



## CHAPTER 4

### SIMPOW POWER SYSTEM SIMULATION

#### 4.1 Introduction

The computer program package SIMPOW is a tool for power system analysis. It offers calculations of loadflows, transient stabilities, eigenvalue and short circuit analysis.

The SIMPOW program package consists of:

- OPTPOW for load flow calculations
- STAPOW for short circuit calculations
- DYNPOW for dynamic calculations and
- DSL dynamic simulation language for modelling of special function

The OPTPOW program is a part of the SIMPOW family. It calculates an initial power flow in networks of unlimited number of nodes and the components (practically limited only by the computer as no limits are build into the program).

The electrical state in the ac system is assumed to be



symmetrical and sinusoidal at the power frequency. Hence, the ac system is represented by a single phase model for the power frequency. The electrical state is described by the positive sequence phasors of the node voltages, the injected currents from loads and the productions, and the turns ratios of the transformers and the phase shifters.

#### 4.2 Program system structure

A function diagram of the program system is shown in figure 4.1. The basic program functions are the optimal power flow and the transient stability calculations, program subsystem OPTPOW and TRANSTA, respectively.

The transmission system configuration and the data of the transmission system elements, given by their positive sequence parameters, the static PQ models of the production sources and load are given as input data to the OPTPOW. As the result of the calculation, the steady-state defined by the complex node voltages, the LTC-positions of the transformer and phase shifters etc. is obtained.

OPTPOW is structured into three basic modules: the preprocessor that reads the input data, writes it in an edited form, converts it to perunit-quantities, performs checks, arranges the nodes in an optimal order etc., the calculation module that solves the system of the equations, and the postprocessor that lists the results.

No limits on the number of the different types of system elements, transmission lines, transformers, generators etc., are built into the program. The maximum size of the power system that can be simulated is merely determined by the capacity of the computer system



employed for the calculations.

#### 4.3 Modelling

Most system elements can be represented such as passive and motor loads, active and reactive productions, transformers, transmission lines, shunt reactors and capacitors, and series capacitors.

Most control functions and constraints can be represented e.g. voltage control by means of reactive power sources and transformer tap changes, control of the power flow by means of power injections and phase shifters.

#### 4.4 Numerical methods

The numerical technique employed, (Gear's method) assures convergence of the solution defined by the system model.

The solution procedure for a new case starts with the system de-energized, with zero currents i.e. with a known solution. Then the reactive power sources are energized and the voltages are established, after which the active power is taken up, and finally the control variables are adjusted so that all constraints on power flow and voltages are fulfilled.

#### 4.5 Program execution

The preparation of input file to the program can be made  
- in a separate activity using the computer editor



- in a separate activity using the forms input system

All data are given in data groups. The power flow output can be printed out in lists or displayed on the single-line diagram of the network.

#### 4.6 Network model

The network will be modeled by standard system models available in SIMPOW. The models are described in the SIMPOW modelling manual.

The network model is built by the following data groups.

CONTROL DATA (program control)

...

...

...

GENERAL (power base)

...

...

...

NODES (node data)

...

...

...

LINES (transmission line data)

...

...

...

TRANSFORMERS (transformer data)  
...  
...  
...  
LOAD (system load data)  
...  
...  
...  
POWER INSTRUCTION (system constraints data)  
...  
...  
...

#### 4.6.1 Control data

Execution control parameters for normal use.

EDIT = n            Selector for printing of input data.  
n = -1    Input data is not printed  
          = 0    A list of input data is obtained  
          = 1    Input data is printed in an edited form

Used in the study

CONTROL DATA

EDIT = 0

END



#### 4.6.2 General

The data group defines certain parameters for the whole network.

SN = n (100)      n = Base power of the network in MVA. Used for  
 converting to p.u. Should be chosen so that  
 the power flows are approximately 1 p.u.

Used in the study

GENERAL

SN = 1

END

#### 4.6.3 Nodes

Parameters for normal use

N                      N = Name of the node beginning in col. 1-4.  
 UB = n                n = Base voltage of the node (phase-phase) in Kv.  
 AREA = n             n = Area code. Positive integer 1-9999.

Each node may belong to a certain area and the result is printed one area after the other. If AREA is not specified for any node, the nodes are printed in the result in the same order as the nodes were give in the input data.



