

PROPOSED DATA STRUCTURE FOR EXCHANGE OF  
POWER SYSTEM ANALYTICAL DATA

Draft Working Group Report by  
Working Group on Exchange of Power  
System Analytical Data

Abstract

This working group report presents the principal characteristics of a proposed definition of a file for the exchange of power system analytical data. The data covered by this proposed exchange mechanism is intended to update the existing "Common Format for the Exchange of Solved Load Flow Data" which has been in use since 1965. The principles outlined in this report will be implemented, after review, in a manual specifying the data exchange file in detail.

INTRODUCTION

This paper presents the concept and principal characteristics of a data file (referred to hereafter as the EPSAD file) intended for use in the exchange of power system analytical data between computers and between programs within a computer.

The EPSAD file is the result of a review of the "Common Format for the Exchange of Solved Load Flow Data," described in Reference 1, which has been in use since about 1965. The design of the EPSAD file was stimulated by advances in computer capabilities and data recording media, by advances in power system analysis technique, and by limitations in the "Common Format." Among its limitations, the "Common Format" has inadequate capability for expansion, does not handle many data items used by Load Flow programs now in general use, and does not handle data for many programs closely associated with load flow, such as optimal power flow, economic dispatch, short circuit, and state estimation. A further, and important, limitation of the "Common Format" is that it presumes the use of some very approximate equipment models (notably a transformer model) which were dictated by the computer limitations existing in 1965. This prevents complete unambiguous transfer of data and is unnecessary in presently available computers.

The complete definition of the EPSAD file is a manual showing the arrangement of all data items, their definitions, their units, constraints on their use, and default values where applicable. The manual is too voluminous to be included in this paper. It will, after review and acceptance, become an IEEE special publication; for the time being draft copies can be obtained from members of the EPSAD Working Group.

The purpose of this paper is to introduce the EPSAD file, to describe its anticipated application, and to encourage comment and discussion.

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OBJECTIVES AND SCOPE

The objectives in the design of the EPSAD file were:

- to provide a data exchange file whose scope meets the full spectrum of needs and capabilities of load flow programs presently in use
- to provide an expandable file design which will allow new data items to be handled by the file as power system analysis technique advances and data requirements broaden
- to be able to handle data pertaining to the broad spectrum of network solution, dispatching, and data manipulating programs that are used in conjunction with load flow programs
- to ensure that the EPSAD file can be used at a level of detail matching the users' current needs; so that users wishing to exchange data of minimum detail do not have to handle parts of the file that are required only by users working at a higher level of detail
- to allow the level of detail of the power system description in an EPSAD file to be built up progressively as data becomes available.

The EPSAD file is designed on the principles that it should:

- identify power system components to the fullest extent possible by names and naming conventions that can retain the individual identity of components
- transmit basic data on components wherever possible without constraining the choice of mathematical model in which the basic data, or data computed from it, is to be used.

The present definition of the EPSAD file covers standard load flow data, a flexible method of specifying groupings of equipment and ratings, negative and zero-sequence data, and economic dispatch data. The present definition does not cover data such as outage rates, winding capacitances, or metering accuracies; the file is however, designed to permit the addition of such new data categories in the future.

FILE OVERVIEW

Data Records

The EPSAD file consists of data records, each of which contains data on a single item of equipment, control objective, equipment grouping, or rating. The data records are defined in accordance with a tree structure with the level of descriptive detail increasing with increasing distance from the root.

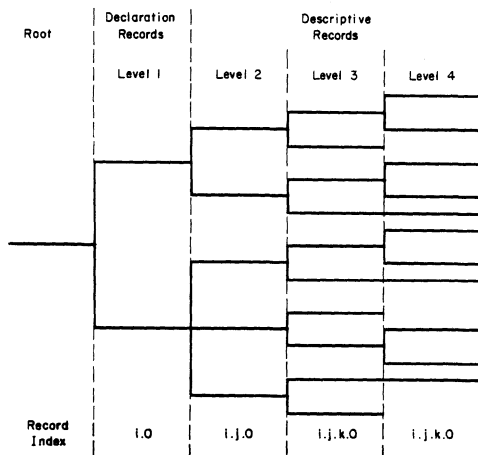


FIGURE 1  
TREE ORGANIZATION OF  
EPSAD FILE

The tree structure of the EPSAD file is shown in Figure 1. Records at level 1 of the tree are Declarative; they declare items of equipment, groupings, or ratings, to exist, and contain the most basic descriptive data. Records at level 2 and beyond contain Descriptive data on the items identified by the records in the tree paths to them. The Declarative records cover:

