

## Scilab as an alternative for Matlab

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# Scilab as an alternative for Matlab

P.W.M. van Zutven

DCT 2006.105

Implementing graphical user interface in Scilab 4 including a short introduction to multi-rate tasking.

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# 1. Introduction

With the increasing number of real-time applications an increasing want to cheap, reliable and easy to use controller software originates. A very reliable software package currently on the market is of course Matlab in combination with Simulink. This software provides a user-friendly interface to design controllers that in combination with the real-time workshop can handle real-time processes. A disadvantage of Matlab is that it is a commercial software package and it is therefore pretty expensive. As an alternative for Matlab, Scilab can be found. This open source software package can be downloaded for free and when used in combination with Real Time Application Interface (RTAI) it is possible to control real-time applications.

Scilab works with Microsoft Windows and Linux. Regarding Microsoft Windows, only Microsoft Windows CE is suitable with real-time processes, but this is a very expensive software package too. For that reason Linux has been chosen as operating system.

In Maassen (2006) it has been approved that Scilab is a good alternative for Matlab showing proper result with real time processes. Another conclusion was that Scilab is not as user friendly as Matlab and that its user interface is a bit out of date. The main goal of this report is to investigate if Scilab offers the ability of creating custom user interface and if so to explain how it can be used. This explanation can be done by converting the REF3 user interface from Matlab to Scilab.

As real-time application become more complex, different sensors and actuators need to be integrated. By using all those different components in one single controller, different sample rates are needed. The second goal of this report is to give a introduction to this so called multi-rate tasking or distributed control.

This report consists of three sections. Since Maassen (2006) was written a new version of Scilab and a new version of RTAI have been released. In the first part the differences between Scilab 3 and Scilab 4 and between RTAI 3.2 and RTAI 3.3 are discussed including a new installation guide.

The second part describes the user interface of Scilab and its tools and how to create custom user interface. As an example the conversion of the REF3 user interface from Matlab to Scilab is used.

As third a short introduction to multi-rate tasking is reported.

## **2. Scilab 4 and RTAI 3.3**

### **2.1 Major changes**

#### **2.1.1 Scilab 4**

Since Maassen (2006) was written, two new versions of Scilab were introduced. Namely Scilab 3.2 and Scilab 4. In this report, the newest version of Scilab has been used: Scilab 4. This newest version will be the last using the 'old' graphics mode. So probably in newer versions the graphics will be more up-to-date and more Matlab-like.

The major changes between Scilab 3 and Scilab 4 are also mostly graphical changes and changes in functions to let them be more Matlab equivalent. Tools like Scipad and the Matlab to Scipad converter are changed too. For example Scipad, the sci-file editor, is changed especially in a graphical way. With different colours for different functions, statements and variables the environment is more M-File Editor like.

A big missing in the list of changes between Scilab 3 and Scilab 4 is Scicos. This still uses old graphics and a out of date user interface. For example drag and drop is still not supported and in that way its development is far behind in comparison with Simulink. Nevertheless the control capabilities are tested in Maassen (2006) and the overall conclusion is that Scicos is a good alternative for Simulink. Newer versions will be more user friendly hopefully.

For a full list of changes between Scilab 3 and Scilab 4 see appendix A.

#### **2.1.2 RTAI 3.3**

Not only Scilab has changed, also the Real Time Application Interface (RTAI) has been developed. The newest version is RTAI 3.3 were RTAI 3.2 was used in Maassen (2006). Regarding the change log included in the installation file a lot has changed in the new version. Most changes are bug fixes and implementations to derive better stability. In general a lot has changed in the core files, but the user won't notice the difference. In this report RTAI has not been used very often, so there has not been made a deep investigation in the possibilities of the new version of RTAI.

For a full list of changes between RTAI 3.2 and RTAI 3.3 see the change log included in the installation file on the CD.

## **2.2 Installation**

The installation of Scilab 4 and RTAI 3.3 has not changed a lot in comparison with Scilab 3 and RTAI 3.2. Just like described in Maassen (2006) the installation consists of three steps. First a compatible Linux version has to be installed, in this report the Knoppix v.0.3.19.12 has been used. This version is included in the TUEdAX DVD (Linux Live DVD for TUEdACS

QAD/AQI devices) version 3.2.2. In Maassen (2006) an older version of Knoppix was used, but the installation and use of the newer version is exactly the same as the old. Secondly the kernel needs to be patched in order to install RTAI. A new patch is used, but the installation steps are the same. First install Mesa and EFLTK and then patch the kernel. Finally RTAI 3.3 and Scilab 4 need to be installed. These installation steps are also exactly the same as in Maassen (2006).

Be aware that the following steps need to be adapted in order to install everything:

- Everywhere replace *linux-2.6.10* by *linux-2.6.15*
- Everywhere replace *rtai-3.2* by *rtai-3.3*
- Everywhere replace *linux-2.6.11-fusion-0.7* by *linux-2.6.12.6-fusion-0.9.1*
- Everywhere replace *scilab-3.1.1* by *scilab-4.0*

In appendix B the installation steps are adapted as written above. Only the installation steps are copied, so for more information or error solutions see Maassen (2006).

## 2.3 Solutions to known issues and problems

In Maassen (2006) already a couple issues were mentioned regarding the installation and usage of Matlab, Scilab and Linux. The installation errors can occur with the new installation too, but no more errors were discovered while installing the new versions. Nevertheless a couple new errors were discovered during usage of Matlab, Scilab and Linux.

### 2.3.1 Matlab

- Problem: start-up error when trying to start Matlab from within a console window. Matlab starts in console window, displaying following error:

```
xlib: connection to ":0.0" refused by server
xlib: No protocol specified
```

```
xlib: connection to ":0.0" refused by server
xlib: No protocol specified
```

```
warning: unable to open display :0.0, MATLAB is starting
without a display.
You will not be able to display graphics on the screen
```

- Solution:
  - Leave Matlab by typing *exit*
  - In the console type *exit* to exit super user mode
  - Enter *hostname* in the console
  - Go back to super user mode by entering *su* and password
  - Type *matlab* to start Matlab
  - Now Matlab will start in its own window
- Problem: when using Matlab Symbolic Toolbox the following error might be displayed:

```
??? Invalid MEX-file
'/usr/local/matlabr14sp2/toolbox/symbolic/maplemex.mexglx':
/usr/local/matlabr14sp2/bin/glnx86/libmaple.so: symbol errno,
version GLIBC_2.0 not defined in file libc.so.6 with link time
reference.
```

- Solution: this issue is the result of a conflict between the Linux kernel 2.4.2 and the MAPLE function, and can be resolved by following the steps below:

- Close Matlab
- Go to directory `/usr/local/matlabr14sp2/bin`
- Right-click file `matlab` and select *KWrite* from the *Open With* menu.
- Scroll down until you see `arg0_=$0` probably at line 166
- Insert `export LD_ASSUME_KERNEL=2.4.1` above this line, it will look like this:

```
export LD_ASSUME_KERNEL=2.4.1
arg0_=$0
```

- Now save and close the file and restart Matlab

- Problem: custom Simulink models won't work
- Solution: be sure that the matlab paths are set correctly
  - Choose *Set path* from the *File* menu
  - Choose *Add with subfolders* and repeat this step until all of the following are added:
    - `/usr/local/matlab6p1/toolbox/local`
    - `/usr/local/matlab6p1/rtw/`
    - `/usr/local/matlabr14sp2/toolbox/qadscope`
    - `/usr/local/matlabr14sp2/toolbox/wintarget`
    - `/usr/local/matlabr14sp2/toolbox/diet`
    - `/usr/local/matlabr14sp2/toolbox/pizza`
    - `/usr/local/matlabr14sp2/toolbox/printer`
    - `/usr/local/matlabr14sp2/toolbox/demo01`
    - `/usr/local/matlabr14sp2/toolbox/minipato`
    - `/usr/local/matlabr14sp2/toolbox/pato`
    - `/usr/local/matlabr14sp2/toolbox/ref3ma`
  - Choose *Save* and *Close*

- Problem: testref3 displays the following error:

```
Error evaluating 'OpenFcn' callback of Ref3 block (mask)
'edit_part/S-Function'.
Undefined function or variable "irepeat".
```

- Solution: before starting testref3 type *global irepeat* or don't use testref3, but ref3sa\_template by typing `ref3sa_template`.



### 2.3.2 Scilab

- Problem: help browser doesn't work.
- Solution:
  - Exit Scilab
  - Download file *man-eng-scilab-4.0.tar.tar* from [www.scilab.org](http://www.scilab.org)
  - Untar all files from the folder *man-eng-scilab-4.0* in *man-eng-scilab-4.0.tar.tar* to */usr/local/scilab-4.0/man/eng/*. Overwrite all files.
  
- Problem: during RTAI Code generation in Scicos the following error might occur:  

```
sorry file name not defined in c block
```
- Solution: click on all blocks in the scheme so that all blocks are opened once.

### 2.3.3 Linux

- Problem: when for some reason Microsoft Windows is installed or reinstalled after Linux was installed in a other partition, the start up grub menu won't appear anymore.
- Solution: A new installation of Microsoft Windows to another partition will overwrite the Master Boot Record (mbr) so that the link to the grub menu is deleted. This can be solved in the following way:
  - Boot computer from TUEdAX DVD or another bootable Linux CD/DVD.
  - Start a console window and type *grub*.
  - In the grub command line type:
    - *root(hd0,6)* where *hd0* represents the hard disk where Linux is installed on and *6* represents the Reiserf partition.
    - *setup(hd0)*
    - *quit*
  - Reboot the computer and grub is recovered.

## 3. User Interface in Scilab 4

### 3.1 Scilab user interface

User interface is very important when creating programs and tools. The user needs to find his way around easily. With the development of Scilab, at first, the user interface wasn't the biggest concern, but with new version being released, the user interface starts to more and more 'up to date'. Users used to work with Matlab can find there way around in Scilab too, because the user interface is beginning to mimic Matlabs user interface. Not only the graphical objects are becoming more and more the same, also functions, syntax and statements are developing in a Matlab way.

#### 3.1.1 Main window

In general the user interface (gui) of Scilab is pretty familiar with the gui of Matlab. It's also possible to type commands in a command window. Just like Matlab there is a toolbar on top of the window. This is a new feature first introduced in Scilab 4. But at first sight there are also a couple differences. Scilab hasn't got any separate windows like Matlabs command history, current directory and workspace. Those features are nevertheless available in Scilab. So is the command history accessible by typing *gethistory*, the result is a string matrix with all commands typed. To clear the history simply select *Clear History* from the *Preferences* menu or type *resethistory* in the command window. The menu's mentioned are menu's available in windows, in Linux those menu's are not available, but typing the commands will result in the same.

It's possible to view the current directory by typing *pwd* or *getcwd* and this directory can be set by typing *cd path* or *chdir(path)*, with *path* the path to which the working directory has to be set to. It's also possible to retrieve and change the current directory by clicking *Get Current Directory* and *Change Directory* within the *File* menu, respectively.

The workspace is available by typing *browsevar* or selecting *Browser Variables* from the *Application* menu. A new window will appear with all the variables which are loaded in the memory. To see all the variables in the command window it's possible to type *who*.

Finally help is available by selecting *Scilab Help* from the *?* menu or typing *help function name* in the command window, where *function name* is a function from Scilab.

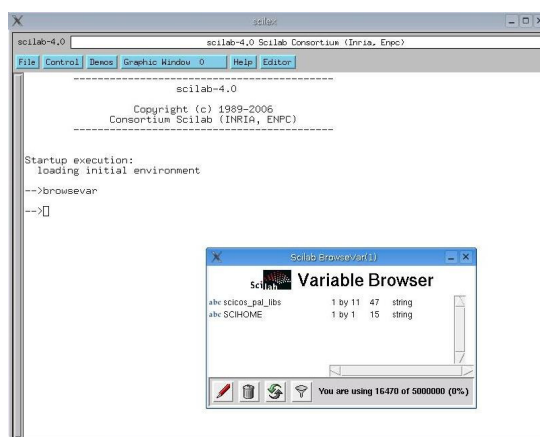


Figure 1: Scilab main window and variable browser

### 3.1.2 Scipad

Just like the m-file editor from Matlab, Scilab has a own sci-file editor named Scipad. This editor can be loaded by typing *scipad* or selecting the *Editor* menu. This editor is very familiar with the m-file editor. It's possible to load sci-files into the editor and with different colours different functions, keywords, statements and variables are indicated just like in the m-file editor. In this sci-file editor even the short keys are the same, for example pushing the F5-button will save and run the script. From within the *File* menu it is possible to select *Import Matlab file...*, this function uses the *mfile2sci* tool to convert a m-file to a sci-file. Later on more about this tool.

The syntax in sci-files is almost the same as in m-files. Be aware by using the conditional execution *if*. In Scilab this statement has to be followed by a condition and the keyword *then*. This is in contradiction with Matlab where *then* is not a valid keyword.

Another difference between m-files and sci-files is the fact that a sci-file can contain more than one function. Every function needs to be closed by using the *endfunction* statement and another function can be added to the sci-file just after this statement.

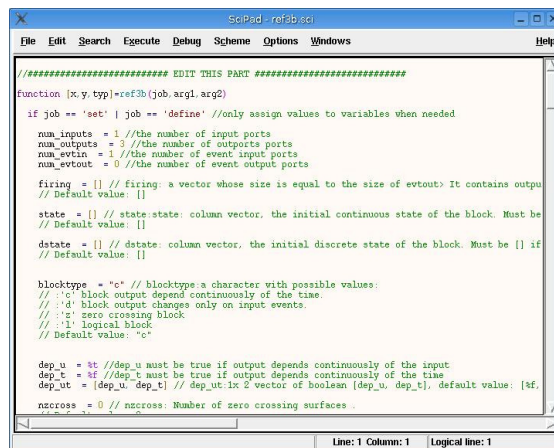


Figure 2: Scipad

### 3.1.3 Scicos

The simulink mimic of Scilab is called Scicos. With this tool it is possible to make schemes by connecting blocks together. The user interface is a little bit different from Simulink. It's also a bit different from the main window and from Scipad. Because a drag and drop command is missing in the Scilab user interface all actions have to be accessed from the menu or from using short keys. A list of available short keys can be found by typing *%scicos short*. The following short keys are defined by default:

Table 1 Short keys in Scicos

A	Align
D	Delete
C	Copy
M	Move
U	Undo
F	Flip

A	Align
O	Open/Set
S	Save
I	Get Info
R	Replot
L	Link
Q	Quit

By pressing one of these short keys, the operation is selected and is available for all blocks. The white info line on top of the Scicos window displays information about which operation is currently selected. It will take some time to get used to this kind of user interface and probably it will change in future versions of Scilab. For more information see also Maassen (2006).

