VLSI Digital Design

Functional simulation tool for the microcontroller

0. Introduction

The main goal of the functional simulation tool is to simplify and facilitate the simulation and debugging process of the applications developed for the microcontroller.

To achieve this goal the tool permits to visualise the values of the signals and the contents of the most important registers of the microcontroller. It also allows for inspecting and modifying the contents of the program and data memory, and the register file as well. Finally, it is possible to set several kinds breakpoints and to manage the whole simulation process.

This tool has been developed using the Tcl (Tool Command Language) language, since the ModelSim simulator has a communication interface that permits to interact with applications written in this language.

1. Installing the simulation tool

To install the simulation tool just uncompress the file ***interface.zip*** that is provided in the laboratory. This file has to be uncompressed in the folder that contains the ModelSim design project to be simulated.

2. Using the simulation tool

Once the ModelSim simulator is started, and after elaborating the design (it is important to bear in mind that when elaborating the design the temporal resolution to be chosen in the dialog windows is ps) just execute in the information and command window (***Transcript***) the command ***do interface.do***. After executing this command a graphical interface like that represented in figure 1 should appear. Before using the simulation tool it will be necessary to apply the stimuli for the system, using the appropriate ****.do*** file.

As it can be seen in figure 1, the interface is divided in three clearly identified sections:

- **Command section:** It permits to carry out the most common functions during a simulation process.
- **Interaction section:** It permits to visualise the contents of the RAM and ROM memory units and the register file. Within this window it is also possible to set breakpoints, and also to modify the contents of the RAM and the register file.
- **Information section:** This section provides information about several important signals and registers of the microcontroller, but it does not allow for interacting with them.

Now the different functions available in each section will be described.

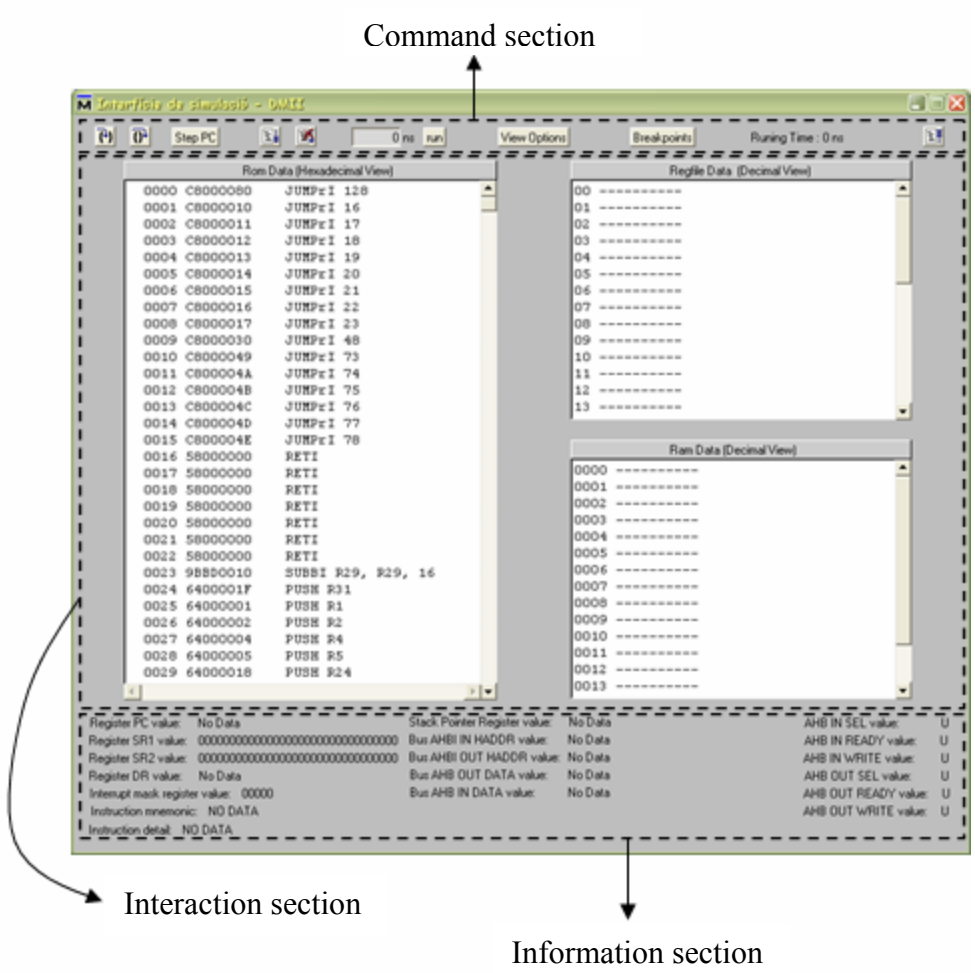

Figure 1. Graphical interface of the functional simulation tool.

