data record can be used to exclude buses by comparing the total active power settings of induction machines at the buses against the 'r' value.

```
SKIP BUS WITH [IN-SERVICE] INDUCMACHINE |LESS    | r MWAR
                                        |GREATER|
```

A “SKIP” record can be used to exclude a single bus or a group of buses from a subsystem, as shown in the following example.

```
SYSTEM  MONITOR5
AREA 5
SKIP BUS 567
SKIP BUS WITH GENUPLIMIT LESS 10 MW
END
```

SKIP records must “follow” the simple subsystem specification records and/or join group block structures within the subsystem specification block.

Activities TLTG, SPIL, and POLY and the PV Analysis calculation modify the generation/load profile within designated subsystems to determine transfer capability. The participation block structure allows the user to specify those buses that are to participate in the generation/load shift, along with their participation factors that determine how the change in subsystem power injection is to be shared among the designated buses. To establish the participating buses and their participation factors, the PARTICIPATE block structure is used.

The form of the participation block structure is:

```
PARTICIPATE
  BUS bsid r
  .
  .
  BUS bsid r
END
```

Each participation block structure must appear within the subsystem block structure described above, and *must follow* the simple record types and/or join group block structures defining the SUBSYSTEM; that is, it must be the last data record block in the SUBSYSTEM specification.

Each bus specified must be present in the subsystem being processed. Any bus that violates this requirement or which is disconnected (i.e., its type code is four or greater) generates an alarm and is excluded from the group of participating buses.

The `r` values are non-zero participation factors that are normally expressed in percent or per unit of the total subsystem generation shift. While individual `r` values may be negative, the sum of the `r` values within a participate block structure must be positive.

1.3. Monitored Element Data File

This file identifies those elements, or groups of elements that are to be monitored for flow violations and those buses that are to be monitored for voltage violations.

1.3.1. Individual Flow Monitoring Records

Each monitored element may consist of either a single branch or a group of branches (an interface), where the flow on an interface is taken as the sum of the flows on the branches comprising the interface.

Up to 1,000 interfaces are allowed, and the total of single branches plus branches contained in all interfaces may not exceed the number of branches for which PSS®E is dimensioned. Only in-service branches are added to the monitored element list.

To specify a single substation switching device for monitoring, the following data record may be used:

```
MONITOR |BREAKER| |SUBSTATION| staid FROM NODE ndid TO NODE ndid [|CIRCUIT | ckid]
        |SWITCH | |SUB       |                                    |CKT     |
        |SWD    |
```

To specify a single branch for monitoring, the following data record may be used:

```
[MONITOR] |BRANCH| FROM BUS bsid TO BUS bsid [|CIRCUIT| ckid]
          |LINE  |                            |CKT    |
```

To specify one winding of a three-winding transformer for monitoring, the bus to which the winding is connected must be the first bus specified in the following data record:

```
[MONITOR] |BRANCH| FROM BUS bsid TO BUS bsid TO BUS bsid [|CIRCUIT| ckid]
          |LINE  |                                        |CKT    |
```

Example:

```
Monitor branch from bus 288 to bus 2000 to bus 398
```

The above example will only monitor flow into the winding of the three-winding transformer connected to bus 288. If it is desired to monitor bus 2000 and bus 398 flows into the transformer additional monitor statements are required.

If the optional circuit identifier keyword and data value are omitted, a circuit identifier of '1' is assumed.

As a convenience to save typing, the following block structure may be used to designate a series of single branches for monitoring where, as above, the default circuit identifier is '1'. Three-winding transformers cannot be specified using this block structure.

```
[MONITOR] BRANCHES|LINES
bsid bsid [ckid]
```

```
.
.
bsid bsid [ckid]
END
```

In specifying a branch with the above records, if it is already in the monitored element list in the specified direction, an appropriate message is printed and the record is ignored. If a branch is included in the monitored element list in both directions, flows (and distribution factors) for the two entries are printed in activities OTDF, DCCC, TLTG, SPIL, IMPC, and POLY with equal magnitude and opposite sign; in activity ACCC, the same results are shown in both directions.

When the multi-section line reporting option is enabled (refer to Section 3.3.3, "Program Run-Time Option Settings" and activity OPTN), in-service multi-section line groupings may be specified with the above records. If an in-service member of a multi-section line grouping is specified, the multi-section line (rather than the specified member) is added to the monitored element list in the same direction as the specified member.

When the multi-section line reporting option is disabled, multi-section line groupings may not be specified in the above records; in-service members of multi-section line groupings may be designated and are added as specified to the monitored element list.

1.3.2. Group Flow Monitoring Records

The following four record types provide for the addition of a group of branches to the monitored element list with a single record. When the keyword BRANCHES, LINES, or TIES is used, all branches in the grouping except breakers and switches are added as monitored elements. When using the BREAKERS keyword, only breaker and switch branches in the grouping are added as monitored elements. Any branch that is included in the subset specified by the record, but which is already included in the monitored element list in either direction, is skipped.

For these record types, when the multi-section line reporting option is enabled, multi-section line groupings within the specified subset, but not the individual members of such groupings, are added to the monitored line list. When the multi-section line reporting option is disabled, members of multi-section line groupings within the specified subset, but not the multi-section line groupings, are added to the monitored line list.

To place all branches in the monitored element list, the following data record may be used:

```
[MONITOR] ALL |BRANCHES|
              |LINES   |
              |BREAKERS|
```

Branches are entered into the monitored element list in single entry form, with the lower ordered bus (number or name, according to the bus output option currently in effect) as the from bus.

The following data record may be used to select for monitoring all branches connected to a specified bus:

```
[MONITOR] |BRANCHES| FROM BUS bsid
          |LINES   |
          |BREAKERS|
```

All branches within a specified subsystem may be monitored by entering the data record:

```
[MONITOR] |BRANCHES| IN |AREA     i        | [3WLOWVOLTAGE] [IN KVRANGE r1 r2]
          |LINES   |    |AREAS    i  j     |
                        |ZONE     i        |
                        |ZONES    i  j     |
                        |OWNER    i        |
                        |OWNERS   i  j     |
                        |KV       r1       |
                        |KVRANGE r1 r2     |
                        |SYSTEM     label|
                        |SUBSYSTEM label|
```

When using the SYSTEM or SUBSYSTEM keywords, the label must correspond to a subsystem label specified in a previously accessed Subsystem Definition data file (refer to Section 1.2, “Subsystem Definition Data File”).

For a three-winding transformer to be included, without the keyword 3WLOWVOLTAGE specified all of its in-service windings must be connected to subsystem buses; when using the keyword 3WLOWVOLTAGE, checking on connection of its low voltage winding to a subsystem bus is disabled if all its three winding bus voltages are specified as non-zero values. For any such three-winding transformer, all of its in-service windings connected to subsystem buses are added to the monitored element list.

The IN KVRANGE keyword can be added to simplify defining monitored elements within a desired voltage range. The first r1 is the lower bound of the voltage range, and the second r2 is the upper bound of the voltage range. With IN KVRANGE keyword, all terminal buses of selected branches are within the desired voltage range.

When AREAS, ZONES or OWNERS is specified, a range of items is selected based on the i and j values entered.

To place branches that are assigned to a line owner into the monitored element list, the following data record can be used:

```
[MONITOR] |LINES   | WITH LINE OWNER i
          |BRANCHES|
          |BREAKERS|
```

1.3.3. Subsystem Tie Monitoring Records

The following record provides for the monitoring of all ties from a specified subsystem, or all ties between a pair of subsystems:

```
[MONITOR] |TIES| FROM |AREA     i        | [TO |AREA     i        |] [IN KVRANGE r1 r2]
          |TIE |      |AREAS    i j      |     |AREAS    i j      |
                      |ZONE     i        |     |ZONE     i        |
                      |ZONES    i j      |     |ZONES    i j      |
                      |OWNER    i        |     |OWNER    i        |
                      |OWNERS   i j      |     |OWNERS   i j      |
                      |KV       r1       |     |KV       r2       |
                      |KVRANGE r1 r2     |     |KVRANGE r1 r2     |
                      |SYSTEM     label|       |SYSTEM     label|
                      |SUBSYSTEM label|        |SUBSYSTEM label|
```

The main difference between the IN, FROM, and TO specifications is that IN specifies the kV requirement of both terminal buses for the selected branches, while the FROM and TO specifications define only the from or to selection, respectively.

For a three-winding transformer to be included, at least one of its in-service windings must be connected to a subsystem bus, and at least one of its in-service windings must be connected to a bus that is either not in the subsystem or in the to subsystem, as appropriate; for any such three-winding transformer, all of its in-service windings connected to subsystem buses are added to the monitored element list.

The following provides several examples of selecting monitored branches using the formats described above.

Example:

```
MONITOR BRANCHES IN AREA 1
MONITOR BRANCHES IN KVRANGE 200 999
MONITOR BRANCHES IN AREAS 40 42 IN KVRANGE 100 300
MONITOR BRANCHES IN AREA 1 IN KVRANGE 100 300
MONITOR TIES FROM AREA 1 IN KVRANGE 100 999}
MONITOR TIES FROM AREA 1 TO AREA 5 IN KVRANGE 100 999
```

The user must be aware that specification:

```
MONITOR BRANCHES IN AREAS 40 42 IN KVRANGE 100 300
```

includes not only branches within areas 40, 41, and 42, but also all ties between areas 40, 41, and 42.

For a tie branch between a pair of subsystems to be added to the monitored element list, both of the following must be satisfied:

1. One bus is in the FROM subsystem.

2. Another bus is in the TO subsystem, and it is not in the FROM subsystem.

For the case of disjoint subsystems (e.g., TIES FROM AREA 1 TO AREA 2), the selection of tie branches is clear and unambiguous. However, in the case of overlapping subsystems (e.g., TIES FROM AREA 1 TO ZONE 5), the user must be aware of the above rules in specifying TIES records. The possibility exists that, in applying the above criteria, the set of branches included as ties may not be the same if the from and to subsystems are interchanged. Consider, for example, the following area and zone assignments:

Bus	*Area*	*Zone*
1	1	10
2	1	5
3	2	5
4	1	5

Further, assume that a branch exists between each pair of buses. The following record would include branches 1-3, 2-3, and 4-3, but not 1-2, 1-4, or 2-4:

```
TIES FROM AREA 1 TO ZONE 5
```

Conversely, the following record would include branches 2-1, 3-1, and 4-1, but not 2-3, 2-4, or 3-4:

```
TIES FROM ZONE 5 TO AREA 1
```

When the multi-section line reporting option is enabled (refer to Section 3.3.3, “Program Run-Time Option Settings” and activity OPTN) the subsystem assignments of the dummy buses of each multi-section line grouping are ignored; a multi-section line grouping is treated as a tie branch if and only if its endpoint buses satisfy items (1) and (2) above. When the multi-section line reporting option is disabled, the multi-section line grouping definitions are ignored and any member of a multi-section line grouping satisfying items (1) and (2) above is considered a tie branch.

The `IN KVRANGE` keyword can be added to simplfy defining monitored elements within a desired voltage range. The first `r1` is the lower bound of the voltage range, and the second `r2` is the upper bound of the voltage range. The KVRANGE is ignored if it is defined after the `FROM KV r1` or `TO KV r1` keywords. With KVRANGE keyword, all terminal buses of selected branches are within the desired voltage range

To demonstrate the use of KVRANGE specifications, assume that subsystem COMPANY1 was defined as:

```
SUBSYSTEM COMPANY1
  JOIN
    AREAS 25 35
    KVRANGE 200 999
  END
END
```

The example below shows how to add all ties from COMPANY1, including step-up transformers within COMPANY2 and all ties from COMPANY1 to other neighbors:

```
MONITOR TIES FROM SYSTEM COMPANY1
```

To avoid adding step-up transformers, a user should use:

```
MONITOR TIES FROM SYSTEM COMPANY1 TO KVRANGE 200 300
```

This specification excludes from the selection all 345-kV ties from COMPANY1.

A KVRANGE specification eliminates the need to create intermediate subsystems if a user wants to define ties from some area(s)/zone(s) within some kV level as shown below:

```
MONITOR TIES FROM AREAS 40 45 IN KVRANGE 200 240
```

An INTERFACE is defined using the following block structure:

```
[MONITOR] INTERFACE label[|RATING r [MW]            |]
                         [|RATINGS r1 r2 ...r12 [MW]|]
(branch specification record; see below)
.
.
```

```
(branch specification record; see below)
END
```

where the branch specification records may specify sets of tie lines:

```
[MONITOR] |TIES| FROM |AREA      i        | [TO |AREA      i        |] [IN KVRANGE r1 r2]
          |TIE |      |AREAS     i j      |     |AREAS     i j      |
                      |ZONE      i        |     |ZONE      i        |
                      |ZONES     i j      |     |ZONES     i j      |
                      |OWNER     i        |     |OWNER     i        |
                      |OWNERS    i j      |     |OWNERS    i j      |
                      |KV        r1       |     |KV        r2       |
                      |KVRANGE r1 r2      |     |KVRANGE r1 r2      |
                      |SYSTEM     label|        |SYSTEM     label|
                      |SUBSYSTEM label|         |SUBSYSTEM label|
```

individual branches:

```
[MONITOR] |BRANCH| FROM BUS bsid TO BUS bsid [|CIRCUIT | ckid]
          |LINE  |                            |CKT     |
```

individual three-winding transformer windings:

```
[MONITOR] |BRANCH| FROM BUS bsid TO BUS bsid TO BUS bsid [|CIRCUIT| ckid]
          |LINE  |                                        |CKT    |
```

or, simply:

```
bsid bsid [ckid]
```

The 32-character interface labels are used to identify interfaces in the output reports of those activities that use the Distribution Factor data file. As with ac branches, provision is made for up to twelve interface ratings. Interface ratings that are entered as zero, or omitted, are handled in the same way as branch ratings of zero in activities DCCC, TLTG, SPIL, POLY,IMPC, and ACCC.

If the optional specification of ratings is omitted, the sum of the appropriate rating set values of each of the interface members is taken as the interface rating. An interface rating is usually specified as something other than a thermal limit; for example, contractual or stability considerations may determine the interface rating to be used.

The SKIP block structure is used to specify individual branches that are to be excluded from the monitored element list generated as a result of subsequent specification records that are used to define a group of branches.

```
SKIP
(branch specification record; see below)
(branch specification record; see below)
END
```

Non-transformer branches and two-winding transformers are specified on branch specification records using the following record format:

```
bsid TO bsid [|CIRCUIT| ckid]
              |CKT    |
```

Three-winding transformers are specified on branch specification records using the following record format:

```
bsid TO bsid TO bsid [|CIRCUIT| ckid]
                      |CKT    |
```

The default circuit identifier is '1' if this specification is omitted.

“SKIP blocks” can also be used to omit individual branches from the monitored element list generated by subsequent automatic specification commands, as shown in the following example.

```
SKIP
    3008  TO 154
    100 TO 200 TO 300
END
MONITOR BRANCHES IN AREA 5
```

The SKIP block must be “above” the automatic specification records.

Branches specified in a SKIP block structure apply only to MONITOR ALL, MONITOR LINES and MONITOR TIES records which define a group of branches and are below it in the Monitored Element data file. Multiple SKIP block structures are allowed, and each SKIP block structure appends to the list of branches to be omitted from monitoring as a result of subsequent group specification records.

1.3.4. Subsystem Switching Device Monitoring Records

All switching devices within a specified subsystem may be monitored by entering the data record:

```
[MONITOR] |BREAKERS| IN |AREA     i        | [IN KVRANGE r1 r2]
          |SWITCHES|    |AREAS    i j      |
          |SWDS    |    |ZONE     i        |
                        |ZONES    i j      |
                        |OWNER    i        |
                        |OWNERS   i j      |
                        |KV       r        |
                        |KVRANGE r1 r2     |
                        |SYSTEM      label|
                        |SUBSYSTEM   label|
                        |SUB         staid|
                        |SUBSTATION staid|
```

When using the SYSTEM or SUBSYSTEM keywords, the label must correspond to a subsystem label specified in a previously accessed Subsystem Definition data file (refer to Section 1.2, “Subsystem Definition Data File”).

When the keyword SWDS is used, all the system and substation switching devices will be included. Using the keyword BREAKERS will limit the selected switching devices to those designated as breakers. Using the keyword SWITCHES will limit the selected switching devices to those designated as switches.

1.3.5. Voltage Monitoring Records

Buses that are to be monitored for voltage violations by the AC Contingency Solution (refer to Section 6.12.1, "AC Contingency Solution Options") are specified in the Monitored Element data file. Two types of voltage violations may be detected.

The following data record defines a voltage band along with a set of buses where voltages are to be checked against the band.

```
[MONITOR] VOLTAGE RANGE |ALL BUSES                 | [|KV r         |] rlow [rhigh]
                        |ALL NODES                 |  |KVRANGE r1 r2|
                        |AREA    i                 |
                        |AREAS   i j               |
                        |ZONE    i                 |
                        |ZONES   i j               |
                        |OWNER   i                 |
                        |OWNERS  i j               |
                        |KV      r                 |
                        |KVRANGE r1 r2             |
                        |BUS     bsid              |
                        |BUSES   bsid1 bsid2       |
                        |SYSTEM    label           |
                        |SUBSYSTEM label           |
                        |SUB        staid NODE ndid|
                        |SUBSTATION staid NODE ndid|
```

This example monitors all 500kV bus voltages in areas 1 through 5 within 0.98 to 1.10 per unit, all lower voltage buses within 0.95 to 1.05 per unit and monitors bus number 1234 within 0.93 to 1.05 per unit.

Example:

```
monitor voltage range areas 1 5 .95 1.05
monitor voltage range areas 1 5 kvrange 500 9999 .98 1.10
monitor voltage range bus 1234 .93 1.05
```

```
[MONITOR] VOLTAGE RANGE NODES IN |AREA    i          | [|KV r         |] rlow [rhigh]
                                 |AREAS   i j        |  |KVRANGE r1 r2|
                                 |ZONE    i          |
                                 |ZONES   i j        |
                                 |OWNER   i          |
                                 |OWNERS  i j        |
                                 |KV      r          |
                                 |KVRANGE r1 r2      |
                                 |BUS     bsid       |
                                 |BUSES   bsid1 bsid2|
```

```
                                             |SYSTEM     label   |
                                             |SUBSYSTEM  label   |
                                             |SUB        staid   |
                                             |SUBSTATION staid   |
```

Where the first r value is the lower bound of the per unit voltage band and the optional second r value is the upper bound. If the upper bound is omitted, the upper end of the band is not checked.

