Model*Sim* EE/PLUS

Tutorial

The Model*Sim* Elite Edition for

VHDL, Verilog, and Mixed-HDL Simulation

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1 - Introduction

Chapter contents

The purpose of this tutorial is to help you become familiar with Model*Sim* EE, Model Technology's HDL-simulation software for UNIX, Microsoft Windows NT 4.0, and Windows 95/98. Tutorials are included that apply to one or more of the following Model*Sim* simulators:

- **Model*Sim* EE/VHDL**
  for VHDL simulation only
- **Model*Sim* EE/VLOG**
  for Verilog simulation only
- **Model*Sim* EE/LNL**
  Language-Neutral Licensing - for either VHDL, **or** Verilog simulation
- **Model*Sim* EE/PLUS**
  for single language, or mixed VDHL/Verilog simulation

Software versions

This documentation was written to support Model*Sim* EE/PLUS 5.2 for UNIX, Microsoft Windows NT 4.0, and Windows 95/98. If the Model*Sim* software you are using is a later release, check the README file that accompanied the software. Any supplemental information will be there.

Although this document covers both VHDL and Verilog simulation, you will find it a useful reference even if your design work is limited to a single HDL.

Model*Sim*’s graphic interface

While your operating system interface provides the window-management frame, Model*Sim* controls all internal-window features including menus, buttons, and scroll bars. The resulting simulator interface remains consistent within these operating systems:

- SPARCstation with OpenWindows or OSF/Motif
- IBM RISC System/6000 with OSF/Motif
- Hewlett-Packard HP 9000 Series 700 with HP VUE or OSF/Motif
- Microsoft Windows NT and Windows 95/98

Because Model*Sim*’s graphic interface is based on Tcl/TK, you also have the tools to build your own simulation environment. Easily accessible preference variables and configuration commands give you control over the use and placement of windows, menus, menu options and buttons.

For an in-depth look at Model*Sim*’s graphic interface see, "ModelSim EE Graphic Interface" (p17).

Standards supported

Model*Sim* VHDL supports both the IEEE 1076-1987, 1076-1993 VHDL, 1164-1993 *Standard Multivalue Logic System for VHDL Interoperability*, and the 1076.2-1996 *Standard VHDL Mathematical Packages* standards. Any design developed with Model*Sim* will be compatible with any other VHDL system that is compliant with either IEEE Standard 1076-1987 or 1076-1993.

Model*Sim* Verilog is based on the IEEE Std 1364-1995 *Standard Hardware Description Language Based on the Verilog Hardware Description Language*. The Open Verilog International *Verilog LRM version 2.0* is also applicable to a large extent. The PLI is supported for PE and EE users, while VCD support is available for EE users only.

In addition, all products support SDF 1.0, 2.0, and 2.1, VITAL 2.2b, and VITAL’95 - IEEE 1076.4-1995.

Assumptions

We assume that you are familiar with the use of your operating system. You should be familiar with the window management functions of your graphic interface: either OpenWindows, OSF/Motif, or Microsoft Windows NT/95/98.

We also assume that you have a working knowledge of VHDL and Verilog. Although Model*Sim* is an excellent tool to use while learning HDL concepts and practices, this document is not written to support that goal. If you need more information about HDLs, check out our. "Online References" (p165).

Sections in this document

In addition to this introduction, you will find the following major sections in this document:

2 - ModelSim EE Graphic Interface (p17)
This chapter describes the graphic interface available while operating VSIM, the Model*Sim* simulator. Model*Sim*'s graphic interface is designed to provide consistency throughout all operating system environments.

3 - ModelSim EE Lessons (p91)
This is a collection of lessons for ModelSim EE. Lessons are included for all versions of EE: VHDL, VLOG, and PLUS. The Tcl lesson gives you a chance to create a custom simulation environment.

A - Technical Support, Updates, and Licensing (p159)

How and where to get tech support, updates and licensing for Model*Sim*. Links to the Model Technology web site; a collection of references to books, organizations, and companies involved in EDA and simulation.

Text conventions

Text conventions used in this manual include:

italic text	provides emphasis and sets off file and path names
bold text	indicates commands, command options, and menu choices, as well as package and library logical names
`monospaced type`	monospace type is used for program and command examples
The right angle (>)	is used to connect menu choices when traversing menus as in: **File > Save**
path separators	examples will show either UNIX or Windows path separators - use separators appropriate for you operating system when trying the examples

HDL and HDL item defined

"HDL" refers to either VHDL or Verilog when a specific language reference is not needed. Depending on the context, "HDL item" can refer to any of the following:

- **VHDL**
  block statement, component instantiation, constant, generate statement, generic, package, signal, or variable
- **Verilog**
  function, module instantiation, named fork, named begin, net, task, or register variable

Syntax conventions

The syntax elements of Model*Sim* commands are signified as follows:

< >	angled brackets surrounding a syntax item indicate a user-defined argument; do not enter the brackets in commands
[ ]	square brackets indicate an optional item; if the brackets surround several words, all must be entered as a group; the brackets are not entered
...	an ellipsis indicates items that may appear more than once; the ellipsis itself does not appear in commands.
|	the vertical bar indicates a choice between items on either side of it. Do not include the bar in the command
#	comments are preceded by the number sign (#)

Where to find our documentation

Model Technology's documentation is available in the following formats and locations:

Document	Format	How to get it
Start Here for ModelSim (installation & support reference)	paper	shipped with the product
	PDF online	find "ee_start_here.pdf" in the "<install_dir>/<modelsim_dir>/docs" directory; also available from the Support page of our web site: www.model.com
Documentation Index	PDF online	find "ee_doc_index.pdf" in the "<install_dir>/<modelsim_dir>/docs" directory after installation; also see Doc Index bookmark in PDF docs; provides links to all installed PDF documentation
ModelSim EE Tutorial	PDF online	find "ee_tutorial_<version>.pdf" in the "<install_dir>/<modelsim_dir>/docs" directory; current version available from the Support page of our web site: www.model.com
	paper	first two copies free with request cards in *Start Here* document; additional copies at $50 each (for customers with current maintenance)
EE Reference Manual	PDF online	find "ee_manual_<version>.pdf" in "<install_dir>/<modelsim_dir>/docs"; current version available for ftp from the Support page of our web site: www.model.com (password required)
	paper	first two copies free with request cards in *Start Here* document; additional copies at $50 each (for customers with current maintenance)
Tcl man pages	HTML	find "contents.html" in "<install_dir>/<modelsim_dir>/docs/html/", or use the Main window menu selection: Help > Tcl Man Pages
tech notes	ASCII	located in the "<install_dir>/<modelsim_dir>/docs/technotes"directory after installation

Download a free PDF reader

Model Technology's PDF documentation requires an Adobe Acrobat Reader for viewing. The Reader may be installed from the Model*Sim* CD. It is also available without cost from Adobe at http://www.adobe.com. Be sure to download the Acrobat Reader with Search to take advantage of the index file supplied with our reference manuals; the index makes searching the documentation much faster.

Comments

Comments and questions about this manual and Model*Sim* software are welcome. Call, write, or fax or email:

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2 - Model*Sim* EE Graphic Interface

Chapter contents

This chapter describes Model*Sim's* graphic interface.

The example graphics in this chapter illustrate Model*Sim*'s graphic interface within both Windows and UNIX. Since our interface is designed to provide consistency in all system environments, your operating system's job is to provide the basic window-management frames, while Model*Sim* controls all internal window features such as menus, buttons, and scroll bars.

Because Model*Sim*'s graphic interface is based on Tcl/Tk, you are able to customize your simulation environment. Easily-accessible preference variables and configuration commands give you control over the use and placement of windows, menus, menu options, and buttons.

The "Tcl/Tk and ModelSim" (p115) section in the ModelSim EE Lessons (p91) chapter will provide you with some hands-on experience using Tcl/Tk with Model*Sim*.

Window overview

The ModelSim simulation environment consists of nine window types. Multiple windows of each type may be used during simulation (with the exception of the Main window) A brief description of each window follows:

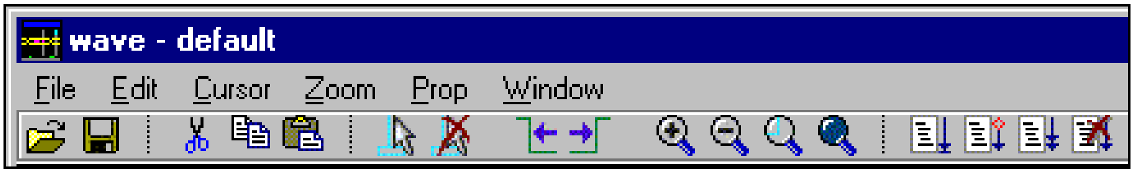
- Main window (p24)
  The main window from which all subsequent VSIM windows are available.
- Dataflow window (p35)
  Lets you trace signals and nets through your design by showing related processes.
- List window (p38)
  Shows the simulation values of selected VHDL signals, and Verilog nets and register variables in tabular format.
- Process window (p52)
  Displays a list of processes that are scheduled to run during the current simulation cycle.
- Signals window (p55)
  Shows the names and current values of VHDL signals, and Verilog nets and register variables in the region currently selected in the Structure window.
- Source window (p61)
  Displays the HDL source code for the design.
- Structure window (p67)
  Displays the hierarchy of structural elements such as VHDL component instances, packages, blocks, generate statements, and Verilog model instances, named blocks, tasks and functions.
- Variables window (p70)
  Displays VHDL constants, generics, variables, and Verilog register variables in the current process and their current values.
- Wave window (p73)
  Displays waveforms, and current values for the VHDL signals, and Verilog nets and register variables you have selected.

Window features

Model*Sim*'s graphic interface provides many features that add to its usability; features common to many of the windows are described below.

Feature	Feature applies to these windows
Quick access toolbar (p19)	Main, Source, and Wave
Drag and Drop (p20)	Dataflow, List, Signals, Source, Structure, Variables, and Wave windows
Automatic window updating (p20)	Dataflow, Process, Signals, and Structure
Finding names, and searching for values (p21)	various windows
Sorting HDL items (p21)	Process, Signals, Source, Structure, Variables and Wave windows
Multiple window copies (p21)	all windows except the Main window
Menu tear off (p21)	all windows
Tree window hierarchical view (p22)	all windows
Tree window hierarchical view (p22)	Structure, Signals, Variables, and Wave windows

Quick access toolbar



Buttons on the Main, Source, and Wave windows provide access to commonly used commands and functions. See, "The Main window tool bar" (p30), "The Source window tool bar" (p64), and "Wave window tool bar" (p78).

Drag and Drop

Drag and drop of HDL items is possible between the following windows. Using the left mouse button, click and release to select an item, then click and hold to drag it.

- **Drag items from these windows:**
  Dataflow, List, Signals, Source, Structure, Variables, and Wave windows
- **Drop items in these windows:**
  List and Wave windows

Note: Drag and drop works to move items *within* the List and Wave windows as well.

Automatic window updating

Selecting an item in the following windows automatically updates other related Model*Sim* windows as indicated below:

Select an item in this window	To update these windows
Dataflow window (p35) (with a process selected in the center of the window)	Process window (p52)
	Signals window (p55)
	Source window (p61)
	Structure window (p67)
	Variables window (p70)
Process window (p52)	Dataflow window (p35)
	Signals window (p55)
	Structure window (p67)
	Variables window (p70)
Signals window (p55)	Dataflow window (p35)
Structure window (p67)	Signals window (p55)
	Source window (p61)

Finding names, and searching for values

- **Find** HDL item names with the **Edit** > **Find** menu selection in these windows: List, Process, Signals, Source, Structure, Variables, and Wave windows.
- **Search** for HDL item values with the **Edit** > **Search** menu selection in these windows: List, and Wave windows.

You can also:

- **Locate** time markers in the List window with the **Markers** > **Goto** menu selection.
- **Locate** time cursors in the Wave window with the **Cursor** > **Goto** menu selection.

In addition to the menu selections above, the virtual event **<<Find>>** is defined for all windows. The default binding is to **<Key-F19>** in most windows (the Find key on a Sun keyboard). You can bind **<<Find>>** to other events with the Tcl/Tk command **event add**. For example,

```
event add <<Find>> <control-Key-F>
```

Sorting HDL items

Use the **Edit** > **Sort** menu selection in the windows below to sort HDL items in ascending, descending or declaration order.

Process, Signals, Source, Structure, Variables and Wave windows

Names such as net_1, net_10, and net_2 will sort numerically in the Signals and Wave windows.

Multiple window copies

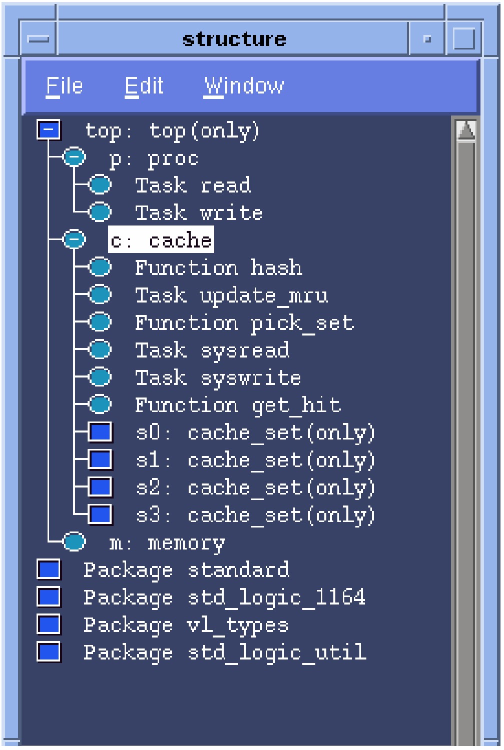
Use the **View** > **New** menu selection from the Main window (p24) to create multiple copies of the same window type. The new window will become the default window for that type.

Menu tear off

All window menus may be "torn off " to create a separate menu window. To tear off, click on the menu, then select the dotted-line button at the top of the menu.

Tree window hierarchical view

Model*Sim* provides a hierarchical, or "tree view" of some aspect of your design in the Structure, Signals, Variables, and Wave windows.



```
top: top(only)
  p: proc
    Task read
    Task write
  c: cache
    Function hash
    Task update_mru
    Function pick_set
    Task sysread
    Task syswrite
    Function get_hit
    s0: cache_set(only)
    s1: cache_set(only)
    s2: cache_set(only)
    s3: cache_set(only)
  m: memory
Package standard
Package std_logic_1164
Package vl_types
Package std_logic_util
```

HDL items you can view
Depending on which window you are viewing, one entry is created for each of the following VHDL and Verilog HDL item within the design:

VHDL items
(indicated by a "box" prefix)
signals, variables, component instantiation, generate statement, block statement, and package

Verilog items
(indicated by a "circle" prefix)
parameters, registers, nets, module instantiation, named fork, named begin, task, and function

Viewing the hierarchy

Whenever you see a tree view, as in the Structure window above, you can use the mouse to collapse or expand the hierarchy. Select the symbols as shown below to change the view of the structure.

Symbol	Description
[+]	click a plus box/circle to expand the item and view the structure
[-]	click a minus box/circle to hide a hierarchy that has been expanded
[ ]	an empty box/circle indicates a single-level item

Tree window action list

Action	Use	Do
expand a level	left mouse button	click on a "+" box/circle
collapse a level	left mouse button	click on a "-" box/circle
select a single item	left mouse button	click on the HDL item name (not the box/circle prefix)
select multiple contiguous items (not in Structure window)	left mouse button	click on the HDL item name and drag to complete selection
select a range of contiguous items (not in Structure window)	shift + left mouse button	select first item, shift/click on last item in range
select multiple random items (not in Structure window)	control + left mouse button	click on the desired items in any order
move an item	left mouse button	click on an item, then reselect, hold, and drag it to reposition

Finding items within tree windows

You can open the find dialog box within all windows (except the Main, and Source windows) by using this keyboard shortcut:

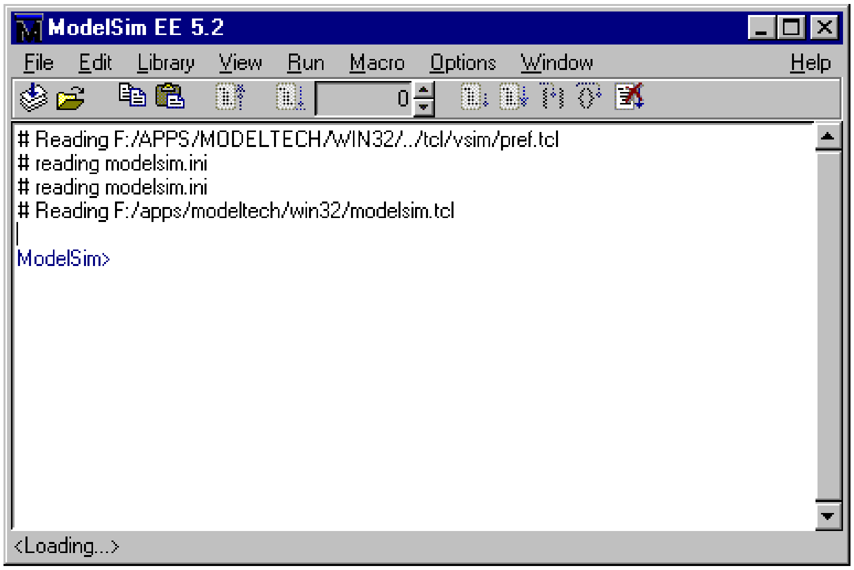
<control-f>

Options within the Find dialog box allow you to search unique text-string fields within the specific window. See also,

- "Finding items by name in the List window" (p48),
- "Finding HDL items in the Signals window" (p60), and
- "Finding items by name or value in the Wave window" (p85).

Main window

The Main window is pictured below as it appears when VSIM is first invoked. Note that your operating system graphic interface provides the window-management frame only; Model*Sim* handles all internal-window features including menus, buttons, and scroll bars.



```
# Reading F:/APPS/MODELTECH/WIN32/../tcl/vsim/pref.tcl
# reading modelsim.ini
# reading modelsim.ini
# Reading F:/apps/modeltech/win32/modelsim.tcl

ModelSim>
```

<Loading...>

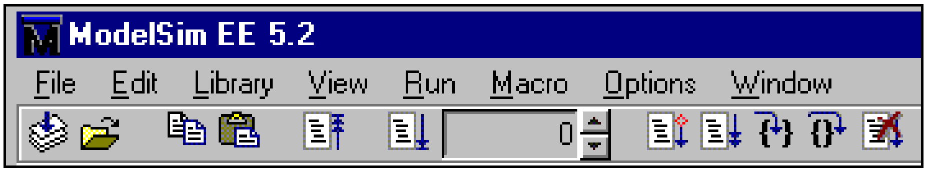
The menu bar at the top of the window provides access to a wide variety of simulation commands and Model*Sim* preferences. The status bar at the bottom of the window gives you information about the data in the active Model*Sim* window. The tool bar provides buttons for quick access to the many common commands.

When a simulation is running, the Main window displays a VSIM prompt, allowing you to enter command-line commands from within the graphic interface. Messages output by VSIM during simulation are also displayed in this window. You can scroll backward and forward through the current work history by using the vertical scrollbar. You can also copy and paste using the mouse within the window, see "Editing the command line, the current source file, and notepads" (p33).

The Main window menu bar, tool bar, and status bar are detailed below.

The Main window menu bar

The menu bar at the top of the Main window lets you access many Model*Sim* commands and features. The menus are listed below with brief descriptions of the command's use.



File menu

Change Directory	change to a different working directory
Load New Design	start a new simulation via the Load Design dialog box
Restart	restart the current simulation from time zero; a dialog box provides options to keep the List and Wave formats, breakpoints, and logged signals
End Simulation	Quit the current simulation and return to the ModelSim prompt, the GUI remains open; same as the **quit -sim** command
Save Main	save the current contents of the transcript window to the previously defined file, see "Saving the transcript file" (p29)
Save Main as...	save the current contents of the transcript window to a file, see "Reusing commands from the Main transcript" (p93)
Clear Transcript	clear the Main window transcript display
Options (all options are set for the current session only)	Transcript File: sets a transcript file to save for this session only Command History: file for saving command history only, no comments Save File: sets filename for Save Main, and Save Main as Saved Lines: limits the number of lines saved in the transcript (default is all) Line Prefix: specify the comment prefix for the transcript Update Rate: specify the update frequency for the Main status bar ModelSim Prompt: change the title of the ModelSim prompt VSIM Prompt: change the title of the VSIM prompt Paused Prompt: change the title of the Paused prompt
Path list	**Windows only** - a list of the most recent working directory changes
Quit	quit Model*Sim* (returns to the command line if UNIX)

Edit menu

Copy	copy the selected text
Paste	paste the previously cut or copied item to the left of the currently selected item
Select All	delete the selected item field
Unselect All	combine the selected fields into a user-defined bus; keep copies of the original items rather than moving them
Find	search the transcript forward or backward for the specified text string

Library menu

Browse Libraries	browse all libraries within the scope of the design
Create a New Library	create a new library or map a library to a new name
View Library Contents	view or delete the contents of a library

View menu

All	open all VSIM windows
Source	open and/or view the Source window (p61)
Structure	open and/or view the Structure window (p67)
Variables	open and/or view the Variables window (p70)
Signals	open and/or view the Signals window (p55)
List	open and/or view the List window (p38)
Process	open and/or view the Process window (p52)
Wave	open and/or view the Wave window (p73)
Dataflow	open and/or view the Dataflow window (p35)
New	create a new VSIM window of the specified type

Run menu

Run <default>	run simulation for one default run length; change the run length with Options > Simulation, or use the Run Length list on the tool bar
Run -All	run simulation until you stop it
Continue	continue the simulation
Run -Next	run to the next event time
Step	single-step the simulator
Step-Over	execute without single-stepping through a subprogram call

Macro menu

Execute Macro	allows you to browse for and execute a DO file (macro)
Macro Helper	**Unix only** - invokes the Macro Helper tool
Tcl Debugger	invokes the Tcl debugger, TDebug

Options menu

Compile	returns the Compile Options dialog box; options cover both VHDL and Verilog compile options
Simulation	returns the Simulation Options dialog box; options include: default radix, default force type, default run length, iteration limit, warning suppression, and break on assertion specification
Edit Preferences...	returns the Preferences dialog box; color preferences can be set for window background, text and graphic items (i.e., waves in the Wave window)
Save Preferences	save current Model*Sim* settings to a Tcl preference file

Window menu

Initial Layout	restore all windows to the size and placement of the initial full-screen layout
Cascade	cascade all open windows
Tile Horizontally	tile all open windows horizontally
Tile Vertically	tile all open windows vertically
Icon Children	icon all but the Main window
Icon All	icon all windows
Deicon All	deicon all windows
Customize	use the Button Adder to define and add a button to either the menu bar, tool bar, or status bar of the specified window
<window_name>	lists the currently open windows; select a window name to switch to, or show that window if it is hidden; when the source window is available, the source file name is also indicated; open additional windows from the "View menu" (p26)

Help menu

About ModelSim	display Model*Sim* application information
Release Notes	view current release notes
Information about Help	view the readme file pertaining to Model*Sim*'s online documentation
ModelSim EE Tutorial	open and read the *ModelSim EE Tutorial* (.pdf) file; PDF files can be read with a free Adode Acrobat reader available through www.adobe.com
ModelSim EE/PLUS Reference Manual	open and read the *EE Reference Manual* Acrobat (.pdf) file; PDF files can be read with a free Adode Acrobat reader available through www.adobe.com
Tcl Man Pages	open and read Tcl 7.6/Tk 4.2 manual in HTML format (uses a Tcl/Tk HTML viewer)
Technotes	select a technical note to view from the drop-down list

Saving the transcript file

Variable settings determine the filename used for saving the Main window transcript. If either PrefMain(file) in *modelsim.tcl*, or TranscriptFile in *modelsim.ini* file is set, then the transcript output is logged to the specified file. By default the TranscriptFile variable in *modelsim.ini* is set to *transcript*. If either variable is set, the transcript contents are always saved and no explicit saving is necessary.

Note: The log file specified above cannot be changed during the simulation session.

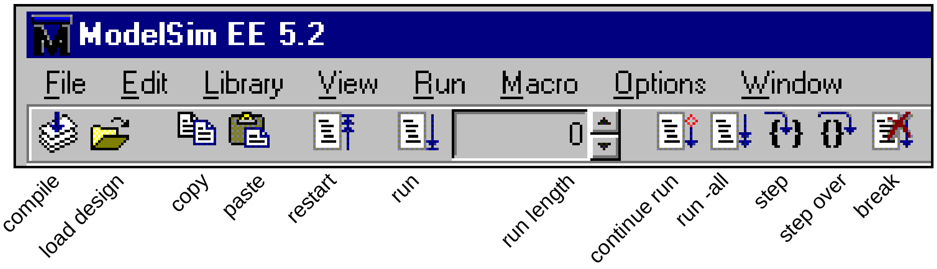
If you would like to save an additional copy of the transcript with a different filename, you can use the File > Save Main As, or File > Save Main menu items. The initial save must be made with the Save Main As selection, which stores the filename in the Tcl variable PrefMain(saveFile). Subsequent saves can be made with the Save Main selection. Since no automatic saves are performed for this file, it is written only when a Save... menu selection is made. The file is written to the current working directory and records the contents of the transcript at the time of the save.

Using the saved transcript as a macro (DO file)

Saved transcript files can be used as macros (DO files), see "Reusing commands from the Main transcript" (p93) for more information.

The Main window tool bar

Buttons on the Main window tool bar give you quick access to these Model*Sim* commands and functions.



Main window tool bar buttons

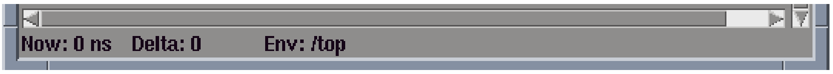
Button	Menu equivalent	Command equivalents
Compile open the Compile HDL Source Files dialog box to select files for compilation	none, however, Options > Compile opens the Compile Options dialog box	**vcom** <arguments>, or **vlog** <arguments>
Load Design open the Load a Design dialog box to initiate simulation	File > Load New Design	**vsim** <arguments>
Copy copy the selected text within the Main window transcript	Edit > Copy	see: "Editing the command line, the current source file, and notepads" (p33)
Paste paste the copied text to the cursor location	Edit > Paste	see: "Editing the command line, the current source file, and notepads" (p33)

Main window tool bar buttons

Button	Menu equivalent	Command equivalents
Restart restart the current simulation with the option of use current formatting, breakpoints, and log file	File > Restart	**restart** <arguments>
Run run the current simulation for the default time length	Run > Run <default_run_length>…	**run** (no arguments)
0 **Run Length** specify the run length for the current simulation	none	**run** <specific run length>
Continue Run continue the current simulation run	Run > Continue	**run -continue**
Run -All run to current simulation forever, or until it hits a breakpoint or specified break event *	Run > Run -All	**run -all**
Step steps the current simulation to the next HDL statement	Run > Step….	**step**
Step Over HDL statements are executed but treated as simple statements instead of entered and traced line by line	Run > Step Over….	**step -over**

Main window tool bar buttons		
Button	**Menu equivalent**	**Command equivalents**
Break stop the current simulation run	none	execute a break when the Main window is active with <control-c>

The Main window status bar



Now: 0 ns Delta: 0 Env: /top

Fields at the bottom of the Main window provide the following information about the current simulation:

Field	Description
Now	the current simulation time or a larger time unit if one can be used without a fractional remainder
Delta	the current simulation iteration number
Env	name of the current environment (item selected in the Structure window (p67))

Editing the command line, the current source file, and notepads

The following mouse actions and special keystrokes can be used to edit commands in the entry region of the Main window. They can also be used in editing the file displayed in the Source window (p61) and all **notepad** windows (enter the notepad command at the VSIM prompt to open the notepad editor).

Mouse - UNIX	Mouse - Windows	Result
< left-button - click >		move the insertion cursor
< left-button - press > + drag		select
< shift - left-button - press >		extend selection
< left-button - double-click >		select word
< left-button - double-click > + drag		select word + word
< control - left-button - click >		move insertion cursor without changing the selection
< left-button - click > on previous ModelSim or VSIM prompt		copy and paste previous command string to current prompt
< middle-button - click >	none	paste clipboard
< middle-button - press > + drag	none	scroll the window

Keystrokes - UNIX	Keystrokes - Windows	Result
< left | right - arrow >		move the insertion cursor
< up | down - arrow >		scroll through command history
< control - p >		move insertion cursor to previous line
< control - n >		move insertion cursor to next line
< control - f >		move insertion cursor forward
< control - b >		move insertion cursor backward
< backspace >		delete character to the left

Keystrokes - UNIX	Keystrokes - Windows	Result
< control - d >		delete character to the right
< control - k >		delete to the end of line
< control - a >	< control - a >, <Home>	move insertion cursor to beginning of line
< control - e >	< control - e >, <End>	move insertion cursor to end of line
< * meta - "<" >	none	move insertion cursor to beginning of file
< * meta - ">" >	none	move insertion cursor to end of file
< control - w >	< control - x >	cut selection
< *meta - w >	< control - c > **	copy selection
< control - y >	< control - v >	insert clipboard

The Main window allows insertions or pastes only after the prompt, therefore, you don’t need to set the cursor when copying strings to the command line.

