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THE PANACEA OUTPUTPROCESSOR

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Masters thesis on a project done at the Philips CADCentre in Eindhoven, in the period Sept 1986 - May 1987, under supervision of

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ABSTRACT

At the Philips CAD-Centre, a new general purpose circuit-simulator is being developed, that will become the successor of Philpac, which is the simulator that at the moment is being used. The new simulator will be called PANACEA, and will be upwards compatible to Philpac.

This report deals with the implementation of the OUTPUT PROCESSOR of Panacea. Within this output processor, all the Panacea output is created: tabular and plot output, and file-output.
Those aspects of the Panacea input-language will be discussed that are of direct importance for the output process: what sort of commands can be given, and what sort of items can be requested in these commands.
Then, the structure of the Output Processor will be discussed: every module will be described on function level.

Preface

This report describes the final year project that formed the conclusion of my study at the department of Electrical engineering at the Eindhoven University of Technology. I have worked on this project at the Philips CAD-Centre, in the period from September 1986 to May 1987.

I would like to thank Ir. A.C. Karman, manager CAD-E within the Philips CAD-Centre, and Drs. J.M.H. Jacobs , Panacea project-manager, for giving me the opportunity to do this project within their group.
Also, I would like to thank Prof. Dr. Ing. J.A.G. Jess, from the group Automatic Systems-design of the department of Electrical Engineering of the Eindhoven University of Technology, for allowing me to do my graduate project at the Philips CAD-Centre, and Ir. M.T. van Stiphout, my coach from the Eindhoven University of Technology.

Furthermore, I would like to thank everybody within the Panacea-team for the hospitality I enjoyed during the last year. I would like to single out the following persons:
Ir. A.A.G. Geerts, who coached me during the design-phase of the output-processor; we worked together on the Output processor, of which he implemented the item-expansion part while I took care of the rest of it;
Ing. H.M.M. van de Schoot, who had to answer all those questions about the VAX computers we used, since he is the system-specialist within our team; and Ing. G.F.M. Varga, my room-mate.

Frans Lammers, May 1987.

Table of Contents

CHAPTER 1

INTRODUCTION.

Panacea is the new general purpose circuitsimulator that is being developed at the Corporate CAD-Centre, a department of the Corporate ISA organisation (group Information Systems and Automation). The ISA is responsible for automation throughout the whole Philips concern.

In this report, the Output-processor of Panacea will be described. First, in Chapter 2, a description is given of the working environment, describing the history of the project, the computers and tools we used, and the programming language that has been chosen.

In Chapter 3 an Introduction to Panacea is given. It describes the background of Panacea, with respect to existing circuit simulators like Philpac. The Panacea input-language is described, with emphasis on those aspects that are of direct importance for the Output-processor, i.e. the commands that can be given, the sort of output-items that may be requested, and the options that can be used for the commands.

In Chapter 4 the detailed design of the Output processor is discussed: first a short description is given of all the modules in the Output processor. Then every module is described on function-level; sourcecode is not included.

Finally, in Chapter 5 the current state of the Panacea output processor is described, as it is at the end of my graduate project.

2.1 THE PANACEA HISTORY.

Panacea is the new general purpose circuitsimulator that is being developed at the Corporate CAD-Centre, a department of the Corporate ISA organisation (group Information Systems and Automation). The ISA is responsible for automation throughout the whole Philips concern.

Within the CAD-Centre, there is a group that is specialized in software tools for electro-technical analysis: the CAD-E (CAD-Electronics) group, which has responsibility for tools like PHILPAC, the circuitsimulator currently used, Scetch, a schematic-entry program for electronic circuits, and Minnie, a complete CAD/CAE-environment for analog simulations on workstations, with links to existing simulation-programs like Philpac.

At the moment, the biggest project that is under development within the CAD-E group is the Panacea project, the new circuitsimulator that has to become the successor of Philpac.

The history of the project reaches back to the end of 1984. At that time, it became clear that the users of circuitsimulators like Philpac or Espice needed a new general-purpose circuit-simulation package for the future.
A special usergroup committee was established, with the task to determine the requirements for the new analysis package: in short, it should be upwards compatible with Philpac, but without any of the drawbacks of it.
As part of the functional specification of the new package, the first part of Panacea that was written was the USER MANUAL, which describes exactly what Panacea would have to be able to do.
Then, the design and implementation of Panacea started. At first the design-team was a group of 5 persons, but at the moment, with the release of version 1.0 coming up pretty soon, it has expanded to about 14 (including students).

In the past months, Panacea has developed into a stage where the package can be used for circuit analysis. In Februari 1987 the Beta-test of Panacea started, in accordance with the original time-schedule: a selected group of users were enabled to test the preliminary version of Panacea.
In July 1987 the definitive 1.0 version of Panacea will be launched, in which a lot of features are still missing, but all the basic ones are available: for example DC, AC, and TR analysis can be used, but statistical analysis is not possible.
In January 1988 it is planned to release version 2.0, which should be the completely finished Panacea.

2.2 PROGRAMMING ENVIRONMENT.

2.2.1 The Computers.

The computers on which Panacea is being developed are 3 VAX computers:
2 * VAX 780 and a VAX 785.
They are coupled into a CLUSTER: i.e. after a user logs in onto the cluster, he is placed at the VAX with the least CPU-load; the disks that contain the files of the users are common to all 3 VAX computers. Thus independent of the VAX the user is connected to, he always can use the same files.

The computing power of this configuration is such, that on normal days one can work without too many delays: only certain tools that take a lot of CPU time, sometimes become rather slow: the Debugger for instance is one of the tools where the user often has to have a lot of patience.
However, when the system gets crowded things start slowing up: and when for some reason one of the VAX computers is down, working on the other two is hardly possible because they all get overloaded.

For this reason, in the near future the whole configuration is going to be changed: VAX-STATIONS will be installed, to be used by not more then 2 or 3 users, thus providing more then enough processing power; the file-io of all these VAX-Stations will be handled by a VAX 780, that is connected to some fast diskpacks. And for those jobs that really are to big to be run on a VAX-Station, a big VAX 8650 will be installed (8 times faster then a 780).

With regard to the operating system on our computers, I must say that the VMS-system is much easier to work with then for instance a UNIX system: the Digital Command Language is more comfortable in its usage then UNIX, because in DCL, the commands are named after what they do, rather then some weird 2 character abbreviation.
And the HELP function in VMS is a function that really helps, instead of providing the user with lots of useless data, as in MAN under UNIX.

2.2.2 The C Language.

Panacea is being written in C. C is a language that permits the programmer to do almost anything he likes, from constructing the most bizarre control-structures, to mixing data up with weird pointer constructions.
Therefore, in order to produce Panacea sourcecode that is clear and readable, so that maintenance is well possible, a number of strict rules have been chosen which have to be obeyed. Besides that, one should of course always write the code as clear as possible, adding comments wherever necessary.

LAYOUT RULES:

- Use of a standard format for module- and function headings.
- Compound statements must always be enclosed in { }
- Use of the
  ```
  do { ...
     } while (..) ;
  ```
  statement is dissuaded, because it easily confuses with the normal while - loop; Macros have been defined to create a
  ```
  repeat { ...
         } until (..);
  ```
  statement.
- Put at most a single statement per line.
- keep functions small.

PORTABILITY:

Because of the fact that Panacea will have to be used on all sorts of computers, the code must be written in such a way that it will be easy to adapt Panacea for a different computer:
therefore only those aspects of C may be used of which one may expect that they have been implemented in any reasonable C compiler: for example, we were not allowed to use structure-assignments or enumerated types.

MODULARITY:

- maximal cohesion within each module.
- minimal interfacing between modules.

Every module will be split in a DEFINITION PART and an IMPLEMENTATION PART:
- The definition or HEADER file:
  In this file, every constant, typedef, variable and function that is exported by this module to the outside world will be declared.
  The file will be included in every module that uses anything out of this module, including its own implementation module. In this way, the exported quantities are always declared on one single spot.

- The IMPLEMENTATION file:
  This part contains the source code and local variable declarations.
  By using a set of #INCLUDE statements, we will include in this module the header-files of all the modules out of which parts are used by this module: inclusive the #INCLUDE of its own header-file!.

2.2.3 The Software Development Tools.

2.2.3.1 The LSE-EDITOR:

This is a language-sensitive editor, tuned to the C language: when entering source-code, the programmer just types the first few characters of the next statement to be entered, and then lets the editor expand them into C-code: for example, the programmer types 'for' and then expands this: the result of the expand is:

```
  for ( [@expression@] ;  [@expression@] ;  [@expression@] ) {
      {@statement@}...
  }
```

and the programmer just has to fill in the begin- end step-statements and the end-condition; then he starts to fill-in the statement-block, without having to worry about the {} and the indentation.

Unfortunately, the LSE-editor has one serious drawback: it is slow.
Even when the system is not heavily loaded, you often have to wait a long time until the desired action happens.
(Personally, I haven't used the LSE-editor much; instead of it I use the MicroEmacs editor, with the huge advantage of being able to use the same editor on almost any computer system, be it VAX, HP, or IBM PC.
And: however loaded the system may be, somehow I NEVER have any troubles at all concerning lack of speed in my editor!).

2.2.3.2 CMS - Code Management System

This is a tool that is being used to store files in such a way that it is possible to retrieve any earlier version of a file, but without storing every version itself.
CMS creates libraries containing files; after chosing one of the libraries one can fetch any version of any file in this library. A history is maintained, of all the actions that are performed on a library.

All the team-members use the same CMS libraries.
When someone intends to change a file, he first has to reserve the file.
This ensures, that it's not possible that 2 persons are making changes in the same file: for one of them, the file is locked by the other user.

For replacing a file, a special command-procedure has been developed that before replacing the old file, compiles the source-file; when no errors occur, the resulting object-file is placed in the Panacea object-library, and the source-file is placed in the CMS library.
Using the object-library, a run-image of Panacea is created that always will contain the latest developments.

2.2.3.3 MMS - Module Management System.

This tool is closely related to CMS: it is used to automatically compile a module, whenever changes have occurred in some of the header-files that are included by this module. Every evening the MMS-procedure will examine every module, and recompile it when necessary, storing the new object-file in the Panacea object-library so that always all modules are consistent with each other.

2.2.3.4 NOTES.

This tool (a computer conferencing tool) is used to make notes of problems that have been detected.
For instance, someone detects an error in Panacea. He creates a note, containing an explanation of what goes wrong, together with the Panacea input-file that causes the error. Sometime hereafter, somebody else reads the note and repairs the error: a reply to the note will be made, stating that the problem has been taken care of.

In this way, the team members can communicate freely with each other, even when they are at home at their own terminal, or are in some foreign country, or when it's in the middle of the night.

2.2.3.5 VAX-DEBUG

A VERY powerful debugger, with which one can trace every thing that happens inside a program: for example, it is possible to set breakpoints, to examine the content of variables (even of complete structures), and to examine the source- or machine-code of the program that is being executed. However, it has the same drawback that the LSE-editor has: it tends to get realy slow when the system is heavily loaded.

2.2.3.6 PCA - Performance And Coverage Analyser.

With this tool, a program is automatically traced, thereby collecting data about CPU usage, page faults, IO requests etc. etc. Plots are made that represent this data: for instance, a plot that shows how much CPU time is spend in every function: thus, one can easily see, up to statement level, which parts of the program spend the most CPU-time, indicating the exact locations where one might want to change the code in order to produce a faster program: instead of changing 20 routines, that use 5 percent, change the 5 routines that spend 20 percent of the total CPU-time.

INTRODUCTION TO PANACEA.

3.1 PROJECT BACKGROUND.

PANACEA is the new general purpose circuitsimulator, which is destined to become the successor of PHILPAC, the circuitsimulator currently used everywhere within Philips where analog circuits have to be analysed.

The problem with Philpac is that it, originating form the early 70's, has reached the end of its lifetime. Since the first release of Philpac, there have been many new developments in the field of circuit-analysis; extension of Philpac with these new algorithms is nearly impossible without redesigning big parts of the program.
Since the first version, a great number of new versions and releases have appeared. As a result of this, large parts of the program have become very disorganized, which causes a lot of trouble in maintenance.

All in all, there are so many things that could be improved, that the best way to handle them is to start all over again. A new program will be created that has all the advantages of Philpac, and which can be used to process circuitdescriptions that were written for Philpac. It will, however, have none of Philpac's disadvantages. A great number of new features concerning analysis possibilities will be provided :

- Waveform-relaxation algorithms will be implemented;
- Extrapolation algorithms to compute the periodic steady state in a very efficient way, will be implemented;
- Hierarchical input data will be handled in a hierarchical way, throughout the whole analysis;
- It will be structured in such a way that models can be built-in with minimum effort;
- It will be designed to allow interactive use; this requires that changes to the circuit to be analysed must be handled in an "incremental" manner, providing fast response;
- It will become a highly modular, well documented package which will allow extensions (like new analysis techniques, for limited applications) to be easily added, and which will allow incorporation of (parts of) the package in other CAD systems;
- It will have a performance, at least competitive with the existing programs for comparable types of algorithms; the size of circuits that can economically be analysed will at least be in the order of 5000 nodes or elements.

The new package has been given the name P A N A C E A :

Package for the ANAlysis of Circuits in Electronic Applications.

3.2 THE PANACEA INPUT LANGUAGE.

3.2.1 Introduction

The Panacea input language is very similar to the Philpac input language. This is not just a coincidence: the Philpac language is an efficient way to describe an electronic circuit in, regardless of the fact that there are a lot of restrictions within Philpac with respect to the possibilities of this input language.

Another reason to make the Panacea input language similar to the Philpac language, is the consideration that the users of Philpac eventually will have to start using Panacea, because Philpac support and maintenance will be terminated, some time after the definitive version of Panacea is released. The switch to Panacea now is very easy: the users can write circuit descriptions for their new simulator without having to adjust themselves to a new input language.

A special utility has been written to translate existing Philpac circuit descriptions into Panacea circuit descriptions: This because there is a very large amount of these circuit descriptions around, with lots of models and process-models, for all sorts of small, medium, large and over-sized circuits: I've seen files of over 3500 lines of input.

In this Chapter, a short description of the Panacea input language is given. This is certainly not meant to be a complete description of the language: there are far too many possibilities in it, ranging from Process blocks to Change blocks (see note).
Therefore, only those aspects of the language will be discussed that are of direct importance for the output process:

- how to enter a circuit description, and how to specify an analysis job
- what kind of output commands can be requested
- what sort of output items can be specified
- the options that can be used for the output commands

(Note: In a Process-block, a physical proces is described; with it, Panacea can compute electrical parameters that are related to the physical characteristics of the process.
In a Change block, the user can change program parameters: when for example an analysis fails, a program parameter can be set, so that the next time extra debug-information is given, in order for the user to be able to examine the analysis process.)

