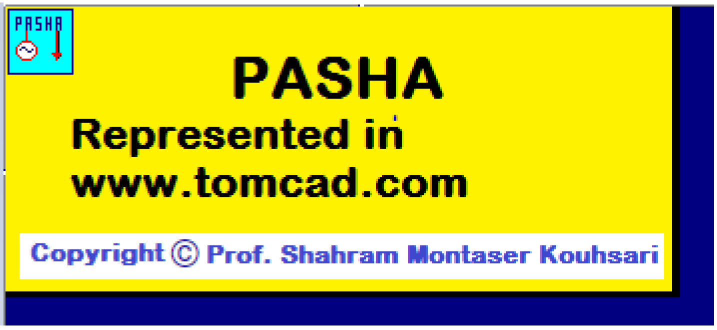


Chapter 10
User Defined Equipment Modelling (UDEM) Facility

10.1 About the UDEM facility

This part of the manual is a guide for users of the UDEM facility, which permits the simulation of a desired dynamic model. The algorithms implemented provide a flexible modelling tool, which handles the models defined in a block diagram form. The block diagram approach is closely related to that used in the analogue computer methods. Hence, the UDEM program can capitalize on all models established previously for analogue simulations. Models of this type are common in mathematics, biology, economics, and in many branches of engineering. The UDEM program has an interactive feature and is a menu-driven package, which makes it easy for users to work with dynamical systems.

10.1.1 Connection between PASHA and UDEM

The UDEM program can be used as a stand-alone package. In this way, it is similar to analogue computers. It may also be connected to any dynamical package such as PASHA. The basic function of the UDEM program in PASHA is to allow the user to input a mathematical representation of controllers and radial plants or any other power system apparatus and to store the associated information for later simulation studies.

10.1.2 Functions of UDEM

The UDEM program allows the user to construct a block diagram transfer function module of a desired dynamical system on the computer screen by typing simple code letters or selecting them from tool bars. Each code draws a predefined element whose parameters, initial conditions and system descriptions can be modified interactively. The constructed module can be stored with a unique ID code, password, and tittle. The stored module can then be read either by its retrieval section for a later modification of the block diagram, or by the transient stability routines.

Once a module has been constructed, tested and filed, it is directly accessible by PASHA. To include a module in an electrical power network within PASHA, the user simply enters the

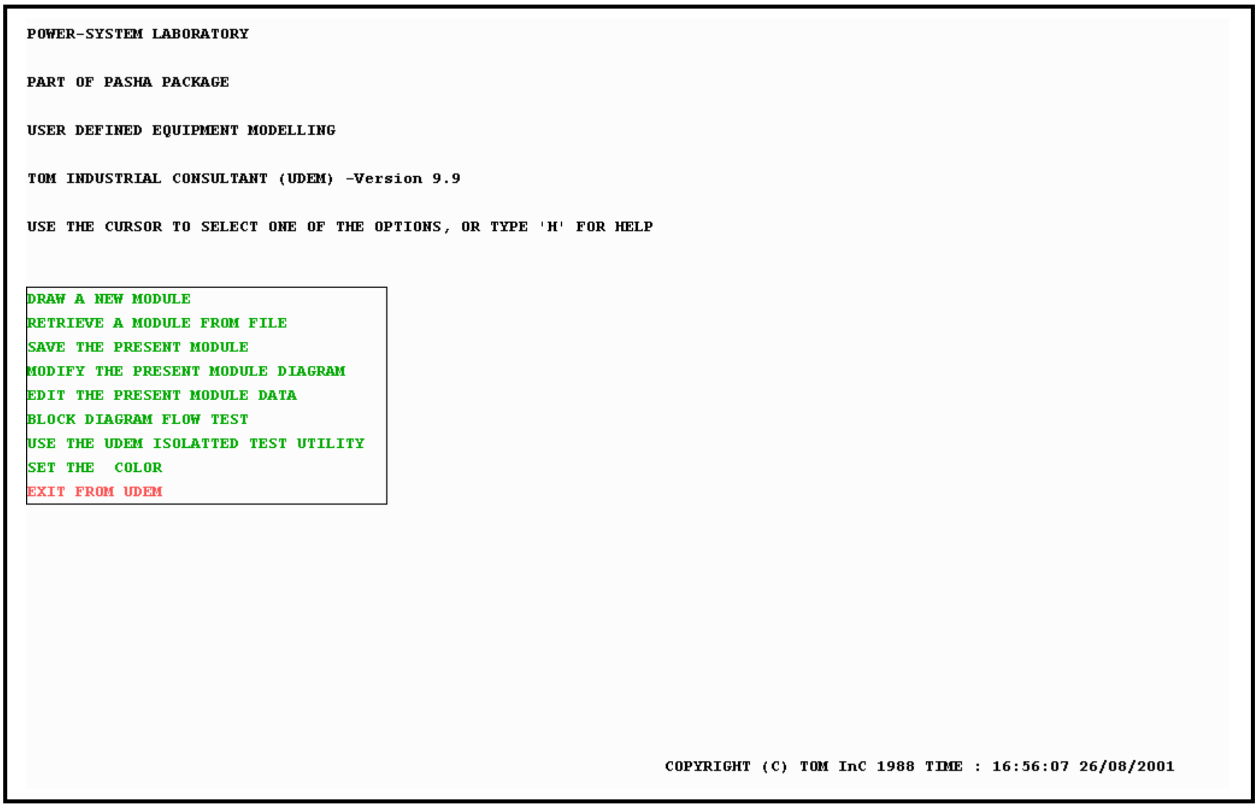


Figure 10.1

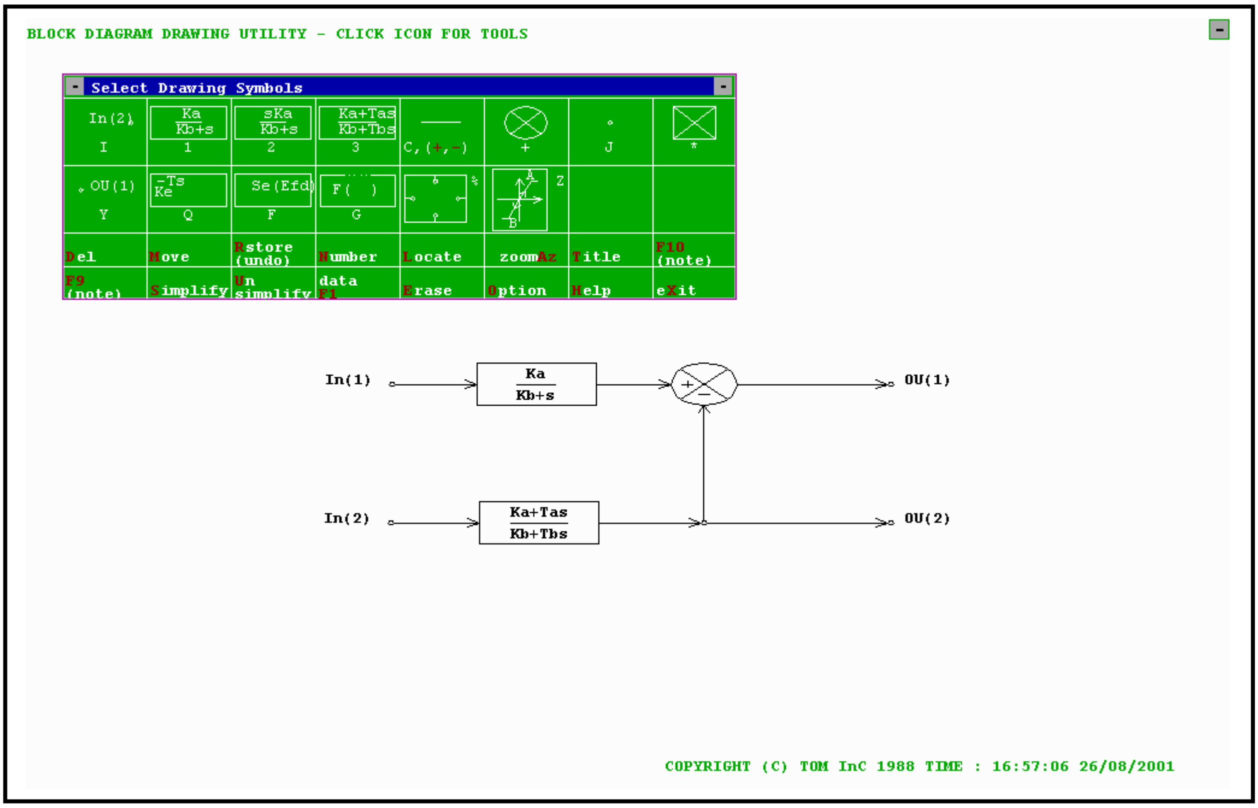


Figure 10.2

module ID code on the data page previously used for the standard models of controllers, loads, induction motors, or generators. At this point, the EDIT routines in PASHA search for the module ID code in UDEM storage files. Following these stages, the information are read into UDEM arrays ready for use by PASHA. A facility for displaying the block diagram of the retrieved module is included to check if it is the correct one. The input and output variables of the module are also checked against the validity of the model.

10.1.3 Structure of the chapter

The conceptual framework is first described in Section 2. Sections 3 and 4 show how to construct and modify simple modules and how to represent them. The function of each element of the UDEM program is described in Appendix E. Section 5 describes the method of data entry for constructed modules. Sections 6 and 7 deal with the modules archiving facility. In Section 8 the modules prepared for the simulation study will be presented, and Sections 9 and 10 describe how to run an isolated study and how to display the results. Section 12 shows how you can introduce your constructed modules in a transient stability run in PASHA.

Remember that you can always type the <H> key or select the [HELP] option to access the on line help facilities.

10.2 Framework

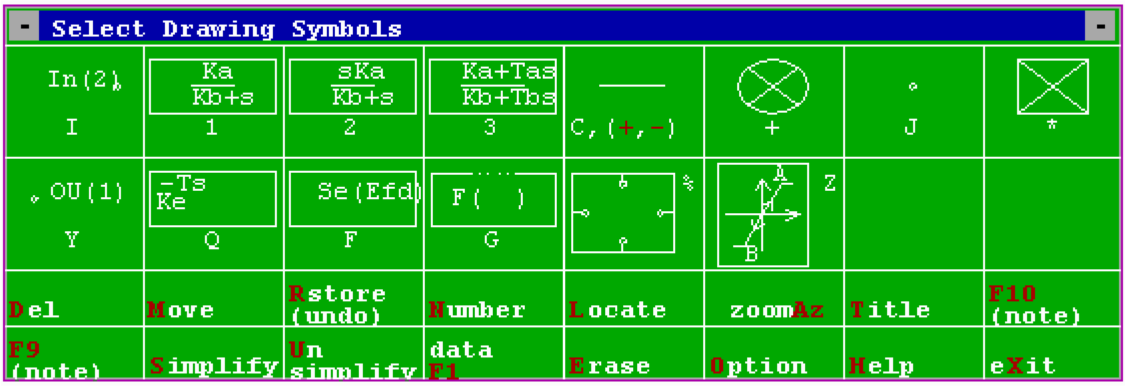
This section gives an overview of the interaction principles used in the UDEM program.

UDEM is driven by a set of options displayed on the screen. The options can be selected by positioning the mouse cursor over the option required and clicking or pressing any other keys. Note that in some special cases, certain variations in response can be obtained by pressing special keys. The function of these keys are shown in PASHA on line green boxes and the details of these additional keys are given throughout this manual.

UDEM can be entered by selecting the [User Defined Equipment Modelling] option from the main menu of PASHA. It then shows an initial menu which contains a set of options that define the main functions of the program. This menu is shown in Figure 10.1. Of the nine options displayed only [Draw a new module], [Retrieve a module from file], [Set color and options], and [Exit form UDEM] are available at the first entry to the program, and the remaining options cannot function. The full set of options is displayed after constructing a block diagram, or retrieving an old one from a file.

10.3 Draw a new module

The selection of this option allows you to draw a block diagram on an empty screen with a green tool bar. Put the cursor on an arbitrary position and type any of the following codes OR



click on a drawing object in the green tool bars and click on the desired position. The drawing routine then draws the symbols for the selected element at this point. Figure 10.2 shows the graphics symbols of the blocks presently generated by UDEM in response to the "Code" letters typed to draw them and the current green tool bars is shown below. The function of these elements are described in Appendix E.

10.3.1Connection of elements

Once two or more elements have been drawn on the screen, they can be connected together using a number of codes. The connection process is described below.

To connect two elements, first the starting element is selected by moving the mouse cursor and typing the code letter <L>. You may select the LOCATE from the green tool bars too. Note that the last element drawn, automatically becomes the default starting element for the next connection process. Following the selection of the starting element, the cursor is positioned over the ending element and the code letter <C> is typed. You may select the code <C> from the tool bars too. When a connection is to be made to an adder, <C> must be replaced with <+> or <->. The codes <+> and <-> are used for positive or negative input to an adder respectively.

When an input connection is made to an algebraic function block, the program automatically stipulates a character ('x', 'y' or 'z') on the connection side. These letters indicate the input variables names which will be associated with the data arrangement of the block. When a switch is connected, the same procedure is followed as for algebraic function block, but the indicator character in this case will be 'A', 'B' or 'C'.

Note that the connection routines were written to satisfy the following conditions:

(i) all connection lines must contain strictly vertical and horizontal lines,
(ii) all elements must be connected either at their top, bottom, left or right sides.