Another difference between the user interface of Scicos and Simulink is the fact that Scicos uses trigger signals that need to be implemented by putting a red clock in the scheme. This clock needs to be connected to a red activation input on some blocks. These blocks are triggered in a certain sample rate which is assigned to the clock. Most blocks have also black in- or outputs, these are the data signals.

For more information about building RTAI code or an example how to build a Scicos-scheme refer to Maassen (2006) or Bucher.

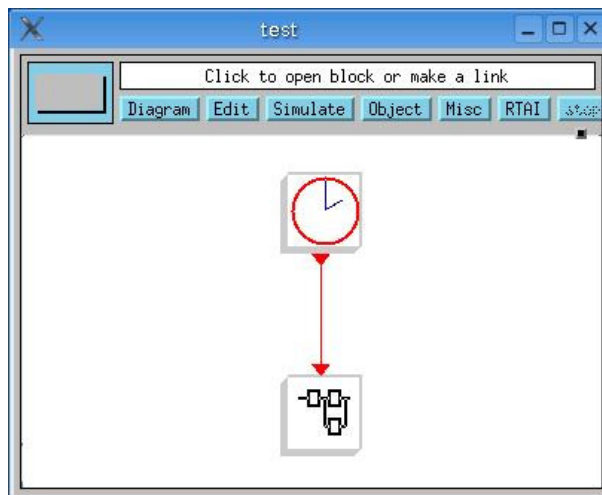


Figure 3: Scicos

### 3.1.4 Graphics and figures

In Scilab, graphs and figures are not the same like in Matlab. In Matlab a graph is drawn into a figure object. In Scilab these objects are separated. It is not possible to plot a graph into a figure object. A graph is always plotted into a graphic window. These graphic windows have their own menus and toolbars and look like the figures created by the *plot* statement in Matlab. In these windows it is possible to zoom, save, load and edit properties. Most commands available in the menu are the same as in Matlab.

The figure object in Scilab looks like the figure object in Matlab when no graph is plotted. In this object controls like buttons or labels can be put. While in Matlab a graph and a control

can be put together into a figure, in Scilab it's not possible to plot a graph into a figure object. The figure objects are only designed to make custom user interface and graphs are always plotted into graphic windows.

The best way to explain the difference between Matlab and Simulink at this point is to use the following commands straight after each other: *figure* and *plot(1)*. In Matlab firstly an empty figure will be shown and then this figure is filled with the plot. In Scilab there will be shown an empty figure too, but secondly a new window will be opened, a graphic window, which displays the plot.

Difference between the figure and graphic window object is very important when creating graphical user interface in Scilab. In the next paragraph is explained how to create custom user interface in Scilab 4.

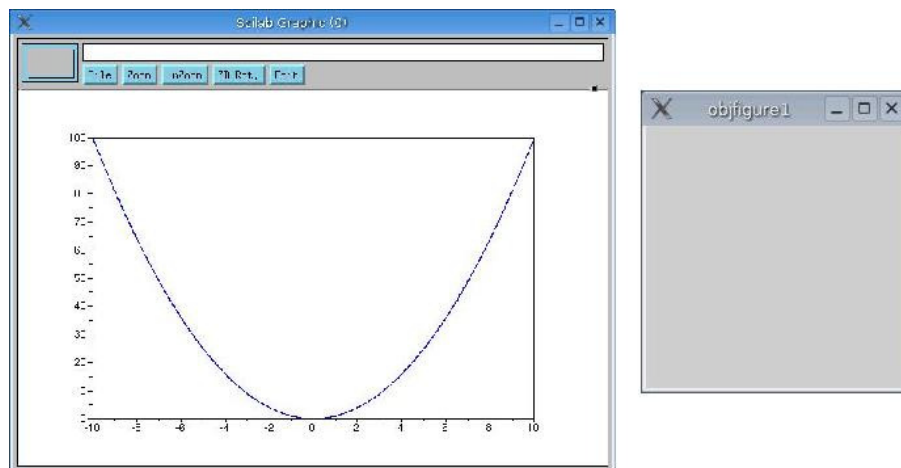


Figure 4: Graphic window and figure object

### 3.1.5 M-file to sci converter

When switching from Matlab to Scilab all m-files need to be adapted to sci-files. The syntax of sci-files is almost the same as the syntax used in m-files. As mentioned before a big difference is the use of a *then* statement. A bigger issue concerns the functions. Not all Matlab functions are adapted to sci-files yet and even when they are adapted, not always the names are familiar. To solve this problem a smart tool has been created, which can convert m-files to sci-files. Unfortunately a couple bugs can appear when using this tool.

At first when converting a m-file a lot of warnings will appear. Far most warnings concern syntax issues or function missing issues. The syntax warnings can be ignored mostly, because syntax is almost the same. Function missing warnings are caused due to the fact that the tool 'thinks' that a function doesn't exist in Scilab. But often this appears to be wrong because the functions do exist. This is strange and can only be explained by suggesting that the tool isn't up-to-date. Furthermore this is not really a problem, because the warnings can easily be ignored. Sometimes however the tool replaces the function by a Matlab equivalent which has a *mtlb\_* prefix. Pretty often this is not necessary and the prefixes can be deleted.

Another error occurs when trying to convert a whole directory at once. This option should be available, but doesn't work. A simple workaround script can be written to convert a whole directory at once:

```
mfilepath = '';  
resultpath = '';  
recmode = %f;  
onlydouble = %f;
```

```

verbosemode = 0;
prettyprint = %f;

S = dir(mfilepath);
myfiles = S(2);
nof = size(myfiles);

for i = 1:nof(1)
    myfile = myfiles(i);
    if max(strindex(myfile, '.m')) == length(myfile)-1 then
        mfile2sci(mfilepath + '/' + myfile, resultpath, ...
            recmode, onlydouble, verbosemode, prettyprint)
    end
end
end

```

This script is implemented in a sci-file and it can be found on the CD. For help on the input variables see the help file of `mfile2sci` by typing `help mfile2sci` in the Scilab command window.

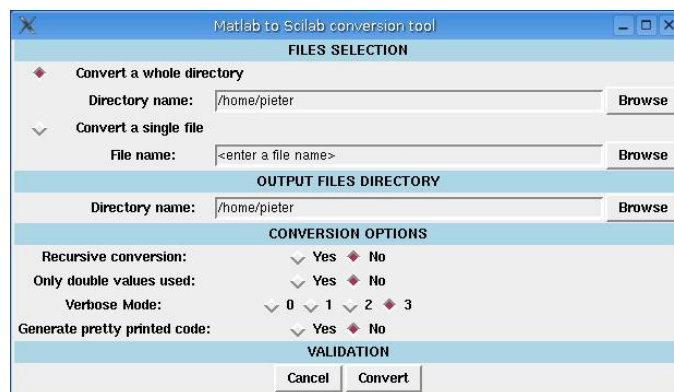


Figure 5: Mfile2sci converter

## 3.2 Custom user interface

User interface is used to simplify certain tasks which otherwise would have been very circuitous. At this time user interface on a computer is often represented by a window or dialog with certain controls. These controls have different ways of handling and can do different tasks. Within Scilab there are two different ways in which custom user interface can be designed. Scilab itself has a user interface 'toolbox' and it's possible to use `tlc` and `tk` shared libraries to make a user interface.

### 3.2.1 Scilabs own GUI and dialogs

The first way is by using the user interface of Scilab itself. Scilab has a couple predefined gui functions and dialogs. These functions and dialogs can be used to make a simple predefined user interface. As mentioned before, Scilab makes a difference between figures and graphic windows. Using this gui method it is not possible to create custom figures with own controls. Everything is predefined with only a small number of properties that can be edited. The following list shows all dialogs that can be accessed in Scilabs own user interface with a short explanation of how to use them. For more information refer to the help files of the different dialogs.

- `buttndialog` - this dialog shows a message, icon and one or more buttons. The result is the number of the button that has been clicked.

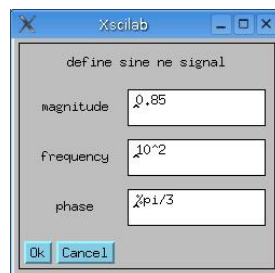
```
result=buttndialog(message,button1|button2|...|buttoni,icon)
```



**Figure 6: Buttndialog**

- `getvalue` dialog - this dialog shows a window with different labels and textboxes. In all the textboxes different values can be put. These values are the result of the dialog.

```
[ok,x1,x2,...,xi]=getvalue(message,labels,type,initialvalues)
```



**Figure 7: getvalue dialog**

- `progressionbar` - this dialog shows a bar in which a red square 'walks' from the left to the right and back. Every time the function is called, the progressionbar is updated. This dialog can be used in order to indicate that the computer is busy.

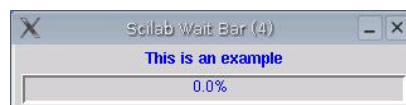
```
winid=progressionbar(message)
progressionbar(winid,message) //to update the bar
```



**Figure 8: progressionbar**

- `waitbar` - this dialog is pretty much the same as the progression bar with one difference. The bar in this dialog fills from the left to the right with a red square instead of a 'walking' square. Dialog can be used to indicate the progress of a task the computer is doing.

```
winid=waitbar(message)
waitbar(percent_filled,winid) //to update the bar
```



**Figure 9: waitbar**

- `x_choices` - this dialog shows different labels and different toggle boxes. Values can be chosen from these toggle boxes. The result is a list of the chosen items.

```
result=x_choices(message,list_of_items)
```



Figure 10: x\_choices dialog

- x\_choose - this dialog looks like the x\_choices dialog, but this dialog shows one list with items from which a item can be chosen. The result is the number of the chosen item.

```
result=x_choose(items,message,custom_button)
```

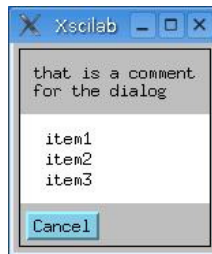


Figure 11: x\_choose dialog

- x\_dialog - this dialog shows a message with a textbox in which one value can be given. This value is the result of the dialog.

```
result=x_dialog(message,initial_value)
```

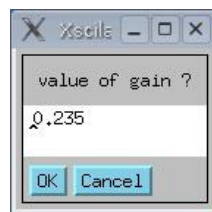


Figure 12: x\_dialog dialog

- x\_matrix - this dialog looks like the x\_dialog but is meant to put matrices in.

```
result=x_matrix(message,initial_matrix)
```

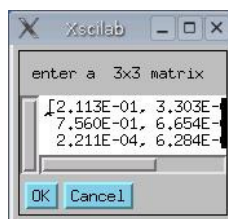


Figure 13: x\_matrix dialog



- `x_mdialog` - this dialog is exactly the same as the `getvalue` dialog.

```
result=x_mdialog(message,labels,initial_values)
```

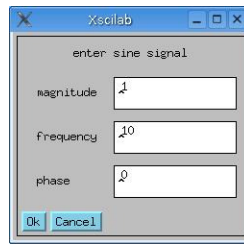


Figure 14: `x_mdialog` dialog

- `x_message` - this dialog shows a message with custom buttons. The result is the number of the button that has been pressed.

```
result=x_message(message,buttons1|button2|...|buttoni)
```

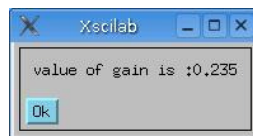


Figure 15: `x_message` dialog

- `x_message_modeless` - this dialog shows a message and a ok button, just as the `x_message` dialog. But when this dialog is shown, Scilab remains available for commands.

```
x_message_modeless(message)
```

The biggest advantage of these dialogs is that they are easy to use and pretty fast to implement, because there are just a small amount of properties. But that is also a disadvantage when complex user interfaces need to be built. These dialogs have a lack of customization. The only properties that can be set are all listed above. When complex user interface with for example graphs are needed, these dialogs aren't compatible anymore.

For example in Maassen (2006) a `getvalue` dialog was used for the REF3 block. It was sufficient for the tests that had to be done, but when more complex signals are needed it is way too user unfriendly. In that case a custom made dialog needs to be implemented. This can also be done with Scilab in combination with the `tlc` and `tk` shared libraries.

### 3.2.2 GUI using `tlc` and `tk` shared libraries

When the standard dialogs of Scilab aren't sufficient anymore, the shared libraries of `tlc` and `tk` are the solution. With those libraries it is possible to make custom dialogs with controls like buttons and labels. The commands that access these libraries are familiar with Matlab.