* **Unix only**

Which keyboard key functions as the meta key depends on how your X-windows KeySym mapping is set up. You may need help from your system administrator to map a particular key, such as the <alt> key, to the meta KeySym.

** **Windows**

<control - c> copies text in all but the Main window; in the Main window <control-c> performs a Break.

Dataflow window

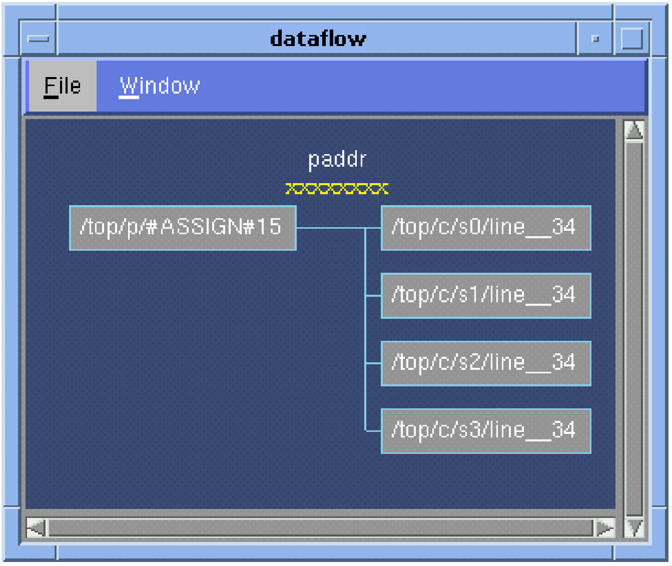
The Dataflow window allows you to trace VHDL signals or Verilog nets through your design. Double-click an item with the left mouse button to move it to the center of the Dataflow display.

VHDL signals or processes in the Dataflow window:

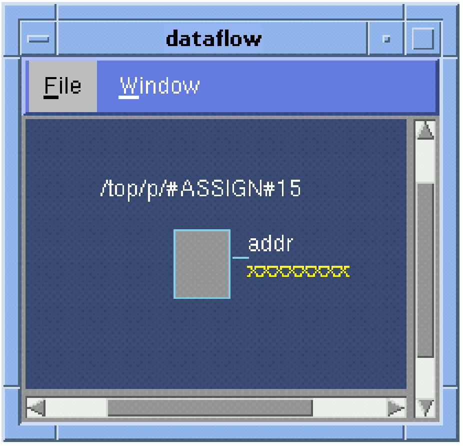
- A signal displays in the center of the window with all the processes that drive the signal on the left, and all the processes that read the signal on the right, or
- a process is displayed with all the signals read by the process shown as inputs on the left of the window, and all the signals driven by the process on the right.

Verilog nets or processes in the Dataflow window:

- A net displays in the center of the window with all the processes that drive the net on the left, and all the processes triggered by the net on the right, or
- a process is displayed with all the nets that trigger the process shown as inputs on the left of the window, and all the nets driven by the process on the right.



signal or net "paddr"



process "#ASSIGN#15"

The Dataflow window menu bar

The following menu commands and button options are available from the Dataflow window menu bar.

File menu

Save Postscript	save the current dataflow view as a Postscript file
Selection	Selection > Follow Selection updates window when the Process window (p52) or Signals window (p55) changes; Fix Selection freezes the view selected from within the Dataflow window
Close	close this copy of the Dataflow window; you can create a new window with View > New from the "The Main window menu bar" (p25)

Window menu

Initial Layout	restore all windows to the size and placement of the initial full-screen layout
Cascade	cascade all open windows
Tile Horizontally	tile all open windows horizontally
Tile Vertically	tile all open windows vertically
Icon Children	icon all but the Main window
Icon All	icon all windows
Deicon All	deicon all windows
Customize	use the Button Adder to define and add a button to either the menu bar, tool bar, or status bar of the specified window
<window_name>	lists the currently open windows; select a window name to switch to, or show that window if it is hidden; when the source window is available, the source file name is also indicated; open additional windows from the "View menu" (p26)

Tracing HDL items with the Dataflow window

The Dataflow window is linked with the Signals window (p55) and the Process window (p52). To examine a particular process in the Dataflow window, click on the process name in the Process window. To examine a particular HDL item in the Dataflow window, click on the item name in the Signals window.

with a signal in center of the Dataflow window, you can:

- click once on a process name in the Dataflow window to make the Source and Variable windows update to show that process,
- click twice on a process name in the Dataflow window to move the process to the center of the Dataflow window

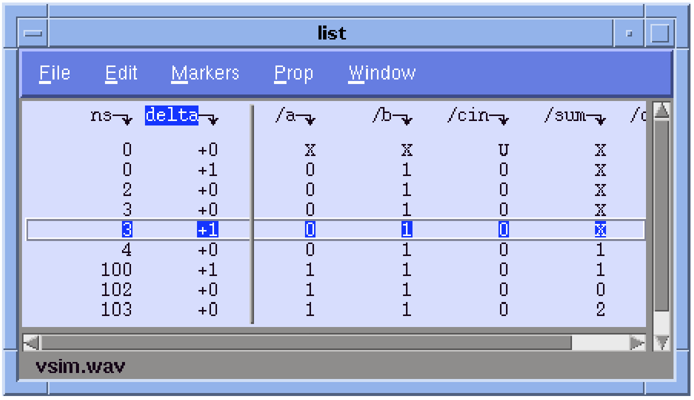
with a process in center of the Dataflow window, you can:

- click once on an item name to make the Source and Signals windows update to show that item,
- click twice on an item name to move that item to the center of the Dataflow window.

The Dataflow window will display the current process when you single-step or when VSIM hits a breakpoint.

List window

The List window displays the results of your simulation run in tabular format. The window is divided into two adjustable panes, which allow you to scroll horizontally through the listing on the right, while keeping time and delta visible on the left.



```
    ns   delta    /a      /b     /cin    /sum   /c
     0    +0       X       X       U       X
     0    +1       0       1       0       X
     2    +0       0       1       0       X
     3    +0       0       1       0       X
     3    +1       0       1       0       X
     4    +0       0       1       0       1
   100    +1       1       1       0       1
   102    +0       1       1       0       0
   103    +0       1       1       0       2
```

HDL items you can view

One entry is created for each of the following VHDL and Verilog HDL items within the design:

VHDL items

signals and process variables

Verilog items

nets and register variables

Note: Constants, generics, parameters, and memories are not viewable in the List or Wave windows.

List window action list

This action list provides a quick reference to menu selections and mouse actions in the List window. See the "Tree window action list" (p23) for additional information.

Action	Menu or mouse	See also
place specific HDL items in the List window	Signals window (p55) menu: View > List (choose Selected Signals, Signals in Region, or Signals in Design) drag and drop: from the Process, Signals, or Signals window	"Adding HDL items to the List window" (p44)

Action	Menu or mouse	See also
move or delete items already in the List window	menu selection: Edit > (select Cut, Copy, Paste, Delete, Combine, Select All, or Unselect All) drag and drop: within the List window	"Adding HDL items to the List window" (p44)
set display properties such as name length, trigger on options, delta views, and strobe timing	menu selection: Prop > Display Props	"Setting List window display properties" (p42)
format an item's radix, label, width, and triggering properties	menu selection: Prop > Signal Props	"Editing and formatting HDL items in the List window" (p45)
save your listing to an ASCII file	menu selection: File > Write List (select tabular, events or TSSI format)	"Saving List window data to a file" (p51)
save your List window configuration for future use	menu selection: File > Save Format	"Adding HDL items to the List window" (p44)
reuse a List window configuration	menu selection: File > Load Format	"Adding HDL items to the List window" (p44)
finding an HDL item by name	menu selection: Edit > Find	"Finding items by name in the List window" (p48)
finding the value of an HDL item	menu selection: Edit > Search	"Searching for item values in the List window" (p48)
set, delete or go to a time marker in the listing	menu selection: Markers > (choose Add Marker, Delete Marker, or Goto)	"Setting time markers in the List window" (p50)

The List window menu bar

The following menu commands and button options are available from the List window menu bar.

File menu

Write List (format)	save the listing as a text file in one of three formats: tabular, events, or TSSI
Load Format	run a List window format DO file previously saved with Save Format
Save Format	saves the current List window display and signal preferences to a do (macro) file; running the DO file will reformat the List window to match the display as it appeared when the DO file was created
Close	close this copy of the List window; you can create a new window with View > New from the "The Main window menu bar" (p25)

Edit menu

Cut	cut the selected item field from the listing; see "Editing and formatting HDL items in the List window" (p45)
Copy	copy the selected item field
Paste	paste the previously cut or copied item to the left of the currently selected item
Delete	delete the selected item field
Combine	combine the selected fields into a user-defined bus; keep copies of the original items rather than moving them
Select All	select all signals in the List window
Unselect All	deselect all signals in the List window
Find...	find specified item label within the List window
Search...	search the List window for a specified value, or the next transition for the selected signal

Markers menu

Add Marker	add a time marker at the top of the listing page
Delete Marker	delete the selected marker from the listing
Goto	choose the time marker to go to from a list of current markers

Prop menu

Display Props	set display properties for all items in the window: delta settings, trigger on selection, strobe period, and label size
Signal Props	set label, radix, trigger on/off, and field width for the selected item

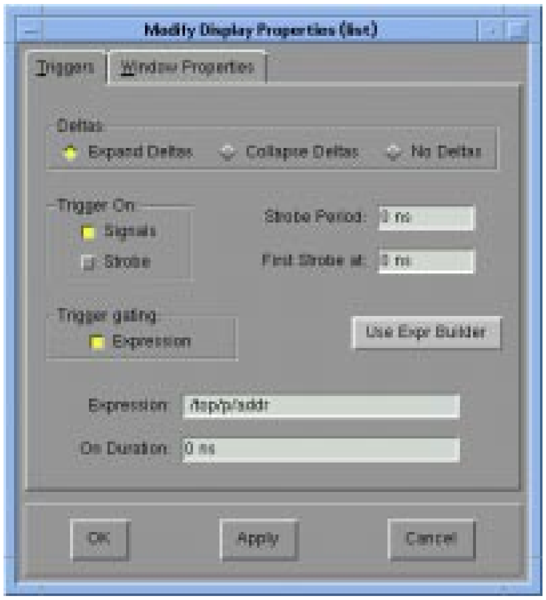
Window menu

Initial Layout	restore all windows to the size and placement of the initial full-screen layout
Cascade	cascade all open windows
Tile Horizontally	tile all open windows horizontally
Tile Vertically	tile all open windows vertically
Icon Children	icon all but the Main window
Icon All	icon all windows
Deicon All	deicon all windows
Customize	use the Button Adder to define and add a button to either the menu bar, tool bar, or status bar of the specified window
<window_name>	lists the currently open windows; select a window name to switch to, or show that window if it is hidden; when the source window is available, the source file name is also indicated; open additional windows from the "View menu" (p26)

Setting List window display properties

Before you add items to the List window you can set the window’s display properties. To change when and how a signal is displayed in the List window, make this selection from the List window menu bar: **Prop > Display Props**. The resulting Modify Display Properties dialog box has the following options.

Trigger settings page


Modify Display Properties (list)

Deltas: ● Expand Deltas ○ Collapse Deltas ○ No Deltas

Trigger On: ☑ Signals □ Strobe

Strobe Period: 0 ns

First Strobe at: 0 ns

Trigger gating: ☑ Expression

Expression: /top/p/addr

On Duration: 0 ns

The Triggers page controls the triggering for the display of new lines in the List window. You can specify whether an HDL item trigger or a strobe trigger is used to determine when the List window displays a new line. If you choose **Trigger on: Signals**, then you can choose between collapsed or expanded delta displays. You can also choose a combination of signal or strobe triggers. To use gating, Signals or Strobe or both must be selected.

The Triggers page includes these options:

- **Deltas:Expand Deltas**
  When selected with the **Trigger on: Signals** check box, displays a new line for each time step on which items change, including deltas within a single unit of time resolution.
- **Deltas:Collapse Deltas**
  Displays only the final value for each time unit in the List window.
- **Deltas:No Deltas**
  No simulation cycle (delta) column is displayed in the List window.
- **Trigger On: Signals**
  Triggers on signal changes. Defaults to all signals. Individual signals may be excluded from triggering by using the **Prop > Signals Props** dialog box.
- **Trigger On: Strobe**
  Triggers on the **Strobe Period** you specify; specify the first strobe with **First Strobe at:**.
- **Trigger Gating: Expression**
  Enables triggers to be gated on and off by an overriding expression, much like a hardware signal analyzer might be set up to start recording data on a specified

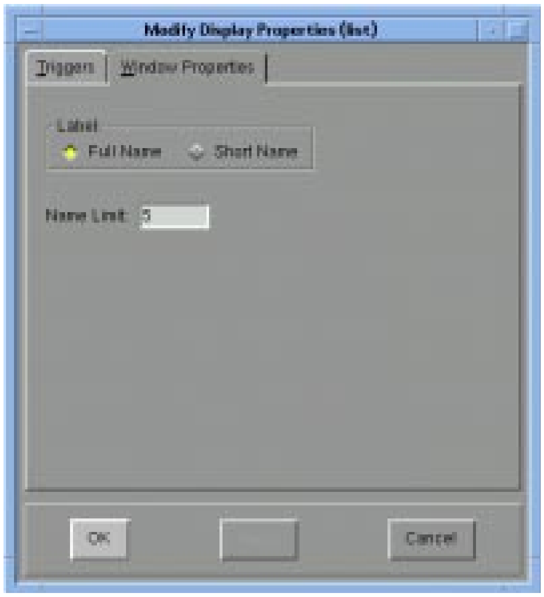
setup of address bits and clock edges. Affects the display of data, not the acquisition of the data.

- **Use Expression Builder** (button)
  Opens the Expression Builder to help you write a gating expression.
- **Expression**
  Enter the expression for trigger gating into this field, or use the Expression Builder (select the Use Expression Builder button). The expression is evaluated when the List window would normally have displayed a row of data (given the trigger on signals and strobe settings above).
- **On Duration**
  The duration for gating to remain open after the last list row in which the expression evaluates to true; expressed in x number of default timescale units. Gating is level-sensitive rather than edge-triggered.

List window gating information is saved as configuration statements when the list format is saved. The gating portion of a configuration statement might look like this:

```
.list.tbl config -usegating 1
.list.tbl config -gateduration 100
.list.tbl config -gateexpr {<expression>}
```

Window Properties page



Label: ● Full Name ○ Short Name

Name Limit: 5

The **Window Properties** page includes these options:

- **Label: Full Name**
  Display the full pathname of the item.
- **Label: Short Name**
  Display the item name without the path.
- **Name Limit**
  The maximum number of number of rows in the name pane.

Adding HDL items to the List window

Before adding items to the List window you may want to set the window display properties (see "Setting List window display properties" (p42)). You can add items to the List window in several ways.

Adding items with drag and drop

You can drag and drop items into the List window from the Process, Signals, or Structure window. Select the items in the first window, then drop them into the List window. Depending on what you select, all items or any portion of the design may be added. See the "Tree window action list" (p23) for information about making item selections.

Adding items from the Main window command line

Invoke the **add list** command to add one or more individual items; separate the names with a space:

```
add list <item_name> <item_name>
```

You can add all the items in the current region with this command:

```
add list *
```

Or add all the items in the design with:

```
add list -r /*
```

Adding items with a List window format file

To use a List window format file you must first save a format file for the design you are simulating. The saved format file can then be used as a DO file to recreate the List window formatting.

- add HDL items to your List window
- edit and format the items to create the view you want, see "Editing and formatting HDL items in the List window" (p45)
- save the format to a file with the List window menu selection: **File** > **Save Format**

To use the format (do) file, start with a blank List window, and run the DO file in one of two ways:

- use the **do** command on the command line:
  ```
  do <my_list_format>
  ```
- select **File** > **Load Format** from the List window menu bar

Use **Edit > Select All** and **Edit > Delete** to remove the items from the current List window or create a new, blank List window with the **View > New > List** selection from the "Main window" (p24). You may find it useful to have two differently formatted windows open at the same time, see "Examining simulation results with the List window" (p47).

Note: List window format files are design-specific; use them only with the design you were simulating when they were created. If you try to the wrong format file, Model*Sim* will advise you of the HDL items it expects to find.

Editing and formatting HDL items in the List window

Once you have the HDL items you want in the List window, you can edit and format the list to create the view you find most useful. (See also, "Adding HDL items to the List window" (p44))

To edit an item:

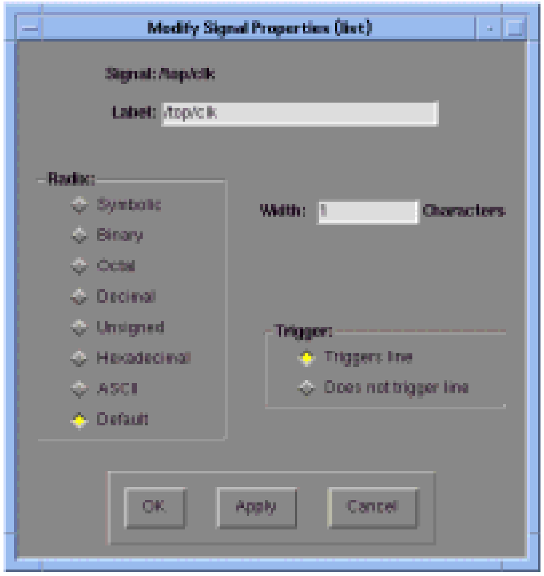
Select the item's label at the top of the List window or one of its values from the listing. Move, copy or remove the item by selecting commands from the List window Edit menu (p40) menu.

You can also click+drag to move items within the window:

- to select several contiguous items:
  click+drag to select additional items to the right or the left of the original selection
- to select several items randomly:
  Control+click to add or subtract from the selected group
- to move the selected items:
  re-click on one of the selected items, hold and drag it to the new location

To format an item:

Select the item's label at the top of the List window or one of its values from the listing, then use the **Prop > Signal Props** menu selection. The resulting Modify Signal Properties dialog box allows you to set the item's label, label width, triggering, and radix.



Modify Signal Properties (list)

Signal: /top/clk

Label: /top/clk

Radix:
- ○ Symbolic
- ○ Binary
- ○ Octal
- ○ Decimal
- ○ Unsigned
- ○ Hexadecimal
- ○ ASCII
- ● Default

Width: 1 Characters

Trigger:
- ● Triggers line
- ○ Does not trigger line

The **Modify Signal Properties** dialog box includes these options:

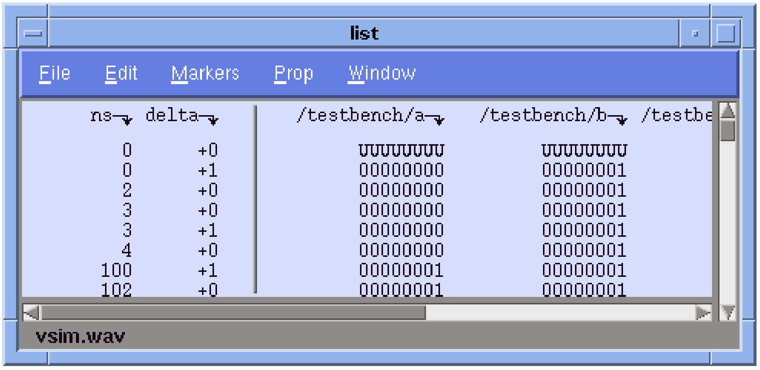
- **Signal**
  Shows the item you selected with the mouse.
- **Label**
  Allows you to specify the label that is to appear at the top of the List window column for the specified item.
- **Radix**
  Allows you to specify the radix (base) in which the item value is expressed. The default radix is symbolic, which means that for an enumerated type, the List window lists the actual values of the enumerated type of that item.

  For the other radixes - binary, octal, decimal, unsigned, hexadecimal, or ASCII - the item value is converted to an appropriate representation in that radix. In the system initialization file, *modelsim.tcl*, you can specify the list translation rules for arrays of enumerated types for binary, octal, decimal, unsigned decimal, or hexadecimal item values in the design unit.
- **Width**
  Allows you to specify the desired width of the column used to list the item value. The default is an approximation of the width of the current value.
- **Trigger: Triggers line**
  Specifies that a change in the value of the selected item causes a new line to be displayed in the List window.
- **Trigger: Does not trigger line**
  Selecting this option in the List Signals window specifies that a change in the value of the selected item does not affect the List window.

The trigger specification affects the trigger property of the selected item. See also, "Setting List window display properties" (p42).

Examining simulation results with the List window

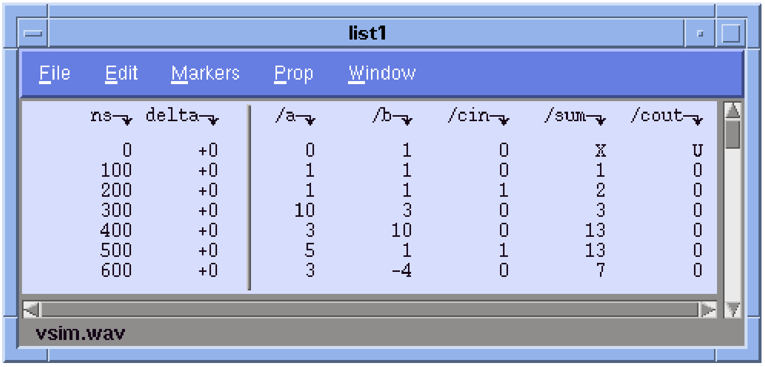
Because you can use the Main window View menu (p26) to create a second List window, you can reformat another List window after the simulation run if you decide a different format would reveal the information you're after. Compare the two illustrations.



```
      ns   delta  |      /testbench/a     /testbench/b   /testbe
                  |
       0      +0  |          UUUUUUUU         UUUUUUUU
       0      +1  |          00000000         00000001
       2      +0  |          00000000         00000001
       3      +0  |          00000000         00000001
       3      +1  |          00000000         00000001
       4      +0  |          00000000         00000001
     100      +1  |          00000001         00000001
     102      +0  |          00000001         00000001
```

symbolic item format -
item change triggers a new line

- the divider bar separates resolution and delta from values



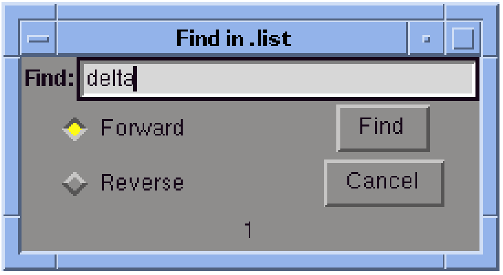
```
      ns   delta  |  /a      /b      /cin     /sum    /cout
                  |
       0      +0  |   0       1        0        X       U
     100      +0  |   1       1        0        1       0
     200      +0  |   1       1        1        2       0
     300      +0  |  10       3        0        3       0
     400      +0  |   3      10        0       13       0
     500      +0  |   5       1        1       13       0
     600      +0  |   3      -4        0        7       0
```

decimal and symbolic formats - 100ns strobe triggers a new line

In the first List window, the HDL items are formatted as symbolic and use an item change to trigger a line; the field width was changed to accommodate the default label width. The window divider maintains the time and delta in the left pane; signals in the right pane may be viewed by scrolling. For the second listing, the specification for triggering was changed to a 100-ns strobe, and the item radix for **a**, **b**, **cin**, and **sum** is now decimal.

Finding items by name in the List window

The Find dialog box allows you to search for text strings in the List window. From the List window select **Edit** > **Find** to bring up the Find dialog box.



Find: delta

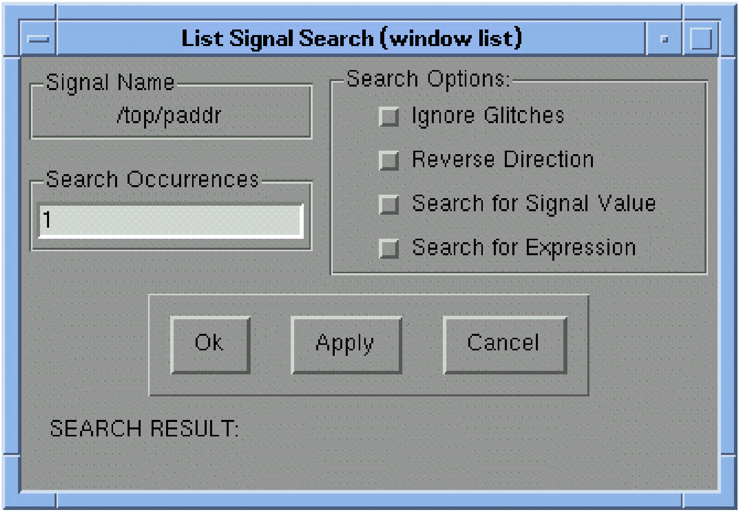
● Forward
○ Reverse

1

Enter an item label and **Find** it by searching **Forward** (right) or **Reverse** (left) through the List window display. The column number of the item found displays at the bottom of the dialog box. Note that you can change an item's label, see "Setting List window display properties" (p42).

Searching for item values in the List window

Select an item in the List window. From the List window menu bar select **Edit** > **Search** to bring up the List Signal Search dialog box.



Signal Name: /top/paddr

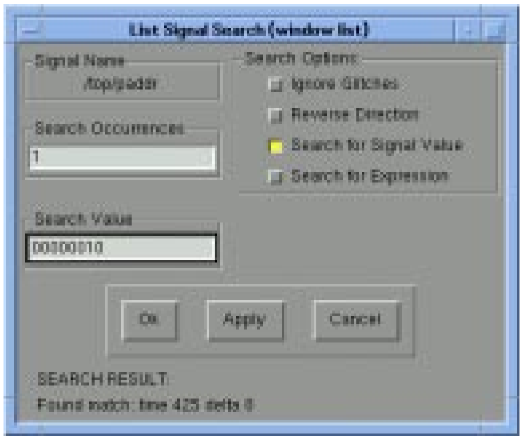
Search Occurrences: 1

Search Options:
- □ Ignore Glitches
- □ Reverse Direction
- □ Search for Signal Value
- □ Search for Expression

SEARCH RESULT:

The List Signal Search dialog box includes these options:

- **Signal Name <item_label>**
This indicates the item currently selected in the List window; the subject of the search.
- **Search Options: Ignore Glitches**
Ignore zero width glitches in VHDL signals and Verilog nets.
- **Search Options: Reverse Direction**
Select to search the list from bottom to top. Deselect to search from top to bottom.


List Signal Search (window list)

Signal Name: /top/paddr

Search Options:
□ Ignore Glitches
□ Reverse Direction
● Search for Signal Value
□ Search for Expression

Search Occurrences: 1

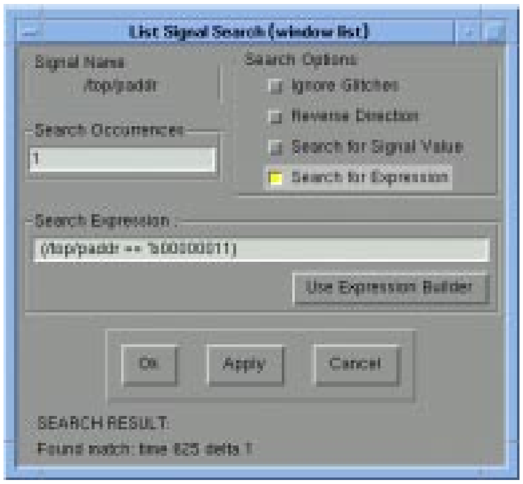
Search Value: 00000010

SEARCH RESULT:
Found match: time 425 delta 0

List Signal Search dialog box with Search for Signal Value selected

- **Search Options: Search for Signal Value**
Reveals the Search Value field; search for the value specified in the Search Value field (the value must be formatted in the same radix as the display). If no value is specified look for transitions.

- **Search Options: Search for Expression**
Reveals the Search Expression field and the Use Expression Builder button; searches for the expression specified in the Search Expression field evaluating to a boolean true.


List Signal Search (window list)

Signal Name: /top/paddr

Search Options:
□ Ignore Glitches
□ Reverse Direction
□ Search for Signal Value
● Search for Expression

Search Occurrences: 1

Search Expression: (/top/paddr == 'b00000011)

SEARCH RESULT:
Found match: time 625 delta 1

List Signal Search dialog box with Search for Expression selected

The expression may involve more than one signal but is limited to signals logged in the List window. Expressions may include constants, variables and macros. If no expression is specified, the search will give an error.

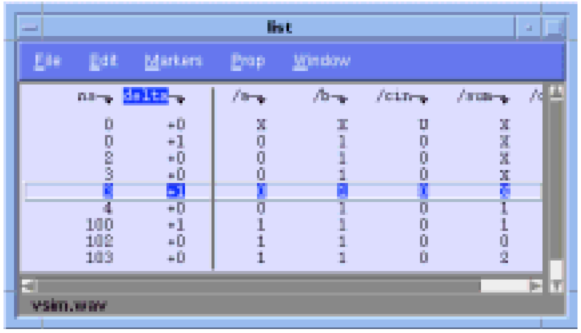
To help build the expression, click the **Use Expression Builder** button.

- **Search Occurrences**
You can search for the n-th transition or the n-th match on value or expression; Search Occurrences indicates the number of transitions or matches for which to search.