3.2.2 Example Of Panacea Input.

Here follows an example of a circuit-description in Panacea input-language. The output that results from this particular example can be found in appendix A.

```
title: This is an example of a Panacea circuit description. ;
numform: engineering, fix, digits=4 ;

circuit ;
   j1 (0,1) sinewave(2.0,0) ;
   j2 (0,1) 2 * par ;
   r1 (1,0) 0.5 ;

   ec1 (0,2) i(r1)*i(r1) ;
   c1 (2,4) 22u ;
   r2 (3,2) 0.5 ;
   r3 (3,4) 0.5 ;

   r_name (3,0) i = exp(vn(4)) ;
   r_thisisaverylongname (4,0) 0.5 ;
   c2 (3,0) 47u ;
end;

ac;
   f= an( 10, 1000, 9 ) ;
   par = 1, 2 ;

   print:  v(r*) ;
   mplot:  v(r_name),  v(r_thisisaverylongname)
        (options:  grid, plotchar=(R,I) , width = 70, iscale) ;
   prplot: v(r_3)  (options: plotchar=@);
   file: vn, i ;

end;

run: ac ;

finish ;
```

3.2.3 Stand Alone Statements.

In the Panacea input language the circuit and analysis descriptions are organized in BLOCKS, like the CIRCUIT block.
However, there are also some statements that appear outside a block. In our context the following functions are important:

LENGTH: this function is used to specify the pagelength: after the given number of lines a formfeed is forced, and a pageheader will be generated. When no paging is wanted, the page-length should be set to 0.

WIDTH: This function is used to specify the width of a line of output: for instance 80 on a terminal, or 132 on a big lineprinter. Any output -tables or -plots will fit within the given width.

LIST/NOLIST: with these commands the echoing of the Panacea input can be allowed and suppressed: this is very useful, for instance when a PROCESS-block is being used of 100 pages of Panacea input, and which is of no importance at all for the user.

NODELIST: With this function, the user can indicate that he wants to get a list of all the nodes in his circuit, with for every node a list of the elements connected to it.

TITLE: This title will be printed on top of every page of Panacea output.

NUMFORM: Using this function the user can specify in what manner he wants the values in the output to be formatted:

	EXAMPLE:
- SCIENTIFIC	
normal exponential notation	1.27345 E-04
- ENGINEERING NOTATION	
exponential notation with the exponent always a multiple of 3.	127.34500 E-06
- SCALED	
using scaling factors like K,ML,U etc.	127.34500 U
- FIXED / FLOAT	
keep the point at a fixed position,	127.34500 E-06
or let it float through the number:	127.345 E-06
	98.7654 E-09

- DIGITS = k
  set the precision with which the values must be printed to k. In case of FLOAT exactly k digits are printed; in case of FIX the number of digits after the point is always k-1; this means that sometimes extra digits will be printed, namely when more then one digit stands in front of the point.

RUN: Perform the given analysis, using the last analysis-block of the given type.

FINISH: End of Panacea input.

3.2.4 The Circuit Block.

The CIRCUIT block contains the description of the circuit that has to be analysed. The circuit is described by specifying every element in it: each element is specified by a list of the nodes it is connected to, and a list of values that specify the values of internal parameters of the element:

```
elemname ( node1, node2, ... ) parvalue1, parvalue2, .... ;
```

The name of an element consists of two parts: a type indication, and an occurrence indicator. The type-indication describes what sort of element we have, while the occurrence indicator is used to give each occurrence of some sort of element a unique name.
An element can be a build-in component, or a model occurrence (this can be user defined models, or models from one of the Panacea libraries).

The build-in components.

basic elements:		basic devices:	
R	resistor	D	diode
C	capacitance	TN/TP	NPN / PNP transistor
L	inductor	TNS	NPN transistor with substrate
M	mutual inductors	TPL	lateral PNP transistor
E	voltage source	MN/MP	N/P-channel MOS
J	current source	YY/SS	two-port described by y / s parameters
EC / JC	controlled sources		
EN / JN	noise sources	YNPORT/ SNPORT	N-port described by y / s parameters
S	short circuit		

The occurrence-indicator consists of one or more characters. If the first character of it is not a digit, it must be preceded by an underscore.
Some examples of element names are: R1 C_abc M76d TNS_aa12b

The order in which the node-names appear in the node-list specifies which node is connected to which terminal of the element; the names of the nodes can be any character-string. When two elements have a common node-name in their node-lists, then the corresponding terminals are connected to each other.

The parameter-values specify the values that will be given to certain parameters in this element; one can specify just a list of values, which then will be assigned to the first (n_of_values) parameters; or, one can specify the name of a specific parameter that has to be assigned.
The 'values' are specified using expressions, with as operands:
- constants,
- electrical variables (i.e. certain electrical quantities in the circuit),
- independent parameters.

Also, it is possible to use a TYPE_SPECIFICATION. A type is a sort of abbreviation for a list of parameter-assignments: by using a type, one does not have to enter the complete list of parameters every time one uses an element with some specific set of parameter-values.

FOR EXAMPLE: TN_11 (node_1, 2, just_a_name) 'BC148C', BETA=100*par ;

TN, has as connections: 1) collector, 2) base and 3) emitter. The string " 'BC148C' " is a type-specifier: the TN that is used will get the parameter-values as specified in the definition of this type. Then, the BETA is assigned again, overriding the assignment of this parameter done by the type-specification.
It is assigned the result of evaluating the expression 100 * par, where par is an independent parameter that will move through a series of values while the analysis is being performed (see ANALYSIS block): every time that par changes, the parameter BETA in TN_11 will also be changed.

MODELS.

Just like a program is split up in functions, a circuit-description can be split up in sub-circuits by using models: which is very usefull when some subcircuits appears often, and also of course for deviding a large circuit in clearly separated sub-circuits:

```
MODEL: subcircuitname ( terminal_list ) formal_parameter_list ;
   -- Circuit Description --
END;
```

Actual values will be assigned to the formal parameters by the circuit in which this model is used: in every model-occurrence the specified values determine the setting of element-values etc. within the model. If a parameter is missing in the model-occurrence, it will get the for this parameter specified default value.

The terminal_list is a list in which are listed all the nodes in the model that are connected to the outside-world. When the model is used within another circuit, these nodes will be connected to nodes in the surrounding circuit.
The scope of names of elements and nodes is limited to the block where they are used in: this means that inside a model we can use some name, which can be the same as a name outside this model, without indicating the same object.

Models are used to describe a circuit in a hierarchical way, because within a model we can use sub_models, containing sub-sub-models, etc. For example:

```
Model: block (a,b,c,d) ;                        /*  8 resistors.  */
  R_1 (a,b) 2 ;          R_5 (a,1) 2 ;
  R_2 (b,c) 2 ;          R_6 (b,1) 2 ;
  R_3 (c,d) 2 ;          R_7 (c,1) 2 ;
  R_4 (d,a) 2 ;          R_8 (d,1) 2 ;
End ;

Model: bigger_block (a,b,c,d) ;                 /* 32 resistors.  */
  block1 (a,1,5,4) ;     block3 (5,2,c,3) ;
  block2 (1,b,2,5) ;     block4 (4,5,3,d) ;
End ;
```

3.2.5 The Analysis Block.

In this block the analysis to be performed is described, together with the output that is requested for this analysis. When more then one analysis must be performed, they will be handled in separate analysis blocks.

The NAME of the block specifies the type of analysis:

DC	for dc analysis	DCSTAT	dc statistical analysis
AC	for linear ac analysis	ACSTAT	ac statistical analysis
TR	for transient analysis	TRSTAT	transient statistical analysis

Within the analysisblock the INDEPENDENT PARAMETERS are being specified. These are used when it is required to vary some element in the circuit during the analysis, for example to measure the effects that result from changing the value of some resistor. In such case, an independent parameter is used that will step through a specified series of values; for each value, a complete analysis will be performed.

When more then 1 independent parameter is specified, then for all the value-combinations of their series an analysis will be performed: the combinations are generated in a lexicographically ordered way, i.e. the "fastest" independent parameter will move through its series of values, while the other independent parameters are kept frozen; then, the second fastest indep par will step to its next value, after which the fastest will again move through its complete series, etc, until the second fastest par has reached its last value: then the third steps to its next, etc, etc, until all combinations have been processed.

The fastest changing independent parameter is called the PRINCIPAL independent parameter; the others are called the SUBSIDIARY indep pars. In the analysis, a STEP will be made for every value of the principal indep par; the analysis-RUN (i.e. run over all steps) will be repeated for all subs indep par combinations.

For an example see Appendix A; there is F the princ indep par, and par is the subs indep par: first all output is produced with par = 1, and then the output for par = 2.

The number of combinations of the independent parameters can be restricted using the TRACK statement:
with this statement one can specify that some indep pars will change their values together: when we would specify that a and b are tracked, we would get the combinations 1,5 2,10 and 2,15 . When an indep par reaches its last value, this value is repeated until the indep par with the most values is finished.
In a TRACK statement it is also possible to use the principal indep par: this results in a situation where we have more then 1 principal independent parameter.

The specification of the values for an independent parameter can be done using special series-functions:

AN (x, y, k)	Arithmetic progression from x to y in k intervals.
AS (x, y, z)	Arithmetic progression from x to y, stepsize = z
GN (x, y, z)	Geometric progression from x to y, in k intervals.
GS (x, y, z)	Geometric progression from x to y, stepsize = z
EN (x, y, k)	Rounded geometric progression from x to y; k = nr of intervals in a decade (k=12 ==> E12 series!)

It is also possible to give a list of values; this can even be mixed with the series functions. There is no need whatsoever for any ordering in the value list, and values may even appear more then once.

For example: F = AN(10,100K,30) , 200K , 300K , GN(1,1000,17), 134.5567 ;
Output will be generated for every F-value, in the precise order in which the values were given; if it's plotted you'll probably get a real weird plot, but.. it's what was requested by the user.

Besides the independent parameter specifications, in the analysis block we find the OUTPUT SPECIFICATIONS: these commands specify the output that must be created for this analysis.
For a description, see the next section.

3.2.6 THE PANACEA OUTPUT SPECIFICATIONS :

The Panacea output is specified using special outputcommands that have the following format:

```
outputcommand: output_item-list  (OPTIONS: options-list);
```

3.2.6.1 The Output Commands.

PRINT	creates tabular output.
PLOT	creates plots of the given items; one item per plot.
PRPLOT	creates plots of the given items, thereby also printing on each line the value of the item; one item per plot.
MPLOT	creates plots of the given items; more then one item per plot: the number of items is determined by the number of plotchars. (A plotchar is a character that is used to produce a plot with.)
FILE	creates file-output: makes a file in the SDIF format, containing the analysis-results for the requested items. This file can then be used as input for certain post-processors, for instance to create a real plot, in stead of the Panacea line-printer plots.
HISTOGRAM	creates histogram-output in case of statistical analysis: in the resulting plot, the statistical distribution is visualized.

With respect to the PLOT, MPLOT, PRPLOT and HISTOGRAM outputcommands, an important side-effect should be noted:
In order to create the correct SCALING of the y-axis, we must know BEFORE we start printing, what the MINIMUM and MAXIMUM values of the item to be plotted are. This demands that we first must STORE ALL THE RESULTVALUES of the item, and then determine the minimum and maximum values, which then determine the scaling of the y-axis; finally, the plot can be made.

This is the major reason for the Output Processor to be designed as a POST-PROCESS: FIRST collect all the data necessary for the output, THEN format the requested tables, plots etc.

Processing the output as a post-process has the drawback that for a big simulation-job in an interactive environment, the user has to wait a long time before seeing any output, at whch moment he gets everything at once. Therefore, Panacea will probably get an extra output-command, the MONITOR: command: this command will write analysis-results to output as soon as they are produced, i.e. after every analysis-step the values of the requested items are written to output.
The items that can be used in a MONITOR command are restricted to LEVEL 1 items (See next section): this because an higher-level item can only be produced in a post-process.

3.2.6.2 The Output Items.

The items that can be requested are all kinds of electrical quantities and other results that follow from the analysis, see table below.
When a node or element specification is part of the item, wildcards are allowed: for instance, " PRINT: VN, V(R*); ". In the table must appear:
- VN all the nodal voltages of the circuit.
- V(R*) the voltages across every resistor in the circuit.

<u>Output items:</u>

1) basic element values.
2) parameter values.
3) expressions (output-functions may be special operands).
4) nodal voltages (with respect to ground).
5) voltages between any two nodes.
6) electrical variables.
7) voltages across an element.
8) terminal-currents for an element.
9) power-dissipation in an element.
10) electrical state: voltage across, current through and power dissipation in an element.
11) Output-functions: see below.
12) Sensitivity and Gradient:
    Sensitivity and rate of change of an output-quantity (e.g. electrical variable or a nodal-voltage) with respect to the value of a particular circuit element or parameter.
13) For AC and ACSTAT analysis a great number of extra output-facilities are available:
    Twoport outputs:
    All sorts of Twoport outputfunctions, using twoport-quantities like the input reflection coefficient.
    Noise outputs:
    In noise analysis:for example, NOISEMSVDENS: noise power density.
    Statistical outputs:
    In statistical analysis: NOM, MEAN, SPREAD, LIMITS.

An electrical variable is a certain electrical quantity in the circuit, that has been given a name of its own. The usage of electrical variables was necessary in Philpac, in order to describe the relation between certain quantities: for example,

```
  il (rl) ;           il  = electr. variable, giving the current through rl
  ecl(0,2) il * il;   ecl = controlled source, value = i(rl) * i(rl).
```

In Panacea, the use of electrical variables is not necessary anymore: it is now possible to directly use the i(rl) in the specification of the source:

```
  ecl(0,2) i(rl) * i(rl);
```

But in order to maintain the compatibility between Philpac and Panacea, the use of electrical parameters is also implemented in Panacea.

3.2.6.3 The Output Functions.

It is possible to specify in Panacea that one is not interested in the value of some circuit-quantity for every analysis-step made, but that one instead is interested in some result-value that is computed using the result-values for every analysis-step: for example, the mean of the current through some element. For a list of the possible output-functions, see the table below.

It would be nice, if we could use the results of these output-functions as operands in an output-item expression, so that we for instance could request:

```
  PRINT:  V(R1) - MEAN ( I(R2) );
```

When we consider this expression, it is clear that first the result-value of the output-function must be known, before we can print the table containing for every value of the principal independent parameter the value of
V(R1) - MEAN (I(R2)).

This can be expanded to more complex situations, like:

```
   MAX( I(C3) - VALUE(  MIN( V(R1) - MEAN(I(R2) - VALUE(MAX(par_A)) ) )  ) )
```

We now get LEVELS in our output-items: first the results on the lowest level must be known, before we can compute the values at the second level (i.e. the MAX must be known before I(R2) - VALUE (MAX()) can be determined). Then we can handle the next level (i.e. MIN(V(R1)) - MEAN (i-VALUE())), etc, until all levels have been determined, after which the results can be written to output.

The algorithm to handle these output-expression levels requires that when computing the results for the next level, we must have access to the analysis-results; this can be done by analysing the circuit again, which of course is very inefficient, or by storing all the analysis-results that are necessary for the computation of the expression, in such a way, that we can retrieve them every time again when we handle the next level.
Because the output was already planned as a post-process (see the remark at the paragraph over the Output-commands) the last solution will be not to difficult to implement, being only an extension to the storage-process.