The following data records define a set of buses to be monitored for voltage limit violations.

```
[MONITOR] VOLTAGE LIMIT |ALL BUSES                  |
                        |ALL NODES                  |
                        |AREA     i                 |
                        |AREAS    i j               |
                        |ZONE     i                 |
                        |ZONES    i j               |
                        |OWNER    i                 |
                        |OWNERS   i j               |
                        |KV       r                 |
                        |KVRANGE r1 r2              |
                        |BUS      bsid              |
                        |BUSES    bsid1 bsid2       |
                        |SYSTEM    label            |
                        |SUBSYSTEM label            |
                        |SUB          staid NODE ndid|
                        |SUBSTATION staid NODE ndid|
```

```
[MONITOR] VOLTAGE LIMIT NODES IN |AREA     i          |
                                 |AREAS    i j        |
                                 |ZONE     i          |
                                 |ZONES    i j        |
                                 |OWNER    i          |
                                 |OWNERS   i j        |
                                 |KV       r          |
                                 |KVRANGE r1 r2       |
                                 |BUS      bsid       |
                                 |BUSES    bsid1 bsid2|
                                 |SYSTEM     label    |
                                 |SUBSYSTEM  label    |
                                 |SUB        staid    |
                                 |SUBSTATION staid    |
```

When multiple voltage limit records are used in a monitored element data file, buses that have already been included in the set will be ignored. Bus data includes normal and emergency bus voltage limits. The designation of the voltage limit to be used is made at result post-processing stage.

The following data record defines voltage drop and voltage rise deviation thresholds along with a set of buses where voltage changes in contingency cases from their base case values are to be checked.

```
[MONITOR] VOLTAGE DEVIATION |ALL BUSES                  | [|KV r         |] rlow [rhigh]
                            |ALL NODES                  |  |KVRANGE r1 r2|
                            |AREA     i                 |
                            |AREAS    i j               |
                            |ZONE     i                 |
                            |ZONES    i j               |
                            |OWNER    i                 |
                            |OWNERS   i j               |
                            |KV       r                 |
                            |KVRANGE r1 r2              |
                            |BUS      bsid              |
                            |BUSES    bsid1 bsid2       |
                            |SYSTEM     label           |
                            |SUBSYSTEM label            |
                            |SUB         staid NODE ndid|
                            |SUBSTATION staid NODE ndid|

[MONITOR] VOLTAGE DEVIATION NODES IN |AREA     i           | [|KV r         |] rlow [rhigh]
                                     |AREAS    i j         |  |KVRANGE r1 r2|
                                     |ZONE     i           |
                                     |ZONES    i j         |
                                     |OWNER    i           |
                                     |OWNERS   i j         |
                                     |KV       r           |
                                     |KVRANGE r1 r2        |
                                     |BUS      bsid        |
                                     |BUSES    bsid1 bsid2|
                                     |SYSTEM     label     |
                                     |SUBSYSTEM label      |
                                     |SUB         staid    |
                                     |SUBSTATION staid     |
```

Where the first `r` value is the magnitude of voltage drop in per unit and the optional second `r` value is the magnitude of voltage rise. If the voltage rise threshold is omitted, the voltage rise check is omitted.

1.4. Contingency Definition Data File

Contingency cases are defined in a Contingency Definition data file. While activity OTDF allows only single event contingencies, the remaining activities provide for contingency cases consisting of up to 32 events.

The Contingency Defintion data file provides two means by which contingency cases may be specified. Individual contingency cases consisting of single or multiple events involving bus boundary condition and/or branch status changes may be specified in a contingency case block structure (refer to Contingency Case Block Structure In addition, the selection of a group of single or double line outage contingency cases may be specified with a single data record (refer to Automatic Contingency Specification). Default contingency categories are defined with the following structure:

```
CATEGORY category-string
VALUE category-string
VALUE category-string
.
END
```

If the contingency cases below a contingency category structure do not have categories specified then they are assigned to the contingency categories defined in the structure. Multiple category structures can be used in a contingency description file to change default categories.

1.4.1. Contingency Case Block Structure

In this method, a contingency case is defined in a block structure as follows:

```
CONTINGENCY label  | [r  r]  [CATEGORY category-string] |
                   | CATEGORY category-string  r  r     |
(contingency event specification record;  below)
.
.
(contingency event specification record;  below)
END
```

The 32-character contingency label is printed in output reports to identify each contingency. The first `r` value on the data record represents frequency in occurrence/year and the second `r` value on the data record represents duration in hours of the contingency. They are used for probabilistic reliability assessment. The category-string can be a single string or a quoted comma-delimited set of strings. Categories are used to select elements of report tables. A contingency can contain up to 32 contingency event specification records

The remainder of this section describes the contingency event specification records supported.

The outaging of an in-service non-transformer branch or two-winding transformer is specified with the following record, where the default circuit identifier is '1' if this specification is omitted:

```
|DISCONNECT| |BRANCH| FROM BUS bsid TO BUS bsid [|CIRCUIT| ckid]
|OPEN      | |LINE  |                            |CKT    |
|TRIP      |
```

Similarly, an out-of-service non-transformer branch or two-winding transformer may be placed in-service with a record of the form:

```
CLOSE   |BRANCH| FROM BUS bsid TO BUS bsid [|CIRCUIT| ckid]
        |LINE  |                           |CKT    |
```

When the multi-section line reporting option is enabled (refer to Section 3.3.3, “Program Run-Time Option Settings” and activity OPTN), multi-section line groupings may be specified with the above records. If a member of a multi-section line grouping is specified, switching the entire multi-section line (rather than the specified member) is treated as the contingency event.

When the multi-section line reporting option is disabled, multi-section line groupings may not be specified in the above records; members of multi-section line groupings may be designated on OPEN and CLOSE records, and only the specified member is switched.

The outaging of an in-service three-winding transformer is specified with the following record, where the default circuit identifier is '1' if this specification is omitted:

```
|DISCONNECT| |BRANCH| FROM BUS bsid TO BUS bsid TO BUS bsid [|CIRCUIT| ckid]
|OPEN      | |LINE  |                                        |CKT    |
|TRIP      |
```

Similarly, all windings of an out-of-service three-winding transformer may be placed in-service with a record of the form:

```
CLOSE   |BRANCH| FROM BUS bsid TO BUS bsid to BUS bsid [|CIRCUIT| ckid]
        |LINE  |                                       |CKT    |
```

The outaging of one winding of a three-winding transformer is specified with the following record, where the default circuit identifier is 1 if this specification is omitted:

```
|DISCONNECT|THREEWINDING AT BUS bsid TO BUS bsid TO BUS bsid [|CIRCUIT| ckid]
|OPEN      |                                                 |CKT    |
|TRIP      |
```

Similarly, one winding of a three-winding transformer may be placed in-service with a record of the form:

```
CLOSE THREEWINDING AT BUS bsid TO BUS bsid to BUS bsid [|CIRCUIT| ckid]
                                                        |CKT    |
```

The winding to be opened or closed is the winding connected to the first bus specified. Prior to opening one winding of a three-winding transformer, all three windings of the transformer must be in-service; prior to closing one winding of a three-winding transformer, the other two windings of the transformer must be in-service.

An out-of-service two-terminal dc line may be placed in-service with a record of the form:

```
CLOSE TWOTERMDC devid AT r |MW   |
                           |AMPS |
```

When keyword MW is used, the two terminal dc line must be in power control mode and `r` is the power demand to be designated. When keyword AMPS is used, the two terminal dc line must be in current control mode and `r` is the current demand to be designated.

An out-of-service VSC dc line may be placed in-service with a record of the form:

```
CLOSE VSCDC devid AT r MW
```

When keyword MW is used, the VSC dc line's power demand to be designated to `r`.

An in-service FACTS device or dc line may be blocked with a record of the form:

```
BLOCK |TWOTERMDC   | devid
      |MULTITERMDC|
      |VSCDC       |
      |FACTS       |
```

where the four tokens in the selection list allow access to two-terminal dc lines, multi-terminal dc lines, VSC dc lines, and FACTS devices, respectively.

The settings of an in-service two terminal dc line may be specified with a record of the form:

```
SET TWOTERMDC devid TO r |MW  |
                         |AMPS|
                         |KV  |
                         |OHMS|
```

When keyword MW is used, the two terminal dc line must be in power control mode and `r` is the power demand to be designated. When keyword AMPS is used, the two terminal dc line must be in current control mode and `r` is the current demand to be designated. The scheduled compounded dc voltage is changed to `r` when keyword KV is employed. The ohms of two terminal dc line is changed when OHMS is employed.

The settings of an in-service VSC dc line may be specified with a record of the form:

```
SET VSCDC devid TO r |MW  |
                     |KV  |
                     |OHMS|
```

When keyword MW is used, the VSC dc line power demand is set to `r`. The scheduled VSC dc voltage is changed to `r` when keyword KV is employed. The ohms of VSC dc line is changed when OHMS is employed.

The outaging of all in-service branches connected to a bus may be specified with a record of the form:

```
|DISCONNECT| BUS bsid
|OPEN      |
|TRIP      |
```

This command is converted to as many OPEN BRANCH commands as are required before it is passed to the Distribution Factor data file.

When the multi-section line reporting option is enabled (refer to Section 3.3.3, "Program Run-Time Option Settings" and activity OPTN), each in-service multi-section line connected to the specified bus is switched out as a unit. If the specified bus is a dummy bus of a multi-section line, this command is converted to a single OPEN BRANCH command that outages the corresponding multi-section line.

When the multi-section line reporting option is disabled, only the line section adjacent to the specified bus is outaged for each multi-section line connected to the bus.

The next four record types allow the user to specify contingency events in which the load and generation boundary conditions may be changed at a selected bus. Load and shunt are synonymous in the linearized network model and specifying either results in identical contingency events. When changing generation, the bus must have in-service generation connected to it and it may not be a swing bus.

The following data record is used to set the load or generation at a bus either to a designated value or to a specified percentage of its initial value:

```
SET BUS bsid |GENERATION| TO r |MW     | [DISPATCH]
             |LOAD      |      |PERCENT|
             |SHUNT     |
```

The number `r` specified must not be a negative number when the PERCENT keyword is used.

When LOAD is set either by PERCENT or MW, the power factor of load is constant (i.e., the reactive power is changed by the same ratio as the active power). When GENERATION or SHUNT is set either by PERCENT or MW, only active power is changed.

When the optional keyword DISPATCH is included at the end of the SET record, the user may designate how the change in the bus boundary condition is to be apportioned among selected network buses rather than having it all assigned to the system swing bus(es). In this case, the SET data record *must* be followed by records of the form:

```
BUS bsid r
.
.
BUS bsid r
END
```

The `r` values are positive participation factors that are normally expressed in percent or per unit of the total MW change specified by the contingency event specification record.

When SET commands operate on the bus fixed shunt, an additional keyword MVAR can be used to change reactive power component of a bus fixed shunt:

```
SET BUS bsid SHUNT  TO r MVAR
```

The real power component of bus fixed shunts remains constant. DISPATCH keyword is not allowed to be included in the above command.

The following data record is used to set an **individual** load either to a designated amount or by a specified percentage of its initial value:

```
SET LOAD ldid AT BUS bsid TO r |MW     |
                               |PERCENT|
```

When LOAD is set either by PERCENT or MW, the power factor of load is constant (i.e., the reactive power is changed by the same ratio as the active power).

The following data record is used to set an **individual** machine's Voltage Scheduled/Active Power/Reactive Power either to a designated amount or by a specified percentage of its initial value:

```
SET |MACHINE| mcid AT BUS bsid VSCHED   TO r PERUNIT
    |UNIT   |
SET |MACHINE| mcid AT BUS bsid ACTIVE   TO r |MW     |
    |UNIT   |                                |PERCENT|
SET |MACHINE| mcid AT BUS bsid REACTIVE TO r |MVAR   |
    |UNIT   |                                |PERCENT|
SET |MACHINE| mcid AT BUS bsid REACTIVE TO ACTIVE
    |UNIT   |
```

The following data record is used to set an **individual** shunt either to a designated amount or by a specified percentage of its initial value:

```
SET SHUNT shid AT BUS bsid TO r |MW     |
                                |MVAR   |
                                |PERCENT|
```

The following data record is used to set an **individual** switched shunt's Voltage Scheduled/VMAX/VMIN/Reactive Power either to a designated amount or by a specified percentage of its initial value:

```
SET SWSHUNT swid AT BUS bsid |VSCHED| TO r PERUNIT
                             |VMAX  |
                             |VMIN  |

SET SWSHUNT swid AT BUS bsid |REACTIVE| TO r |MVAR   |
                                             |PERCENT|
```

The following data record is used to change the load/generation/shunt at a bus either by a designated amount or by a specified percentage of its initial value:

```
|CHANGE| BUS bsid |GENERATION| BY r |MW     | [DISPATCH]
|ALTER |          |LOAD      |      |PERCENT|
|MODIFY|          |SHUNT     |
```

When LOAD is changed either by PERCENT or MW, the power factor of load is constant (i.e., the reactive power is changed by the same ratio as the active power). When GENERATION or SHUNT is changed either by PERCENT or MW, only active power is changed.

When the PERCENT keyword is specified, the magnitude of the initial value of the quantity to be modified is used to determine the amount of the change; i.e.,

$P_{new} = P_{orig} + r \times |P_{orig}| / 100$

When changing either by PERCENT or MW, when the quantity to be modified is initially positive and the change is a reduction (i.e., r is negative), a negative result is treated as an error condition.

The presence of the optional keyword DISPATCH is handled as described above for the SET data record.

The next two data record types are similar to the CHANGE record, except the direction of the change is defined by the first keyword, and r must be a positive number:

```
|INCREASE| BUS bsid |GENERATION| BY r |MW     | [DISPATCH]
|RAISE   |          |LOAD      |      |PERCENT|
                    |SHUNT     |
|DECREASE| BUS bsid |GENERATION| BY r |MW     | [DISPATCH]
|REDUCE  |          |LOAD      |      |PERCENT|
                    |SHUNT     |
```

The presence of the optional keyword DISPATCH is handled as described above for the SET datarecord.

When LOAD is changed either by PERCENT or MW, the power factor of load is constant (i.e., the reactive power is changed by the same ratio as the active power). When GENERATION or SHUNT is changed either by PERCENT or MW, only active power is changed.

Similarly, keyword MVAR can be used in CHANGE/INCREASE/DECREASE commands to change reactive power component of bus fixed shunts, e.g.:

```
|CHANGE  | BUS bsid SHUNT BY r MVAR
|ALTER   |
|MODIFY  |
|INCREASE|
|RAISE   |
|DECREASE|
|REDUCE  |
```

The following data record is used to change an **individual** load either by a designated amount or by a specified percentage of its initial value:

```
|CHANGE  | LOAD ldid AT BUS bsid BY r |MW     |
|ALTER   |                            |PERCENT|
|MODIFY  |
|INCREASE|
|RAISE   |
|DECREASE|
|REDUCE  |
```

When LOAD is changed either by PERCENT or MW, the power factor of load is constant (i.e., the reactive power is changed by the same ratio as the active power).

The following data record is used to change an **individual** machine's Voltage Schedule/Active Power/Reactive Power either by a designated amount or by a specified percentage of its initial value:

```
|CHANGE  | |MACHINE| mcid AT BUS bsid VSCHED BY r PERUNIT
|ALTER   | |UNIT   |
|MODIFY  |
|INCREASE|
|RAISE   |
|DECREASE|
|REDUCE  |

|CHANGE  | |MACHINE| mcid AT BUS bsid ACTIVE BY r |MW     |
|ALTER   | |UNIT   |                              |PERCENT|
|MODIFY  |
|INCREASE|
|RAISE   |
|DECREASE|
|REDUCE  |

|CHANGE  | |MACHINE| mcid AT BUS bsid REACTIVE BY r |MVAR   |
|ALTER   | |UNIT   |                                |PERCENT|
|MODIFY  |
|INCREASE|
|RAISE   |
|DECREASE|
|REDUCE  |
```

The following data record is used to change an **individual** shunt's power either by a designated amount or by a specified percentage of its initial value:

```
|CHANGE  | SHUNT shid AT BUS bsid BY r |MW     |
|ALTER   |                             |PERCENT|
|MODIFY  |                             |MVAR   |
|INCREASE|
|RAISE   |
|DECREASE|
|REDUCE  |
```

The following data record is used to change an **individual** switched shunt's Voltage Scheduled/VMAX/VMIN/ Reactive Power either by a designated amount or by a specified percentage of its initial value:

```
|CHANGE  | SWSHUNT swid AT BUS bsid |VSCHED| BY r PERUNIT
|ALTER   |                          |VMAX  |
|MODIFY  |                          |VMIN  |
|INCREASE|
|RAISE   |
|DECREASE|
|REDUCE  |
```

```
|CHANGE   | SWSHUNT swid AT BUS bsid |REACTIVE| BY r |MVAR   |
|ALTER    |                                          |PERCENT|
|MODIFY   |
|INCREASE|
|RAISE    |
|DECREASE|
|REDUCE   |
```

The following data record is used to change the two-terminal dc line either by a designated amount of power or by a specified percentage of its initial value:

```
|CHANGE   | TWOTERMDC devid BY r |MW     |
|ALTER    |                      |AMPS   |
|MODIFY   |                      |PERCENT|
|INCREASE|
|RAISE    |
|DECREASE|
|REDUCE   |
```

When keyword MW is used, the two-terminal dc line must be in power control mode and`r` is the power demand to be changed. When keyword AMPS is used, the two terminal dc line must be in current control mode and`r` is the current demand to be changed. When the PERCENTkeyword is specified, the power demand of two-terminal dc line is changed by`r` percent.

The following data record is used to change the VSC dc line either by a designated amount of power or by a specified percentage of its initial value:

```
|CHANGE   | VSCDC devid BY r |MW     |
|ALTER    |                  |PERCENT|
|MODIFY   |
|INCREASE|
|RAISE    |
|DECREASE|
|REDUCE   |
```

When keyword MW is used, the VSC dc line power demand is increased by`r`. When the PERCENT keyword is specified, the power demand of VSC dc line is changed by `r` percent.

The following data record is used to transfer load or generation from one bus to another:

```
MOVE r |MW     | |GENERATION| FROM BUS bsid TO BUS bsid
       |PERCENT| |LOAD      |
                 |SHUNT     |
```

When LOAD is moved either by PERCENT or MW, the power factor of load is constant (i.e., the reactive power is changed by the same ratio as the active power). When GENERATION or SHUNT is moved either by PERCENT or MW, only active power is changed.