Used in the study

NODES

1    UB = 0.40    AREA = 1

2    UB = 0.40    AREA = 1

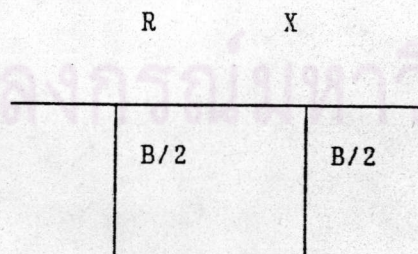
END

#### 4.6.4 Lines

Modelling : Lines may be represented as

- a line with zero impedance
- an impedance
- a  $\pi$  - link
- a d.c.-line

In the study following  $\pi$ -link model is used



R = Resistance per length unit.

X = Reactance per length unit.

B = Susceptance per length unit. The line is represented as a  $\pi$ -equivalent with the susceptance B/2 at each bus.







P = n                    n = Active power absorbed in MW.  
 Q = n                    n = Reactive power absorbed in Mvar.

Example used in the study

LOADS

30    P = 0.318    Q = 0.197

END

#### 4.6.7 Power instruction

Parameters are given for production sources (e.g. generators).  
 If a source is split up in individual units these must be declared one by one. Source of different types (see RTYP below) can be connected to a node.

N                        N = Name of the node beginning in col 1-4

TYPE n                n = NODE

RTYP n                n = SW    Swing bus.

Phase angle FI is fixed and must be given.

U or UMIN and UMAX must be given.    PMIN, PMAX,

QMIN and QMAX may be given.

U n                    n = Voltage in kV.

FI n                    n = Phase angle in degrees.

Example used in the study

POWER INSTRUCTION

12KV    TYPE = NODE    RTYP = SW    U = 12    FI = 50

END



#### 4.7 Input file preparing

After creating a file with an arbitrary name with a system editor the data is written in free file format.

The input data file must be with a title on arbitrary number of card images in col.1-80. To mark the end of the title \*\* is written in column 1 and 2.

After the title the data groups follows. Each data group is defined by its name written with the beginning in col.1, followed by the input data parameters on the subsequent card images and the finished with an END in col.1-3. Only relevant data groups must be given. The data groups can be given in an arbitrary order and an arbitrary number of times.

The input data within a data group always starts with a parameter name for the component beginning in col. 1-4 followed by the required parameters on the same card images up to col.80 or following card images in col.5-80. Only parameters with non-standard values must be given.

As separation character between the parameter name and its value a blank or a sign of the equality is used. Names of nodes and/or elements may have up to eight characters. Names must not contain blank characters. Data for different nodes/lines etc. follow each other within the data group. To mark the end of all input data an END must be written with the beginning in col.1.

The input data file is built up as is shown in the following :

Title

\*\*



CONTROL DATA

----

END

GENERAL

----

END

NODES

----

END

LINES

----

END

----

----

POWER INSTRUCTION

----

END

END

#### 4.8 Graphics drawing

The basic information needed to draw a node is the coordinates for the node. These coordinates are primarily given in the data group NODES in the OPTPOW program. Modifications shall be made in the file "XXX.GRAPHIC".

The coordinates for the midpoint of the node shall be given with the following parameters :



X n                    n = x-coordinate in m.m.  
 Y n                    n = y-coordinate in m.m.  
 C n                    n = 0 or H The node is drawn horizontally  
                           n = 1 or V The node is drawn vertically

The original of coordinates is at the lower left hand corner of the display or sheet.

#### 4.9 Load flow calculation

To run the load flow calculation by SIMPOW the engineer have to insert the following command string.

```
$ SIMPOW
SIMPOW COMMANDED ?
FUNC = 0    JOB = MEA    PGRAPH = YES    RUN
```

The command items have the following meaning.

```
FUNC = 0            start an OPTPOW or load flow run
JOB = MEA           job identification for result files
PGRAPH = YES        one line diagram will be printed
RUN                 start calculation
```

Following the above command the engineer will see the following prompt telling that SIMPOW expects him/her to take some action.

```
***** OPTPOW *****
DATE 07 DEC 1990    TIME 13.04.47
OPTPOW COMMAND ?
```



When this prompt is shown on the screen SIMPOW has checked the input data for syntax errors without finding any which means Simpow can continue and run calculation. SIMPOW will now start the calculation and the following information will finally show up on screen followed by the OPTPOW COMMAND prompt.

```
*****START OF POWERFLOW COMPUTATION*****  
*****STOP OF THE POWERFLOW COMPUTATION*****  
POWERFLOW COMPLETED  
OPTPOW COMMAND ?  
OUT  
OPTPOW OUTPUT COMMAND ?  
ALL
```

Now the loadflow result will be listed on the screen and saved on the result file.

```
OPTPOW OUTPUT COMMAND ?  
GRAPH  
GRAPHIC OUTPUT COMMAND ?  
DRAW *
```

The one line diagram including the load flow result will now show up on the screen. The diagram will remain until the engineer hit the return key. Then the following prompt will show again. To exit and complete the case, enter only X at the prompt as show below.