<u>BASIC OUTPUT FUNCTIONS</u>

FALL	p.i.p.v. for which the item passes with a negative slope through 0.
MAX	p.i.p.v. where the item reaches its maximum.
MEAN	mean value of the given item,over every value of the princ indep par.
MIN	p.i.p.v. where the item reaches its minimum.
RISE	p.i.p.v. for which the item passes with a positive slope through 0.
SUM	The INTEGRAL of the given item over all values of the princ indep par.
VALUE	The VALUE of the item for the given p.i.p.v.

(p.i.p.v. == principal independent parameter value.)

3.2.6.4 The Output Options.

The following options can be specified for the command mentioned:

PRINT:

WIDTH	set the line-width to the given value, for this command only.
RANGE	limit the princ indep par values to the given range.
XVAR	use another parameter than the princ indep par for the x-axis.
XRANGE	When using XVAR, limit the values of this par to the given range

PLOT, PRPLOT:

WIDTH	set the line-width to the given value, for this command only.
GRID	superimpose a rectangular grid upon the line-printer plot.
PLOTCHAR	set the plotchar that is used in the plot to the specified char.
RANGE	limit the princ indep par values to the given range.
XVAR	use another parameter than the princ indep par for the x-axis.
XRANGE	When using XVAR, limit the values of this par to the given range
YRANGE	the y-axis will be scaled using the specified range.
XLABEL	the x-axis is labelled with the specified string.
YLABEL	the y-axis is labelled with the specified string.

MPLOT:

The PLOT options, but now more then a single plotchar and YLABEL may be specified, because now more then one item can be plotted at the same time.

ISCALE	individual scales are chosen for every item to be plotted.

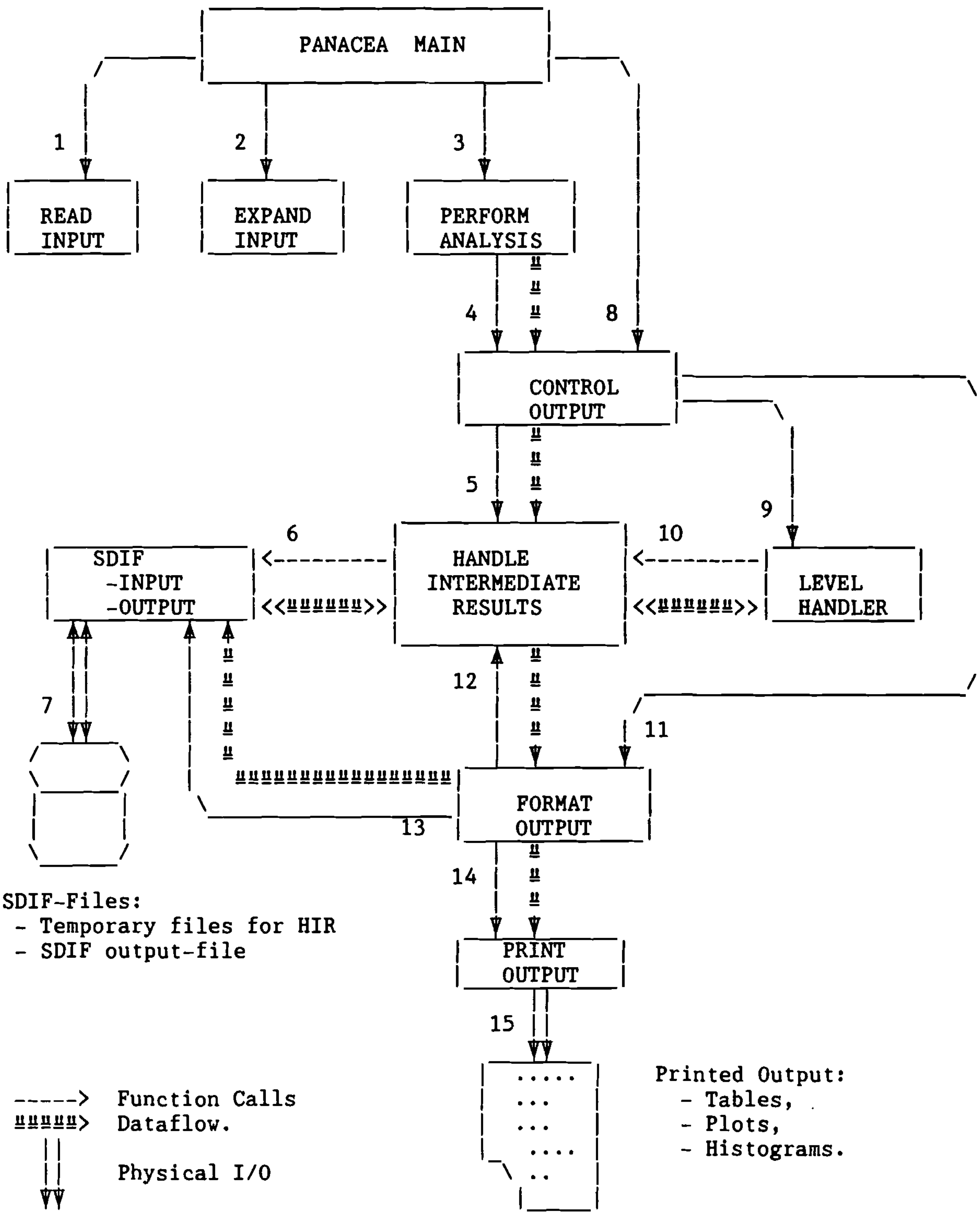
FILE:

RANGE	limit the princ indep par values to the given range.
XVAR	use another parameter than the princ indep par for the x-axis.
XRANGE	When using XVAR, limit the values of this par to the given range

HISTOGRAM:

WIDTH	set the line-width to the given value, for this command only.
RANGE	limit the princ indep par values to the given range.
XVAR	use another parameter than the princ indep par for the x-axis.
XRANGE	When using XVAR, limit the values of this par to the given range
YRANGE	the y-axis will be scaled using the specified range.
XLABEL	the x-axis is labelled with the specified string.
YLABEL	the y-axis is labelled with the specified string.
INT	the number of histogram-intervals on the x-axis.

4.1 THE OUTPUT-PROCESSOR STRUCTURE.



THE OUTPUT PROCESSOR.

4.1.1 Explanation.

When Panacea is activated, it starts reading the input-file containing the circuit-description (1). This input will then be expanded (2) in such a way, that afterwards the analysis can be performed on the resulting analysis-datastructures. Then, the analysis is done. (3)

The analysis of a circuit consists of separate analysis-steps: for every combination of the subsidiary independent parameters, a complete analysis of the circuit will be performed. Such an analysis consists of a series of steps over the principal independent parameters.
After a step has been analysed, the analysis datastructures contain the simulationresults for this step: from these structures we now must extract the values that belong to the in the output_commands requested items.
This is done by calling from the Analysis module certain functions in the module CONTROL OUTPUT. (4) These functions will gather the required data.

The output is organised in such a way, that we will first perform the complete analysis, before we start producing any of the requested output; we will SAVE the analysis-results temporarily, using functions in the HANDLE INTERMEDIATE RESULTS module. (5)
This module (abbreviated to HIR) tries to store the data in core; however, when there is too much data, it will open a file and write the data into it; this file has the standard SDIF format, and is written using the functions in the SDIF_IO module. (6) (7)

After the complete analysis has been finished, we shall start producing the requested output. (8)
First, we will compute all the higher level output-items, i.e. expressions using both analysis-results and output-function results.
This is done by the LEVEL_HANDLER (9) which can be found in the function OUT_terminate_output() in module CONTROL_OUTPUT.
It retrieves the data that was stored in the HIR module, processes it and then writes the new results back to the HIR module. This will be repeated until all the levels have been processed. (10)

Then the FORMAT_OUTPUT module is activated (11) which retrieves the data from HIR (12) and uses it to produce the output that belongs to the given output_commands.
FILE output will be created using the functions in the SDIF_IO module (13).
The other outputcommands result in printed output; after a line of output has been created, it will be handed over to the PRINT_OUTPUT module (14).
This module takes care of the layout of the Panacea-output (creating a page-header on top of a new page, and handling line-overflow in a decent way: the last word is wrapped around to the next line). It is an extra layer between Panacea and the outside world, EVERYTHING that is printed during a Panacea job goes via this module: be it input-listing, error-messages, or lines of output -tables or -plots.

4.2 LIST/CLASSIFICATION OF USED SYMBOLS/NAMES.

HIR : HANDLE INTERMEDIATE RESULTS.
This module is used to store the analysis results, until they can be processed in the output processor.
There are functions for storing data, for retrieving data, and for initializing, rewinding and terminating the used file.

SIO : SDIF INPUT/OUTPUT.
This module handles the file-io with files in the standard SDIF fileformat, consisting of INFO and TITLE records, followed by HEADER records with the names belonging to all values occurring in the TUPLE records that follow hereafter.

PRO : PRINT OUTPUT.
This module is used as an extra interface between Panacea, and the paper-output: we check on line-overflow and on page-overflow.
The module is also used for printing error-messages.

FTO FORMAT OUTPUT.
In this module the Panacea output is formatted: plots and tables are created, and file-output is produced.

INDEP array,
RESULT array,
OUTFUNC array :
This are the names of the arrays that are used while evaluating all output-expressions, to store the resulting values.
The INDEP array is used to store the current subsidiary independent parameter values, the RESULT array to store the principal indep par values and the values of every analysis-step dependent output_item, and the OUTFUNC array is used to store the values belonging to output-functions.

4.3 THE CONTROL_OUTPUT MODULE.

4.3.1 Introduction.

This module controls the output process. It contains functions that:
- expand the commands that are read from input;
- collect independent parameter values and analysis results;
- terminate the output process, by evaluating all the higher level items, and then producing the requested output (by calling FTO_format_output()).

4.3.2 Module Interface Description Of CONTROL_OUTPUT.

4.3.2.1 EXPORT Specification.

The module CONTROL_OUTPUT exports a lot of functions:
- for storing and retrieving of information concerning the NUMFORM-format;
- for storing and retrieving of information concerning the TITLE string;
- for creating the NODELIST output.
- for giving the pointers to the data-structures in CONTROL_OUTPUT that contain all the information with respect to the output to be produced. The most important of these structures is the OUT_general_data data-structure, see below.

The most important functions (these will be described in the next sections) are:

```
OUT_expand_output()
OUT_subs_indep_par_values()
OUT_results()
OUT_function_results()
OUT_terminate_output()
```

The OUT_GENERAL_DATA data-structure:

This structure contains all the necessary information about the output process: it contains general information like the time and date of the current Panacea-job, and pointers to the lists of output_item - descriptions: this are structures that contain the name of an item, and a pointer to the location where we can find the value that belongs to this item. This location is fixed, and is located within the INDEP-, RESULT- or OUTFUNC- array. When producing output, these arrays are filled by calling the HIR retrieve-functions, with the results that belong to a certain step made in the Analysis, and we will use the value on the location where the item-description points to. After having processed the current step, we move to the next step in the Analysis: we will re-fill the arrays, and we can now produce the next line of output by using the new value that has appeared on the given location.

4.3.2.2 IMPORT Specification.

The CONTROL_OUTPUT module uses a number of functions from the other modules in the Output Processor:

HANDLE_INTERMEDIATE_RESULTS:
This module is used to store all the analysis results, that later will be used to generate the output with:

HIR_initialize ()	Initializes the HIR module.
HIR_store_INDEP ()	stores a set of subs indep par values.
HIR_store_RESULT ()	stores the array of analysis-results for the current princ indep par value.
HIR_store_OUTFUNC ()	stores a set of output-function values.
HIR_retrieve_INDEP ()	retrieves a set of subs indep par values.
HIR_retrieve_RESULT ()	retrieves a set of analysis results.
HIR_retrieve_OUTFUNC ()	retrieves a set of output_function results.
HIR_terminate ()	terminates the storing of data into the HIR datastructures.

FORMAT_OUTPUT:

FTO_format_output()	Creates the output that belongs to the set of commands that has been read from input.

4.3.3 Function Descriptions.

4.3.3.1 OUT_expand_output.

This function is used to expand the list of commands that are read from input thus creating data-structures that can be processed by the output-processor for creating output.

The most important action is the creation of the link between the requested items, and the analysis data-structures: when some item is read, we still don't know where the value of this item is to be found.
The details of this expansion are omitted, because of the fact that for understanding them one has to know the analysis data-structures in precise detail; which was the reason that the expand has been implemented by my coach, him being the one who developed these datastructures.

Besides creating the link to the analysis, other expansions must be done:

- every WILDCARD that is found in an item must be expanded into a list of occurrences;

- whenever higher-level output-items are found, being expressions that use output-functions as operands, these items must be expanded into:
  - a set of lower-level subexpressions;
  - an expression, that uses as operands references to the results of these lower-level subexpressions.

  The sub-expressions will be treated in the same way, resulting in a tree of expressions, with as leaves only LEVEL 1 expressions: this are
    - references to direct analysis-results,
    - constants, or
    - output-functions using only LEVEL 1 parameters, like MEAN (V(R2)): such an output-function can be evaluated on the fly while performing the analysis, each time updating the stored value.

  In the function OUT_results() we now will save all the LEVEL 1 results. After the complete analysis has been finished, for every subs indep par combination, the function OUT_terminate_output() will be called, where we will evaluate all the higher level expressions: before an expression on a certain level is evaluated, the values of all its lower level operands must have been determined.

4.3.3.2 OUT_subs_indep_par_values.

This function stores a set of values for the subsidiary independent parameters.
In this function, first an array containing the current values for the subs indep pars is fetched, using a function in the Panacea-module that handles the independent parameters.
Then this array is stored, by calling the function HIR_store_INDEP().

4.3.3.3 OUT_results.

After an analysis step has been performed, the analysis-results must be extracted from the analysis data-structures. These results, together with the current values of the princ indep pars, then are stored in the HIR data-structures.

First, the function will get the current princ indep par values, in the same way as the subs indep par values were handled.
Then, a function is called that will evaluate all the LEVEL 1 output-items: using the link between an item and the analysis-datastructures, we will collect the current value of the item. When an item is an expression that uses as operands analysis-results, all the operand-values will be fetched, and the expression will be evaluated.

When the item is a LEVEL 1 output-function, we will update the value that was stored for it, using the new values of the operands for this function: for example, when MAX (I(C1)) is demanded, we must check if the current value of I(C1) is bigger then the value that is stored for the MAX-function; if so, the MAX-function will be set to this new maximum.

4.3.3.4 OUT_function_results.

This function handles the results of the LEVEL 1 output-function items: after a complete analysis-run over the princ indep par has been completed, the result of the item has got its final value, and can now be saved in the HIR data-structures, using the function HIR_store_OUTFUNC().

4.3.3.5 OUT_terminate_output.

Within this function, we will
- handle all the higher level output-items;
- create the output, by calling the FTO_format_output() function.

The LEVEL HANDLER.

The evaluation of the higher level items is performed level by level, starting at Level 2 (the Level 1 results were already evaluated during the analysis). After having all the items at Level 2, we have determined the values of every operand of the Level 3 items, so then we can compute these; and so on, until all the items have been evaluated.