Figure 10.3 shows a typical block diagram transfer function. For construction of this figure the following codes are typed in sequence while the mouse cursor is positioned appropriately

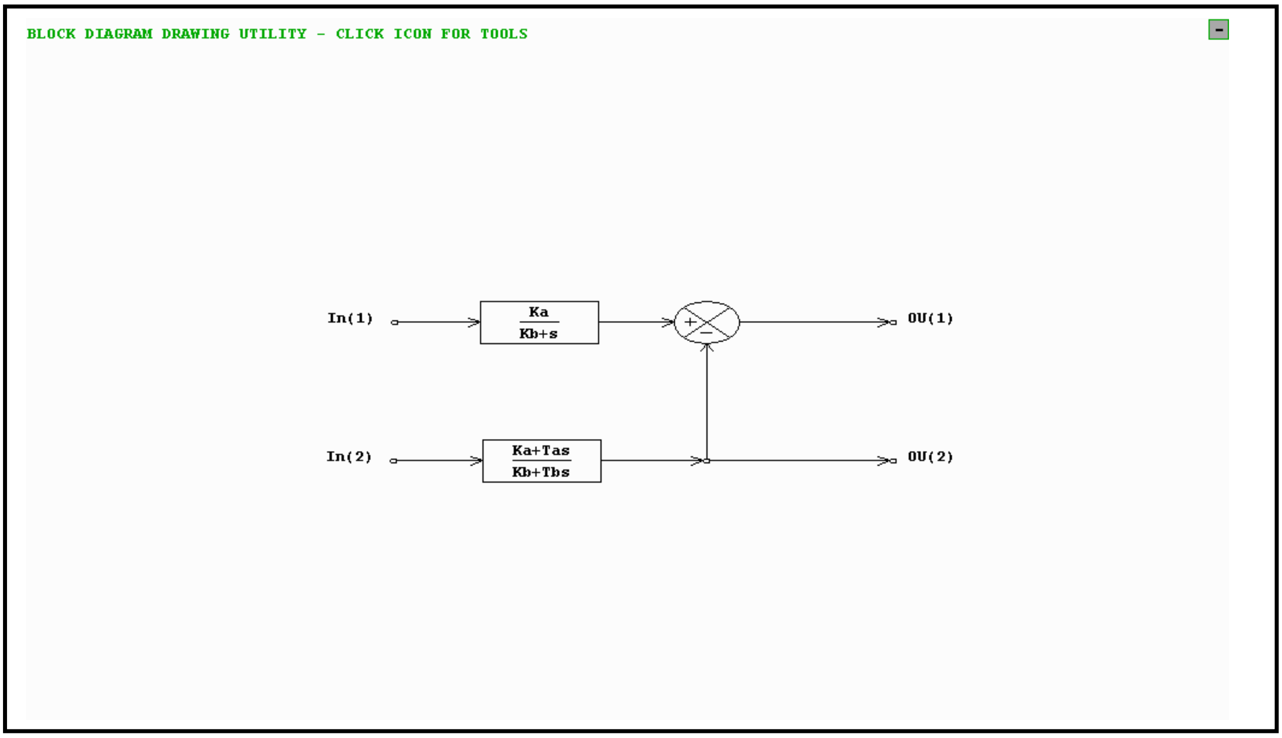


Figure 10.3

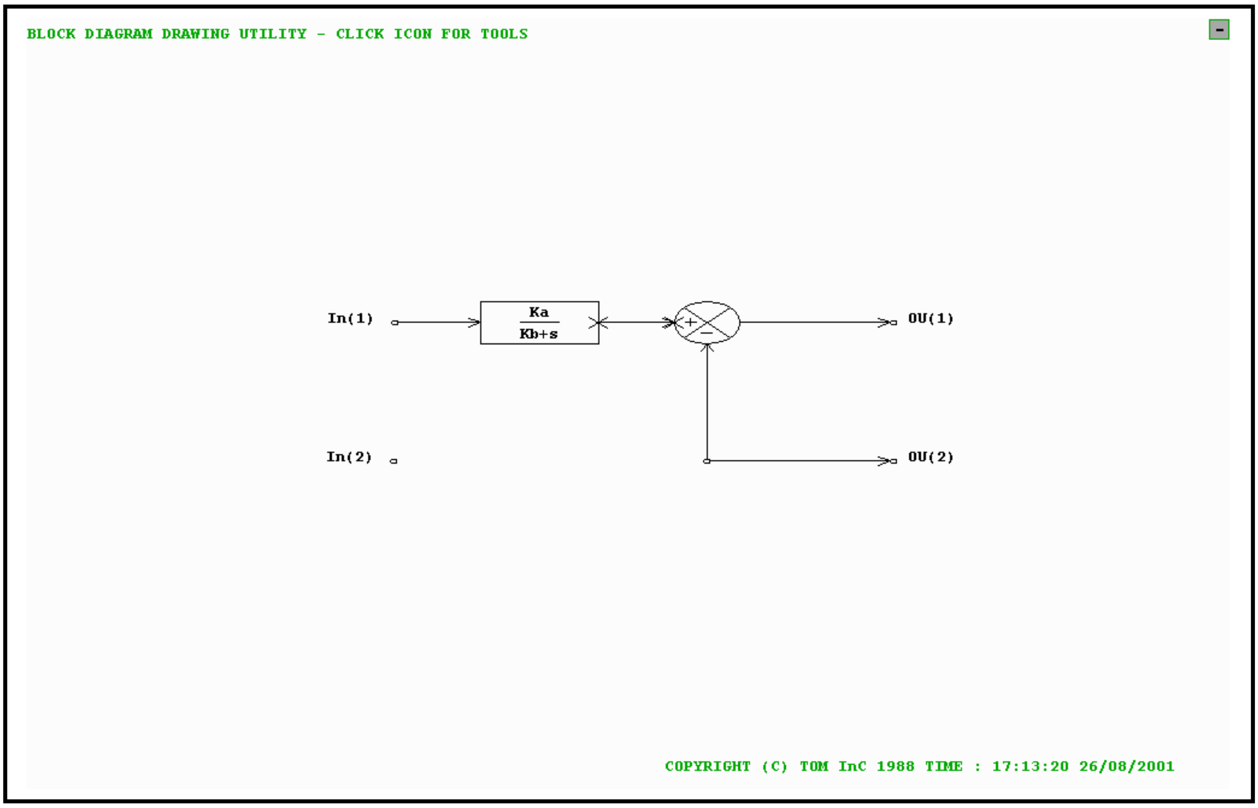


Figure 10.4

<I> for input element
<1> for lead-lag (operational element)
<C> for connection
<+> for adder element
<+> for connection to an adder
<Y> for output
<C> for connection
<I> for input number two
<3> for lead-lag (operational element)
<C> for connection
<J> for junction element
<C> for connection to a junction
<-> for connection to an adder
<Y> for output number two
<L> while the cursor is positioned over a junction to select it as the starting point of the connection process
<C> for connection to the output number two

The same process can be followed in order to draw this block diagram by using the green tool bars too. In this case the symbols must be selected from green tool bars.

10.3.2 Drawing of junctions

When a junction is drawn, its position is first checked against a preset distance from a connection line. If the junction lies on or within the distance, the connection is broken and the program will interpret this junction to be connected to that line.

10.3.3 Deletion mode

If you are using green tool bars select the Del on the tool bars. This starts the deletion mode. From now on a click on an element deletes that element. A second click or pressing key <E> will delete the element and redisplays the screen. If you want to delete a line you will just click on the starting and the ending elements.

If you want to use keys instead of tool bars you must follow the following instructions for deletion. The <D> key is used to start the 'delete mode' that enables the user to delete any element or connection line of a diagram that has been previously drawn. To enter the delete mode, it is first necessary to position the cursor over the required element at which the deletion process is to commence and to type the <D> key. If the <D> key is followed by the <E> key, the element located at the cursor position will be deleted and subsequently all connections to that element will be removed.

Also, if the cursor is positioned over another element and the < C > key is typed, the connection between the elements specified by the cursor position when < D > is depressed and the element at the location of the cursor when < C > is depressed will be deleted. Figure

10.4 shows the process of the deletion commands. The deletion process appears on the screen as a 'cross - out 'sign (in the new version toll bars is used, as described, no cross out sign).

10.3.4 Moving mode

The <M> key is used to move elements from one position to another. Depress <M> when the cursor is over the element to be moved, and then locate the cursor to the desired new position of the element and depress any key or a click. The element will be repositioned at this point and the program attempt to redraw any previously existing connections. This is also shown in figure 10.4. You may use the tool bars for moving an element. In this case just select Move from the tool bars and click on the desired element. Then move the cursor on the new position and click again.

10.3.5 Other features of the deletion and moving routines

When an algebraic function or a logical block is the element from which an input connection is to be deleted, the program automatically resets the indicator characters of the block.

When an input or output is the element which is to be deleted, the screen will be erased and the block diagram will be redrawn with the remaining input and output elements renumbered in sequence.

The code letter <R>, which can also be selected from the tool bars, is used to restore the last delete command, i.e. undo the previous deletion. It forces the screen to refresh and can only be used after a 'delete', 'move', or 'erase and redraw' command. The 'erase and redraw' command is described in the following section.

10.3.6 Other useful keys in the drawing routines

The <E> Key

Pressing this key or selecting it from the tool bars erases the screen and subsequently redraws the diagram. Figure 10.5 shows the function of this key, which is applied to Figure 10.4.

The <P> Key

While the cursor is positioned over an already existing element that requires data, pressing this key calls up the data entry section and requests the user to enter the parameters associated with that element (refer to the parameter entry section in this manual). Otherwise, the entire diagram is stored for plotting. See plotting in PASHA.

The <F1> Key

While the cursor is positioned over an already existing element that requires data, pressing this key calls up the data entry section and requests the user to enter the parameters associated with that element (refer to the parameter entry section in this manual). You may select the key from the tool bars too.

The <O> Key

Pressing this key or selecting it from the tool bars calls up the options for re-centering the diagram. Figure 10.6 shows the option box. This key acts as the option box in PASHA, i.e. recenters the block diagram.

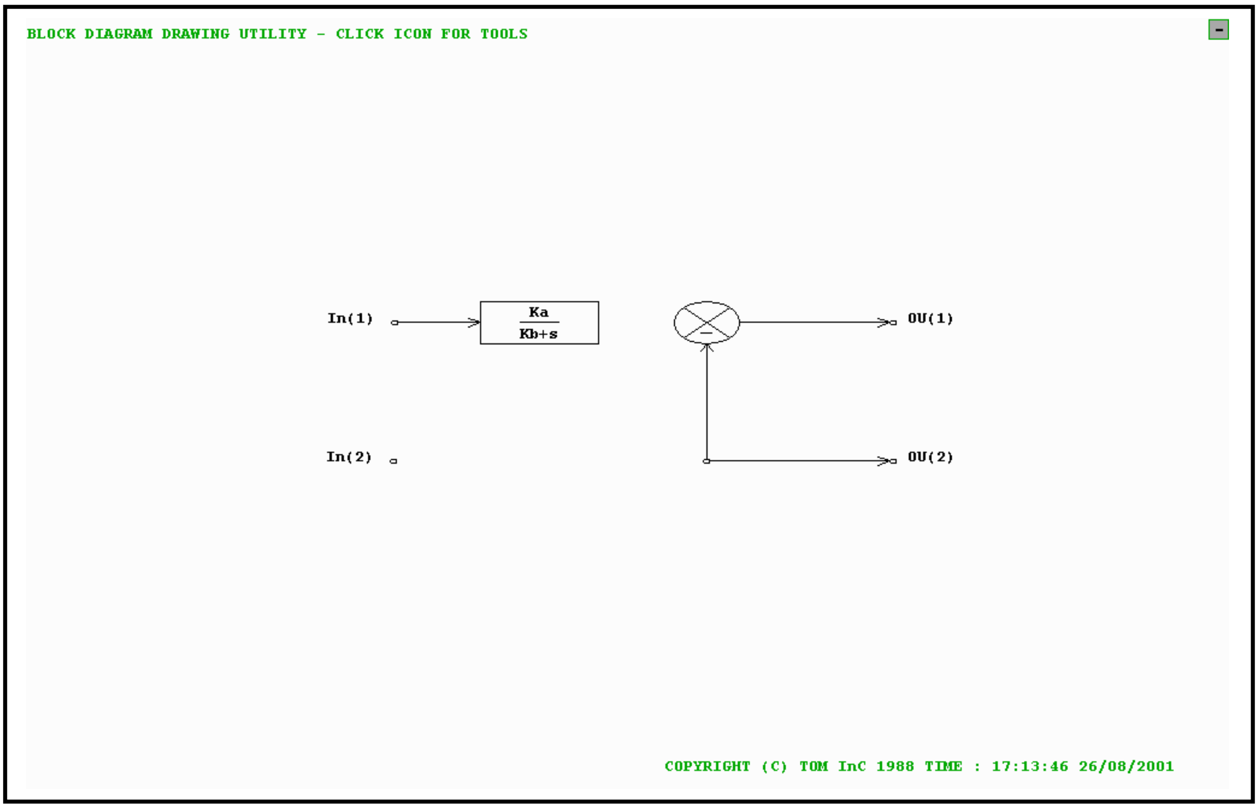


Figure 10.5

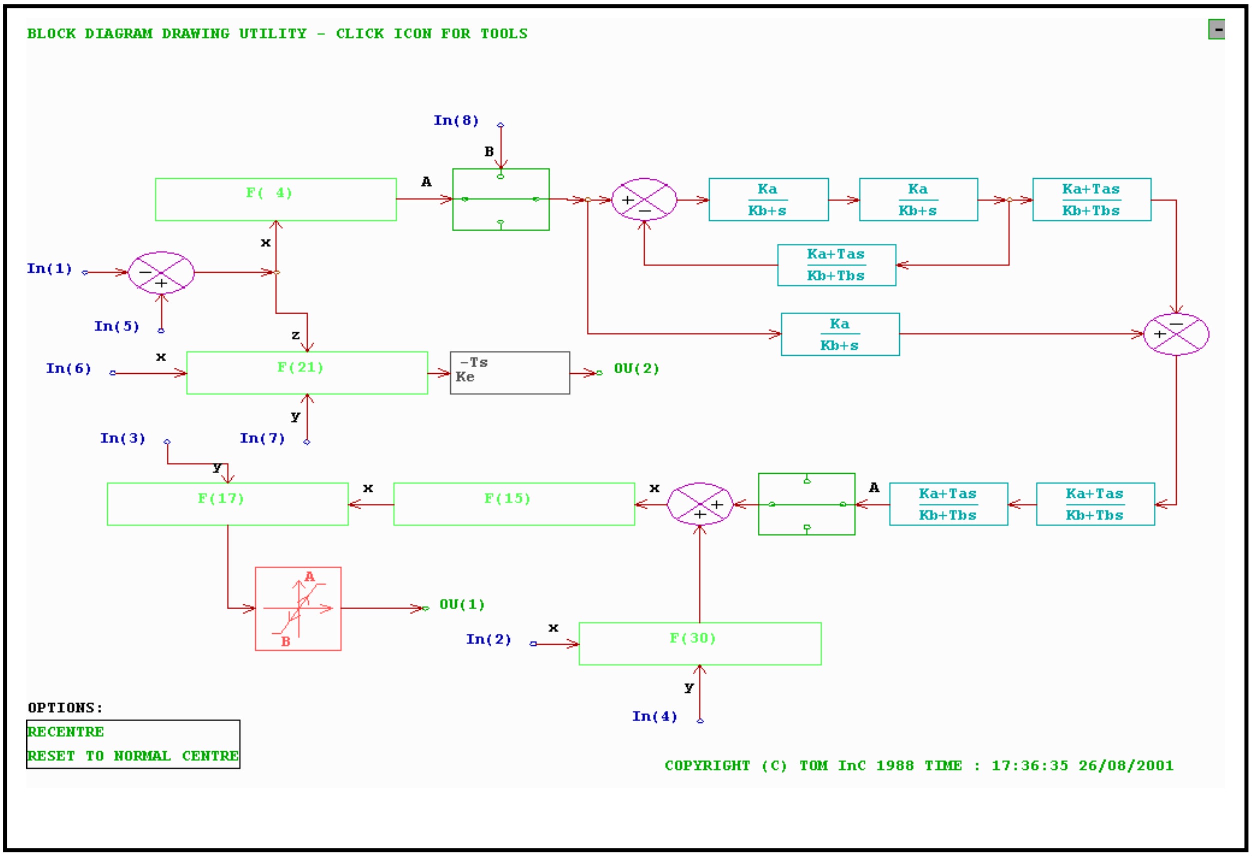


Figure 10.6

The <N> key

Pressing this key or selecting it from the tool bars displays the numbers, associated with each element which is drawn on the screen. These numbers are used in the editing section (next section). Also, any values associated with the elements during the simulation reports will be connected to these numbers.