As mentioned before these libraries make use of the figure object, so firstly a new figure needs to be called:

```
figure_hdl=figure(properties)
```

With *figure\_hdl* the handle to the just created figure. This handle is needed when controls are placed into the figure. The properties statement can contain a lot of different properties listened below:

- *children* - this is a vector with handles to the children of the figure window. All the children are axes, which represent the outer border of the figure window. This property is not used a lot.
- *figure\_style* - this represents the style of the figure. It can be set to *old* or *new*. When set to *old* the figure uses the 'old graphic mode' of Scilab. This mode is actually only used by Scicos and will no longer be in use in newer Scilab versions. Otherwise the figure uses the 'new graphic mode' which is used by all other tools of Scilab, such as Scipad. This property is not used a lot, it's standard on *new* and it's better to use the 'new graphic mode' in Scilab.
- *figure\_position* - this is a vector with the position of the figure in pixels. The vector contains two values, the first value is the x-coordinate and the second the y-coordinate:  $[x, y]$ . This property is used almost always.
- *figure\_size* - this is the size of the figure window in pixels. Just like the *figure\_position* this is a vector containing two values, the first is the width and the second the height:  $[width, height]$ . This property is used almost always too.
- *axes\_size* - this is the outer border of the figure window, the virtual graphic window. This is also a vector containing two values:  $[width, height]$ . This property is not used a lot.
- *auto\_resize* - this property can be set to two different values, *on* or *off*. When set to *on* the *axes\_size* is equal to the *figure\_size* and when set to *off* the *axes\_size* cannot be changed. This property is just like the *axes\_size* property almost never used. It's best to keep it just in it's default state.
- *figure\_name* - this is the name of the figure. The name is on top of the figure window. This property is used almost always.
- *figure\_id* - this is the figure identifier and cannot be set. This property is read-only and is set at figure creation. When using more than one figure, this property can be used to set the active figure window. It is a integer number the same as the handle of the figure window.
- *color\_map* - this represents the colour map used by the figure. It is a matrix of colours that can be used. The property is not used a lot and can be hold at default values best.
- *pixmap* - this property sets the pixmap status. This is used to determine the way a pixel is drawn on the screen, but there is no graphical difference in setting this property to *on* or *off*. So this is never used.
- *pixel\_drawing\_mode* - familiar with *pixmap* and also a property that handles the way a pixel is drawn. So this property is also never used.

- `immediate_drawing` - also a property for drawing and never used.
- `background` - property to set the background colour of the window. It's a vector with three values between zero and 1, the first is the red component, the second the green and the third the blue component: *[red, green, blue]*.
- `user_data` - this is to store and retrieve data into the figure structure, but not used very often.
- `tag` - here a identification name can be stored. This property is used a lot to retrieve the handle of the figure window by using the command *findobj*.

These properties can be set when the figure is called, for example:

```
figure_hdl=figure('figure_position',[100 100],'tag','figure')
```

It's also possible to change properties during runtime by using the following:

```
figure_hdl=findobj('tag','figure')
set(figure_hdl,'figure_position',[200 200])
```

Within a figure window it's possible to put certain controls that handle certain user actions. These controls are called by using the following command.

```
control_hdl=uicontrol(figure_hdl,properties)
```

This control will be put into a figure with handle *figure\_hdl* and *control\_hdl* is a handle to the control. The handle can be used to use the following properties.

- `backgroundcolor` - this property sets the backgroundcolor of the control. Use a vector with three values between zero and one, a red component, green component and blue component: *[red, green, blue]*.
- `callback` - this property is used when a callback is needed after a certain action of a user. The callback can only be applied to pushbuttons and sliders. Other user controls can't have a callback. The property refers to a function which handles the callback.
- `fontangle` - a property to set the style of text on the user control. This property can be set to three different value's: *normal, italic* or *oblique*.
- `fontsize` - property to set the size of the text on a control. The size is set in fontunits, see the next property.
- `fontunits` - this property can be set to *points, pixels* or *normalized* and handles the units in which the fontsize is specified.
- `fontweight` - this property is a text style property too. It sets the font thickness of text on a usercontrol. It can be set to four different value's: *light, normal, demi* or *bold*.

- `fontname` - also a property that sets a textstyle. This property sets the font of text on a usercontrol.
- `foregroundcolor` - just like background colour a style property that sets the colour of the text on a user control. Also a vector containing three value's: [*red, green, blue*].
- `horizontalalignment` - property that sets the positioning of the text on a user control. This property can be set to *left, center* or *right*.
- `listboxtop` - this property can only be used with a listbox. It sets the item which will be shown first in the list.
- `max` - a property that sets the highest value of a control. This can be used with checkboxes, sliders and listboxes. With checkboxes the value represents the value when the checkbox is checked. With sliders this value sets the highest possible slider position. With listboxes the property sets the possibility of multi-selection. If the difference between `max` and `min` is greater then one multi-selection is enabled.
- `min` - this property sets the lowest value of a control and can also be used with checkboxes, sliders and listboxes. This property sets the value of checkboxes when unchecked, the lowest possible slider position on sliders and the possibility of multi-selection in listboxes.
- `parent` - this is the handle of the control. By changing this property, the handle can be moved from one figure to another.
- `path` - read-only property that gives a string to the TK-path of the control. This property is not used very often.
- `position` - property to set the x- and y-coordinate and the width and height of the control. Use a vector with four different value's, the first two indicate the x- and y-position and the last two the width and height: [*x, y, width, height*].
- `sliderstep` - only available with slider controls. This property sets the small and big slider step size. The small step is when the user clicks on the arrow, the big step is activated when clicked on the slide bar. Vector with two value's: [*small step, big step*].
- `string` - this property sets the text on a user control. Within listboxes and popupmenu's this property can be a vector of strings separated by 'l'.
- `style` - this is the style of the user control. There are nine different styles available. Pushbuttons are buttons that can be pressed and a callback is called. A radiobutton can be checked or unchecked, only one radiobutton can be checked at the same time. A checkbox is the same as a radiobutton, accept for the fact that those can be checked all at the same time. An edit control is a editable field in which a user can put a string in. A text control is a not editable label. With a slider the user can select a value by sliding the bar. A frame is a border to separate different places in a figure window.

Listboxes are controls in which a list of strings is displayed. A popupmenu is a menu which can be displayed when the user clicks.



**Figure 16: all controls on one dialog**

- tag - identification string with which the control can be identified. Using *findobj* it's possible to retrieve the handle of the control.
- units - this property sets the units used when setting the position property. Can be set to *points*, *pixels*, *normalized*.
- userdata - property to associate Scilab object to controls. Not used very often.
- value - this is the value of certain user controls. With checkboxes and radiobuttons value is max when checked or min when unchecked. With listboxes and popupmenu, value is a vector of strings. With sliders, value is the sliderposition.
- verticalalignment - property that sets the vertical text position on a control. Can be set using one of the following three strings: *top*, *middle* or *bottom*. It's only possible to use this property on text and checkboxes controls

Properties of controls can be set when called:

```
control_hdl=icontrol(figure_hdl,'style','edit','tag','control')
```

But it is also possible to change properties during runtime:

```
control_hdl=findobj('tag','control')
set(control_hdl,'position',[5,35,200 200])
```

Finally it is also possible to place menu's into a figure window. These menu's are shown on top of the window. Menu's can be called using the following code:

```
menu_hdl=icontrol(figure_hdl,properties)
menu_hdl=uidoncontrol(menu_hdl,properties)
```

The *figure\_hdl* is the handle of the window in which the menu has to be placed. It's also to put a menu into another menu by using a *menu\_hdl* instead of a *figure\_hdl*. A menu object has three different properties:

- callback - this property is used to refer to a function which is called when the menu is pressed.
- label - this is the text displayed in the menu.
- tag - just as mentioned before a identification string.

Combining all those different user interface objects it is possible to build complex and user friendly dialogs. For an example refer to paragraph 3.4.

### 3.3 Guide

In Matlab it's possible to create user interface using a tool called guide. This tool helps users to create custom dialogs. It uses drag and drop to put controls on a figure object and it's possible to set different properties per control. In Scilab such a tool doesn't exist, so to make it easier to design a user interface a stripped version of the Matlab guide tool is created for Scilab. With this tool, also called guide, it is possible to place different controls on a figure in an easy way. Before this tool was created, the only way of designing a user interface was to use trial and error. All the positions and sizes of all controls needed to be set before it could be compiled. When compilation was ready it was necessary to run the file to see if the controls were placed right. With guide it is possible to move and resize controls, seeing the result directly.

With guide it is possible to set the x- and y-coordinate, the width and height, and the name of a control. So it's not possible to set other properties like in Matlab, but these properties can also be set in the sci-file which is exported by guide. Guide sets the background colour and text alignment to default values, because in that way it is easier to place the buttons. These properties can also be changed in the sci-file.

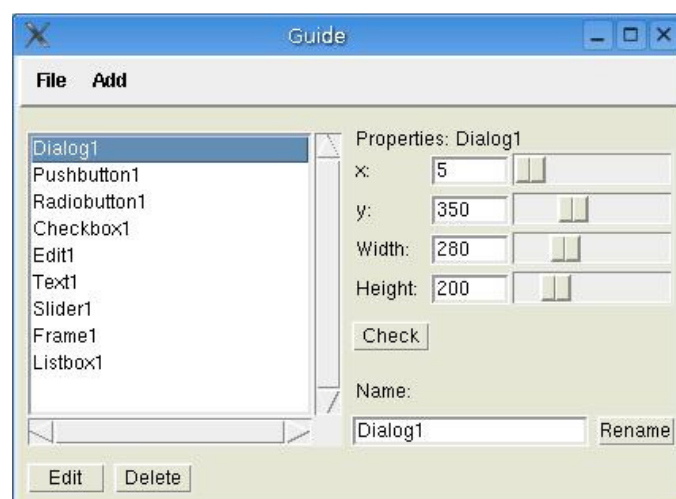


Figure 17: guide user interface

### 3.3.1 User manual

Using guide is pretty easy. First start the tool by typing *guide* in the command window. It's possible that Scilab doesn't recognize the function and returns an error. Then the function guide needs to be loaded into Scilab first using *getf(path)*, with *path* the path to the file containing the guide function. If the function is loaded retry starting guide. Be sure to use only one guide at the same time, see paragraph 3.3.3 for more information.

When guide is started the main window will appear. Select *New* or *Load* from the *File* menu to create or load a figure respectively. Selecting *New* will display a empty figure and *load* will display a figure containing controls as saved last time.

A new menu will appear in the main window called *Add* and in the *File* menu the buttons *New* and *Load* are replaced by *Save* and *Export* respectively. It is only possible to create or load a new figure by restarting guide. In the listbox the name of the created or loaded figure is shown. Select this and click *Edit* to load its position, size and name into the property fields. Now it is possible to replace, resize and rename the figure window. It is also possible to add some controls first and edit the figure window later on.

Controls can be added by using the *Add* menu. There are eight controls to choose from: *Pushbutton*, *Radiobutton*, *Checkbox*, *Edit*, *Text*, *Slider*, *Frame*, *Listbox*. The popupmenu control is missing because it's position and size are set automatic when called. It is also not possible to add a menu to the figure for the same reason. A menu is placed and sized automatically too. These controls can be added manually when a sci-file is exported. When a control is selected it will be added to the figure in the default position and size. Also a default name is set to the control and displayed in the listbox. Guide also sets default background colours and text alignment for easy positioning purposes. These values can be edited manually when a sci-file is exported. The position and size of the controls can be edited by selecting a control in the listbox and pressing *Edit*. The position, size and name will then be loaded into the property fields.

When a figure or a control is loaded into the property fields its position can be changed in two ways. Firstly sliding the *x* and *y* sliders will replace the control or by typing a value into the *x* and *y* textboxes and pressing *Check*. In the same way the size of a figure or control can be changed in two ways. By sliding the *width* and *height* sliders or by typing the correct value's into the *width* and *height* textfields. Renaming a figure or control can be done by entering a string into the *Name* textbox and pressing the *Rename* button.

To delete a control, select the name from the listbox and press *Delete*. The name will disappear from the listbox and the control will be deleted from the figure.

It is possible to save the user interface during design by selecting *Save* from the *File* menu. The file will be save as a Scilab Graphical Interface file (\*.sgi). In this file all positions, sizes and names are saved. The file can later on be loaded as described above, it is not possible to load a sci-file in guide.

To use the user interface created with guide, the whole graphical user interface needs to be exported to a sci-file. This file contains the user interface script and can be loaded from within Scilab. When this file is called the figure window created with guide will be shown containing all the controls with their names, positions and sizes. Export a user interface by selecting *Export* in the *File* menu.

Always close guide by selecting *Exit* from the *File* menu. So do not close guide by clicking on the cross button in the right corner of the window. In that way guide is not correctly closed and problems can occur when using it the next time.

### 3.3.2 Working of Guide

While programming guide some problems were discovered with the Scilab user interface. The biggest issue that needed to be solved in order to make a workable guide tool was the fact that Scilab isn't compatible with drag and drop. So dragging a control from one window to another isn't possible.

The second problem is that not all controls use callback when clicked. So selecting a control by clicking on the figure object isn't possible. This would only be possible with a pushbutton- and slider control, because only these two controls use a callback function, but more controls are needed.

These problems are solved together by using a listbox which displays the figure name and all control names which are added to the figure. When a control is added to the figure object, it is placed in the left lower corner with standard width and height. The control gets a name and a tag which is the same. This name is also added to the listbox. Guide checks whether no other control has the same name, so duplicate names aren't possible and every control can be identified by their own tag. When a control is selected it can be edited by clicking the edit button, the position and size of the selected control will then be loaded into the property fields. The selected control can be recognised by its unique tag. In the same way a control can be deleted by clicking the delete button.

Saving and loading files is easily done by using the *save* and *load* and functions. Variables can be saved using `save(path, variable1,...,variablei)` and loaded using `load(path, variable1,...,variablei)`, just like in Matlab.

Exporting a file is done by using the *fprintf* function. With this function it is possible to write data into a file, just like in Matlab. When saving the file as sci-file it can be compiled and ran in Scilab, resulting in a graphical user interface.

In appendix C the most important functions that control guide are mentioned.

### 3.3.3 Known bugs and issues

A couple issues were discovered using the guide tool:

- Sliding the sliders to fast will effect in bad program behaviour. For some reason the sliders aren't able to use the callback fast enough when the slider is moved to fast. When for some reason the slider moves in a strange way, it's possible to click the check button to reset the sliders or to click on the slider bar. In that way the sliders and controls are reset to there actual position.
- Be sure to use only one guide tool at the same time. Opening guide while another window of guide was still running will result in unwanted behaviour. To start a new design of a user interface close guide by clicking *Exit* in the *File* window and restart the tool by typing *guide* in the Scilab main command window. It's not possible to design two different figures at the same time.