Setting time markers in the List window

From the List window select **Markers > Add Marker** to tag the selected list line with a marker. The marker is indicated by a thin box surrounding the marked line. The selected line uses the same indicator, but its values are highlighted. Delete markers by first selecting the marked line, then making the **Markers > Delete Marker** menu selection.

Finding a marker



```
      ns  delta    /a     /b    /cin    /sum   /c
       0    +0      X      X      U       X
       0    +1      0      1      0       X
       2    +0      0      1      0       X
       3    +0      0      1      0       X
[illegible]
       4    +0      0      1      0       1
     100    +1      1      1      0       1
     102    +0      1      1      0       0
     103    +0      1      1      0       2
```

Choose a specific marked line to view with **Markers > Goto** menu selection. The marker name (on the **Goto** list) corresponds to the simulation time of the selected line.

List window keyboard shortcuts

Using the following keys when the mouse cursor is within the List window will cause the indicated actions:

Key	Action
<arrow up>	scroll listing up
<arrow down>	scroll listing down
<arrow left>	scroll listing left
<arrow right>	scroll listing right
<page up>	scroll listing up by page
<page down>	scroll listing down by page

Key	Action
<tab>	searches forward (down) to the next transition on the selected signal
<shift-tab>	searches backward (up) to the previous transition on the selected signal (does not function on HP workstations)
<control-f>	opens the find dialog box; find the specified item label within the list display

Saving List window data to a file

From the List window select **Edit > Write List (format)** to save the List window data in one of these formats:

- **tabular**
  writes a text file that looks like the window listing

```
ns   delta       /a       /b     /cin     /sum    /cout
0      +0        X        X        U        X        U
0      +1        0        1        0        X        U
2      +0        0        1        0        X        U
```

- **event**
  writes a text file containing transitions during simulation

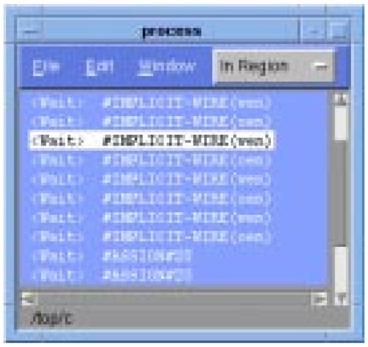
```
@0 +0
/a X
/b X
/cin U
/sum X
/cout U
@0 +1
/a 0
/b 1
/cin 0
```

- **TSSI**
  writes a file in standard TSSI format.

```
0 00000000000000010?????????
2 00000000000000010???????1?
3 00000000000000010??????010
4 00000000000000010000000010
100 00000001000000010000000010
```

Process window

The Process window displays a list of processes and indicates the pathname of the instance in which the process is located.



```
<Wait>  #IMPLICIT-WIRE(wen)
<Wait>  #IMPLICIT-WIRE(cen)
<Wait>  #IMPLICIT-WIRE(wen)
<Wait>  #IMPLICIT-WIRE(cen)
<Wait>  #IMPLICIT-WIRE(wen)
<Wait>  #IMPLICIT-WIRE(cen)
<Wait>  #IMPLICIT-WIRE(wen)
<Wait>  #IMPLICIT-WIRE(cen)
<Wait>  #ASSIGN#20
<Wait>  #ASSIGN#20
```

/top/c

Each HDL item in the scrollbox is preceded by one of the following indicators:

- **<Ready>**
  Indicates that the process is scheduled to be executed within the current delta time.
- **<Wait>**
  Indicates that the process is waiting for a VHDL signal or Verilog net or variable to change or for a specified time-out period.
- **<Done>**
  Indicates that the process has executed a VHDL wait statement without a time-out or a sensitivity list. The process will not restart during the current simulation run.

If you select a "Ready" process, it will be executed next by the simulator.

When you click on a process in the Process window the following windows are updated:

Window updated	Result
Structure window (p67)	shows the region in which the process is located
Variables window (p70)	shows the VHDL variables and Verilog register variables in the process
Source window (p61)	shows the associated source code
Dataflow window (p35)	shows the process, the signals and nets the process reads, and the signals and nets driven by the process.

The Process window menu bar

The following menu commands and button options are available from the Process window menu bar.

File menu

Save As	save the process tree to a text file viewable with the Model*Sim* notepad
Environment	Follow Environment: update the window based on the selection in the Structure window (p67); Fix Environment: maintain the current view, do not update
Close	close this copy of the Process window; you can create a new window with View > New from the "The Main window menu bar" (p25)

Edit menu

Copy	copy the selected process
Sort	sort the process list in either ascending, descending, or declaration order
Select All	select all signals in the Process window
Unselect All	deselect all signals in the Process window
Find...	find specified text string within the structure tree; choose the Status (ready, wait or done) or Process label to search and the search direction: forward or reverse

Window menu

Initial Layout	restore all windows to the size and placement of the initial full-screen layout
Cascade	cascade all open windows
Tile Horizontally	tile all open windows horizontally
Tile Vertically	tile all open windows vertically
Icon Children	icon all but the Main window
Icon All	icon all windows
Deicon All	deicon all windows

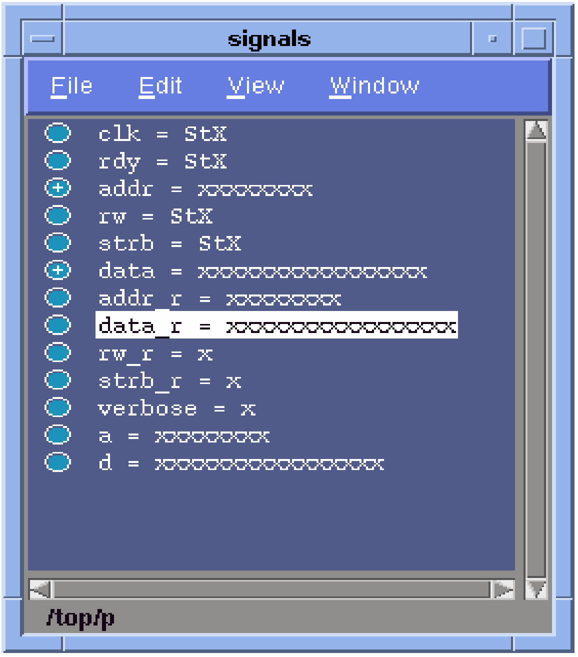
Customize	use the Button Adder to define and add a button to either the menu bar, tool bar, or status bar of the specified window
<window_name>	lists the currently open windows; select a window name to switch to, or show that window if it is hidden; when the source window is available, the source file name is also indicated; open additional windows from the "View menu" (p26)

Active/In Region toggle button

Active	Displays all the processes that are scheduled to run during the current simulation cycle.
In Region	Displays any processes that exist in the region that is selected in the Structure window.

Signals window

The Signals window shows the names and values of HDL items in the current region (which is selected in the Structure window). Items may be sorted in ascending, descending, or declaration order.



```
clk = StX
rdy = StX
addr = xxxxxxxx
rw = StX
strb = StX
data = xxxxxxxxxxxxxxxx
addr_r = xxxxxxxx
data_r = xxxxxxxxxxxxxxxx
rw_r = x
strb_r = x
verbose = x
a = xxxxxxxx
d = xxxxxxxxxxxxxxxx
```

HDL items you can view

One entry is created for each of the following VHDL and Verilog HDL items within the design:

VHDL items
signals

Verilog items
nets, register variables, and named events

The names of any VHDL composite types (arrays and record types) are shown in a hierarchical fashion. Hierarchy also applies to Verilog nets and vector memories. (Verilog vector registers do not have hierarchy because they are not internally represented as arrays.) Hierarchy is indicated in typical Model*Sim* fashion with plus (expandable), minus (expanded), and blank (single level) boxes.

See "Tree window hierarchical view" (p22) for more information.

The Signals window menu bar

The following menu commands are available from the Signals window menu bar.

File menu

Save As	save the signals tree to a text file viewable with the Model*Sim* notepad
Environment	Follow Environment: update the window based on the selection in the Structure window (p67); Fix Environment: maintain the current view, do not update
Close	close this copy of the Signals window; you can create a new window with View > New from the "The Main window menu bar" (p25)

Edit menu

Copy	copy the current selection in the Signals window
Sort	sort the signals tree in either ascending, descending, or declaration order
Select All	select all items in the Signals window
Unselect All	unselect all items in the Signals window
Force...	apply stimulus to the specified Signal Name; specify Value, Kind (Freeze/Drive/Deposit), Delay, and Repeat
Noforce	removes the effect of any active force command on the selected HDL item
Find...	find specified text string within the Signals window; choose the Name or Value field to search and the search direction: forward or reverse

View menu

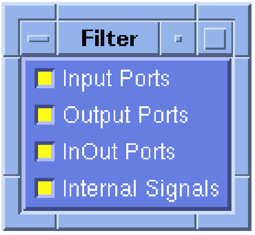
Wave/List/Log	place the Selected Signals, Signals in Region, or Signals in Design in the Wave window (p73), List window (p38), or Log file
Filter	choose the port and signal types to view (Input Ports, Output Ports, InOut Ports and Internal Signals) in the Signals window

Window menu

Initial Layout	restore all windows to the size and placement of the initial full-screen layout
Cascade	cascade all open windows

Tile Horizontally	tile all open windows horizontally
Tile Vertically	tile all open windows vertically
Icon Children	icon all but the Main window
Icon All	icon all windows
Deicon All	deicon all windows
Customize	use the Button Adder to define and add a button to either the menu bar, tool bar, or status bar of the specified window
<window_name>	lists the currently open windows; select a window name to switch to, or show that window if it is hidden; when the source window is available, the source file name is also indicated; open additional windows from the "View menu" (p26)

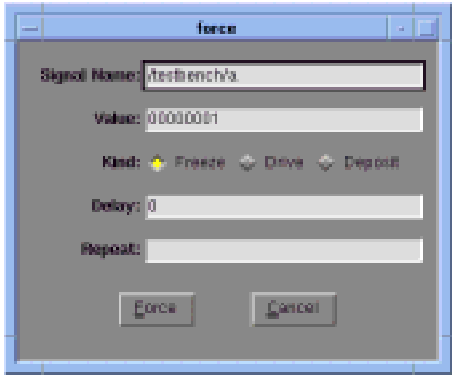
Selecting HDL item types to view



The **View** > **Filter...** menu selection allows you to specify which HDL items are shown in the Signals window. Multiple options may be selected.

Forcing signal and net values

The **Edit** > **Force** menu selection displays a dialog box that allows you to apply stimulus to the selected signal or net. You can specify that the stimulus is to repeat at a regular time interval, expressed in the time units set in the Startup window when you invoked the simulator.



Signal Name: /testbench/a

Value: 00000001

Kind: ● Freeze ○ Drive ○ Deposit

Delay: 0

Repeat:

The **Force** dialog box includes these options:

- **Signal Name**
  Specify the signal or net for the applied stimulus.
- **Value**
  Initially displays the current value, which can be changed by entering a new value into the field. A value can be specified in radixes other than decimal by using the form (for VHDL and Verilog, respectively):

```
base#value  -or-  b|o|d|h'value
```

16#EE or h'EE, for example, specifies the hexadecimal value EE.

- **Kind: Freeze**
  Freezes the signal or net at the specified value until it is forced again or until it is unforced with a **noforce** command.
- **Kind: Drive**
  Attaches a driver to the signal and drives the specified value until the signal or net is forced again or until it is unforced with a **noforce** command. This value is illegal for unresolved VHDL signals.
- **Kind: Deposit**
  Sets the signal or net to the specified value. The value remains until there is a subsequent driver transaction, or until the signal or net is forced again, or until it is unforced with a **noforce** command.

Freeze is the default for Verilog nets and unresolved VHDL signals and **Drive** is the default for resolved signals.

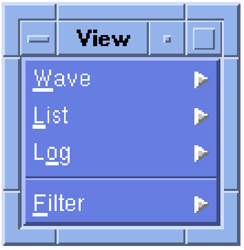
If you prefer **Freeze** as the default for resolved and unresolved signals, you can change the default force kind in the *modelsim.ini* file.

- **Delay**
  Allows you to specify how many time units from the current time the stimulus is to be applied.
- **Repeat**
  Allows you to specify the time interval after which the stimulus is to be repeated. A value of 0 indicates that the stimulus is not to be repeated.
- **Force**
  When you click the **Force** button, a **force** command is issued with the parameters you have set and echoed in the Main window.

Adding HDL items to the Wave and List windows or a log file

Before adding items to the List or Wave window you may want to set the window display properties (see "Setting List window display properties" (p42)). Once display properties have been set, you can add items to the windows or log file in several ways.

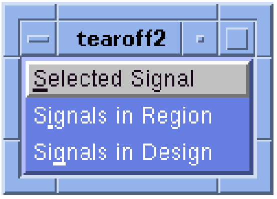
Adding items from the Main window command line



Use the **View** menu with either the **Wave**, **List**, or **Log** selection to add HDL items to the Wave window (p73), List window (p38)or a log file, respectively.

The log file is written as an archive file in binary format and is used to drive the List and Wave window at a later time. Once signals are added to the log file they cannot be removed. If you begin a simulation by invoking VSIM with the -view <logfile_name> option, VSIM reads the log file to drive the Wave and List windows.

Choose one of the following options (Model*Sim* opens the target window for you):



- **Selected signal**
  Lists only the item(s) selected in the Signals window.
- **Signals in region**
  Lists all items in the region that is selected in the Structure window.
- **Signals in design**
  Lists all items in the design.

Adding items from the Main window command line

Another way to add items to the Wave or List window or the log file is to enter the one of the following commands at the VSIM prompt:

```
add list | add wave | log <item_name> <item_name>
```

You can add all the items in the current region with this command:

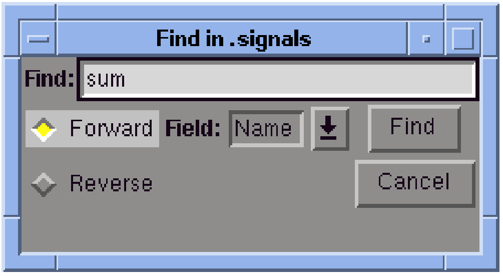
```
add list | add wave | log *
```

Or add all the items in the design with:

```
add list | add wave | log -r /*
```

If the target window (Wave or List) is closed, Model*Sim* opens it when you when you invoke the command.

Finding HDL items in the Signals window



Find: sum

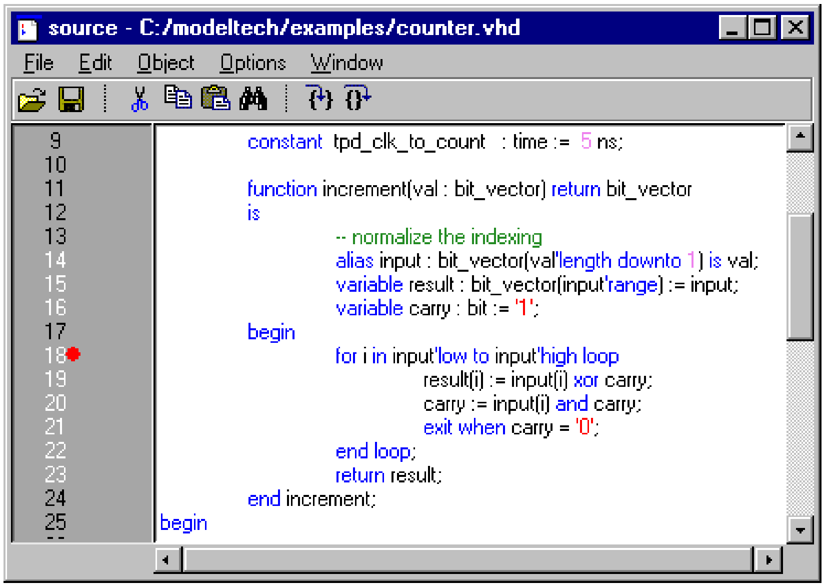
● Forward ○ Reverse

Field: Name

Find the specified text string within the Signals window; choose the **Name** or **Value** field to search and the search direction: **Forward** or **Reverse**.

Source window

The Source window allows you to view and edit your HDL source code. Select an item in the Structure window (p67) or use the **File** menu to add a source file to the window, then select a process in the Process window (p52) to view that process; an arrow next to the line numbers indicates the selected process.



```
        constant  tpd_clk_to_count   : time :=  5 ns;

        function increment(val : bit_vector) return bit_vector
        is
                -- normalize the indexing
                alias input : bit_vector(val'length downto 1) is val;
                variable result : bit_vector(input'range) := input;
                variable carry : bit := '1';
        begin
                for i in input'low to input'high loop
                        result(i) := input(i) xor carry;
                        carry := input(i) and carry;
                        exit when carry = '0';
                end loop;
                return result;
        end increment;
begin
```

If any breakpoints have been set, each is signified by a colored dot next to a line number at the left side of the window pane. To set a breakpoint, click at or near the line number in the numbered area at the left side of the window. The breakpoints are toggles, so you can click again to delete an existing breakpoint. There is no limit to the number of breakpoints you can set.

To look at a file that is not currently being displayed, use the Structure window (p67) to select a different design unit or use the Source menu selection: **File** > **Open**. The pathname of the source file is indicated in the header of the Source window.

You can copy and paste text between the Source window and the Main window (p24); select the text you want to copy, then paste it into the Main window with the middle mouse button.

The Source window menu bar

The following menu commands are available from the Source window menu bar.

File menu

New	edit a new source file
Open	select a source file to open
Use Source	specifies an alternative file to use for the current source file; this alternative source mapping exists for the current simulation only
Source Directory	add to a list of directories (the SourceDir variable in modelsim.tcl) to search for source files
Save	save the current source file
Save_As	save the current source file with a different name
Close	close this copy of the Source window; you can create a new window with View > New from the "The Main window menu bar" (p25)

Edit menu

To edit a source file, make sure the **Read Only** option in the Source Options dialog box is *not* selected (use the Source menu **Options** > **Options** selection).

<editing option>	basic editing options include: Cut, Copy, Paste, Select All, and Unselect All; see: "Editing the command line, the current source file, and notepads" (p33)
Find...	find the specified text string within the source file; match case option
read only	toggles the read-only status of the current source file

Object menu

Describe	displays information about the selected HDL item; the item name is shown in the title bar
Examine	displays the current value of the selected HDL item; the item name is shown in the title bar

Options menu

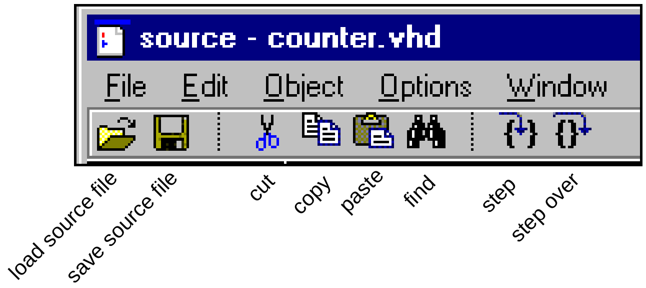
Options	open the Source Options dialog box, see "Setting Source window options" (p66)

Window menu

Initial Layout	restore all windows to the size and placement of the initial full-screen layout
Cascade	cascade all open windows
Tile Horizontally	tile all open windows horizontally
Tile Vertically	tile all open windows vertically
Icon Children	icon all but the Main window
Icon All	icon all windows
Deicon All	deicon all windows
Customize	use the Button Adder to define and add a button to either the menu bar, tool bar, or status bar of the specified window
<window_name>	lists the currently open windows; select a window name to switch to, or show that window if it is hidden; when the source window is available, the source file name is also indicated; open additional windows from the "View menu" (p26)

The Source window tool bar

Buttons on the Source window tool bar gives you quick access to these Model*Sim* commands and functions.



Source window tool bar buttons

Button	Menu equivalent	Other equivalents
Load Source File open the Open dialog box (you can open any text file for editing in the Source window)	File > Open	select an HDL item in the Structure window, the associated source file is loaded into the Source window
Save Source File save the file in the Source window	File > Save	none
Cut cut the selected text within the Source window	Edit > Cut	see: "Editing the command line, the current source file, and notepads" (p33)
Copy copy the selected text within the Source window	Edit > Copy	see: "Editing the command line, the current source file, and notepads" (p33)

Source window tool bar buttons

Button	Menu equivalent	Other equivalents
Paste paste the copied text to the cursor location	Edit > Paste	see: "Editing the command line, the current source file, and notepads" (p33)
Find find the specified text string within the source file; match case option	Edit > Find	none
Step steps the current simulation to the next HDL statement	none	**step**
Step Over HDL statements are executed but treated as simple statements instead of entered and traced line by line	none	**step -over**

Editing the source file in the Source window

Several tool bar buttons (shown above), mouse actions, and special keystrokes can be used to edit the source file in the Source window. See "Editing the command line, the current source file, and notepads" (p33) for a list of mouse and keyboard editing options.

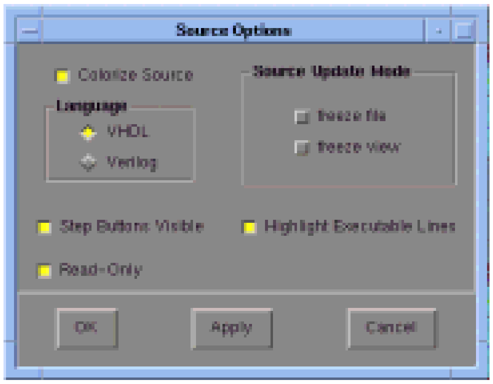
Checking HDL item values and descriptions

There are two quick methods to determine the value and description of an HDL item displayed in the Source window:

- select an item, then chose **Object > Examine** or **Object > Description** from the Source window menu
- select an item with the right mouse button to view examine pop-up (select "now" to examine the current simulation time in VHDL code)

Setting Source window options

Access the Source window options with this Source menu selection: **Options > Options**.



☑ Colorize Source

Language

● VHDL

○ Verilog

Source Update Mode

□ freeze file

□ freeze view

☑ Step Buttons Visible

☑ Highlight Executable Lines

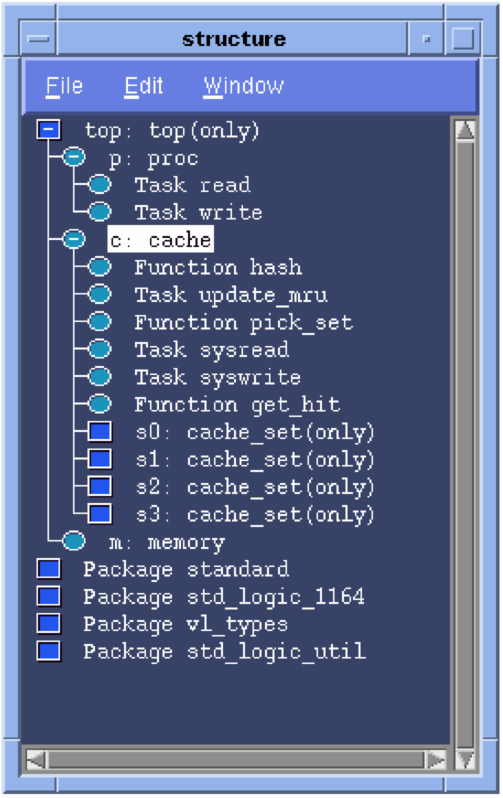
☑ Read-Only

The **Source Options** dialog box includes these options:

- **Language**
  select either **VHDL** or **Verilog**; sets language for key word colorizing
- **Source Update Mode**
  select **freeze file** to maintain the same source file in the Source window (useful when you have two Source windows open; one can be updated from the Structure window (p67), the other frozen) or **freeze view** to disable updating the source view from the Process window (p52)
- **Colorize Source**
  colorize key words, variables and comments
- **Step Buttons Visible**
  select to add **Step** and **Step Over** buttons to the Source window menu bar
- **Read-Only**
  sets the source file to read-only mode
- **Highlight Executable Lines**
  highlights the line number of executable lines

Structure window

The Structure window provides a hierarchical view of the structure of your design. An entry is created by each HDL item within the design.



```
top: top(only)
  p: proc
    Task read
    Task write
  c: cache
    Function hash
    Task update_mru
    Function pick_set
    Task sysread
    Task syswrite
    Function get_hit
    s0: cache_set(only)
    s1: cache_set(only)
    s2: cache_set(only)
    s3: cache_set(only)
  m: memory
Package standard
Package std_logic_1164
Package vl_types
Package std_logic_util
```

HDL items you can view

The following HDL items for VHDL and Verilog are represented by hierarchy within Structure window.

VHDL items

component instantiation, generate statement, block statement, and package

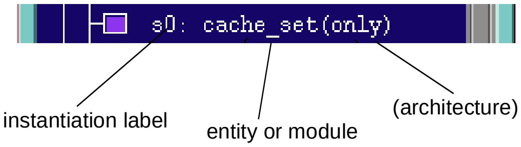
Verilog items

module instantiation, named fork, named begin,
task and function

Within the Structure window, VHDL items are indicated by a box and Verilog items are indicated by a circle.You can expand and contract the display to view the elements by clicking on the boxes or circles at the left of the Window. The first line of the Structure window indicates the top-level design unit being simulated.

Instance name components in the Structure window

An instance name displayed in the Structure window consists of the following parts:



where:

- **instantiation label**
  Indicates the label assigned to the component or module instance in the instantiation statement.
- **entity or module**
  Indicates the name of the entity or module that has been instantiated.
- **architecture**
  Indicates the name of the architecture associated with the entity (not present for Verilog).

When you select a region in the Structure window, it becomes the *current region* and is highlighted; the Source window (p61) and Signals window (p55) change dynamically to reflect the information for that region. This feature provides a useful method for finding the source code for a selected region because the system keeps track of the pathname where the source is located and displays it automatically, without the need for you to provide the pathname.

Also, when you select a region in the Structure window, the Process window (p52) is updated if **In Region** is selected in that window; the Process window will in turn update the Variables window (p70).

The Structure window menu bar

The following menu commands are available from the Structure window menu bar.

File menu

Save_As	save the structure tree to a text file viewable with the Model*Sim* **notepad**
Close	close this copy of the Structure window; you can create a new window with View > New from the "The Main window menu bar" (p25)

Edit menu

Copy	copy the current selection in the Structure window
Sort	sort the structure tree in either ascending, descending, or declaration order
Unselect All	unselect all items in the Structure window

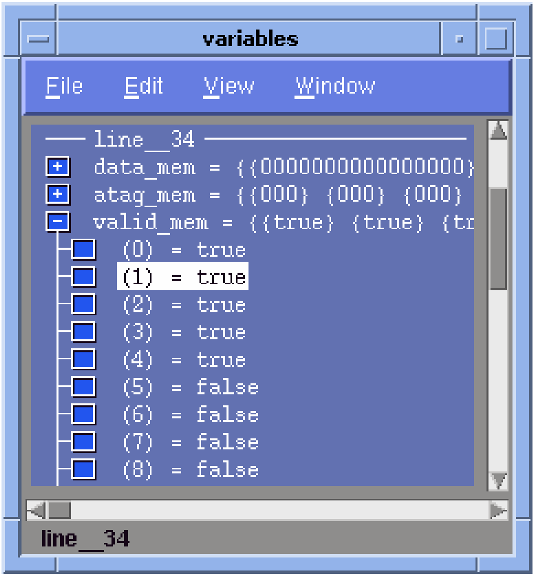
Find...	find specified text string within the structure tree; choose the label for instance, entity/module or architecture to search for and the search direction: forward or reverse

Window menu

Initial Layout	restore all windows to the size and placement of the initial full-screen layout
Cascade	cascade all open windows
Tile Horizontally	tile all open windows horizontally
Tile Vertically	tile all open windows vertically
Icon Children	icon all but the Main window
Icon All	icon all windows
Deicon All	deicon all windows
Customize	use the Button Adder to define and add a button to either the menu bar, tool bar, or status bar of the specified window
<window_name>	lists the currently open windows; select a window name to switch to, or show that window if it is hidden; when the source window is available, the source file name is also indicated; open additional windows from the "View menu" (p26)

Variables window

The Variables window lists the names of HDL items within the current process, followed by the current value(s) associated with each name. The pathname of the current process is displayed at the bottom of the window.



```
—— line__34 ——————————————
[+] data_mem = {{0000000000000000}
[+] atag_mem = {{000} {000} {000}
[-] valid_mem = {{true} {true} {tr
     (0) = true
     (1) = true
     (2) = true
     (3) = true
     (4) = true
     (5) = false
     (6) = false
     (7) = false
     (8) = false
line__34
```

HDL items you can view

The following HDL items for VHDL and Verilog are viewable within the Variables window.

VHDL items
constants, generics, and variables

Verilog items
register variables

The names of any VHDL composite types (arrays and record types) are shown in a hierarchical fashion. Hierarchy also applies to Verilog vector memories. (Verilog vector registers do not have hierarchy because they are not internally represented as arrays.) Hierarchy is indicated in typical Model*Sim* fashion with plus (expandable), minus (expanded), and blank (single level) boxes. See "Tree window hierarchical view" (p22) for more information.