When transferring MW, the power shift, P_{shift}, is set to `r`; when the PERCENT keyword is specified, the power shift is calculated as:

$P_{shift} = r \times P_{orig} / 100$

where P_{orig} is initial load or generation, as appropriate, at the from bus. The power shift is then subtracted from the original power at the from bus and added to the original power at the to bus. When the quantity to be modified at the from bus is initially positive, a negative post-shift power at the from bus is treated as an error condition.

When generation is being transferred, the from bus must have in-service generation. If the to bus is not a generator bus, an appropriate message is printed and the power shift is treated as negative load at the to bus. Either of the two buses may be a swing bus.

The following data record is used to transfer the active power and reactive power of load from one bus to another:

```
MOVE r |MW     | ACTIVE LOAD FROM BUS bsid TO BUS bsid
       |PERCENT|

MOVE r |MVAR   | REACTIVE LOAD FROM BUS bsid TO BUS bsid
       |PERCENT|
```

The keyword MVAR can be used to transfer the reactive power component of bus fixed shunts with the data record:

```
MOVE r MVAR SHUNT FROM BUS bsid TO BUS bsid
```

The following data record is used to transfer **individual** load from one bus to another:

```
MOVE LOAD ldid r |MW     | FROM BUS bsid TO BUS bsid
                 |PERCENT|
                 |MVAR   |
                 |MWPF   |
```

When the keyword MW is used, only the active power of the individual load is moved; when the keyword MVAR is used, only the reactive power of the individual load is moved; when the keyword PERCENT is used, both active power and reactive power of the individual load is moved by **r** percent; when the keyword MWPF is used, the active power of the individual load is moved by **r** MW, and the reactive power is changed by the same ratio as the active power.

The following data record is used to transfer **individual** machine from one bus to another:

```
MOVE |MACHINE| mcid r |MW     | FROM BUS bsid TO BUS bsid
     |UNIT   |        |PERCENT|
```

The following data record is used to transfer **individual** shunt from one bus to another:

```
MOVE SHUNT shid r |MW     | FROM BUS bsid TO BUS bsid
                  |PERCENT|
                  |MVAR   |
```

The following data record is used to transfer **individual** switched shunt from one bus to another:

```
MOVE SWSHUNT swid r |MVAR   | FROM BUS bsid TO BUS bsid
                    |PERCENT|
```

An in-service synchronous machine, induction machine, load or fixed bus shunt may be removed from service using the following data record:

```
REMOVE |MACHINE      mcid| FROM BUS bsid [DISPATCH]
       |UNIT         mcid|
       |INDUCMACHINE imid|
       |LOAD         ldid|
       |SHUNT        shid|
```

Similarly, an out-of-service synchronous machine, induction machine, load or fixed bus shunt may be placed in-service with a record of the form:

```
ADD |MACHINE      mcid| TO BUS bsid [DISPATCH]
    |UNIT         mcid|
    |INDUCMACHINE imid|
    |LOAD         ldid|
    |SHUNT        shid|
```

The presence of the optional keyword DISPATCH is handled as described above for the SET data record. The machine status contingency events are not permitted at swing buses.

An in-service switched shunt may be removed form service with the following data record:

```
REMOVE SWSHUNT swid FROM BUS bsid
```

Similarly, an out-of-service switched shunt may be placed in-service with a record of the form:

```
ADD SWSHUNT swid TO BUS bsid
```

1.4.2. Automatic Contingency Specification

Automatic Single and Double Line Outage Contingency Specification

When the keyword `BRANCH`, `LINE`, or `TIE` is used in automatic single and double line outage contingency specification commands, all branches except breakers and switches are included in the contingencies. When the keyword BREAKER is used, only breaker and switch branches are included in the contingencies.

The following data record provides for the designation of a series of single line outage contingency cases:

```
SINGLE |BRANCH | FROM BUS bsid
       |LINE   |
       |BREAKER|
```

Each in-service branch connected to the designated bus is outaged, one at a time. Similarly, a series of double line outage contingency cases may be specified with the data record:

```
DOUBLE |BRANCH | FROM BUS bsid
       |LINE   |
       |BREAKER|
```

All branches within a specified subsystem may be outaged, either singly or in pairs, by entering the data record:

```
|SINGLE    | |BRANCH | IN |AREA i          | [3WLOWVOLTAGE]
|DOUBLE    | |LINE   |    |ZONE i          |
|BUSDOUBLE| |BREAKER|    |OWNER i         |
|PARALLEL |               |KV r            |
                          |SYSTEM label    |
                          |SUBSYSTEM label|
```

Without the token '3WLOWVOLTAGE', for a three-winding transformer to be included, all of its in-service windings must be connected to subsystem buses. In using the token '3WLOWVOLTAGE', the three-winding transformer is included if its in-service high and median voltage windings are connected to subsystem buses.

The DOUBLE, BUSDOUBLE, and PARALLEL contingency specification records all generate contingency cases consisting of two simultaneous line outages. The DOUBLE record generates all combinations of double line outage contingencies for all branches where endpoint buses are contained in the specified subsystem. That is, each branch in the subsystem is outaged in turn with every other branch in the subsystem. DOUBLE may be viewed as considering independent events causing simultaneous outages.

The BUSDOUBLE record is more restrictive than the DOUBLE record. For each bus in the specified subsystem, it generates all combinations of double line outage contingencies for all branches between that bus and other subsystem buses. BUSDOUBLE may be viewed as considering single events in substations that affect pairs of branches connected to a substation.

The PARALLEL record is more restrictive than the BUSDOUBLE record. It generates double line outage contingencies only for parallel branches (i.e., for each contingency case, the two branches being outaged connect the same pair of subsystem buses). Three-winding transformer contingencies are not generated by the PARALLEL record. PARALLEL may be viewed as considering single events on rights-of-way that affect pairs of branches on a right-of-way.

In using the SYSTEM or SUBSYSTEM keywords, the label must correspond to a subsystem label specified in a previously accessed Subsystem Definition data file (refer to Section 1.2, "Subsystem Definition Data File").

Branches that are assigned to a line owner can be outaged, either singly or in pairs by using the following data record:

```
|SINGLE    | |BRANCH| WITH LINE OWNER i
|DOUBLE    | |LINE  |
|BUSDOUBLE|
|PARALLEL |
```

All in-service buses within a specified subsystem may be singly disconnected with the data record:

```
SINGLE BUS IN |AREA i         |
              |ZONE i         |
              |OWNER i        |
              |KV r           |
              |SYSTEM label   |
              |SUBSYSTEM label|
```

Each single bus outage is converted to as many OPEN BRANCH commands as are required to open all in-service branches connected to the bus before it is passed to Distribution Factor Data File.

In-service machines connected to in-service generator buses within a specified subsystem may be removed from service singly with the data record:

```
 SINGLE |MACHINE| IN |AREA i         |
        |UNIT   |    |ZONE i         |
                     |OWNER i        |
                     |KV r           |
                     |SYSTEM label   |
                     |SUBSYSTEM label|
```

Only one machine can be outaged for each generator bus. When a generator bus has multiple in-service machines, the machine with the biggest real power generation is chosen to be outaged.

Finally, the following data record provides for the outaging, either singly or in pairs, of all ties from a specified subsystem or all ties between a pair of subsystems:

```
|SINGLE    | TIE FROM  |AREA i         | TO |AREA i         |
|DOUBLE    |           |ZONE i         |    |ZONE i         |
|BUSDOUBLE|            |OWNER i        |    |OWNER i        |
|PARALLEL |            |KV r           |    |KV r           |
                       |SYSTEM label   |    |SYSTEM label   |
                       |SUBSYSTEM label|    |SUBSYTEM label|
```

The selection of tie branches in the case of overlapping subsystems is handled using the same criteria defined in Monitored Element Data File for the monitoring of ties.

For these record types, when the multi-section line reporting option is enabled, the outaging of a multi-section line grouping within the specified subset is treated as a contingency event; the entire multi-section line is outaged. When the multi-section line reporting option is disabled, individual members of multi-section line groupings within the specified subset (rather than entire multi-section line groupings) are outaged.

The SKIP block structure is used to specify individual branches that are to be excluded from outaging in contingencies generated as a result of subsequent SINGLE, DOUBLE, BUSDOUBLE, and PARALLEL contingency specification records. Each SKIP block structure is specified as follows:

```
SKIP |LINE  |
     |BRANCH|
(branch specification record;  below)
.
```

```
.
(branch specification record;  below)
END
```

Non-transformer branches and two-winding transformers are specified on branch specification records using the following record format:

```
bsid TO bsid [|CIRCUIT| ckid]
              |CKT    |
```

Three-winding transformers are specified on branch specification records using the following record format:

```
bsid TO bsid TO bsid [|CIRCUIT| ckid]
                      |CKT    |
```

The default circuit identifier is '1' if this specification is omitted,

Branches specified in a SKIP block structure apply only to SINGLE, DOUBLE, BUSDOUBLE, and PARALLEL contingency specification records which are below it in the Contingency Definition data file. Multiple SKIP block structures are allowed, and each SKIP block structure appends to the list of branches to be omitted from outaging as a result of subsequent automatic contingency specification records.

When the multi-section line reporting option is enabled and a branch that is a member of a multi-section line is specified, the multi-section line is excluded from outaging. When the multi-section line reporting option is disabled and a multi-section line is specified, an error message is printed and the record is ignored.

1.4.3. Node-Breaker Contingency Specification

The following commands can be processed only when the PSS®E network case contains node breaker data, otherwise they are ignored by the applications where they are simulated.

The following command will isolate an in-service branch, system switching device or two- winding transformer by breaker operations.

```
ISOLATE |BRANCH| FROM BUS bsid TO BUS bsid [|CIRCUIT| ckid]
        |LINE  |                            |CKT    |
```

The processing of this and other isolate contingencies consists of:

- Using the full topology network model to systematically follow the circuits outward from the line to be isolated, and identify and open breakers in order to clear the fault on the circuit. The operation may result in one or multiple circuits (i.e. branches, transformers, etc.) being opened en route to the opening of a breaker. Once a breaker is successfully opened, the search along that path terminates. If the process extends along paths beyond a user specified number of bus levels outward (OPTN) and the line has not been successfully isolated, then the process will terminate with a message.
- The breakers include those defined as both system switching devices and substation switching devices. The operations may result in one or more breakers being opened.
- If a stuck breaker status is encountered, the process will continue without opening the breaker and a message will be displayed. Refer to the Stuck Breaker command below.

- With the successful isolation of the line the following process are completed in order:
- The topology processor will automatically be run to update the bus branch model based the status of switching devices.
- Once the topology processing is complete, the power flow solution will be run to solve the new contingency state.

The following command will isolate an in-service three-winding transformer by breaker operations:

```
ISOLATE |BRANCH| FROM BUS bsid TO BUS bsid TO BUS bsid [|CIRCUIT| ckid]
        |LINE  |                                        |CKT    |
```

The following command will isolate one winding of a three-winding transformer by breaker operations:

```
ISOLATE THREEWINDING AT BUS bsid TO BUS bsid TO BUS bsid [|CIRCUIT| ckid]
                                                          |CKT    |
```

Isolation of all in-service branches connected to a bus may be specified with a record of the form:

```
ISOLATE BUS bsid
```

The following commands will isolate in-service bus-connected equipment by breaker operations:

```
ISOLATE |MACHINE      mcid| AT BUS bsid
        |UNIT         mcid|
        |LOAD         ldid|
        |SHUNT        shid|
        |SWSHUNT      swid|
        |INDUCMACHINE imid|
```

The following commands will isolate in-service dc lines or a FACTS device by breaker operations:

```
ISOLATE |TWOTERMDC  | devid
        |MULTITERMDC|
        |VSCDC      |
        |FACTS      |
```

The following command opens an in-service switching device (SWD) in a substation:

```
|DISCONNECT| |SWD    | |SUBSTATION| staid FROM NODE ndid TO NODE ndid [|CIRCUIT| ckid]
|OPEN      | |SWITCH | |SUB       |                                    |CKT    |
|TRIP      | |BREAKER|
```

The following command closes an out-of-service switching device in a substation:

```
CLOSE |SWD    | |SUBSTATION| staid FROM NODE ndid TO NODE ndid [|CIRCUIT| ckid]
```

```
    |SWITCH | |SUB       |                                    |CKT     |
    |BREAKER|
```

The following command isolates an in-service switching device in a substation by breaker operations.

```
ISOLATE |SWD    | |SUBSTATION| staid FROM NODE ndid TO NODE ndid
        |SWITCH | |SUB       |
        |BREAKER|
```

The following command will isolate a single end of an in-service branch, system switching device or two-winding transformer by breaker operations:

```
|DISCONNECT| TERMINAL FROM BUS bsid TO BUS bsid [|CIRCUIT| ckid]
|OPEN      |                                     |CKT    |
```

The following command will isolate a single terminal of an in-service three-winding transformer by breaker operations:

```
|DISCONNECT| TERMINAL FROM BUS bsid TO BUS bsid TO BUS bsid [|CIRCUIT| ckid]
|OPEN      |                                                 |CKT    |
```

The following command will isolate a single node of a substation by breaker operations:

```
ISOLATE |SUBSTATION| staid NODE ndid
        |SUB       |
```

The following command will place a closed breaker in the status of “stuck”. It will fail to open in subsequent isolation operations in that contingency:

```
STUCK BREAKER |SUBSTATION| staid FROM NODE ndid TO NODE ndid [|CIRCUIT| ckid]
              |SUB       |                                    |CKT    |
```

Automatic Contingency Specification

The following record will create contingencies for every in-service branch or transformer connected to a bus:

```
|SINGLE| |OPEN TERMINAL | FROM BUS bsid
|DOUBLE| |ISOLATE LINE  |
         |ISOLATE BRANCH|
```

The following records will create contingencies for every in-service branch or transformer in a subsystem:

```
|SINGLE   | |ISOLATE LINE  | IN |AREA i          | [3WLOWVOLTAGE]
|DOUBLE   | |ISOLATE BRANCH|    |ZONE i          |
|BUSDOUBLE|                     |OWNER i         |
|PARALLEL |                     |KV r            |
```

```
                                        |SYSTEM label   |
                                        |SUBSYSTEM label|
```

```
|SINGLE| OPEN TERMINAL IN |AREA i         |
|DOUBLE|                  |ZONE i         |
                          |OWNER i        |
                          |KV r           |
                          |SYSTEM label   |
                          |SUBSYSTEM label|
```

The following record will create contingencies for every in-service substation switching device (which can be limited to switches or breakers) in a subsystem:

```
SINGLE |OPEN   | |SWD    | IN |AREA i         |
       |CLOSE  | |SWITCH |    |ZONE i         |
       |ISOLATE| |BREAKER|    |OWNER i        |
                              |KV r           |
                              |SYSTEM label   |
                              |SUBSYSTEM label|
```

The following record will create contingencies for every in-service bus in a subsystem:

```
SINGLE ISOLATE BUS IN |AREA i         |
                      |ZONE i         |
                      |OWNER i        |
                      |KV r           |
                      |SYSTEM label   |
                      |SUBSYSTEM label|
```

The following record will create stuck breaker contingencies for a subsystem. For each substation in the subsystem, for each node in that substation, all combinations of in-service branches or transformers and closed breakers connected to that node will be found. Each combination will generate a contingency consisting of a stuck breaker record for that breaker and an isolate record for that branch or transformer.

```
SINGLE STUCK BREAKER IN |AREA i         |
                        |ZONE i         |
                        |OWNER i        |
                        |KV r           |
                        |SYSTEM label   |
                        |SUBSYSTEM label|
```

The SKIP block structure is used to specify individual substation switching device that are to be excluded from outaging in contingencies generated as a result of subsequent SINGLE, DOUBLE, BUSDOUBLE, and PARALLEL contingency specification records. Each SKIP block structure is specified as follows:

```
SKIP SWD
(substation switching device specification record;  below)
```

```
.
.
(substation switching device specification record;  below)
END
```

Substation switching devices are specified on branch specification records using the following record format:

```
staid FROM ndid TO ndid [|CIRCUIT| ckid]
                         |CKT    |
```

The default circuit identifier is ’1’ if this specification is omitted,

Substation switching devices (SWDs) specified in a SKIP block structure apply only to SINGLE, DOUBLE, BUS-DOUBLE, and PARALLEL contingency specification records which are below it in the Contingency Definition data file. Multiple SKIP block structures are allowed, and each SKIP block structure appends to the list of SWDs to be omitted from outaging as a result of subsequent automatic contingency specification records.

Chapter 2

Advanced Linear Analysis/MUST SUB/MON/CON File Extensions and Options

2.1. Description of Input Data

An effort has been made to harmonize the SUB, MON, and CON files between PSS®E and the Advanced Linear Analysis/MUST module. To this end, items in these files that share the exact same syntax will only be found in the previous chapter. This chapter will only contain the the elements that are *different* in their syntax.

The approach to harmonizing these files has taken three approaches:

1. Make sure that the SUB/MON/CON files for *either* module does not cause an issue when run in the *other* module i.e. PSS®E files run in Advanced Linear Analysis/MUST and vice versa

   If there are unsupported elements or syntax contained in the files when run in the opposing system thengenerate an error message, ignorethe record, and continue execution.

2. *Extend* the supported syntax in *both* modules to close gaps

3. Extend, where practical, recognized elements to further close gaps. The caveat to this is approach is we will *not* make both modules equal in their functionality. The Advanced Linear Analysis/MUST module will support certain logical network elements that are key to its analysis. PSS®E will not support these element where it is not key to its analysis. An example of this would be flowgates. These are key to the Advanced Linear Analysis/MUST module calculations but play no part in PSS®E core calculations.

2.1.1. Input Data Types

Several types of input data files are required to run Advanced Linear Analysis/MUST

- A solved load flow case.
- Subsystems data file, which defines potential sources and sinks for transactions and subsystems that may be used later for defining monitored elements and contingencies.
- Monitored element data file, which specifies monitored branches, interfaces and flowgates.
- Contingency data file, which defines user-specified contingencies.
- Optional exclude data file, which allows custom adjustments to the monitored element data file, excluding specific pairs of monitored elements and contingencies, changing branch ratings, or interface limits.

2.1.2. Conventions and Special Data Records

In describing the input file syntax, the following notational conventions are used. Keywords and data values must be separated by one or more blanks. As noted above, this table lists only those items are in addition to those described in Section 1.1.1 or differ in some way.

label	A 12- or 14-character (depending on the contents) label identifier. If a label contains blanks or special characters, it must be enclosed in single quotes. This differs from the PSS®E label description.
contingency names	The maximum contingency name length is 50 characters

	Contingency labels must be unique and can have a maximum width of 42 characters. This differs from PSS®E where the contingency name field is not identified specifically but is a *label* field.
flowgate_id	flowgate_id is an integer number in the range from 1 to 99999.
flowgate_label	flowgate_label is the flowgate text descriptor with a maximum width of 45 characters.
Contingencies	The number of elementary events (excluding dispatch events) for a contingency is 100.