### 3.4 REF3 user interface example

In Maassen (2006) a couple blocks were designed to be able to use the TUE DACS QAD/AQI devices with Scilab. One of that blocks was the REF3 block. This block was built to create custom reference trajectories to use in control systems for real time devices. It was built in Matlab/Simulink and Maassen (2006) describes how it was recently implemented in Scilab. Everything works nicely, except for the user interface. In Maassen (2006) a `x_dialog` (see paragraph 3.2.1) was used as user interface for the input parameters. In Simulink a custom user interface was used to retrieve those input parameters, but the implementation in Scilab and especially Scicos is a bit different.

When a user clicks on a user defined block in Simulink a function is called. This function can be set in the properties of the block. In Scicos it is possible to put user interface code in the sci-file which handles the user events. Functions can be called from within this sci-file just like the functions called in Simulink. For example in the REF3 sci-file, the `x_dialog` needs to be replaced by custom user interface code to use a custom user interface. To implement the user interface from Simulink into Scicos it is necessary to know something more about the working of the REF3 user interface.

#### 3.4.1 Working of REF3 user interface

The working of the REF3 user interface is pretty complex and it is not necessary to explain all details but a short explanation is handy to understand how the implementation in Scilab has been done.

To start the REF3 user interface in Linux in Matlab type `testref3` in the main command window. A simulink file will open with the REF3 block on. Double-click on the REF3 block and the REF3 user interface will show up. A callback in the REF3 block properties calls a function in Matlab which at his way shows a figure object saved in a fig-file created with guide. All dialogs are fig-files created with guide and can be called from m-files.

It is possible that an error occurs when double clicking on the block, see paragraph 2.3 for more information.

The REF3 main window shows a graph with the total trajectory and buttons like *load*, *save*, *new* and *accept*. It is possible to add, delete or edit a part of the total trajectory by clicking those buttons. When done a new window will appear with four graphs representing the position, velocity, acceleration and jerk of the trajectory. Edit these parameters to change the trajectory and click accept to save it. In the main window it is also possible to choose for *jogmode* to create a jogmode signal.

The strength of the REF3 user interface is of course the graphs showing the user directly changes in parameters. This is the core feature of the REF3 user interface and needs to be implemented in Scilab. The working of the graphs in Simulink is pretty easy. With the function *sim* it is possible to simulate a Simulink model and retrieve the different outputs. To draw the graphs in the REF3 user interface, the REF3 Simulink model, using a s-function as mentioned in Maassen (2006), is used. With the outputs, graphs can be drawn.

The s-function which is linked to a user-defined block in Simulink contains the code that calculates positions, velocities, accelerations and jerks. In paragraph 3.4.2 it can be seen that it's useful to know how this function works, so a short explanation follows.

To retrieve the desired trajectory a position, velocity and acceleration like in figure 18 can be plotted. This acceleration consist of a couple linear functions that describes the desired acceleration for the trajectory. This plot can be separated into eight different zones,  $t_0$  to  $t_8$ . For each zone a linear function can be formulated. Integrating this functions once respectively

twice gives functions for velocity and position. Differentiating the acceleration functions once gives the required jerk functions. When the functions are known it is possible to make a loop over time from  $t_0$  to  $t_e$ . Within this loop check for every time which zone is active and use the corresponding functions to calculate position, velocity, acceleration and jerk.

### 3.4.2 REF3 user interface in Scilab

Because the REF3 user interface already exists in Matlab, the `mfile2sci` tool is able to convert all files from Matlab to Scilab. If a user interface doesn't exist already, a new user interface has to be made. Using the `tlc` and `tk` shared libraries a figure can be called to put controls on as mentioned above. Of course it is also possible to use the `guide` tool to create graphic interface. For an example of how to use figures and `uicontrols` see appendix D, where the functions that create the user interface for the REF3 tool are described. Manually add functions to the exported file to create a user interface. But in this case all files from Matlab were converted. All functions were put into four different files, for each dialog a file is created and one file for some main scripts used in all dialogs. After the conversion, when trying to run the files for the first time errors will occur because not all functions are converted correctly. The conversion of REF3 led to a couple errors regarding missing functions like *sim* and *ginput*.

As mentioned in paragraph 3.4.1 the core of the REF3 user interface consists of a couple graphs which are drawn using the function *sim* in Matlab to simulate a Simulink model. This function is one of the missing functions in Scilab. There are two alternatives that can be used, *scicos\_simulate* and *scicosim*. Both functions can simulate a Scicos scheme, but with *scicos\_simulate* the scheme has to be compiled first while *scicosim* can do a compilation itself. So just replacing *sim* by one of these functions would do the job, but it isn't that easy. These functions are very complex, the input and output parameters are hard to understand structures containing hundreds of values. This wouldn't have been a problem if the documentation had been up to date and more detailed. Trying to use one of these functions failed, so another way had to be figured out. At this point the knowledge of the working of the REF3 user interface becomes useful.

The solution to this problem is to write a sci-file containing the part of code that calculates the position, velocity, acceleration and jerk. The working of this part of code is already explained. Because no s-function can be simulated the part of code needs to be converted to sci-language. In this way, the function can be called giving the opportunity to make graphs. To see the full function which is created in Scilab refer to appendix E.

The REF3 user interface in Matlab uses callback functions in textboxes to auto update the graphs. In Scilab call-backs are only allowed with buttons and sliders, so graphs can not be updated automatically. This is not really a problem, but every time a value is entered in a textbox, the check button needs to be pressed to update the graphs. There is no other solution to this problem.

Another problem is that in Matlab, buttons can be disabled and enabled. This function ability is missing in Scilab, so all the buttons can be clicked at any time. This can cause problems, but there is no solution for this problem. See paragraph 3.4.3 for more details.

When editing a certain part of the trajectory, it is necessary to select the part by clicking in the graph. In Matlab the function *ginput* is used, but Scilab hasn't got this function. Nevertheless

a pretty familiar function called `xclick` is able to do the same. The function must be used in the following way:

```
[c_i,c_x,c_y,c_w,c_m]=xclick()
```

With `c_i` the button that is pressed or clicked, `c_x` and `c_y` the coordinates of the position of the mouse click, `c_w` the window number where the click has occurred and `c_m` the number of a menu, when clicked in a menu. See Scilab help for more information.

In paragraph 3.1.4 has been mentioned that graphs can not be plotted into figures. This brings a certain deficiency in programming REF3 user interface. A communication between the figure and graphic window needs to be implemented. Fortunately this is not really hard to do. When a graphic window is called a handle is saved in a variable. When this variable is first declared as *global*, it can be used in every function. So when something needs to be plotted in a graphic window, just call the handle and the plot can be done.

Because the REF3 user interface needs to be implemented in a sci-file created in Maassen (2006) a *pause* statement needs to be implemented just after the main dialog is loaded. Otherwise the main dialog would appear, but the sci-file from Maassen (2006) would still be running and cause errors because no trajectory is created yet. This sci-file needs to be paused until the accept button is clicked and a trajectory is designed. When a trajectory is designed the accept button can be pressed, all windows will close, but to return to the Scicos scheme the *return* statement needs to be entered in the main Scilab window.

At last the syntax needed to be adapted. As mentioned in paragraph 3.1.5 the `mfile2sci` tool isn't up to date and here and there some syntax errors were discovered. Furthermore no big adjustments had to be made.

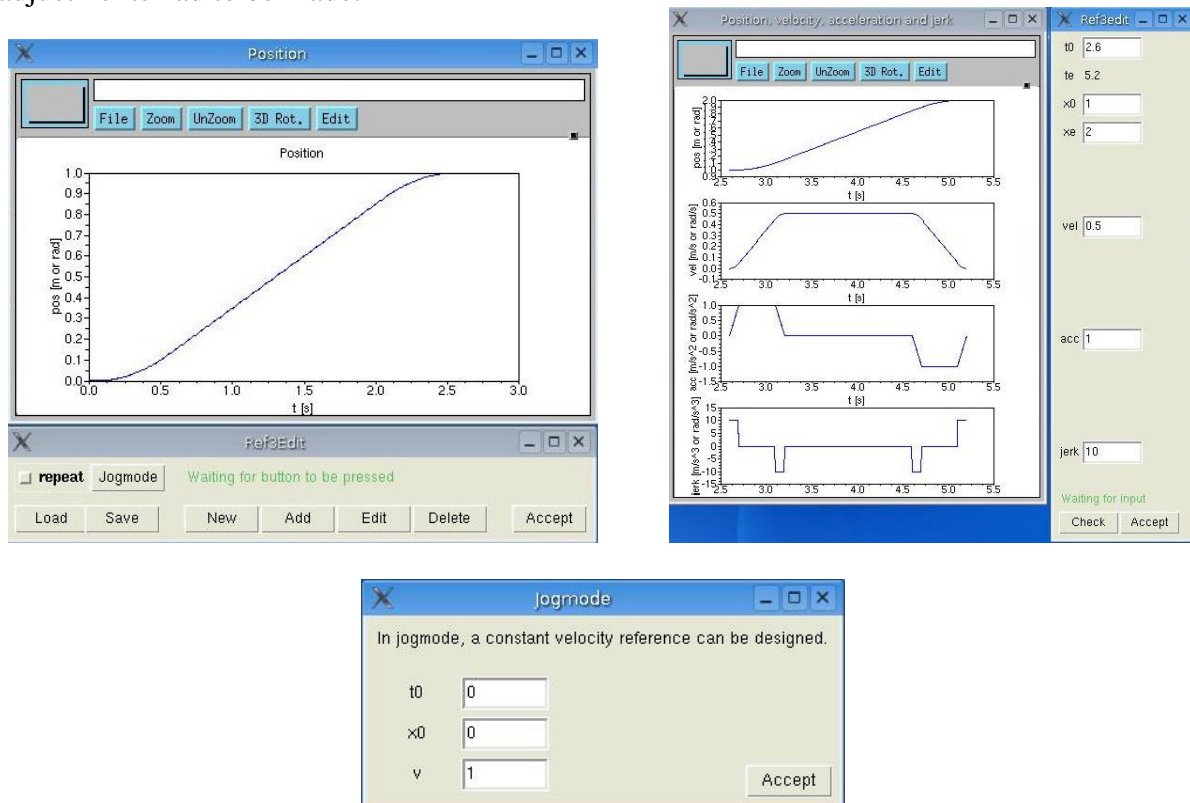


Figure 18: REF3 main window, REF3 edit trajectory window and REF3 jogmode window

### 3.4.3 Known bugs and issues

Because not all function could be translated as mentioned above, a couple issues and bugs can appear:

- Enabling and disabling controls is not possible in Scilab so when the edit trajectory or jogmode dialog is shown it is not possible to use the main dialog. In Matlab this was resolved by disabling all buttons on the main dialog. When accidentally pressed a button on the main dialog while another dialog was already loaded, just close all dialogs and restart REF3. Otherwise the tool doesn't work correctly and errors may occur.
- Scicos is still using the old graphic mode while the rest of Scilab is using a new graphic mode. In this old graphic mode it is not possible to position and size graphic windows. The result is that a graphic window is positioned and sized with default value's and the windows are displayed across the screen which can be frustrating. In the new graphic mode positioning and sizing graphic windows is implemented, but until Scicos will use the new graphic mode, this problem remains undissolved. This version of Scilab is the last using the old graphic mode, so probably this issue will be fixed in the next version.
- For some reason Scilab doesn't always load all functions. To resolve this problem use the *getf(path)* to load all function in a sci-file. The easiest way is to put the four files containing all functions in the working directory, which by default is */home/username* with *username* the name of the active user in Linux. Then it is namely possible to only use the name of the file in *getf* instead of the entire path.

## 4. Multi-rate tasking in Scilab 4

In many systems different sensors and actuators are used. For example the soccer playing robots such as used in the Robocup have camera's to visualize their environment and a couple motors to drive. In such systems the camera's typically work at 20 or 30 frames per second. Therefore the sample rate which controls the camera's doesn't need to be higher than 20 Hertz. On the other hand the control for the motion typically uses a sample rate of 1000 Hertz. So when both controls systems are integrated, it is not necessary to use a sample rate of 1000 Hertz for the visualization, but a multi rate system can be designed. The robots in the Robocup use therefore two different controllers working at 20 and 1000 Hertz for the visualization and motion respectively. Those controllers are created with Simulink. Communication between those two controllers takes place with so called shared memory. Another application where communication between different tasks is necessary is when distributed control is desirable. Distributed control are also controllers separated over different tasks, these tasks can run on a local computer or on a network of more than one computer. The big question is if multi rate systems can be designed with Scilab.

### 4.1 General notes regarding multi-rate tasking

To start multiple tasks in Linux using RTAI and RTAILab some commands need to be executed. First create two or more executable programs with Scicos and RTAICodegen as described in Maassen (2006). These programs may use different sample frequencies. Communication between those tasks can be done with one of the different ways described in paragraph 4.2. The easiest way is to create the executables in the users home directory. When those executables are created, open as much console windows as tasks that need to run simultaneously and be sure that in all windows super user mode is turned on by typing su and a password. The first task needs to be called using the following commands:

```
./r1  
./filename1 -n host_interface_task_name1
```

With *filename1* the name of the executable that has to be run as first task and *host\_interface\_task\_name1* is a identifier for the task. When running multiple tasks this is needed to identify each task, so all tasks must have their own unique identifier. Next tasks can all be started by using another console window and typing:

```
./filenamei -n host_interface_task_namei
```

If all tasks are running RTAILab can be started by opening a new console window in normal mode, not as super user, and entering the following commands:

```
xhost +  
su  
password  
xrtailab
```

With *password* the password of your account. The program is started. To connect to a task select *Connect to target* in the *File* menu. A dialog will appear with standard value's. Change the value for *Task identifier* into the name of the identifier of the task that needs to be scoped and click *Ok*. RTAILab is now connected to the selected task. To scope more than one task, it is possible to start a new RTAILab or to disconnect by clicking *Disconnect* in the *File menu* and reconnecting to another task using another *Task identifier*. Running multiple RTAILabs at the same time requires a lot of cpu and as a result the computer may become unstable or RTAILab isn't updated fast enough anymore. It is better to reconnect to another task.

To stop a task it is possible to select *Stop realtime code* in the RTAILab toolbar or by pressing ctrl-c in the console window of the task that has to be quitted.