The <S> key

Pressing this key or selecting it from the tool bars invokes the 'simplicity' command which displays the actual value of the parameters entered for the elements on the data pages within the element boxes. Although it is tried that the simplified diagram will be a self addressed diagram, there are some exceptions which need explanations. These are raised as follows.

a) In algebraic function blocks the term 'a pow b(x + θ)' , where a, b, and θ are parameters, means $a\,(x + \theta)^b$.

b) In logical switch blocks <CVR> (see the next section) is written as:

MAX , MIN , TIME, Oa

depending on the controller action. The parameter 'a' is a number, which refers to the block whose output controls the logical switch block.

c) The coefficients are rounded off values of the actual data. This restriction is raised because of limitation of space in blocks.

The <W> key.

By pressing this key any arbitrary notes can be displayed, although these messages will not be filed with the module. < F9 > and < F10 > keys can also make notes. F10 may also be selected from the tool bars.

The <T> key.

Pressing this key or selecting it from the tool bars displays the title of the current module.

The <U> key.

This key is opposite to the <S> key, i.e. reverses the 'simplicity' command.

The <X> key.

Pressing this key enables one to exit form the drawing routine and to return to the main UDEM options. Figure 10.7 shows a simplified diagram, which has been obtained using the <S>, <T>, and <N> keys.

Mouse right click

Brings some of the options in a blue menu bars as described in chapter 2.

10.4 Modify the present module diagram

The selection of this option from the UDEM main menu enables you to go back to the drawing routine. It allows you to modify the structure of a block diagram you are working with, i.e. it is the same as the [draw a new module] option except that it does not initiate the program for drawing of a new block diagram. If this option is entered using the code <L>, the block diagram will be drawn in the simplified mode with element numbering, and has a title written at the top.

10.5 Editing the present module data

The edit section of UDEM is used to enter or change the numerical elements, parameters and functions. After construction of a block diagram, you may exit the drawing section by typing the <X> key or selecting the key from tool bars. You may also select the exit key from the right click menu bar. Now you have the main options on the screen. Select the [Edit the present module data] option. Another menu will appear on the screen. This is the edit main menu which is shown in Figure 10.8. Note that between these options only those which are related to the element groups and are drawn on the drawing section might be available. This is because UDEM knows what you have drawn on the block diagram in the drawing mode.

Also note that there is no data page for Adders, Multipliers, and Junctions since they do not need any data. Therefore, there are maximum six options for data entry. Upon selection of an edit option you will access the data table for the corresponding element group. The tables of data are divided into what are termed edit pages.

As stated in section 4, you may also go directly to the edit pages from drawings by pressing key <F1> over the required elements.

10.5.1 The edit pages

The layouts of various data pages are represented in Figures 10.9, 10.10, 10.11, 10.12, 10.13, and 10.14, These are described in the following sections.

Associated with each element there is a number, which shows the UDEM number of the element. The program automatically generates this number together with the type of element. At the bottom of the page, the diagrams of the available elements are given to remind the user what the parameters refer to. Should the number of the elements exceed one page, further pages are generated to handle extra entries.

The method of data entry is to position the cursor over the box next to the required element number, and to press any key. The parameters can then be typed in one after the other delimited by spaces. When all parameters are entered for a particular element, a carriage return must be typed or a click must be pressed and the data entry continues for the next element. It should be mentioned that any numbers entered in excess of the parameters for a particular element are disregarded.

To change any entry, the same process is followed except that when the correct value has been input, the return key is pressed immediately.

The input/output selection page (edit data page four) is different from the other edit pages. It lists the possible inputs & outputs and requires the user to enter the UDEM number of input or output against the required variable.

Associated with each page there are five options. However, only two of them will be displayed when more than one edit page exists on a particular table section. These five options are as follows.

[HELP]

Selection of this option displays an on-line help information about the current page variables.

[NEXT PAGE]

Further page of data can be accessed via selection of this option (if available).

[PREVIOUS PAGE]

As with the [NEXT PAGE] but paging is backward.

[REDISPLAY]

Selection of this option clears the screen and displays it again. Any data previously entered are become well ordered.

[RETURN]

This option returns you to the edit menu where you can select another edit page or return to the main menu. If you have entered the edit page directly from the drawing mode, it returns you to the drawing section. Note that the traveling between edit pages is possible by pressing the desired page number while positioning the cursor on the [REDISPLAY] option.

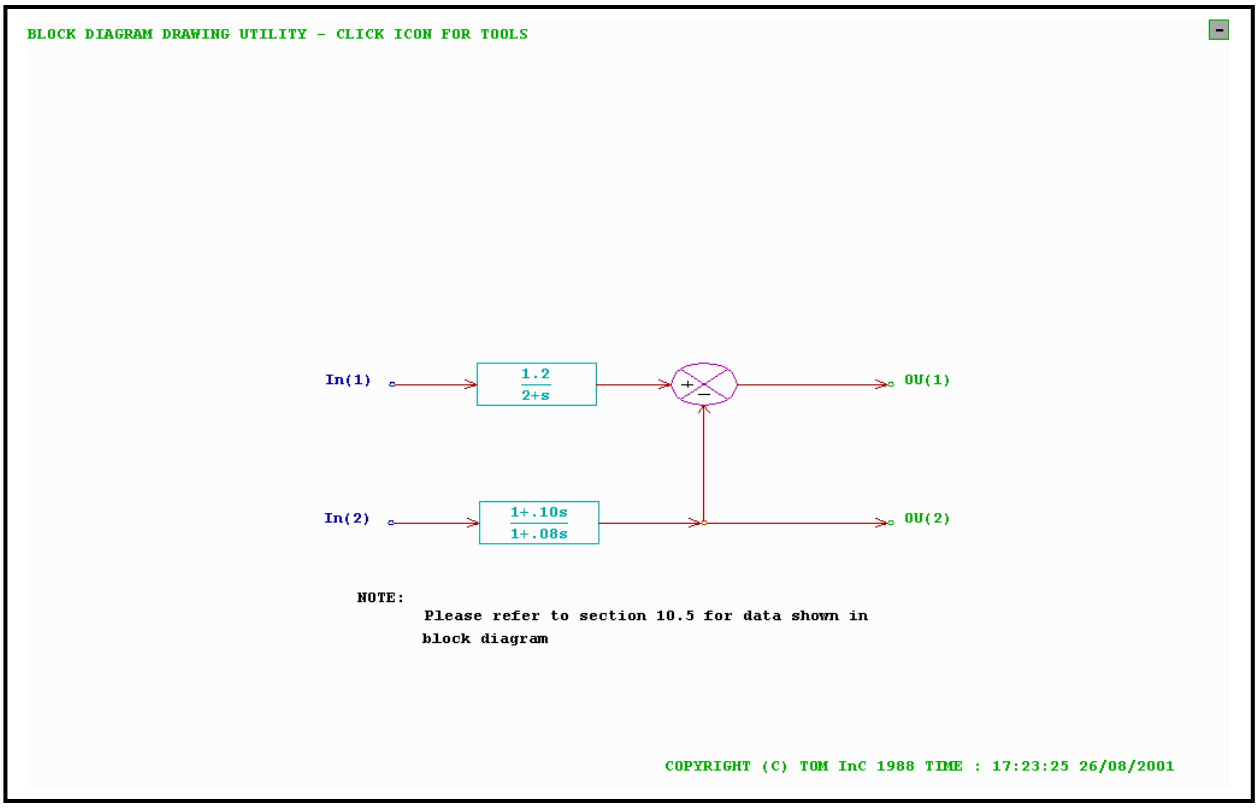


Figure 10.7

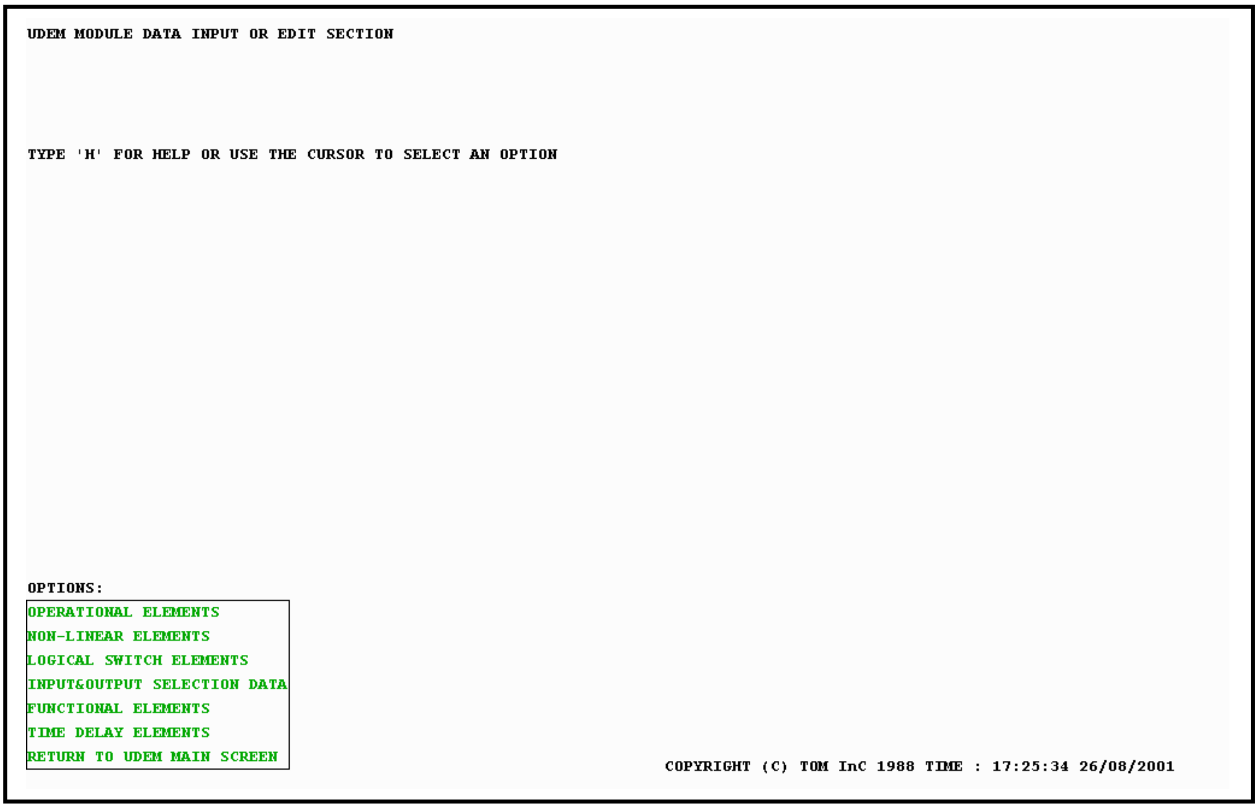
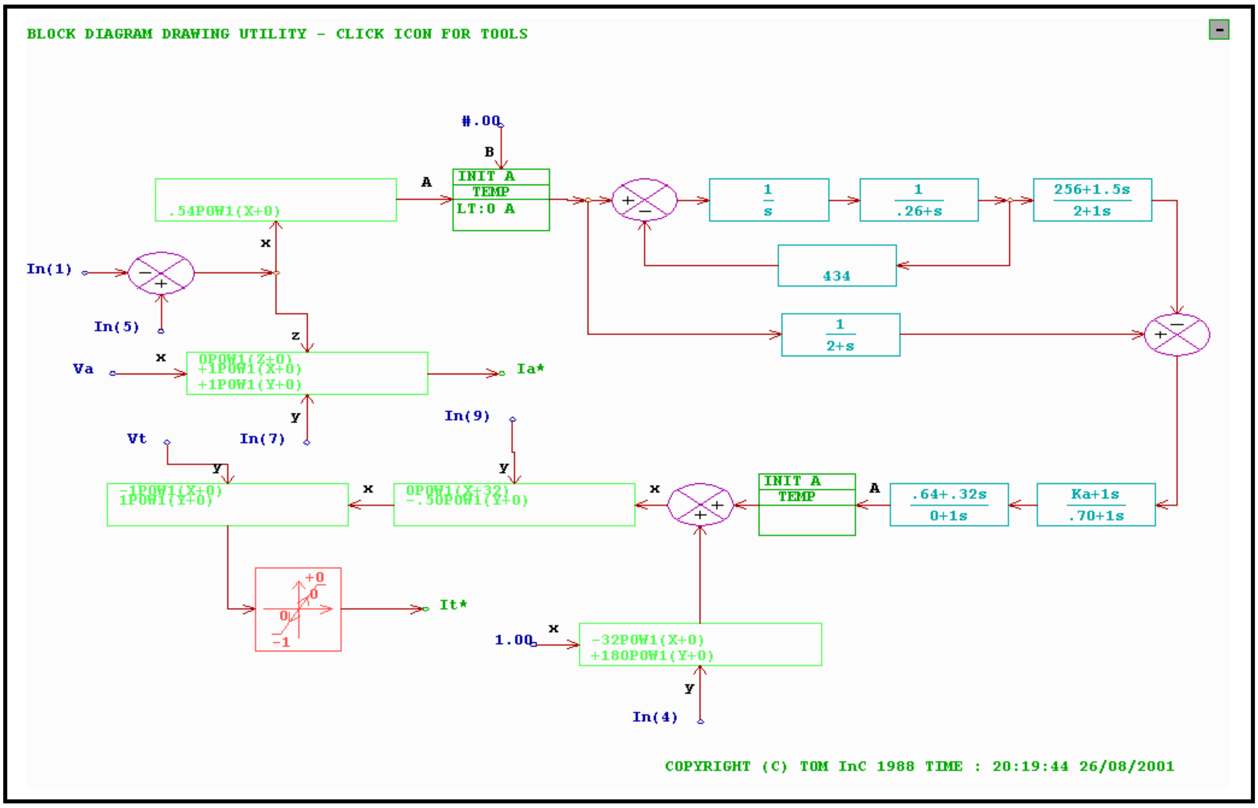
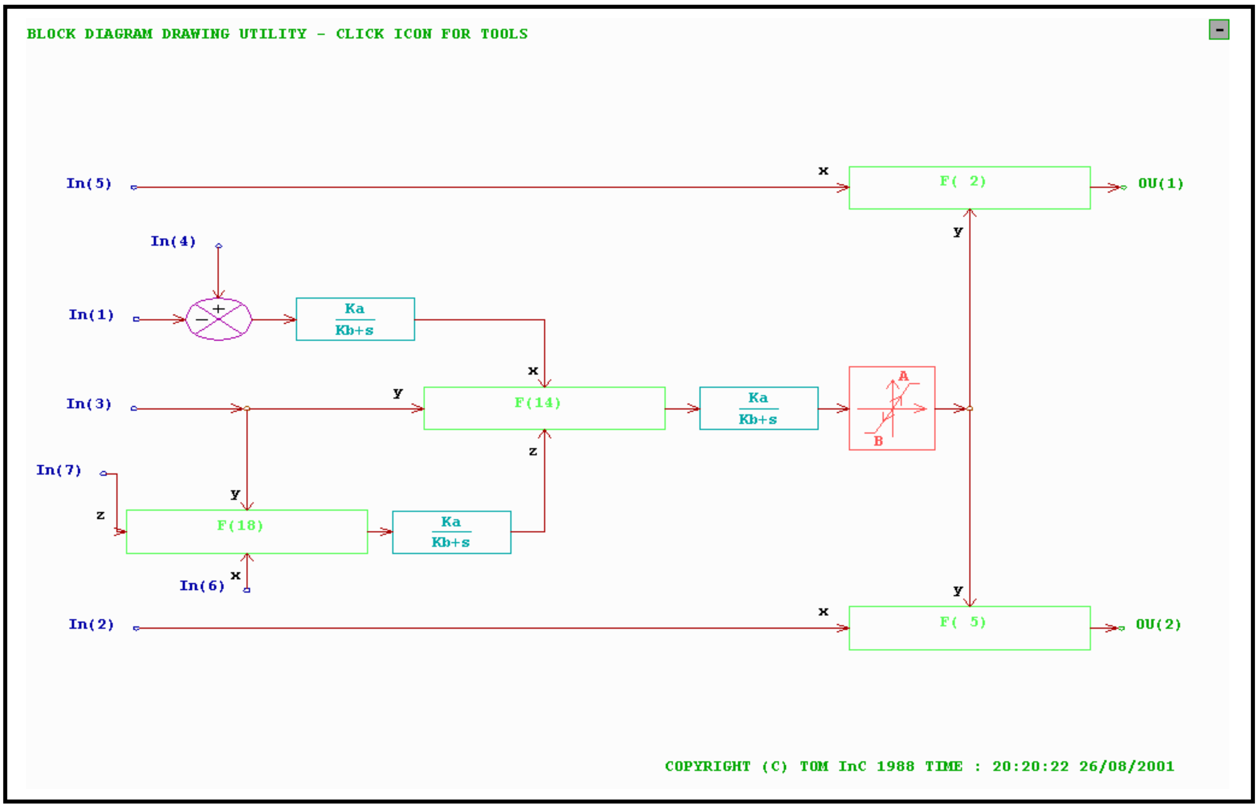