The algorithmic structure of the Level-Handler is as follows:

```
FOR( every level other then Level 1 ) {
    HIR_rewind();     /* start reading the in the HIR_module stored data */

    FOR ( every combination of subs indep par values ) {
       HIR_retrieve_INDEP();
       HIR_store_INDEP();
       HIR_retrieve_OUTFUNC();
       FOR ( every step made over the princ indep par in the analysis ) {
           HIR_retrieve_RESULT();
           Evaluate the items on the current Level;
           HIR_store_RESULT();
       }
       HIR_store_OUTFUNC();
    }
}
```

The first FOR-loop causes every level to be handled, every time restarting retrieving data from the beginning.
Then we will for every value-combination of the subs indep pars, evaluate the items on the current level for every step made over the principal indep par: via HIR_retrieve_INDEP() we fetch the next indep-par combination, and then store this combination back to HIR via HIR_store_INDEP().
Next, we retrieve the OUTFUNC-resultvalues as stored for the current subs indep par combination, via HIR_retrieve_OUTFUNC().
Then, for every step made over the principal independent parameters, we use the already produced lower level results for this step (this includes the lower level OUTFUNC results) as operands while computing the values of the now to be evaluated items.
This is done by retrieving the data that has been stored in the HIR module, using the function HIR_retrieve_RESULT() , and then add to this array of results, the results of the evaluation of the items on the current level.
The new result-array then is saved, using the HIR_store_RESULT() function.

After having repeated this for every step, we have reached the point where the output-function items in the new level have got their final values, and therefore these values can be saved, using the HIR_store_OUTFUNC() function.

4.4 THE HANDLE_INTERM_RESULTS MODULE.

4.4.1 Introduction.

The HANDLE_INTERMEDIATE_RESULTS (HIR) module is used to store the produced analysis results, until the complete analysis is finished and the output can be produced.
In order to make this storage as efficiently as possible, we will try to store the data in core. For this purpose a big block of memory will be reserved: the default size is set to 1 Megabyte.
When it occurs that so much data is produced that it does not fit into this block anymore, then we will write the data to a diskfile: this file will be written in the standard SDIF file format, so that the contents of this file may eventually be processed by other programs.

The interfacing between the HIR module and the rest of the output processor is kept as simple as possible: separated functions have been created for storing and retrieving of data in the INDEP, RESULT and OUTFUNC arrays.
A function has been made to position the "datapointer" to the beginning of the current block of results, so that we can easily restart retrieving data for the current set of subs indep par values (this is required in the module FORMAT_OUTPUT where we must reposition the datapointer to the beginning of a block, for example when we start with the plot for some next item).
Furthermore, functions have been made for initialization, termination and restarting of the storage process.

The HIR - module can be operated in some various ways:

<u>- WRITE ONLY :</u>

This mode of operation is active during the analysis-phase, when we will write the analysis-results to the HIR module:

```
FOR every subs indep par value-combination:
    HIR_store_INDEP();
    FOR every step made over the princ indep pars: {
        do analysis step;  /*  after this action, the RESULT array  */
                           /*  contains the new result-values.      */
        HIR_store_RESULT ();
    }
  /* after all steps have been made, the OUTFUNC array contains */
  /* the final values of the LEVEL 1 output functions.          */
    HIR_store_OUTFUNC ();
}
```

- READ/WRITE :

This mode of operation is active when the LEVEL_HANDLER is computing all the results for the output-items of Level 2 and higher:
The results that were stored in HIR are retrieved, and the results for the next level will be computed using these results. The resulting array, updated with the new values, is then stored again via HIR, so that on the next level we can use the just computed results. See the section that describes the LEVEL_HANDLER for the algorithmic structure.

- READ ONLY :

When we enter the FORMAT_OUTPUT proces, we will retrieve the stored results and use them to create our output -tables and -plots.

```
FOR every subs indep par combination: {
   HIR_retrieve_INDEP();
   FOR all commands: {
      FOR all output-figures for this command
                /* i.e. all separated plots etc. */
         HIR_reposition_on_INDEP()
         HIR_retrieve_OUTFUNC();
         create the table/plot, by retrieving every RESULT array;
      }
   }
}
```

We thus get blocks of output, one block for every indep par combination, each containing all the output tables and plots that belong to this combination. Most of the given commands, result in more then 1 table/plot: for instance a PLOT command with 6 items will result in 6 plots, each of a single item.
For producing these plots, we must restart retrieving the RESULT-data for the current subs indep par combination for every next plot: this is done by the call to HIR_reposition_on_INDEP(). Then the plot is made, by retrieving the RESULT-data for every princ indep par value, and using this data while creating the plot.

4.4.2 Module Interface Description Of HANDLE_INTERM_RESULTS.

4.4.2.1 EXPORT Specification.

The module HANDLE_INTERMEDIATE_RESULTS exports the following functions:

```
HIR_initialize ()                  HIR_rewind ()
HIR_terminate ()                   HIR_reopen ()
HIR_store_INDEP ()                 HIR_retrieve_INDEP ()
HIR_store_RESULT ()                HIR_retrieve_RESULT ()
HIR_store_OUTFUNC ()               HIR_retrieve_OUTFUNC ()
HIR_reposition_on_INDEP ()
```

4.4.2.2 IMPORT Specification.

The HIR module uses the functions in the SDIF_IO module, in order to be able to write/read the file that contains the intermediate results, in those cases where there is very much data.

4.4.3 Functional Module Structure Design.

The 'store' -functions make use of the HIR_write_file() function: whenever it is detected that we have not enough space left to store the array of values, the contents of the memoryblock is saved to the file. This file can therefore be seen as consisting of blocks of data: each block consisting of the contents of the coreblock at that time.
The 'retrieve' -functions make use of the HIR_read_file() function: when a file is being used, and we detect that we have reached the end of the data stored in the coreblock, then we will have to read data from the disk-file: the next block will be read.

All the functions in the HIR-module are heavily related to each other via the global static datastructures in the HIR-module: there are numerous boolean variables that are used for stering the store/retrieve-process, each of which can be set in some function and then later will influence the programm-flow in some other function.

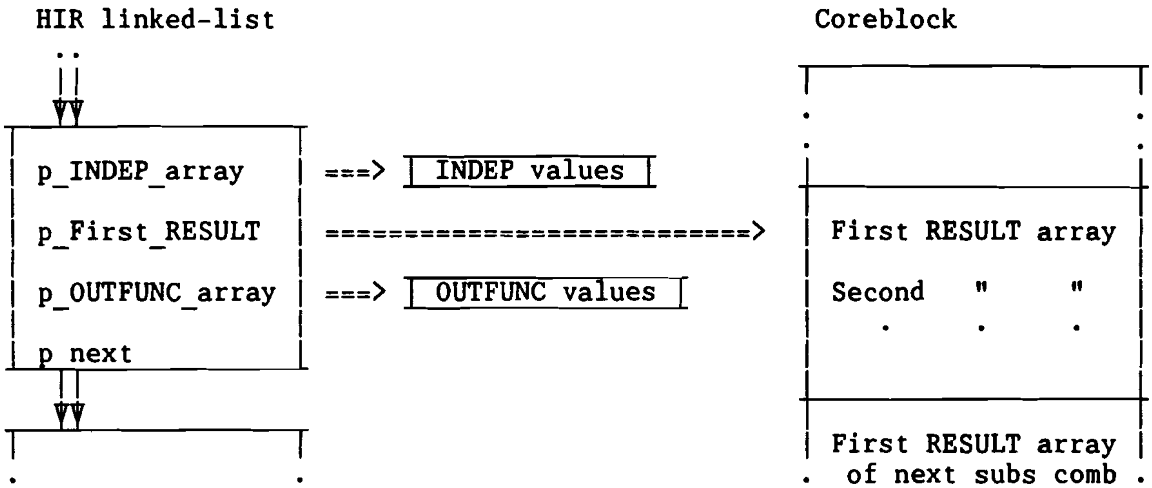
4.4.4 Function Descriptions.

4.4.4.1 The Used Data-structure:

Within the HIR module a linked list of structures is used, each element repesenting a certain subs indep par combination: the elements describe the places where the data that belongs to this combination can be found:

- there is a pointer to an array that contains the subs indep par values;
- there is a pointer to the place in the coreblock where the first RESULT-array contents is stored;
- there is a pointer to an array that contains the OUTFUNC array contents.

Besides this list, another important structure is used: a big block of memory in wich the RESULT-data will be stored. It is nothing motre then a big array of reals, with a default size of 1 Megabyte (== 128k reals).



With regard to the RESULT and OUTFUNC arrays, it should be noted that they contain value-fields for the items of EVERY level: the value-fields belonging to items on not yet evaluated levels will remain empty until the level where they belong to is evaluated: when evaluating such a level, we will retrieve the data from Core, by copying an array of values from the Coreblock into the RESULT-array. Then the results of the items on this level are added to the array, by storing the result-values in the fields dedicated to them: hereafter the RESULT-array is written back to Core, where it will be stored on the same location as where it originally was read from.

When so much data was produced in the analysis that a file had to be be used, we must save the contents of the coreblock after having processed the last RESULT-array in the current block: after this, we then read the next block of data from the file; we process this block, save it, read the next, etc. etc. This causes us to use 2 files, one for writing data to, and one for reading data from: this, because it is not possible to write data somewhere inside an already existing file: data can only be added to the ened of a file.
When stepping to the next level, the file that WAS the write-file will become the read-file for the new level.

4.4.4.2 HIR_store_INDEP.

In this function, first a new element is added to the linked list. Then, the values of the current subs indep par combination are stored.

4.4.4.3 HIR_store_RESULT.

This function is used to store the contents of the RESULT array into the coreblock, when there is still room for it left: otherwise, we first write the contents of the coreblock to file using HIR_write_to_file(), and then store the RESULT array in the now vacant coreblock.

4.4.4.4 HIR_store_OUTFUNC.

This function stores the array of output-function results. The values in this array have their final values after all the analysis-steps have been made for the current subs indep par combination, therefore these results will be stored as the last array of the block of data for some subs indep par comb.

4.4.4.5 HIR_retrieve_INDEP.

Steps to the next element in the linked-list, and copies the content of the array pointed to by the p_INDEP_array into the INDEP array.
Initializations are made make sure that the first time that the function HIR_retrieve_RESULT() is called, it will return the first RESULT-array for this subs indep par combination.
The function returns FALSE when there is no next list-element available.

4.4.4.6 HIR_retrieve_RESULT.

This function retrieves the next set of RESULT data from the coreblock and stores it in the RESULT array; the function returns FALSE after having reached the last stored array.

4.4.4.7 HIR_retrieve_OUTFUNC.

This function retrieves the OUTFUNC array that is pointed to by the current list-element. Here we find the reason why the content of the OUTFUNC array is NOT stored in the coreblock, but in separate arrays:
When retrieving data in the LEVEL_HANDLER, we will use the results of the lower-level items to compute the items on the current level. This means that the contents of the OUTFUNC array must be available for the evaluation; and because it is possible that the amount of RESULT-data for a single subs indep par combination is so much that it does not fit into the coreblock at once, it is clear that we can not put the OUTFUNC behind the RESULT data in the coreblock. We can not put it in front of the RESULT data neither, because then we get into troubles when we have finished an analysis-run and we have to store the OUTFUNC array.
Thus, the easiest solution is to store the OUTFUNC array in a separate array that can always directly be accessed.

4.4.4.8 HIR_reposition_on_INDEP.

This function is used to reinitialize the HIR module in such manner, that we can restart retrieving the data for the current subs indep par combination (READ_ONLY mode only).
The function steps back to the previous element in the linked list; when we now after the call to HIR_reposition_on_INDEP make a call to the function HIR_retrieve_INDEP() we step to the element after this previous element, i.e. we simply re-enter the list-element of the current subs indep par combination, and we can now restart retrieving the RESULT data for it.

4.4.4.9 HIR_initialize.

This function initializes the HIR module: in it, the coreblock is allocated. Because of the fact that a very large block is taken, it is well possible that an allocation problem occurs, i.e. there is not enough free memory.
In such a case, we simply try to allocate a more modest block, and repeat this procedure until the allocation succeeds, or until we find that there is too little free memory for even a minimum-sized coreblock, in which case an errormessage is created, and Panacea aborts.
It is possible for the Panacea-user to specify the size of the coreblock: via a parameter in the Change-block in the Panacea-input, the coreblock-size can be set to a smaller or bigger value.

4.4.4.10 HIR_terminate.

This function is used to stop the storage-process: all open files are closed.

4.4.4.11 HIR_rewind.

This function is used in the READ/WRITE mode when switching from one level to the next level: the current WRITE file will become the READ file of the next level, and the current READ file will become the new WRITE file.

4.4.4.12 HIR_reopen.

This function is used in the READ_ONLY mode: it opens the last used WRITE file for read. The data in this file is the data that results after the last level has been handled by the LEVEL_HANDLER: this is the data that has to be used to create the output.

4.5 THE FORMAT_OUTPUT MODULE.

4.5.1 Introduction.

In this module, the real PANACEA OUTPUT will be produced, i.e. the requested output tables, plots, histograms, and files will be created.

At the moment that this module is activated, by the call to the function FTO_format_output(), the complete analysis has been performed. All the analysis-data that is required in order to produce the correct output, has been generated, and has been stored using the HANDLE_INTERMEDIATE_RESULTS module.

When we now start producing the requested output, we will retrieve the data from the HANDLE_INTERMEDIATE_RESULTS data-structures, and with this data we will create our plots, tables etc.

The output is organised in such a way, that we will start with generating ALL the output (for every normal output command, see below) for the FIRST combination of values for the subs indep pars.
Then we will create the output for the next combinations, every time generating all the output for a combination as a single group: i.e. we will get the following order in the output:

```
 - subs combination 1 -
      TABLE_1
      PLOT
      TABLE_2
  - subs combination 2 -
      TABLE_1
      PLOT
      TABLE_2
  - subs combination 3 -
      :
```

There are two sorts of output commands:
First, the NORMAL commands: those commands that do NOT use the XVAR option.
Secondly, the XVAR commands: those commands that DO use the XVAR option.

The reason for the separation of these two types is, that the output for the XVAR commands can not be mixed with output for the other commands.
This is so , because of the fact that for the XVAR command we will create output for other combinations of independent parameters then for the normal output commands: the XVAR parameter that for a normal command will be treated as a subs indep par, is in the XVAR command used as the PRINCIPAL indep par, while the principal indep par of the normal commands, now is treated as being a subs indep par.

4.5.2 Module Interface Description Of FORMAT_OUTPUT.

4.5.2.1 EXPORT Specification.

The module FORMAT_OUTPUT has only 1 function that is being exported:
FTO_format_output()

It is called from the module OUTPUT, in function OUT_terminate_output() : After the analysis has been completed and the LEVEL_HANDLER has evaluated all higher level items, the output can be produced.

4.5.2.2 IMPORT Specification.

The FORMAT_OUTPUT module uses a number of functions from the other modules in the Output Processor:

HANDLE_INTERMEDIATE_RESULTS:
This module has stored all the analysis results, that now will be used to generate the output: the data will be retrieved using the functions:

HIR_reopen ()	restart retrieving data from the beginning.
HIR_retrieve_INDEP ()	retrieve set of subs indep par values.
HIR_reposition_on_INDEP ()	restart retrieving data for this INDEP set.
HIR_retrieve_RESULT ()	retrieve array of results for next principal independent parameter value.
HIR_retrieve_OUTFUNC ()	retrieve set of output-function values.