- File Description
- Buses
- Branches
- Transformers
- Generators and Rotating Machines
- Loads
- Nonsynchronous Shunt Reactive Devices
- Groupings of Equipment
- Ratings
- Interchange Control
- D.C. Converters

Each Bus, grouping, and rating is given both an alphanumeric identifier and a number in its declarative record, and is referenced by number in all other records. Each Branch, load, and other equipment is given an alphanumeric identifier in its declaration record, and is identified by this and the number of the bus or buses to which it is connected in all records.

A simple basic load flow file would consist mainly of Declarative records with relatively few Descriptive records. The more detailed data file required to take full advantage of the capabilities of advanced load flow and related programs would include several Descriptive records to expand on each Declarative record.

Descriptive records are required to follow their Declarative record immediately in an order defined by the tree, but Declarative records may occur in any order.

The Declarative records pertain to individual items of equipment; hence a substation serving three loads could be described in the file by a single Bus Declaration record, three Load Declaration records, and a set of Descriptive records following each load Declaration record. The three loads could be of the same type or different but, in any case, each could be identified, described, and switched separately. Where applicable, the data records contain status information so that the file may contain data on all equipment in a system, whether or not it is in use in the case from which the file is generated.

The issues of equipment ownership, loss accounting zones, interchange control areas, assignment of jointly owned plant output, and so on are handled by a very flexible system of grouping definitions and grouping references as described further below.

#### Data Definition Principles

The data defined in the EPSAD file, as far as possible, describes actual equipment rather than mathematical models of equipment. To this end equipment data are given in terms of nameplate items, standard test parameters, and ratings wherever possible, and reference to model parameters that can be deduced from the physical data is avoided wherever possible. For example:

- Transformers are described in terms of standard test parameters, such as the set of leakage impedances, ZLH, ZLT, ZHT of a three-winding unit, that can be measured by short circuiting each winding in turn.
- Transmission line impedances are expressed in per unit with respect to the system MVA base and the base voltage of each individual line.
- All other parameters that are stated in per unit are based on the MVA base and base voltage of the individual item of equipment.

#### Mode of Use

Current power system analysis technique calls for the exchange of data both between separate computers, and between different analytical functions within a single computer. The origin and destination of the data may be different programs belonging to different corporate entities, or may be one and the same program used at different times or by different departments. For example, the bus loads needed for a future-year load flow study might be generated in a load projection program and then handed over to a load flow program in the same computer. The resulting load flow solution might then be forwarded to another power company.

The key point is that data is exchanged between programs whose scope, vintage, analytical basis, and hardware environments may be quite different, but which have either a need for, or the ability to provide, values for some of the data for which provisions are made in the EPSAD file. It is anticipated that the EPSAD file will be used in a variety of ways, as shown in Figure 2. The majority of read and write operations on the EPSAD file will be made by the bulk input/output sections of application programs as shown by paths 1 through 4 in Figure 2. Ideally, each application program could have a bulk data interface for direct reading and writing to EPSAD files. This will not be practical in all cases and some programs, particularly older ones, will communicate with EPSAD files only by way of data transcription programs. The writing and maintenance of data transcription programs is a major burden on power system programming staffs, and it is an objective of the EPSAD file to provide a common reference point that will minimize the need for such work in the future.

It is anticipated that, in addition to its function as a bulk program-to-program communication tool, the EPSAD file will be used in transaction-oriented human data interfaces as indicated by path 5 in Figure 2. Such a human interface could involve direct inspection or modification of an EPSAD file with the conventional text editors of many current computers. However, the EPSAD file has been designed with the expectation that data display and updating

programs will emerge to aid users in handling EPSAD files. These typically might provide pre-formatted displays where specific data items can appear, or be entered into, identified fields on a video terminal.