Figure 10.8



An arc furnace model constructed by UDEM



An SVC model constructed by UDEM

10.5.1.1 Operational elements

NUMBER : Element number as shown in the block diagram, can be seen by using the 'N' command, when in the drawing mode.

TYPE : Element type, used to identify the kind of element drawn.

Ka : Parameter 1 for the element - see the box representations at the bottom of the edit page.

Kb : Parameter 2.

Ta : Parameter 3.

Tb : Parameter 4.

NOTES :

1 All the parameters Ka etc. refer to the variables shown in transfer functions, illustrated at the bottom of the edit page.

2 When the module is simulated, certain checking goes on to ensure that each element contains valid parameters. E.g. for a lead-lag type element, if Kb=0 ,and Tb=0 the set-up routines will flag this as an error, and stop the run printing out an error message both to the screen and to the RESULTS file.

3 All the time constants (Ta, Tb) are in seconds.

4.Please refer to in line help for most up to date information.

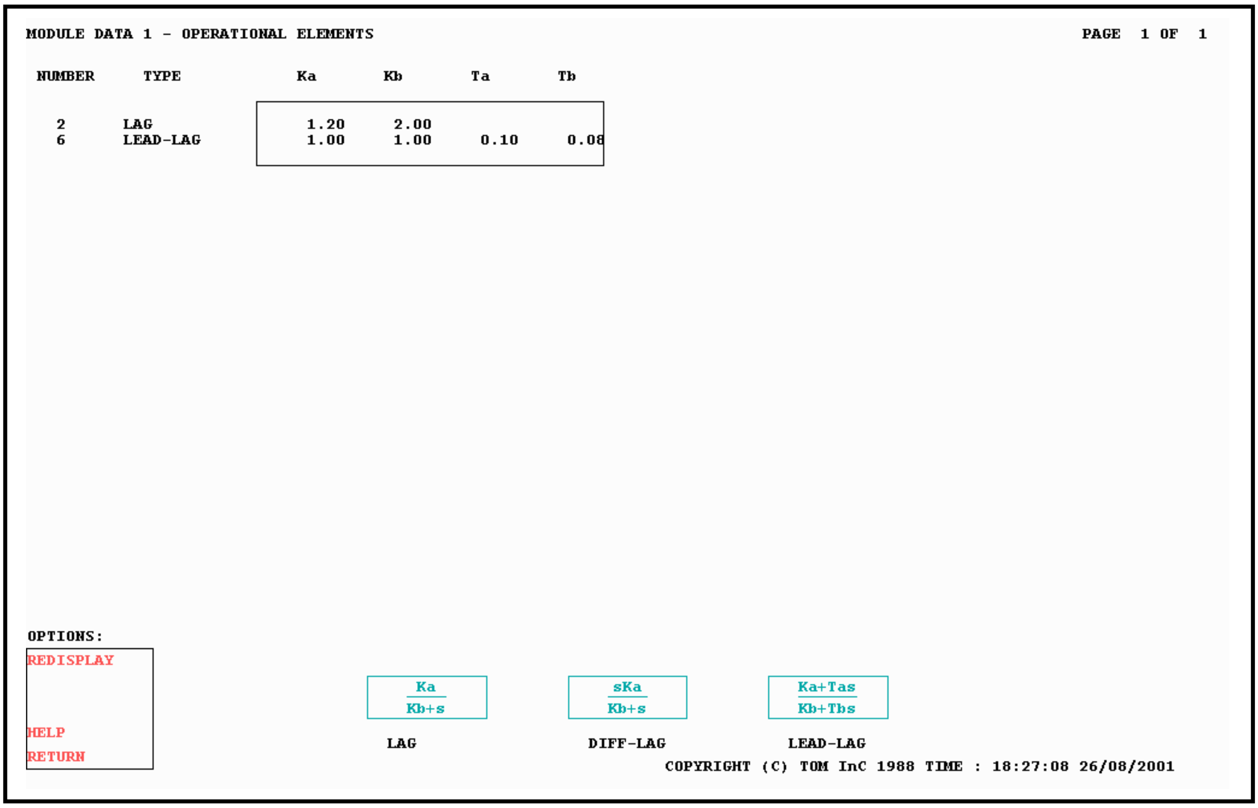

MODULE DATA 1 - OPERATIONAL ELEMENTS
PAGE 1 OF 1
NUMBER TYPE Ka Kb Ta Tb
2 LAG 1.20 2.00
6 LEAD-LAG 1.00 1.00 0.10 0.08
OPTIONS:
REDISPLAY
HELP
RETURN
Ka
Kb+s
LAG
sKa
Kb+s
DIFF-LAG
Ka+Tas
Kb+Tbs
LEAD-LAG
COPYRIGHT (C) TOM InC 1988 TIME : 18:27:08 26/08/2001

Figure 10.9

10.5.1.2 Non - linear elements

NUMBER : Element number as shown in the block diagram, can be seen by using the 'N' command, when in the drawing mode.

TYPE : Element type, used to identify the kind of element drawn.

A : Upper limit

B : Lower limit

C : Rate of rise limit (--/sec) Default value 99999.9

D : Rate of decrease limit (--/sec). if this is left blank the same value as 'C' will be used.

E : Maximum value of the dead-band.

F : Minimum value of the dead-band.

INIT : Initial value of output, if the input value is in the dead-band.

NOTES :

1 The parameters for non-linear elements take on different units depending on the module type.

2 For the saturation function, there are two available models:

(i) Enter constants A, B and C to get the standard IEE model of saturation function where Se is a multiplier of Efd and Se is specified at .75 Emax and at Emax. The constants A, B and C are then:

A = Se at .75 Emax
B = Se at Emax
C = Emax (this must be non-zero)

(ii) Enter only constants A and B (set C=0) to get an exponential model, where Se is again a multiplier of Efd, and Se is defined as:

$$Se = A*EXP(B*Efd)$$

3 Please refer to in line help for most up to date information.

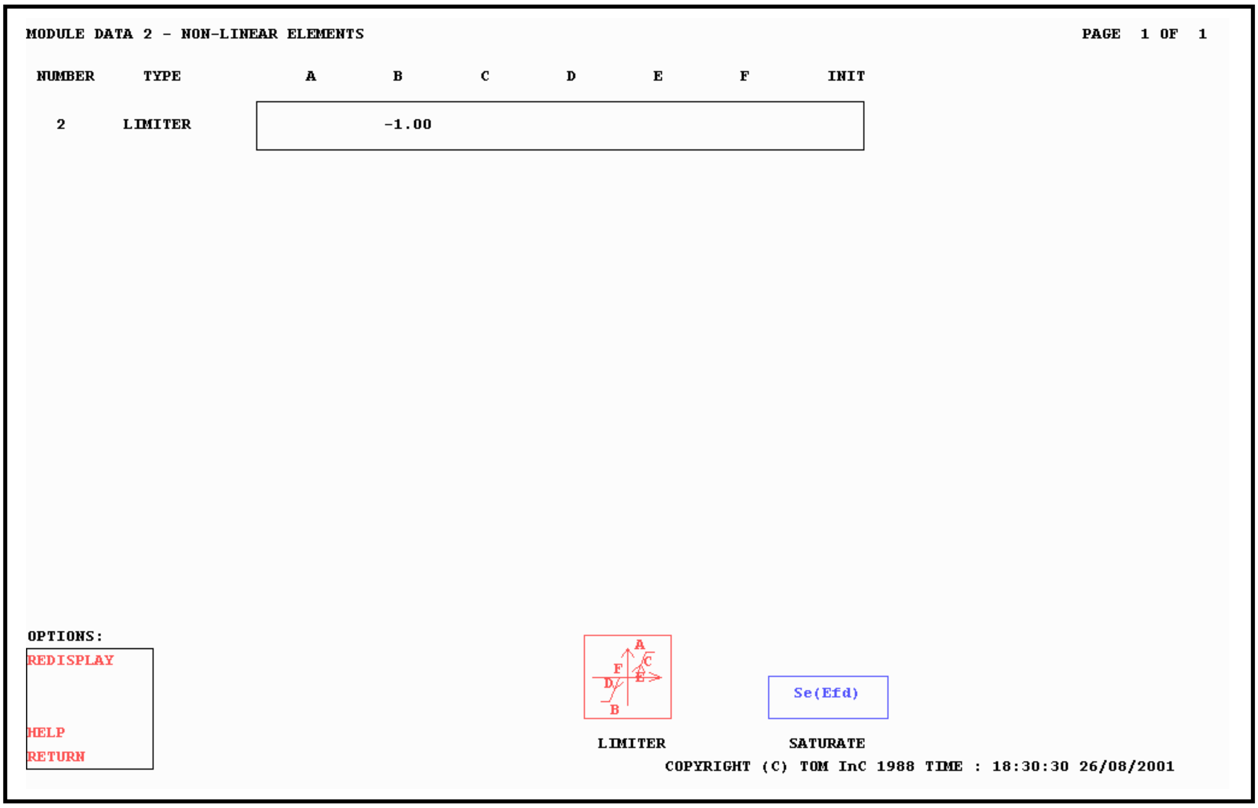

MODULE DATA 2 - NON-LINEAR ELEMENTS
PAGE 1 OF 1
NUMBER
TYPE
A
B
C
D
E
F
INIT
2
LIMITER
-1.00
OPTIONS:
REDISPLAY
HELP
RETURN
A
F
C
D
E
B
Se(Efd)
LIMITER
SATURATE
COPYRIGHT (C) TOM InC 1988 TIME : 18:30:30 26/08/2001

Figure 10.10

10.5.1.3 Logical switch elements

The logical switch elements provide an output from any of three inputs depending on the value of a user-defined control variable [CVR].

NUMBER : Element number as shown in the block diagram, can be seen by using the 'N' command, when in the drawing mode.

CVR : This is the control variable it can be MAX : The input which has the maximum value will be connected to the output.

MIN : The input which has the minimum value will be connected to the output.

TIME :The magnitude of time decides which input must be connected to the output.

O11 : The magnitude of the output of element number '11' decides which input must be connected to the output. '11' is only an example, shows the element number.

S11 : The slip of the output of element number '11' decides which input must be connected to the output. '11' is only an example, shows the element number.

INT-POS : Enter 'A' or 'B' or 'C' , indicates the initial position of the switch.

LOGIC : Enter 'LT' or 'GT'
A : Parameter 1 (a), Default value is - or + infinity depending on the 'LOGIC'.
B : Parameter 1 (b), Default value is - or + infinity depending on the 'LOGIC'.
CHANGE : Not used

Example:

Suppose that TIME is entered for CVR, and LT is entered for LOGIC, then:
when: -&<[CVR]<a The output is connected to A
when: a<[CVR]<b The output is connected to B
when: b<[CVR]<& The output is connected to C
where & stands for infinity.