SDIF_INPUT/OUTPUT:
All exported functions; used while creating FILE output, which will be a file in the SDIF format, containing the results for the in the FILE: - statement requested outputitems.

PRINT_OUTPUT:
All exported functions: used while creating output, other then FILE: Everything that is written by Panacea to (standard) Output is buffered by the PRINT_OUTPUT module, in order to be able to generate formfeeds and pageheaders on the right moments, and to prevent line-overflow.

4.5.3 Functional Module Structure Design.

The FORMAT_OUTPUT module has the following functional decomposition:

```
 FTO format output                controls the format process.
   |
   | handle_options               process the options_list.
   | handle_XVAR                  gather and format data for XVAR commands.
   |
   | FTO_create_INDEP_header      print list of subs indep par names+values
   |                                uses:   create_list_dump
   | FTO_print                    format the output for a PRINT command.
   |                                uses:   create_table
   |                                        create_list_dump
   | FTO_plot_prplot              format the output for a (PR)PLOT command.
   |                                uses:   create_plot
   |                                        create_list_dump
   | FTO_mplot                    format the output for a MPLOT command.
   |                                uses:   create_mplot
   |                                        create_list_dump
   | FTO_file                     format the output for a FILE command.
   |                                uses:   write_block_to_file
   | FTO_histogram                HISTOGRAM output:  not yet implemented.


create_list_dump                 makes a list of outputitems and values.

create_table                     format a single table.
    | name_substitution            replace too long names by an alias.
    | centre_name                  centre an item-name above its column.
    | format_value                 format a floating-point value.

create_plot                      make a plot of the given item.
create_mplot                     make a mplot of (nr_of_plotchars) items.
    | compute_header               determine the plot scaling.
    | print_header_value_lines     prints the scale-lines of the y-axis.
    | create_interval_line         make a +---+---+--.. line.
    | format_value                 format a floating-point value.

write_block_to_file              write data for current INDEP set.
```

4.5.4 Function Descriptions.

4.5.4.1 FTO_format_output.

In the FTO_format_output() function the list of outputcommands is being processed, to produce the required output tables, plots, file etc.

First, the 'normal' outputcommands are handled, creating all the output for a certain combination of subs indep par values at once:

```
FOR ( all subs indep par value-combinations ) {
    FOR ( all NORMAL commands ) {
         handle_options (command) ;
         create output belonging to the current command ;
    }
}
```

Then, we create the output for the XVAR commands:

```
FOR ( all XVAR commands ) {
    handle_options (command) ;
    handle_XVAR (command) ;
}
```

The handle_XVAR() function shall create the output for the given command, for every combination of the not-XVAR indep pars.

The FILE command is treated as a normal outputcommand. Not because the output should be grouped for a certain set of subs indep par values, as for the normal <u>printing</u> output commands, but only for efficiency reasons:
we now can use the data that was read for the other normal outputcommands, to produce a block of data in the file-output, containing all the analysis results belonging to the current subs indep set.
In case we are working with large amounts of data, so big that in the HIR module data is written to a temporary disk-file, we now save ourselves a scan through this file, which would be necessary when we would treat the FILE command separated from the normal output commands.

4.5.4.2 Handle_XVAR.

In the handle_XVAR() function the data for the given command is collected from the HANDLE_INTERMEDIATE_RESULTS module, resulting in a datastructure that contains a set of outputitem_values for every value of the XVAR parameter that is being used.
Then this datastructure is used to generated the output table or plot for the given command.

This process will repeat it self for every combination of values for subsidiary AND principal independent parameters, but EXCLUSIVE the XVAR parameter.
As a result, we must very often scan through the analysis data stored by the HIR module: and in case that we have so much data that a file is being used to store the data in, this means that very much file-access is necessary: which takes a lot of CPU-time.
An exception to this occurs when the XVAR is just another PRINCIPAL independent parameter: in that case we only have to swap the XVAR and the most principal independent parameter and then produce the tables, because the values of ALL the princ indep pars are stored in the RESULT arrays.

We use a datastructure to store the retrieved results in, to limit the number of file scans to a minimum: for example, when a PLOT: command is given with 10 outputitems, this results in 10 separated plots. When we now would create the plots by scanning through the file, every time retrieving only the value for the current outputitem, we would make 10 file-scans; when we first collect the data and then produce the plots using the data that was stored in the datastructure, we need only a single file-scan: i.e. we trade speed for memory-usage.

A second reason for using the datastructure is that we must compute the maximum and minimum values of the items to be plotted, these values are required for the scaling of the y-axis of the plot.
For normal PLOT commands we can determine the max and min of the items while evaluating the items themselves; for a XVAR plot, it's NOT possible to do so: we will have to compute the min and max just before we start the plot.
To minimize file-access we now use the data-structure in which all the XVAR-data is stored; thus we can compute the max and min without having to scan the file.

4.5.4.2.1 EXAMPLE OF THE XVAR-OPTION:

```
subsidiary:   par  A : 2 values ;  par  B : 3 values ;  par  C : 2 values.
principal:    par  p       6 values

command:     PLOT: items (OPTIONS: XVAR = B) ;
```

DATA IN THE HIR STRUCTURES:

```
No:
      INDEP :           A 1 -- B 1 -- C 1
 1      RESULT:         p 1  +  item-data
 :      :
 6      RESULT:         p 6  +  item-data

      INDEP :           A 1 -- B 1 -- C 2
 7      RESULT:         p 1  +  item-data
 :      :
12      RESULT:         p 6  +  item-data

      INDEP :           A 1 -- B 2 -- C 1
13      RESULT:         p 1  +  item-data
 :      :
18      RESULT:         p 6  +  item-data

      INDEP :           A 1 -- B 2 -- C 2
19      RESULT:         p 1  +  item-data
 :      :
24      RESULT:         p 6  +  item-data

      INDEP:            A 1 -- B 3 -- C 1
25      RESULT:         p 1  +  item-data
 :      :
30      RESULT:         p 6  +  item-data

      INDEP:            A 1 -- B 3 -- C 2
31      RESULT:         p 1  +  item-data
 :      :
36      RESULT:         p 6  +  item-data

      INDEP:            A 2 -- B 1 -- C 1
37      RESULT:         p 1  +  item-data
 :      :
42      RESULT:         p 6  +  item-data

      INDEP:            A 2 -- B 1 -- C 2
43      RESULT:         p 1  +  item-data
 :      :
 :      :
```

XVAR PLOT SEQUENCE:

```
PLOT No  1:     A1 C1 P1
     1)   B1
    13)   B2
    25)   B3
:
:
PLOT No  6:     A1 C1 P6
     6)   B1
    18)   B2
    30)   B3

PLOT No  7:     A1 C2 P1
     7)   B1
    19)   B2
    31)   B3
:
:
PLOT No 12:     A1 C2 P6
    12)   B1
    24)   B2
    36)   B3

PLOT No 13:     A2 C1 P1
    37)   B1
    49)   B2
    61)   B3
:
:
PLOT No 18:     A2 C1 P6
    42)   B1
    54)   B2
    66)   B3
:
:

PLOT No 24:     A2 C2 P6
    48)   B1
    60)   B2
    72)   B3
:
:
```

4.5.4.3 Handle_options.

The handle_options() function is used to process the list of options, as given by the user for the current output command.
In the datastructure that describes an outputcommand, there is a pointer to a list of option-structures. These structures contain an option-indicator, that tells which option it is, and an option-setting: this is a 'union', i.e. a datastructure that can be read as integer, real, real-pair, character etc.
For example:
for the WIDTH option we have to read an integer value from the union:

```
width = p_option->data.int_value ;
```

for the RANGE option we have to read an real-pair from the union:

```
lower_bound  = p_option->data.real_pair.lower_bound;
upper_bound  = p_option->data.real_pair.upper_bound;
```

The handle_options() function now processes each element of the options-list, for every option that is encountered adjusting the values of certain local variables that influence throughout the FORMAT_OUTPUT module the manner in which the output is produced.

4.5.4.4 FTO_create_INDEP_header.

When subsidiary independent parameters are being used, we want to see in the output witch subs indep par combination a certain plot or table belongs to. Therefore a list of the subs indep par names and the current values will be printed when we start producing output for a new subs indep par combination. The list is made by a call to the function create_list_dump () .

4.5.4.5 FTO_print.

This function is used to create the output that results from giving a PRINT command in the panacea input: create output in a tabular form.

When creating the tables, it should be noted that we have a limited line_width, i.e. it is very well possible that more items must be printed then fit on a line: in such cases we will first create a table containing the princ indep par and the first output-items. Then, we create a table for the princ indep par and the next output-items, etc, until all the items have been handled.

We can easily determine the number of items that fit in a table, by counting the number of characters in the ascii-representation of a floating-point number, in the by the NUMFORM: command specified format. This ascii-string is created using the function format_value (). By dividing the line-width by the value-width, we determine the number of columns in a table.

The value-width is furthermore used to determine the maximum nr_of_characters that can appear in a column-heading: in the table we must give an indication which column represents which outputitem. We do this by printing the name of the item above the column. However, when this name is too long, we will replace it for a substitute name; at the start of the table a list will be printed containing the substitute-names and the item-names that will be replaced by them.
The name substitution is handled by the function name_substitution() .

After this substitute-name legend has been printed, containing the names of ALL the too long outputitems, we will first print, in those cases where there is more then 1 principal independent parameter, a table of the most principal indep par and the other principal indep pars. The most principal indep par will hereafter be used as the first column of every other table for the current command. Then, we produce these result-tables.
The tables are produced by the function create_table().

EXAMPLE: (NUMFORM format = ENGINEERING, FIX, DIGITS=4)

legend:
OUT_1 = I(TNES_123.MODA1 | C,E)

F	VN(1)	OUT_1	VN(2)
1.000 E 03	-80.000 E-03	5.000 E 00	40.500 E 03
2.000 E 03	-200.000 E-03	10.000 E 00	600.788 E 06
3.000 E 03	-250.000 E-03	40.000 E 00	-170.000 E 21

4.5.4.6 FTO_plot_prplot.

The PLOT and PRPLOT commands are completely equal to each other, beside the fact that in a PRPLOT we will print the VALUE of the plotted item alongside the plot: by using a single flag, we can determine when starting to print a line whether we must print the item-value or not. This flag is also important in the functions that calculate how the plot header must be created.

Within the FTO_plot_prplot function we check whether there are items for which it is useful to make a plot: i.e.single valued results will not be plotted, but they are printed as a list using create_list_dump().
Then, for every item a plot will be made, by repeatedly calling the function create_plot() .

4.5.4.7 FTO_mplot.

This functions handles the creation of the MPLOT plots, i.e. plots containing the curves of more then 1 output item.
The user can specify how much outputitems may be plotted in a single mplot, by specifying the plot_characters that must be used to create the plot: no more then nr_of_plotchars output_items will be printed in the plot.
The multi-plots are created by repeatedly calling the function create_mplot().

4.5.4.8 FTO_histogram.

Because in the current development phase of Panacea the STATISTICAL ANALYSIS is not yet implemented, there was no need to implement the HISTOGRAM output, which therefore has been omitted.

4.5.4.9 Create_list_dump.

This function is used whenever a list of names and the values belonging to them must be printed:

- from FTO_create_INDEP_header:
  Printing of the current subs indep par combination.
- from FTO_print, FTO_plot_prplot, FTO_mplot:
  In those cases where it is detected that there is only a single set of resultdata, for example when a DC-simulation has been performed without any independent parameters, we will not make a table of these results, but print them as a list of outputitems with their values.
  Also, a list will be made for the OUTPUT_FUNCTION resultvalues: these are constants over all values of the princ indep pars, and therefore it's useless to print them in the tables or to make a plot of them.

4.5.4.10 Create_table.

This function is used to create an output table. It is handed as parameters:

- pointer to the structure containing a description of the princ indep par
- pointer to an element in the list of items to be printed
- an integer, giving the NUMBER of items that can be printed in a table

The function returns the pointer to the first element in the list that was not printed, or a NULL pointer when all items have been printed: this means that in FTO_print() we can produce all tables via a very simple loop:

```
p_item = pointer to the first output-item;
while ( (p_item = create_table (p_princ, p_item, n_items) ) != NULL ) ;
```

First the table-header is made, using the substitute-names when necessary. The names are centered above the column using the function centre_name(). Then the result-values are printed, each value is formatted in the by the NUMFORM: command specified manner, using the function format_value().

4.5.4.11 Name_substitution.

This function is handed as input a pointer to a string, and returns as output a pointer to either the same string, or to a substitute name: when the name is longer then 1 + (stringlength of a by format_value() formatted number).

The function maintains a static list of all the too long names and their substitutenames: this is necessary because we want to return the same substitute name when we get the same name as input.

4.5.4.12 Centre_name.

This function is used to print a name-string in the heading of a table, centered above the column where this name belongs to:

1) If name is short enough, let it start at the position just before the decimal point. The last character of the name may not be printed at a position past the last digit of the exponent.
2) If this is not possible, let the name start at an earlier position, but not at a position before the sign of the fractional part.
3) If the name still does not fit, then in a last desperate try to print the name itself, let the last character be printed at the position directly after the last digit of the exponent, i.e. above the first of the spaces that keep the columns separated.
   (Longer names do not exist: they are substituted in an earlier phase.)

4.5.4.13 Format_value.

This function is called everywhere where a number must be written to output. It must be printed in the by the NUMFORM: command specified format, i.e.

- exponent (normal, or multiple of 3) or scaling factors;
- using the specified nr of digits;
- decimal point at a fixed location or floating within the representation.

The function is handed as input a double precision real value; it returns as output a string of constant length, containing the ascii representation of the real value, formatted using the NUMFORM specification.

When the exponent of the value that has to be printed is smaller then E-18, and the notation is SCALED, then we will print the value as ZERO: this because there are no scaling factors smaller then ATTO. On the other hand, there are no scaling factors above TERA: values that are greater then 999.999.. E12 are printed as '*********'.

4.5.4.14 Create_plot.

This function is used to create a plot. It is handed as parameters a pointer to the princ indep par, and a pointer to the item to be plotted.
First, the minimum and maximum values of the item are determined. Using these values, the function Compute_header() will determine the scaling of the plot.
Then the plot is created: first the plotheader is made, using the function print_header_value_lines() to create the two lines with y-values, and the function create_interval_line() to make the +-----+-----+----.. line.
(See the headers of the plots in Appendix A).
Then the graph of the item is made, by writing for every analysis-step a line that contains the used plotchar at the place that corresponds to the current item-value. On the beginning of the line, the princ indep par value is printed using the format_value() function. For PRPLOT, also the current item-value is printed.
Finally, the plot is terminated with an +-----+-----+-.. line.

4.5.4.15 Create_mplot.

This function is used to create a multi-plot, containing the curves of (nr_of_plotchars) items at the same time.
The function is very similar to the create_plot command; however, it is a bit more complex because we now have to plot the curves of more then one item in a single plot.

4.5.4.16 Compute_header.

This function is used to determine the exact scaling of the y-axis: given the minimum and maximum values of the item to be plotted, determine a scaling in such a way that:
- the minimum value lies as much as possible on the left side of the plot
- the maximum value lies as much as possible on the right side of the plot
- the values on the y-axis are nice, rounded figures
- the nr. of values on the y-axis is maximal, given the set NUMFORM format.