GRAPHIC OUTPUT COMMAND ?

X

OPTPOW OUTPUT COMMAND ?

X

OPTPOW COMMAND ?

X

Now the calculation is completed and the one line diagram will be printed. The loadflow result is saved on the file OPTPOW.MEA and the engineer can get this file printed by the command :

\$ PRINT OPTPOW.MEA

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# SIMPOW

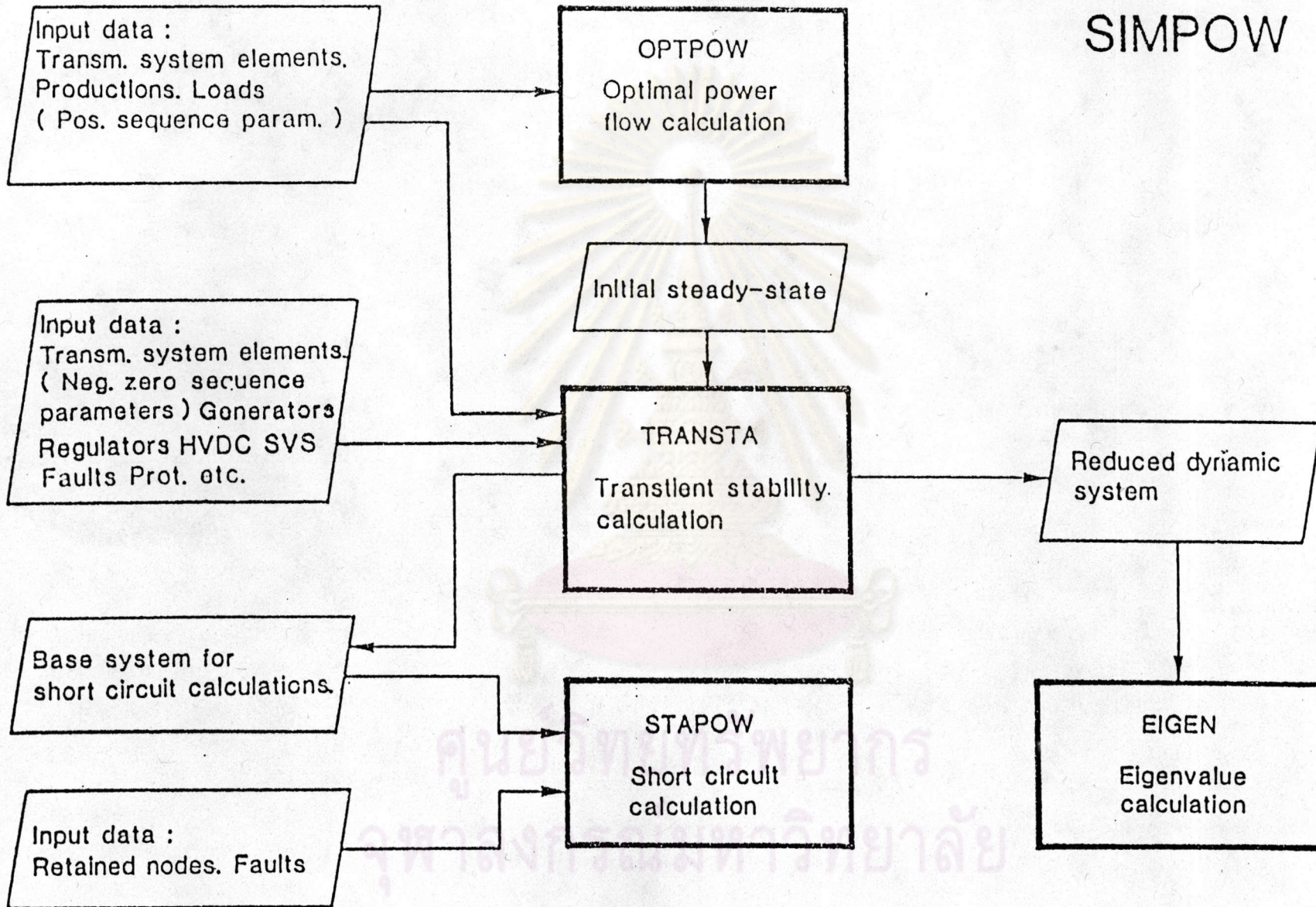


Figure 4.1 A function diagram of the program system