NOTES:

1 The non parametric names can be typed in one after the other delimited by spaces.

2. Please refer to in line help for most up to date information.

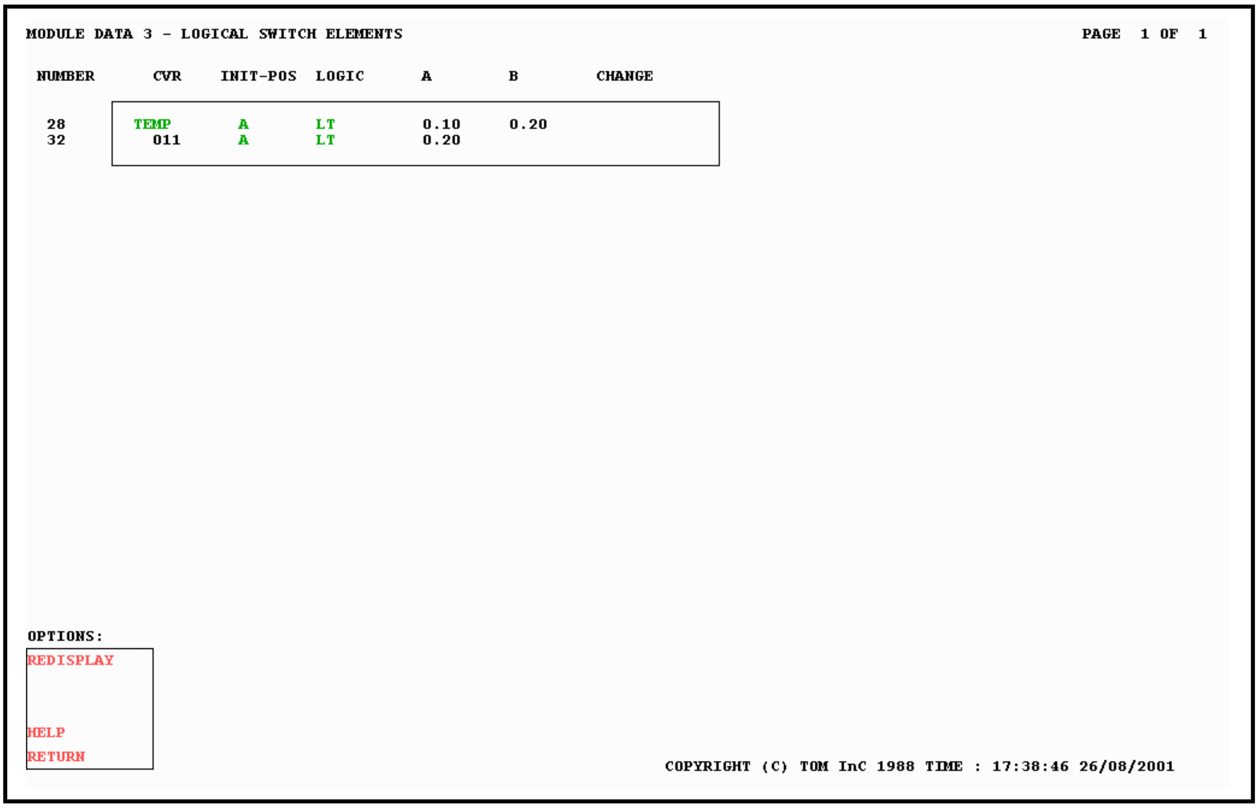

MODULE DATA 3 - LOGICAL SWITCH ELEMENTS
PAGE 1 OF 1
NUMBER CVR INIT-POS LOGIC A B CHANGE
28 TEMP A LT 0.10 0.20
32 011 A LT 0.20
OPTIONS:
REDISPLAY
HELP
RETURN
COPYRIGHT (C) TOM InC 1988 TIME : 17:38:46 26/08/2001

Figure 10.11

10.5.1.4 Input selection data

This page is used to match up the inputs/outputs to pre-defined system quantities, such as machine frequency etc. For all modules we must specify the inputs and outputs. Note that, in the present version, the POWER SYSTEM VARIABLES are used, it can be matched to any other on the user request. Please refer to in line help for most up to date information. At the present version the following inputs and outputs are provided:

REAL VOLTAGE (Vr)	REAL CURRENT (Ir)
IMAG VOLTAGE (Vi)	IMAG CURRENT (Ii)
TERMINAL VOLTAGE (Vt)	TERMINAL CURRENT (It)
VOLTAGE ANGLE (Va)	CURRENT ANGLE (Ia)
DIRECT VOLTAGE (Vd)	DIRECT CURRENT (Id)
QUADRA VOLTAGE (Vq)	QUADRA CURRENT (Iq)
ROTOR ANGLE (Ra)	ROTOR ANGLE (Ra)
ACTIVE POWER (Pe)	ACTIVE POWER (Pe)
REACTIVE POWER (Qe)	REACTIVE POWER (Qe)
SHAFT POWER (Pm)	SHAFT POWER (Pm)
FIELD VOLTAGE (Ef)	FIELD VOLTAGE (Ef)
FIELD CURRENT (If)	FIELD CURRENT (If)
FREQUENCY (f)	FREQUENCY (f)
ROTOR SLIP (s)	ROTOR SLIP (s)
TERMINAL CURRENT (It)	TERMINAL VOLTAGE (Vt)
CONSTANT INPUT	SPARE
CONSTANT INPUT	SPARE
TIME	SPARE
SPARE	SPARE
SPARE	SPARE

The dependency between the power system variables are regarded in the program routines e.g. Vt=SQRT(Vr**2+Vi**2). When 'TIME' is selected as a variable associated with input, indeed, a ramp function of time will be generated at this input. The ramp can be used to generate any other function, by putting this through any algebraic function. To select the correct variable for a particular input/output the following procedure must be carried out:

1 Position the cross-hairs over the first column of the box on the line on which the required variable is located.
2 Press the space-bar or a click.
3 Enter the input/output number (1,2,3,.....,10) and press <CR> or a click.
4 If you wish to select the next line as another input/output enter the input/output number, otherwise press <CR>.

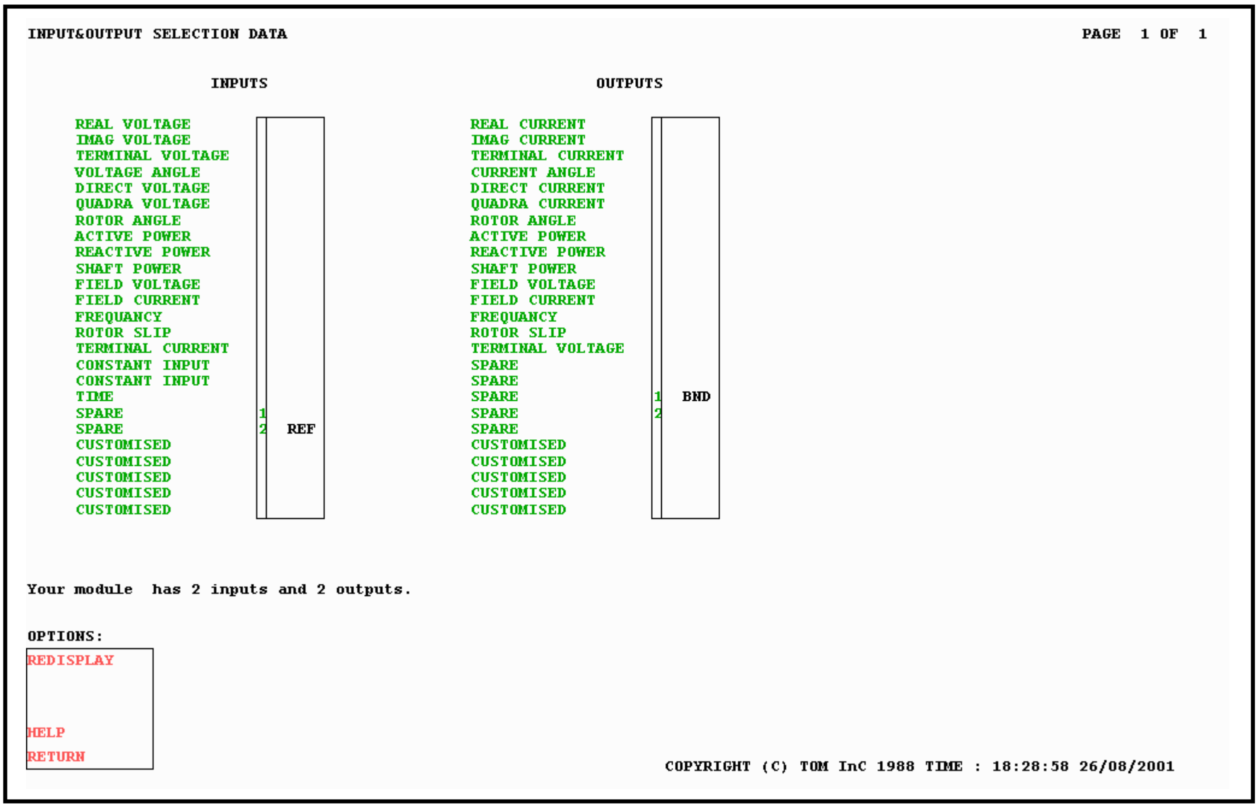


Figure 10.12

NOTE:

1 When a particular input/output has been entered, it can be overwritten by selecting the same line and entering a fresh number the input/output will no longer appear in the selection box, and will have to be entered elsewhere.

2 The second column is used to identify the following aspects:

a- The outputs of the module which are bounded. In this case, a '*' must be entered on the line on which the required output number was located. These are the outputs which their initial values are known. The program will ask for these initial values later on when using the UDEM test utility.

b- The reference inputs. These are the inputs, which their initial values are not known. The program, in the initialization routines automatically sets them. A '*' must be entered on the line on which the required input number was located, in order to make the input variable as a reference.

3 For CONSTANT INPUT, this column is used to enter the numeric value of that input. X Note that, the routines assume that the system is in the steady state at time zero. The number of reference inputs must be equal to the bounded outputs.

10.5.1.5 Algebraic function selection data

Each input signal (X,Y,Z) can be associated with one of the specific functions defined in the Appendix E. Each function is also associated with three coefficients which determine the function gain, signal gain and phase shift. The general form of the function is:

$$Cx.Fx(Px.X+@x) * Cy.Fy(Py.Y+@y) * Cz.Fz(Pz.Z+@z)$$

It is possible to represent each term of the function in the form :

$$Cx(X+@x)^{Px} * Cy(Y+@y)^{Py} * Cz(Z+@z)^{Pz}$$

by specifying the 'POW' function name for Fx, or Fy, or Fz.

NUMBER : Element number as shown in the block diagram, can be seen in the block in the form F(number) or by using the 'N' command, when in the drawing mode.
TYPE : Enter '+' to add, or '*' to multiply, or '3' to add and multiply, or '4' to multiply and add, or 'sqrt' to square roots the functions which are created on inputs 'X' , 'Y' and 'Z'.
Fx : Enter any function name which is required to do on input 'X' from those listed in the following table.
Fy : Enter any function name which is required to do on input 'Y' from those listed in the following table.
Fz : Enter any function name which is required to do on input 'Z' from those listed in the following table.
Cx : Enter the value of the coefficient desired to form the function.
Cy : Enter the value of the coefficient desired to form the function.
Cz : Enter the value of the coefficient desired to form the function.
Px : Enter the value of the coefficient desired to form the function.
Py : Enter the value of the coefficient desired to form the function.
Pz : Enter the value of the coefficient desired to form the function.
@x : Enter the value of the coefficient desired to form the function.
@y : Enter the value of the coefficient desired to form the function.
@z : Enter the value of the coefficient desired to form the function.

NOTES:

1 The phase shift '@' is in radian and the signal gain 'P' is in radian/sec when the SIN or COS or TAN is used as the function name.
2 For details of data entry see section 10.5. The function name can also be typed in one after the other delimited by spaces.

3 Please refer to in line help for up to date information.

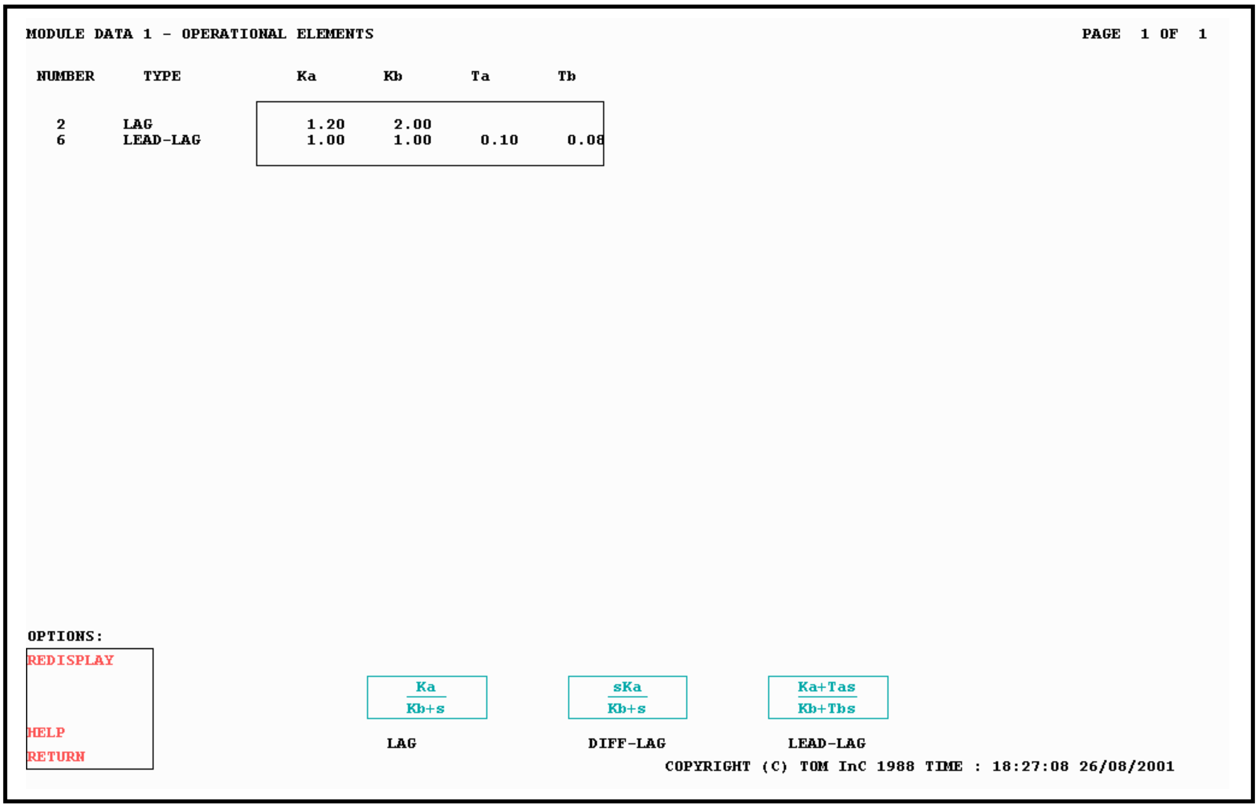

MODULE DATA 1 - OPERATIONAL ELEMENTS
PAGE 1 OF 1
NUMBER TYPE Ka Kb Ta Tb
2 LAG 1.20 2.00
6 LEAD-LAG 1.00 1.00 0.10 0.08
OPTIONS:
REDISPLAY
HELP
RETURN
Ka
Kb+s
LAG
sKa
Kb+s
DIFF-LAG
Ka+Tas
Kb+Tbs
LEAD-LAG
COPYRIGHT (C) TOM InC 1988 TIME : 18:27:08 26/08/2001

Figure 10.13

10.5.1.6 Time delay elements

NUMBER : Element number as shown in the block diagram, can be seen by using the 'N' command, when in the drawing mode.

TYPE : Element type, used to identify the kind of element drawn.

K : Attenuation or amplification coefficient.

T : Dead-time delay of the block.

C : Not used.