2.1.3. INCLUDE Record

The INCLUDE record allows the user to split large input files into several smaller ones, which are then processed via the INCLUDE statement. The INCLUDE statement has the following format:

```
INCLUDE filename
```

Every INCLUDE statement should start from a new line. Included files may also contain another INCLUDE record. The user is limited to 10 levels of nesting of INCLUDE statements.

Data files included via the INCLUDE statement can reside in different directories. The directory of the main file (the file specified by the user for the MUST request) is considered the current directory. All paths provided in the INCLUDE statement should be relative to this current directory or should provide an absolute path. If, for example, c:\MUST\userdata\main contains the main subsystem file specified for the MUST requests, the following two examples will be equivalent:

```
INCLUDE ..\pjmdata\pseg.sub
INCLUDE c:\must\userdata\pjmdata\pseg.sub
```

The INCLUDE statement simplifies data maintenance of large files especially if different parts of the data come from different sources. The example below demonstrates how a large number of subsystem files can be maintained by using a master subsystem file. As shown in the example below, the master subsystem file contains several automatic subsystem specification records and INCLUDE statements for every control area of interest.

Example:

```
ADD ALL AREAS FOR EXPORT SUFFIX _EXA WITH PMAX GREATER 50 MW
ADD ALL AREAS SCALE GENERATION SUFFIX _SCG WITH PMAX GREATER 50 MW
ADD ALL AREAS SCALE LOAD SUFFIX _LD
ADD ALL AREAS FOR IMPORT SUFFIX _IMA WITH PMAX GREATER 50 MW
/
INCLUDE aep.sub
INCLUDE ap.sub
INCLUDE cin.sub
INCLUDE cple.sub
```

```
.
.
INCLUDE southern.sub
INCLUDE tva.sub
INCLUDE vp.sub
/
```

The first four records result in creating up to four subsystems for every existing area in the load flow case. Each of the included files should contain subsystem definitions specific to the corresponding control area. The same multilevel approach can be used for maintaining large monitored element data files, including large flowgate files and large contingency files because it distributes the data maintenance support functions.

2.2. Subsystem Definition Data File

2.2.1. General Description and Advanced Linear Analysis/MUST Subsystem Extensions

Subsystems of the working case are defined via the subsystem data file. Currently, the notion of a subsystem is used in two senses

1. Sources and sinks (or purchasing and selling entities) by defining the set of buses involved in the transactions

2. Control areas defined as any groups of buses. Several Advanced Linear Analysis/MUST activities allow evaluations of transaction impacts on defined subsystems. Also, defined subsystems can be used later to specify monitored elements and contingencies.

Separating these two notions can increase flexibility of modeling and accounting for transactions.

Advanced Linear Analysis/MUST allows automatic definition of many subsystems on an area and zone basis. A key feature of Advanced Linear Analysis/MUST is the independence of the subsystem definition and the current load flow case data. The same subsystem definitions can be used simultaneously for different load flow cases. For example, a single ADD ALL record defines one subsystem for each area existing in the current load flow case, and automatically selects generator participation factors such that all generators would reach their upper/lower limit simultaneously. This is a convenient shortcut for defining external systems and fast screening studies.

Advanced Linear Analysis/MUST allows definition of participation factors on the fly according to current generation, generation minimum and maximum, and generator current status from the load flow. This makes subsystem definitions less dependent on the current load flow case generation dispatch. Advanced Linear Analysis/MUST provides automatic selection of only large generators with maximum or current generation above a user-specified threshold. This provides, for example, a convenient approach for selecting all essential generators on the area-wide basis for generator sensitivity analysis.

Advanced Linear Analysis/MUST allows load scaling by areas, zones, or subsystems. When scaling load, Advanced Linear Analysis/MUST adjusts all selected load buses in the subsystems in proportion to the bus loads.

2.2.2. Defining Buses within a Subsystem

Advanced Linear Analysis/MUST allows many ways to define the buses of a subsystem, using the bus ids, areas, zones, kV, owner or join blocks. It also allows several ways to show how buses participate and which ones do participate using the PARTICIPATE command or some form of scaling (Section 3.2.6). However, in all cases, buses making up the subsystem must be defined somehow. Just scaling is not enough.

This applies to all scaling methods (FOR EXPORT, FOR IMPORT, GENERATION and LOAD) methods. The PARTICIPATE command is an exception; buses defined by PARTICIPATE will also be included in the subsystem.

Bus Names can be of the format 'nnnnnnnnvvvv' (old format) or 'nnnnnnnnnnnnvvvv' (new format); where nnnnnnnn or nnnnnnnnnnnn is the name portion and vvvv the voltage portion of the bus name. Bus names have to be specified via a name and voltage level as shown below:

```
BUS '01PLEAS126.0' 140.000 /old format name with participation factor
BUS '02SAMMIS 345' 11.000 /old format name with participation factor
```

```
BUS 'ALPHABETA 345' /new format name
BUS 'GAMMAALPHAXX 169' /new format name
```

Below is an incorrect definition, and correct definitions for a subsystem. Generation scaling is used in the example, but all scaling methods except for PARTICIPATE have the same requirement.

Example:

Incorrect Subsystem Definition (no buses defined)

```
SUBSYSTEM "MY GENERATORS"
    SCALE GENERATION
      BUS 11111
      BUS 22222
      BUS 33333
    END
END
```

Example:

Correct Subsystem Definition (Subsystem consists of buses 11111,22222, and 33333)

```
SUBSYSTEM "MY GENERATORS"
    BUS 11111
    BUS 22222
    BUS 33333
    SCALE ALL GENERATION
END
```

Example:

Correct Subsystem Definition

```
SUBSYSTEM "MY GENERATORS"
    BUS 11111
    BUS 22222
    BUS 33333
    SCALE GENERATION
        BUS 11111
        BUS 22222
        BUS 33333
    END
END
```

Example:

Correct Subsystem Definition (same as above but more wordy)

```
SUBSYSTEM "MY GENERATORS"
    any good definition of a subsystem
    SCALE GENERATION
        BUS 11111
        BUS 22222
```

```
        BUS 33333
    END
END
```

To specify participation buses via the PARTICIPATE command, Advanced Linear Analysis/MUST users do not have to specify buses within the subsystem definition. If Advanced Linear Analysis/MUST finds a bus defined within a participate record but not defined in the subsystem above, it will add such bus to the subsystem automatically.

The portion of the working case buses to be contained in each subsystem definition is specified in the following block structure:

```
SUBSYSTEM|SYSTEM [label]
(subsystem specification data record)
.
.
(subsystem specification data record)
END
```

where the subsystem specification data records allowed are as described below. Subsystem/system label width in Advanced Linear Analysis/MUST can be up to 20 characters. If no label is specified on a SUBSYSTEM record, the label "UNNAMED N" is assigned to the subsystem, where "N" is a unique integer.

Selected buses may be designated as part of a subsystem with data records of the following form:

```
BUS bsid
BUSES bsid bsid
```

Example:

```
BUS 200
BUSES 300 400
```

BUS and BUSES records are valid only when using bus input by bus numbers. The BUSES record assigns the designated buses, as well as all buses whose bus numbers fall between the two bus numbers specified, to the subsystem being defined.

All buses in selected areas may be assigned to a subsystem with data records in the following format:

```
AREA i
AREAS i j
```

where "i" and "j" are area numbers. The AREAS record type assigns all buses in a range of area numbers to the subsystem being defined.

Example:

```
AREAS 5 7
```

In the example above, the data record "AREAS 5 7" may be used to assign all buses in areas five, six, and seven to the subsystem.

Similarly, all buses in selected zones may be assigned to a subsystem with data records of the following form:

```
ZONE i
ZONES i j
```

where "i" and "j" are zone numbers.

Buses at designated voltage levels may be assigned to a subsystem with records of the following form, where, the KVRANGE record defines a range of voltage levels:

```
KV r
KVRANGE r1 r2
```

Example:

```
KVRANGE 100 500
```

In specifying ranges of bus numbers, areas, zones, and voltage levels, the second specified value should be a positive number greater than the first one.

Example:

```
AREAS 7 3 -wrong
KVRANGE 135 -500 -wrong
```

All buses with selected owners may be assigned to a subsystem with data records in the following format:

Example:

```
OWNER i
OWNERS i j
```

where "i" and "j" are owner numbers. The OWNERS record type assigns all buses in a range of owner numbers to the subsystem being defined.

Example:

```
OWNERS 2 4
```

In the example above, the data record "OWNERS 2 4" may be used to assign all buses with owners two, three, and four to the subsystem.

In addition, a JOIN specification block structure provides for the specification of a group of buses through the logical "anding" of two or more of the four selection criteria described above. A JOIN specification has the following block structure:

```
JOIN [label]
(subsystem specification data record)
.
.
(subsystem specification data record)
END
```

where each subsystem specification data record is one of the simple record types (BUS, AREA, ZONE, KV, or the corresponding "range of" records) described above. The optional JOIN specification label is for the user's convenience and is not used by Advanced Linear Analysis/MUST functions.

Each JOIN specification block structure must appear within the subsystem block structure described above. Both JOIN specification block structures and the simple record types may be included within a subsystem block structure.

Example:

```
SUBSYSTEM 'MY COMPANY'
    AREA 5
    JOIN 'GROUP 1'
        AREA 6
        ZONES 8 10
    END
END
```

The above example defines the subsystem "MY COMPANY", that consists of all buses in area 5, along with all buses in area 6, which are in zones 8 through 10.

2.2.3. Subsystem Adjustments Methods

There are several methods for adjusting power injection in sending and receiving systems. These methods can be categorized into several groups:

- Adjustments according to user-specified participation factors using the PARTICIPATE record.
- Adjusting generation in proportion to available generator reserves in a load flow case. This is defined as the difference between maximum and current generation (Pmax - Pcur). Several selected generators are adjusted in such a way that all selected generators would reach their maximum simultaneously. This type of adjustment can be defined using the EXPORT specification.
- Adjusting generation based on the current and minimum generation in a load flow case. For this method, generators will be adjusted so that all generators would reach their minimum at the same time (but stay on line if Pmin is greater than zero). This type of adjustment can be defined using the IMPORT specification. Reaching zero generation will not change the generator status to OFF.
- The SCALE GENERATION specification defines generator participation factors in proportion to the current generation. Generators will be adjusted in a way that, for example, all selected generators would reach zero generation level simultaneously.
- The SCALE LOAD specification defines bus participation factors in proportion to the current bus load relative to the total load in the system.

Participation factors used for adjustments can be either explicitly specified by a user or selected automatically according to the adjustment methods described above.

Report	Notation
PartFactSpec	Participating generators and factors are user specified
PartFactSpecOff	Participating generators and factors are user specified, subsystem transfer limit checking will consider offline generators.
PartFactDef	Default PARTICIPATE type in case the PARTICIPATE record was omitted in the subsystem specification and participation factors were selected in MBASE on the basis of machine availability

Report	Notation
ExportSpec	Participating generators are user specified, but participation factors are selected automatically according to export specification
ExportSpecOff	Participating generators are user specified, but participation factors are selected automatically according to export specification (off-line generators included)
ExportDef	All available subsystem generators were selected to participate automatically with export type participation factors
ExportDefOff	All available subsystem generators were selected to participate automatically with export type participation factors (off-line generators included)
ImportSpec	Participating generators are user specified with import type participation factors
ImportDef	All available subsystem generators were selected to participate automatically with import type participation factors
ScaleGenSpec	Participating generators are user specified with participation factors proportional to generation in a load flow case.
ScaleGenDef	All available subsystem generators were selected with participation factors proportional to generation in a load flow case
ScaleLoadSpec	Participation buses are user specified with adjustments proportional to load level in a load flow case
ScaleLoadDef	All load buses will be scaled in the subsystem
SingleBus	Systems added by the BUS method.
SingleGen	Systems added by the GENERATOR method.
SingleGenOff	Systems added by the GENERATOR method (off-line generators included)

Advanced Linear Analysis/MUST transfer limit analysis calculation functions do not enforce generator limits. A user can use the detailed subsystem report to identify the maximum shifts possible before violating generation limits.

2.2.4. Automatic Specifications Using the ADD Command

The ADD ALL command allows the addition of multiple subsystems based on the user-specified criteria using areas and zones definitions. One record allows the addition of all subsystems with generation or load being adjusted according to the record type. The ADD ALL command provides a convenient means for approximate definition of external systems for screening studies. For MMWG load flow cases, one ADD ALL areas command adds 60 to 100 subsystems allowing transactions from or to any automatically created subsystem.

There are four different types of ADD ALL commands which define different ways of adjusting/scaling specified subsystems:

```
ADD ALL |AREAS| |FOR EXPORT      | [SUFFIX label] [WITH_GROUP] [INCLUDE OFFLINE]
        |ZONES| |FOR IMPORT      |
                |SCALE GENERATION|
```

and

```
ADD ALL |AREAS| SCALE LOAD [SUFFIX label]
        |ZONES|
```

ADD ALL records add one subsystem for each valid area or zone existing in the current load flow case. For adjusting generation, Advanced Linear Analysis/MUST creates subsystems for every area or zone that has generation that can be adjusted without violating the corresponding limit. For example, an area with all generators at maximum will not be considered as a valid EXPORT subsystem. Specifications FOR EXPORT and FOR IMPORT result in creating subsystems with the maximum export/import capability before violating generator limits.

For automatically specified contingencies, Advanced Linear Analysis/MUST uses area/zone to build a subsystem name. An optional SUFFIX specification provides a simple solution for resolving possible name collision problems. The specified suffix is added to subsystems area/zone names. If the SUFFIX specification is omitted, the program will use the default suffixes EXA, EXZ, IMA, IMZ, SGA, SGZ, LDA, LDZ, which correspond to EXPORT, IMPORT, SCALE GENERATION, and SCALE LOAD records by areas and zones. The user-defined suffix can have up to six characters.

An optional WITH_GROUP specification allows the user to apply additional criteria to automatic generator selection by selecting only generators with the current or maximum generation above a user-specified threshold. The WITH GROUP record has the following format:

```
WITH |PMAX| GREATER r [MW]
     |PGEN|
```

The extension INCLUDE OFFLINE allows the user to include off-line units in automatically defined subsystems; INCLUDE OFFLINE is most useful within FOR EXPORT specifications. The INCLUDE OFFLINE specification changes Advanced Linear Analysis/MUST logic for automatic participation factors definition. Advanced Linear Analysis/MUST internally computes the maximum plant output for all units, including off-line units, if FOR EXPORT was used. By default, Advanced Linear Analysis/MUST uses maximum plant output arrays, which exclude off-line units.

The INCLUDE OFFLINE keywords belong after WITH_GROUP, if any, as shown in the ADD ALL definition above.

Example:

```
ADD ALL AREAS FOR EXPORT SUFFIX _EXA50 WITH PMAX GREATER 50 MW
```

As illustrated above, ADD ALL automatically selects all areas with available generation reserve for export type scaling. Using this method, all generators reach their maximum level simultaneously. All export type subsystem names have the suffix _EXA50. Only generators with available reserve and maximum generation greater than 50 MW will be included. Areas without available export will not be added.

Example:

```
ADD ALL AREAS SCALE GENERATION SUFFIX _SCG
```

This command automatically selects all areas with nonzero generation for scaling in proportion to current case generation.

Example:

```
ADD ALL ZONES SCALE LOAD SUFFIX _LD
```

This command selects all zones existing in the load flows as subsystems for scaling load in proportion to the current bus loads.

Example:

```
ADD ALL AREAS FOR IMPORT SUFFIX _IMA WITH PGEN GREATER 50 MW
```

```
ADD ALL ZONES FOR EXPORT SUFFIX _50E WITH PMAX GREATER 50 MW
```

The above examples show how to select all areas/zones for import/export. Only generators with the current/maximum generation above 50 MW will be selected for adjustments.

Example:

```
ADD AREAS 40 45 FOR EXPORT INCLUDE OFFLINE
ADD ALL ZONES FOR EXPORT SUFFIX _EXAOF INCLUDE OFFLINE
```

The above examples demonstrate how to include off-line generators in subsystem definitions. Participating factors for off-line generators will be proportional to maximum generation at each generator.

Automatically selected participation factors can be reported using the detailed report for the subsystem of interest.

ADD records allows the addition of several specified areas or zones using scaling methods similar to the ADD ALL command based on the grammar rules shown below:

```
ADD |AREA  i  | |FOR EXPORT      | [SUFFIX label][WITH_GROUP][INCLUDE OFFLINE]
    |AREAS i j| |FOR IMPORT      |
    |ZONE  i  | |SCALE GENERATION|
    |ZONES i j|
```

The SCALE LOAD record has a very similar format but does not use WITH_GROUP and INCLUDE OFFLINE specification:

```
ADD |AREA  i  | SCALE LOAD [SUFFIX label]
    |AREAS i j|
    |ZONE  i  |
    |ZONES i j|
```

Several restrictions are applied:

- Subsystems defined using the SCALE GENERATION record should have at least one generator bus among selected buses with positive generation
- In the case of EXPORT and IMPORT records, only generators with available required reserves are accepted. The area or zone is valid only if at least one generator has available reserve (correspondingly FOR EXPORT or FOR IMPORT) depending on the type of ADD ALL record.
- Any area or zone with at least one bus with positive load will be accepted as a valid subsystem for load scaling. Buses with negative load are not selected for load scaling.
- Automatically defined participation factors are calculated on the fly internally within Advanced Linear Analysis/MUST. These factors can be reported using a detailed subsystem report, but cannot be edited by the user.

2.2.5. Defining Buses Using the PARTICIPATE Command

These paragraphs describe the method to define participating buses via the PARTICIPATE command. The participation block structure allows the user to specify those buses that are to participate in the generation shift along with their participation factors, which determine how the change in subsystem generation is to be shared among the designated buses.

The form of the participation block structure is:

```
PARTICIPATE [INCLUDE OFFLINE]
    BUS bsid r
    .
    .
    BUS bsid r
END
```

Each participation block structure must appear within the subsystem block structure described above, and must follow the simple record types and/or JOIN specification block structures defining the subsystem. Each bus specified must reside in the subsystem being processed. Any bus that violates this requirement or is disconnected (i.e., its type code is four or greater) is alarmed, and ignored.

The "r" values are participation factors that are normally expressed in percent or per unit of the total subsystem generation shift. The sum of the "r" values within a participate block structure must be positive.