A user could keep a library of EPSAD files, as indicated by path 6 of Figure 2 to directly parallel the libraries of case files that have, hitherto, been a standard method of recording power system analytical data.

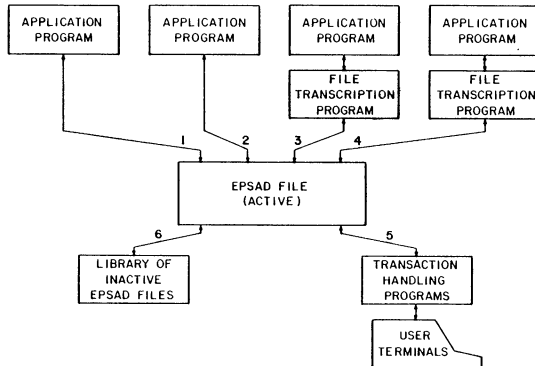


FIGURE 2  
USE OF EPSAD FILE

### Significant Features

As an indication of the level of detail of system description permitted by the EPSAD file, this section summarizes some key points where it differs from some of the several power system data exchange files now in common use:

- File Description - The EPSAD file may contain an unlimited number of general title lines, and includes counts of basic system components.
- Bus Data - Voltage control objectives are a bus attribute. Both control and limit checking values may be specified.
- Branch Data - Each branch may contain multiple pi-sections. Line connected shunt and series devices are represented as a part of the line and are switched with it. Data for automatic control of series elements (capacitors and reactors) may be included.
- Transformer Data - Up to four windings are recognized explicitly in each transformer. Impedances are expressed in short circuit and open circuit test form without reference to any transformer model. Winding connections (such as wye or delta) may be stated. Both manual and automatically changed taps may be described, and the variation of leakage impedances with tap position may be stated.
- Generator and Rotating Machine Data - Economic dispatch data may be included. The machine capability curve may be stated. Station service load is recognized. Machine impedances for short circuit purposes are recognized. Energy storage units (such as pumped storage) are recognized.
- Load Data - Multiple loads may be connected at any bus. A range of polynomial load characteristics, and a specific

induction motor load characteristic, are recognized.

- Non-synchronous Shunt Reactive Devices Data - Controlled shunt reactive devices are recognized. These devices may be connected to buses or branches.
- Grouping Data - The concept of areas and zones is expanded to allow any number of groupings of buses and equipments. This allows flexibility in recording functions such as accounting for losses or assignment of generator output.
- Rating Data - The user may define any number of rating types.
- Interchange Data - A control area may be assigned multiple adjustable (slack) generators. Specific interchange transactions schedules, as well as net interchange, are recognized.
- D.C. Converter Data - Provision is made for data on dc converters.

### FILE STRUCTURE

#### Data Form and Media

The EPSAD file is defined without reference to the medium in which it is stored, the computer operating system discipline under which it will be accessed, or the language and programming technique that might be used to handle it. The data in the file is encoded in alphanumeric character form, but no reference is made to the details of the character set (e.g. ASCII) used, since it is expected that the computer in which the file is used will dictate this choice, as it does the choice of storage medium, and access technique.

Each record of the file consists of a record identifier and a data list. The record identifier and data list are separated by a slash, and the data list is terminated by a slash. The record identifier consists of one or more integer numbers separated by blanks which identify the record in accordance with the numbering system presented in Figure 1 and Table I. Trailing zeroes and trailing blanks may be omitted from the record identifier. The contents of each record are identified and defined by a data index and dictionary whose forms are shown, respectively, in Table I and II.

The data list consists of a sequence of values of real, integer, logical, complex, or character variables in accordance with section 13.6 of ANSI Standard X3.9-1978, (reference 2). As provided in the standard, data items are separated by commas or blanks and items may be skipped by the use of successive commas.

The Fortran standard is referenced, not as an endorsement of Fortran or suggestion that Fortran be used, but simply because it is applicable, well tested in practice, and widely available. It is recognized that it will not be possible to process a record of the EPSAD file and its record identifier together with a single statement of Fortran, or of many other languages. It is noted that a very wide variety of programming techniques and tools is available to permit processing of records such as those defined here.