NOTES :

1 The parameters K and T refer to the variables shown in transfer functions, illustrated at the bottom of the edit page.

2 The Dead-time 'T' is in seconds.

3 Please refer to in line help for up to date information.

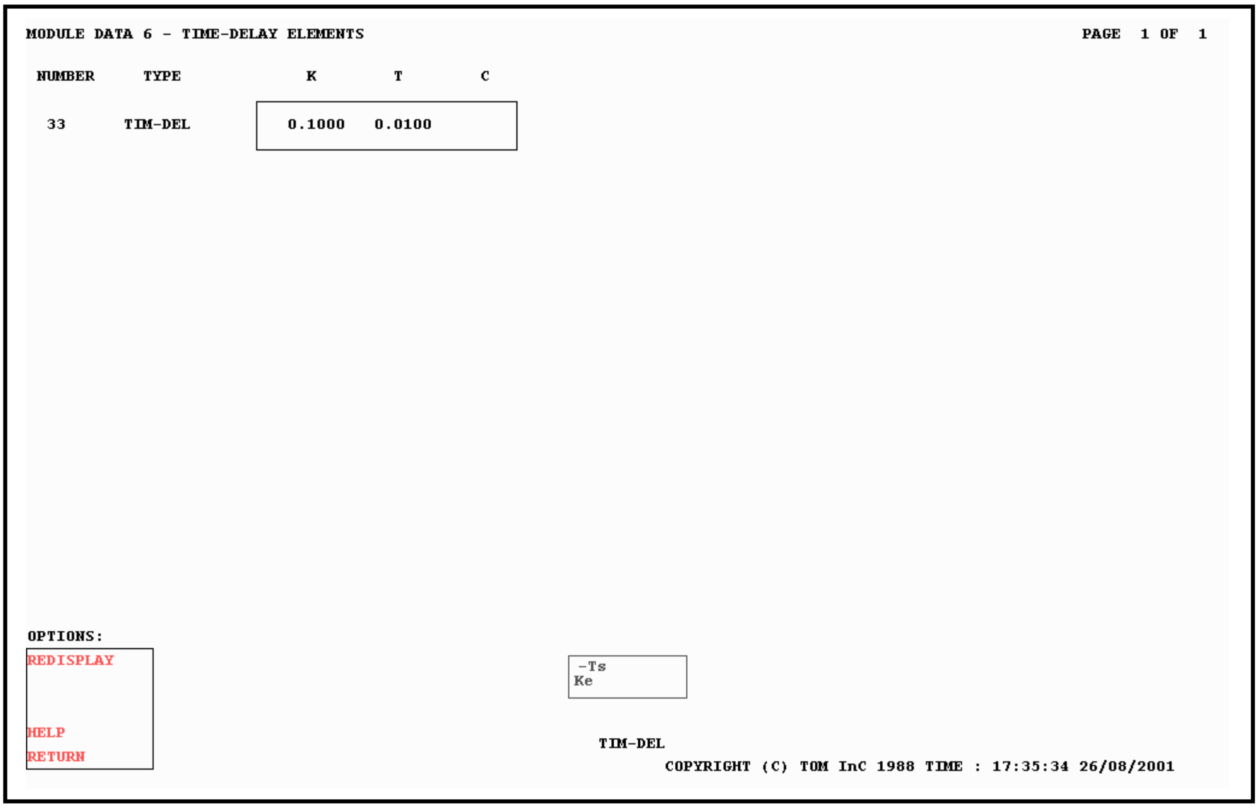

MODULE DATA 6 - TIME-DELAY ELEMENTS
PAGE 1 OF 1
NUMBER TYPE K T C
33 TIM-DEL 0.1000 0.0100
OPTIONS:
REDISPLAY
HELP
RETURN
-Ts
Ke
TIM-DEL
COPYRIGHT (C) TOM InC 1988 TIME : 17:35:34 26/08/2001

Figure 10.14

10.5.2 Effect of the deletion process on the edit pages

Any data associated with a deleted element will be automatically removed from the data 'slot'. During the deletion process, the associated data are saved in storing arrays so that if a 'restore' command is received, the data can be returned to their pre-edit state. Whenever a connection to an element is deleted, the data associated with the element is not affected and does not change, except when the element represents an algebraic functional or a logical switch block.

When an input connection has to be deleted from an algebraic function block, the data associated with the deleted 'connection character' will be changed over. For example, consider an algebraic function block with three input connected lines, indicated by ' X, Y, Z ' , and it is proposed to delete the connection ' Y '. The drawing routine will reset the indicator characters to be in the lowest and sequential order. This means that the connection ' Z ' will be changed to be the connection ' Y '. During this changeover of the connection character name, the data associated with the connection character will also be shifted. However, the associated data are saved for use if a restore command is received.

For a logical switch block the same process will be followed. If the initial position of a switch is the connection-site to which its ' connection character ' is to be deleted, the program will change the initial position of the switch and will inform the situation to the user.

10.5.3 Direct access to the edit pages

It is possible to access the edit pages directly from the drawing section. Pressing the <P> or <F1> key in the drawing mode, while the cursor is positioned over an already existing element that requires data, will call up the data entry section of that type of element. The program is then ready for entering the parameters associated with that particular element. This is a useful key to facilitate direct access to the data entry page. Selecting the [RETURN] option on the edit pages will bring you back to the drawing section.

10.5.4. Other features of the editing routines

The duplication of any line of data is possible. If you wish to duplicate any data line which, has been previously input somewhere else on the same page, the following steps should be taken. First position the cursor over the data line to be repeated and press the <R> key to remember it. Then select the new line and enter the <R> key instead of data values. In case you wish to duplicate the last line entered, the first part of this procedure does not have to be carried out; only the selection of the new line is necessary.

In functional and logical data entry pages, the user can enter alphabetic characters to identify some of the required functions. These are typed in one after the other delimited by spaces in the same manner as the numerical values.

10.6 Save the present module

The selection of this option enables the user to store a newly created module or a modified module. It is also possible to delete any unwanted modules. In this connection, a self-explanatory dialogue will take place and the module will be filed while a maximum 60 character name, a password, and a 4 character ID is associated with it.

10.7 Retrieve module from file

This option is used to access any modules constructed and filed on previous occasions. Thus, the selection of this option will clear the existing module and replace it with the module in the required file.

10.8 Block diagram flow test

This option must be used before running the simulation routines. The 'flow test' section identifies any element, which is not appropriately connected. While doing this, it draws the block diagram on the screen in order to visualize the errors that might be encountered in the block diagram configuration.

10.9 Use the UDEM test utility

This option must be selected after constructing a module and after testing the block diagram flow, or after retrieving a module from a file in order to simulate the behavior of the block diagram in an isolated situation, i.e. testing the module open loop response. When this section is first entered, the first screen that is encountered provides a method of entering the study variables and constants. An example of this page is shown in figure 10.15.

Generally, the isolated test section is arranged in three main sections:

a) the input/output specification section,
b) the simulation section, and
c) the results display section.

The first section allows the user to specify the initial conditions, the disturbance to be simulated, and the time period over which the simulation is to enter and the effects that can be observed. The simulation section is the part that actually runs the time response of the module including the initial iterative solution for the initialization of the module. The display section provides the graph drawing and listing options for the simulation results.

10.9.1 The study specification section

When the test section is first entered, the first screen encountered provides a method of entering the study variables. These are:

The study duration

This is the length of time in seconds that the simulation will run.

The step length

This is the step length used during the study for the numerical integration. Its value depends on the minimum natural frequency of the system under study (usually about 0.001s).

The scale

This is the maximum scale used for dimensioning the plot axes. Default value is the absolute maximum magnitude entered on this page.

The step functions

The step functions replace the system inputs. These are specified in terms of three quantities, i.e. the initial value of the step, the final value of the step, and the switching time between them. Note that the initial value for the reference inputs will be set automatically by the program in the initialization routines; see the analysis parameter section in this chapter.

The output initial values

The initial values for bounded outputs are defined here. These are used to initialize the system unknown inputs, i.e. the references. The bounded outputs are described in the following section.

10.9.2 Analysis parameters

The UDEM program assumes that the module is in the steady state before any transient can occur. Therefore, it will automatically set the input/output values of the module elements. This procedure is called initialization. During the initialization, some input which are defined as REFERENCE in the input/output page, will be set to the appropriate values according to the initial values of the BOUNDED outputs. Also, the feedback loops are treated as nonlinear equations, which must be set up appropriately. Moreover, the output of simple integrators, i.e. those for which Kb= 0, must be set such that the input to these elements become zero. These are unknown variables. The procedure of setting up these values is a complex nonlinear problem, which is handled by UDEM in an iterative manner.

Upon the selection of this option an edit page as shown in Figure 10.16 will be entered. This page contains all the system data necessary for initialization procedure of the module, and, initially, displays the default value for each parameter. These values may be changed using the normal edit procedure. However, it is usually not necessary to change the values. Note that the unknown variables which need initial guess (feedback loops and outputs of the simple integrators) will be found automatically by the program, and will be shown here together with those inputs which are selected by user as REFERENCE inputs.

10.9.3 Run study

The selection of this option will run the simulation study. All inputs and outputs of the module will be plotted on a graph against time and the user can interrupt the simulation study at any time by pressing the <O> key. The inputs and outputs will be identified with their numbers on the graph. An example of this graph is shown in Figure 10.17.

Once the study is completed or interrupted by the user, the plotting will be stopped. To display the options, the user must press the <O> key or just a click. It is then possible to select the plotting, listing or printing facilities by choosing the [PLOT - TIME], [PLOT - XY], [LIST], or [PRINT] options from the menu provided. This is shown in figure 10.18.

```
UDEM MODULE TEST SECTION - VERSION 2

This  section allows you to specify step functions to replace the  input
variables,  and so test the module in isolatted test condition. You must
specify the length of the study,  and the step length in addition to the
step function variables.
The  module  you  are testing has 2 inputs and 2 outputs,   and is filed
with an ID of "1040".

                                       STEP FUNCTION VARIABLES
     INPUT NUMBER       TYPE      INITIAL-VAL     FINAL-VAL      SW-TIME
          1            spare          0.000         1.000          0.100
          2           *spare

   OUTPUT NUMBER          1
   OUTPUT TYPE
   OUTPUT INIT-VALUE :  0.000

     STUDY DURATION :  2.000   STEP LENGTH :  0.010           SCALE
OPTIONS:                                                      1.500
REDISPLAY
ANALYSIS PARAMETERS
RUN STUDY
HELP
RETURN
                                                COPYRIGHT (C) TOM InC 1988 TIME : 18:33:26 26/08/2001
```

Figure 10.15

```
UDEM ANALYSIS PARAMETERS

INITIALISATION CONVERGENCE ACCURACY   0.000100   PU
INITIALISATION DIFFERANTIAL STEP      0.000100   PU
MAXIMUM INITIALISATION ITERATIONS           40
INITIAL  ESTIMATE  OF  INPUT  NO: 2   1.0000

OPTIONS:
REDISPLAY

HELP
RETURN
                                                COPYRIGHT (C) TOM InC 1988 TIME : 18:33:58 26/08/2001
```

Figure 10.16

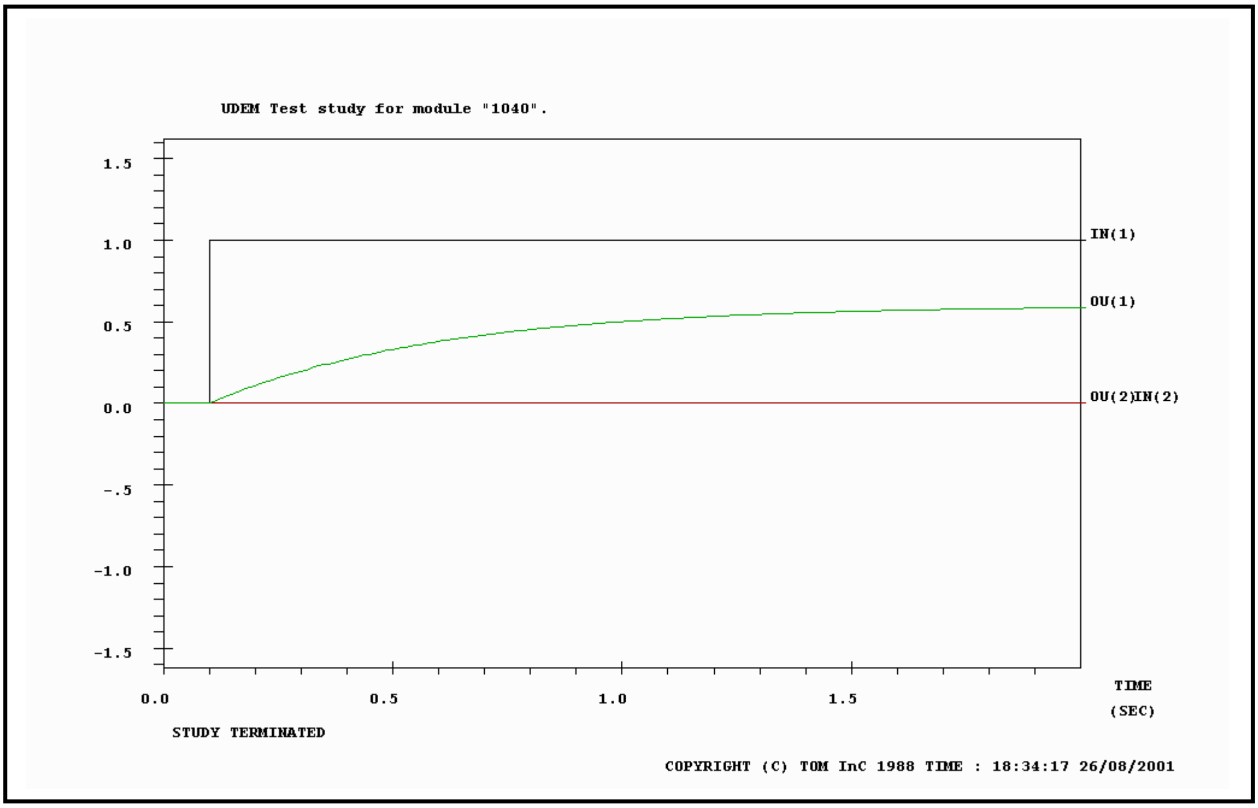


Figure 10.17

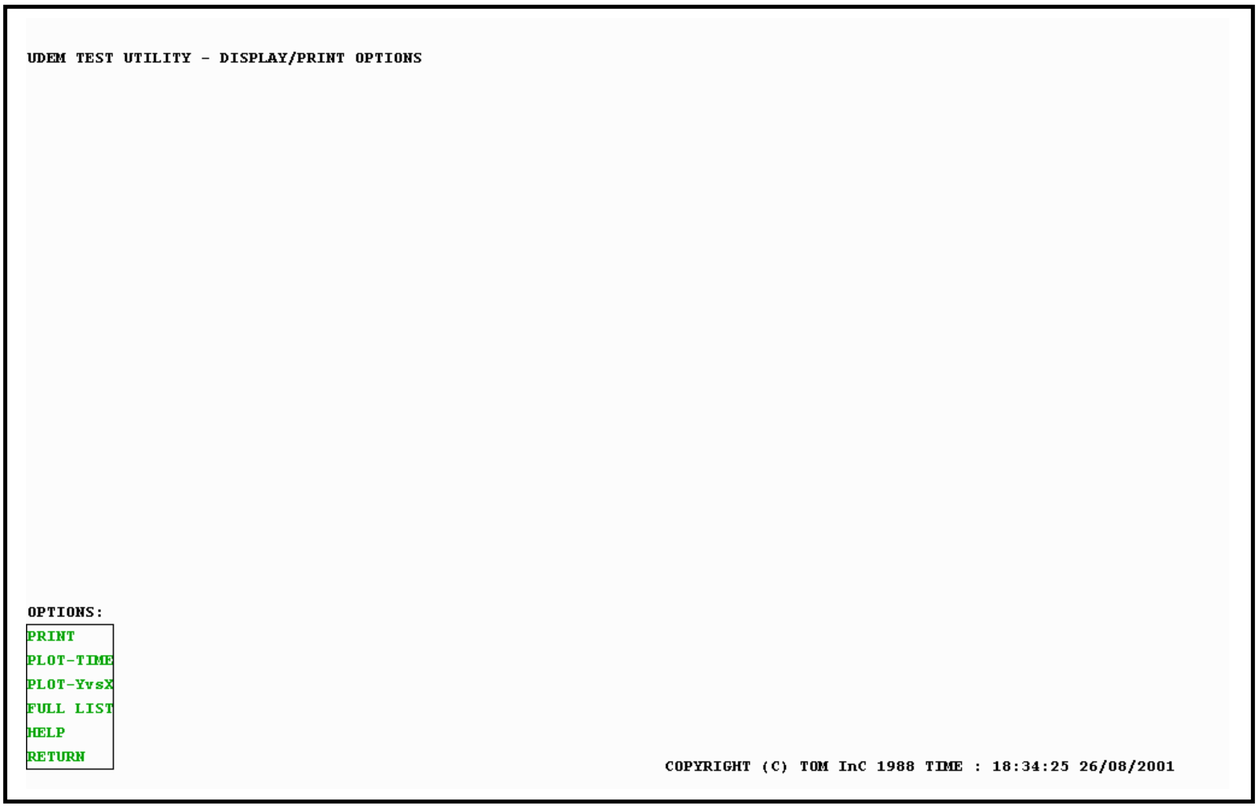


Figure 10.18

10.10 The display section

Although the simulation section of the test utility produces a graph of the 'system' inputs into and outputs from the module, this alone was considered rather a limited method of interpreting the module response. This is specially so because of the wealth of information produced by the simulation section of each step. The outputs of all the module elements are stored after each step to allow subsequent analysis.