Example:

```
PARTICIPATE
    BUS 100 100 /* PGEN = 100 PMAX = 200
    BUS 110 300 /* PGEN = 300 PMAX = 400
END
```

In the example above, the sum of the "r" values is 400, i.e,. total participation =400. BUS 100 participates at 25% (100/400), while BUS 110 participates at 75% (300/400).

For generation sensitivity analysis within Advanced Linear Analysis/MUST it is convenient to assign zero participation factors for a generator that should be considered for worst dispatch scenarios, but not for study transfers.

The optional [INCLUDE OFFLINE] specification has no impact on the defined participating factors, but will be used for checking subsystem export capability. The maximum capability of all generators including offline will be used for maximum generation output.

2.2.6. Automatic Participation Factors Definition within the SUBSYSTEM Group

The SCALE record specification within the SUBSYSTEM group provides an alternative to the PARTICIPATE record method for defining participation buses. Only one PARTICIPATE or SCALE record can be defined for each subsystem definition. The SCALE record does not require the user to specify hard-coded participation factors, which represent the main advantage compared to the PARTICIPATE record. Participation factors are computed automatically. SCALE records are only recognized by Advanced Linear Analysis/MUST.

The use of SCALE still requires that the user define the buses in the subsystem. Unlike PARTICIPATE, SCALE does not do this for the user.

The SCALE record allows specification of either all generators (load buses) within a specified subsystem using SCALE ALL specification or by specifying the user-defined list of participating buses.

The SCALE ALL specification has the following format:

```
SCALE ALL |FOR EXPORT [WITH_GROUP] [INCLUDE OFFLINE]|
          |FOR IMPORT [WITH_GROUP] [INCLUDE OFFLINE]|
          |GENERATION [WITH_GROUP] [INCLUDE OFFLINE]|
          |LOAD                                     |
```

Example:

```
SUBSYSTEM VACAR_LOAD
    AREAS 40 45
    SCALE ALL LOAD
END
```

The example above demonstrates the creation of a subsystem for scaling load within the group of areas.

Example:

```
SUBSYSTEM 'MY COMPANY'
    AREA 5
    JOIN 'GROUP 1'
        AREA 6
        ZONES 8 10
    END
    SCALE ALL FOR EXPORT INCLUDE OFFLINE
END
```

The above example demonstrates automatic creation of scaling factors using FOR EXPORT for subsystems built by using the JOIN specification:

Optional EXCEPT specification for automatic scaling specifications allows the user to exclude several buses from scaling using the following format:

```
SCALE ALL |FOR EXPORT [WITH_GROUP] [INCLUDE OFFLINE]| [EXCEPT]
          |FOR IMPORT [WITH_GROUP] [INCLUDE OFFLINE]|
          |GENERATION [WITH_GROUP] [INCLUDE OFFLINE]|
          |LOAD                                     |
  bus bsid
  bus bsid
  ...
  bus bsid
END
```

It is quite convenient to exclude several generators that cannot participate in transfer or allow the user to exclude non-conforming load buses from load scaling.

The following example will define the subsystem for import but exclude several plants from adjustments.

Example:

```
System AMEREN
    Area 356
    scale all for generation with pmax greater 100 MW except
        Bus 12345 / excludes plant1
```

```
        Bus 23456 / excludes plant2
    End
End
```

The following example creates a subsystem for load scaling with the exclusion of several buses to simulate non-conforming load adjustments.

Example:

```
System CE
    Area 363
    scale all load except
      Bus 12345 / excluded
      Bus 23456 / excluded
    End
End
```

The SCALE command allows specification by individual buses with the following format:

```
SCALE |FOR EXPORT| [INCLUDE OFFLINE]
      |FOR IMPORT|
      |GENERATION|
      |LOAD      |
   BUS bsid
   .
   .
   BUS bsid
END
```

Assume that all three specified buses have on-line generation values of 100 MW at bus 12345, 200 MW at bus 12346, and 100 MW at bus 12347. The SCALE GENERATION specification for these buses is shown below:

```
SUBSYSTEM NORTH
    ZONE 1 2
    SCALE GENERATION
        bus 12345
        bus 12346
        bus 12347
    END
END
```

Buses 12345 and 12347 have a normalized participation factor of 0.25, while bus 12346 has a participation factor of 0.5.

The ADD ALL GENERATORS record allows users to select all generators as participation points in the user defined subset of buses (normally control area). The format is similar to the SCALE ALL command within subsystem definition as shown below:

```
SYSTEM SYS_LABEL
    ADD ALL GENERATATORS [WITH_GROUP] [INCLUDE OFFLINE] [EXCEPT]
        bus bsid
        bus bsid
        . . .
```

```
        bus bsid
    END
END
```

This option simplifies defining a subsystem for Advanced Linear Analysis/MUST sensitivity analysis when a user would like to get the sensitivity report for all generators in a control area as shown in the example below.

Example:

```
SYSTEM PJM
    AREA 1 99
    Add all generators
END
```

2.2.7. Defining New Subsystems Based on Already Defined Subsystems

Advanced Linear Analysis/MUST allows the use of previously defined subsystems for defining new subsystems as described above.

```
SUBSYSTEM|SYSTEM [label]
    (definition of subsystem buses)
    PARTICIPATE
        BUS bsid r
        subsystem label r
        subsystem label r
        . . .
        BUS bsid r
        subsystem label r
    END
END
```

There are various applications for this extension such as scaling loads in different areas/zones with different proportions, and mixing scaled loads with scaled generation specifications as it shown in the next example.

Example:

```
/ Next record will create a subsystem with the name AMRNl_GENEX
Add area 356 for export suffix GENEX
Add area 356 scale load suffix _LOAD
System AMRN_EXPORT
    Participate
        System AMRN_GENEX 70
        System AMRN_LOAD 30
    End
End
```

Advanced Linear Analysis/MUST allows the simultaneous use of bus and subsystem specifications within one participate group as shown below.

Example:

```
System TEST
    Participate
```

```
        Bus 12345 40
        System AMRN_LOAD 30
    End
End
```

2.2.8. Adding Subsystems by Bus or Generator

Adding subsystems by BUS provides a convenient method for defining subsystems for every specified bus in a user-provided list using the following format:

```
ADD SYSTEMS BY BUS
(subsystem specification data record)
.
.
(subsystem specification data record)
END
```

Subsystem names are built from bus name and number. If the current mode of bus input is input by numbers, then subsystem names will be formed by concatenating first the bus number and then the bus name. If the bus input mode is bus input by bus names, bus names will precede bus numbers in the automatically built subsystem names.

Example:

```
ADD SYSTEMS BY BUS
    BUS 12345
    BUSES 12347 12350
    JOIN
        AREA 25
        KVRANGE 300 999
    END
END
```

The example above illustrates how a subsystem is created for every specified bus.

Similarly, adding subsystems by GENERATOR specification provides a convenient method for defining subsystems for every generator bus using the following format:

```
ADD SYSTEMS BY GENERATOR [WITH_GROUP] [INCLUDE OFFLINE]
(subsystem specification data record)
.
.
(subsystem specification data record)
END
```

Example:

```
ADD SYSTEMS BY GENERATOR WITH PMAX GREATER 100 MW INCLUDE OFFLINE
    AREAS 40 45
END
```

In the example above a subsystem is created for every generator with maximum generation greater than 100 MW, including off-line generators.

2.2.9. Reporting Available Subsystems

The report provides summary information for every existing subsystem including subsystem type and maximum import and export capability without violating generators limits.

2.2.10. Subsystem Detailed Report

The subsystem detailed report provides detailed information on a user selected subsystem including generator participation factors and generators that violate capability limits at the userspecified level of Export or Import.

The subsystem detailed report is computed when a user selects a generator subsystem and a transfer level.

2.2.11. Saving Subsystem Adjustments in a Load Flow Case

Advanced Linear Analysis/MUST can be used to save subsystem adjustments in a load flow case. This feature allows updating the load flow case by saving transaction dispatches in the load flow case without adjusting individual buses.

Advanced Linear Analysis/MUST uses several rules when saving adjustments in load flow cases:

- For PARTICIPATE records, Advanced Linear Analysis/MUST attempts to save adjustments in the generation array. If the PARTICIPATE record is used to specify load buses, for nongenerator buses or off-line generators, Advanced Linear Analysis/MUST saves adjustments in the load arrays preserving the same power factor (Q/P ratio).
- Generation scaling methods (SCALE GENERATION, FOR EXPORT, and FOR IMPORT methods) are accomplished by generation changes only. No load buses or buses with off-line generation can be assigned for adjustments; scale generation records can select only generator buses and honor generation status.
- Load scaling will always be accomplished by scaling load with a fixed power factor (e.g., reactive load will be adjusted too.)

When saving subsystem adjustments in the load flow case, Advanced Linear Analysis/MUST also adjusts the change area interchange data for that load flow case.

2.3. Monitored Element Data File

2.3.1. General Description and Advanced Linear Analysis/MUST Extensions

The user designates those elements to be monitored via the monitored element data file. Advanced Linear Analysis/MUST supports all flow type monitoring records available in PSS®E and also all voltage monitoring records except for those involving SUBSTATION (and NODE), BREAKER, SWITCH, and SWD. This subsection describes in full the flow monitoring records available within Advanced Linear Analysis/MUST.

Four types of monitored elements are supported by Advanced Linear Analysis/MUST:

1. Monitored branches

2. Monitored interfaces, where the flow on an interface is taken as the sum of the flows on the branches comprising the interface. As many as 5000 interfaces can be specified within Advanced Linear Analysis/MUST. The total number of branches contained in all interfaces may not exceed the total number of branches in the load flow.

3. Monitored flowgates. Up to 5000 flowgates are allowed by Advanced Linear Analysis/MUST. The total number of branches contained in all flowgates may not exceed the total number of branches in the load flow.

4. Monitored bus voltages

Only in-service branches are processed; out-of-service branches, if specified, will be ignored. Branches closed in contingencies are monitored for violations.

MUST uses two sets of ratings for every monitored branch and interface: base case and contingency. One of the user-specified options allows the user to disable checking/reporting base case violations. By default, MUST checks contingency violations (using the same contingency rating) for all specified contingencies. The MUST EXCLUDE function allows the user to disable checking violations for some of defined contingencies, and allows the user to specify different rating parameters for specified branches.

2.3.2. Monitored Branches Specifications

MUST does not support the Multisection Line Reporting option available within PSS®E. MUST does support the outage of multi-sectionlines.

DC and Linear Analysis - Branch Limit Checking

The user specifies the percentage of ratings to be used by MUST in branch limit checking on the MUST Options Menu. A typical specification would be to check against 100% of RATEA (Normal) in the base case and against 100% of RATEB (Long Term Emergency) post-contingency.

In the linear transfer and contingency analysis functions, MUST checks the MW loadings against the specified ratings which are in MVA (if the user chooses not to Convert Branch Ratings To Estimated MW in MUST Options). If the Convert Branch Ratings To Estimated MW option is chosen, MUST calculates a MW Rating using the base case power factor to reduce the MVA rating to an estimated MW value. In all cases MUST will use the flow at the branch metered end.

Non-Linear AC Models - Branch Limit Checking

In the AC transfer and contingency analysis functions, the way MUST checks branch limits depends on the branch type. For nontransformer branches, MUST checks the current loading against designated branch ratings. Ratings are assumed to have been entered as:

$$MVA_{rated} = SQRT(3) \times E_{base} \times I_{rated} \times 10^{-6}$$

where:

- E_{base} is the base voltage in volts of the bus to which the terminal of the branch is connected.
- I_{rated} is the rated phase current in amps.

Any checked branch whose current loading, including line charging and line connected shunt components, exceeds the percentage of rating, specified in MUST Options, is reported.

For transformers, MUST checks the MVA loading against designated branch ratings that are assumed to have been entered as MVA ratings. Any checked transformer branch whose MVA loading, including line charging and line connected shunt components, exceeds the percentage of rating, specified in MUST Options, is reported.

MUST always checks both terminals of the monitored branches and reports the highest branch loading irrelevant of the metered end location.

2.3.3. Interface Specifications

An interface is defined using the following block structure:

```
[MONITOR] INTERFACE label [RATING_GROUP]
   (branch specification record)
   .
   .
   (branch specification record)
END
```

where RATING GROUP has one of the following formats:

```
|RATING r [MW]                                              |
|RATINGS r r r [MW]                                         |
|BIRATINGS AmaxImp AmaxExp BmaxImp BmaxExp CmaxImp CmaxExp [MW]|
```

RATING and RATINGS specifications assume that interface minimum flows (e.g., imports through the interface) are negative and equal in absolute values to maximum flow (exports).

BIRATINGS specifications allows the user to specify bidirectional ratings (e.g., Pmin not equal to - Pmax); there are no limitations on the sign of IMPORT and EXPORT. Using the RATING command provides that AmaxImp = -AmaxExp.

Branch specification records allowing the user to specify sets of TIE lines are identical to the MONITOR TIES command:

```
[MONITOR] |TIES| FROM SUBSET [TO SUBSET] [IN KVRANGE r1 r2]
          |TIE |
```

where SUBSET is one of the following:

```
AREA i
ZONE i
AREAS i j
ZONES i j
SYSTEM label
SUBSYSTEM label
KV r1
KVRANGE r1 r2
```

and individual branches:

```
[MONITOR] |BRANCH| FROM BUS bsid [|CIRCUIT | ckid ] TO BUS bsid
          |LINE  |                |CKT     |
```

or, simply:

```
bsid bsid [ckid]
```

The following provides two identical examples of defining interfaces.

```
MONITOR INTERFACE NORTHEAST RATINGS 1000 1100 1200 MW
   MONITOR BRANCH FROM BUS 12345 TO BUS 23456 CKT 1
   MONITOR BRANCH FROM BUS 12345 TO BUS 23456 CKT 2
END
MONITOR INTERFACE NORTHEAST BIRATINGS -1000 1000 -1100 1100 -1200 1200 MW
   MONITOR BRANCH FROM BUS 12345 TO BUS 23456 CKT 1
   MONITOR BRANCH FROM BUS 12345 TO BUS 23456 CKT 2
END
MONITOR INTERFACE "AEP_VP" BIRATINGS 0 1000 0 1100 0 1200 MW
   TIES FROM AREA 5 TO AREA 45
END
```

To create an interface containing only 230kV lines as ties from system MAACEHV, a user should use:

```
MONITOR INTERFACE 'MAAC 230 TIES' RATING 12345 MW
   MONITOR TIES FROM SYSTEM MAACEHV IN KVRANGE 200 240
END
```

A 12-character interface label is printed in the output reports of these activities to identify each interface. As with AC branches, provision is made for three interface ratings. When the first form of the INTERFACE record above is used (i.e., the keyword RATING and a single value are specified), the designated value is used for each of the three interface ratings. When the second form of the INTERFACE record is used (i.e., the keyword

RATINGS and three values are specified), the designated values are used as the interface's A, B, and C ratings, respectively. Interfaces with ratings specified as zero are not checked by MUST violation analysis activities.

If the optional specification of ratings is omitted, the sum of the appropriate rating set values of each of the interface members is taken as the interface rating. An interface rating is intended to be specified as something different than a thermal limit; for example, contractual or stability considerations may determine the interface rating to be used.

2.3.4. Flowgates Formats

Flowgates in MUST can be specified using the following format:

```
[MONITOR] FLOWGATE flowgate_id flowgate_label RATING r [MW]
     { monitored branch specification }
     { monitored branch specification }
     . . .
     { monitored branch specification }
   CONTINGENCY
      { contingency event }
      { contingency event }
      . . .
      { contingency event }
   END
   [ CA LABEL [LABEL2] [LABEL3] [LABEL4] [LABEL5] ]
   [ SC LABEL [LABEL2] [LABEL3] [LABEL4] [LABEL5] ]
   [ TP LABEL [LABEL2] [LABEL3] [LABEL4] [LABEL5] ]
END
```

where:

- Contingency definition is optional. If omitted, MUST will consider the flowgate as the base case flowgate and will use PTDF factors to update flowgate values. The contingency definition within the flowgate has the same format as the contingency definitions within contingency files with the only exception that contingency labels following the keyword contingency are ignored.
- If the flowgate limit is omitted, MUST determines the flowgate rating using the rating of the monitored branches.
- Optional Flowgate properties (Control Area (CA), Security Coordinator (SC) and Transmission Provider (TP)) are optional and currently are used for reporting purposes only. Keywords CA, SC, and TP can be specified in any order. CA, SC, and TP properties are used for reporting only.

There are no limitations on the number of monitored branches within one flowgate. MUST processes the reading of monitored branches until it finds one of the following keywords: CONTINGENCY, TP, CA, SC or END. Up to 100 elementary events can be specified within one contingency definition.

Bus IDs can be specified using either bus numbers or names. MUST allows switching between input from bus name to bus number within input files using the BUSNUMBERS and BUSNAMES records. It appears that bus names are more convenient for defining flowgates. The use of bus input by bus names tends to be more stable (i.e., bus names don't change when buses are renumbered) than that of bus by numbers.

The following are several examples of flowgate definitions.

Example 1 defines base case flowgate.

```
MONITOR FLOWGATE 1004 'MccTieAEC'
      BRANCH FROM BUS 'MCCRED 7 345' TO BUS 'MCCREDIE 345' CKT 1
      CA       AECI AMRN
      SC       EES MAIN
      TP       AECI AMRN
END
```

Example 2 defines contingency (OTDF) flowgate with the single branch outage as the contingency. For this type of flowgate MUST will provide various additional information describing the contingency impact on monitored elements (LODF) and various other factors.

```
FLOWGATE 3133 'JOPPA-CAPE GIRARDEAU-SHAWNEE-KELSO'
    BRANCH FROM BUS 'JOPPA S 161' TO BUS 'CAPE GIR 161' CKT 1
    CONTINGENCY 999
        OPEN BRANCH FROM BUS '7SHAWNEE 345' TO BUS 'KELSO 345' CKT 1
    END
    CA   AMRN EEI
    SC   MAIN
    TP   AMRN EEI
END
```

Example 3 defines contingency (OTDF) flowgate with a multiple event contingency.

```
MONITOR FLOWGATE 3222 'Lock-LisleB for Lock-Li R +G'/ reliability(OTDF)
   BRANCH FROM BUS 'LOCKP; B 345' TO BUS 'LISLE; B 345' CKT 1
   CONTINGENCY 999
        TRIP BRANCH FROM BUS 'LOCKP; R 345' TO BUS 'LISLE; R 345' CKT 1
        CLOSE BRANCH FROM BUS 'MCCOO; B 345' TO BUS 'MCCOO; R 345' CKT 1
   END
   CA    CE
   SC    MAIN
   TP    CE
END
```

Flowgates are reported in similar ways as branches and interfaces in all MUST reports.