#### Record Hierarchy

The EPSAD file is a hierarchical set of records organized as shown in Figure 1. The record types, their contents, and the rules governing their order of

TABLE I

Section of EPSAD Data Index

	Record/Item Index	Record/Item Description
Declaration Record Data Items	3 0 0 0 0	0/ Branch Data
	3 0 1 0 0	0/ From bus identifier
	3 0 2 0 0	0/ To bus identifier
	3 0 3 0 0	0/ Circuit Identifier
	3 0 4 0 0	0/ Section number
	3 0 5 0 0	0/ Status
	3 0 6 0 0	0/ Section Base kV
	3 0 7 0 0	0/ Section series resistance
	3 0 8 0 0	0/ Section series reactance
	3 0 9 0 0	0/ Shunt conductance
	3 0 10 0 0	0/ Shunt susceptance
3 0 11 0 0	0/ Line Name	
Descriptive Record Data Items	3 1 0 0 0	0/ Grouping References
	3 1 0 1 0	0/ Group Identifier (1...n)
	3 1 0 2 0	0/ Per unit assignment to group (1...n)
	3 1 0 3 0	0/ Per unit losses assigned to group (1...n)
	3 2 0 0 0	0/ Descriptive Data
	3 2 0 1 0	0/ Type Identifier
	3 2 0 2 0	0/ Length
	3 2 0 3 0	0/ Descriptive Text
	3 3 0 0 0	0/ Rating Data
	3 3 0 1 0	0/ Rating Number (1...n)
	3 3 0 2 0	0/ Rating Value (1...n)
	3 4 0 0 0	0/ Branch Section Lumped Shunt Element Data
	3 4 0 1 0	0/ From Bus Conductance
	3 4 0 2 0	0/ From Bus Susceptance
	3 4 0 3 0	0/ To Bus Conductance
	3 4 0 4 0	0/ To Bus Susceptance
	3 5 0 0 0	0/ Section bypass control
	3 5 0 1 0	0/ Control mode
	3 5 0 2 0	0/ Control priority
	3 5 0 3 0	0/ Controlled element bus 1
	3 5 0 4 0	0/ Controlled element bus 2
	3 5 0 5 0	0/ Generator, circuit, or transformer identifier
	3 5 0 6 0	0/ Lower MW flow for bypass control
	3 5 0 7 0	0/ Upper MW flow for bypass control
	3 6 0 0 0	0/ Branch Zero Sequence Data
	3 6 0 1 0	0/ Section zero sequence series resistance
	3 6 0 2 0	0/ Section zero sequence series reactance
	3 6 0 3 0	0/ Section zero sequence shunt conductance
	3 6 0 4 0	0/ Section zero sequence shunt susceptance
	3 6 1 0 0	0/ Branch section lumped zero sequence shunt element data
	3 6 1 0 1	0/ From bus zero sequence conductance
	3 6 1 0 2	0/ From bus zero sequence susceptance
	3 6 1 0 3	0/ To bus zero sequence conductance
	3 6 1 0 4	0/ To bus zero sequence susceptance
	3 6 1 0 5	0/ From bus grounding resistance, 3Rg
	3 6 1 0 6	0/ From bus grounding reactance, 3Xg
	3 6 1 0 7	0/ To bus grounding resistance, 3Rg
	3 6 1 0 8	0/ To bus grounding reactance, 3Xg
	3 6 2 0 0	0/ Zero Sequence Mutual Data
	3 6 2 0 1	0/ From bus identifier
	3 6 2 0 2	0/ To bus identifier
	3 6 2 0 3	0/ Circuit identifier
	3 6 2 0 4	0/ Section number
	3 6 2 0 5	0/ Zero sequence mutual coupling resistance
	3 6 2 0 6	0/ Zero sequence mutual coupling reactance
	3 6 2 0 7	0/ Zero sequence mutual coupling conductance
	3 6 2 0 8	0/ Zero sequence mutual coupling susceptance