To change the value of a VHDL variable, constant, generic or Verilog register variable, move the pointer to the desired name and click to highlight the selection. Then select **Edit** > **Change** from the Variables window menu. This brings up a dialog box that lets you specify a new value. Note that "Variable Name" is a term that is used loosely in this case to signify VHDL constants and generics as well as VHDL and Verilog register variables. You can enter any value that is valid for the variable. An array value must be specified as a string (without surrounding quotation marks). To modify the values in a record, you need to change each field separately.

The Variables window menu bar

The following menu commands are available from the Variables window menu bar.

File menu

Save As	save the variables tree to a text file viewable with the Model*Sim* **notepad**
Environment	Follow Environment: update the window based on the selection in the Structure window (p67); Fix Environment: maintain the current view, do not update
Close	close this copy of the Variables window; you can create a new window with View > New from the "The Main window menu bar" (p25)

Edit menu

Copy	copy the selected items in the Variables window
Sort	sort the variables tree in either ascending, descending, or declaration order
Select All	select all items in the Variables window
Unselect All	deselect all items in the Variables window
Change	change the value of the selected HDL item
Find...	find specified text string within the variables tree; choose the Name or Value field to search and the search direction: forward or reverse

View menu

Wave/List/Log	place the Selected Variables, Variables in Region, or Variables in Design in the Wave window (p73), List window (p38), or Log file

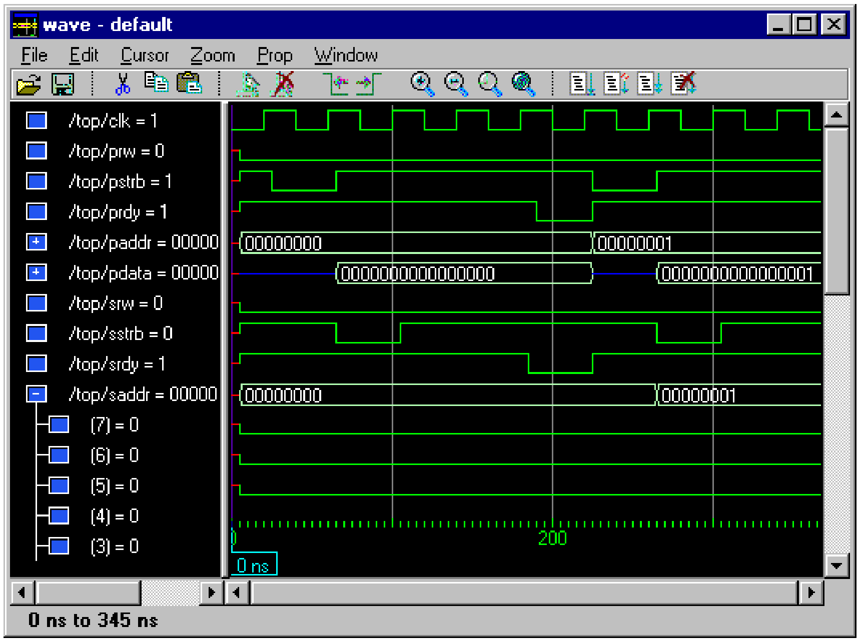
Window menu

Initial Layout	restore all windows to the size and placement of the initial full-screen layout
Cascade	cascade all open windows
Tile Horizontally	tile all open windows horizontally
Tile Vertically	tile all open windows vertically
Icon Children	icon all but the Main window
Icon All	icon all windows
Deicon All	deicon all windows
Customize	use the Button Adder to define and add a button to either the menu bar, tool bar, or status bar of the specified window
<window_name>	lists the currently open windows; select a window name to switch to, or show that window if it is hidden; when the source window is available, the source file name is also indicated; open additional windows from the "View menu" (p26)

Wave window

The Wave window, like the List window, allows you to view the results of your simulation. In the Wave window, however, you can see the results as HDL item waveforms and their values.

The Wave window is divided into two windowpanes: the left pane displays item names and their values at the active cursor (located in the right pane); the right pane displays waveforms corresponding to each item and any cursors you may have added.



HDL items you can view

VHDL items signals and process variables

Verilog items nets, register variables, and named events

Note: Constants, generics, parameters, and memories are not viewable in the List or Wave windows.

The data in the item values windowpane is very similar to the Signals window, except that the values change dynamically whenever a cursor in the waveform windowpane is moved.

At the bottom of the waveform windowpane you can see a time line, tick marks, and a readout of the cursor(s) position(s). As you click and drag to move a cursor, the time value at the cursor location is updated at the bottom of the cursor.

You can resize the windowpanes by clicking and dragging the bar between the two windowpanes.

Waveform and signal-name formatting are easily changed via the Prop menu (p77). You can reuse any formatting changes you make by saving a Wave window format file, see "Adding items with a Wave window format file" (p82).

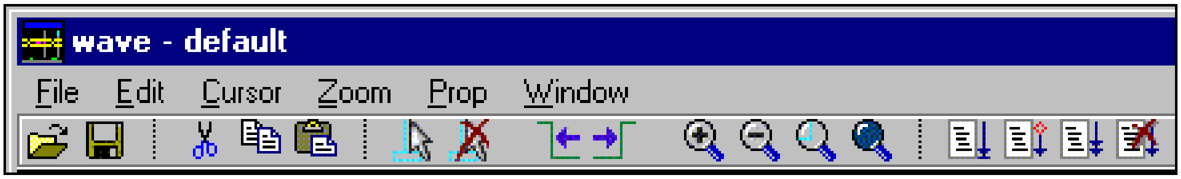
Wave window action list

This action list provides a quick reference to menu selections and mouse actions in the Wave window. See the "Tree window action list" (p23) for additional information.

Action	Menu or mouse	See also
collapse and expand composites	left mouse button: click on a "-" or "+" box/ circle	"Tree window action list" (p23)
move items, make single and multiple item selections	left mouse button and control + left mouse button	"Tree window action list" (p23)
search for transitions in the waveform display and signal values	menu selection: Edit > Find...	"Searching for item values in the Wave window" (p85)
find an item name or value	menu selection: Edit > Find	"Finding items by name or value in the Wave window" (p85)
find a specific cursor	menu selection: Cursor > Goto	"Making cursor measurements" (p87)
sort items: ascending, descending, declaration order	menu selection: Edit > Sort	"Sorting a group of HDL items" (p85)
making cursor measurements	menu selection: Cursor > Add Cursor	"Making cursor measurements" (p87)
reformat items, change their display colors, and position them within the window	menu selection: Prop > Display Props...	"Editing and formatting HDL items in the Wave window" (p82)

Action	Menu or mouse	See also
zoom in or out to change the amount of simulation time shown in the window	menu selection: Zoom > (select zoom option) center mouse button: click and drag to zoom rubberband section	"Zooming - changing the waveform display range" (p88)
change signal properties: radix, color, height, format (analog/literal/logic/event)	menu selection: Prop > Signal Props	"Setting Wave window display properties" (p81)
save the Wave window configuration; load a new configuration	menu selection: File > Save (or Load) Format	
adding and editing items in the name/value pane	menu selection: Edit > (select edit option)	"Adding HDL items in the Wave window" (p81)

The Wave window menu bar



The following menu commands and button options are available from the Wave window menu bar. If you see a dotted line at the top of a drop-down menu, click and drag the dotted line to create a separate menu window.

File menu

Write Postscript	save the waveform display as a Postscript file
Load Format	run a Wave window format (do) file previously saved with Save Format

Save Format	saves the current Wave window display and signal preferences to a do (macro) file; running the DO file will reformat the Wave window to match the display as it appeared when the DO file was created
Close	close this copy of the Wave window; you can create a new window with View > New from the "The Main window menu bar" (p25)

Edit menu

Cut	cut the selected item from the wave name pane; see "Editing and formatting HDL items in the Wave window" (p82)
Copy	copy the selected item and waveform
Paste	paste the previously cut or copied item above the currently selected item
Combine	combine the selected fields into a user defined bus
Sort	sort the top-level items in the name pane; sort with full path name or viewed name; use ascending, descending or declaration order
Delete	delete the selected item and its waveform
Select All Unselect All	select, or unselect, all item names in name pane
Find...	find specified item label within the Wave name window
Search...	search the waveform display for a specified value, or the next transition for the selected signal; see: "Searching for item values in the Wave window" (p85)

Cursors menu

Add Cursor	add a cursor to the center of the waveform window
Delete Cursor	delete the selected cursor from the window
Goto	choose a cursor to go to from a list of current cursors

Zoom menu

Zoom <selection>	selection: Full, In, Out, Last, or Range to change the waveform display range

Prop menu

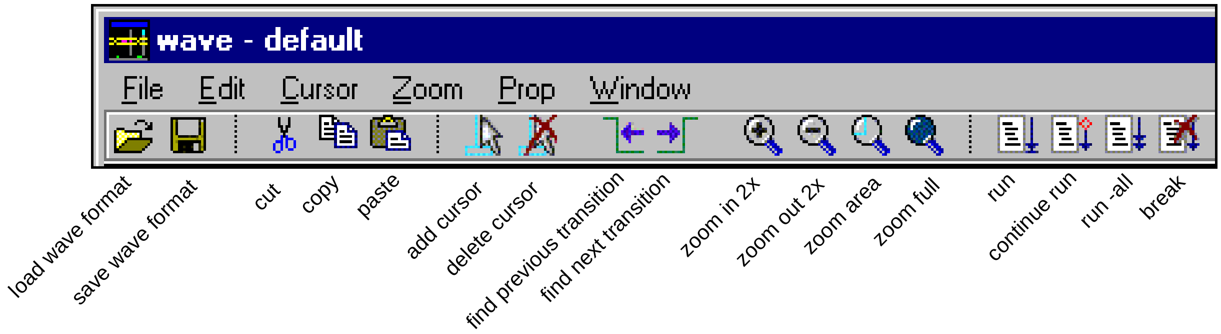
Display Props	set display properties for all items in the window: delta settings, trigger on selection, strobe period, and label size
Signal Props	set label, radix, trigger on/off, and field width for the selected item (use the menu selections below to quickly change individual properties)
Radix	set the selected item’s radix
Format	set the waveform format for the selected item
Color	set the color for the selected item from a color palette
Height	set the waveform height in pixels for the selected item

Window menu

Initial Layout	restore all windows to the size and placement of the initial full-screen layout
Cascade	cascade all open windows
Tile Horizontally	tile all open windows horizontally
Tile Vertically	tile all open windows vertically
Icon Children	icon all but the Main window
Icon All	icon all windows
Deicon All	deicon all windows
Customize	use the Button Adder to define and add a button to either the menu bar, tool bar, or status bar of the specified window
<window_name>	lists the currently open windows; select a window name to switch to, or show that window if it is hidden; when the source window is available, the source file name is also indicated; open additional windows from the "View menu" (p26)

Wave window tool bar

The Wave window tool bar gives you quick access to these Model*Sim* commands and functions.



Wave window tool bar buttons

Button	Menu equivalent	Other options
Load Wave Format run a Wave window format (do) file previously saved with Save Format	File > Load Format	none
Save Wave Format saves the current Wave window display and signal preferences to a do (macro) file	File > Save Format	none
Cut cut the selected text within the Source window	Edit > Cut	none

Wave window tool bar buttons

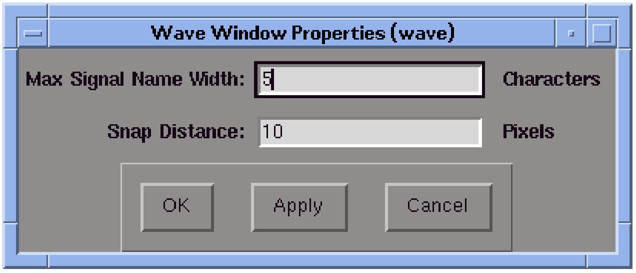
Button	Menu equivalent	Other options
Copy copy the selected text within the Main window transcript	Edit > Copy	none
Paste paste the copied text to the cursor location	Edit > Paste	see: "Editing the command line, the current source file, and notepads" (p33)
Add Cursor add a cursor to the center of the waveform window	Cursor > Add Cursor	none
Delete Cursor delete the selected cursor from the window	Cursor > Delete Cursor	none
Find Previous Transition locate the previous signal value change for the selected signal	Edit > Find > Reverse	none
Find Next Transition locate the next signal value change for the selected signal	Edit > Find > Forward	none
Zoom in 2x zoom in by a factor of two from the current view	Zoom > Zoom In	see: "Zooming - changing the waveform display range" (p88)
Zoom out 2x zoom out by a factor of two from current view	Zoom > Zoom Out	see: "Zooming - changing the waveform display range" (p88)

Wave window tool bar buttons

Button	Menu equivalent	Other options
Zoom area use the cursor to outline a zoom area	Zoom > Zoom Range	see: "Zooming - changing the waveform display range" (p88)
Zoom Full zoom out to view the full range of the simulation from time 0 to the current time	Zoom > Zoom Full	see: "Zooming - changing the waveform display range" (p88)
Run run the current simulation for the default time length	none	use the **run** command at the VSIM prompt
Continue Run continue the current simulation run	none	use the **run -continue** command at the VSIM prompt
Run -All run to current simulation forever, or until it hits a breakpoint or specified break event*	none	use the **run -all** command at the VSIM prompt
Break stop the current simulation run	none	execute a break when the Main window is active with <control-c>

Setting Wave window display properties

You can define the item name width and the cursor snap distance of all items in the Wave window with the **Prop** > **Display Props...** menu selection.



Max Signal Name Width: 5 Characters

Snap Distance: 10 Pixels

The **Wave Window Properties** dialog box includes these options:

- **Max Signal Name Width**
Sets the item name width. This is especially useful for items that have a long pathname. Choose a maximum name width setting, say 10 characters, and then item pathnames longer than 10 characters are truncated on the left. All truncations take place at the slash boundary so you will never see a partial item name. The default value for this field is 0, which means to display the full path. Negative numbers allow you to specify the number of regions, instead of characters, to display.

- **Snap Distance**
Specifies the distance the cursor needs to be placed from an item edge to jump to that edge (a 0 specification turns off the snap). The value displayed in the item value windowpane is updated to reflect the snap.

Adding HDL items in the Wave window

Before adding items to the Wave window you may want to set the window display properties (see "Setting Wave window display properties" (p81)). You can add items to the Wave window in several ways.

Adding items from the Signals window with drag and drop

You can drag and drop items into the Wave window from the Process, Signals, or Structure window. Select the items in the first window, then drop them into the Wave window. Depending on what you select, all items or any portion of the design may be added. See the "Tree window action list" (p23) for information about making item selections.

Adding items from the Main window command line

To add specific HDL items to the window, enter (separate the item names with a space):

```
add wave <item_name> <item_name>
```

You can add all the items in the current region with this command:

```
add wave *
```

Or add all the items in the design with:

```
add wave -r /*
```

Adding items with a Wave window format file

To use a Wave window format file you must first save a format file for the design you are simulating.

- add the items you want in the Wave window with any other method shown above
- edit and format the items, see "Editing and formatting HDL items in the Wave window" (p82) to create the view you want
- save the format to a file with the Wave window menu selection: **File** > **Save Format**

To use the format file, start with a blank Wave window and run the DO file in one of two ways:

- use the do command on the command line:
  `do <my_wave_format>`
- select **File** > **Load Format** from the Wave window menu bar

Use **Edit** > **Select All** and **Edit** > **Delete** to remove the items from the current Wave window, use the **delete** command with the **wave** option, or create a new, blank Wave window with the **View** > **New** > **Wave** selection from the Main window (p24).

Note: Wave window format files are design-specific; use them only with the design you were simulating when they were created.

Editing and formatting HDL items in the Wave window

Once you have the HDL items you want in the Wave window, you can edit and format the list in the name/value pane to create the view you find most useful. (See also, "Adding HDL items in the Wave window" (p81).)

To edit an item:

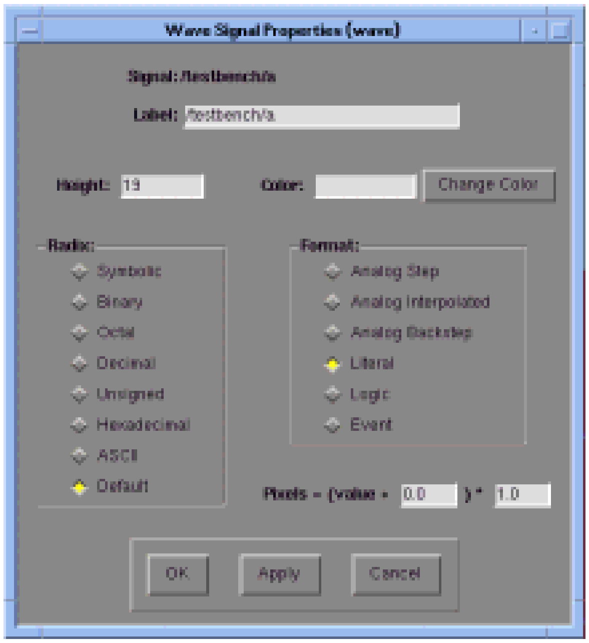
Select the item's label in the left name/value windowpane or its waveform in the right windowpane. Move, copy or remove the item by selecting commands from the Wave window Edit menu (p76) menu.

You can also **click+drag** to move items within the name/value windowpane:

- to select several contiguous items:
  click+drag to select additional items above or below the original selection
- to select several items randomly:
  control+click to add or subtract from the selected group
- to move the selected items:
  re-click and hold on one of the selected items, then drag to the new location

To format an item:

Select the item’s label in the left name/value pane or its waveform in the right windowpane, then use the **Prop > Signal Props...** menu selection. The resulting Wave Signal Properties dialog box allows you to set the item’s height, color, format, range, and radix.



Wave Signal Properties (wave)

Signal: /testbench/a

Label: /testbench/a

Height: 19

Color:

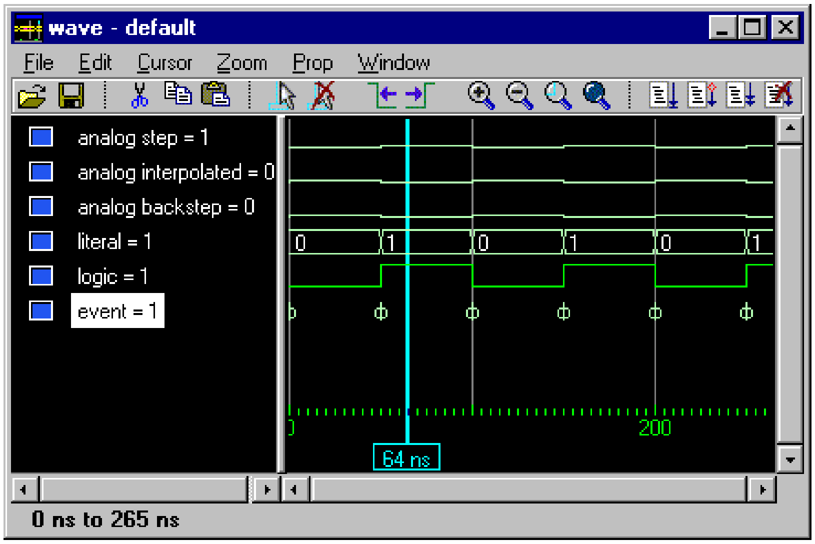
Radix:
- ◇ Symbolic
- ◇ Binary
- ◇ Octal
- ◇ Decimal
- ◇ Unsigned
- ◇ Hexadecimal
- ◇ ASCII
- ◆ Default

Format:
- ◇ Analog Step
- ◇ Analog Interpolated
- ◇ Analog Backstep
- ◆ Literal
- ◇ Logic
- ◇ Event

Pixels = (value + 0.0) * 1.0

The **Wave Signal Properties** dialog box includes these options:

- **Signal**
  Indicates the name of the currently selected signal.
- **Label**
  Allows you to specify a new label (in the name/value pane) for the selected item.
- **Height**
  Allows you to specify the height (in pixels) of the waveform.
- **Color**
  Lets you override the default color of a waveform by selecting a new color from the color palette, or by entering an X-Windows color name.



This illustration shows the same item displayed in each wave format outlined below. Note that the signal labels were also changed.

HDL items of VHDL type integer and floating point, and Verilog type real can be formatted as analog in the Wave window.

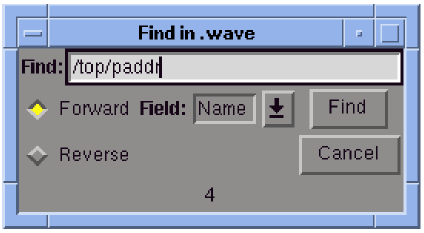
- **Format: Analog Step**
  Displays a waveform of an integer, real or time type, with the height and offset determined by the **Pixels** = specification and the value of the item.
- **Format: Analog Interpolated**
  Displays the waveform in interpolated style.
- **Format: Analog Backstep**
  Displays the waveform in backstep style. Used for power calculations.
- **Format: Literal**
  Displays the waveform as a box containing the item value (if the value fits the space available). This is the only format that can be used to list a record.
- **Format: Logic**
  Displays values as 0, 1, X, Z, H, L, U, or -.
- **Format: Event**
  Marks each transition during the simulation run.
- **Pixels = (value + <offset>) * <scale factor>**
  This choice works with analog items only and allows you to decide on the scale of the item as it is seen on the display. Value is the value of the signal at a given time, <offset> is the number of pixels offset from zero. The <scale factor> reduces (if less than 1) or increases (if greater than 1) the number of pixels displayed.
- **Radix**
  The explicit choices are Symbolic, Binary, Octal, Decimal, Unsigned, Hexadecimal, and ASCII. If you select Default the signal's radix changes whenever the default is changed using the radix command. Item values are not translated if you select Symbolic.

Sorting a group of HDL items

Use the **Edit** > **Sort** menu selection to sort the items in the name/value pane.

Finding items by name or value in the Wave window

The Find dialog box allows you to search for text strings in the Wave window. From the Wave window select **Edit > Find** to bring up the Find dialog box.



Find in .wave

Find: /top/paddr

● Forward Field: Name

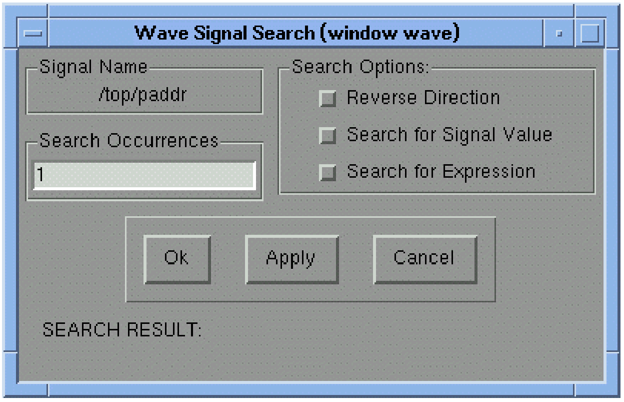
○ Reverse

4

Choose either the Name or Value field to search from the drop-down menu, and enter the value to search for in the Find field. **Find** the item by searching **Forward** (down) or **Reverse** (up) through the Wave window display.

Searching for item values in the Wave window

Select an item in the Wave window. From the Wave window menu bar select **Edit > Search** to bring up the Wave Signal Search dialog box.



Wave Signal Search (window wave)

Signal Name: /top/paddr

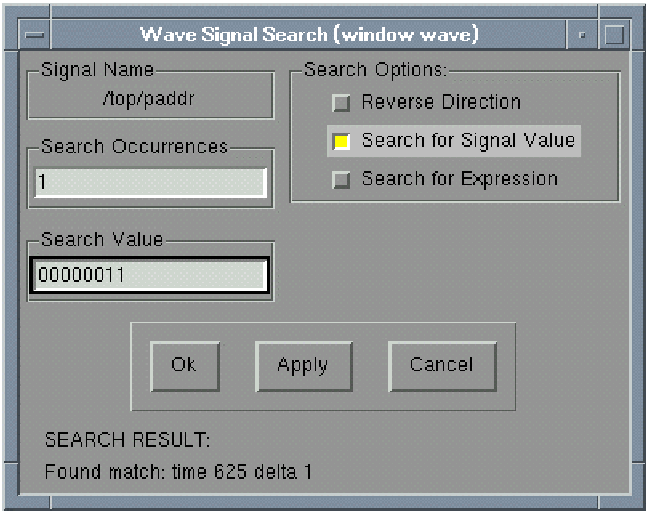
Search Occurrences: 1

Search Options:
□ Reverse Direction
□ Search for Signal Value
□ Search for Expression

SEARCH RESULT:

The **Wave Signal Search** dialog box includes these options:

- **Signal Name <item_label>**
  This indicates the item currently selected in the Wave window; the subject of the search.
- **Search Options: Ignore Glitches**
  Ignore zero width glitches in VHDL signals and Verilog nets.
- **Search Options: Reverse Direction**
  Search the list from right to left. Deselect to search from left to right.
- **Search Options: Search for Signal Value**
  Reveals the Search Value field; search for the value specified in the Search Value field (the value must be formatted in the same radix as the display). If no value is specified the search will look for transitions.



Signal Name: /top/paddr

Search Occurrences: 1

Search Value: 00000011

Search Options:

□ Reverse Direction

☑ Search for Signal Value

□ Search for Expression

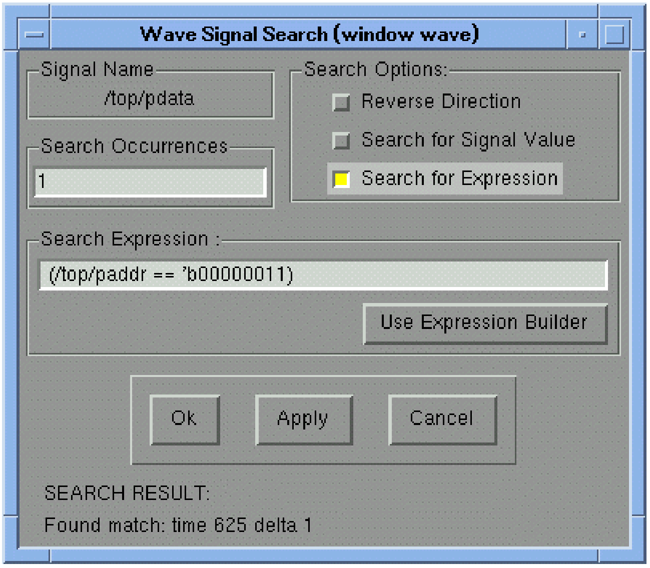
SEARCH RESULT:

Found match: time 625 delta 1

Wave Signal Search dialog box with Search for Signal Value selected

- **Search Options: Search for Expression**
  Reveals the Search Expression field and the Use Expression Builder button; searches for the expression specified in the Search Expression field evaluating to a boolean true.

  The expression may involve more than one signal but is limited to signals logged in the List window. Expressions may include constants, variables, and macros. If no expression is specified, the search will give an error. See the *ModelSim EE/PLUS Reference Manual* for more information on expression syntax and the use of the Expression Builder.



Signal Name: /top/pdata

Search Occurrences: 1

Search Options:

□ Reverse Direction

□ Search for Signal Value

☑ Search for Expression

Search Expression : (/top/paddr == 'b00000011)

SEARCH RESULT:

Found match: time 625 delta 1

Wave Signal Search dialog box with Search for Expression selected

- **Search Occurrences**
  You can search for the n-th transition or the n-th match on value or expression; Search Occurrences indicates the number of transitions or matches for which to search.

Using time cursors in the Wave window

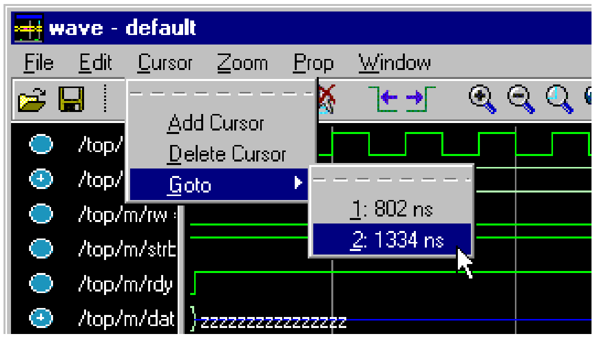
When the Wave window is first drawn, there is one cursor in it at time zero. Clicking anywhere in the waveform display brings that cursor to the mouse location.

You can add additional cursors to the waveform pane with the **Cursor** > **Add Cursor** menu selection, or with the **Add Cursor** button on the toolbar.

The selected cursor is drawn as a solid line; all other cursors are drawn with dotted lines.

Remove a cursor by selecting it and choosing using the **Cursor** > **Delete Cursor** menu selection, or use the **Add Cursor** button on the toolbar.

Finding a cursor



Choose a specific cursor view with **Cursor** > **Goto** menu selection. The cursor value (on the **Goto** list) corresponds to the simulation time of that cursor.

Making cursor measurements

Each cursor is displayed with a time box showing the precise simulation time at the bottom. When you have more than one cursor, each time box appears in a separate track at the bottom of the display. VSIM also adds a delta measurement showing the time difference between the two cursor positions.

If you click in the waveform display, the cursor closest to the mouse position is selected and then moved to the mouse position. Another way to position multiple cursors is to use the mouse in the time box tracks at the bottom of the display. Clicking anywhere in a track selects that cursor and brings it to the mouse position.

The cursors are designed to snap to the closest wave edge to the left on the waveform that the mouse pointer is positioned over. You can control the snap distance from "Wave category" in the dialog box available from the **Properties > Display** menu selection; see "Setting Wave window display properties" (p81).