2.3.5. Defining Rating Multiplier by Areas or Zones

Rating multiplier specification allows the user to redefine the base case and contingent branch rating specified via the MUST Options button. There are several applications of this format. MUST users report that when rating B, usually used as a contingent rating, is not available for some control areas they have to use the base case rating A with a multiplier. In some regions Transmission Reliability Margin (TRM) are modeled via rating adjustments with a different multiplier factor for different control areas.

Rating multiplier specification has the following format:

```
rating multipliers '\n'
  Area/Zone definition
  Area/Zone definition
  . . .
  Area/Zone definition
end
```

where Area/Zone definition has one of the following formats:

```
|area  i  | BaseRateId BaseRateMult ContRateId ContRateMult
|areas i j|
|zone  i  |
|zones i j|
```

The rating multipliers adjustment may be used for either areas or zones, but not for both in the same monitor file.

The example below shows the redefinition of the default ratings A and B as set in the MUST Options, i.e., base case and contingent ratings. In general, it defines a default of 100% (A) for base case and 100% (B) for contingent ratings. Then, for area 151 it defines rating A with the 120% multiplier as the contingent rating. Further, for areas 300-400 it reduces the base case ratings to 98% of A and the contingent ratings to 95% of B.

Example:

```
Rating multipliers
  Areas 1 999 A 100 B 100
  Area 151 A 100 A 120 / the second definition will overwrite
                       / the previous definition for that area
  Areas 300 400 A 98 B 95
End
```

2.3.6. Defining Distribution Factors Cutoff by Control Areas and Zones

The default distribution factor cutoff specified via MUST Options allows the user to skip reporting monitored elements which are impacted by a study transfer below a user specified threshold. This single threshold defines both the Base Case (PTDF) and Contingent Case (OTDF) distribution factor cutoffs. There are a few examples when a user may need to apply different cutoff values for different control areas. The most common example is in using a relatively large cutoff value for external control areas (3-5%) and a smaller value (2-3%) for internal control areas. Also, this specification allows the user to use different distribution factor cutoff values for the base and contingent cases constraints.

Distribution factors cutoff record has the following format:

```
Factors cutoff '\n'
   Area/Zone definition
   Area/Zone definition
   . . .
   Area/Zone definition
end
```

where Area/Zone definition has one of the following formats:

```
|area i   |  BaseCutoff ContCutOff
|areas i j|
|zone i   |
|zones i j|
```

The example below redefines the default distribution factor cutoff of 0.05 (PTDF and OTDF) to the lower values of 0.02 (PTDF) and 0.03 (OTDF) for the group of control areas with the area number in the range between 300 and 400.

Example:

```
Factors cutoff
  Areas 1 300 0.05 0.05
  Areas 301 400 0.02 0.03
End
```

2.4. Contingency Definition Data File

Advanced Linear Analysis/MUST supports contingency records available in PSS®E except for those involving SUBSTATION (and NODE), BREAKER, SWITCH, and SWD.

The contingency description data file provides two means by which contingency cases may be specified. Individual contingency cases containing branches with status changes may be specified in a contingency case block structure (described in the following subsections) or by using an automatic contingency specification allowing the selection of a group of single- or doubleline/ generator/bus outage contingency cases within a single data record.

MUST has a function that allows generation of new contingency files. MUST-generated contingency files always contain only explicit individual contingency definitions without automatic specifications. This feature allows a user to customize the contingency definition files originally created using automatic specifications.

Section 5.2.2, "Statistics on All Contingencies" and Section 5.2.6, "Details for Selected Contingencies" describes the MUST interactive facilities for examining specified contingencies and checking for dataerrors. The MUST log file contains all errors and warnings about specified input data, mismatches between load flow case and input files. It is strongly recommended that the user review this file after significant modification to the load flow case.

2.4.1. Individual Contingency Specifications

Each contingency is defined by a contingency block which consists of a contingency label record, a number of contingency event specification records, and an end record.

A contingency case block structure is of the form:

```
CONTINGENCY label
(contingency event specification record) [dispatch group]
.
.
(contingency event specification record) [dispatch group]
END
```

MUST incorporates a duplicate contingency label checker. Duplicate contingency labels will be flagged as an error and the duplicate contingency will be disabled.

Most of the elementary contingency events can be specified using DISPATCH_GROUP. Use of the DISPATCH_GROUP option causes any power mismatch within the contingency event to be distributed among the buses specified within the DISPATCH_GROUP.

The outaging of an in-service branch is specified with the following record where the default circuit identifier is '1' if this specification is omitted:

```
|DISCONNECT| |BRANCH       FROM BUS bsid TO BUS bsid             | [|CIRCUIT| ckid]
|OPEN      | |LINE         FROM BUS bsid TO BUS bsid             |  |CKT    |
|TRIP      | |WND [WND_ID] FROM BUS bsid TO BUS bsid TO BUS bsid|
|OUTAGE    |
```

Use of the record operator WND assumes that the FROM BUS bisd is bus number 1, the first TO BUS bsid is bus number 2 and the second TO BUS bsid is bus number 3. The operator WND is followed by a number

WND_ID which can take on the values 1, 2, 3, or any two digit combinations of these values; ex 23, 13, 31, ... indicating which buses are to be opened or closed.

Similarly, an out-of-service branch may be placed in service with a record of the form:

```
| CLOSE | | BRANCH       FROM BUS bsid TO BUS bsid            | [| CIRCUIT| ckid]
          | LINE         FROM BUS bsid TO BUS bsid            |  | CKT    |
          | WND [WND_ID] FROM BUS bsid TO BUS bsid TO BUS bsid|
```

Various record types allow the user to specify bus contingency events in which the load and generation boundary conditions may be changed at a selected bus. When changing generation, the bus must have in-service generation connected to it and it cannot be a swing bus.

A single bus outage record has the following format:

```
DISCONNECT BUS bsid [DISPATCH_GROUP]
```

A single DISCONNECT BUS specification results in defining several branch openings for all branches connected to a specified bus. Bus outage records provide a convenient means to specify multisection line outages by specifying boundary bus outages. Bus outage specifications are shorter than branch outage records and do not require testing the status of specified branches.

2.4.2. Automatic Contingency Specifications

All contingencies are labeled. Automatic contingency labels include the circuit identification code and in the case of three-winding transformers, the transformer name. Automatic contingency labeling follows the convention as shown below.

Single Automatic Contingency Labels – Single Branch

Automatic contingency labels referencing a single branch are labeled using an automatic branch name. The automatic branch name includes the FROM bus number, FROM bus name, FROM bus voltage, TO bus number, TO bus name, bus voltage and circuit identifier.

Example:

```
28354 Yolanda 315 35555 East Jibit 315 1
54941 HSL   4 138 54973 RENO 4     138 1
```

Single Automatic Contingency Labels – Three-Winding Transformer

The automatic branch name for a three-winding transformer consists of the three-winding star bus number, the transformer name and circuit identifier. Automatic contingency labels referencing a three-winding transformer as labeled using the prefix, "3Wnd: OPEN", followed by the automatic branch name.

Example:

```
3Wnd: OPEN B$070 T3XXXX 3 1
Double Automatic Contingency Labels
```

Double automatic contingency labels are built using the automatic branch names of both contingency pairs. Because the automatic branch name for a single branch is rather long as defined above, the automatic branch name for the single branch (double automatic contingencies only) is shortened to be the FROM bus name, the term "-", the TO bus name, and the circuit identifier.

The double automatic contingency label consists of the prefix, "D:", followed by the automatic branch name for first contingency, the term "+", and the automatic branch name for second contingency.

Example:

(Double with two branches one on circuit 22, the other 33)

```
D:20ABCDEF-10XXXXXX22+001BBBBB-CCCCCCCC33
```

Example:

(Double with a single branch on circuit 44 and a three-winding transformer on circuit 22)

```
D:HAZEL -WALNUT 44+ B$211 TREES 1 22
```

Automatic IN Contingencies

All branches within a specified subsystem may be outaged, either singly or in pairs, by entering the data record:

```
|SINGLE   | |BRANCH| IN SUBSET [IN KVRANGE r1 r2] [DISPATCH_GROUP]
|DOUBLE   | |LINE  |
|BUSDOUBLE| |
|PARALLEL | |
```

where SUBSET is one of the following:

```
AREA i
ZONE i
AREAS i j
ZONES i j
SYSTEM label
SUBSYSTEM label
KV r1
KVRANGE r1 r2
```

When using the SYSTEM or SUBSYSTEM keywords, the label must correspond to a subsystem label specified in a previously accessed subsystem description data file.

The DOUBLE, BUSDOUBLE, and PARALLEL contingency specification records all generate contingency cases consisting of two simultaneous branch outages. The DOUBLE record generates all combinations of double line outage contingencies for all branches whose endpoint buses are contained in the specified subsystem. That is, each branch in the subsystem is outaged, in turn, with every other branch in the subsystem. DOUBLE may be viewed as considering independent events causing simultaneous outages.

The BUSDOUBLE record is more restrictive than the double record. For each bus in the specified subsystem, it generates all combinations of double line outage contingencies for all branches between that bus and other subsystem buses. BUSDOUBLE may be viewed as considering single events in substations that affect pairs of branches connected to a substation (e.g., stuck breaker events).

The PARALLEL record is more restrictive than the BUSDOUBLE record. It generates double line outage contingencies only for parallel branches (i.e., for each contingency case, the two branches being outaged connect the same pair of subsystem buses). PARALLEL may be viewed as considering single events on right-of-ways, which affect pairs of branches on a right-of-way.

Example:

```
SINGLE BRANCH IN AREA 1
SINGLE BRANCH IN AREA 1 IN KVRANGE 100 9999
SINGLE BRANCH IN KVRANGE 100 9999
SINGLE BRANCH IN SYSTEM SOUTH IN KVRANGE 100 9999
```

The use of the SINGLE/DOUBLE/BUSDOUBLE/PARALLEL branch outages may result in the loss of load or generation, or island creation. The optional keyword DISPATCH allows a user to designate how the change in the bus boundary condition is to be apportioned among selected network buses rather than having it all assigned to the system swing bus(es). Without the DISPATCH specification, island mismatch causes swing bus adjustments, which is most likely an erroneous solution. The DISPATCH_GROUP specification is only used with single/double branch outages. The following example specifies how to adjust subsystem INERTIA in the case of a single line outage resulting in the loss of load, generation, or island creation.

Example:

```
single branch in area 45 dispatch
   subsystem INERTIA
end
```

The following data record designates a series of single/double line outage contingencies from a selected bus:

```
|SINGLE| |BRANCH| FROM BUS bsid
|DOUBLE| |LINE  |
```

Automatic TIE Contingencies

The following data record creates a list of single/double outages encompassing all ties from a specified subsystem or all ties between a pair of subsystems:

```
|SINGLE| |TIE | FROM SUBSET [TO SUBSET] [IN KVRANGE r1 r2]
|DOUBLE| |TIES|
```

where SUBSET is one of the following:

```
AREA i
ZONE i
```

```
AREAS i j
ZONES i j
SYSTEM label
SUBSYSTEM label
KV r1
KVRANGE r1 r2
```

The main difference between the IN, FROM, and TO specifications is that IN specifies the kV requirement for both terminal buses for the selected branches, while FROM and TO specifications define only corresponding FROM or TO selection. The selection of tie branches in the case of overlapping subsystems is handled using the criteria described above for monitored ties between systems.

The KVRANGE specification selects single branch outages only if both terminal buses are within the selected kV range. To select all transformers between two kV levels or ranges, the user should use the TIE command. Optional DISPATCH_GROUP specifications are used only for single/double branch outages resulting in creating an island.

The selection of tie branches in the case of overlapping subsystems is handled using the criteria described for monitored element selection.

The following several examples show automatic contingency specifications records.

Example:

```
SINGLE TIE FROM AREA 1 IN KVRANGE 100 9999
SINGLE TIE FROM AREA 1 TO AREA 2 IN KVRANGE 100 9999
SINGLE TIE FROM SYSTEM SOUTH TO AREA 2 KVRANGE 100 9999
SINGLE TIE FROM ZONE 15 TO AREA 2 KVRANGE 100 9999
```

Automatic Generator and Bus Contingencies

The following data record creates a list of single unit/generator/bus outages in the specified subsystem:

```
SINGLE |UNIT     | OUTAGE IN SUBSET [DISPATCH_GROUP]
       |GENERATOR|
       |BUS      |
```

where SUBSET is one of the following:

```
AREA i
ZONE i
AREAS i j
ZONES i j
SYSTEM label
SUBSYSTEM label
KV r1
KVRANGE r1 r2
```

In the case of a UNIT specification, MUST selects the single largest unit contingency at every generator bus in the specified subset.

A GENERATOR specification creates the set contingencies for every single plant outage (all units) of all generator buses in the specified subsystem.

A BUS outage record allows the user to select as contingencies every single bus outage in the selected subset.

Example:

```
SINGLE UNIT OUTAGE IN AREA 45 DISPATCH
   SUBSYSTEM INERTIA
END
```

2.4.3. DISPATCH Record Format

DISPATCH Record

When the optional keyword DISPATCH is included with the contingency event or automatic contingency specifications, a user may designate how the change in the bus boundary condition is to be apportioned among selected network buses rather than having it all assigned to the system swing bus(es). DISPATCH records can be used when specifying individual events and within automatic contingency specifications, involving changes in bus boundary conditions. DISPATCH records may not be used with branch open/close specifications.

DISPATCH records have the following format:

```
(single event or automatic contingency specification record) DISPATCH
   BUS bsid r
   subsystem label r
   system label    r
   .
   .
   BUS bsid        r
   subsystem label r
   system label    r
END
```

The "r" values are positive participation factors that are normally expressed in percent or per unit of the total MW change. MUST allows the user to use BUS and SYSTEM records simultaneously within one DISPATCH_GROUP definition. If a user wants to specify only one subsystem within a subsystem group, then the "r" value specification can be omitted.

Using bus dispatch records, as shown below:

```
REMOVE MACHINE A FROM BUS 12345 DISPATCH
   BUS 12346 100
   BUS 12347 100
END
```

If participating factors in subsystem INERTIA have been defined to simulate inertia redispatch, then the example below will provide a simple solution to simulate inertia redispatch for every single largest generator outage.

If only one subsystem has to be specified, then there is no need to specify "r" value.

```
SINGLE UNIT IN AREA 45 DISPATCH
   SYSTEM INERTIA
END
```

BUS and SYSTEM records can be used within one DISPATCH_GROUP, as shown below:

```
SINGLE UNIT IN AREA 45 DISPATCH
   SYSTEM INERTIA 100
   BUS 12345       50
   BUS 12346       50
END
```

In the above example, 50% of mismatch will be accomplished by adjusting subsystem INERTIA; 25% by adjusting generation at bus 12345; and 25% at bus 12346.

The following is an example of single bus outage event specification:

```
DISCONNECT BUS 123456 DISPATCH
   BUS 2100 100
END
```

Default Dispatch

By default, for imbalanced contingencies (with the loss of load or generation) MUST will adjust the system swing bus. Imbalanced contingencies are commonly created by using automatic contingency definition (single branch in area, for example). In most cases system swing bus adjustment does not provide adequate model. It is the user's responsibility to identify imbalanced contingencies and then improve contingency definitions. MUST has several ways to identify imbalanced contingencies within DC contingency analysis

The DEFAULT DISPATCH specification described below provides a simple and convenient solution to defining a "default dispatch" subsystem that would pick up the power mismatch introduced by contingency events. A default dispatch subsystem can be defined using all features available for defining subsystems, for example, proportional scaling of all generators in the LF case as the default subsystem.

Default Dispatch has the following format:

```
default dispatch
   bsid      x
   subsystem x
   . . .
End
```

For every imbalanced contingency MUST will apply the default dispatch. The default dispatch subsystem can be redefined several times within one contingency file.

Example:

```
Subsystem file
   subsystem inertia
      areas 1 999
      scale all generation with pmax greater 100 MW
   end
Contingency file
   default dispatch
      system inertia
   end
```

2.4.4. Multi-Section Line Outages

If the Multi-section Line option is ON, then for multi-section branches, the single branch contingency specification will outage the whole multi-section line instead of one segment at a time when using both single or automatic contingency definitions as it is shown in the example below.

Example:

```
open branch from bus 123 to bus 234 ckt &1
single branch in area 1
```

If multi-section reporting is on, MUST will outage only multi-section lines.

2.4.5. Load Throwover

If a bus that has a connected load becomes isolated due to a contingency, the bus-load will be automatically transferred from the FROM bus to the TO bus using the following format:

```
load throwover
   from_bus_id to_bus_id
   . . .
End
```

where from_bus_id and to_bus_id are bus numbers.

In addition, a load throwover data file may be used as in the example below:

```
LOAD THROWOVER
   include Ldthrowover.dat
END
```

The file Ldthrowover.dat contains from / to bus pairs in the format:

```
from_bus_id to_bus_id
. . .
0
```

the last entry being a bus number of zero "0".

The load throwover file is available within all MUST activities including DC and AC based contingency analysis and transfer limit analysis.

2.4.6. Three-Winding Transformer Contingency

The syntax for three-winding transformer contingency specification is similar to that of single branch contingency specification.

All windings of a three-winding transformer may be placed in/out of-service with a record of the form:

```
|CLOSE     | BRANCH FROM BUS bsid TO BUS bsid TO BUS bsid [ | CIRCUIT | ckid ]
|OPEN      |                                                | CKT     |
|TRIP      |
|OUTAGE    |
|DISCONNECT|
```

(where the default circuit identifier of '1 ' is assumed if omitted)

Each TO BUS bsid and the FROM BUS bsid must be unique and specific to the intended threewinding transformer.

Example:

```
Open branch from bus 288 to bus 2000 to bus 398
```

The above example will open all three windings of the in-service three-winding transformer connected to bus 288, bus 2000 and bus 398. This single contingency will be internally registered as three single branch events, one for each of the three winding buses of the transformer.

Three-winding transformers are modeled as three two winding transformers connected together by a common bus, known as the star bus. Star buses are indicated in MUST by the bus number B$xxx; where xxx is an artificial number assigned to the three-winding transformer. Report lines containing three-winding transformers are highlighted in yellow.

2.5. EXCLUDE Data File

2.5.1. Why Use an Exclude Data File?

The exclude data file allows adjustment of monitored elements defined in the monitored element and contingency specification files. The exclude data file can be read in at any time while running MUST activities.