TABLE II

Section of EPSAD Data Dictionary

## Record Index

↓ Data Item Index

3	0	0	Branch Data	Definition - declares a branch to exist Data Type - record
3	0	1	From bus identifier	Definition - number of "from" bus of this branch Units - Default - Constraints - mandatory; must be declared in (2 0 3) Data Type - integer
3	0	2	To bus identifier	Definition - number of "to" bus of this branch Units - Default - Constraints - mandatory; must be declared in (2 0 3) Data Type - integer
3	0	3	Circuit Identifier	Definition - alphanumeric circuit identifier to distinguish between several branches joining same pair of buses Units - Default - defaults to blanks Constraints - Data Type - character * 8
3	0	4	Section number	Definition - indicates position of this branch section in the branch Units - Default - defaults to 0 Constraints - sections must be numbered in ascending order beginning with section adjacent to "from" bus; section no. >= 0 Data Type - integer
3	0	5	Status	Definition - indicates condition of the section: 0 = not connected at both ends 1 = connected at both ends 2 = bypassed by zero impedance with no control 3 = bypassed by zero impedance but with control (3.5) 4 = not bypassed by zero impedance but with control (3.5) Units - Default - defaults to 1 Constraints - Data Type - integer
3	0	6	Section Base kV	Definition - base voltage used in calculating section impedances, line-to-line RMS if a.c., line-to-ground if d.c. Units - kV Default - defaults to base voltage (2.0.2) of from bus (3.0.1) Constraints - Data Type - real
3	0	7	Section series resistance	Definition - series resistance of this section Units - per unit on system base MVA and section base voltage (3.0.6) Default - Constraints - mandatory Data Type - real
3	0	8	Section series reactance	Definition - series reactance of this section Units - per unit on system base MVA and section base voltage (3.0.6) Default - Constraints - mandatory; for a d.c. line base frequency must be system value (1 1 0 2) Data Type - real

appearance are based on the tree structure and on the objective that the level of detail of the system description in the file is increased by adding records at successively higher levels of the tree.

The rules relating to record types and ordering are given in detail in the EPSAD file handbook. The principal rule is that all records must appear in the EPSAD file in tree-order with the Declaration Record for each component being the first record in the sub-tree pertaining to it. All records located outward in the tree from a given record must appear before the next record at the same tree level as the given record. Further, each record must be preceded by all records in the tree path from the root to itself. This ensures that all Descriptive records pertaining to a given component appear directly behind the Declaration record of that component, and hence that the subject of each Descriptive record is known.

Records at the same tree level may appear in any order.

#### Declaration Records

Each declaration record specifies the identifying name and location of a component. For example, the record

```
2 / 'MIDWAY' 230 52173,1,1.0316 -17.92/
```

declares the existence of the 230kv bus named MIDWAY. This bus has the number 52173, its status is 1 (in service), and its voltage in the system condition for which the file applies is 1.0316 per unit, at a phase angle of -17.92 degrees.

The record

```
4 / 52173 9046,,, 'T56' 1 150 .007 .075/
```

declares the existence of a 150MVA transformer connecting bus 52173 (MIDWAY 230) to another bus whose number is 9046. The transformer is identified, among other transformers in the substation, by the name T56, its status is 1, and it has an impedance on its own 150MVA base of (.007+j.075) per unit.

The records

```
7 / 52173 ,,, 'CAP-1' 1 20 230 0 -20
7 / 52173 ,,, 'CAP-2' 0 10 230 0 -10
```

declare that two capacitor banks, one of 20 MVAR and one of 10 MVAR, are located at bus 52173 (MIDWAY 230), that the 20 MVAR bank is connected, and that the 10 MVAR bank is disconnected.

In all cases further records are needed to provide more detailed data on the equipment declared by the Declaration records. It is intended, however, that a very basic solved load flow case could be exchanged with only a very few records other than Declaration records.

The following rules apply to Declaration records:

- Each Declaration record identifies an item of equipment by the numbers of the bus, or buses, to which it is connected, and by a device identifier.
- The existence of a bus does not imply the existence of any equipment connected to it; each item of equipment must be declared by an individual Declaration record.