## 4.2 Multi-tasking possibilities

According to Yaghmour a couple different communication ways can be created by using RTAI. These ways are shortly explained below as an introduction to multi-rate tasking and if tested a recommendation is made whether that way can be used in multi-rate tasking. Tests are done with mailboxes, semaphores and I/O, because these methods are integrated into blocks in RTAI by default. The other ways are not tested yet. In every test the sender is sampled at ten Hertz and the receiver at one hundred Hertz. A sinus signal has been send from sender to receiver. To visualize the signals in RTAILab one scope is used in each task. Because a single task can't contain two different sample rates, there are always two tasks created and ran simultaneously.

### 4.2.1 Mailboxes

Mailboxes are particularly designed to let two different computers interact with each other, but can also be used on one single computer to communicate between tasks. This type of communication works just like a mailbox. A task can send data to a buffer and another task can read the data from the buffer. Within RTAI there are blocks which can send and receive data through mailboxes. In figure 19 the schemes that are made to test mailboxes can be seen. The results of the tests are shown in figure 20 and are a strange because the sinusoidal signal of one Hertz which is send, is received with a frequency of ten Hertz. The cause of this problem is not yet discovered, but it could have something to do with the scopes used. Scopes used by RTAI are activated by the red clock with the frequency of the sample rate. So the scope of the receiver is triggered ten times more than a signal is sent, probably is that causing the problem. All in all more investigation is needed in this way.

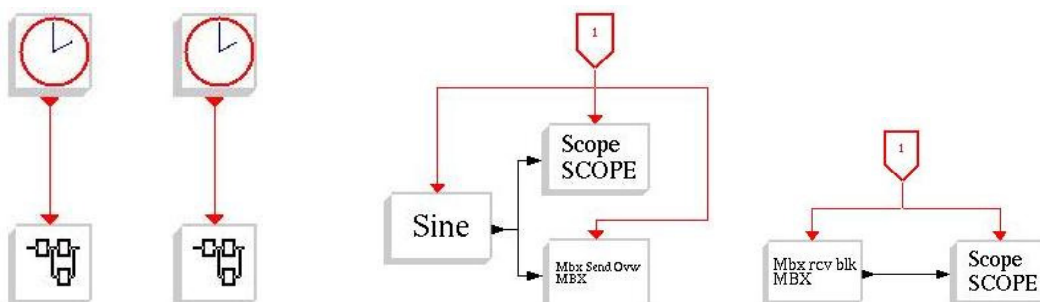


Figure 19: Scicos schemes using mailbox send and mailbox receive

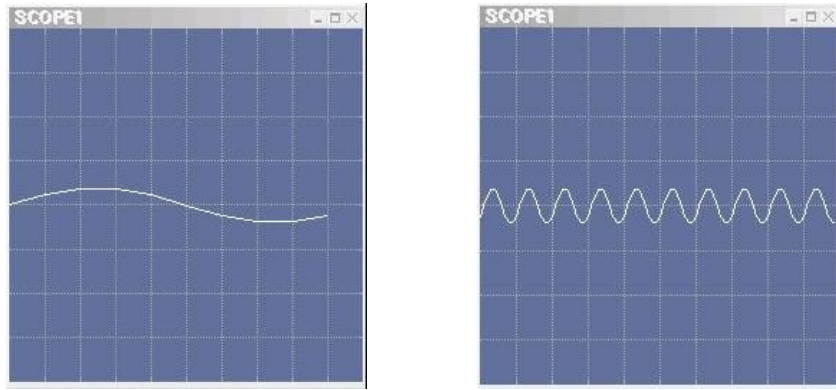


Figure 20: results of mailbox communication, send and receive side respectively

### 4.2.2 Messages and RPC

With this method it is also possible to send and receive data between different computers, but can also be used on a local computer. Like mailboxes a sender sends data, but in this case, it's not stored in a buffer but send directly to the receiver. Therefore the receiver needs to be a active task and waiting to receive data. Unlike mailboxes the data that is send has a fixed size. There are no blocks in RTAI that can handle messages and RPC so no tests are executed.

### 4.2.3 Semaphores

Data can also be sent using a semaphore. This method creates a channel between two task and data can be sent over this channel when the tasks want to synchronize. RTAI contains two blocks which use semaphores to communicate. In figure 21 the schemes are displayed that have been used to test. With this method the data is sent correctly when the same sample rates are used in both tasks. But when different sample rates are used, the tasks become unstable and plots in RTAILab will freeze. It is also possible that the whole system freezes. To conclude semaphores are not working with different sample rates and so can not be used in multi-rate systems.

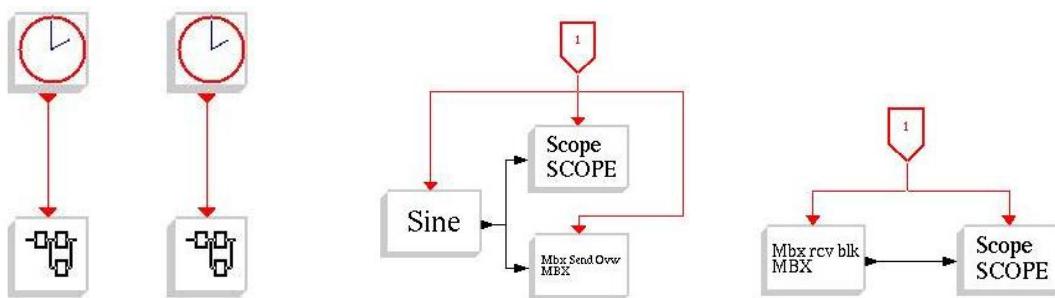


Figure 21: Scicos schemes using semaphore send and semaphore receive

### 4.2.4 FIFO

This method is used to put data parts into a buffer. Unlike mailboxes, where all data from the buffer can be read, this method uses first-in-first-out. This method is particularly used to communicate between real time tasks and the user space. It handles communication between real-time tasks and tasks which are not real-time. Although RTAI library contains one block

which handles communication with FIFO, this method was not tested because all tasks must be real-time in this case.

### 4.2.5 Shared memory

Just like with the Robocup robots it is possible to use shared memory as communication method. With this method multiple tasks are sharing the same memory region and all tasks can access variables stored in the memory. This type of communication can also be used with real-time and user space tasks. This method has not been tested.

### 4.2.6 I/O

With this communication way RTAI is not used. The blocks that handle this method are in a standard library of Scicos. I/O can only be used on a local computer, it is not possible to connect different computers with each other. The schemes that were used during testing are displayed in figure 22. The result from RTAILab are the same as with the mailboxes in figure 20. The frequency of the signal is ten times higher on the receiver side than on the sender side. To check if this could have something to do with the RTAI scopes a new model is built, shown in figure 23. This model uses scopes from the Scicos library which are not triggered by an activation signal. The results are displayed in figure 24 and as can be seen, the frequency is the same in both scopes. Also it can be seen that the receive scope is drawn in more sharp edged way. This is caused by the higher frequency and these results were expected at first. This strengthens the first idea, but it is not yet a fact that the problem is caused by the scopes and more research will be needed.

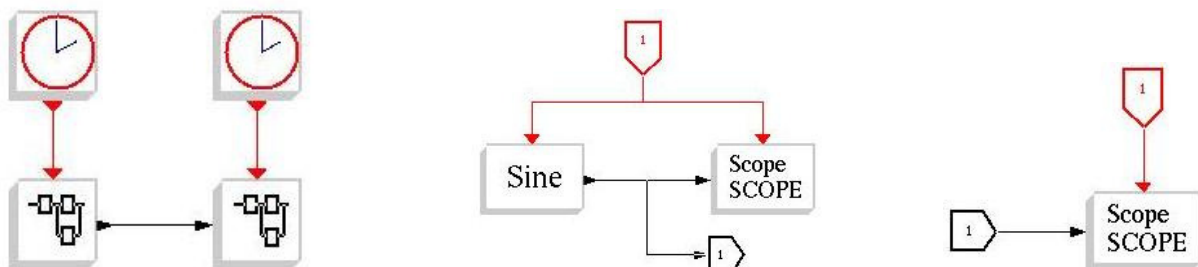


Figure 22: Scicos schemes using I/O send and I/O receive

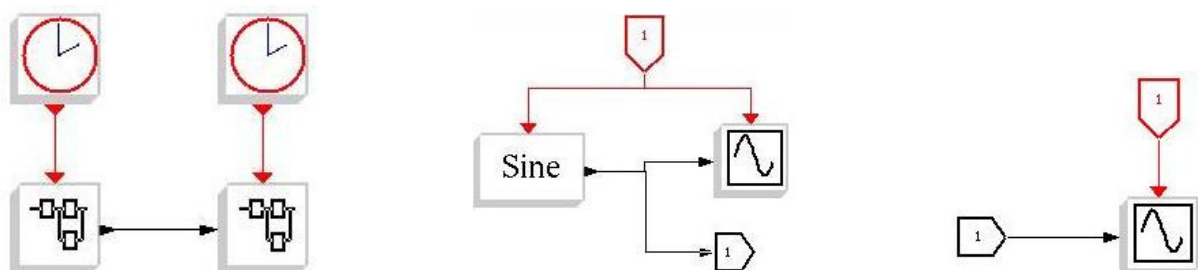
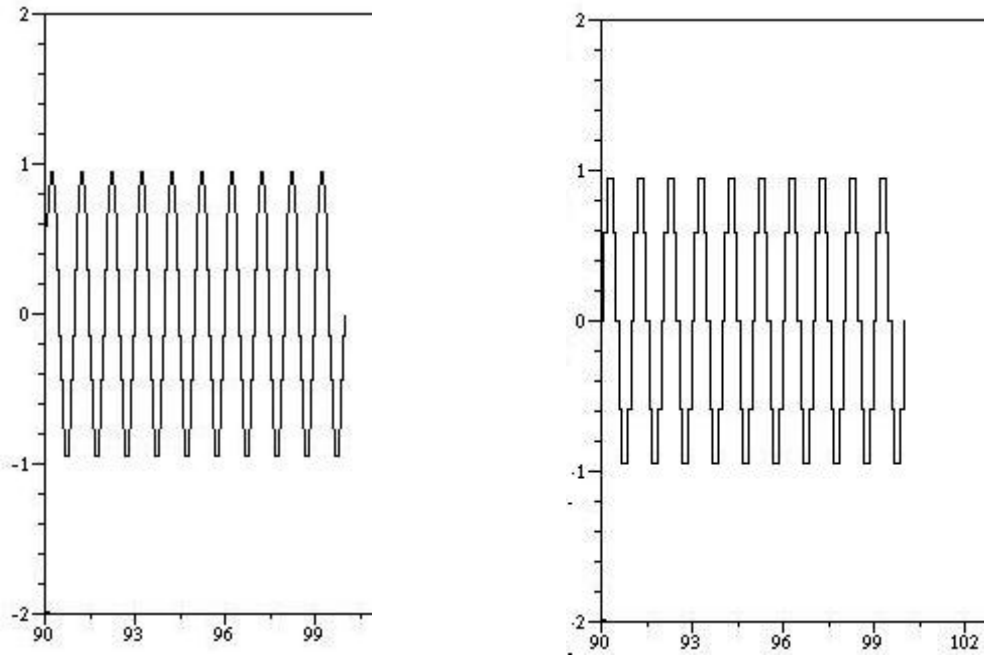


Figure 23: Scicos schemes using I/O send and I/O receive without RTAI scopes





**Figure 24: results of send and receive side respectively without using RTAI scopes**

## 5. Conclusions

The differences between Scilab 4 and Scilab 3 and between RTAI 3.2 and RTAI 3.3 are pretty small. Especially with RTAI only some core changes were made. In Scilab 4 the user interface is changes, so that it becomes more user friendly and Matlab-like. Also some functions are adapted so that these can be used in a same way as in Matlab. Unfortunately Scicos is not updated and its user interface is still out of date and user unfriendly, but this will be solved in the next version probably because this version is the last using the old graphic style. Within the installation not that much is changed, although a couple new errors were discovered and solved.

Although the user interface of Scilab and especially Scicos is not as user friendly as Matlabs, there are a few ways to create custom user interface. By using Scilabs own user interface some predefined dialogs can be used or by using tlc and tk shared libraries own dialogs can be created. A lot of functions that handle custom user interface with tlc and tk shared libraries are the same as in Matlab so the mfile2sci tool can be used to convert m-files to sci-files if the user interface already exists in Matlab. Otherwise it is possible to create graphical user interface manually or by using the guide tool which is created to simplify the graphics design process.

The different ways to create user interface in Scilab are all investigated and discussed in this report and therefore this goal is achieved. Also the objective to implement a user friendly REF3 user interface into Scilab is achieved. The graphic user interface of REF3 in Scilab looks like Matlabs as much as possible.

Finally a short introduction has been made to multi-rate tasking. Different ways of communication between different tasks are described. Some of this ways are tested and recommendations are given if it is possible to create multi-rate systems using that kind of communication way. Some more investigation is needed to ultimately create a multi-rate real-time application in Scilab, but all in all it is possible.

The overall conclusion is that Scilabs user interface is pretty extensive and looks like Matlabs. Multi-rate tasking is probably possible with Scilab and RTAI, but a lot of investigation needs to done.