You can position a cursor without snapping by dragging in the area below the waveforms.

Finding next and previous transitions

You can move the cursors to the next and previous transition of the selected item with the Find Transition buttons on the toolbar:

Find Previous Transition locate the previous signal value change for the selected signal	**Find Next Transition** locate the next signal value change for the selected signal

Zooming - changing the waveform display range

Zooming lets you change the simulation range in the windowpane display. You can zoom with either the **Zoom** menu, the toolbar buttons, mouse, keyboard, or VSIM commands.

Using the Zoom menu - **three-button mouse only**

You can use the Wave window menu bar, or call up a **Zoom** menu window with the right mouse button in the right windowpane. The menu options include:

- **Zoom Full**
  Redraws the display to show the entire simulation from time 0 to the current simulation time.
- **Zoom In**
  Zooms in by a factor of two, increasing the resolution and decreasing the visible range horizontally, cropping the view on the right. The starting time is held static.
- **Zoom Out**
  Zooms out by a factor of two, decreasing the resolution and increasing the

visible range horizontally, extending the view on the right. The starting time is held static.

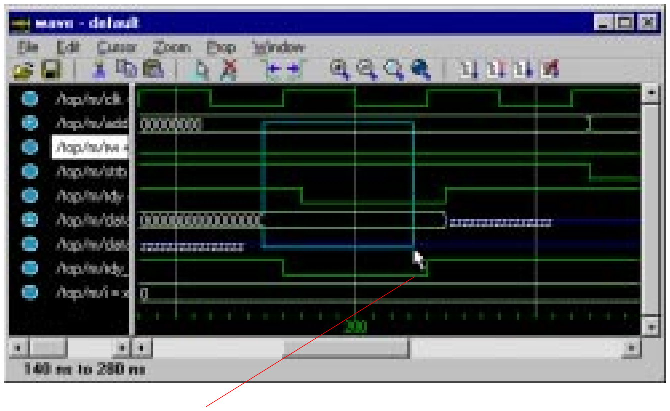
- **Zoom Last**
  Restores the display to where it was before the last zoom operation.
- **Zoom Range**
  Brings up a dialog box that allows you to enter the beginning and ending times for a range of time units to be displayed.

Zooming with the toolbar buttons

Use these buttons on the Wave window toolbar to zoom.

🔍	**Zoom in 2x** zoom in by a factor of two from the current view	🔍	**Zoom area** use the cursor to outline a zoom area
🔍	**Zoom out 2x** zoom out by a factor of two from current view	🔍	**Zoom Full** zoom out to view the full range of the simulation from time 0 to the current time

Zooming with the mouse



drag from left to right with the mouse button to zoom
(3-button mouse - middle button, 2-button mouse - right button)

To zoom with the mouse, position the mouse cursor to the left side of the desired zoom interval, press the middle mouse button (3-button mouse) or the right button (2-button mouse), continue to press, and drag to the right, then release when the box has expanded to the right side of the desired zoom interval.

Zooming keyboard shortcuts

See the table below for list of Wave window keyboard shortcuts.

Wave window keyboard shortcuts

Using the following keys when the mouse cursor is within the Wave window will cause the indicated actions:

Key	Action
i I or +	zoom in
o O or -	zoom out
f or F	zoom full
l or L	zoom last
r or R	zoom range
<arrow up>	scroll waveform display up
<arrow down>	scroll waveform display down
<arrow left>	scroll waveform display left
<arrow right>	scroll waveform display right
<page up>	scroll waveform display up by page
<page down>	scroll waveform display down by page
<tab>	searches forward (right) to the next transition on the selected signal - finds the next edge
<shift-tab>	searches backward (left) to the previous transition on the selected signal - finds the previous edge
<control-f>	opens the find dialog box; search within the specified field in the wave-name pane for text strings

3 - Model*Sim* EE Lessons

Chapter contents

Choose the lessons appropriate for your simulator version:

PLUS, and VHDL lessons

PLUS, and VLOG lesson

PLUS lesson

PLUS, VHDL, and VLOG practice

Assumptions

We assume that you are familiar with the your platform’s operating system and graphical interface. Preparation for some of the examples leaves certain details up to you - you will decide the best way to create directories, copy files and execute programs within your operating system. (When you are operating the simulator within Model*Sim*’s GUI, the interface is consistent for all platforms.)

We also assume that you have a working knowledge of HDL design. Although Model*Sim* is an excellent tool to use while learning HDL concepts and practices, this guide is not written to support that goal.

Additional details for VHDL, Verilog, and mixed VHDL/Verilog simulation can be found in the *ModelSim EE/PLUS Reference Manual*. (See "Where to find our documentation" (p15).)

Examples may show either UNIX or Windows path separators - use separators appropriate for your operating system when trying the examples.

Command, button, and menu equivalents

Many of the lesson steps are accomplished by a button or menu selection. When appropriate, VSIM command-line (PROMPT:) or menu (MENU:) equivalents for these selections are shown in parentheses within the step. This example shows three options to the **run -all** command, a button, prompt command, and a menu selection.

(PROMPT: run -all) (MENU: Run > Run -All)

Drag and drop too

"Drag and Drop" (p20) allows you to copy and move signals among windows. If drag and drop applies to a lesson step, it is noted in a fashion similar to MENUS and PROMPTS with: DRAG&DROP.

Commands and their history

As you work on the lessons keep an eye on the Main transcript. The commands invoked by buttons and menu selections are echoed there. You can scroll through the command history with the up and down arrow keys, or the command history may be reviewed with several shortcuts at the Model*Sim*/VSIM prompt.

Shortcut	Description
`!!`	repeats the last command
`!n`	repeats command number n; n is the VSIM prompt number, i.e., for this prompt: VSIM 12>, n =12
`!abc`	repeats the most recent command starting with "abc"
`^xyz^ab^`	replaces "xyz" in the last command with "ab"
`click on prompt`	left-click once on a previous ModelSim or VSIM prompt in the transcript to copy the command typed at that prompt to the active cursor
`his or history`	shows the last few commands (up to 50 are kept)

Reusing commands from the Main transcript

ModelSim’s Main transcript may be saved, and the resulting file used as a DO (macro) file to replay the transcribed commands. You can save the transcript at any time before or during simulation. You have the option of clearing the transcript (File > Clear Transcript) if you don’t want to save the entire command history.

To save the contents of the transcript select **File > Save Main As** from the Main menu.

Replay the saved transcript with the **do** command:

```
do <do file name>
```

For example, if you saved a series of compiler commands as *mycompile.do* (the.do extension is optional), you could recompile with one command:

```
do mycompile.do
```

Note: Neither the prompt nor the Return that ends a command line are shown in the examples.

Basic VHDL simulation

The goals for the first lesson are:

- create a library
- compile a VHDL file
- start the simulator
- understand the basic VSIM windows, mouse, and menu conventions
- run VSIM using the **run** command
- list some signals
- use the waveform display
- force the value of a signal
- single-step through a simulation run
- set a breakpoint
- use the Wave window

1 You'll start out by creating a new directory for this exercise (in case other users will be working these lesson). Create the directory, then copy all of the VHDL (.vhd) files from the */<install_dir>/<modelsim_dir>/examples* to the new directory.

Make sure the new directory is the current directory.

2 Start Model*Sim* with one of the following:

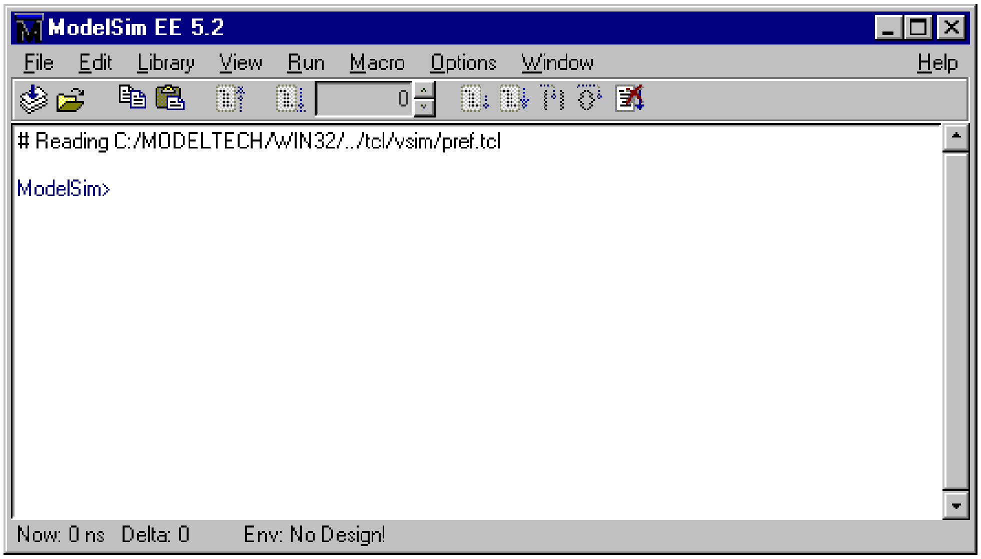
for UNIX at the shell prompt:

```
vsim -gui
```

for Windows - your option - DOS prompt, shortcut, or Start menu:

```
modelsim.exe
```

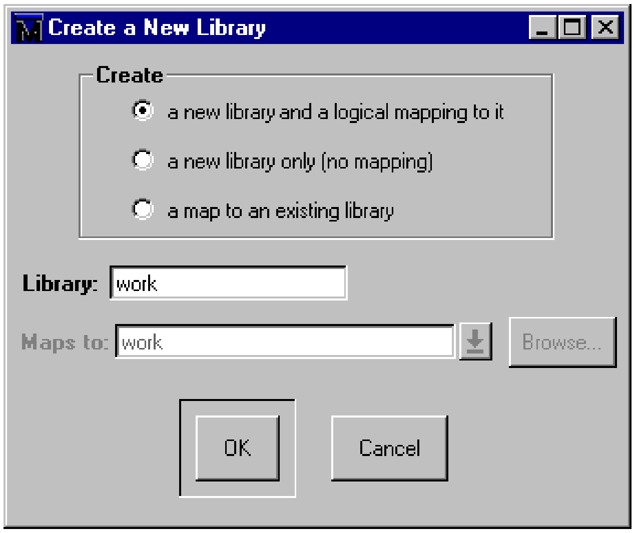
This opens the Model*Sim* Main window without loading a design.



```
# Reading C:/MODELTECH/WIN32/../tcl/vsim/pref.tcl

ModelSim>
```

```
Now: 0 ns   Delta: 0        Env: No Design!
```

3 Before you compile any HDL code, you’ll need a design library to hold the compilation results. To create a new design library, make this menu selection in the Main window: **Library** > **Create a New Library**. (PROMPT: vlib work)



Create

● a new library and a logical mapping to it

○ a new library only (no mapping)

○ a map to an existing library

Library: work

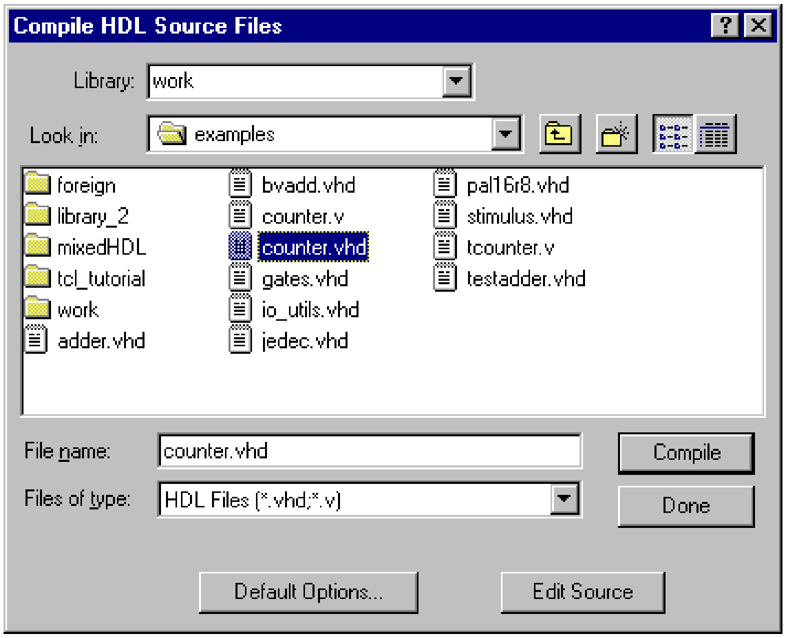
Maps to: work

In the Create a New Library dialog box select **Create: a new library and a logical mapping to it**. Make sure **Library:** indicates **work**, then select **OK**. This creates a subdirectory named *work* - your design library - within the current directory. This subdirectory contains a special file named *_info*. (Do not create these using UNIX or Windows commands—always use the Library menu or the **vlib** command from either the Model*Sim* or UNIX/DOS prompt.)

4 Compile the file *counter.vhd* into the new library by selecting the **Compile** button on the toolbar:

(PROMPT: vcom counter.vhd)

This opens the Compile HDL Source Files dialog box.



Compile HDL Source Files

Library: work

Look in: examples

foreign
library_2
mixedHDL
tcl_tutorial
work
adder.vhd
bvadd.vhd
counter.v
counter.vhd
gates.vhd
io_utils.vhd
jedec.vhd
pal16r8.vhd
stimulus.vhd
tcounter.v
testadder.vhd

File name: counter.vhd

Files of type: HDL Files (*.vhd;*.v)

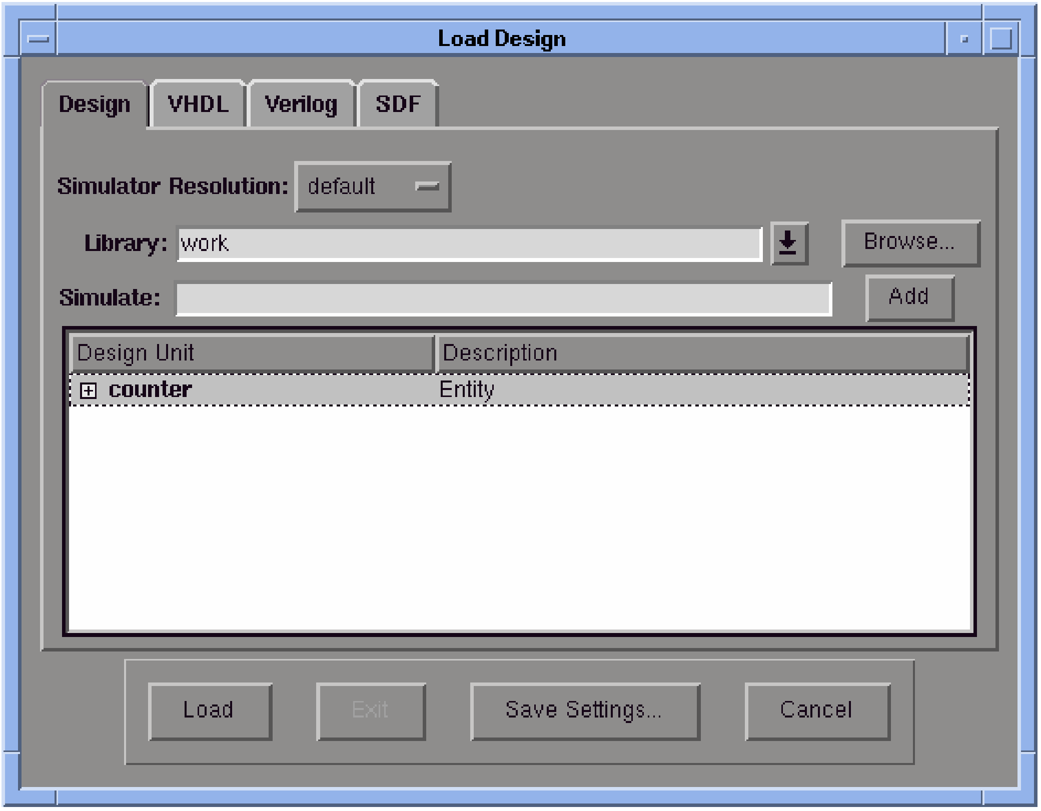
Complete the compilation by selecting *counter.vhd* from the file list and clicking **Compile**. Select **Done** when you are finished.

You can compile multiple files in one session from the file list. Individually select and Compile the files in the order required by your design.

5 Start the simulator by selecting the **Load Design** button from the toolbar:

(PROMPT: vsim counter)

The Load Design dialog box comes up, as shown below (you won't see this dialog box if you invoked **vsim** with *counter* from the command line).



Simulator Resolution: default

Library: work

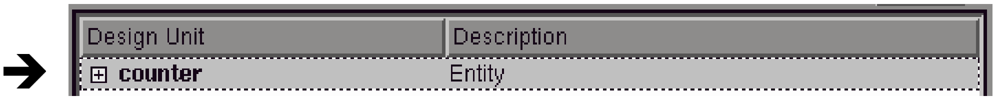
Simulate:

Design Unit	Description
⊞ counter	Entity

The Load Design dialog box allows you to select the library and the top-level design unit to simulate. You can also select the resolution limit for this simulation. By default, the following will appear for this simulation run:

- Simulator Resolution: default (the default is 1 ns)
- Library: work
- Design Unit: counter
- Description: entity

Note: If the Design Unit is an entity (like **counter** in this design) you can click on the plus-box prefix to view any associated architectures; see the graphic below.



Design Unit	Description
⊞ counter	Entity

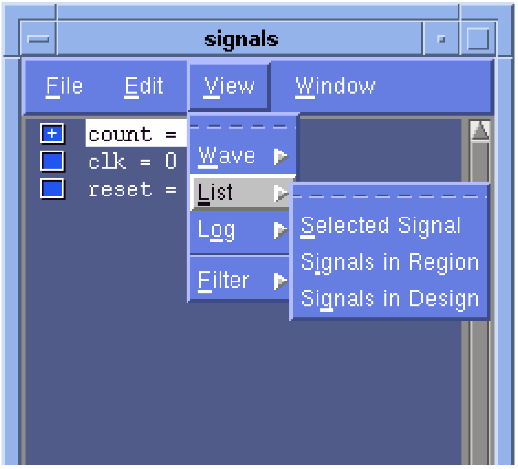
6 Select the entity **counter** and choose **Load** to accept these settings.

7 Now you can open all of the VSIM windows with this **Main window** menu selection: **View** > **All**.

(PROMPT: view *)

8 To display the top-level signals in the List window, select the **Signals window** and make this Signal menu selection: **View** > **List** > **Signals in Region**.

(PROMPT: add list /counter/*)



9 Next add top-level signals to the Wave window with a similar Signals menu selection: **View** > **Wave** > **Signals in Region**.

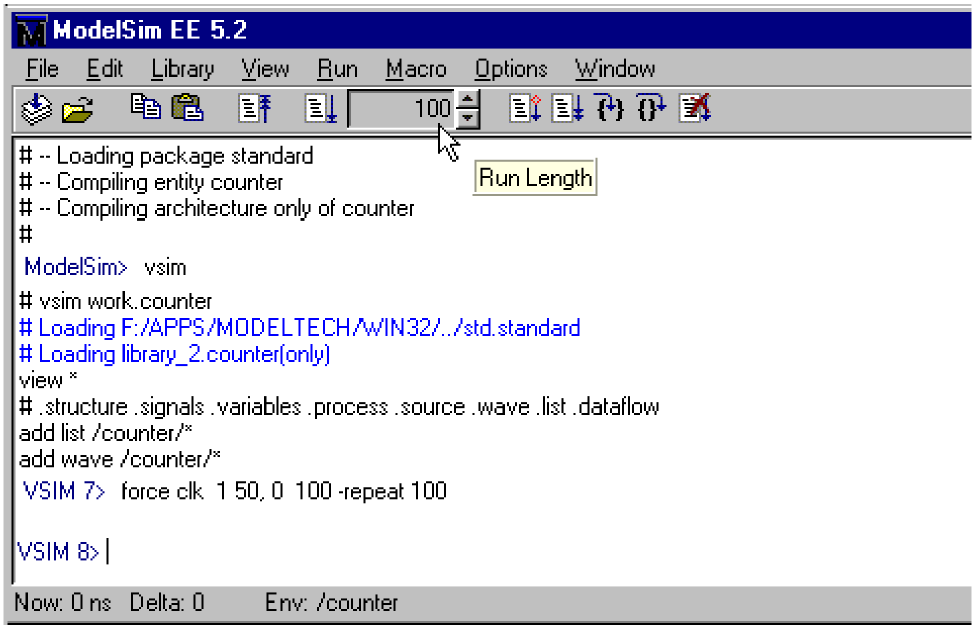
(PROMPT: add wave /counter/*)

10 You can apply stimulus to the clock input by moving the pointer to the **Main window** and entering the following command at the VSIM prompt:

```
force clk 1 50, 0 100 -repeat 100
```

The **force** command you just invoked is interpreted by VSIM to mean:

- force clk to the value 1 at 50 ns after the current time
- then to 0 at 100 ns after the current time
- repeat this cycle every 100 ns



```
# -- Loading package standard
# -- Compiling entity counter
# -- Compiling architecture only of counter
#
 ModelSim>  vsim
# vsim work.counter
# Loading F:/APPS/MODELTECH/WIN32/../std.standard
# Loading library_2.counter(only)
view *
# .structure .signals .variables .process .source .wave .list .dataflow
add list /counter/*
add wave /counter/*
 VSIM 7>  force clk  1 50, 0  100 -repeat 100

VSIM 8>
```

Now: 0 ns   Delta: 0   Env: /counter

Note how the Run Length selector on the toolbar now indicates 100 (ns is the current default resolution). You will see the effects of this **force** command as soon as you tell the simulator to run.

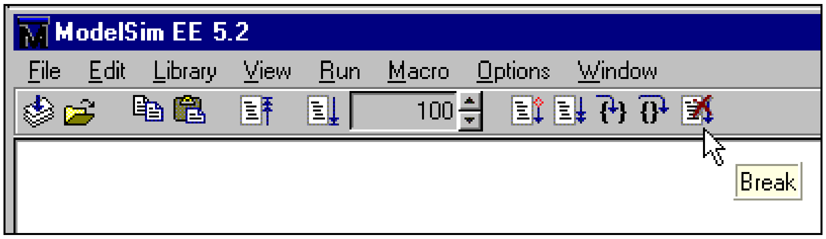
11 Now you will exercise two different **Run** functions from buttons on the Main or Wave window toolbar. Select the **Run** button first. When the run is complete, select **Run All**.

Run. This causes the simulation to run and then stop after 100 ns.
(PROMPT: run 100) (MENU: Run > Run 100ns)

Run -All. This causes the simulator to run forever. To stop the run, go on to the next step.
(PROMPT: run -all) (MENU: Run > Run -All)

12 Select the **Break** button on the **Main toolbar** to end the run.

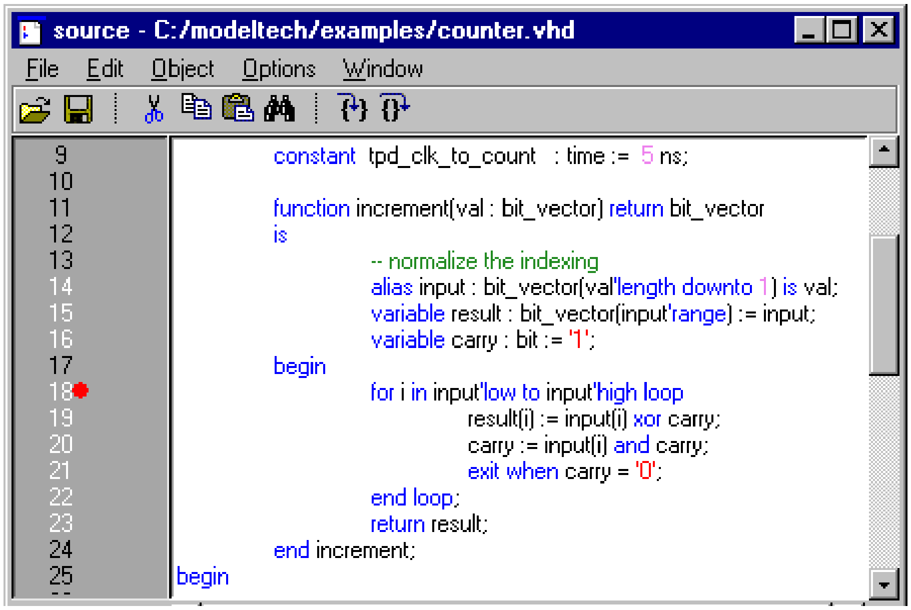
(KEYBOARD: control+c)



The arrow points to the next HDL statement to be executed. Next, you will set a breakpoint in the function on line 18.

13 Move the pointer to the VSIM Source window. Using the vertical scroll bar, scroll until line 18 is visible. Click at or near line number 18 to set the breakpoint. You should see a dot next to the line number where the breakpoint is set. This breakpoint can be toggled on and off by clicking it.

(PROMPT: bp counter.vhd 18)


source - C:/modeltech/examples/counter.vhd
File Edit Object Options Window

```
 9          constant tpd_clk_to_count   : time := 5 ns;
10
11          function increment(val : bit_vector) return bit_vector
12          is
13                  -- normalize the indexing
14                  alias input : bit_vector(val'length downto 1) is val;
15                  variable result : bit_vector(input'range) := input;
16                  variable carry : bit := '1';
17          begin
18●                 for i in input'low to input'high loop
19                          result(i) := input(i) xor carry;
20                          carry := input(i) and carry;
21                          exit when carry = '0';
22                  end loop;
23                  return result;
24          end increment;
25  begin
```

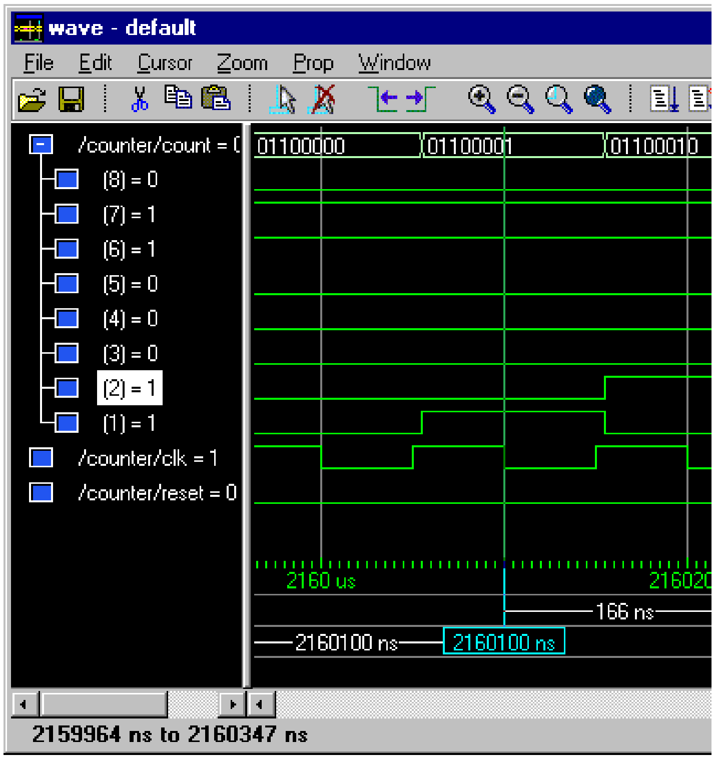
14 Select the **Continue Run** button to resume the run that you interrupted. VSIM will hit the breakpoint, as shown by an arrow in the VSIM Source window and by a message in the Main window. Also note that the parameters and variables within the function are displayed in the VSIM Variables window.

(PROMPT: run -continue) (MENU: Run > Continue)

15 Click the **Step** button to single-step through the simulation. Notice that the values change in the VSIM Variables window. You can keep clicking **Step** if you wish.