The function returns a structure that contains all the necessary information for the scaling of the plot: lower_bound, step_size, n_y_values etc. etc.
The details of how the scaling exactly is determined are omitted.

4.5.4.17 FTO_file.

Within this function, the Panacea FILE-OUTPUT is handled.
The function is used to write data to the file, a BLOCK at a time, a block being all the data that belongs to the current subs indep par combination.

When the function is called for the first time, the output_file still has to be opened, and initialized: the INFO-statement and the TITLE-statement must be written to the file, that has the SDIF file-format (See appendix B). Furthermore, some internal datastructures will be initialized: as a result of these initializing actions, we can in the function write_block_to_file() in an easy way extract the data that must be written to the file from the INDEP, RESULT and OUTFUNC arrays, and write it to the file.

4.5.4.18 Write_block_to_file.

This function writes a block of data to the output_file in the SDIF format. The file has already been opened and correctly been initialized by the FTO_file() function itself; write_block_to_file() only has to write the analysisdata that belongs to the in the file-command requested output_items to the file.

A block of data consists of:

- the current value-combination of the subs indep pars;
- for every step made over the principal indep pars, an array with the step-dependent analysis-results;
- an array of output-function results.

Within the write_block_to_file() function, data is written in precisely this sequence: See 4.7.1 : Introduction to the SDIF_IO module.

4.6 THE PRINT_OUTPUT MODULE.

4.6.1 Introduction.

This module is used as an extra buffer between Panacea, and the output that is printed. The reason for this is, that we want to create page-headers when a page is full, and that we want to take certain actions when line-overflow occurs. Because it is not desirable to check everywhere within Panacea where something must be printed, whether this text still fits or not, functions have been created that replace the normal printf() C-function.
Within these functions, all the required tests are made, taking action when necessary, and then printing the handed textstring.

Error-messages:

When during a Panacea-job errors occur, a message describing the occurred error must be given. Instead of printing the message as soon as the error is detected, we would rather wait with printing the message until the current line of Panacea output is finished, and then print as a group all the messages that belong to this line.
Thus, given the input-line: AC; PRINT: VX; END; RIUN; FINISH;
we want to get output in the format:

```
AC; PRINT: VX; END; RIUN; FINISH;
             *          *
<ERROR>  Syntax error while....
<ERROR>  Syntax error while....
```

and not:

```
AC; PRINT: VX;
             *
<ERROR>  Syntax error while....
END; RIUN; FINISH;
         *
<ERROR>  Syntax error while....
```

Storing the error-messages, and printing them after a line is finished, must be handled in the PRINT_OUTPUT module. This is so, because of the fact that in case of line-overflow, the last word on the line is wrapped around to the beginning of the next line. Any error-messages that belong to this word, may not be printed now, but must be kept in storage until this next line finally is printed. It is clear, that the best place for making the decision about which error-messages can be printed now and which will have to wait, lies in the same module, as where the decision is made about which part of the line will be printed now, and which part will have to wait.
Therefore, the PRINT_OUTPUT module will be used to store and print the error-messages.

4.6.2 Module Interface Description Of PRINT_OUTPUT.

4.6.2.1 EXPORT Specification.

The module PRINT_OUTPUT exports a great number of functions. A lot of these functions are very simple, and only used for storing and retrieving of information concerning pagelength, width, etc.
Besides these self-evident functions, there are some more complex functions, that will be described in the next sections::

PRO_print_char()
PRO_print_string()
PRO_print_line()
PRO_print_error_message()

4.6.2.2 IMPORT Specification.

The PRINT_OUTPUT module does not use any of the functions in the other modules of the Output-processor.

4.6.3 Functional Module Structure Design.

The PRINT_OUTPUT module has the following functional decomposition:

```
            PRO_print_line ()
             /          \
            V            \
   PRO_print_string()     |
            \            /
             V          V
            PRO_print_char()        PRO_print_error_message()
            /      |                    |
           /       V                    |
          /     write_line()            |
         |         |     \              |
         |         |      V             V
         |         |    write_error_messages()
         |         |      /
         |         V     V
          \       put_line()
           \          |
            V         V
          put_page_header()
```

4.6.4 Function Descriptions.

4.6.4.1 PRO_print_char.

This function is handed a single character, that will be added to an internal textbuffer. When the length of the text in the buffer exceeds the current linewidth, or when the received character is a NEWLINE character, the stored text is printed, using the function write_line(). This function prints the part of the textbuffer that fits on a single line: it returns a pointer to the first word that could not be printed completely on this line anymore. The not-printed text will then be moved to the beginning of the buffer.

Any errormessages that belong to the just printed part of the buffer, will be printed.

When the received character was a FORMFEED character, the buffer will be emptied by calling write_line(), after which a formfeed is forced by calling the function put_page_header().

4.6.4.2 PRO_print_string.

This function prints a given string: for every character in the string, the function PRO_print_char() is called.

4.6.4.3 PRO_print_line.

This function prints a given string on its own line of output:
First, the function checks if the buffer is empty. If not, a NEWLINE character is send to PRO_print_char(): the buffer will be printed, and will be empty afterwards.
Then the given string is printed by calling PRO_print_string().
Finally, the text in the buffer is send to output, by again sending a NEWLINE character to PRO_print_char(). Thus, we make sure that no text can be added to this line afterwards.

4.6.4.4 PRO_print_error_message.

This function stores a given error-message in a list of messages. In this list, the text of the message is stored, together with the position in the textbuffer where this message belongs to.

When the textbuffer is empty at the moment that the message is received, the message will be printed immediately by calling the write_error_meessages() function. (When the buffer is not empty, the messages are stored until the text in the buffer is printed, after which all the messages that were received are printed at once).

4.6.4.5 Write_line.

This function writes the string in the textbuffer to output, by calling the put_line() function, which prints the part of a given string that fits on a single line of output.
After the string has been written, the error-messages that belong to this part of the textbuffer will be printed, by calling write_error_messages().
Then, the not printed part of the string is moved to the beginning of the textbuffer.

4.6.4.6 Put_line.

This function is used to create a single line of output.
It is handed as input-parameter a pointer to the beginning of the string that must be printed.
It will print as much characters of this string as will fit on a single line of output, but when this part of the string ends somewhere inside a word, the letters that belong to this word are not yet printed.

Before writing the selected part of the string to output, first it is checked if there still is space on the current page. For this purpose a line-counter is maintained, that is increased whenever a line is send to output, and is set to zero each time a formfeed is given. This formfeed is created in the function put_page_header(), which also creates the page_header for the next page, and which is called as soon as the line-counter reaches the page-length value, or after reading a form-feed character in the Panacea-input.

4.6.4.7 Write_error_messages.

This function writes the error-messages in the messages-list to output. It is handed as input-parameter the position in the textbuffer of the first not printed character; any message belonging to a later position may not be printed yet, because the text where it belongs to has been wrapped around to the next line of output.

Printing of an arbitrary long error-messages is done by repeated calls to the put_line() function that will write a part of the string to a line of output (p_text = pointer to begin of error-message) :

```
while ( ! *(p_text = put_line(p_text))  );
```

Thus, as long as the return-pointer of put_line() does not point to the END_OF_STRING indicator, we will repeat writing parts of the message to output.

4.6.4.8 Put_page_header.

This function generates a formfeed, and then prints a page-header on top of the new page, consisting of a pagenumber and, when supplied in the input, the text of the TITLE: statement.

4.7 THE SDIF IO MODULE.

4.7.1 Introduction.

Within the SDIF_IO module (for SDIF INPUT OUTPUT), data is written to, or read from, a file in the new SDIF file format.
This file format is the new standard file format that will be used in all sorts of CAD-tools that are in use within Philips. It has, for example, at the moment been implemented in Panacea, Philpac, GAP (a graphical postprocessor), and DIPRO (a program to compute filter characteristics).
For a description of the SDIF fileformat I would like to refer to Appendix B, where the complete SDIF Reference Manual has been included. It should be noted, that a SDIF file is not a text file, but a binary file with variable length records.

The functions in this module are called from the HANDLE_INTERMEDIATE_RESULTS module, for writing/reading the intermediate-results file, and in the FORMAT_OUTPUT module, when file-output must be created.

The SDIF_IO module is only used to CAMOUFLAGE all the tiny details that belong to the SDIF format, like the use of preceding keywords, the size of a keyword, etc. etc.
The module is NOT meant to read from some arbitrary file, thereby deciding, given the last record that has been read, what sort of record the next record is going to be.
THE DECISION WHAT SORT OF RECORD MUST BE READ IS MADE IN THE CALLING MODULES!
The SDIF_IO module has no influence whatsoever upon this.

For Example: the routine that creates an SDIF file in FORMAT_OUTPUT.
It is an extract from the write_block_to_file() function.

```
SIO_open_sdif() ;                               open file
SIO_write_sdif_info() ;                         write INFO statement
SIO_write_sdif_title() ;                        write TITLE statement
loop:
   SIO_write_sdif_header ( INDEP ) ;            write INDEP headers
   SIO_write_sdif_tuple ( INDEP ) ;             write INDEP values
   SIO_write_sdif_header ( RESULT ) ;           write RESULT headers
   loop:
      SIO_write_sdif_tuple ( RESULT ) ;         write RESULT data
   end;
   SIO_write_sdif_header ( OUTFUNC ) ;          write OUTFUNC headers
   SIO_write_sdif_tuple ( OUTFUNC ) ;           write OUTFUNC data
end;
```

In this example we see that the STRUCTURE of the SDIF file is determined by the FORMAT_OUTPUT, while all the details concerning how the header exactly will appear in the file etc. are left to the SDIF_IO .

4.7.2 Module Interface Description Of SDIF_IO

4.7.2.1 EXPORT Specification.

The following functions are being exported by the SDIF_IO module:

SIO_read_sdif_info () ;	Read the FILE INFORMATION statement.
SIO_read_sdif_title () ;	Read the TITLE statement from the file.
SIO_read_sdif_headers () ;	Read a HEADING statement from the file.
SIO_read_sdif_tuples () ;	Read a TUPLE statement from the file.
SIO_write_sdif_info () ;	Write the FILE INFORMATION statement.
SIO_write_sdif_title () ;	Write the TITLE statement to the file.
SIO_write_sdif_headers () ;	Write a HEADING statement to the file.
SIO_write_sdif_tuples () ;	Write a TUPLE statement to the file.
SIO_open_sdif () ;	Open an SDIF file.
SIO_close_sdif () ;	Close an SDIF file.

The SIO_open_sdif() function returns a filepointer to the opened file. Whenever something must be read from or written to this file, this pointer is used as a parameter in the call to the required SDIF_IO function, so that it is possible to use more then 1 file at the same time.

4.7.2.2 IMPORT Specification.

The SDIF_IO module does not use any particular functions from the other modules of the Output-processor, except for some of the information-supplying-functions in CONTROL OUTPUT.

One very important piece of information that is fetched with such a function, is the pointer to the OUT_general_data datastructure in CONTROL_OUTPUT: when reading data from or writing data to a SDIF file the OUT_general_data structure is often used: for instance, when the HEADER-statement must be written, we will use the names that are stored in lists in OUT_general_data.

4.7.3 Functional Module Structure Design.

The functions are more or less stand-alone functions, not using other functions then some internal functions for reading/writing a given number of characters, integers or reals, and for terminating a record.

4.7.4 Function Descriptions.

4.7.4.1 SIO_read_sdif_info.

This function reads the INFO statement from the SDIF file.
It starts with reading a KEYWORD from the file. This must be the INFOKEY keyword (See the specification of the INFO statement in Appendix B); if its not, then something has gone wrong, and an error-message will be given.
When reading a keyword, we simply read the next few bytes from the file: we will NOT search in the file after a matching keyword.

When the correct keyword is found, we can read the data that belongs to the INFO statement, See Appendix B.
The data will be stored in the OUT_general_data datastructure.

4.7.4.2 SIO_write_sdif_info.

Writes an INFO statement to the file: first a INFOKEY keyword is written, followed by the data that belongs to the INFO statement, using the information in the OUT_general_data data-structure.

4.7.4.3 SIO_read_sdif_title.

This function reads a TITLE statement from the file, existing of a TITLKEY keyword, an integer giving the number of characters in the title, and the title-string.
The title-statement is optional: it is missing from the file, when no title has been specified in the Panacea input. In such case, the keyword that has been read will be a HEADINFK keyword, and we know that the title is missing.
When after the call to SIO_read_sdif_title() a call to the function SIO_read_sdif_headers() occurs, then we must know, that its keyword has been read already.

4.7.4.4 SIO_write_sdif_title.

Only when a title has been specified in the Panacea input, the TITLE statement will be written to the file, otherwise nothing is written.

4.7.4.5 SIO_read_sdif_headers.

This function is used to read a HEADING statement from the file.
Each heading consists of a name and a number of child headings that are connected to it. Every heading that has no childs, is connected to a single valuefield in the later tuple-records: for example:

```
 COMPLEX, 2 childs :  -- REAL, 0 childs --> first value in tuple record
                      -- IMAG, 0 childs --> second value in tuple record
```

First we will test if the next records in the file are indeed the heading records, i.e. we read a keyword and test if it is the HEADINFK. In those cases where the title-statement was missing, the keyword was read already. Next we read the HEADINF1 record: a characterstring that describes the TUPLETYPE of the tuple where this heading belongs to. The tuple-type can be INDEP, RESULT or OUTFUNC, indicating the what sort of values are stored in the tuple-statement(s) that follow after this header-statement.

Then we read the HEADINF2 record: the total nr of headings.
It is followed by HEADINF3 records, containing pairs of integers, each pair describing the number of childs belonging to this header, and the nr of characters in the headerstring.
These records will be followed by records containing the names of the headers: first a HEADKEY keyword, and then HEADDATA records containing all the names, as one large characterstring.
Using the Headinfo data, the string is split up in the separate names; these are stored in the by the tuple-type indicated list in OUT_general_data.

4.7.4.6 SIO_write_sdif_headers.

Analog to the the SIO_read_sdif_headers() function, we now will write the HEADING records to the file. As input-parameter, the function is given a TUPLETYPE indication: INDEP, RESULT or OUTFUNC. The function then will write the header-statement to the file, using the list of item-descriptions that belongs to the given type; this list is found in the OUT_general_data datastructure.

4.7.4.7 SIO_read_sdif_tuple.

This function is handed as inputparameters a pointer to an array, and an integer that gives the number of values to be read.
The function will first read the TUPLEKEY keyword and the tuple-identifier. Then the given number of (double real) values are read from the file, and stored in the given array.

4.7.4.8 SIO_write_sdif_tuple.

Analog to the SIO_read_sdif_tuple() function, but now the records are written using the values stored in the given array.

4.7.4.9 SIO_open_sdif.

This function is handed as input-parameters the name of the file that must be opened, and the manner how it should be opened: for Read or for Write.
Then the file is opened; it must become a binary file with variable length records. This causes a System-dependent piece of code: on a VAX computer one has to specify "CTX=BIN" in the fopen() statement with which the file is opened; on other computers, it will probably work in a different way.
For this reason, a special FILE - module has been created, which contains functions for opening, closing, rewinding and deleting files. When somewhere in Panacea something needs to be done with a file, the functions in this module will be used; the System-dependent code is now concentrated in a single module, so that the adaption to a new type of computer can easily be performed.