A user can read in the file by using the exclude Data File button, which brings in the file selector. In command line mode, a user can read the exclude data file by invoking function CONSTR/CHANGE.

If a user has restarted MUST with different options, data files, or a new load flow case, the user has to read the exclude data file again to exclude elements or reactivate excluded elements.

Also, a user can exclude/include selected contingencies on the fly with a MUST session within contingency analysis group functions. MUST can generate the new exclude data file based on the current selection of excluded monitored elements, contingencies, and monitored/contingencies combinations.

For more detailed explanation for Exclusion see Section 7.1, “Overview Of Exclusion”

2.5.2. Exclude Input Data Formats

The BRANCH record has the following format:

```
|LINE   | FROM BUS bsid TO BUS bsid [| CIRCUIT | CktId ]
|BRANCH|                            | CKT     |
```

The INTERFACE record has the following format:

```
INTERFACE |NAME   Label |
          |NUMBER Number|
```

The difference between the above format of the INTERFACE record and that of the monitored element definition file. The user must use one of the keywords (NAME or NUMBER) as there are two possible ways to identify interfaces.

The CONTINGENCY record has the following format:

```
CONTINGENCY |NUMBER i       |
            |(BRANCH RECORD)|
            |NAME Label     |
```

The contingency number can be obtained from the list of contingencies and is also reported by many MUST reports.

The RATING record has the following format:

```
|RATING r       [MW]|
|RATINGS r r r [MW]|
```

The first record type assumes that all three ratings are equal.

2.5.3. Exclude File

```
EXCLUDE [INITIAL] VIOLATIONS
```

The EXCLUDE record above allows the user to exclude all initial overloads. This record provides a simple solution when running MUST for the first time; a user can then create an explicit exclude data file at a later date.

The following format allows excluding initial violations just in several selected areas and zones. It is quite a common and simple solution to avoid reporting local problems in the external control areas.

```
EXCLUDE [INITIAL]VIOLATIONS IN |AREA  i  |
                            IN |AREAS i j|
                            IN |ZONE  i  |
                            IN |ZONES i j|
```

An exclude monitored element statement can have one of the following formats:

```
|EXCLUDE| |(BRANCH RECORD)   | |                                  |  (1)
|INCLUDE| |(INTERFACE RECORD)| |IN BASE CASE                      |  (2)
                               |IN ALL CONTINGENCIES              |  (3)
                               |IN [New Line](CONTINGENCY RECORD)|  (5)
```

where:

- Type (1) excludes a monitored element from the base case and all contingencies
- Type (2) excludes a monitored element only from the base case
- Type (3) excludes a monitored element from all contingencies, but it is monitored in the base case

The include command in combination with exclude command allows the user to exclude a monitored element under all contingencies and then to include checking that constraint back in for only a few contingencies.

The following format should be used to exclude flowgates:

```
EXCLUDE flowgate fgate_ID
```

Example:

```
exclude branch from bus 70001 to bus 70003 circuit 2 in base case
exclude branch from bus 70001 to bus 70003 cktid 2 in all contingencies
exclude interface number 3 in base case
exclude interface name XYZ_1 3 in all contingencies
exclude            branch from bus 70001 to bus 70003 circuit 2 in
       contingency branch from bus 70001 to bus 70002 circuit 3
exclude branch from bus 10 to bus 20 in contingency number 527
```

The EXCLUDE BRANCH/INTERFACE in the contingency record specification can use one or two lines. In the case of two lines, it is important that the IN keyword is the last keyword on the first line with a monitored branch specification as shown above.

The EXCLUDE CONTINGENCY statement has the following format:

```
EXCLUDE (CONTINGENCY RECORD)
```

Example:

```
exclude contingency branch from bus 70001 to bus 70002 circuit 3
exclude contingency number 12
```

The CHANGE RATING statement has the following format:

```
CHANGE |(BRANCH RECORD)   | (RATING RECORD)
       |(INTERFACE RECORD)|
```

For branches, the CHANGE record changes A, B, and C ratings defined in the load flow case. For interfaces, it changes limits specified in the monitored file.

When new ratings are specified, these ratings will be assigned to the load flow case ratings (A, B, C). These ratings will be scaled according to the rating multiplier specified on the MUST Startup dialog.

Example:

```
CHANGE BRANCH FROM BUS 70001 TO BUS 70002 CIRCUIT 3 rating 120 MW
CHANGE BRANCH FROM BUS 70001 TO BUS 70002 CIRCUIT 3 ratings 100 110 120
```

Contingencies and branches can be excluded by circuit number.

Example:

```
exclude contingencies ckt 99
exclude branches circuit 99
```

Buses can be excluded from the monitored bus set. Buses can be excluded using the bus name or bus number.

```
exclude bus bsid
```

2.6. Summary of Advanced Linear Analysis/MUST File Extensions Not Available in PSS®E

2.6.1. General Input Files Extensions

- INCLUDE records allow nesting while reading input files. This feature can essentially simplify the burden of data maintenance.
- Function EXCLUDE allows customizing specified monitored elements and contingencies

2.6.2. Subsystems Definition Extension

- Automatic subsystem definitions FOR EXPORT, FOR IMPORT, and SCALE GENERATION allow various new types of subsystem adjustments. Automatic specifications minimize subsystem definition dependencies on the current load flow conditions, which simplifies input data maintenance.
- SCALE LOAD for subsystem adjustments can be explicitly specified (e.g., "scale load in area ...").
- Maximum number of subsystems is 5000, compared to 100 in PSS®E.
- INCLUDE OFFLINE specification provides simple solution to include off-line generators in subsystems and enhances reporting/limit checking.
- Advanced Linear Analysis/MUST allows the automatic adding of subsystems by every bus or generator within a user-defined subset of buses (areas, zones, bus ranges).
- Advanced Linear Analysis/MUST allows defining new subsystems by combining previously defined subsystems with user defined participating factor.

2.6.3. Monitored Elements Files Extensions

- Advanced Linear Analysis/MUST allows modeling bidirectional ratings for interfaces, which provides efficient modeling of bidirectional relay protection devices.
- Advanced Linear Analysis/MUST has the EMS Flows Method, which allows using flows provided by a user (not obtained from the load flow case).
- Flowgates as an additional type of monitored parameters is not available within PSS®E.
- Advanced Linear Analysis/MUST allows to specify rating selection and multipliers on the area and zone basis.
- Advanced Linear Analysis/MUST allows selective selection of the distribution factors cutoff on area and zone basis.
- Optional exclude files allows to customize reporting violations. Primary objective of this function is to reflect existing operating guides (in the very simplified form).

2.6.4. Contingency Data File Extensions

- All contingency definition formats are consistently available with all Advanced Linear Analysis/MUST activities, allows for example, all type bus events, branch closing events within AC contingency analysis and load throwover file support within linear transfer analysis.

- Default dispatch subsystem definition provides convenient approach to model imbalanced contingencies. DISPATCH records can be used for automatic contingency specifications.
- Subsystems can be used to define dispatch records.
- Automatic unit/generator/bus contingency specifications.
- Advanced Linear Analysis/MUST checks contingent violations for branches opened in the base case, but closed in the contingencies; PSS®E does not do this.
- Advanced Linear Analysis/MUST provides better modeling of dynamic bus events in the case of interaction between study transfer and the size of bus injections in contingencies.
- Advanced Linear Analysis/MUST allows generating a new contingency file for user-selected contingencies. Advanced Linear Analysis/MUST always generates individual contingency definitions even if contingencies are specified using automatic specifications.

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Graphic Report Generator GRPG User's Ready Reference

```
ABORT

APPEND LINE [FROM x,y] TO x,y

APPEND LINE FOR x,y

APPEND VECTOR [FROM x,y] FOR length [c] ANGLE angle [c]

APPEND BOX FROM x,y TO x,y [c] [RADIUS rad]

APPEND BOX CENTERED AT x,y WITH SIDES length-x BY length-y [c] [RADIUS
rad]

APPEND CIRCLE [c] AT x,y [c] RADIUS rad

APPEND ARC [c] AT x,y [c] RADIUS rad [c] FROM angle [c] TO angle
[c]

       |CLOCKWISE       |
APPEND |CW              | ELLIPSE FROM x,y TO x,y
       |COUNTERCLOCKWISE|
       |CCW             |

APPEND POLYGON[S] FROM filename [c] [OFFSET x,y] [c] [SCALE scale]

CLOSE POLYGON

COMMENT string

DECLARE |REAL  | &label [&label2...&label10]
        |STRING|

DEFINE MACRO macroname

DRAW LINE [FROM x,y] TO x,y

DRAW LINE FOR x,y

DRAW LOGO AT x,y WITH SIZE size [c] [ANGLE angle] [c]

DRAW VECTOR [FROM x,y] FOR length [c] ANGLE angle [c]
```

```
DRAW BOX FROM x,y TO x,y [c] [RADIUS rad]

DRAW BOX CENTERED AT x,y WITH SIDES length-x BY length-y [c] [RADIUS
rad]

DRAW CIRCLE [c] AT x,y [c] RADIUS rad

DRAW ARC [c] AT x,y [c] RADIUS rad [c] FROM angle [c] TO angle [c]

     |CLOCKWISE       |
DRAW |CW              | ELLIPSE FROM x,y TO x,y
     |COUNTERCLOCKWISE|
     |CCW             |

DRAW POLYGON[S] FROM filename [c] [OFFSET x,y] [c] [SCALE scale]

DRAW GRID FROM x,y TO x,y [c] DELTA x,y

ELSE

       |&label|      |&label|
ELSEIF |string| oper |string|
       |real  |      |real  |

   where "oper" is "EQ", "=", "NE", "<>", "GT", ">",  "GE",
">=", "LT", "<", "LE", or "<=".

END [c]

ENDIF

ENDMACRO

FLUSH ACCUMULATED POLYGON[S]

HELP [command]

   |&label|      |&label|
IF |string| oper |string|
   |real  |      |real  |

   where "oper" is "EQ", "=", "NE", "<>", "GT", ">", "GE", ">=",
"LT", "<", "LE", or "<=".

INCLUDE filename [c] [OFFSET x,y] [c] [SCALE scale]

INCLUDE [BINARY] ONE-LINE [c] FROM filename

INVOKE MACRO macroname USING p1 [p2...p9]
```

```
              |LEFT    |
JUSTIFY TEXT |RIGHT   |
              |CENTERED|

              |real  |
LET &label = |string|
              |&label|

LET &label = |real  |  oper |real  |
              |&label|       |&label|

   where "oper" is "PLUS", "+", "MINUS", "-", "TIMES", "*", "OVER",
or "/".

LET &label = THE CABS OF |real  | AND |real  |
                          |&label|     |&label|

LET &label2 = THE CASE TITLE

LET &label = THE NAME FOR |AREA| n
                           |ZONE|

LET &label2 = THE INTERCHANGE FROM AREA n TO AREA n

LET &label2 = THE INTERCHANGE FROM ZONE n TO ZONE n

LET &label2 = THE NET INTERCHANGE FROM |AREA| n
                                        |ZONE|

                   |GENERATION|
LET &label2 = THE |LOAD      | FOR |AREA| n
                   |LOSSES    |     |ZONE|

LET &label2 = THE GENERATION AT BUS busid

LET &label2 = THE LOAD AT BUS busid [LOADID lid]

LET &label = THE ANGLE AT BUS busid

                          |GENERATION|
LET &label2 = THE SYSTEM |LOAD      |
                          |LOSSES    |

LET &label = THE [EXTENDED] NAME FOR BUS busid

LET &label = THE BASE VOLTAGE FOR BUS busid

LET &label = THE VOLTAGE AT BUS busid [ IN |PU| ]
                                       [    |KV| ]

LET &label = THE STATUS FOR |BRANCH| FROM BUS busid TO BUS busid
```

```
                             |LINE  |                      [CIRCUIT
cid]

LET &label2 = THE FLOW FOR |BRANCH| FROM BUS busid TO BUS busid
                           |LINE  |                    [CIRCUIT
cid]

LET &label2 = THE |INVERTER | FLOW FOR 2-TERMINAL DC LINE n
                  |RECTIFIER|

LET &label2 = THE |ACTUAL | |FIXED   | SHUNT AT BUS busid
                  |NOMINAL| |SWITCHED|

LET &label2 = THE CONVERTER FLOW AT BUS busid FOR N-TERMINAL
DC LINE n

LET &label = THE MW TRANSACTION FROM AREA n TO
AREA n [IDENTIFIER id]

LET &label = THE CONTROL MODE FOR |2-TERMINAL| DC LINE n
                                  |N-TERMINAL|

MOVE LINE TO x,y

MOVE LINE FOR x,y

MOVE VECTOR FOR length [c] ANGLE angle [c]

     |SCATTER PLOT  |
PLOT |STRAIGHT LINES| FROM filename
     |SPLINE CURVES |

ROTATE PLOT angle [c] AROUND x,y

SET |X| COORDINATE |PAPER   | LIMITS TO min AND max
    |Y|            |DATA    |
                   |PLOTTING|

SET UNITS TO |INCHES     |
             |CENTIMETERS|

SET ANGLE TO |DEGREES|
             |RADIANS|

         |TYPE |
SET LINE |WIDTH| TO integer
         |COLOR|

SET FONT TYPE TO |STANDARD |
                 |LOWERCASE|
                 |integer  |
```

```
SET PLOT ORIENTATION TO |PORTRAIT |
                        |LANDSCAPE|

SET PLOT SYMBOL TO integer

SET PRINT FORMAT TO integer,integer

SET |TEXT  | [HEIGHT TO size] [c] [ANGLE TO angle] [c]
    |SYMBOL|

SET SHADING PATTERN TO integer

SET SHADING OUTLINE |VISIBLE  |
                    |INVISIBLE|

SHADE BOX FROM x,y TO x,y [c] [RADIUS rad]

SHADE BOX CENTERED AT x,y WITH SIDES length-x BY length-y [c] [RADIUS
rad]

SHADE CIRCLE [c] AT x,y [c] RADIUS rad

SHADE ARC [c] AT x,y [c] RADIUS rad [c] FROM angle [c] TO angle
[c]

      |CLOCKWISE       |
SHADE |CW              | ELLIPSE FROM x,y TO x,y
      |COUNTERCLOCKWISE|
      |CCW             |

SHADE POLYGON[S] FROM filename [c] [OFFSET x,y] [c] [SCALE scale]

SHADE ACCUMULATED POLYGON[S]

START NEW PLOT

WRITE item1 [item2...item10] [AT x,y]

Each "item" may be a string, a reserved symbolic name (%name%),
or an ampersand label (&label) which was previously declared
and assigned a value.  Up to ten items may be output with a single
WRITE command.
```

3.1. NOTES:

1. [c] => Optional comments
2. | | => "or" - pick one from list
3. [ ] => optional argument
4. Lower case words are variable fields. For more information on a specific variable, refer to Section C.4.1 of the *PSS®E Program Operation Manual*.
5. Words in CAPITALS must be entered exactly as shown.
6. Commas and "=" can be used in lieu of spaces for clarity.
7. If "CIRCUIT cid" is not specified, default is circuit "1". If "LOADID lid" is not specified, default is load "1".
8. "busid" may be specified as either the extended bus name enclosed in single quotes or the bus number.
9. A $ is used to continue a GRPG command on the following line.
10. &label2 is used to show which statements will return 2 values.
11. If "IDENTIFIER id" is not specified for MW TRANSACTION, default is 1.

3.2. GRPG Command Help

Entering the command "HELP" while executing GRPG causes the list of GRPG commands to be displayed on the user terminal. "HELP, command" causes the format for the specified command to be displayed.

3.3. GRPG Input Files

Commands may be taken from a file as well as from the terminal. If a file is to be used for input, the commands are entered in the file exactly as they would be from the terminal. When GRPG has processed all input file commands (the "END" command has been reached), the program prompts the user for a valid plotting device on which the resulting picture will be generated. If any errors are encountered while processing the input file, an error message is sent to the terminal and the input line is ignored. The resulting drawing, without the erroneous commands, may be displayed.

3.4. To Execute GRPG From PSSLF4

Type "GRPG" to the prompt "ACTIVITY?".

GRPG requests input and output filenames. To enter commands interactively, type a carriage return to the input file request. GRPG prompts with "GRPG:" when ready for a new command.