(PROMPT: run -step) (PROMPT: step)

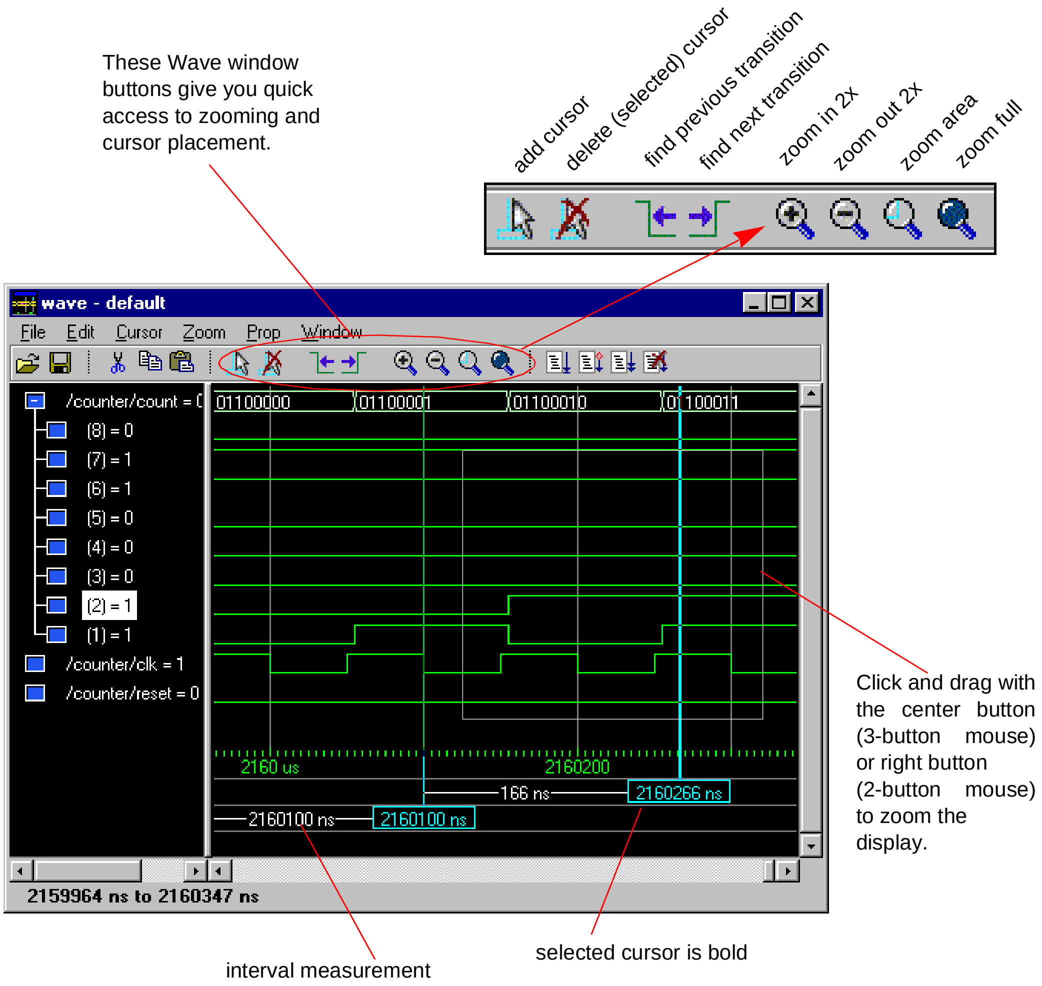
Now let’s take a look at the simulation in the Wave window.



In the Wave window, you can use cursors to:

- **probe for values** - Signal values update whenever you move the cursor.
- **find signal transition times** - Click a signal edge, the cursor displays the time.
- **measure time intervals** - Time is displayed between two cursors.

16 Experiment with using the cursors, buttons, scrolling, and zooming (see page 157 for Wave window shortcuts).



These Wave window buttons give you quick access to zooming and cursor placement.

Click and drag with the center button (3-button mouse) or right button (2-button mouse) to zoom the display.

interval measurement

selected cursor is bold

17 When you’re done experimenting, quit the simulator by entering the command:

```
quit -force
```

This command exits VSIM without saving data. Your window positions will be saved in the *modelsim.ini* file and the windows will close. (Refer to the *ModelSim Reference Manual* for additional information on the *modelsim.ini* file.)

Debugging a VHDL design

The goals for this lesson are:

- show an example of a VHDL testbench - a VHDL architecture that instantiates the VHDL design units to be tested, provides simulation stimuli, and checks the results
- map a logical library name to an actual library
- change the default run length
- recognize assertion messages in the command window
- change the assertion break level
- restart the simulation run using the **restart** command
- examine composite types displayed in the VSIM Variables window
- change the value of a variable
- use a strobe to trigger lines in the VSIM List window
- change the radix of signals displayed in the VSIM List window

1 Return to the directory you created in "Basic VHDL simulation" (p94), and invoke Model*Sim*:

for UNIX at the shell prompt:

```
vsim -gui
```

for Windows - your option - from the DOS prompt, a shortcut, or the Start menu:

```
modelsim.exe
```

2 Enter the following command at the Model*Sim* prompt to create the a new library:

```
vlib library_2
```

3 Compile the source files into the new library by entering this command at the system prompt:

```
vcom -work library_2 gates.vhd adder.vhd testadder.vhd
```

4 Now let's map the new library to the work library. To create a mapping you can edit the [Library] section of the *modelsim.ini* file, or you can create a logical library name with the **vmap** command:

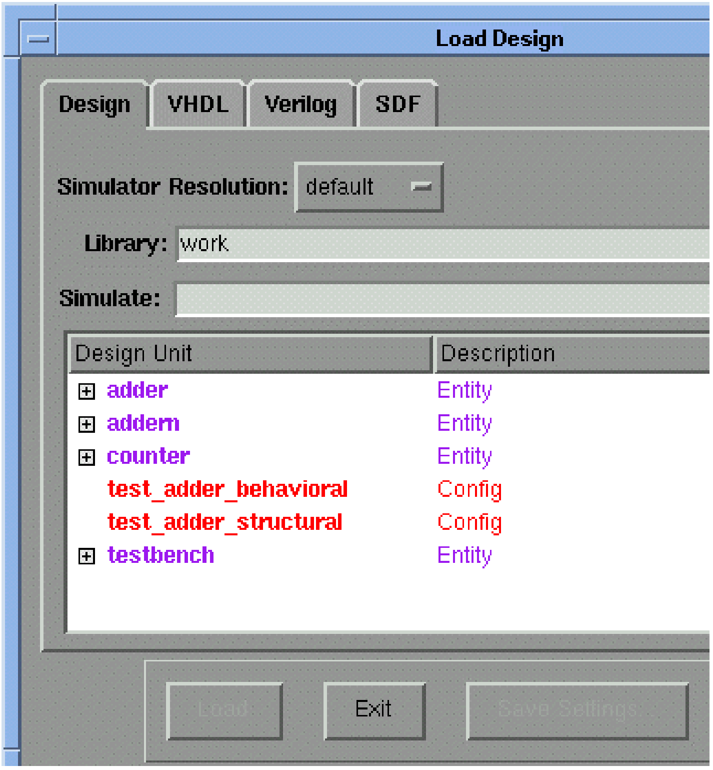
```
vmap work library_2
```

Model*Sim* modifies the *modelsim.ini* file for you.

5 Start the simulator by entering the following command at the UNIX/DOS prompt:

```
vsim
```

The Load Design dialog box is displayed, as shown below.



Simulator Resolution: default

Library: work

Simulate:

Design Unit	Description
⊞ adder	Entity
⊞ addern	Entity
⊞ counter	Entity
test_adder_behavioral	Config
test_adder_structural	Config
⊞ testbench	Entity

6 Perform the following steps in this dialog box:

- Make sure that the simulator resolution is **ns (default)**.
- Look in the Design Unit scroll box and select the configuration named **test_adder_structural**.
- Click **Load** to accept the settings.

(PROMPT: vsim -t ns work.test_adder_structural)

7 To open all of the VSIM windows, enter the following command in the Main window at the VSIM prompt:

```
view *
```

(Main MENU: View > All)

Model*Sim* will open all the windows in the positions you left them in at the end of the last exercise if no one has run the simulator since then.

8 Drag and drop the top-level signals to the List window in the following manner: make sure the hierarchy is not expanded (no minus boxes), select all signals in the Signals window with Edit > Select All, then drag the selected signals to the List window.

(Signals MENU: View > List > Signals in Region) (PROMPT: add list /*)

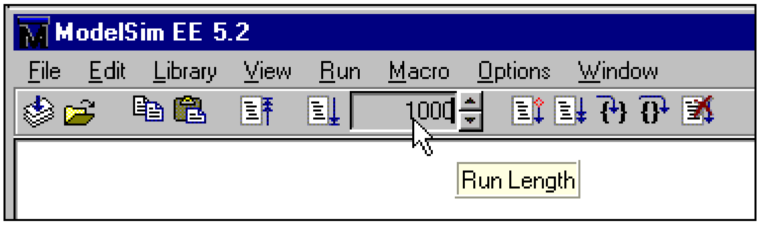
9 To add top-level signals to the Wave window, enter the command:

```
add wave /*
```

(Signals MENU: View > Wave > Signals in Region) (DRAG&DROP)

10 Now change the default simulation run length to 1000 (ns) with the run length selector on the Main toolbar. Click on the field to edit the number to 1000 (notice how the arrows allow you to change the run length in increments).

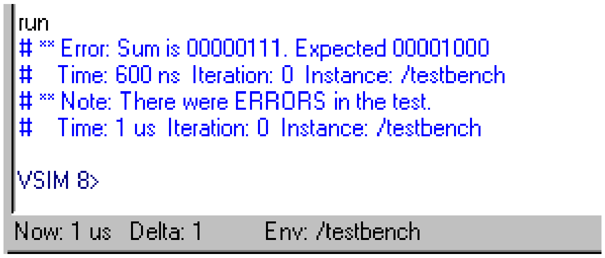
(Main MENU: Options > Simulation > Defaults)



11 Next, you will run the simulator. Select the **Run** button on the Main toolbar.

(PROMPT: run)

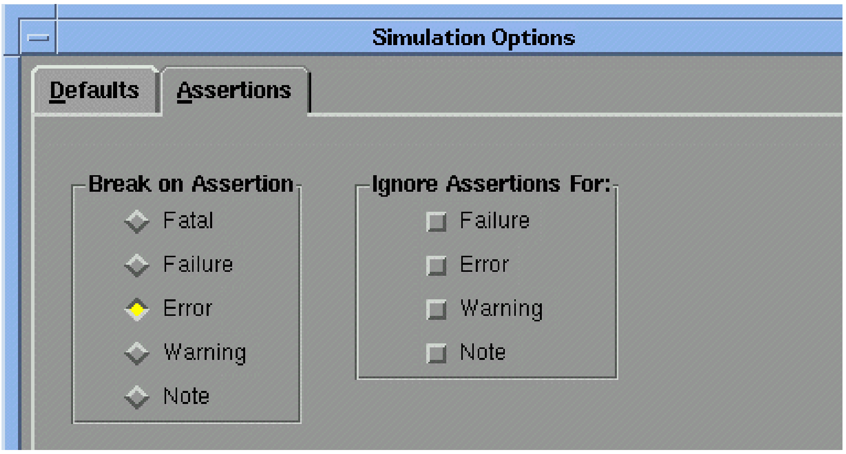
A message in the Main window will notify you that there was an assertion error.



```
run
# ** Error: Sum is 00000111. Expected 00001000
#    Time: 600 ns  Iteration: 0  Instance: /testbench
# ** Note: There were ERRORS in the test.
#    Time: 1 us  Iteration: 0  Instance: /testbench

VSIM 8>
Now: 1 us   Delta: 1        Env: /testbench
```

Let's find out what's wrong. Perform the following steps to track down the assertion message.

12 First, change the simulation assertion options. Make this Main menu selection: **Options** > **Simulation**.

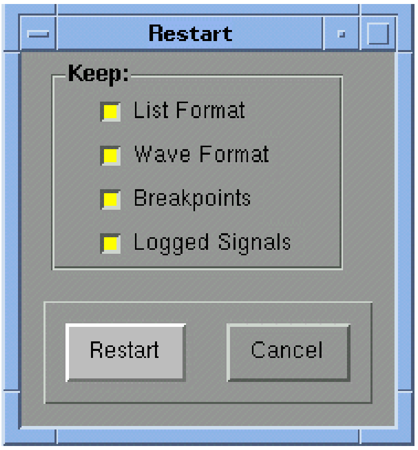


13 Select the **Assertions** page. Change the selection for **Break on Assertion** to **Error** and click **OK**. This will cause the simulator to stop at the HDL statement *after* the assertion is displayed.

14 To restart the simulation select the **Restart** button on the Main toolbar.

(Main MENU: File > Restart) (PROMPT: restart)

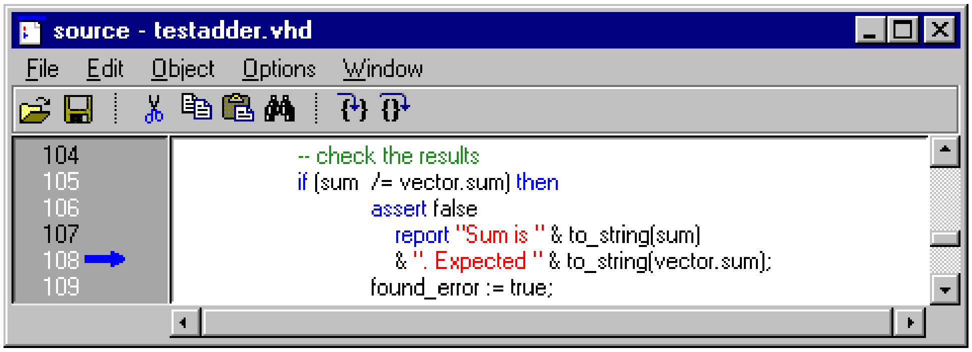
Make sure all items in the Restart dialog box are selected, then click **Restart**.



15 From the Main toolbar select the **Run** button.

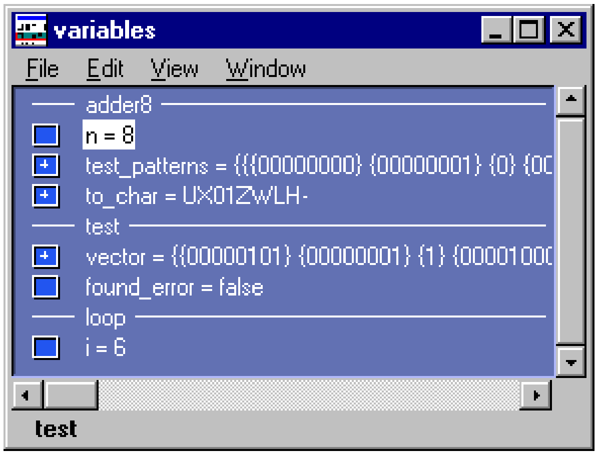
(Main MENU: Run > Run 1000 ns) (PROMPT: run)

Notice that the arrow in the Source window is pointing to the statement after the assertion.



```
-- check the results
if (sum  /= vector.sum) then
    assert false
      report "Sum is " & to_string(sum)
      & ". Expected " & to_string(vector.sum);
    found_error := true;
```

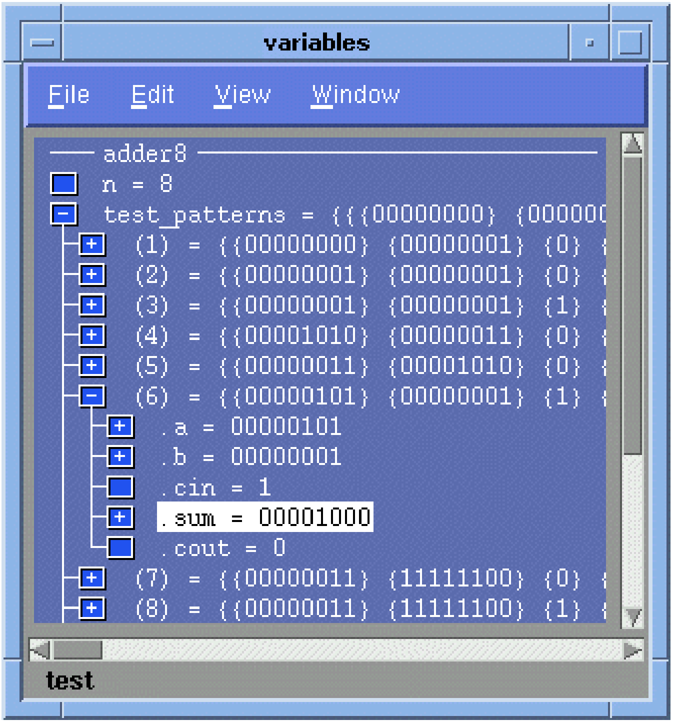
16 If you turn to the Variables window now, you can see that i = 6. This indicates that the simulation stopped in the sixth iteration of the test pattern’s loop.



```
adder8
n = 8
test_patterns = {{{00000000} {00000001} {0} {00
to_char = UX01ZWLH-
test
vector = {{00000101} {00000001} {1} {0000100(
found_error = false
loop
i = 6
test
```

17 Expand the variable named **test_patterns** by clicking the [+]. (You may need to resize the window for a better view.)

18 Also expand the sixth record in the array, that is, **test_patterns(6)**, by clicking the [+]. The Variables window should be similar to the one below.



```
adder8
n = 8
test_patterns = {{{00000000} {00000
  (1) = {{00000000} {00000001} {0}
  (2) = {{00000001} {00000001} {0}
  (3) = {{00000001} {00000001} {1}
  (4) = {{00001010} {00000011} {0}
  (5) = {{00000011} {00001010} {0}
  (6) = {{00000101} {00000001} {1}
    .a = 00000101
    .b = 00000001
    .cin = 1
    .sum = 00001000
    .cout = 0
  (7) = {{00000011} {11111100} {0}
  (8) = {{00000011} {11111100} {1}
test
```

The assertion shows that the signal **sum** does not equal the **sum** field in **test_patterns(6)**. Note that the sum of the inputs **a**, **b**, and **cin** should be equal to the output **sum**. But there is an error in the test vectors. To correct this error, you need to restart the simulation and modify the initial value of the test vectors.

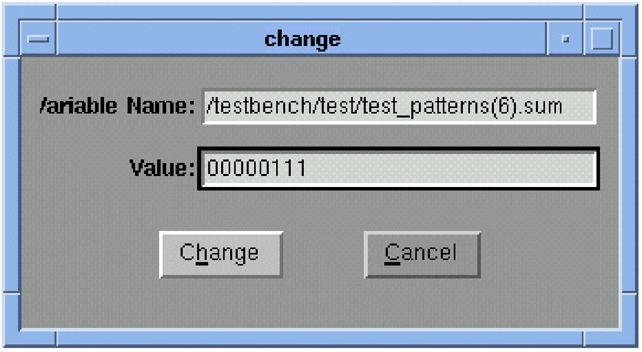
19 In the Main window, type:

```
restart -f
```

The **-f** option causes VSIM to restart without popping up the confirmation dialog.

20 Once the simulation has restarted, add variables to the Variables window by selecting the **test /testbench** process in the Process window.

21 In the Variables window, expand **test_patterns**, and **test_pattern(6)** again. Then highlight the **sum** record by clicking on the variable name (not the box before the name) and then use the **Edit** > **Change** menu selection.



/ariable Name: /testbench/test/test_patterns(6).sum

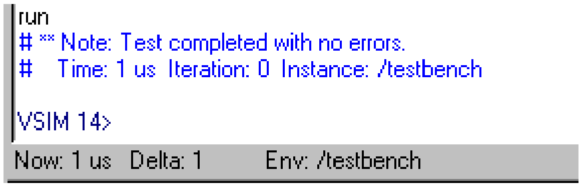
Value: 00000111

22 Select the last four bits in the value field **1000** by dragging the pointer across them. Then replace them with **0111**, and click **Change**. (Note that this is a temporary edit, you must use your text editor to permanently change the source code.)

23 Select the **Run** button from the Main toolbar.

(Main MENU: Run > Run 1000 ns) (PROMPT: run)

At this point, the simulation will run without any errors.

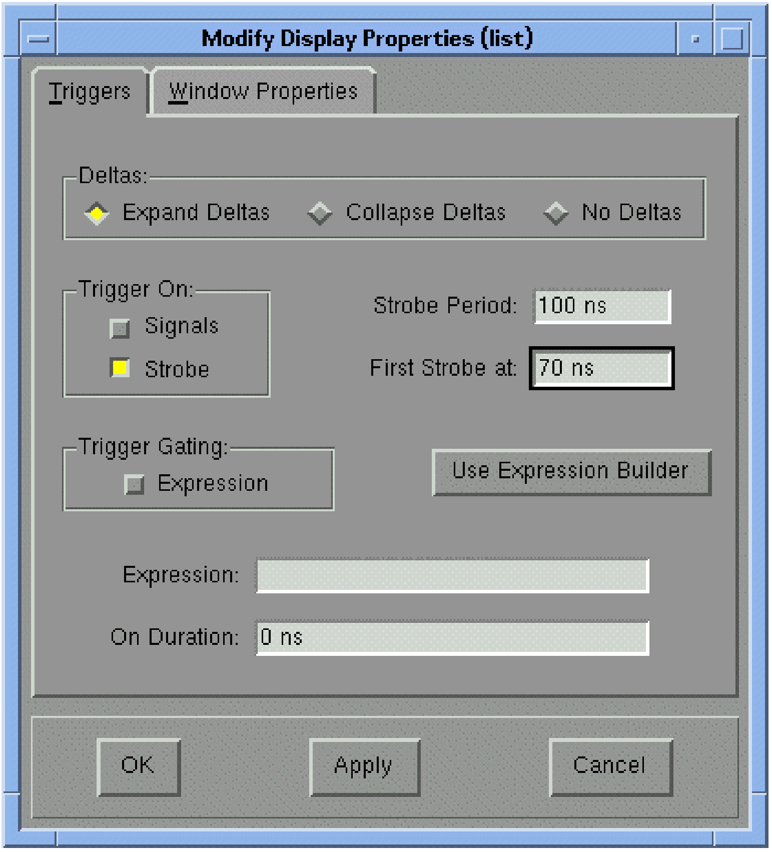


```
run
# ** Note: Test completed with no errors.
#    Time: 1 us  Iteration: 0  Instance: /testbench

VSIM 14>
Now: 1 us   Delta: 1          Env: /testbench
```

Next you will learn how to change the new-line triggering for the List window.

By default, a new line is displayed in the List window for each transition of a listed signal. The following steps will change the triggering so the values are listed every 100 ns.

24 In the List window make this menu selection: **Prop** > **Display Props**.



Modify Display Properties (list)

Deltas: ● Expand Deltas ○ Collapse Deltas ○ No Deltas

Trigger On: □ Signals ☑ Strobe

Strobe Period: 100 ns

First Strobe at: 70 ns

Trigger Gating: □ Expression

Expression:

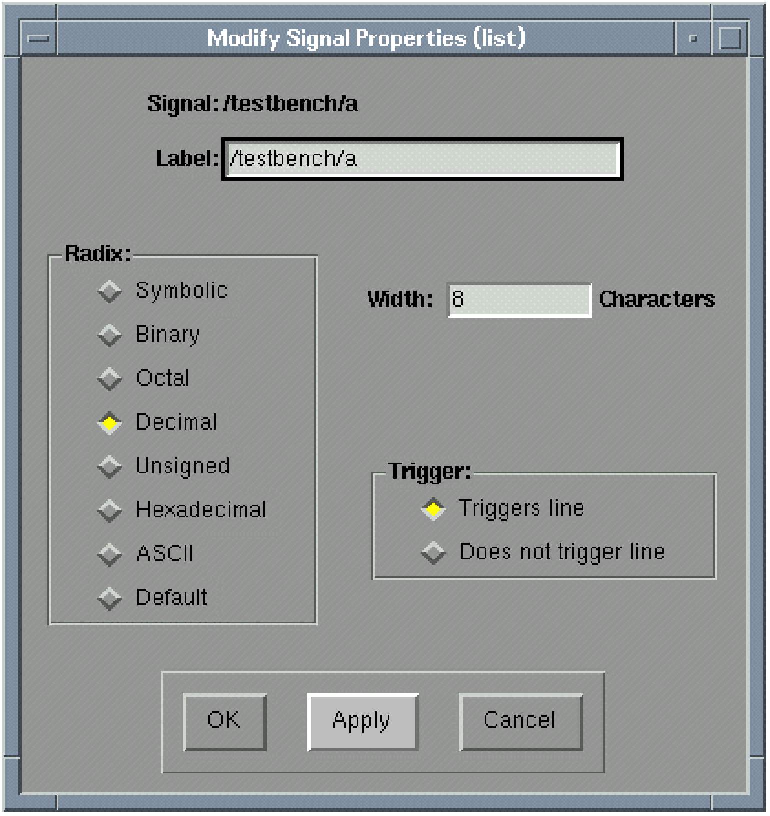
On Duration: 0 ns

25 Perform these steps on **Triggers** page in the Modify Display Properties (list) dialog box:

- Deselect **Trigger On: Signals** to disable triggering on signals.
- Select **Trigger On: Strobe** to enable the strobe.
- Enter **100** in the **Strobe Period** field.
- Enter **70** in the **First Strobe at** field.
- Click **OK** to accept the settings.

26 Your next action will be to change the radix for a, b, and sum to decimal.

Make this List window menu selection: **Prop > Signal Props**. This will open the Modify Signal Properties (list) dialog box.



Modify Signal Properties (list)

Signal: /testbench/a

Label: /testbench/a

Radix:
○ Symbolic
○ Binary
○ Octal
● Decimal
○ Unsigned
○ Hexadecimal
○ ASCII
○ Default

Width: 8 Characters

Trigger:
● Triggers line
○ Does not trigger line

27 In the List window select the signal you want to change, then make the property changes in the dialog box. Make the following property changes:

- Select signal **a**, then click **Decimal**, then click **Apply**.
- Select signal **b**, then click **Decimal**, then **Apply**.
- Select signal **sum**, then click **Decimal**, then **OK**.

This brings you to the end of this lesson, but feel free to experiment further with the menu system. When you are ready to end the simulation session, quit VSIM without saving data by entering the following command at the VSIM prompt:

```
quit -force
```

Running a batch-mode simulation

The goals for this lesson are:

- run a batch-mode VHDL simulation
- execute a macro (DO) file
- view a saved simulation

You'll work this lesson from a DOS or UNIX prompt.

1 To set up for this lesson you'll need to create a new directory and make it the current directory. Copy this file into your new directory:

```
/<install_dir>/<modelsim_dir>/examples/counter.vhd
```

2 Create a new design library:

```
vlib work
```

3 Map the library:

```
vmap work work
```

4 Then compile the source file:

```
vcom counter.vhd
```

5 You will use a macro file that provides stimulus for the counter. For your convenience, a macro file has been provided with Model*Sim* EE. You need to copy this macro file from the installation directory to the current directory:

```
<install_dir>/<modelsim_dir>/examples/stim.do
```

6 Create a batch file using an editor; name it *yourfile*. With the editor, put the following on separate lines in the file:

```
add list -decimal *
do stim.do
write format list counter.lst
```

7 To run the batch-mode simulation, enter the following command:

```
vsim -wav saved.wav counter < yourfile
```

This is what you just did in Step 7:

- invoked the VSIM simulator on a design unit called "counter"

- the **-wav** switch instructed the simulator to save the simulation results in a log file named *saved.wav*
- used the contents of *yourfile* to specify that values are to be listed in decimal, to execute a stimulus file called *stim.do*, and to write the results to a file named *counter.lst*, the default for a design named counter

8 Since you saved the simulation results in *saved.wav*, you can view the simulation results by starting up VSIM with its **-view** switch:

```
vsim -view saved.wav
```

9 Open these windows with the VIEW button or the equivalent command:

```
view structure signals list wave
```

Note: If you open the Process or Variables windows they will be empty. You are looking at a saved simulation, not examining one interactively; the logfile saved in *saved.wav* was used to reconstruct the current windows.

10 Now that you have the windows open, put the signals in them:

```
add wave *
add list *
```

11 Use the available VSIM windows to experiment with the saved simulation results and quit when you are ready:

```
quit -f
```

For additional information on the batch and command line modes, please refer to the *ModelSim EE/PLUS Reference Manual.*

Executing commands at startup

The goals for this lesson are:

- specify the design unit to be simulated on the command line
- edit the *modelsim.ini* file
- execute commands at startup with a DO file

Start this lesson from either the UNIX or DOS prompt.

1 For this lesson, you will use a macro (DO) file that provides startup information. For convenience, a startup file has been provided with the Model*Sim* program. You need to copy this DO file from the installation directory to your current directory:

```
/<install_dir>/<modelsim_dir>/examples/startup.do
```

2 Next, you will edit the system initialization file in the */<modelsim_dir>* directory to specify a command that is to be executed after the design is loaded. To do this, open the *modelsim.ini* file using a text editor and uncomment the following line in the [vsim] section of the file:

```
Startup = do startup.do
```

3 Take a look at the DO file. It uses the predefined variable **$entity** to do different things at startup for different designs.

4 Start the simulator and specify the top-level design unit to be simulated by entering the following command at the UNIX/DOS prompt:

```
vsim counter
```

Notice that the simulator loads the design unit without displaying the Load Design dialog box. This is handy if you are simulating the same design unit over and over. Also notice that all the windows are open. This is because the **view *** command is included in the startup macro.

5 If you plan to continue with the following practice sessions, keep Model*Sim* running. If you would like to quit the simulator, enter the following command at the VSIM prompt:

```
 quit -force
```

6 You won’t need the *startup.do* file for any other examples, so use your text editor to comment out the "Startup" line in *modelsim.ini*.

Tcl/Tk and Model*Sim*

This lesson is divided into several Tcl examples intended to give you a sense of Tcl/Tk's function within Model*Sim*. The examples include a custom simulation interface created with Tcl/Tk. You must be using Model*Sim* EE/PLUS or Model*Sim* EE/VHDL to complete these exercises.

Examples in this lesson

More information on Tcl/Tk

Tcl print references

Sources of information about Tcl include *Tcl and the Tk Toolkit* by John K. Ousterhout, published by Addison-Wesley Publishing Company, Inc., and *Practical Programming in Tcl and Tk by* Brent Welch published by Prentice Hall.

Tcl online references

The following are a few of the many Tcl references available:

- When using Model*Sim* make this VSIM Main menu selection: **Help** > **Tcl Man Pages**.
- Tcl man pages are also available at: www.elf.org/tcltk-man-html/contents.htm
- Tcl/Tk general information is available from the Tcl/Tk Consortium: www.tclconsortium.org
- The Scriptics Corporation, John Ousterhout's company (the original Tcl developer): www.scriptics.com.