## 6. References

### 6.1 Books and reports

H. Bruyninckx, (2002), *Real-Time and Embedded Guide*, K.U. Leuven - mechanical engineering, Belgium

R. Bucher, Lorenzo Dozio and Paolo Mantegazza, (publication year unknown), *Rapid Control Prototyping with Scilab/Scicos and Linux RTAI*, SUPSI and DIAPM

R. Bucher, (publication year unknown), *Interfacing Linux RTAI with Scilab/Scicos*, University of Applied Sciences of Southern Switzerland

R. Bucher, S. Mannori (publication year unknown), *Using Scilab/Scicos with RTAI-Lab*, University of Applied Sciences of Southern, Switzerland and proXima electronics, Italy

R. Djenidi, C. Lavarenne, R. Nikoukhah, Y. Sorel and S. Steer, (1999), *From Hybrid System Simulation to Real-Time Implementation*, INRIA

M.G.J.M. Maassen, (2006), *Scicos as an alternative for Simulink*, Technical University of Eindhoven, Holland

R. Nikoukhah and S. Steer, (publication year unknown), *Scicos - A Dynamic System Builder and Simulator User's Guide*

G. E. Urroz, (2003), *Scilab scripts, functions, and dairy files - a summary*

G. Vernaève, (2000), *Cursus C*, Zeus WPI - workgroup informatics

K. Yaghmour, (publication year unknown), *The Real-Time Application Interface*

Multiple writers, *Scilab help* (2006), INRIA

### 6.2 Websites

*Scilab 4 Features*, <http://www.scilab.org/download/features/scilab40.php>

*Scilab documentation (4.0 version)*, <http://www.scilab.org/product/man-eng/index.html>

## Appendix A: Major changes between Scilab 3 and Scilab 4

Source: <http://www.scilab.org/download/features/scilab40.php>

- Graphics:
  - Graphical entities (objects) have been extended with a particular effort on:
    - The Axes entity with respect to change of coordinates (logscale enable, axes inversion in 2D and 3D) and graduation display.
    - Versatile Title and labels entities in 2D and 3D.
    - 3D object merge and zoom
    - Rotation of text entities
    - Save and load of all graphical entities
  - New functions have been defined to mimic their Matlab equivalent:
    - plot
    - surf
    - mesh
    - bar, barh and barhomogenize
    - pie
  - Graphical Environment improved and extended:
    - Manipulation of the hierarchy of the entities has been made easier thanks to a hierarchy browser.
    - A toolbar has been added to the graphic windows, the function toolbar can be used to set or unset it. (Windows specific)
  - Graphic window Events (mouse, keyboard,...) handling have been improved and extended:
    - Click, double-click, press, release, move
    - Key press and release, with or without Shift and Ctrl modifiers.
  - xs2bmp and xs2emf functions added to export graphics under bmp and EMF (Enhanced Meta File) formats. (Windows specific)
  - colour bar function added
- Numerical computation:
  - Sparse operations and functions like real, imag, matrix, spones revisited to improve efficiency
  - Bessel functions extended to work in the complex case (using Slatec routines)  
Incompatibilities: The semantics of besseli, besselj, bess elk and bessely functions has been changed and extended.  
The oldbesseli, oldbesselj, oldbess elk and oldbessely correspond to the old obsolete semantics.
  - New version of linpro and quapro. *Thanks to Cecilia Pola.*
  - bvodeS function added to solve differential equation with boundary value. *Thanks to Rainer Von Seggern.*
  - detrend function added to remove constant, linear or piecewise linear trend from a vector
  - Interface with Excel (Functions to read Excel files).
- Matlab to Scilab converter:
  - Translate paths function improved to allow conversion on an entire toolbox propagating inference through toolbox functions.

- The set of translated function has been extended in particular with the basic graphic functions.
- Scilab function sum, prod,... extended to the "first non singleton" matlab semantics to improve readability and efficiency of translated code.
- Try catch construct added to Scilab for a better translation.
- Scipad editor:
  - A debugging tool is now available
  - Drag and drop is now supported
  - Split a Scipad window
  - Print file from Scipad is now available
  - Scipad is easily localized (See "Adding translations..." in the Scipad Help Menu).  
Today English, German, French, Swedish, Polish, Norwegian and Italian languages are supported
  - User settings and text colours are now configurable and saved across editing sessions
  - Colorization of strings rewritten - now supports strings on continued lines
  - Colorization of files launched in the background, with progress bar.
  - Quick access in the file menu for recently opened/saved files
  - Identification of Scilab predefined variables and library functions in Scilab scripts
  - Miscellaneous file management improvements: read-only flag, absolute pathnames to files, pruned pathnames display, revert to saved feature, MRU (Most Recently Used) list.
  - Keyword completion added, keyword list now completely dynamical
  - Undo/Redo rewritten
  - Go to... functions rewritten and expanded
  - Find/Replace rewritten, includes find files, find in files, find in multiple buffers, find in selection only, find full word
  - Creation of XML help page templates and xml to html compilation available from within Scipad
- Syntax:
  - try-catch instruction added to improve programming with error control.
- Other improvements:
  - Configure adapted to Linux 64bit architectures
  - Use tcltk 8.4.12 - TCL interface has been totally rewritten (for better error detection and better data transfer). ScilabEval improve to handle synchronism.
  - Memory improvements under Windows platforms (particularly the management of virtual memory or swap file)
  - Exception management added under Windows version
  - Windows platforms with:
    - Intel C Compiler 9.0
    - Intel Fortran 9.0
  - The source files have been updated to optimise the compiled version built with VC6 tool  
*Please note that the Windows binary version provided on our Web site is built with .NET*

- Improvement of the integration of Visual Studio Compiler to the dynamic links: findmsvccompiler() and configure\_msvc() macros have been added
  - Integration of the ATLAS library (*specific Windows version*).  
During the installation of Scilab, dynamic library (Atlas.dll) is automatically chosen according to the CPU detected  
See details in the Atlas.spec file under scilab\bin directory
  - For advanced users: Scilab can be used with Atlas library on all platforms by:
    - downloading Atlas library sources,
    - compiling Atlas sources,
    - compiling Scilab sources with the following configure option : --with-atlas-library=ATLAS\_LIB\_DIRECTORY  
(see /configure --help)
  - Java interface written to allow calling Scilab computational engine from Java
  - Font rotation is now possible under Xwindow
  - SCI and HOME are redefined if not correct ( *Bug 1488 Only for Windows* )
  - home variable (%HOME%) defined under Windows: c:/Documents and Setting/USER
  - New environment variable SCIHOME:
    - Under Windows: %HOME%\Scilab\SCILAB\_VERSION
    - Under Linux: \$HOME/USER/.Scilab/SCILAB\_VERSION
  - Function what() has been rewritten : alphabetical sort, print modified
- New primitives:
    - clipboard (*specific Windows*)
    - perl
    - calendar
    - mkdir
    - rmdir
    - copyfile
    - sleep
    - getos
    - setenv
    - toprint("file")
    - getmemory()
    - getshortpathname (*specific Windows*)
    - getlongpathname (*specific Windows*)
    - toolbar (*specific Windows*)
    - hidetoolbar (*specific Windows*)
    - console (*specific Windows*)
    - mcisendstring (*specific Windows*)
    - banner
    - winqueryreg (*specific Windows*)
    - xls\_open
    - xls\_read
  - Please note:
    - "xgetmouse", "eventhandler" event set extended to click, double-click, <Ctrl> Key. See more details in xclick and xgetmouse on line help.  
Warning: Because of distinction of click events, some users' scripts can have a different behaviour.

To make it work as before please check and modified test on events as follow:  
supposing that button contains the value returned by xclick (left most  
argument) or xgetmouse (third component of returned vector) then replace test  
like:

button==0 by or (button==[0,3])

button==1 by or (button==[1,4])

button==2 by or (button==[2,5])

## Appendix B: Installation of Scilab 4 and RTAI 3.3

This appendix describes the installation of Scilab 4 and RTAI 3.3 from the TUEdACS DVD and the installation CD added to this report. For more information or when errors occur refer to Maassen (2006).

### *Installation of Knoppix*

- Start Knoppix from the TUEdACS DVD
- Open console (Terminal Program) and type: *sudo knoppix-installer*
- Wait a moment till the program starts and configure a new installation
- Choose the system: *beginner: Multi-User System with hw-detection*
- Make a new user account and choose a short administration password because this password is needed more often
- Install grub to the *mbr: Master Boot Record*
- Start the installation and make a boot diskette (not necessary but might be helpful in case the system won't start anymore because the start-up file is messed up)
- Restart the computer without the cd (start the hard disk copy of Knoppix)

### *Installation steps in Linux*

#### **Mesa**

- Untar *MesaLib-6.3.2.tar.gz* from the installation CD in a temporary directory
- Open console enter *su* and the administration password. Then go to the Mesa directory (*cd /tmp/Mesa-6.3.2*)
- Type *make linux-x86-static*
- Type *make install (enter-enter-enter)*

#### **EFLTK**

- Untar *efltk-2.0.5.tar.bz2* from the installation CD in a temporary directory
- Type *cd /tmp/efltk*
- Open *File Manager – Super User Mode*, go to */tmp/efltk* and open the properties of *efltk-config.in*. Open the permissions tab and be sure that all permissions are set to *Can Read & Write* and that *Is Executable* is checked
- Type *./efltk-config.in --prefix=/usr/local --multithread*
- Type *./emake*
- Type *./emake install*
- Add */usr/local/lib* to the file */etc/ld.so.conf* (already done when using the TUEdACS cd)



- Type ldconfig

## A new patched kernel

- Untar *linux-2.6.15.tar.bz2* from the installation CD to */usr/src/linux-2.6.15-rtai-3.3*
- Untar *rtai-3.3.tar.tar* from the installation CD to */usr/src/rtai-3.3*
- Type cd /usr/src
- Type rm linux
- Type y
- Type ln -s /usr/src/linux-2.6.15-rtai-3.3 linux
- Type ln -s /usr/src/rtai-3.3 rtai
- Type cd /usr/src/Linux
- Type patch -p1 < /usr/src/rtai/base/arch/i386/patches/hal-linux-2.6.15-i386-r9.patch
- Type cp /usr/src/linux-2.6.12.6-fusion-0.9.1/.config /usr/src/linux-2.6.15-rtai-3.3
- Type rm /usr/include/asm
- Type y
- Type ln -s /usr/src/linux/include/asm-i386 /usr/include/asm
- Type make menuconfig
- Change *General setup* >> *Local version* to *-rtai-3.3*
- Exclude *Processor type and features* >> *Symmetric multi-processing support*
- Include *Processor type and features* >> *Preemptible Kernel*
- Exclude *Device Drivers* >> *Parallel Port support*
- Exclude *Device Drivers* >> *Multi-device support*
- Exclude *Device Drivers* >> *Fusion MPT device support*
- Exclude *Power management options* >> *APM*
- Include *Power management options* >> *ACPI* >> needed functions (for a laptop include *AC Adapter, Battery, Button, Fan, Processor, Thermal Zone* and other needed features).
- Include *File systems* >> *Reiserfs support*
- Save and exit
- Type cp /usr/local/gcc-3.2.3/lib/gcc-lib/i686-pc-linux-gnu/3.2.3/include/stdarg.h /usr/src/linux-2.6.15-rtai-3.3/include/stdarg.h
- Type cp /usr/src/linux-2.6.15-rtai-3.3/include/mca-legacy.h /usr/src/linux-2.6.15-rtai-3.3/include/linux/mca-legacy.h
- Type make
- Type make modules\_install
- Type make install
- Add the new kernel to */boot/grub/menu.lst*. Use as title 'Debian GNU/Linux, kernel 2.6.15-rtai-3.3, Default', as root use '(hd0,6)', as kernel use '/boot/vmlinuz-2.6.15-rtai-3.3 ro ramdisk\_size=100000 init=/etc/init lang=us acpi=off noapic noapm xmodule=fbdev nomce quiet vga=791'
- Reboot using the new kernel

## RTAI

- Type cd /usr/src/rtai

- Type *make menuconfig*
- Change *General* >> *Installation directory* to */usr/realtime-rtai-3.2*
- Include *RTAI-Lab*
- Type *cd /usr/local/gcc-3.2.3/lib/gcc-lib/i686-pc-linux-gnu/3.2.3/include/stddef.h /usr/include/stddef.h*
- Type *make*
- Type *make install*
- Open */etc/profile* and add */usr/realtime-rtai-3.2/bin* to the PATH variable

## Scilab

- Untar *tcl8.4.11-src.tar.gz* from the installation CD to */usr/src*
- Type *cd /usr/src/tcl8.4.11/unix*
- Type *./configure -enabled-shared*
- Type *make*
- Type *make install*
- Untar *tk8.4.11-src.tar.gz* from the installation CD to */usr/src*
- Type *cd /usr/src/tk8.4.11/unix*
- Type *./configure -enabled-shared*
- Type *make*
- Type *make install*
- Untar *scilab-4.0-src.tar.tar* from the installation CD to */usr/local/*
- Untar all files from the folder *man-eng-scilab-4.0* in *man-eng-scilab-4.0.tar.tar* from the installation CD to */usr/local/scilab-4.0/man/eng/*. Overwrite all files.
- Type *cd /usr/local/scilab-4.0*
- Type *./configure -without-java*
- Type *make all*

## Installing Scilab/Scicos & RTAI add-ons

- Type *cd /usr/src/rtai/rtai-lab/scilab/macros*
- Open */usr/src/rtai/rtai-lab/macros/Makefile* and edit the line: *SCILAB\_DIR = /usr/local/scilab-4.0*
- Type *ln -s /usr/local/gcc-3.2.3/lib/libg2c.so /usr/local/lib/libg2c.so*
- Type *ln -s /usr/local/gcc-3.2.3/lib/libg2c.so.0 /usr/local/lib/libg2c.so.0*
- Type *ldconfig*
- Type *make install*
- Type *exit*
- Type *cd /usr/src/rtai/rtai-lab/scilab/macros*
- Type *make user*
- Type *ln -s /usr/local/scilab-4.0/bin/scilab /usr/local/bin/scilab*

## Appendix C: Most important guide functions

### *New file*

```
function [] = file_new
global ndialogs
global activedialog
ndialogs=ndialogs+1
activedialog = figure('position', [5 350 200 200], 'figure_name', ...
'Dialog'+string(ndialogs), 'backgroundcolor', [236,233,216], 'tag', ...
'Dialog' + string(ndialogs))
listbox_add('Dialog'+string(ndialogs))
setworklayout
endfunction
```