The analysis section provides three main options for looking at the results of the simulation. They are described in the following sections.

10.10.1 Full list

The selection of this option will write the results of the simulation on the screen with the inclusion of titles and headings for more clarity. To all intents and purposes, it is as if the actual printer file was being read and displayed line by line on the screen. However, the organization of the result files will also permit a more selective listing to be obtained. This includes the facility of being able to skip forward to any point in the result files to select a particular step number and to examine the module outputs of the elements. This means that the file need not be displayed sequentially, but the user has the option of looking only that the step numbers that interests him. An example of this page is shown in figure 10.19.

10.10.2 Print

The selection of this option will write the simulation results to a file while adding headings and titles to identify the stored variables. After exiting from PASHA or in course of PASHA run if the option is available, this file can be read by using any text editor.

10.10.3 Plot time

The last and most useful section of the display routines is the plotting section. The transient section of PASHA provides graph-plotting facilities to display certain power system variables after the transient stability simulation has been completed. The format of these graphs was used as a template from which the UDEM graphs were designed. Basically this provides the user with up to four graphs with five traces on each, which can be selected to represent the outputs of any desired element in the module.

The user can specify exactly which outputs should be displayed using the now familiar kind of data - entry 'page', as shown in Figure 10.20. The element number for the plot can be entered by hand, or if required by using the 'fill' option selected by pressing the <F> key over a number entry box. This fills all the graph trace 'slots' with each element number one after the other. The fill option saves a lot of typing if the response of each element in the module needs to be displayed simultaneously on the same set of graphs. Individual elements can, of course, be entered normally.

The graphs have an automatic scaling facility, which displays the output of each element in terms of a percentage of its minimum value. It is also editable in the upper right-hand box, normally between $^{+}/_{-}$105 percent of the maximum scaling value.

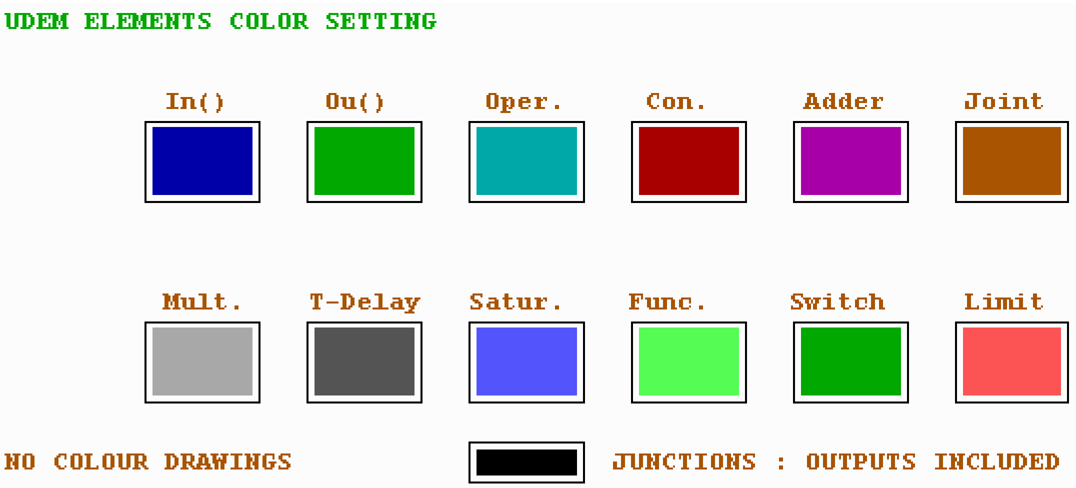
Once the graphs have been selected on the data page, there are then two ways of plotting the graphs, either singly one per 'page', i.e. taking up the whole of the screen, or four of them together per 'page'. Using the [four per page] option gives about four times more details on the screen, but it provides a better impression of the overall performance. Figure 10.21 shows an example of the graphs produced by this section.

10.10.4 Plot x-y

The selection of this option allows the user to plot an output variable of the module element (Y) against its another output variable (X) instead of time. It provides the user with up to two graphs with five traces on each. This is shown in figure 10.22.

10.11 Set colour and symbols

This option is working as it is described in section 2.5.15 except that it is used for color of UDEM elements. To see colorful block diagrams, you must set the NO COLOR DRAWINGS to COLOR DRAWINGS. To do this, just click on the box in front of the option. You can then configure the color of the UDEM blocks to the desired color.