How Tcl/Tk works with Model*Sim*

Model*Sim* incorporates Tcl as an embedded library package. The Tcl library consists of a parser for the Tcl language, routines to implement the Tcl built-in commands, and procedures that allow Tcl to be extended with additional commands specific to Model*Sim*.

Model*Sim* generates Tcl commands and passes them to the Tcl parser for execution. Commands may be generated by reading characters from an input source, or by associating command strings with Model*Sim*'s user interface features, such as menu entries, buttons, or keystrokes.

When the Tcl library receives commands it parses them into component fields and executes built-in commands directly. For commands implemented by Model*Sim*, Tcl calls back to the application to execute the commands. In many cases commands will invoke recursive invocations of the Tcl interpreter by passing in additional strings to execute (procedures, looping commands, and conditional commands all work in this way).

Model*Sim* gains a programming advantage by using Tcl for its command language. Model*Sim* can focus on simulation-specific commands, while Tcl provides many utility commands, graphic interface features, and a general programming interface for building up complex command procedures.

By using Tcl, Model*Sim* need not re-implement these features, a benefit that allows it's graphic interface to remain consistent on all platforms. (The only vestige of the host platform's graphic interface is the window frame manager.)

The custom-traffic-light interface

The subject of our main Tcl/Tk lesson is a simple traffic-light controller. The system is comprised of three primary components: a state machine, a pair of traffic lights, and a pair of traffic sensors. The components are described in three VHDL files: traffic.vhd (the state machine), queue.vhd (the traffic arrival queue) and tb_traffic.vhd (the testbench).

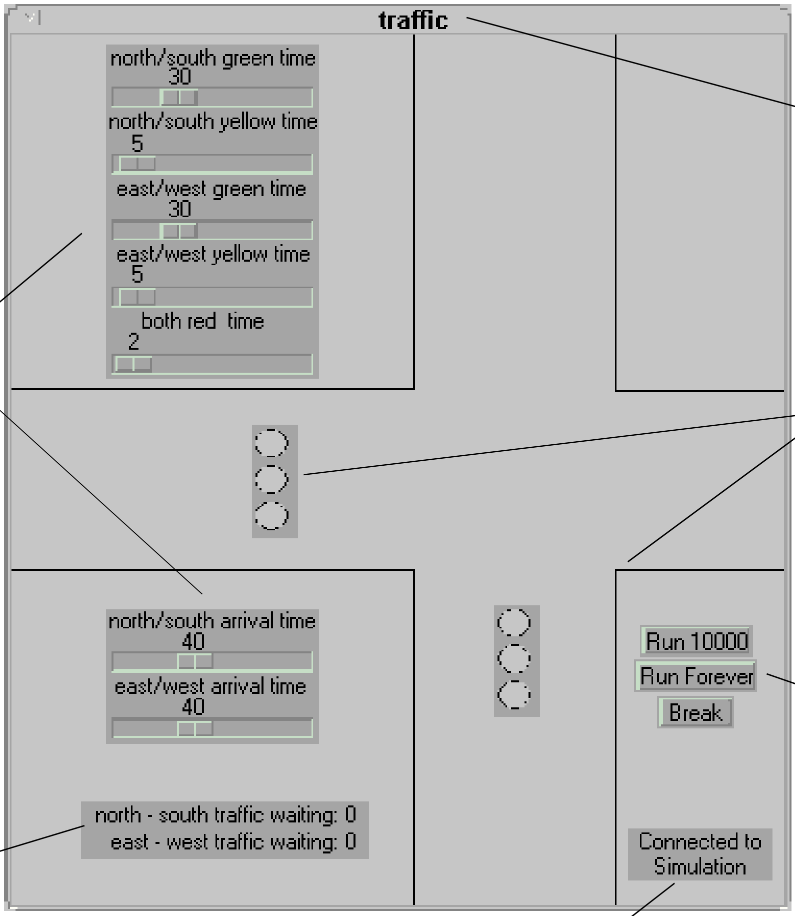
You could, of course, simulate this system with Model*Sim*'s familiar interface, but Tcl/Tk provides us the option to try something different. Since we're simulating something most of us have seen and experienced before, we can create an intuitive interface unique to the simulation.

Assumptions

The example assumes that source files were previously compiled. Here's how it works:

➔ **VHDL source files describe the system**	➔ **Tcl procedures create and connect the interface, plus the source files, to Model*Sim***	➔ **Model*Sim* commands are run via the new interface using the Tcl procedures**
	draw_intersection	
traffic.vhd queue.vhd tb_traffic.vhd	connect_lights	vsim -lib vhdl/work tb_traffic examine -value <light_timing>
	draw_queues	
	draw_controls	force -freeze $var $val ns

The result is a traffic intersection interface similar to this illustration:



north/south green time 30

north/south yellow time 5

east/west green time 30

east/west yellow time 5

both red time 2

north/south arrival time 40

east/west arrival time 40

north - south traffic waiting: 0
east - west traffic waiting: 0

wm widget
Calls to the operating system window manager to create the "traffic" window.

frame and scale widget
A scale widget within a frame widget creates an analog entry device for a minimum to a maximum value and invokes the VSIM force command

canvas widget
The background, lines and traffic lights are created with the canvas widget.

entry widget
The entry widget (contained within a frame widget) can facilitate entry, or in this case, provides a display for a VSIM examine command.

button widgets
Each button invokes the indicated VSIM run or break command.

label widget
A static label is added to the end of the connect_lights procedure to indicate connection to the simulator.

Tk widgets

The intersection illustration points out several Tcl/Tk "widgets". A widget is simply a user interface element, like a menu or scrolled list. Tk widgets are referenced within Tcl procedures to create graphic interface objects. The Tk tool box comes with several widgets, additional widgets can be created using these as a base.

Controlling the simulation

The components of the intersection interface have the following effect within Model*Sim*:

Intersection control used	**Effect in Model*Sim***
Run 1000 button	invokes the run command for 1000 ns
Run Forever button	invokes the run -all command
Break button	invokes the break command
light timing control	invokes the force command with the arguments for the indicated signal and time
arrival time control	invokes the force command with the arguments for the indicated direction and time
waiting queue	any time you change a control the examine command is invoked to display the value of the waiting queue

Saving time

Since several intersection controls invoke a VSIM command and arguments with a single action (such as the movement of a slider), this custom interface saves time compared to invoking the commands from the command line or Model*Sim* menus.

Copies of the original example files

Additional copies of the Tcl example files from these exercises are located in the*../ examples/tcl_tutorial/originals* directory.

Solutions to the examples

Throughout the traffic intersection examples you will be modifying Tcl files to complete the final intersection. You will find a completed set of intersection examples ready-to-run in the *tcl_tutorial/solutions* directory. Invoke these commands from the Model*Sim* prompt to run the intersection:

```
cd solutions
do traffic.do
```

Viewing files

If you would like to view the source for any of the Tcl files in our examples, use the **notepad** command at either the Model*Sim* or VSIM prompt.

```
 notepad <filename>
```

Most files are opened in read-only mode by default; you can edit the file by deselecting **read only** from the notepad **Edit** menu.

The Tcl source command

The Tcl **source** command reads the Tcl file into the Tcl interpreter, which parses the procedures for use within the current environment. Once sourced, a Tcl procedure can be called from the Model*Sim* prompt as shown in the syntax below. VSIM executes the instructions within the procedure.

Syntax

```
source <tcl filename>
<tcl procedure name>
```

Arguments

`<tcl filename>`

The Tcl file read into the VSIM Tcl interpreter with the **source** command.

`<tcl procedure name>`

The Tcl procedure defined within <tcl filename>, called from the Model*Sim* prompt, and executed by VSIM.

The *traffic.do* file is a good example of the **source** command syntax (the file is a macro that runs the traffic light simulation). Check it out with the notepad:

```
notepad traffic.do
```

Example shortcuts

To save some typing, copy the commands from the PDF version of these instructions and paste them at the Model*Sim* prompt. Paste with the right (2 button mouse), or middle (3 button mouse). You can also select a Model*Sim* or VSIM prompt from the Main transcript to paste a previous command to the current command line.

Make a transcript DO file

You can rerun the commands executed during the current session with a Do file created from the Main transcript. Make the DO file by saving the transcript with the **File > Save Main As** menu selection at any time during the exercises. Run the DO file to repeat the commands (do <do filename>).

Preparing for the Tcl/Tk examples

These steps must be completed before running the Tcl examples.

1 Create, and change to a new working directory for the Tcl/Tk exercises. Copy the lesson files in the following directory (include all subdirectories and files) to your new directory:

```
<install_dir>/<modelsim_dir>/examples/tcl_tutorial
```

2 Make the new directory the current directory, then invoke Model*Sim*:

for UNIX

```
vsim -gui
```

for Windows (from a shortcut or Start > Run, etc.)

```
modelsim.exe
```

3 At the ModelSim prompt, create a **work** library in the */vhdl* directory:

```
vlib vhdl/work
```

4 Map the **work** library.

```
vmap work vhdl/work
```

5 Compile the VHDL example files with these commands (or the Compile dialog box):

```
vcom vhdl/traffic.vhd
vcom vhdl/queue.vhd
vcom vhdl/tb_traffic.vhd
```

Now you're now ready to run the examples.

Example 1 - create a "hello world" button widget

Before you begin the examples make sure you have completed "Preparing for the Tcl/Tk examples" (p121).

In this example you will study a "hello world" button that prints a message when pressed.

1 Source the Tcl file from the Model*Sim* prompt:

```
source hello.tcl
```

then run the procedure defined within *hello.tcl*:

```
hello_example
```

The file *hello.tcl* was read into the VSIM Tcl interpreter. The instructions in *hello_example* procedure were then executed by VSIM, and "Hello World" was printed to the Main transcript. Selecting the button will print the message again.

You've just created your first top-level widget!

2 Invoke the *hello_example* procedure again and notice how the new button replaces the original button. The procedure destroyed the first button and created the new one. Get a closer look at the source Tcl file with the **notepad**:

```
notepad hello.tcl
```

Close the hello_example window when you're done.

Example 2 - add a procedure that gets called by a button push

Before you begin this example make sure you have completed "Preparing for the Tcl/Tk examples" (p121).

In this example you will study a larger Tcl example, and add a procedure that gets called by a button push.

This example will display all of the gif images in the images directory. Each button has a binding attached to it for "enter" events, and a binding for a mouse button press. When the mouse enters the button graphic, the image file name is printed to the Main window. When the mouse button is pushed its "widget" name will be printed to the Main window.

1 Build an image viewer by invoking this command, and calling this procedure:

```
source images.tcl
image_example
```

2 Drag the mouse across the buttons and notice what happens in the Main transcript.

Push one of the buttons; you will see an error dialog box. You can solve this problem by modifying the *images.tcl* file.

3 To view the source file press the **See Source Code** button at the bottom of the image display or invoke **notepad** at the Model*Sim* prompt:

```
notepad images.tcl
```

You'll find that the *pushme* procedure is missing; it's commented out in *images.tcl*.

4 Search for "proc push" using the **Edit** > **Find** menu selection in the notepad.

Remove the comments (the "#" symbols) to return the function to your source, then close the image window with the **Destroy** button.

5 Once the *pushme* procedure is in place it will print its one parameter, the object name, to the transcript.

After you have added the *pushme* procedure to your source, you need to resource and rerun the Tcl procedure with these commands (use the up arrow to scroll through the commands or type !source):

```
source images.tcl
image_example
```

Press all the buttons and notice the object names in the Main transcript. Close the image example window when you’re done.

Example 3 - The traffic light simulation

In this example you’ll simulate an intersection with traffic lights. The simulation interface you will create allows you to run "what if" scenarios efficiently.

Introduction of the traffic intersection widget

This portion of our example introduces the traffic intersection widget. You’ll add other widgets to the intersection to create a custom traffic simulation environment.

Once again, make sure you have completed "Preparing for the Tcl/Tk examples" (p121) before working this example.

1 Draw the intersection by invoking this command and procedure at the Model*Sim* prompt:

```
source intersection.tcl
draw_intersection
```

2 From the Model*Sim* prompt, use the procedure set_light_state to change the color of the lights:

```
set_light_state green .traffic.i.ns_light

set_light_state green .traffic.i.ew_light
```

You can use the Copy and Paste buttons on the Main toolbar to help build instructions from previous commands.

3 View the source code with this command at the Model*Sim* prompt:

```
notepad intersection.tcl
```

You can locate the *set_light_state* procedure with **Edit** > **Find** from the Main menu (it’s located toward the middle of the file).

Connect traffic lights to the simulation

Using the intersection widget, you will add *when* statements to connect the lights to the real simulation. Once the connection is made you will simulate the traffic light controller and watch the lights change.

We'll use VSIM *when* statements to condition the simulation to call our Tcl program when a desired simulation condition happens.

For our example, the desired condition is the state of the lights. Whenever the state of the light in the simulation changes, we want to change the color of the light on the screen.

4 Load the VHDL libraries you compiled in preparation for these examples using this command at the Model*Sim* prompt:

```
vsim tb_traffic
```

Be sure you invoke this command before the start of the connect_lights procedure, if you don't load the libraries, you won't have a design to simulate.

5 Connect the lights to the simulation with this command and procedure:

```
source lights.tcl
connect_lights
```

Try running the simulation now; select either run button on the intersection (select **Break** if you used the **Run Forever** button - notice how the Source window opens and indicates the next line to be executed). Only the East/West lights are working. You can make both lights work by editing the *lights.tcl* file.

6 Edit *lights.tcl* with the **notepad** to add a *when* statement for the North/South light.

```
notepad lights.tcl
```

You need to add this because the current statement is for the East/West light only. You’ll find the solution commented. (Remember to change the read-only status of the file so you can edit it.)

You’ll find the code commented-out toward the end of the file (try Edit >Find again).

7 After you have made the changes, reload and run the simulation again.

```
source lights.tcl
connect_lights
```

Both lights are now working.

Note: Remember, if you need to return to the original Tcl files (maybe you’ve edited the file and it doesn’t work right) you’ll find the files in the *tcl_tutorial/originals* directory.

Add widgets to display simulation information

Running the lights may be interesting, but not very useful - let’s add some displays that will tell us what’s happening to the cars at the intersection.

Now you will add queue widgets to display the sum of the length of each pair of queues as we simulate.

8 The East/West widget for displaying the total East/West queue length is already provided. Let's edit the source to add a display for the North/South direction. Use the **notepad**:

```
notepad queues.tcl
```

The solution is commented out in *queues.tcl*.

The Queue Display widget consists of an enclosing frame with two label widgets. The first label is a simple text string. The second label is the value of the queue length. The text in the second label will be updated whenever the queue lengths change.

The update is accomplished by using a **when** statement.

9 After you have added your North/South widget, run your program by invoking this command:

```
source queues.tcl
draw_queues
```

According to the traffic indicators, the cars are leaving the intersection at the same rate. That seems fair, but if you are designing an intersection that responds to the traffic flow into the intersection you might want to change the light cycles. Perhaps one of the directions has more incoming traffic than the other.

Adding controls, in the form of scale widgets, allows you to quickly change the assumptions about traffic flow into the intersection.

Add "scale" widgets to control the simulation

Next you will add Tk "scale" widgets that will control the arrival rates and the length of the lights.

10 The East/West widget for controlling the East/West queue inter-arrival time is provided. You'll edit the source code to add controls for the North/South direction. Use this command:

```
notepad controls.tcl
```

You can remove the comments in the code to make this change.

Similarly, add the North/South widget for controlling the length of the lights. The East/West widget for light control is provided. (You can remove the comments in the code to make this change as well.)

These control widgets are implemented using the Tk "scale" widgets, enclosed in a frame.

When the value of the scale widget changes, it calls the command specified with the **-command** option on each scale.

11 After you have added your North/South widgets, run your program with this command:

```
source controls.tcl
draw_controls
```

Now you have a complete intersection interface. Try the run buttons and the slider scales. You can also view the simulation with Model*Sim*'s GUI. Check the Source window to view the VHDL files, and add signals to a Wave window (**add wave ***). You can also change the run length in the Main window. Try using the Run buttons in the Main window and the intersection window.

Keep the intersection simulation running to complete the next example. If you want to recreate the final intersection environment quickly, invoke these commands from the ModelSim prompt (after "Preparing for the Tcl/Tk examples" (p121)).

```
cd solutions
do traffic.do
```

Example 4 - draw a state machine that represents the simulation

In this final example you will draw a state machine representing the simulation, and connect it to the state signal inside the traffic light controller. Each transition that the controller makes is displayed as it happens.

The intersection environment from the previous example needs to be running for this example. To get it running quickly, invoke these commands from the Model*Sim* prompt (after "Preparing for the Tcl/Tk examples" (p121)).

```
cd solutions
do traffic.do
```

1 Run the state machine with these commands:

```
source state-machine.tcl
draw_state_machine
```

Let’s make some changes to the light colors and transition arrows.

2 Open the source file with this command:

```
notepad state-machine.tcl
```

Note the "ModelSim EXAMPLE part 1" comments in the file. Change "both_red" state coordinates as indicated in the file.

3 Note the "ModelSim EXAMPLE part 2" comments in the file. Change the transition arrow coordinates as indicated in the file.

4 Note the "ModelSim EXAMPLE part 3" comments in the file. Change the active color from "black" to "purple".

5 Reuse the original commands when you're ready to run the state machine (remember, to copy a previous command to the current command line, select the previous Model*Sim* prompt):

```
source state-machine.tcl
draw_state_machine
```

Notice the changes. Try some additional changes if you wish.

This is the end of the Tcl/Tk examples. Continue to modify and test the examples if you wish; you can recover the original files at any time in the *tcl_tutorial/originals* directory.

Basic Verilog simulation

You must be using Model*Sim* EE/PLUS or Model*Sim* EE/VLOG for this lesson.

The goals for this lesson are:

- compile a Verilog design
- examine the hierarchy of the design
- list signals in the design
- change list attributes
- set a breakpoint
- add and remove cursors in the waveform display

If you’ve completed any previous VHDL lesson you’ll notice that the Verilog and VHDL simulation processes are almost identical.

1 Create, and change to a new directory to make it the current directory.

2 Copy the Verilog files from the */<install_dir>/<modelsim_dir>/examples* directory into the current directory.

Before you can compile a Verilog design, you need to create a design library in the new directory. If you are only familiar with interpreted Verilog simulators such as Cadence Verilog XL this will be a new idea for you. Since Model*Sim* is a compiled Verilog, it requires a target design library for the compilation. Model*Sim* can compile both VHDL and Verilog code into the same library if desired.

3 Invoke ModelSim:

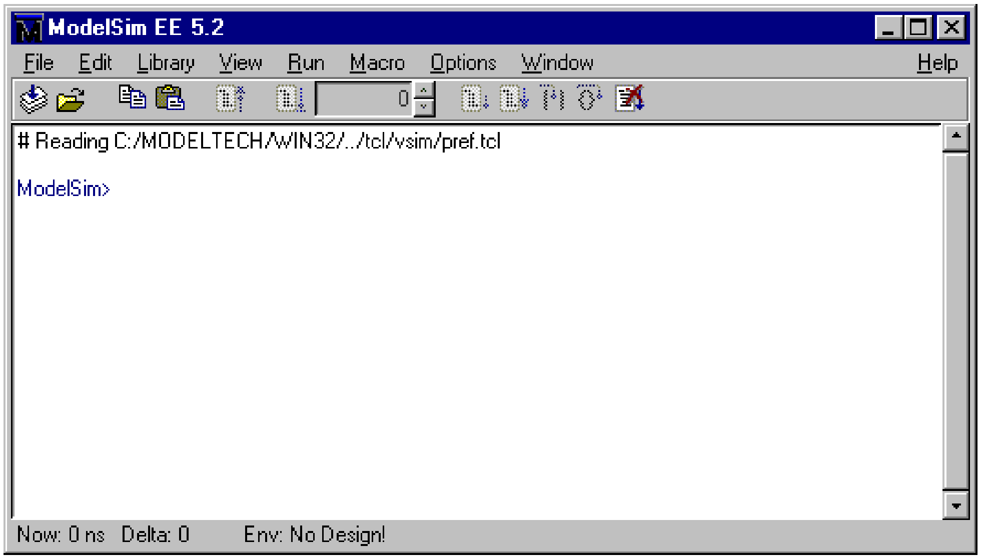
for UNIX at the shell prompt:

```
vsim -gui
```

for Windows - your option - DOS prompt, shortcut, or Start menu:

```
modelsim.exe
```

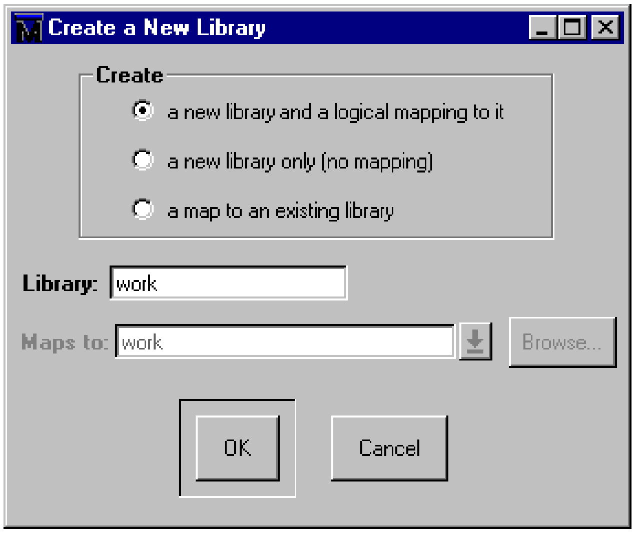
This opens the Model*Sim* Main window without loading a design.



```
# Reading C:/MODELTECH/WIN32/../tcl/vsim/pref.tcl

ModelSim>
```

```
Now: 0 ns   Delta: 0        Env: No Design!
```

4 Before you compile a source file, you'll need a design library to hold the compilation results. To create a new design library, make this menu selection in the Main window: **Library** > **Create a New Library**. (PROMPT: vlib work)



● a new library and a logical mapping to it

○ a new library only (no mapping)

○ a map to an existing library

Library: work

Maps to: work

In the Create a New Library dialog box, select **Create: a new library and a logical mapping to it**. Make sure **Library:** indicates **work**, then select **OK**. This creates a subdirectory named *work* - your design library - within the current directory. This subdirectory contains a special file named *_info*. (Do not create these using UNIX or Windows commands—always use the Library menu or the **vlib** command from either the Model*Sim* or UNIX/DOS prompt.)

Note: Remember, a library directory should not be created using UNIX/DOS commands - always use the Main Library menu or the **vlib** command.

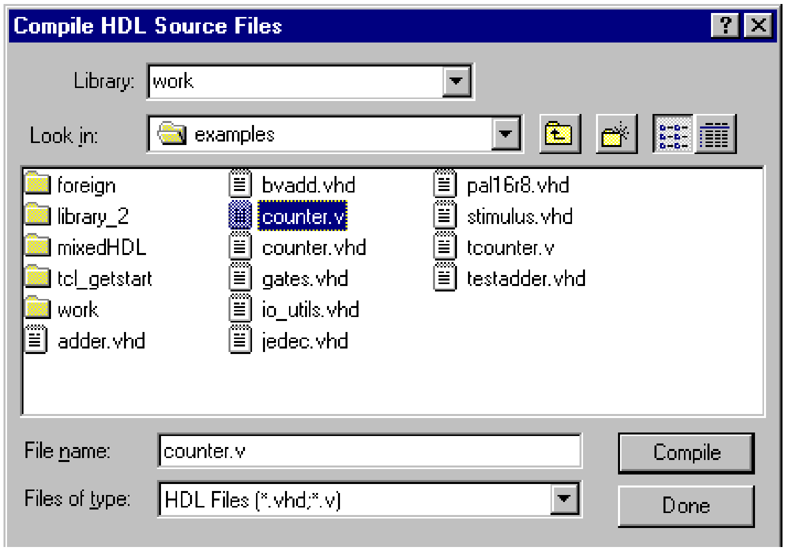
Next, you’ll compile the Verilog design.

The example design consists of two Verilog source files, each containing a unique module. The file *counter.v* contains a module called **counter**, which implements a simple 8-bit binary up-counter. The other file, *tcounter.v*, is a testbench module (**test_counter**) used to verify **counter**. Under simulation you will see that these two files are configured hierarchically with a single instance (instance name **dut**) of module **counter** instantiated by the testbench. You'll get a chance to look at the structure of this code later. For now, you need to compile both files into the **work** design library.

5 Compile the *counter.v*, and *tcounter.v* files into the **work** library by selecting the **Compile** button on the toolbar:

(PROMPT: vlog counter.v)

This opens the Compile HDL Source Files dialog box.



Library: work

Look in: examples

File name: counter.v

Files of type: HDL Files (*.vhd;*.v)

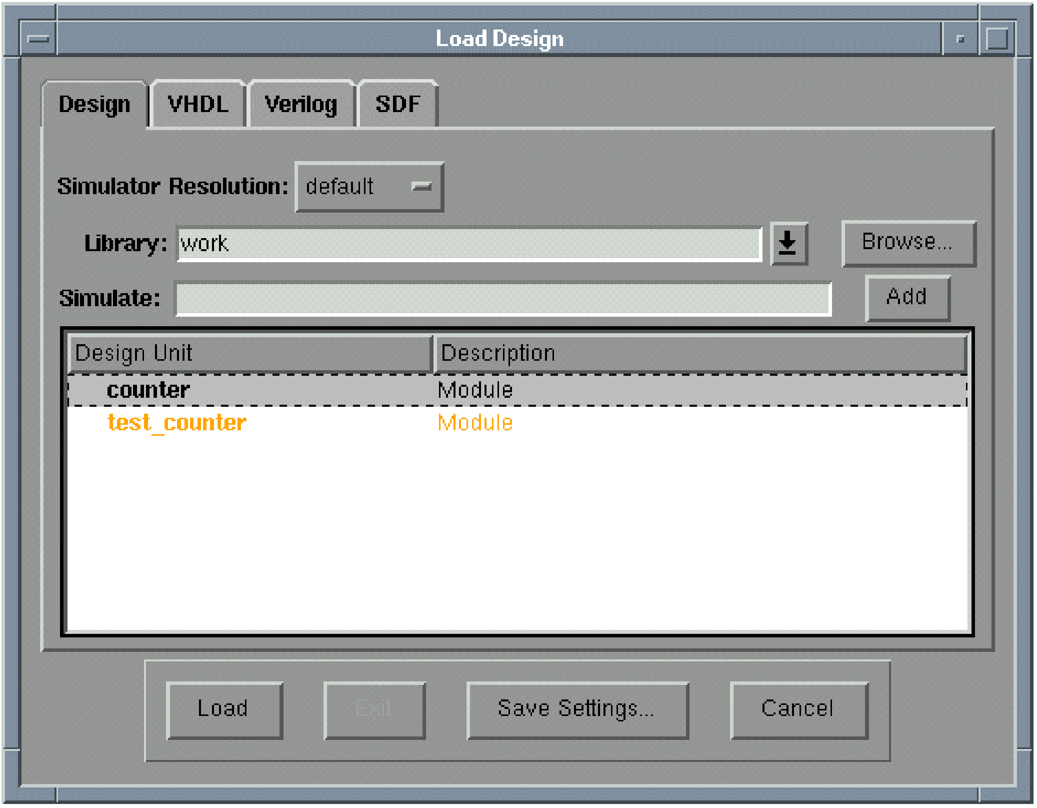
Complete the compilation by selecting both files. **Control+click** (left mouse button) on *counter.v*, then *tcounter.v* from the file list and choose **Compile**, then **Done**.

Note: The order in which you compile the two Verilog modules is not important. This may again seem strange to Verilog XL users who understand the possible problems of interface checking between design units, or compiler directive inheritance. Model*Sim* defers such checks until the design is loaded by VSIM (the HDL simulator). So it doesn't matter here if you choose to compile *counter.v* before or after *tcounter.v*.

6 Start the simulator by selecting the **Load Design** button from the toolbar:

(PROMPT: vsim test_counter)

The Load Design dialog box comes up, as shown below.



Simulator Resolution: default

Library: work

Simulate:

Design Unit	Description
counter	Module
test_counter	Module

The Load Design dialog box allows you to select a design unit to simulate from the specified library. You can also select the resolution limit for the simulation. The default library is **work** and the default resolution is 1 ns (default).