2.1. Command section

The buttons available in this section permit to carry out the following actions:

- The button labelled as  corresponds to the ***step*** ModelSim command, so that it permits to advance the simulation in a step-by-step mode (i.e., the simulation will advance line by line in the VHDL code).
- The button labelled as  corresponds to the ***step over*** ModelSim command. This implies that the simulation will advance step by step, but without entering in the code corresponding to functions or subroutines.
- The button labelled as  permits to advance the simulation the time required to complete the execution of one instruction of the microcontroller.
- The button labelled as  corresponds to the ***run –all*** ModelSim command, so that the simulation is advanced until a breakpoint is found or until the user stops it.
- The button labelled as  corresponds to the ***vsim break*** ModelSim command, so that it stops the current simulation.

- The button labelled as run corresponds to the ***run*** ModelSim command, so that it permits to advance the simulation a time interval equal to that specified (in nanoseconds) in the text field placed on its left.
- The button labelled as View Options permits to configure the visualisation options in the interaction and information sections of the graphical interface. Upon clicking on this button a dialog window like that shown in figure 2 will be displayed.

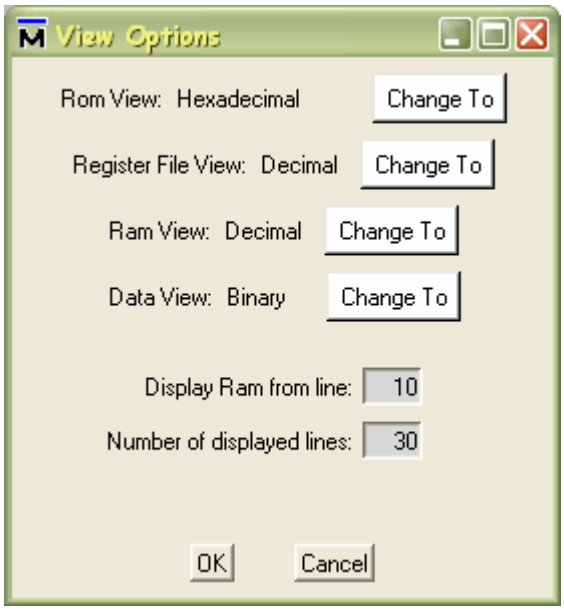

Figure 2. Dialog window for configuring the visualisation options.

In order to modify the representation format just click on the button labelled as ***Change To*** in the corresponding section. When this button is clicked a menu will appear where it will be possible to choose among the binary, octal, hexadecimal and decimal formats. The ***Data View*** section in this dialog window refers to the representation format to be used in the information section of the graphical interface.

- The button labelled as Breakpoints permits to manage the kind of breakpoint to be set during the simulation. Upon clicking on this button the dialog window shown in figure 3 will appear. As it can be seen in this figure, it is possible to establish breakpoints related to the type of instruction executed by the microcontroller, the type of access to the RAM memory unit and the type of access to the register file. The breakpoint configured in this way will be activated when the check box placed on the left of each option is active (i.e., the ***OK*** button placed at the bottom of the dialog window just closes the window). The type of instruction for which a breakpoint will be generated can be changed by clicking on the button labelled as ***Change To***. This will open a menu with the list of the instructions available in the microcontroller. For the rest of the breakpoints it is important to bear in mind that the value entered in their configuration has to be given in the format specified on the left of each configuration line. When the condition corresponding to a given breakpoint is met, apart from stopping the simulation an additional window will be displayed with information related with the condition that triggered it.