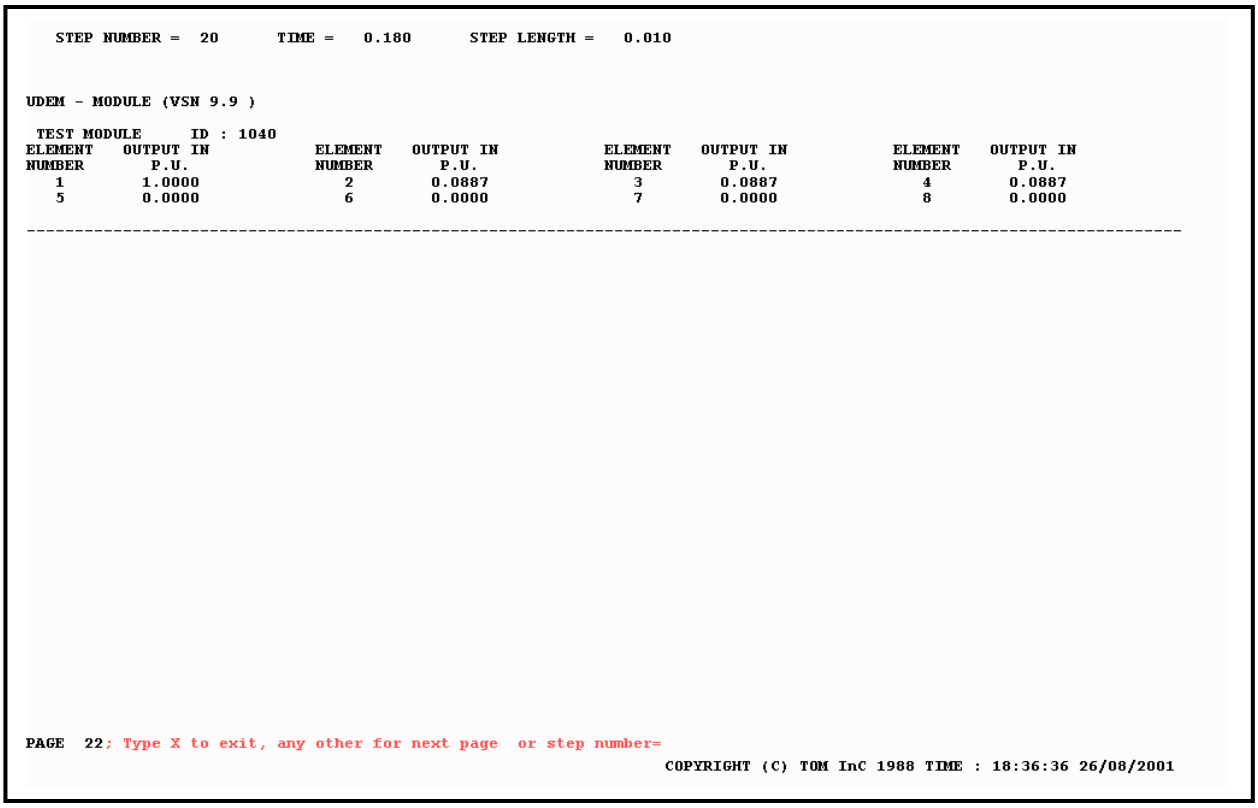


Figure 10.19

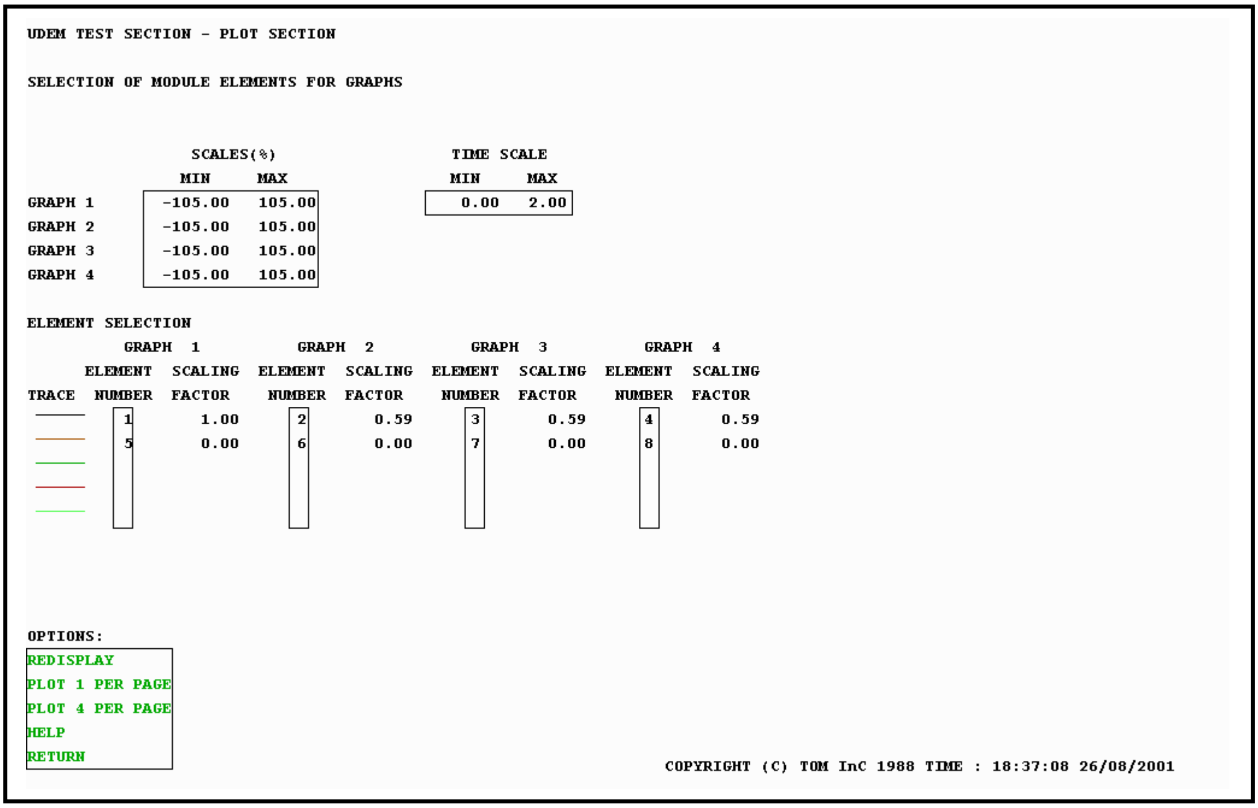


Figure 10.20

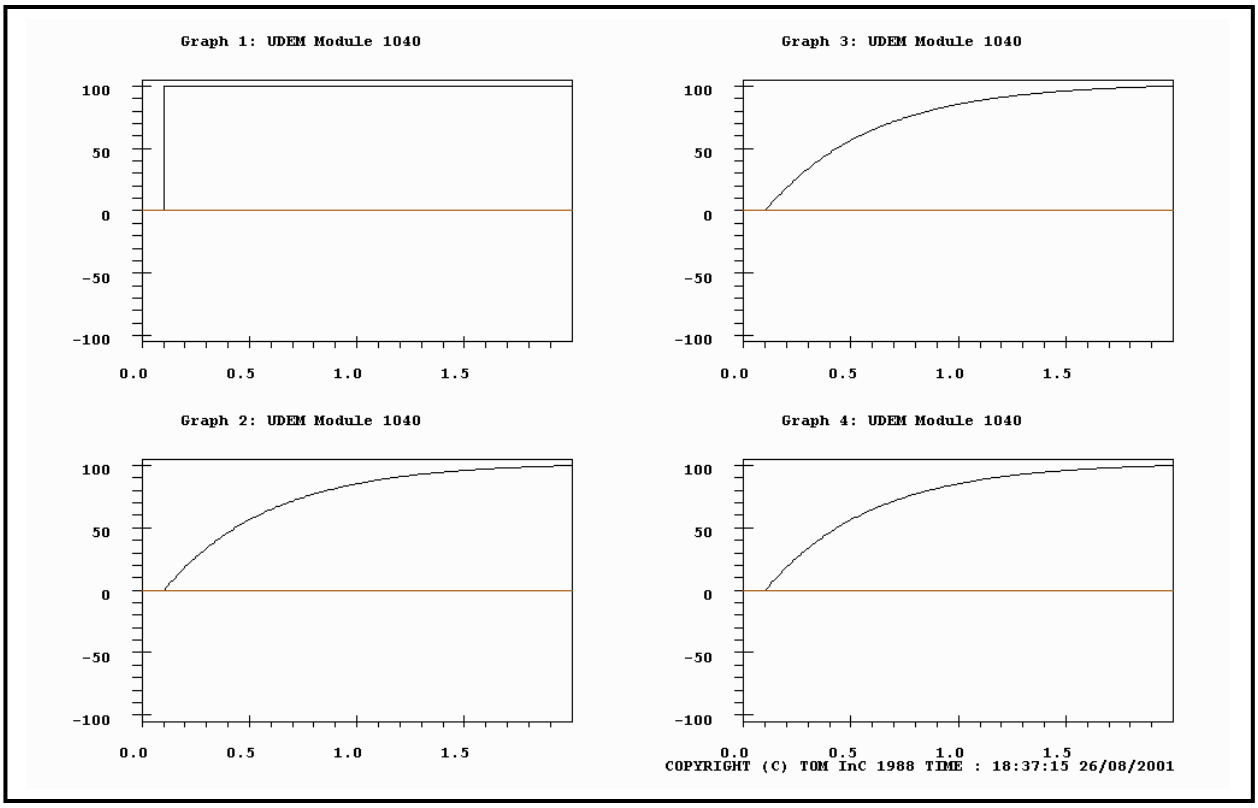


Figure 10.21

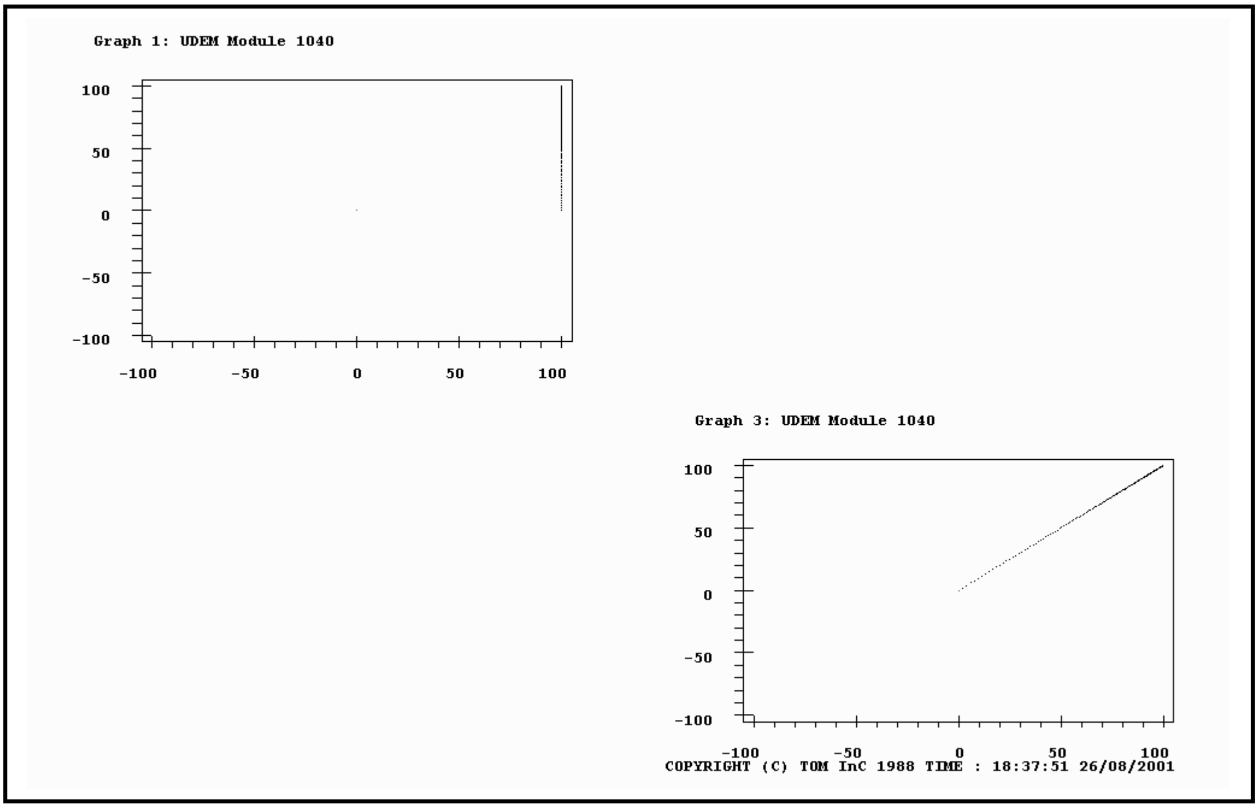


Figure 10.22

10.12 UDEM interaction with PASHA

As described in the previous sections of this chapter, using the UDEM program follows the same procedure as the initial drawing and editing stages in PASHA. It may be summarized as follows.

The user first draws the model in a block diagram representation by typing simple code letters, and then enters data for each block. The next step is to carry out a 'flow test' which checks the validity of the diagram structure and also sets up important variables. This will be used later in the simulation study. Lastly, the module is stored with a four-character ID code, which is used by PASHA. The modules constructed in this way can be included in a power system network to act as a sub-model in the transient stability calculation of PASHA.

10.12.1 Matching up the module

The way a module can interact with the network is through its interface quantities which, in turn, are related to the module input/output variables. These are specified by the user in the input/output edit page of UDEM. For example, a governor has the frequency as its input variable and the mechanical power as its output variable. However, the initialization routine needs a special treatment, which is discussed as follows.

When constructing a module, the objective is simply to achieve a dynamical model of the power system plants. It is then necessary to obtain an initial solution to confirm that the input data is correctly initialized, i.e. the modules are in a steady state condition from which the time solution can begin.

The steady state condition for a module is defined as the 'normal' operating condition of the module at time equal to zero (t = 0). Essentially this is a condition in which the output variables of the module would attain fixed values, after the module has been 'connected in' for a long time without disturbance.

On the other hand, the steady state operating characteristics of a power system are calculated by a load flow study. The standard data for each system component forms the model of the plant in the load flow calculation. The steady state initialization of the load, generator, and motor modules must be initialized after the initialization of their associated plants.

Due to the need for a sequential solution procedure, the initialization problem for a module is of the boundary value type. This means that the outputs of the module, which are related to the steady state system variables, are restricted to have pre-calculated fixed values. In order to reach a solution that satisfies the boundary conditions, it is necessary to allow some degrees of freedom in the module. This process basically needs some of the inputs to the module to be initially 'free' or unset, so that they can be set to the necessary level to satisfy the boundary conditions, i.e. additional inputs are needed to trim the external inputs so that the correct bounded outputs are produced. These inputs are called the 'Reference Inputs'. It would, of course, be possible to replace the reference inputs with preset constant values if their levels

were known. This would free the bounded outputs, but would also change the steady state operating conditions of the system.
For the generator modules, the mechanical power and the electrical field voltage can be specified as reference inputs because they are not among the variables, which are determined by the load flow study.

For the controller modules, (AVR & Governor) the matching up is simple, and usually the preset control signal is used as reference input.

10.12.2 Inclusion of UDEM modules in PASHA

A module can be included in the network 'constructed by PASHA' by accessing the appropriate network data page (Load , Induction Motor, Synchronous Machine, AVR, and Governor) in the EDIT section of PASHA. In the edit page of PASHA, a column exists whose topic is UDEM-TYP. The ID code of the UDEM model can be entered into this column. If the ID column is blank, the analysis procedure is performed as before using the standard models. If, however, the UDEM code is entered, the UDEM storage files are read through to see if this ID exists and if so, the module is read in. Next, the program checks the validity of the module input/output variables. If it matches up, the module will be included as the module of that particular device in transient stability analysis. The user can check if the correct module has been read by calling up the diagram via the EDIT page, simply by positioning the mouse cursor over the line on which the required module ID was located and pressing the <T> key. These are shown in figures 10.23 and 10.24.

10.12.3 Printing, listing and plotting

The results of UDEM elements in a transient stability run will be printed and listed within the PASHA ordinary result files. The output value of any element in a UDEM module can be plotted using the 'User Defined Module' option in the plot section of PASHA. It is also possible to plot the interface quantities using the PASHA plotting facilities. The user defined module plotting page is the same as the UDEM plotting section described in Section 10.10.3, except that the busbar name to which the module is connected must be specified by the user. Another column which must be entered by the user is UDEM-TYPE. This column uses the following codes depending on the type of module:

<LOD> for load, <GEN> for generator, <I-M> for induction motor <AVR> for automatic voltage regulation and <GOV> for governor.

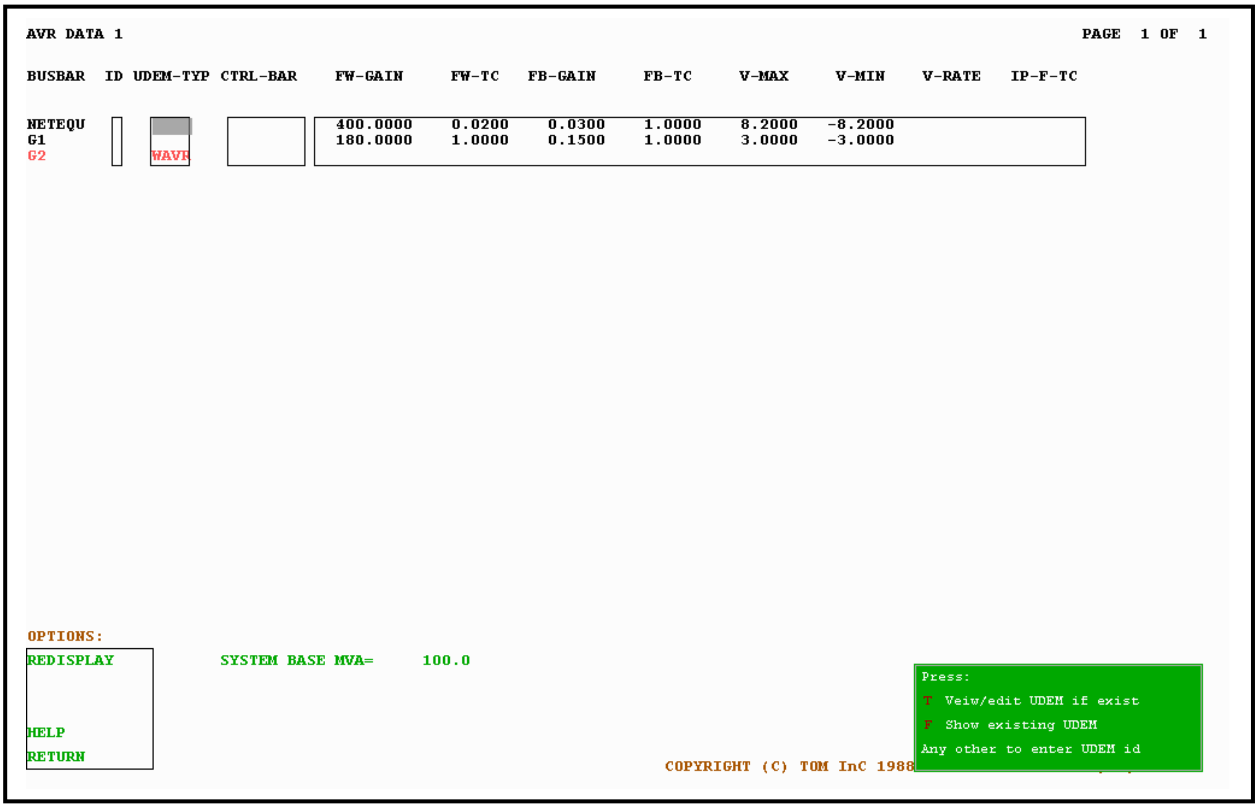


Figure 10.23

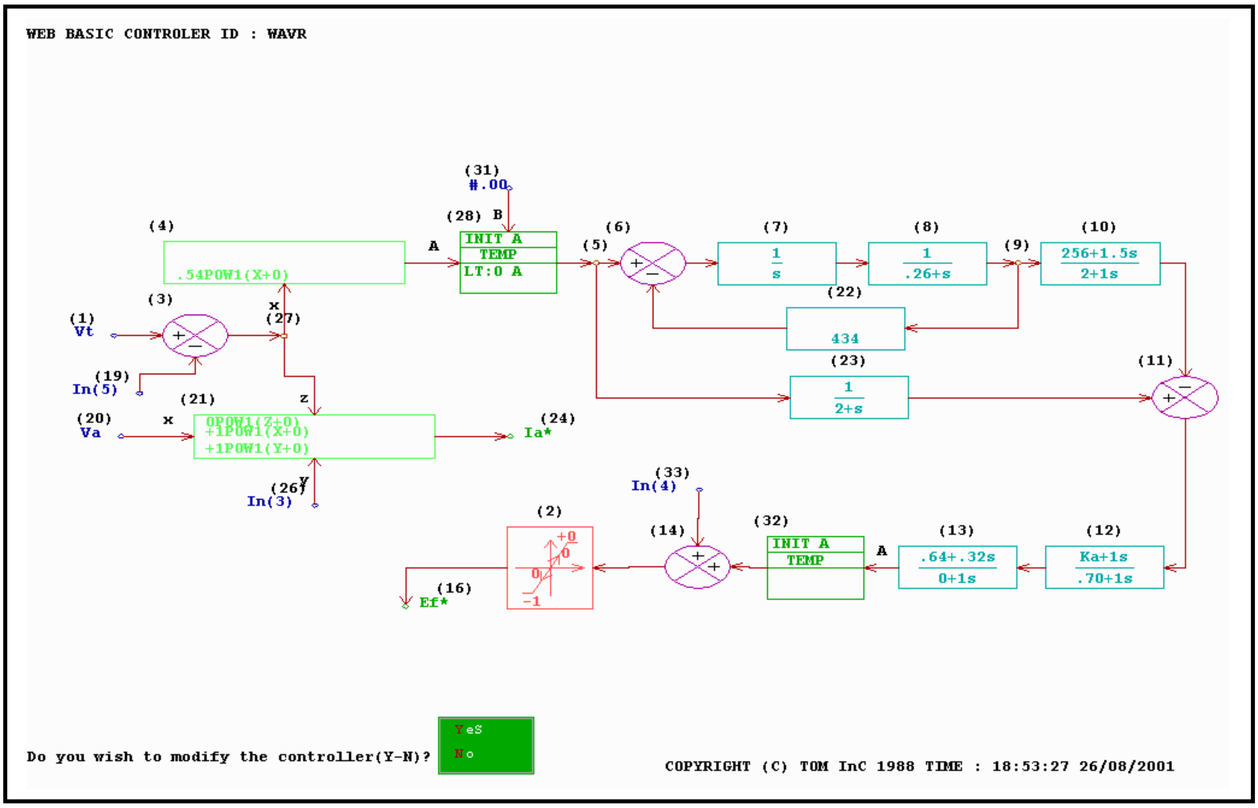


Figure 10.24

10.13 Using Real Time Workshop

Real Time Workshop (RTW) is an executable file provided by some vendors. They can be called in functional block of UDEM. Some vendor programs like SIMULINK® of MATLAB® provides RTW. These RTW executable files can be called within UDEM. Since this function is under enhancement please see the on line help of PASHA or contact with TOM Industrial Consultant representative to find out more about this option.

10.14 Platform dependent menu bars function

If you select the file options from PASHA platform dependent menu bars as described in section 2.2.2.1 of chapter two and you are in UDEM facility the commands for open/save etc. will relate to the UDEM module instead of PASHA networks.

10.15 Summary

The User Defined Equipment Modelling (UDEM) enables users to define their own models of power system plants in block diagram form which are called modules. These modules can be used to simulate the behavior of the models both in isolated condition and in the networks, which are constructed by PASHA where they are acting as a power system plant in the transient stability study.