4.7.4.10 SIO_close_sdif.

This function is handed as input-parameter a file-pointer; the file that it points to will then be closed.

CHAPTER 5

CONCLUSIONS.

During my graduate project, the largest part of the Panacea output processor has been completed. However, a lot still must be done: because of the size of the project, first those parts have been developed that were of crucial importance in order to get any output at all:

- The CONTROL_OUTPUT module has been implemented; However, the evaluation routines are still in a very simple form: the allowed output-items are restricted to: nodal voltages, element voltages, and element currents. At the moment it is thus not possible to use output-functions, or expressions: therefore at the moment no higher-level items are possible, although the rest of the output processor can handle them.
  In the near future (May/June 1987) the use of expressions etc. will be implemented, including the level mechanism.

- The HANDLE_INTERMEDIATE_RESULTS module is completely finished;

- The SDIF_IO module is completely finished;

- The PRINT OUTPUT module is completely finished;

- The FORMAT_OUTPUT module:
  The PRINT, PLOT, PRPLOT and MPLOT:
    - have been completely implemented, although a number of options are not yet implemented; most important of them the XVAR option.

  The FILE: command has been implemented but:
    - always only a single output file possible.
    - no options possible.

  The HISTOGRAM: command has not been implemented because there is as yet no statistical analysis possible in Panacea, so the HISTOGRAM: output is not yet necessary.

With regards to the release-planning of Panacea, in version 1.0 of Panacea that is planned to be released in July 1987, all the above mentioned missing items must have been implemented, except for the HISTOGRAM: output.

APPENDIX A

EXAMPLE OF PANACEA-OUTPUT.

EXAMPLE OF PANACEA-OUTPUT.

```
PANACEA  VERSION: BETA_1.5    COPYRIGHT  1987  NV PHILIPS EINDHOVEN NETHERLANDS

-----------------------------------------------------------------------------
USER_ID :  FLAMMERS                                 DATE :  13-APR-1987  16:15:59
PROG_ID :  $1$dua0:[flammers.work]panacea.exe;21
-----------------------------------------------------------------------------


title: This is an example of a Panacea circuit description. ;
numform: engineering, fix, digits=4 ;

circuit ;
   j1 (0,1) sw(2.0,0) ;
   j2 (0,1) 2 * par ;
   r1 (1,0) 0.5 ;

   ec1 (0,2) i(r1)*i(r1) ;
   c1 (2,4) 22u ;
   r2 (3,2) 0.5 ;
   r3 (3,4) 0.5 ;

   r_name (3,0) i = exp(vn(4)) ;
   r_thisisaverylongname (4,0) 0.5 ;
   c2 (3,0) 47u ;
end;

ac;
   f= an( 10, 1000, 9 ) ;
   par = 1, 2 ;

   print:  v(r*) ;
   mplot:  v(r_name),  v(r_thisisaverylongname)
        (options:  grid, plotchar=(R,I) , width = 70, iscale) ;
   prplot: v(r_3)  (options: plotchar=@);
   file: vn, i ;

end;

run: ac ;
```

EXAMPLE OF PANACEA-OUTPUT.

AC ANALYSIS.

PAR = 1.000 E 00

Legend:
OUT_1 = RE(V(R_THISISAVERYLONGNAME))
OUT_2 = IM(V(R_THISISAVERYLONGNAME))

F	RE(V(R_1))	IM(V(R_1))	RE(V(R_2))	IM(V(R_2))
10.000 E 00	1.000 E 00	0.000 E 00	2.667 E 00	4.021 E-03
120.000 E 00	1.000 E 00	0.000 E 00	2.667 E 00	48.247 E-03
230.000 E 00	1.000 E 00	0.000 E 00	2.669 E 00	92.435 E-03
340.000 E 00	1.000 E 00	0.000 E 00	2.671 E 00	136.549 E-03
450.000 E 00	1.000 E 00	0.000 E 00	2.675 E 00	180.555 E-03
560.000 E 00	1.000 E 00	0.000 E 00	2.679 E 00	224.418 E-03
670.000 E 00	1.000 E 00	0.000 E 00	2.685 E 00	268.105 E-03
780.000 E 00	1.000 E 00	0.000 E 00	2.691 E 00	311.581 E-03
890.000 E 00	1.000 E 00	0.000 E 00	2.698 E 00	354.814 E-03
1.000 E 03	1.000 E 00	0.000 E 00	2.706 E 00	397.772 E-03

F	RE(V(R_3))	IM(V(R_3))	RE(V(R_NAME))	IM(V(R_NAME))
10.000 E 00	-2.667 E 00	3.854 E-03	-5.333 E 00	4.021 E-03
120.000 E 00	-2.666 E 00	46.242 E-03	-5.333 E 00	48.247 E-03
230.000 E 00	-2.666 E 00	88.617 E-03	-5.331 E 00	92.435 E-03
340.000 E 00	-2.664 E 00	130.967 E-03	-5.329 E 00	136.549 E-03
450.000 E 00	-2.663 E 00	173.280 E-03	-5.325 E 00	180.555 E-03
560.000 E 00	-2.661 E 00	215.545 E-03	-5.321 E 00	224.418 E-03
670.000 E 00	-2.658 E 00	257.750 E-03	-5.315 E 00	268.105 E-03
780.000 E 00	-2.655 E 00	299.884 E-03	-5.309 E 00	311.581 E-03
890.000 E 00	-2.651 E 00	341.934 E-03	-5.302 E 00	354.814 E-03
1.000 E 03	-2.647 E 00	383.892 E-03	-5.294 E 00	397.772 E-03

F	OUT_1	OUT_2
10.000 E 00	-2.667 E 00	167.549 E-06
120.000 E 00	-2.666 E 00	2.006 E-03
230.000 E 00	-2.666 E 00	3.818 E-03
340.000 E 00	-2.664 E 00	5.582 E-03
450.000 E 00	-2.663 E 00	7.275 E-03
560.000 E 00	-2.660 E 00	8.873 E-03
670.000 E 00	-2.658 E 00	10.355 E-03
780.000 E 00	-2.654 E 00	11.698 E-03
890.000 E 00	-2.651 E 00	12.880 E-03
1.000 E 03	-2.646 E 00	13.881 E-03

EXAMPLE OF PANACEA-OUTPUT.

```
   R  =  GRAPH OF  RE(V(R_NAME))  VERSUS  F
   I  =  GRAPH OF  IM(V(R_NAME))  VERSUS  F


                     -5.327 E 00       -5.313 E 00       -5.299 E 00
            -5.334 E 00       -5.320 E 00       -5.306 E 00
              R--------R--------R--------R--------R--------R--------

                     70.000 E-03      210.000 E-03      350.000 E-03
             0.000 E 00      140.000 E-03      280.000 E-03
  F           I--------I--------I--------I--------I--------I--------
 10.000 E 00  |R
120.000 E 00  | R   I
230.000 E 00  |   R       I
340.000 E 00  |      R          I
450.000 E 00  |          R           I
560.000 E 00  |                R           I
670.000 E 00  |                       R         I
780.000 E 00  |                               R       I
890.000 E 00  |                                        R    I
  1.000 E 03  |                                                  IR
              +--------+--------+--------+--------+--------+--------


   R  =  GRAPH OF  RE(V(R_THISISAVERYLONGNAME))  VERSUS  F
   I  =  GRAPH OF  IM(V(R_THISISAVERYLONGNAME))  VERSUS  F


                     -2.665 E 00       -2.655 E 00       -2.645 E 00
            -2.670 E 00       -2.660 E 00       -2.650 E 00
              R--------R--------R--------R--------R--------R--------

                      2.500 E-03        7.500 E-03       12.500 E-03
             0.000 E 00        5.000 E-03       10.000 E-03
  F           I--------I--------I--------I--------I--------I--------
 10.000 E 00  |I    R
120.000 E 00  |      R
230.000 E 00  |       R     I
340.000 E 00  |         R         I
450.000 E 00  |            R            I
560.000 E 00  |                 R             I
670.000 E 00  |                     R              I
780.000 E 00  |                           R             I
890.000 E 00  |                                  R          I
  1.000 E 03  |                                         R       I
              +--------+--------+--------+--------+--------+--------
```

EXAMPLE OF PANACEA-OUTPUT.

```
  PRPLOT  OF  RE(V(R_3))  VERSUS  F

                                   -2.663 E 00    -2.655 E 00     -2.647 E 00
                           -2.667 E 00    -2.659 E 00     -2.651 E 00
  F              RE(V(R_3))  +-------+-------+-------+-------+-------+--------
 10.000 E 00    -2.667 E 00  |@
120.000 E 00    -2.666 E 00  |@
230.000 E 00    -2.666 E 00  |  @
340.000 E 00    -2.664 E 00  |    @
450.000 E 00    -2.663 E 00  |        @
560.000 E 00    -2.661 E 00  |            @
670.000 E 00    -2.658 E 00  |                 @
780.000 E 00    -2.655 E 00  |                       @
890.000 E 00    -2.651 E 00  |                              @
  1.000 E 03    -2.647 E 00  |                                      @
                             +-------+-------+-------+-------+-------+--------


  PRPLOT  OF  IM(V(R_3))  VERSUS  F

                                   70.000 E-03   210.000 E-03    350.000 E-03
                            0.000 E 00   140.000 E-03    280.000 E-03
  F              IM(V(R_3))  +-------+-------+-------+-------+-------+--------
 10.000 E 00     3.854 E-03  @
120.000 E 00    46.242 E-03  |    @
230.000 E 00    88.617 E-03  |         @
340.000 E 00   130.967 E-03  |              @
450.000 E 00   173.280 E-03  |                   @
560.000 E 00   215.545 E-03  |                        @
670.000 E 00   257.750 E-03  |                            @
780.000 E 00   299.884 E-03  |                                 @
890.000 E 00   341.934 E-03  |                                      @
  1.000 E 03   383.892 E-03  |                                          @
                             +-------+-------+-------+-------+-------+--------
```

EXAMPLE OF PANACEA-OUTPUT.

PAR = 2.000 E 00

Legend:
OUT_1 = RE(V(R_THISISAVERYLONGNAME))
OUT_2 = IM(V(R_THISISAVERYLONGNAME))

F	RE(V(R_1))	IM(V(R_1))	RE(V(R_2))	IM(V(R_2))
10.000 E 00	1.000 E 00	0.000 E 00	5.333 E 00	8.042 E-03
120.000 E 00	1.000 E 00	0.000 E 00	5.334 E 00	96.494 E-03
230.000 E 00	1.000 E 00	0.000 E 00	5.338 E 00	184.870 E-03
340.000 E 00	1.000 E 00	0.000 E 00	5.343 E 00	273.098 E-03
450.000 E 00	1.000 E 00	0.000 E 00	5.349 E 00	361.110 E-03
560.000 E 00	1.000 E 00	0.000 E 00	5.358 E 00	448.837 E-03
670.000 E 00	1.000 E 00	0.000 E 00	5.369 E 00	536.210 E-03
780.000 E 00	1.000 E 00	0.000 E 00	5.382 E 00	623.162 E-03
890.000 E 00	1.000 E 00	0.000 E 00	5.396 E 00	709.629 E-03
1.000 E 03	1.000 E 00	0.000 E 00	5.412 E 00	795.545 E-03

F	RE(V(R_3))	IM(V(R_3))	RE(V(R_NAME))	IM(V(R_NAME))
10.000 E 00	-5.333 E 00	7.707 E-03	-10.667 E 00	8.042 E-03
120.000 E 00	-5.333 E 00	92.483 E-03	-10.666 E 00	96.494 E-03
230.000 E 00	-5.331 E 00	177.233 E-03	-10.662 E 00	184.870 E-03
340.000 E 00	-5.329 E 00	261.933 E-03	-10.657 E 00	273.098 E-03
450.000 E 00	-5.325 E 00	346.560 E-03	-10.651 E 00	361.110 E-03
560.000 E 00	-5.321 E 00	431.090 E-03	-10.642 E 00	448.837 E-03
670.000 E 00	-5.316 E 00	515.500 E-03	-10.631 E 00	536.210 E-03
780.000 E 00	-5.310 E 00	599.767 E-03	-10.618 E 00	623.162 E-03
890.000 E 00	-5.303 E 00	683.869 E-03	-10.604 E 00	709.629 E-03
1.000 E 03	-5.295 E 00	767.783 E-03	-10.588 E 00	795.545 E-03

F	OUT_1	OUT_2
10.000 E 00	-5.333 E 00	335.097 E-06
120.000 E 00	-5.333 E 00	4.011 E-03
230.000 E 00	-5.331 E 00	7.636 E-03
340.000 E 00	-5.329 E 00	11.165 E-03
450.000 E 00	-5.325 E 00	14.550 E-03
560.000 E 00	-5.321 E 00	17.747 E-03
670.000 E 00	-5.315 E 00	20.710 E-03
780.000 E 00	-5.309 E 00	23.395 E-03
890.000 E 00	-5.301 E 00	25.760 E-03
1.000 E 03	-5.293 E 00	27.761 E-03

EXAMPLE OF PANACEA-OUTPUT.

```
   R  =  GRAPH OF  RE(V(R_NAME))  VERSUS  F
   I  =  GRAPH OF  IM(V(R_NAME))  VERSUS  F


                    -10.655 E 00      -10.625 E 00      -10.595 E 00
           -10.670 E 00      -10.640 E 00      -10.610 E 00
              R--------R--------R--------R--------R--------R--------

                    150.000 E-03      450.000 E-03      750.000 E-03
             0.000 E 00      300.000 E-03      600.000 E-03
  F           I--------I--------I--------I--------I--------I--------
 10.000 E 00  I R
120.000 E 00  |  R  I
230.000 E 00  |    R     I
340.000 E 00  |       R       I
450.000 E 00  |           R         I
560.000 E 00  |                R         I
670.000 E 00  |                      R        I
780.000 E 00  |                              R     I
890.000 E 00  |                                       R  I
  1.000 E 03  |                                              IR
              +--------+--------+--------+--------+--------+--------


   R  =  GRAPH OF  RE(V(R_THISISAVERYLONGNAME))  VERSUS  F
   I  =  GRAPH OF  IM(V(R_THISISAVERYLONGNAME))  VERSUS  F


                     -5.332 E 00       -5.316 E 00       -5.300 E 00
            -5.340 E 00       -5.324 E 00       -5.308 E 00
              R--------R--------R--------R--------R--------R--------

                      5.000 E-03       15.000 E-03       25.000 E-03
             0.000 E 00       10.000 E-03       20.000 E-03
  F           I--------I--------I--------I--------I--------I--------
 10.000 E 00  |I      R
120.000 E 00  |      IR
230.000 E 00  |         R   I
340.000 E 00  |            R      I
450.000 E 00  |                R        I
560.000 E 00  |                     R         I
670.000 E 00  |                           R        I
780.000 E 00  |                                  R      I
890.000 E 00  |                                           R I
  1.000 E 03  |                                                 I  R
              +--------+--------+--------+--------+--------+--------
```