### *Load file*

```
function [] = file_load
global activedialog
global path
global ndialogs
global npushbuttons
global nradiobuttons
global ncheckboxboxes
global nedits
global ntexts
global nsliders
global nframes
global nlistboxes

path=tk_getfile('*.sgi')

if ~path==' ' then
    load(path, 'ndialogs', 'npushbuttons', 'nradiobuttons', 'ncheckboxboxes', ...
        'nedits', 'ntexts', 'nsliders', 'nframes', 'nlistboxes', 'dialogs', ...
        'dialogpositions', 'controls', 'controlpositions', 'controlstyles', ...
        'controlbackgroundcolors')

    activedialog = figure('position', dialogpositions, 'figure_name', ...
        dialogs, 'backgroundcolor', [236,233,216], 'tag', dialogs)

    listbox_add(dialogs)

    for i=1:size(controls,1)
        mycontrol=uicontrol(activedialog, 'style', controlstyles(i), ...
            'string', controls(i), 'position', controlpositions(i,:), ...
            'backgroundcolor', controlbackgroundcolors(i,:), 'tag', ...
            controls(i))
        listbox_add(controls(i))
    end
    setworklayout
end
endfunction
```

## **Save file**

```
function [] = file_save
global activedialog
global path
global ndialogs
global npushbuttons
global nradiobuttons
global ncheckboxes
global nedit
global ntexts
global nsliders
global nframes
global nlistboxes

if path==' ' then
    path=tk_savefile('*.sgi')
end
if ~path==' ' then
    ind=strindex(path, '.sgi')
    if ind == [] then
        path=path+'.sgi'
    end

    hdl_guide_listbox = findobj('tag','guide_listbox')
    items = get(hdl_guide_listbox,'string')

    ind=strindex(items,'|')
    if ~ind==[] then
        items=strsplit(items,ind)
    end
    items=strsubst(items,'|','')

    dialogs = items(1)
    dialogpositions = get(activedialog,'position')
    controls = []
    controlpositions = []
    controlstyles = []
    controlbackgroundcolors = []
    for i=2:size(items,1)
        controls=[controls;items(i)]
        hdl_control = findobj('tag',items(i))
        controlpositions=[controlpositions;get(hdl_control,'position')]
        controlstyles = [controlstyles;get(hdl_control,'style')]
        controlbackgroundcolors = [controlbackgroundcolors;...
            get(hdl_control,'backgroundcolor')]
    end
    save(path,ndialogs,npushbuttons,nradiobuttons,ncheckboxes,nedit,...
        ntexts,nsliders,nframes,nlistboxes,dialogs,dialogpositions,...
        controls,controlpositions,controlstyles,controlbackgroundcolors)
end
endfunction
```

## **Export file**

```
function [] = file_export
global activedialog
global ndialogs
global npushbuttons
global nradiobuttons
global ncheckboxes
global nedit
global ntexts
global nsliders
```

```

global nframes
global nlistboxes

path=tk_savefile('*.sci')
if ~path==' ' then
    ind=strindex(path, '.sci')
    if ind == [] then
        path=path+'.sci'
    end

    hdl_guide_listbox = findobj('tag','guide_listbox')
    items = get(hdl_guide_listbox,'string')

    ind=strindex(items,'|')
    if ~ind==[] then
        items=strsplit(items,ind)
    end
    items=strsubst(items,'|','')

    f=file('open',path)

    dialogposition = get(activatedialog,'position')

    fprintf(f,items(1)+'=figure('position',[+string...
(dialogposition(1))+','+string(dialogposition(2))+','+string...
(dialogposition(3))+','+string(dialogposition(4))+'],'...
'figure_name',''+items(1)+'','backgroundcolor',...
[236,233,216],'tag',''+items(1)+'')')

    for i=2:size(items,1)
        hdl_control = findobj('tag',items(i))
        controlposition=get(hdl_control,'position')
        controlstyle = get(hdl_control,'style')
        controlbackgroundcolor = get(hdl_control,'backgroundcolor')

        fprintf(f,items(i)+'=uicontrol('+items(1)+'','style',...
'''+controlstyle+''','string',''+items(i)+'',...
'position',[+string(controlposition(1))+','+string...
(controlposition(2))+','+string(controlposition(3))+','...
'+string(controlposition(4))+'],'backgroundcolor',...
[+string(controlbackgroundcolor(1))+','+string...
(controlbackgroundcolor(2))+','+string...
(controlbackgroundcolor(3))+'],'tag',''+items(i)+'')')
    end
    file('close',f)
end
endfunction

```

### ***Add a control (for example the pushbutton control)***

```

function [] = add_pushbutton
global activatedialog
global npushbuttons
npushbuttons=npushbuttons+1
mypushbutton = uicontrol(activatedialog,'style','pushbutton','string',...
'Pushbutton'+string(npushbuttons),'horizontalalignment','left',...
'position',[5,5,90,20],'backgroundcolor',[236,233,216],'tag',...
'Pushbutton'+string(npushbuttons))
listbox_add('Pushbutton'+string(npushbuttons))
endfunction

```

## **Delete a control**

```
function [] = delete_control
global activecontrol

hdl_guide_listbox = findobj('tag','guide_listbox')
items = get(hdl_guide_listbox,'string')

ind=strindex(items,'|')
if ind==[] then
    control=items
    items=''
else
    items=strsplit(items,ind)
    items=strsubst(items,'|','')
    val=get(hdl_guide_listbox,'value')
    control=items(val)
    items=[items(1:val-1);items(val+1:size(items,1))]
end
activecontrol = findobj('tag',control)
close(activecontrol)
set(hdl_guide_listbox,'string',items)
endfunction
```

## **Edit a control**

```
function [] = edit_control
global activecontrol
global activedialog
global position

hdl_guide_listbox = findobj('tag','guide_listbox')
items = get(hdl_guide_listbox,'string')

ind=strindex(items,'|')
if ind==[] then
    control=items
else
    items=strsplit(items,ind)
    items=strsubst(items,'|','')
    val=get(hdl_guide_listbox,'value')
    control=items(val)
end

hdl_activecontrol = findobj('tag','guide_activecontrol')
set(hdl_activecontrol,'string','Properties: '+string(control))

activecontrol = findobj('tag',control)
position = get(activecontrol,'position')

hdl_guide_edit_x = findobj('tag','guide_edit_x')
set(hdl_guide_edit_x,'string',string(position(1)))
hdl_guide_slider_x = findobj('tag','guide_slider_x')
set(hdl_guide_slider_x,'value',string(position(1)))
hdl_guide_edit_y = findobj('tag','guide_edit_y')
set(hdl_guide_edit_y,'string',string(position(2)))
hdl_guide_slider_y = findobj('tag','guide_slider_y')
set(hdl_guide_slider_y,'value',string(position(2)))
hdl_guide_edit_w = findobj('tag','guide_edit_w')
set(hdl_guide_edit_w,'string',string(position(3)))
hdl_guide_slider_w = findobj('tag','guide_slider_w')
set(hdl_guide_slider_w,'value',string(position(3)))
hdl_guide_edit_h = findobj('tag','guide_edit_h')
set(hdl_guide_edit_h,'string',string(position(4)))
```

```

hdl_guide_slider_h = findobj('tag','guide_slider_h')
set(hdl_guide_slider_h,'value',string(position(4)))
hdl_guide_edit_rename = findobj('tag','guide_edit_rename')
set(hdl_guide_edit_rename,'string',control)

if ~activecontrol==activedialog then
    dialogposition=get(activedialog,'position')
    set(hdl_guide_slider_x,'max',dialogposition(3))
    set(hdl_guide_slider_y,'max',dialogposition(4))
    set(hdl_guide_slider_w,'max',dialogposition(3))
    set(hdl_guide_slider_h,'max',dialogposition(4))
else
    set(hdl_guide_slider_x,'max',1000)
    set(hdl_guide_slider_y,'max',1000)
    set(hdl_guide_slider_w,'max',1000)
    set(hdl_guide_slider_h,'max',1000)
end
endfunction

```

### ***Add item to list box***

```

function [] = listbox_add(newitem)
hdl_guide_listbox = findobj('tag','guide_listbox')
items=get(hdl_guide_listbox,'string')
ind=strindex(items,newitem)
if ~ind==[] then
    disp('Control already exists, please rename '+ newitem +'.')
else
    if items == '' then
        set(hdl_guide_listbox,'string',newitem)
    else
        set(hdl_guide_listbox,'string',items+'|'+newitem)
    end
end
end
endfunction

```

### ***Replace and resize items (for example x-coordinate slider moves)***

```

function [] = check_control
global position

hdl_guide_edit_x = findobj('tag','guide_edit_x')
hdl_guide_edit_y = findobj('tag','guide_edit_y')
hdl_guide_edit_w = findobj('tag','guide_edit_w')
hdl_guide_edit_h = findobj('tag','guide_edit_h')

x=eval(get(hdl_guide_edit_x,'string'))
y=eval(get(hdl_guide_edit_y,'string'))
w=eval(get(hdl_guide_edit_w,'string'))
h=eval(get(hdl_guide_edit_h,'string'))
position=[x,y,w,h]

hdl_guide_slider_x = findobj('tag','guide_slider_x')
set(hdl_guide_slider_x,'value',x)
slider_x_move
hdl_guide_slider_y = findobj('tag','guide_slider_y')
set(hdl_guide_slider_y,'value',y)
slider_y_move
hdl_guide_slider_w = findobj('tag','guide_slider_w')
set(hdl_guide_slider_w,'value',w)
slider_w_move

```

```

hdl_guide_slider_h = findobj('tag','guide_slider_h')
set(hdl_guide_slider_h,'value',h)
slider_h_move
endfunction

function [] = slider_x_move
global activecontrol
global position
if ~activecontrol==' then
    hdl_guide_slider_x = findobj('tag','guide_slider_x')
    x=get(hdl_guide_slider_x,'value')
    position=[x,position(2:4)]
    set(activecontrol,'position',position)
    hdl_guide_edit_x = findobj('tag','guide_edit_x')
    set(hdl_guide_edit_x,'string',string(x))
end
endfunction

```

## ***Rename control***

```

function [] = rename_control
global activecontrol
global activedialog
hdl_guide_edit_rename = findobj('tag','guide_edit_rename')
name=get(hdl_guide_edit_rename,'string')

hdl_guide_listbox = findobj('tag','guide_listbox')
items = get(hdl_guide_listbox,'string')

ind=strindex(items,name)

if ~ind==[] then
    disp('Control already exists, please rename '+name+'.')
else
    ind=strindex(items,'|')
    if ind==[] then
        items=name
    else
        items=strsplit(items,ind)
        items=strsubst(items,'|','')
        val=get(hdl_guide_listbox,'value')
        items=[items(1:val-1);name;items(val+1:size(items,1))]
    end

    set(hdl_guide_listbox,'string',items)
    set(activecontrol,'tag',name)

    if activecontrol==activedialog then
        set(activedialog,'figure_name',name)
    else
        set(activecontrol,'string',name)
    end

    hdl_activecontrol = findobj('tag','guide_activecontrol')
    set(hdl_activecontrol,'string','Properties: '+name)
end
endfunction

```



## Appendix D: Graphical interface function of REF3

REF3 uses three different dialogs, a main window, a trajectory edit window and a jogmode window. In this appendix the code that creates the graphical part of the user interface is described.

### *Main window*

```
global edit_ref_axes_ref

edit_ref_axes_ref=max(winsid()+1
edit_ref_axes_ref=scf(edit_ref_axes_ref)

xtitle('Position','t [s]','pos [m or rad]')
plot(1)
edit_ref_axes_ref.figure_position = [5,5]
edit_ref_axes_ref.figure_size = [500,300]
edit_ref_axes_ref.figure_name = 'Position'
disp(edit_ref_axes_ref)

R12_r3g_edit_ref=figure('position', [5 380 500 70], 'figure_name',...
'Ref3Edit', 'backgroundcolor', [236,233,216], 'tag', 'tag_R12_r3g_edit_ref')

edit_ref_repeat=icontrol(R12_r3g_edit_ref, 'style', 'checkbox', 'string',...
'repeat', 'position', [5,40,65,25], 'backgroundcolor', [236,233,216], 'tag',...
'tag_edit_ref_repeat')

edit_ref_jogmode=icontrol(R12_r3g_edit_ref, 'style', 'pushbutton',...
'callback', 'cb_edit_ref_jogmode', 'string', 'Jogmode', 'position',...
[70,40,65,25], 'backgroundcolor', [236,233,216], 'tag', 'tag_edit_ref_jogmode')

edit_ref_load=icontrol(R12_r3g_edit_ref, 'style', 'pushbutton',...
'callback', 'cb_edit_ref_load', 'string', 'Load', 'position', [5,5,65,25],...
'backgroundcolor', [236,233,216], 'tag', 'tag_edit_ref_load')

edit_ref_save=icontrol(R12_r3g_edit_ref, 'style', 'pushbutton',...
'callback', 'cb_edit_ref_save', 'string', 'Save', 'position', [65,5,65,25],...
'backgroundcolor', [236,233,216], 'tag', 'tag_edit_ref_save')

edit_ref_new=icontrol(R12_r3g_edit_ref, 'style', 'pushbutton',...
'callback', 'cb_edit_ref_new', 'string', 'New', 'position', [150,5,65,25],...
'backgroundcolor', [236,233,216], 'tag', 'tag_edit_ref_new')

edit_ref_add=icontrol(R12_r3g_edit_ref, 'style', 'pushbutton',...
'callback', 'cb_edit_ref_add', 'string', 'Add', 'position', [215,5,65,25],...
'backgroundcolor', [236,233,216], 'tag', 'tag_edit_ref_add')

edit_ref_edit=icontrol(R12_r3g_edit_ref, 'style', 'pushbutton',...
'callback', 'cb_edit_ref_edit', 'string', 'Edit', 'position', [280,5,65,25],...
'backgroundcolor', [236,233,216], 'tag', 'tag_edit_ref_edit')

edit_ref_del=icontrol(R12_r3g_edit_ref, 'style', 'pushbutton', 'callback',...
'cb_edit_ref_del', 'string', 'Delete', 'position', [345,5,65,25],...
'backgroundcolor', [236,233,216], 'tag', 'tag_edit_ref_del')

edit_ref_accept=icontrol(R12_r3g_edit_ref, 'style', 'pushbutton',...
'callback', 'cb_edit_ref_accept', 'string', 'Accept', 'position',...
[430,5,65,25], 'backgroundcolor', [236,233,216], 'tag', 'tag_edit_ref_accept')

edit_ref_status=icontrol(R12_r3g_edit_ref, 'style', 'text',...
'horizontalalignment', 'left', 'position', [150,40,340,25],...
```

```
'backgroundcolor',[236,233,216],'foregroundColor',[100,191,100],'tag',...
'tag_edit_ref_status')
...
```