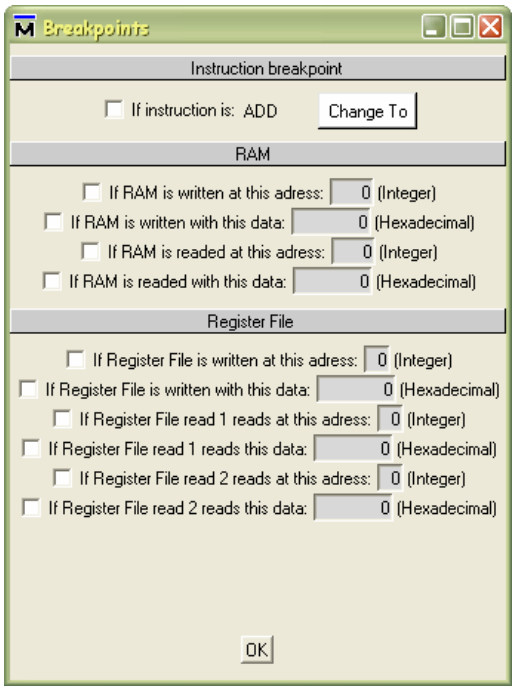

Figure 3. Dialog window for the configuration of the breakpoints.

- The button labelled as  corresponds to the ***restart –f*** ModelSim command, so that it will re-initialise the simulation.

2.2. Interaction section

This section will show detailed information about the current execution state of the code, and also about the contents of the RAM and of the register file. On the left of this section there is a window called ***Rom Data***. This window shows the program to be executed by the microcontroller. For every line it is displayed, from left to right, the memory address, its content and the instruction in assembly code corresponding to this content. When the program counter changes the content of this window will be scrolled, so that its first line will always correspond to the instruction that is being executed at a given moment. Furthermore, at the beginning of this line it will appear the symbol  to indicate the instruction that is being executed.

It is possible to establish breakpoints directly in the ***Rom Data*** window. To do it just click with the right mouse button at the beginning of the line where the breakpoint is to be set. It is possible to set as many breakpoints as desired. They will be identified by the symbol  at the beginning of the corresponding line.

In the upper right part of the interaction section there is a window called ***Regfile Data***. This window allows for visualising the contents of the register file of the microcontroller. The scrolling of this window is done automatically depending on the registers being updated at a given time. It is also possible to modify the content of a specific register. To do it just click with the right mouse button in the line corresponding to a given register. As a consequence a dialog window like that shown in figure 4 will be displayed, where it will be possible to modify the content of the desired register.

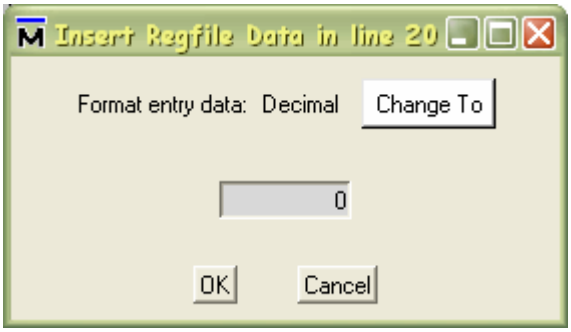

Figure 4. Dialog window for modifying the content of a register.

Finally, in the bottom right part of the interaction section there is a window called ***Ram Data***. It permits to visualise the contents of the RAM memory unit of the microcontroller. The scrolling of this window is performed automatically, depending on the memory location that is being updated at a given time. It is also possible to modify the content of a specific memory position. To do it just click with the right mouse button in the line corresponding to a given memory location. As a consequence a dialog window like that shown in figure 5 will be displayed, where it will be possible to modify the content of the desired memory location.

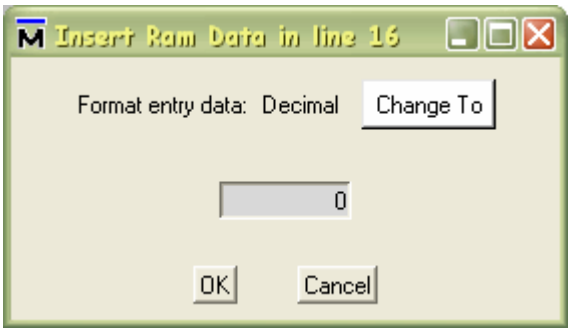

Figure 5. Dialog window for modifying the content of a memory location.

2.3. Information section

As it has been explained previously, this section provides during the simulation process detailed information about the most important signals and registers of the microcontroller, so that it will be possible to inspect the state of the system in every step of the execution of an application.