- Any number of items of equipment may be located at a given bus, but each item at a bus must be assigned a suitable unique identifier.
- Buses are identified in all records except the Bus Declaration record (2 0) by the bus number only; hence the assignment of a unique bus number in the Bus Declaration record is mandatory.

The use of bus numbers rather than names throughout the EPSAD file is based on the fact that the majority of work on the file will be done via computer programs. It is expected that transaction handlers accessing the EPSAD file for human operators will automatically translate between names and numbers as preferred.

#### Descriptive Records

Descriptive records appear at level 2 and beyond in the EPSAD file. They are present in the file when data in addition to that in the Declarative Record is to be included. Descriptive records may also be required to complete the tree path to a particular desired record.

For example, to specify on load tap changer (TCUL) data for the 230kv winding of transformer T56 at bus 52173 (MIDWAY 230), the Declaration record of that transformer would be followed by a Winding Data Descriptive record (4 3) and a TCUL Data Descriptive record (4 3 2), as follows:

```
4 / 52173 9046,,, 'T56' 1 150 .007 .075/
4 3 / 52173 'GY' 230 0 0 1 150 230 2 195 230/
4 3 2 / 13 .925 1.075 1.0375 1 52173/
```

The (4 3) record states that the winding is of Grounded Wye connection, and that its base voltage is 230kV, and gives values of 150MVA and 195MVA at 230kV respectively for its ratings 1 and 2. The (4 3 2) record states that the on-load tap changer has 13 positions, a minimum per unit ratio of .925, a maximum per unit ratio of 1.075, and that it is to control the voltage of the MIDWAY 230 bus.

Additional Descriptive records would be provided if the other winding of this transformer has manually adjusted or TCUL taps, if the transformer is a phase shifter, and so on.

#### GROUPINGS AND RATINGS

##### Groupings

The EPSAD file allows the user to define an arbitrary number of groupings of equipment. These groupings are used throughout the EPSAD file to handle functions such as the specification of corporate boundaries, assignment of equipment ownership, assignment of losses, and net interchange control. Groupings are defined by Grouping Declaration records and associated Descriptive records. Each item of equipment may be assigned to any number of groups by a single Grouping Reference descriptive record.

The user may define exclusive and nonexclusive groups. Exclusive groups are intended to describe hierarchical organizational entities such as Regions (of the North American Electric Reliability Council), Pools, and Interchange Control Areas. Nonexclusive groups are to be used for any purpose that is meaningful to the user.

The rules relating to groupings are:

- A grouping may be exclusive or nonexclusive. The exclusive groups are a hierarchy, as defined below; nonexclusive groups are not restricted by the hierarchical rules.
- The equipments in a grouping need not be contiguous, either electrically or territorially.
- A bus or item of equipment may be assigned directly to only one exclusive group, but may also be assigned to any number of nonexclusive groups.
- Any exclusive group may be assigned to be a member of one, and only one, exclusive group at a higher level and of any number of nonexclusive groups. A nonexclusive group may be assigned to be a member of any other nonexclusive group, but may not be assigned to any exclusive group.
- If a group is made a member of some other group, all equipment in it is so assigned as a member of the including group.
- Any group, exclusive or nonexclusive, may consist of member groups plus individual equipments assigned directly to it.
- All group names and numbers must be unique.

The distinction between exclusive and nonexclusive groups is illustrated by Figures 3 and 4 and by the illustrative example given below.

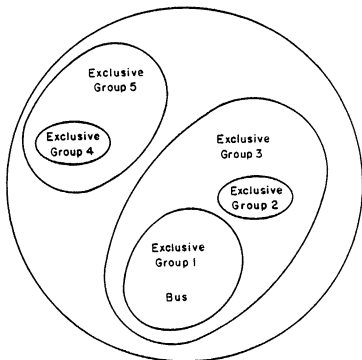


FIGURE 3 EXCLUSIVE GROUPS

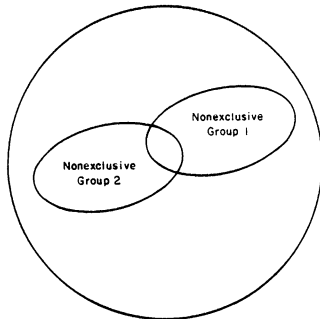


FIGURE 4 NONEXCLUSIVE GROUPS

Ratings

The EPSAD file allows an item of equipment to be assigned an arbitrary number of ratings. For a rating to be used, it must be defined by a Rating Declaration record. The Rating Declaration record identifies a rating by a name, a number, and specifies the physical units in which it is expressed. The type of equipment and the physical units in which the rating is expressed

indicate how equipment loading should be determined for comparison with the rating.