EXAMPLE OF PANACEA-OUTPUT.

```
  PRPLOT  OF  RE(V(R_3))  VERSUS  F

                                   -5.327 E 00     -5.313 E 00     -5.299 E 00
                           -5.334 E 00     -5.320 E 00     -5.306 E 00
  F              RE(V(R_3))  +-------+-------+-------+-------+-------+--------
 10.000 E 00    -5.333 E 00  |@
120.000 E 00    -5.333 E 00  |@
230.000 E 00    -5.331 E 00  |  @
340.000 E 00    -5.329 E 00  |     @
450.000 E 00    -5.325 E 00  |         @
560.000 E 00    -5.321 E 00  |             @
670.000 E 00    -5.316 E 00  |                   @
780.000 E 00    -5.310 E 00  |                          @
890.000 E 00    -5.303 E 00  |                                  @
  1.000 E 03    -5.295 E 00  |                                           @
                             +-------+-------+-------+-------+-------+--------


  PRPLOT  OF  IM(V(R_3))  VERSUS  F

                                  150.000 E-03    450.000 E-03    750.000 E-03
                            0.000 E 00    300.000 E-03    600.000 E-03
  F              IM(V(R_3))  +-------+-------+-------+-------+-------+--------
 10.000 E 00     7.707 E-03  @
120.000 E 00    92.483 E-03  |     @
230.000 E 00   177.233 E-03  |         @
340.000 E 00   261.933 E-03  |              @
450.000 E 00   346.560 E-03  |                  @
560.000 E 00   431.090 E-03  |                      @
670.000 E 00   515.500 E-03  |                           @
780.000 E 00   599.767 E-03  |                                @
890.000 E 00   683.869 E-03  |                                   @
  1.000 E 03   767.783 E-03  |                                         @
                             +-------+-------+-------+-------+-------+--------


finish ;
DATA PROCESSING TIME =     0.70 seconds, ANALYSIS TIME =     2.94 seconds
```

APPENDIX B

DEFINITION OF THE SIGNAL DATA INTERCHANGE FORMAT (SDIF FILEFORMAT)

1. Introduction

The Signal Data Interface Format is a standard for files which are used as interfaces between CAD-tools, particularly for transfer of signal data (e.g. resulting from simulations).
The next two chapters correspond with two abstraction levels:

1. The physical structure of SDIF files.

2. The semantics and syntax of the SDIF language.

2. The physical structure of SDIF files.

An SDIF file is a sequential file, subdivided into records of varying lengths. No blocking of records in any form whatsoever is done. It contains the data in binary form (Unformatted in FORTRAN terms) to obtain fast transfer of data and to make deliberate changes of interface data difficult. The end of the file is indicated by the EOF mark as supported by the computer which is used for generating the SDIF file.

3. The SDIF language.

3.1. Outline

The language uses the character set and the numeric representations standardly available on the computer system used for making the SDIF file. The representation type "long real" corresponds with the numerical floating point representation with the greatest number of significant digits ("double precision" in FORTRAN terms).
The basic information-carrying element of the language is the field. A set of related fields is organized into a statement.
The data is organized in tables. A table consists of a heading-statement and a set of tuple-statements (= rows of signal values). A set of related tables is carried by a fixed set (= block) of statements. No relations are assumed between statements in different blocks.
For each type of data a distinct type of statement is defined in the language, mapped on distinct record types. Each statement begins with a statement-type-identifier (key) record (which always has a length of 8 characters), followed by the actual data-carrying records. The reason for this separation is found in the limitations imposed by existing (heavily used) programming languages: When reading an SDIF file the structure of any record is in this way fully known immediately before reading it.
For cases where a statement is longer than can be accommodated by the maximum record length, continuation record types are provided.

3.2. Definition of the top-level syntax.

Throughout this document the following notation is used for describing languages:

- Items which have to be entered exactly as they stand are written in capitals.
- Items which have to be replaced by actual values are written in lowercase letters.
- Brackets [] enclose optional data.
- Braces {} enclose alternative items.
- An ellipsis ... indicates that repetition of previous item is allowed

Brackets, braces nor ellipses are part of the language; they are for documentation purposes only.

```
SDIF-file ::= { block            }
                SDIF-file block

block     ::= block-information-statement
              [ title-statement ]
              [ table-set ]

block-information-statement
          ::= infokey-record
              infodat1-record infodat2-record infodat3-record

title-statement
          ::= titlkey-record titldat1-record titldat2-record
              [ ( titlckey-record titlcdat-record )... ]

table-set ::= { table            }
                table-set table

table     ::= heading-statement tuple-statement-set

heading-statement
          ::= headinfk-record headinf1-record headinf2-record
              headinf3-record
              [ ( headinck-record headincd-record )... ]
              headkey-record headdata-record
              [ ( headckey-record headcdat-record )... ]

tuple-statement-set
          ::= { tuple-statement                    }
                tuple-statement-set tuple-statement

tuple-statement
          ::= tuplekey-record tupleda1-record tupleda2-record
              [ ( tuplecke-record tuplecda-record )... ]
```

3.3. Definition of the semantics and the lowest-level syntax.

3.3.1. The block-information-statement.

3.3.1.1. Semantics.

This statement carries identification data and format data about the block.

3.3.1.2. Syntax

record type	field nr	field descr	field format	field contents	comment/ example
INFOKEY	1	record type	char[8]	"INFOKEY "	
INFODAT1	1	block identifier	char[8]		"RUN-1 "
	2	originator type	char[8]		"PHILPAC "
	3	simulation-type	char[8]		"ACSTAT "
	4	blocking-type	char[8]		"REGULAR "
INFODAT2	1	time hours	integer	hh	10
	2	time minutes	integer	mm	12
	3	time seconds	integer	ss	08
	4	date year	integer	yy	85
	5	date month	integer	mm	08
	6	date day	integer	dd	13
	7	max rec len (char)	integer		256
	8	max rec len (integ)	integer		64
	9	max rec len (number of double reals)	integer		32
	10	Number of significant digits in decimal representation of tuple field value	integer		7
INFODAT3	1	value of UNDEFINED	longreal		
	2	value of INFINITY	longreal		

Note: Max rec len applies to the record types with varying length. It has to be <= the max length of the physical records of the SDIF file.

3.3.2. The title statement.

3.3.2.1. Semantics

This statement carries general information of the job which created the block (e.g. the model which is used for the simulation).

3.3.2.2. Syntax

record type	field nr	field descr	field format	field contents	comment/ example
TITLKEY	1	record type	char[8]	"TITLKEY "	
TITLDAT1	1	number of chars in title	integer		132
TITLDAT2	1	title text	char[*]		

Continuation record types:

record type	field nr	field descr	field format	field contents	comment/ example
TITLCKEY	1	record type	char[8]	"TITLCKEY"	
TITLCDAT	. . . .				Continuation of field 1 of TITLDAT2

3.3.3. The heading statement.

3.3.3.1. Semantics.

This statement carries data about the headings which are related to the columns in the table.

There are two kinds of heading elements: simple-heading-elements (number of children = 0), which are related to exactly one tuple field, and group-heading-elements (number of children > 0) , which are related to a set of other heading-elements: Its children.
When a group-heading-element occurs in the statement the heading-elements following it are its children. They are related to it as in a tree, e.g.:

```
                 group-heading-element
                  _______|____________________________________
                 |                   |                 |
           group-heading        group-heading   simple-heading       ...
               -element             -element          -element
           ______|_______            |________________________
          |             |              |              |
     simple-heading simple-heading simple-heading simple-heading     ...
           -element       -element       -element       -element
```

A heading structure statement contains the structure information as created by traversing the tree from left to right, with downward as priority direction. The vertices of the tree are group-heading-element, the leaves of the tree are simple-heading-element. A heading structure statement may contain more than one such a structure.

Under all circumstances the simple-heading-elements are found in the same order as the tuple-fields they are related to.

3.3.3.2. Syntax

3.3.3.2.1. The heading-structure record-set.

record type	field nr	field descr	field format	field contents	comment/ example
HEADINFK	1	record type	char[8]	"HEADINFK"	
HEADINF1	1	tuple-type	char[8]		"TRIAL "
HEADINF2	1	tot nr of heading elements in statem.	integer		
HEADINF3	1	number of chars in heading element	integer		
	2	number of children	integer		
	3	number of chars in heading element	integer		
	4	number of children	integer		
	.				
	.				
	.				

Continuation record types:

record type	field nr	field descr	field format	field contents	comment/ example
HEADINCK	1	record type	char[8]	"HEADINCK"	
HEADINCD	.				
	.				
	.				
	n	number of chars in heading element	integer		
	n+1	number of children	integer		
	n+2	number of chars in heading element	integer		
	n+3	number of children	integer		
	.				
	.				
	.				

3.3.3.2.2. The heading-data record-set.

record type	field nr	field descr	field format	field contents	comment/ example
HEADKEY	1	record type	char[8]	"HEADKEY "	
HEADDATA	1	heading text	char[*]		(length = field 1 of HEADINF3 record)
	2	heading text	char[*]		(length = field 3 of HEADINF3 record)
	. . .				

Continuation record types:

record type	field nr	field descr	field format	field contents	comment/ example
HEADCKEY	1	record type	char[8]	"HEADCKEY"	
HEADCDAT	. . .				
	n	heading text	char[*]		
	n+1	heading text	char[*]		
	. . .				

3.3.4. The tuple statement.

3.3.4.1. Semantics

This statement carries data about a set of related signal values.

It contains one row (= vector) of a table of signals:
Column i in the table corresponds with field i in each tuple-statement.

3.3.4.2. Syntax

record type	field nr	field descr	field format	field contents	comment/ example
TUPLEKEY	1	record type	char[8]	"TUPLEKEY"	
TUPLEDA1	1	tuple identifier	char[8]		
TUPLEDA2	1	value	longreal		
	2	value	longreal		
	.				
	.				
	.				

Continuation record types:

record type	field nr	field descr	field format	field contents	comment/ example
TUPLECKE	1	record type	char[8]	"TUPLECKE"	
TUPLECDA	n	value	longreal		
	n+1	value	longreal		
	.				
	.				
	.				

Note:
The tuple identifier in the TUPLEKEY record makes selection of tuple statements in one table possible, e.g. for Monte-Carlo simulation output the trial(= sample) number for each trial could be written here.

4. Semantics which are not specific for one single statement-type.

No relations are assumed between data in different blocks:
Any block-identifier must be unique in the file.
Within a block no relations are assumed between tables, with the following exceptions:

- The data in the block-information-statement applies to all tables in the block.
- Relations between columns of different tables in a block are defined by their respective heading-texts.

The domains (the set of allowed values) of the fields in the SDIF language are defined below.

4.1. Domain of simulation-type.

Value	Description
"UNDEFINE"	None of the types below.
"DC "	Quiescent state.
"AC "	Complex phasor domain.
"TR "	Time domain.
"DCSTAT "	DC statistical.
"ACSTAT "	AC statistical.
"TRSTAT "	TR statistical.

4.2. Domain of blocking-type.

Value	Description
"REGULAR "	File conforms to definitions stated above.
"IRREGULA"	File conforms to definitions stated above as well as those stated in chapter 6.

4.3. Domain of tuple-type.

Value	Description
"UNDEFINE"	None of the types below.
"SEQUENCE"	Sequence of tuples.
"FUNCTION"	Sequence of tuples containing a simulation vector value in field 1-up and corresponding function values in subsequent fields.
"FUNCTNAL"	Functional values (Function of a function in a corresponding table, e.g. rise time of a function of time. The PHILPAC term for a functional is "special output function") All values are given in one single tuple-statement.

"OPERCOND"	Operating condition values. (e.g. temperature, adjustable component settings. The PHILPAC term for this is "subsidiary independent variable"). All values are given in one single tuple-statement.
"TRIAL "	Sequence of tuples, each tuple containing results of one Monte-carlo or optimization trial.

4.4. Standard heading terms.

Applications should use the standard terms as much as possible. Other terms may be used, but no meaning can be associated with them.

Variables

Term	Description
"F"	Frequency.
"FSAMP"	Sampling frequency.
"FMIN"	Minimum frequency.
"FINCR"	Frequency increment.
"T"	Time.
"TEMP"	Temperature.
"COEFF"	Coefficient.
"PARAM"	Parameter.
"V"	Voltage.
"I"	Current.

Operators (Must be followed by "(")

Term	Description
"RE"	Real part of a complex value.
"IM"	Imaginary part of a complex value.
"ABS"	Absolute value of real or complex value.
"PHASE"	Phase of a complex value, in degrees.
"ARG"	Phase of a complex value, in radians.
"LOG"	Logarithm base 10.
"LN"	Natural logarithm.
"DB"	Decibels.
"SQRT"	Square root.
"EXP"	Power of e.
"SIN"	Sine
"COS"	Cosine
"TAN"	Tangent.

5. Examples.

Suppose that we have a very long title, which doesn't fit into a single record. It would result in the following title-statement:

Contents	Description
"TITLKEY "	
1824	TITLDAT1 record
First 256 char of title.	TITLDAT2 record
"TITLCKEY"	
Next 256 char of title.	TITLCDAT record
"TITLCKEY"	
Next 256 char of title.	TITLCDAT record
.	
.	
.	

Suppose there are the heading elements DBPHASE(VN(10)), DB(VN(10)), PHASE(VN(10)), RE(VN(10)) and IM(VN(10)). (elements like these may be produced by circuit analysis programs like PHILPAC). DBPHASE is a group-heading-element: it is related to two tuple fields. The others are related to one tuple field. DB and PHASE are related to the tuple fields which are also related to DBPHASE.
The heading-statement will be:

Contents	Description
"HEADINFK"	
"FUNCTION"	HEADINF1 record.
6	HEADINF2 record.
4	Begin of HEADINF3 record. Nr of chars in first heading element.
0	Number of children of first heading element.
15	Number of chars in second heading field.
2	Number of children of second heading element.
10	Number of chars in third heading element.
0	Number of children of third heading element.
13	Number of chars in fourth heading element.
0	Number of children of fourth heading element.
10	Number of chars in fifth heading element.
0	Number of children of fifth heading element.
10	Number of chars in sixth heading element.
0	Number of children of sixth heading element.
"HEADKEY "	
"F"	Begin of HEADDATA record.
"DBPHASE(VN(10))"	
"DB(VN(10))"	
"PHASE(VN(10))"	
"RE(VN(10))"	
"IM(VN(10))"	

The corresponding tuple-statement will be:

Contents	Description
"TUPLEKEY"	
"1 "	TUPLEDA1 record
3.0	Begin of TUPLEDA2 record: frequency.
-20.0	db(vn(10))
0.0	phase(vn(10))
0.1	re(vn(10))
0.0	im(vn(10))

6. Irregular blocking of files (for the program ESPICE only).

Irregular blocked files are files where some relation exists between blocks: there are several blocks with the same block-id. These blocks are to be considered as one regular block. The first block in such a sequence is organized as defined above, with blocking-type = "IRREGULA", the subsequent blocks are organized as defined above, but the block-information-statement is replaced by an abbreviated one:

record type	field nr	field descr	field format	field contents	comment/ example
INFOKEY2	1	record type	char[8]	"INFOKEY2"	
INFODAT4	1	block identifier	char[8]		"RUN-1 "
	2	simulation-type	char[8]		"AC "