## ***Edit trajectory window***

```
global edit_part_axes

edit_part_axes=max(winsid()+1
edit_part_axes=scf(edit_part_axes)

subplot(4,1,1);
plot(1)
xlabel('t [s]','pos [m or rad]')
subplot(4,1,2);
plot(1);
xlabel('t [s]','vel [m/s or rad/s]')
subplot(4,1,3);
plot(1);
xlabel('t [s]','acc [m/s^2 or rad/s^2]')
subplot(4,1,4);
plot(1);
xlabel('t [s]','jerk [m/s^3 or rad/s^3]')
edit_part_axes.figure_position = [20,20];
edit_part_axes.figure_size = [400,500];
edit_part_axes.figure_name = 'Position, velocity, acceleration and jerk'

R12_r3g_edit_part=figure('position', [430 20 150 540],'figure_name',...
'Ref3edit part','backgroundcolor',[236,233,216],'tag',...
'tag_R12_r3g_edit_part')

edit_part_text_t0=icontrol(R12_r3g_edit_part,'style','text','string',...
't0','position',[5,510,25,25],'background',[236,233,216],'tag',...
'tag_edit_part_text_t0')

edit_part_t0=icontrol(R12_r3g_edit_part,'style','edit','string','0',...
'position',[30,510,65,25],'background',[255,255,255],'tag',...
'tag_edit_part_t0')

edit_part_text_te=icontrol(R12_r3g_edit_part,'style','text','string',...
'te','position',[5,480,25,25],'background',[236,233,216],'tag',...
'tag_edit_part_text_te')

edit_part_te=icontrol(R12_r3g_edit_part,'style','text','string','2.6',...
'horizontalalignment','left','position',[30,480,65,25],'background',...
[236,233,216],'tag','tag_edit_part_te')

edit_part_text_x0=icontrol(R12_r3g_edit_part,'style','text','string',...
'x0','position',[5,450,25,25],'background',[236,233,216],'tag',...
'tag_edit_part_text_x0')

edit_part_x0=icontrol(R12_r3g_edit_part,'style','edit','string','0',...
'position',[30,450,65,25],'background',[255,255,255],'tag',...
'tag_edit_part_x0')

edit_part_text_xe=icontrol(R12_r3g_edit_part,'style','text','string',...
'xe','position',[5,420,25,25],'background',[236,233,216],'tag',...
'tag_edit_part_text_xe')

edit_part_xe=icontrol(R12_r3g_edit_part,'style','edit','string','1',...
'position',[30,420,65,25],'background',[255,255,255],'tag',...
'tag_edit_part_xe')
```

```

edit_part_text_vel=uicontrol(R12_r3g_edit_part,'style','text','string',...
'vel','position',[5,320,25,25],'background',[236,233,216],'tag',...
'tag_edit_part_text_vel')

edit_part_vel=uicontrol(R12_r3g_edit_part,'style','edit','string','0.5',...
'position',[30,320,65,25],'background',[255,255,255],'tag',...
'tag_edit_part_vel')
edit_part_text_te=uicontrol(R12_r3g_edit_part,'style','text','string',...
'acc','position',[5,200,25,25],'background',[236,233,216],'tag',...
'tag_edit_part_text_te')

edit_part_acc=uicontrol(R12_r3g_edit_part,'style','edit','string','1',...
'position',[30,200,65,25],'background',[255,255,255],'tag',...
'tag_edit_part_acc')

edit_part_text_jerk=uicontrol(R12_r3g_edit_part,'style','text','string',...
'jerk','position',[5,80,25,25],'background',[236,233,216],'tag',...
'tag_edit_part_text_jerk')

edit_part_jerk=uicontrol(R12_r3g_edit_part,'style','edit','string','10',...
'position',[30,80,65,25],'background',[255,255,255],'tag',...
'tag_edit_part_jerk')

edit_part_text_status=uicontrol(R12_r3g_edit_part,'style','text',...
'string','waiting for input','horizontalalignment','left','position',...
[5,30,150,25],'background',[236,233,216],'foregroundColor',...
[100,191,100],'tag','tag_edit_part_label_status')

edit_part_check=uicontrol(R12_r3g_edit_part,'style','pushbutton',...
'callback','cb_edit_part_check','string','Check','position',[5,5,65,25],...
'background',[236,233,216],'tag','tag_edit_part_check')

edit_part_accept=uicontrol(R12_r3g_edit_part,'style','pushbutton',...
'callback','cb_edit_part_accept','string','Accept','position',...
[70,5,65,25],'background',[236,233,216],'tag','tag_edit_part_accept')
...

```

## ***Jogmode window***

```

R12_r3g_jogmode=figure('position',[20 20 350 140],'figure_name',...
'Jogmode','background',[236,233,216],'tag','tag_r3g_jogmode')

statictext1=uicontrol(R12_r3g_jogmode,'style','text','string','In ...
jogmode, a constant velocity reference can be designed.',...
'horizontalalignment','left','position',[5,110,340,25],'background',...
[236,233,216],'tag','statictext1')

jogmode_text_t0=uicontrol(R12_r3g_jogmode,'style','text','string','t0',...
'position',[5,70,65,25],'background',[236,233,216],'tag',...
'tag_jogmode_text_t0')

jogmode_t0=uicontrol(R12_r3g_jogmode,'style','edit','string','0',...
'position',[70,70,65,25],'background',[255,255,255],'tag','tag_jogmode_t0')

jogmode_text_x0=uicontrol(R12_r3g_jogmode,'style','text','string','x0',...
'position',[5,40,65,25],'background',[236,233,216],'tag',...
'tag_jogmode_text_x0')

jogmode_x0=uicontrol(R12_r3g_jogmode,'style','edit','string','0',...
'position',[70,40,65,25],'background',[255,255,255],'tag','tag_jogmode_x0')

tag_jogmode_text_vel=uicontrol(R12_r3g_jogmode,'style','text','string',...
'v','position',[5,10,65,25],'background',[236,233,216],'tag',...
'tag_jogmode_text_vel')

```

```
tag_jogmode_vel=uicontrol(R12_r3g_jogmode,'style','edit','string','1',...  
'position',[70,10,65,25],'background',[255,255,255],'tag',...  
'tag_jogmode_vel')
```

```
tag_jogmode_accept=uicontrol(R12_r3g_jogmode,'style','pushbutton',...  
'callback','cb_jogmode_accept','string','Accept','position',...  
[280,5,65,25],'background',[236,233,216],'tag','tag_jogmode_accept')  
...
```

## Appendix E: Sim function in Scilab

```
function [t,y] = sim(ref_part)

aref=[]
vref=[]
qref=[]
tref=[]

s=size(ref_part)
for i=1:s(1)
    xstart=ref_part(i,1)
    tstart=ref_part(i,2)
    xeind=ref_part(i,3)
    vdes=ref_part(i,4)
    tdes=ref_part(i,5)
    maxjerk=ref_part(i,6)
    displ=xeind-xstart
    if displ<0
        REFidir=-1
        displ=-displ
    else
        REFidir=1
    end

    if vdes<0
        vdes=-vdes
    end

    if maxjerk>=0
        REFjerk=maxjerk
    else
        REFjerk=-maxjerk
    end

    dett=tdes*tdes*REFjerk*REFjerk-4*REFjerk*vdes

    if dett<0
        disp('vdes cannot be reached (increase jerk and/or tdes).')
    else
        REFdelta=(tdes*REFjerk-sqrt(dett))/(2*REFjerk)
    end

    REFgamma=tdes-2*REFdelta
    REft0=tstart
    REft1=REft0+REFdelta
    REft2=REft1+REFgamma
    REft3=REft2+REFdelta
    REft4=REft3+(displ-2*REFjerk*REFdelta*REFdelta*REFdelta-
    3*REFjerk*REFdelta*REFdelta*REFgamma-
    REFjerk*REFdelta*REFgamma*REFgamma)/vdes

    if (REft4<REft3)
        disp('vdes too high for displacement (decrease vdes).')
    else
        REft5=REft4+REFdelta
        REft6=REft5+REFgamma
        REft7=REft6+REFdelta
    end

    REFxstrt=xstart
    REfs0=0
    REfa1=REFjerk*(REft1-REft0)
    REfv1=0.5*REFjerk*(REft1-REft0)*(REft1-REft0)
    REfs1=REfs0+REFjerk*(REft1-REft0)*(REft1-REft0)/6
```

```

REFa2=REFa1
REFv2=REFv1+REFa1*(REFt2-REFt1)
REFs2=REFs1+REFv1*(REFt2-REFt1)+0.5*REFa1*(REFt2-REFt1)*(REFt2-REFt1)

REFa3=REFa2-REFjerk*(REFt3-REFt2)
REFv3=REFv2+REFa2*(REFt3-REFt2)-0.5*REFjerk*(REFt3-REFt2)*(REFt3-...
REFt2)
REFs3=REFs2+REFv2*(REFt3-REFt2)+0.5*REFa2*(REFt3-REFt2)*(REFt3-...
REFt2)-REFjerk*(REFt3-REFt2)*(REFt3-REFt2)*(REFt3-REFt2)/6

REFa4=0
REFv4=REFv3
REFs4=REFs3+REFv3*(REFt4-REFt3)

REFa5=-REFjerk*(REFt5-REFt4)
REFv5=REFv4-0.5*REFjerk*(REFt5-REFt4)*(REFt5-REFt4)
REFs5=REFs4+REFv4*(REFt5-REFt4)-REFjerk*(REFt5-REFt4)*(REFt5-...
REFt4)*(REFt5-REFt4)/6

REFa6=REFa5
REFv6=REFv5+REFa5*(REFt6-REFt5)
REFs6=REFs5+REFv5*(REFt6-REFt5)+0.5*REFa5*(REFt6-REFt5)*(REFt6-REFt5)

REFa7=REFa6+REFjerk*(REFt7-REFt6)
REFv7=REFv6+REFa6*(REFt7-REFt6)+0.5*REFjerk*(REFt7-REFt6)*(REFt7-...
REFt6)
REFs7=REFs6+REFv6*(REFt7-REFt6)+0.5*REFa6*(REFt7-REFt6)*(REFt7-...
REFt6)+REFjerk*(REFt7-REFt6)*(REFt7-REFt6)*(REFt7-REFt6)/6

tijd=tstart:.01:REFt7
j=1
while j<=length(tref)
    if tstart<=tref(j)
        if j==1
            tref=[]
            qref=[]
            aref=[]
            vref=[]
        else
            tref=tref(1:j-1)
            qref=qref(1:j-1)
            aref=aref(1:j-1)
            vref=vref(1:j-1)
        end
    end
    j=j+1
end

for t=tijd
    if t<=REFt0
        aref=[aref; 0]
        vref=[vref; 0]
        qref=[qref; REFxstrt+REFs0]
    elseif t<=REFt1
        aref=[aref; REFjerk*(t-REFt0)]
        vref=[vref; 0.5*REFjerk*(t-REFt0)*(t-REFt0)]
        qref=[qref; REFxstrt+REFs0+REFjerk*(t-REFt0)*(t-...
REFt0)*(t-REFt0)/6]
    elseif t<=REFt2
        aref=[aref; REFa1]
        vref=[vref; REFv1+REFa1*(t-REFt1)]
        qref=[qref; REFxstrt+REFs1+REFv1*(t-REFt1)+0.5*REFa1*...
(t-REFt1)*(t-REFt1)]
    elseif t<=REFt3
        aref=[aref; REFa2-REFjerk*(t-REFt2)]
        vref=[vref; REFv2+REFa2*(t-REFt2)-0.5*REFjerk*(t-...
REFt2)*(t-REFt2)]
        qref=[qref; REFxstrt+REFs2+REFv2*(t-REFt2)+0.5*REFa2*...
(t-REFt2)*(t-REFt2)-REFjerk*(t-REFt2)*(t-REFt2)*(t-...
REFt2)/6]

```

```

elseif t<=REft4
    aref=[aref; 0]
    vref=[vref; REFv3]
    qref=[qref; REFxstrt+REFs3+REFv3*(t-REft3)]
elseif t<=REft5
    aref=[aref; -REFjerk*(t-REft4)]
    vref=[vref; REFv4-0.5*REFjerk*(t-REft4)*(t-REft4)]
    qref=[qref; REFxstrt+REFs4+REFv4*(t-REft4)-REFjerk*(t-...
    REft4)*(t-REft4)*(t-REft4)/6]
elseif t<=REft6
    aref=[aref; REfa5]
    vref=[vref; REFv5+REfa5*(t-REft5)]
    qref=[qref; REFxstrt+REFs5+REFv5*(t-REft5)+0.5*REfa5*...
    (t-REft5)*(t-REft5)]
elseif (t<=REft7)
    aref=[aref; REfa6+REFjerk*(t-REft6)]
    vref=[vref; REFv6+REfa6*(t-REft6)+0.5*REFjerk*(t-...
    REft6)*(t-REft6)]
    qref=[qref; REFxstrt+REFs6+REFv6*(t-REft6)+0.5*REfa6*...
    (t-REft6)*(t-REft6)+REFjerk*(t-REft6)*(t-REft6)*(t-...
    REft6)/6]
else
    aref=[aref; 0]
    vref=[vref; 0]
    qref=[qref; REFxstrt+REFs7]
end

if REFidir== -1
    aref=-aref
    vref=-vref
    qref=-qref
end

end
tref=[tref; tijd']
end
t=tref;
y=[aref vref qref]
endfunction

```

## Appendix F: Contents of the CD

All software discussed in this report is written to a CD included with the report. The following files and folders are on the CD:

**Table 2: Documents and folders on CD**

Folder documentation	All documentation used in this report and useful information about Scilab, Scicos and RTAI.
Folder installation	All files that are needed during installation.
Folder home	Files that are created, these files could best be put in the Linux home directory, because this is the standard workspace in Scilab. In that way Scilab is always able to find the functions used.