The assignment of values to declared ratings occurs on Descriptive records associated with individual equipments. For example the records

```
9 /'LIN-CNT-SUM' 3 'AMP' 'summer continuous'/
9 /'LIN-CNT-WNT' 4 'AMP' 'winter continuous'/
9 /'TRF-NORM' 1 'MVA' 'Normal rating'/
9 /'TRF-FOA-EMER' 2 'MVA' 'Emergency FOA'/'
```

declare four rating types to exist. To assign rating values to a transmission line, it's rating descriptive record could then be

```
3 3 / 3 2000 4 2500/
```

which would assign it a summer continuous rating of 2000 Amps and a winter continuous rating of 2500 Amps.

ILLUSTRATIVE EXAMPLES

Three-Winding Transformer

Figure 5 shows the basic data and bus connections of a 2000 MVA transformer interconnecting 765kV and 230kV systems. The transformer has a delta-connected 18kV tertiary winding to accommodate a synchronous condenser, a manually changed tap on its high voltage winding and an on-load tap changer on its 230kV winding. All impedances are stated with respect to the transformer base of 2000 MVA. The voltage base for each of the three windings is set equal to the nameplate nominal voltage of that winding; 765kV, 240kV, and 18kV, respectively. Note that the 240kV winding base voltage of the low voltage winding is not equal to the 230kV base voltage of the bus to which it is connected.

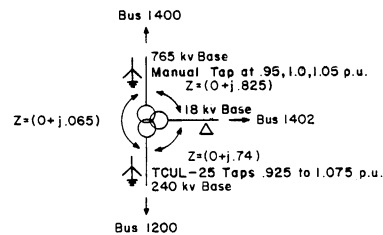


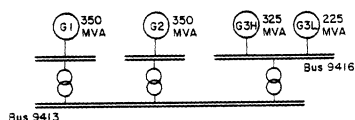
FIGURE 5 DATA RECORDS FOR THREE WINDING TRANSFORMER

The EPSAD records describing this transformer are:

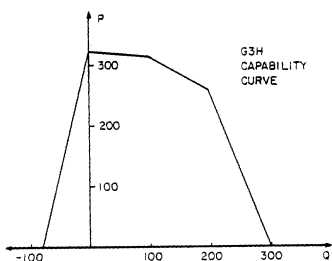
```
4 / 1200 1400 1402 0 'T2' 1 2000 0 .065 0 .825 0 .74/
4 1/ 502/
4 2/ 'SC-TERT' '3 WINDING TRANSF WITH SYNCH COND'/
4 3/ 1200 'GY' 240 0 0 101 2000 102 2500 103 2200 104 2750/
4 3 2/ 25 .925 1.075 .95625 1 1200/
4 3/ 1400 'GY' 765 0 0 101 2100 102 2600 103 2300 104 2850/
4 3 1/ 1 .95 1 1. 1 1.05 1/
4 3 / 1402 'D' 18 0 0 101 400 102 500 103 450 104 600/
```

The (4) record indicates the buses to which the transformer is connected, gives it the name, T2, indicates that it is in service, states its MVA base as 2000, and gives its three impedances. The (4 1) record assigns the transformer to area 502. The (4 2) record gives the transformer type as SC-TERT and gives descriptive text. The first (4 3) record gives data on the low voltage winding which is connected to bus 1200. The winding type is GY and its base voltage is 240kV. The winding magnetizing admittance is set to (0+j0). The rating of this winding under rating type 101 is 2000 MVA, and so on. The (4 3 2) record applies to the low voltage winding because it follows the (4 3) record for the winding before any other (4 3) record. The