3.5. Sample GRPG Command File

```
DECLARE REAL &LOADP, &LOADQ, &GENP, &GENQ

DRAW LINE FROM 0,2.5 TO 0,4.5

DRAW LINE TO 1.5,4.5

DRAW LINE TO 1.5,6

DRAW LINE TO 7,6

DRAW LINE TO 7,2.5

DRAW LINE TO 0,2.5

SET TEXT HEIGHT TO 0.25

SET TEXT ANGLE TO 90.

JUSTIFY TEXT CENTERED

WRITE 'AREA 1' AT 2.5,4.25

SET TEXT HEIGHT TO 0.1

JUSTIFY TEXT LEFT

LET &LOADP = THE LOAD FOR AREA 1

LET &GENP = THE GENERATION FOR AREA 1

WRITE 'LOAD =',&LOADP,'MW<CR>', AT 4.25,3.25

WRITE ' ',&LOADQ,'MVAR<CR><CR>'

WRITE 'GEN =',&GENP,'MW<CR>'

WRITE ' ',&GENQ,'MVAR'

END
```

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```
         |MWP  |
         |MWI  |
|ALTER | |MWY  |                                          [ |MW | ]
|CHANGE| |MVARQ| LOAD [n] BUS (bus id) [L0AD(id)] TO (R) [ |MVAR|]
         |MVARI|
         |MVARY|


|ALTER | |MWG  | |LOAD |                                       [|MW  | ]
|CHANGE| |MVARB| |SHUNT| [n] BUS (bus id) [SHUNT (id)] TO (R) [|MVAR| ]


|ALTER |
|CHANGE| BUS (bus id) CODE TO (I)


|ALTER | |R|                                                       [|CKT    |     ]
|CHANGE| |X| TO (R) [n] FROM [n] BUS (bus id) TO [n] BUS (bus id) [|CIRCUIT| (id)]
         |B|

                                 [|Y         |           |MVA   |              ]
APPLY FAULT [n] BUS (bus id) [n] [|ADMITTANCE| (R1) (R2) |MHO[S]| [BASEKV (R)]]


                                 [|Z        |                              ]
APPLY FAULT [n] BUS (bus id) [n] [|IMPEDANCE| (R1) (R2) OHM[S] [BASEKV(R)]]


                |LINE  |                                            [|CKT    |     ]
APPLY FAULT [n] |TIE   | [n] FROM [n] BUS (bsid) TO [n] BUS (bsid) [|CIRCUIT| (id)] [n]
                |BRANCH|
                                              [|Y         |          |MVA   |              ]
                                              [|ADMITTANCE|(R1) (R2) |MHO[S]| [BASEKV (R)]]


                |LINE  |                                           [|CKT    |     ]
APPLY FAULT [n] |TIE   | [n] FROM [n] BUS (bsid) TO [n] BUS (bsid)[|CIRCUIT| (id)] [n]
                |BRANCH|
                                              [|Z         |                             ]
                                              [|IMPEDANCE|(R1) (R2) OHM[S] [BASEKV (R)]]


     |L-G  |
SCMU |L-L  | FAULT [n] BUS (bsid) [n] [ZL-G (R1) (R2)] [n] [ZL-L (R3) (R4)]
     |L-L-G|
```

```
                                                  [n] [CONVERTDC] [n] [APPLYZCOREC]


     |L-G   |
     |L-L   |                                                           [|CKT    |     ]
SPCB |L-L-G | FAULT (R1) [n] FROM [n] BUS (bsid) TO [n] BUS (bsid)[n] [|CIRCUIT| (id)]
     |3PHASE|
                    [n] [ZL-G (R2) (R3)] [n] [ZL-L (R4) (R5)][n] [CONVERTDC] [n] [APPLYZCOREC]


                                                               [|CKT    |    ]
SPCB 2PHASE OPEN [n] FROM [n] BUS (bsid) TO [n] BUS (bsid) [n] [|CIRCUIT|(id)]

                                               [n] [CONVERTDC] [n] [APPLYZCOREC]


                                                               [|CKT   |     ]
SPCB 1PHASE OPEN [n] FROM [n] BUS (bsid) TO [n] BUS (bsid) [n] [|CIRCUIT|(id)]

                    [n] [PATH (R1) [ [n] [ZL-G (R2) (R3)] ][n] [CONVERTDC] [n] [APPLYZCOREC]


                                                              [|CKT   |     ]
SPCB BREAKER OPEN [n] AT [n] BUS (bsid) TO [n] BUS (bsid) [n] [|CIRCUIT|(id)]

                    [n] [PATH (R1) [ [n] [ZL-G (R2) (R3)]] [n] [CONVERTDC] [n] [APPLYZCOREC]


|BLOCK
|UNBLOCK| DCLINE (dc id)


CLEAR FAULT [n] [BUS (bus id)]


CLEAR BUS [FAULT] [n] [BUS (bus id)]

      |LINE  |
CLEAR |TIE   | FAULT [n]
      |BRANCH|

CONVERT [n] MW TO (R) (R) [MVAR TO (R) (R)]

|RECONNECT| |LINE  |                                                  [|CKT    |     ]
|CLOSE    | |TIE   | [n] FROM [n] BUS (bus id) TO [n] BUS (bus id)[|CIRCUIT| (id)]
|RECLOSE  | |BRANCH|

|DISCONNECT| |LINE  |                                                  [|CKT    |     ]
|TRIP      | |TIE   | [n] FROM [n] BUS (bus id) TO [n] BUS (busid) [|CIRCUIT| (id)]
|OPEN      | |BRANCH|

|RECONNECT|                                                                      [|CKT           ]
|CLOSE    | THREEWINDING [n] FROM [n] BUS (bsid) TO [n] BUS (bsid) TO [n] BUS (bsid) [|CIRCUIT| (id)]
|RECLOSE  |

|DISCONNECT|                                                                     [|CKT           ]
|TRIP      | THREEWINDING [n] FROM [n] BUS (bsid) TO [n] BUS (bsid)TO [n] BUS (bsid) [|CIRCUIT| (id)]
|OPEN      |

|DISCONNECT|                                                                   [|CKT          ]
```

```
|TRIP      | THREEWINDING [n] AT [n] BUS (bsid) TO [n] BUS (bsid)TO [n] BUS (bsid) [|CIRCUIT| (id)]
|OPEN      |


DISCONNECT BUS (bus id) [n]


     |UNIT     |
     |GENERATOR|
DROP |MACHINE  | (id) [n] BUS (bus id)
     |LOAD     |
     |SHUNT    |


          |UNIT     |
          |GENERATOR|
RECONNECT |MACHINE  | (id) [n] BUS (bus id)
          |LOAD     |
          |SHUNT    |


DROP PLANT [n] BUS (bus id)


RECONNECT PLANT [n] BUS (bus id)

                                          [NOW                             ]
HOLD [n] IN (filename-1) AND (filename-2) [SIZE[S] (I1) (I2) (I3)(I4) (I5)]

                    |ON |
CONVERGENCE MONITOR |OFF|


|INITIALIZE| OUTPUT |(filename)| [SNAPSHOT |(filename)|]
|START     |        |NONE      | [         |NONE      |]


|INITIALIZE| EXTENDED [n] OUTPUT |(filename)| [n]
|START     |                     |NONE      |



NEXT [CHANNEL[S] (I)] [VAR[S] (I)] [ICON[S] (I)]


      |FLOWP  |                                     [|CKT    |    ]
PLACE |FLOWPQ | [n] BUS (bus id) TO [n] BUS (bus id) [|CIRCUIT|(id)]
      |FLOWMVA|
      |RELAY2 |
                                            IN CHANNEL[S] [WITH IDENTIFIER[S] (ident) [AND (ident)]]


      |3WNDFLOWP  |                                                        [|CKT    |     ]
PLACE |3WNDFLOWPQ | [n] BUS (bus id) TO [n] BUS (bus id) TO [n]BUS (bus id) [|CIRCUIT| (id)]
      |3WNDFLOWMVA|
      |3WNDRELAY3 |
                                            IN CHANNEL[S] [WITH IDENTIFIER[S] (ident) [AND (ident)]]


PLACE quantity [n] BUS (bus id) [MACHINE (id)] IN CHANNEL[S] [WITH IDENTIFIER[S] (ident) [AND (ident)]]
```

```
      where "quantity" is one of the following mnemonics:
          ANGLE  PELEC   QELEC   ETERM    ECOMP     EFD        PMECH      VREF
          SPEED  XADIFD  VOTHSG  VUEL     VOEL      MACHITERM  MACHAPPIMP


      |PLOAD|
PLACE |QLOAD| [n] BUS (bus id) [LOAD (id)]IN CHANNEL [WITH IDENTIFIER (ident)]


      |BSFREQ  |
PLACE |VOLTAGE | [n] BUS (bus id) IN CHANNEL[S] [WITH IDENTIFIER[S] (ident) [AND (ident)]]
      |VOLT&ANG|


PLACE quantity [n] BUSES (I1) THRU (I2) IN CHANNEL[S]

      where "quantity" is one of the following mnemonics:
          ANGLE  PELEC   QELEC   ETERM    ECOMP     EFD        PMECH      VREF
          SPEED  XADIFD  VOTHSG  VUEL     VOEL      MACHITERM  MACHAPPIMP
          PLOAD  QLOAD   BSFREQ  VOLTAGE  VOLT&ANG


      |VAR[S]  |
PLACE |STATE[S]| (I1) [THRU (I2)] IN CHANNEL[S]


RECOVER [n] FROM (snapshot-filename) AND (saved-case-filename) [NOFACT] [NOTYSL] [NORETURN]


        |TO |      |CYCLE[S] |
RUN [n] |FOR| (R) |SECOND[S]| [PRINT (I)] [PLOT (I)] [CRTPLT (I)]


                        |POWER   |
                        |CURRENT |
SET [n] DCLINE (dc id) |SETPOINT| TO (R)
                        |SCHEDULE|
                        |VOLTAGE |


        |VAR
SET [n] |CON| (I) TO (R)


                     |(C)|
SET [n] ICON (I) TO |(I)|


        |VAR[S]|
SET [n] |CON[S]| (I1) THRU (In) TO (R1) ... (Rn)


                                    |(C1) ... (Cn)|
SET [n] ICON[S] (I1) THRU (In) TO |(I1) ... (In)|


                         [|CYCLE[S] |]
SET [n] STEP TO (R) (n) [|SECOND[S]|] [n]
```

```
SHED LOAD [n] BUS (bus id)


|PSS     |
|PASS    |
|PASSTHRU|

FIN

ABORT

CHECK

WATCH |ON |
      |OFF|

|USE |
|COPY| (response-file-filename) [arg1...[arg9]]
|IDEV|

EXECUTE (iplan-program-filename)

HELP [(command)]

END
```

4.1. NOTES:

1. [n] => Optional comments
2. | | => "or" - pick one from list
3. [ ] => optional argument
4. (I) => INTEGER value to be entered
5. (R) => REAL value to be entered
6. (C) => quoted CHARACTER value to be entered (1 or 2 characters)
7. Words in CAPITALS must be entered exactly as shown.
8. Commas and "=" can be used in lieu of spaces for clarity.
9. Default PSAS output file is PSASnnn.IDV.
10. If "CIRCUIT (ID)" is not specified, default is circuit "1". If "LOAD (id)" is not specified, default is load "1".
11. BASEKV optional with PU. BASEKV required with OHMS or MHOS unless BASEKV is stored with working case.
12. BUS-ID is sensitive to the name/number input options switch of PSS®E (names must be enclosed in quotes and include the voltage field).
13. A $ is used to continue a PSAS command on the following line.
14. Section 16.15.2 of the *PSS® E Program Operation Manual* contains detailed instructions on the use of each PSAS command.

4.2. PSAS Command Help

Entering the command "HELP" while executing PSAS will cause the list of PSAS commands to be displayed on the user terminal. "HELP, command" will cause the format for that command to be displayed.

4.3. User-Entered PSS®E Commands

To enter a series of PSS®E commands into the output file, type "PSS". PSAS responds with the "PASSTHRU:" prompt, indicting pass-thru mode. Each line entered is passed to the output file as ENTERED. To terminate the PSS®E pass-thru mode, type "FIN", the "PSAS:" prompt is then issued. This mode of input is accepted both from the terminal and from input files.

4.4. PSAS Input Files

Commands may be taken from a file as well as from the terminal. If a file is to be used for input, the commands are entered in the file exactly as they would be from the terminal. When PSAS has processed all input file commands (the "END" command has been reached), PSAS exits to the PSS®E dynamics activity selector. If any errors are encountered while processing the input file, an error message is sent to the terminal and the input line is ignored. Execution of the generated response file is not attempted if any errors are detected.

4.5. To Execute PSAS From PSSDS4

Type "PSAS" or "PSAS,CHECK" to the prompt "ACTIVITY?".

PSAS requests input and output filenames. To enter commands interactively, type a carriage return to the input file request. PSAS prompts with "PSAS:" when ready for a new command. If the optional suffix "CHECK" is included, PSAS does not attempt to execute the generated response file.

4.6. Sample PSAS Command File

```
RECOVER data FROM SNU1 AND SME2

PLACE PMECH at BUS 100 IN CHANNEL

START, OUTPUT=OUT1

RUN pre-fault conditions TO 0 SECONDS

APPLY FAULT at BUS 201 z=.05,0 OHMS

RUN with fault FOR 3 CYCLES, PLOT=1

CLEAR FAULT

TRIP LINE FROM BUS 200 TO BUS 201

RUN post-fault conditions TO.5 SECONDS

RECLOSE LINE FROM BUS 201 TO BUS 200

RUN TO 5 SECONDS

HOLD final conditions IN STEMP AND LTEMP

END
```

4.7. NOTES:

1. Optional text is shown in lower case.
2. Commas and equal signs are used only to clarify the dialog. They are not required.

Chapter 5

Engineering Basic PSEB User's Ready Reference

```
ABORT


         |MW   |
         |MWP  |
         |MWI  |
|ALTER | |MWY  |                                        [ |MW | ]
|CHANGE| |MVAR | LOAD [n] BUS (bus id) [LOAD (id)] TO (R) [ |MVAR|]
         |MVARQ|
         |MVARI|
         |MVARY|


         |MW   |
|ALTER | |MWG  |                                          [|MW  |]
|CHANGE| |MVAR | SHUNT [n] BUS (bus id) [SHUNT (id)] TO (R) [|MVAR|]
         |MVARB|


|ALTER |
|CHANGE| BUS (bus id) CODE TO (I)


|ALTER | |R|                                                   [|CKT    |     ]
|CHANGE| |X| TO (R) [n] FROM [n] BUS (bus id) TO [n] BUS (bus id)[|CIRCUIT| (id)]
         |B|


|BLOCK  |
|UNBLOCK| DCLINE (dc id)


CHECK


|RECONNECT| |LINE  |                                              [|CKT    |     ]
|CLOSE    | |TIE   | [n] FROM [n] BUS (bus id) TO [n] BUS (bus id)[|CIRCUIT| (id)]
|RECLOSE  | |BRANCH|


|RECONNECT|                                                                          [|CKT          ]
|CLOSE    | THREEWINDING [n] FROM [n] BUS (bsid) TO [n] BUS (bsid)TO [n] BUS (bsid) [|CIRCUIT| (id)]
|RECLOSE  |


     |UNIT     |
DROP |GENERATOR| (id) [n] BUS (bus id)
     |MACHINE  |
     |LOAD     |
     |SHUNT    |
```

```
          |UNIT     |
RECONNECT |GENERATOR| (id) [n] BUS (bus id)
          |MACHINE  |
          |LOAD     |
          |SHUNT    |
```

```
DROP PLANT [n] BUS (bus id)
```

```
RECONNECT PLANT [n] BUS (bus id)
```

```
END
```

```
FIN
```

```
HELP [(command)]
```

```
HOLD [n] IN (saved-case-filename) [NOW]
```

```
|USE |
|COPY| (response-file-filename) [arg1...[arg9]]
|IDEV|
```

```
EXECUTE (iplan-program-filename)
```

```
|DISCONNECT| |LINE  |                                              [|CKT    |     ]
|TRIP      | |TIE   | [n] FROM [n] BUS (bus id) TO [n] BUS (busid) [|CIRCUIT| (id)]
|OPEN      | |BRANCH|
```

```
|DISCONNECT|                                                                  [|CKT          ]
|TRIP      | THREEWINDING [n] FROM [n] BUS (bsid) TO [n] BUS (bsid)TO [n] BUS (bsid) [|CIRCUIT| (id)]
|OPEN      |
```

```
|DISCONNECT|                                                                [|CKT          ]
|TRIP      | THREEWINDING [n] AT [n] BUS (bsid) TO [n] BUS (bsid)TO [n] BUS (bsid) [|CIRCUIT| (id)]
|OPEN      |
```

```
DISCONNECT BUS (bus id) [n]
```

```
                   |BUS   |
NET GENERATION [n] |BUSES| (bus id) [(bus id)...[(bus id)]]
```

```
NET GENERATION [n] FOR BUSES (I) THRU (I)
```

```
|PSS     |
|PASS    |
|PASSTHRU|


RECOVER [n] FROM (saved-case-filename)


                   |SETPOINT|
SET DCLINE (dc id) |SCHEDULE| TO (R)


SET LOADFLOW TITLE LINE |1| TO '(title)'
                        |2|


SET SOLUTION OPTION[S] TO DEFAULT


SET SOLUTION OPTION[S] TO [|DISCRETE-TAP|],[|AREA-LOCKED|],[FLAT-START],[|DC-LOCKED|],
                          [|DIRECT-TAP  |] [|AREA-INTCHG|]              [|DC-ADJUST|]
                          [|TAP-LOCKED  |] [|TIES&LOADS |]
                                                                    [|SHUNT-LOCKED|],[|PHASE-SHIFT |]
                                                                    [|SHUNT-ADJUST|] [|PSHFT-LOCKED|]
                                                                    [|SHN-ADJ-CONT|]


SHED LOAD [n] BUS (bus id)


                |FNSL|
                |FDNS| [                     |AFTER (I) [ITERATION[S]]|]
SOLVE [n] USING |NSOL| [WITH VAR LIMITS [n] |IMMEDIATE[LY]           |]
                |SOLV| [                     |IGNORED                 |]
                |MSLV|
                |INLF|


WATCH [OFF]
```

5.1. NOTES:

1. [n] => Optional comments
2. | | => "or" - pick one from list
3. [ ] => optional argument
4. (I) => INTEGER value to be entered
5. (R) => REAL value to be entered
6. Words in CAPITALS must be entered exactly as shown.
7. Commas and "=" can be used in lieu of spaces for clarity.
8. Default PSEB output file is PSEBnnn.IDV.
9. If "CIRCUIT (id)" is not specified, default is circuit "1". If "LOAD (id)" is not specified, default is load "1".
10. BUS-ID is sensitive to the name/number input options switch of ®E (names must be enclosed in quotes and include the base voltage field).
11. A $ is used to continue a PSEB command on the following line.
12. (title) => a quoted string specifying the 60 character title line.
13. Section 16.4.2 of the ®*E Program Operation Manual* contains detailed instructions on the use of each PSEB command.

5.2. PSEB Command Help

Entering the command "HELP" while executing PSEB will cause the list of PSEB commands to be displayed on the user terminal. "HELP, command" will cause the format for that command to be displayed.

5.3. User-Entered PSS®E Commands

To enter a series of PSS®E commands into the output file, type "PSS". PSEB responds with the "PASSTHRU:" prompt, indicting pass-thru mode. Each line entered is passed to the output file as ENTERED. To terminate the PSS®E pass-thru mode, type "FIN", the "PSEB:" prompt is then issued. This mode of input is accepted both from the terminal and from input files.

5.4. PSEB Input Files

Commands may be taken from a file as well as from the terminal. If a file is to be used for input, the commands are entered in the file exactly as they would be from the terminal. When PSEB has processed all input file commands (the "END" command has been reached), PSEB exits to the PSS®E power flow activity selector. If any errors are encountered while processing the input file, an error message is sent to the terminal and the input line is ignored. Execution of the generated response file is not attempted if any errors are detected.

5.5. To Execute PSEB From PSSLF4

Type "PSEB" or "PSEB,CHECK" to the prompt "ACTIVITY?".

PSEB requests input and output filenames. To enter commands interactively, type a carriage return to the input file request. PSEB prompts with "PSEB:" when ready for a new command. If the optional suffix "CHECK" is included, PSEB does not attempt to execute the generated responses.

5.6. Sample PSEB Command File

```
RECOVER network FROM SAVNW.SAV

SET SOLUTION OPTIONS TO DIRECT-TAP, $

   AREA-INT, SHUNT-LOCKED

TRIP BRANCH FROM BUS 153 TO BUS 154 CKT 2

SOLVE USING FDNS WITH VAR LIMITS applied $

   AFTER 2 ITERATIONS

HOLD network IN SAVNEW.SAV

END
```

5.7. NOTES:

1. Optional text is shown in lower case.

2. Commas and equal signs are used only to clarify the dialog. They are not required.