(4 3 2) record states that the winding has 25 taps. The minimum tap ratio is .925 (corresponding to a voltage of 222kV in relation to the 240kV base), and the maximum tap ratio is 1.075 p.u. The tap was at the .95625 p.u. position in the load flow case on which the data file is based. The TCUL is in control mode 1, and controls voltage at bus 1200. The (4 3 1) record for the 765kV winding states that the manual tap is at the 1.0 p.u. position, that there are taps at ratios of .95, 1.0, and 1.05 p.u., and that the winding leakage impedance is equal to 1.0 times the nominal winding leakage impedance at each tap position. (Impedance correction data could have been appended to the (4 3 2) record, but was not needed for this transformer.



PLANT CONFIGURATION

FIGURE 6  
MULTI-UNIT PLANT EXAMPLE

### Multi-Unit Generator Bus

Figure 6 shows a plant containing a cross-compound unit whose two generators are connected, in effect, at the same bus. The figure also shows the capability curve for the high pressure generator of the cross-compound set.

The EPSAD records to describe the high-pressure generator are:

```
5 / 9416 'G3H' 1 325 21 286 81.6/
5 1/ 1001 1 1008 1 1009 1/
5 2/ .95 'GS2T' /
5 3/ 101 325 102 305 103 330/
5 4/ 1 9413 0 120 .92 1.01 285 89 .28 .18/
5 5/ 0 -80 300 260 -64 200 315 -7.5 100 325 0 0/
5 6/ 1001 'FP' .65 1008 'FP' .35/
5 9/ .28 .22 .22 .6 .005/
```

The (5) record shows this generator to be connected at bus 9416, to have the name G3H, to be in service, to have MVA/voltage bases of 325MVA/21kV respectively, and to be producing 286 + j81.6 MVA. The (5 1) record assigns this generator to groups 1001, 1008, 1009. The (5 2) record assigns the unit a rated power factor of .95 and states that it is a two-pole synchronous turbine generator. Record (5 3) assigns values of 325, 305, and 330 to ratings 101, 102, 103, respectively. (These ratings would be defined by rating Declaration Records to be in terms of MVA.) The (5 4) record assigns this generator to control voltage at bus 9413, sets minimum and maximum VAR limits at 0 and 120, sets minimum and maximum operating voltages for the generator at 0.92 p.u. and 1.01 p.u., states scheduled power to be 285 + j89 MVA, and assigns regulating participating factors of 0.28 and 0.18 p.u. for real and reactive power respectively. The participating factors in the (5 4) record allocate any real and/or reactive power increment required to regulate voltage at the controlled bus among the several

generators participating in the control action. The (5 5) record expresses the capability curve in terms of the lower and upper limits of allowed reactive power at real power outputs of 0, 260, 315 and 325 MW. The (5 6) record allocates 0.65 p.u. of the actual real power output of the generator to group 1001, and the other 0.35 p.u. to group 1008. The (5 9) record specifies the generator's transient reactance to be 0.28 p.u. on the generator's base of 325 MVA, and so on.

The low pressure generator connected in parallel with generator 'G3H' would be described by similar data records, with the bus number 9416 and the identifier 'G3L' in the (5) record.

### SUMMARY AND CONCLUSION

This paper describes a data file designed for use as the medium of exchange of input data and output results between computer programs related to power system network analysis. The salient features of the file are that:

It is structured to handle a varying level of detail in the system description. A system description of low detail will primarily involve only basic record types. System descriptions of greater detail can be created by adding additional descriptive records as required.

The file has a tree based structure intended to facilitate expansion of its scope by the definition of new record types.

The file is intended to be accessed mainly by computer programs. It is anticipated that the accessing programs will be both application programs reading or writing data in bulk, and transaction oriented data handlers through which human users will examine and update data entries in the file.

The complete definition of the EPSAD file is a manual containing a Dictionary of its contents and their arrangement, with definitions of all data items. It will, after review and acceptance, become an IEEE special publication; for the time being draft copies can be obtained from members of the EPSAD Working Group.

The Working Group seeks and will value comments on this EPSAD file definition and intends to publish the full manual within one year.

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