7 Select **Design Unit: test_counter** and click **Load** to accept these settings.

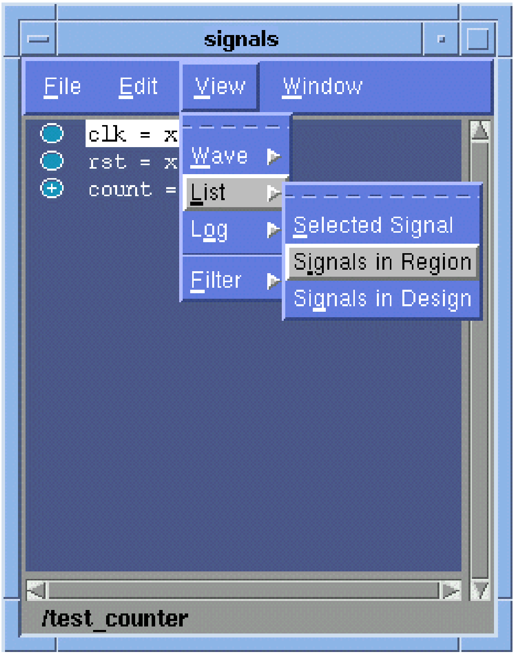
8 Bring up the Signals, List and Wave windows by entering the following line at the VSIM prompt within the Main window:

```
view signals list wave
```

(Main MENU: View > <window name>)

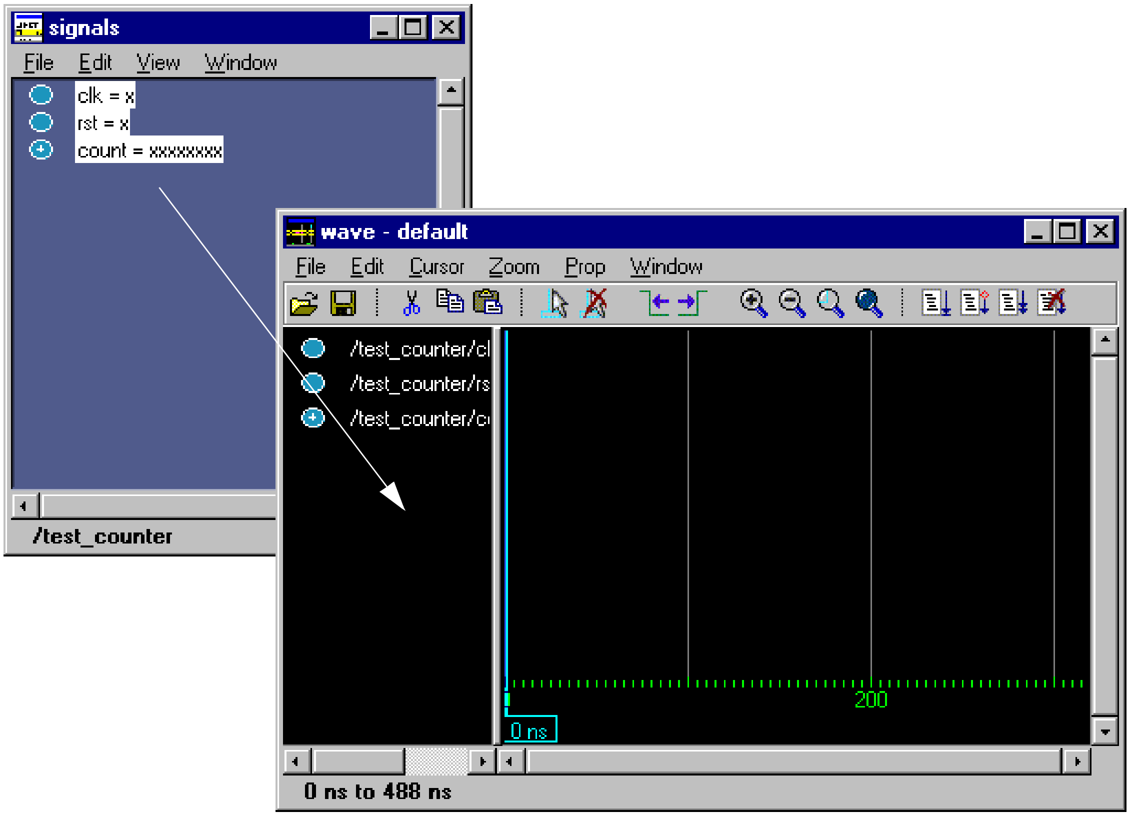
9 To list the top-level signals, move the pointer to the Signals window and make this View menu selection: **View** > **List** > **Signals in Region**.

(PROMPT: add list /counter/*)



10 Now let’s add signals to the Wave window with Model*Sim*’s drag and drop feature.

In the Signals window, **control-click** on each of the *clk*, *rst*, and *count* signals to make a group selection. Click and hold on the group one more time, then drag it to either pane of the Wave window.

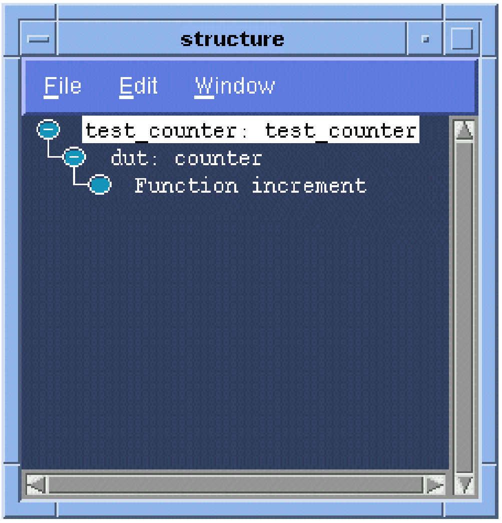


HDL items can also be copied from one window to another (or within the Wave and List windows) with the Edit > Copy and Edit > Paste menu selections. You can also delete selected items with the Edit > Delete selection.

11 Next open the Structure and Source windows. From the **Main window** make these menu selections: **View** > **Structure** and **View** > **Source**.

(PROMPT: view structure source)

12 Rearrange the windows to give yourself a clear view of all open windows (try the **Window** > **Initial Layout** menu selection), then click inside the Structure window.



Notice how this window describes the hierarchical structure of the design. In the illustration the Structure window shows three hierarchical levels: **test_counter**, **counter** and the function called **increment**. (If **test_counter** is not displayed you simulated **counter** instead of **test_counter**.)

You can navigate within the hierarchy by clicking on any line with a "+" (expand) or "-" (contract) symbol. The same navigation technique works anywhere you find these symbols within Model*Sim*.

13 Click on **Function increment** and notice how other VSIM windows are automatically updated as appropriate.

Specifically, the Source window displays the Verilog code at the hierarchical level you selected in the Structure window. The source-file name is also displayed in the Source window title bar.

Using the Structure window in this way is analogous to scoping commands in interpreted Verilogs.

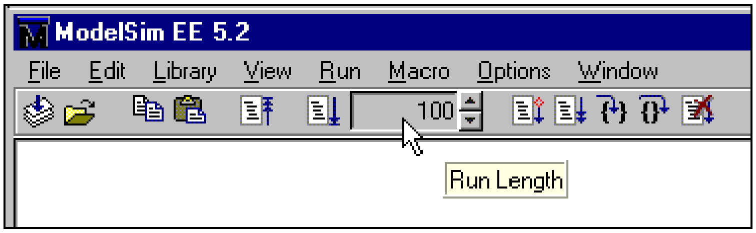
For now, make sure the **test_counter** module is showing in the Source window by clicking on the top line in the Structure window.

14 Now you will exercise different Run functions from the toolbar.

15 Select **Run** button on the Main toolbar. This causes the simulation to run and then stop after 100 ns (the default simulation length).

(PROMPT: run) (MENU: Run > Run 100 ns)

16 Next change the run length to 500 on the **Run Length** selector and select the **Run** button again.



Now the simulation has run for a total of 600ns (the default 100ns plus the 500 you just asked for). A status bar reflects this information at the bottom of the Main window.

17 The last command you executed (**run 500**) caused the simulation to advance for 500ns. You can also advance simulation to a specific time. Type:

```
run @ 3000
```

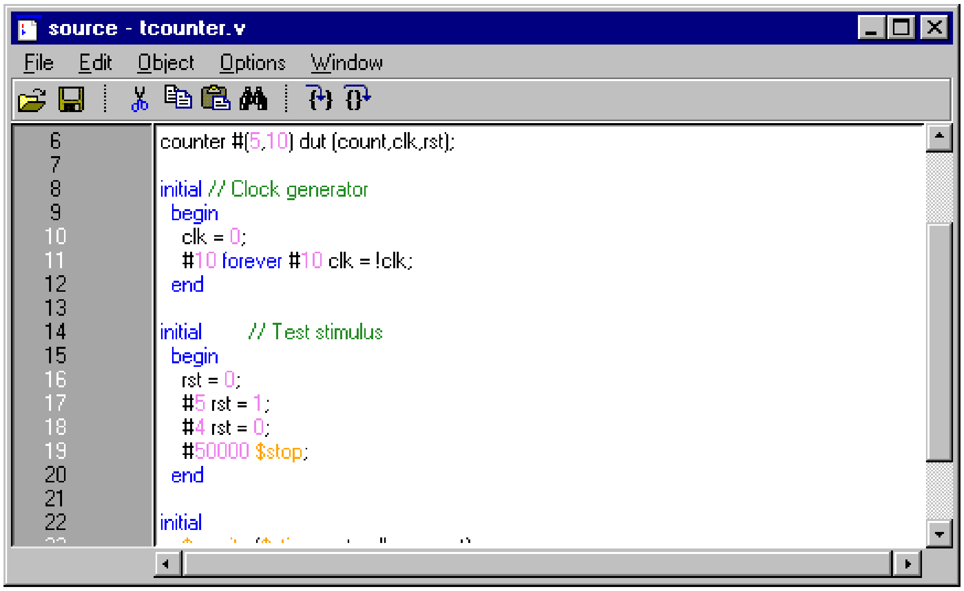
This advances the simulation to time 3000ns. Note that the simulation actually ran for 2400ns (3000 - 600).

18 Now select the **Run All** button from the Main toolbar. This causes the simulator to run forever.

(PROMPT: run -all) (Main MENU: Run > Run -All)

19 Select the **Break** button to stop the run.

(control + c with the Main window active)

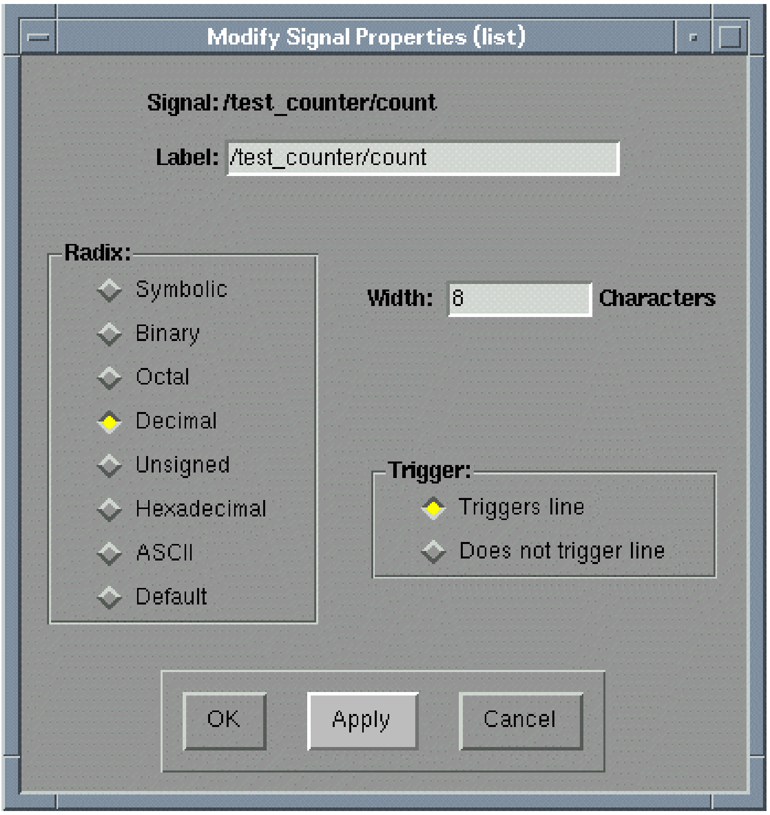


```
counter #(5,10) dut (count,clk,rst);

initial // Clock generator
  begin
    clk = 0;
    #10 forever #10 clk = !clk;
  end

initial       // Test stimulus
  begin
    rst = 0;
    #5 rst = 1;
    #4 rst = 0;
    #50000 $stop;
  end

initial
```

Your window won’t look exactly like the illustration because your simulation very likely stopped at a different point.

Next we'll take a brief look at some interactive debug features of the Model*Sim* environment. To start with, let's see what we can do about the way the List window presents its data.

20 In the List window select **/test_counter/count**. From the List window menu bar select **Prop** > **Signal Props**. The Modify Signal Properties (list) dialog box is opened.



Modify Signal Properties (list)

Signal: /test_counter/count

Label: /test_counter/count

Radix:

○ Symbolic
○ Binary
○ Octal
● Decimal
○ Unsigned
○ Hexadecimal
○ ASCII
○ Default

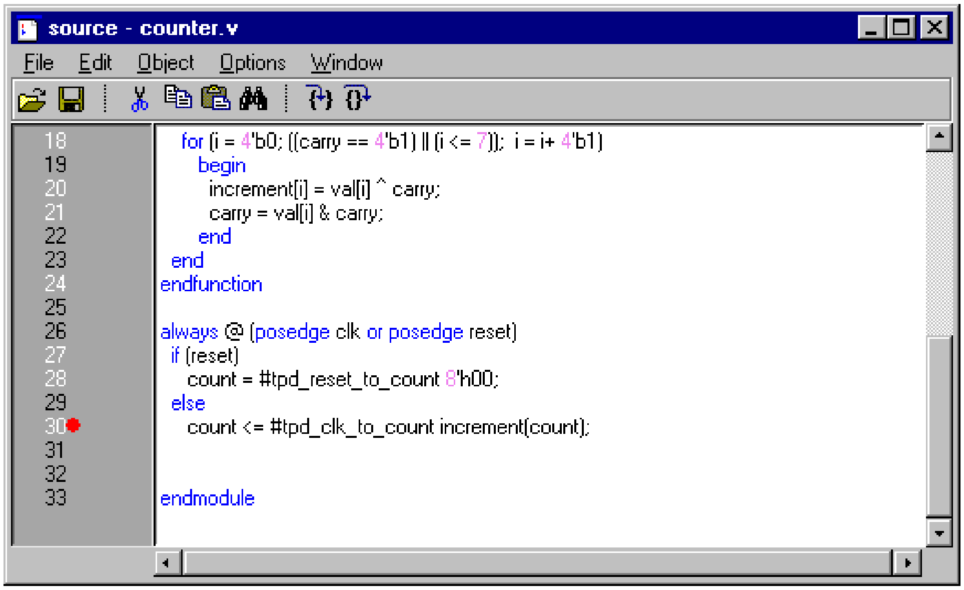
Width: 8 Characters

Trigger:

● Triggers line
○ Does not trigger line

Select a display radix of **Decimal** for the signal **count**. Click **OK**. This causes the List window output to change; the count signal is now listed in decimal rather than the default binary.

21 Let’s set a breakpoint at line 30 in the *counter.v* file (which contains a call to the Verilog function increment). To do this, select **dut: counter** in the Structure window. Move the cursor to the Source window and scroll the window to display line 30. Click at or near line number 30 to set a breakpoint (the executable line number is displayed in green).



```
18   for (i = 4'b0; ((carry == 4'b1) || (i <= 7)); i = i+ 4'b1)
19     begin
20      increment[i] = val[i] ^ carry;
21      carry = val[i] & carry;
22     end
23  end
24 endfunction
25
26 always @ (posedge clk or posedge reset)
27  if (reset)
28    count = #tpd_reset_to_count 8'h00;
29  else
30●   count <= #tpd_clk_to_count increment(count);
31
32
33 endmodule
```

You will see a dot appear next to the line number. This indicates that a breakpoint has been set for that line. Clicking line 30 once more would remove the breakpoint but don’t do that now.

22 Select the **Run** button from the Main toolbar to resume execution of the simulation.

(PROMPT: run) (Main MENU: Run > Run 500 ns)

When the simulation hits the breakpoint, it stops running, highlights the Source window with an arrow, and issues a message in the Main window.

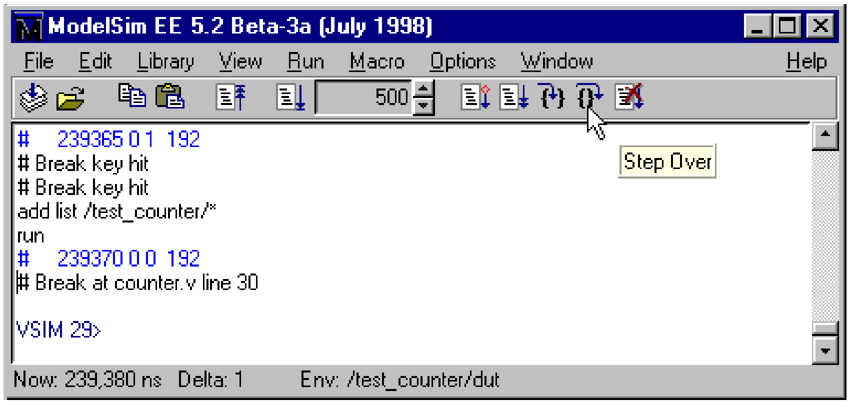
23 Typically when a breakpoint is reached you will be interested in one or more signal values. You have several options for checking values.

You can look at the values shown in the Signals window, you can move you mouse pointer over the *count* variable in the Source window and press the right mouse button, or you can use the **examine** command:

```
examine count
```

As a result of your command the count is output to the Main window.

24 Let’s move through the Verilog source functions with Model*Sim*’s Step and Step Over commands. Click **Step Over** on the toolbar.



```
#    239365 0 1  192
# Break key hit
# Break key hit
add list /test_counter/*
run
#    239370 0 0  192
# Break at counter.v line 30

VSIM 29>
```

Now: 239,380 ns   Delta: 1   Env: /test_counter/dut

This causes the debugger to step over the function call on line 30. The Step button on the toolbar would have single-stepped the debugger, including each line of the increment function.

25 Experiment by yourself for awhile; setting and clearing breakpoints as well as Step’ing and Step Over’ing function calls until you feel comfortable with the operation of these commands.

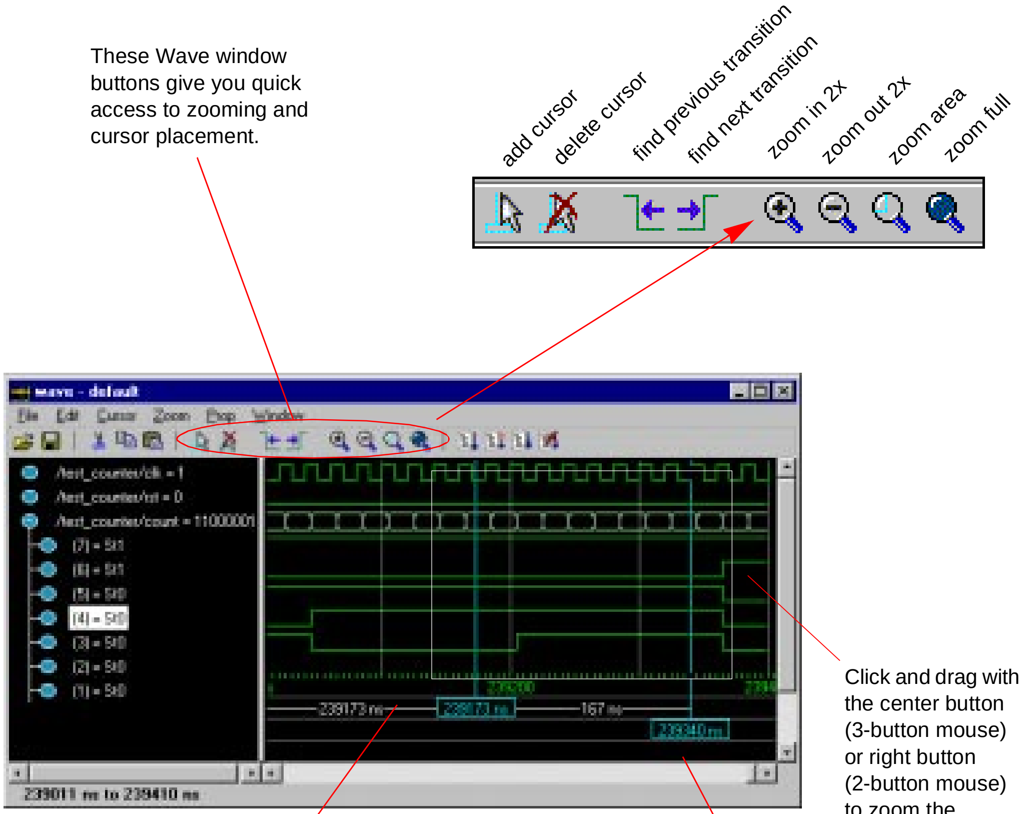
26 Now let’s get a Wave window view of the simulation.

When the Wave window is first drawn, there is one cursor in it at time zero. Clicking anywhere in the waveform display brings that cursor to the mouse location.

Up to ten cursors can be present at the same time. Cursors are displayed with a time box showing the precise simulation time at the bottom. When you have more than one cursor, each time box appears in a separate track at the bottom of the display.

27 Try adding or removing cursors with the **Add Cursor** and **Delete Cursor** buttons.

These Wave window buttons give you quick access to zooming and cursor placement.



Click and drag with the center button (3-button mouse) or right button (2-button mouse) to zoom the display.

interval measurement

selected cursor is bold

When you add a cursor, it is drawn in the middle of the display. Once you have more than one cursor, VSIM adds a delta measurement showing the time difference between the two cursor positions. The selected cursor is drawn as a solid line; all other cursors are drawn with dotted lines.

28 Click in the waveform display. Notice how the cursor closest to the mouse position is selected and then moved to the mouse position.

Another way to position multiple cursors is to use the mouse in the time box tracks at the bottom of the display. Clicking anywhere in a track selects that cursor and brings it to the mouse position.

The cursors are designed to snap to the closest wave edge to the left of the mouse pointer. You can position a cursor without snapping by dragging in the area below the waveforms.

29 Experiment with using the cursors, scrolling, and zooming (see page 157 for Wave window shortcuts).

30 When you’re done experimenting, quit the simulator by entering the command:

```
quit -force
```

Mixed VHDL/Verilog simulation

You must be using Model*Sim* EE/PLUS for this lesson.

The goals for this lesson are:

- compile multiple VHDL and Verilog files
- simulate a mixed VHDL and Verilog design
- list VHDL signals and Verilog nets and registers
- view the design in the Structure window
- view the HDL source code in the Source window

1 First, return to the directory you created in "Basic VHDL simulation" (p94).

```
cd <directory_name>
```

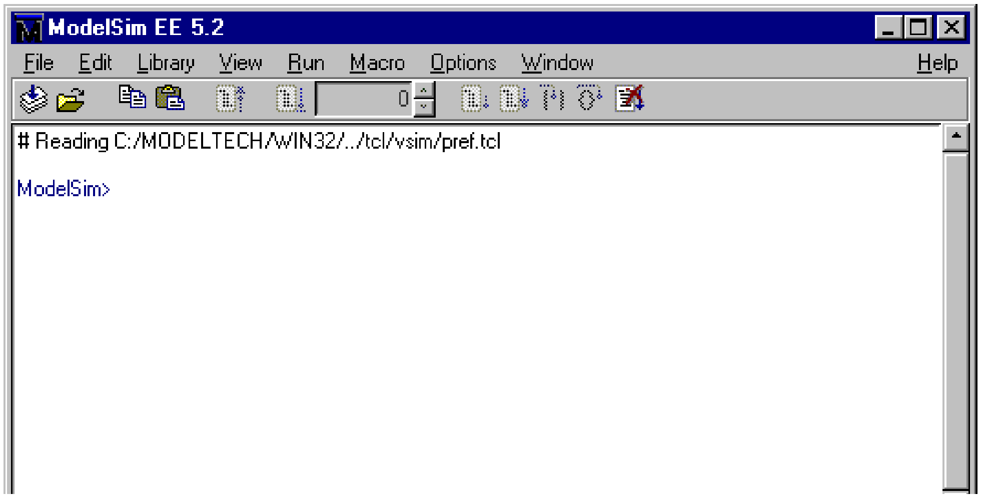
Next copy the VHDL and Verilog example files to the directory:

```
<install_dir>/<modelsim_dir>/examples/mixedHDL/*.vhd
<install_dir>/<modelsim_dir>/examples/mixedHDL/*.v
```

2 Start ModelSim with this command from the UNIX/DOS prompt (or *modelsim.exe* for Windows):

```
vsim -gui
```

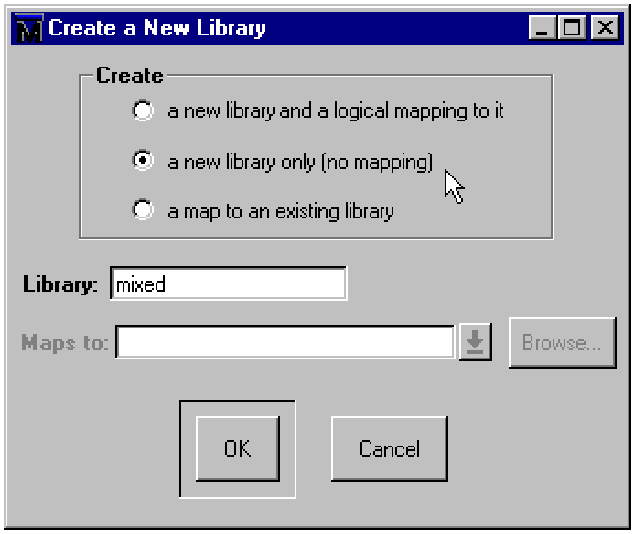
This opens the Model*Sim* Main window without loading a design.



```
# Reading C:/MODELTECH/WIN32/../tcl/vsim/pref.tcl

ModelSim>
```

3 Let's create a new library to hold the mixed design. Make this menu selection in the **Main window: Library > Create a New Library**.

(PROMPT: vlib mixed)



Create

○ a new library and a logical mapping to it

● a new library only (no mapping)

○ a map to an existing library

Library: mixed

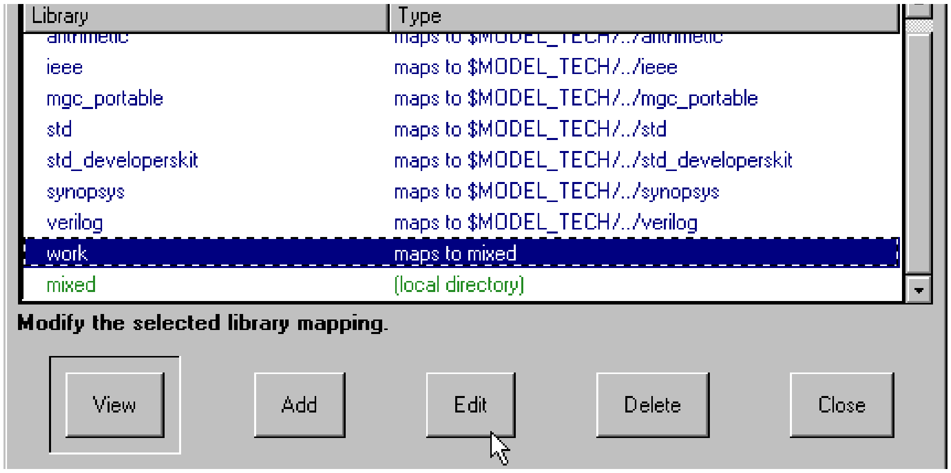
Maps to:

In the Create a New Library dialog box select **Create: a new library only**. In the **Library:** field type **mixed**, then select **OK**.

This creates a subdirectory named *mixed* (your design library) within the current directory. The library contains a special file named *_info* that is created with the library.

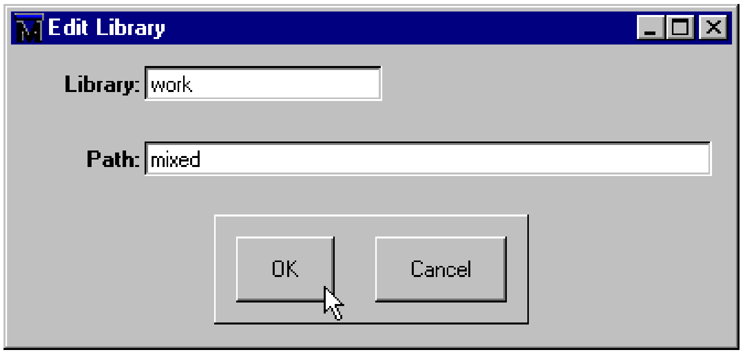
Do not create library subdirectories using UNIX or Windows commands—always use the Library menu or the **vlib** command from either the Model*Sim* or UNIX/DOS prompt.

4 Now you can map the new library to the **work** library. From the Main menu select **Library > Browse Libraries**. In the Library Browser select the **work** library, then **Edit.** (PROMPT: vmap work mixed)



Library	Type
arithmetic	maps to $MODEL_TECH/../arithmetic
ieee	maps to $MODEL_TECH/../ieee
mgc_portable	maps to $MODEL_TECH/../mgc_portable
std	maps to $MODEL_TECH/../std
std_developerskit	maps to $MODEL_TECH/../std_developerskit
synopsys	maps to $MODEL_TECH/../synopsys
verilog	maps to $MODEL_TECH/../verilog
work	maps to mixed
mixed	(local directory)

Modify the selected library mapping.



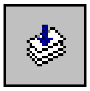
Library: work

Path: mixed

This opens the Edit Library dialog box; where you can set the library mapping between work and mixed.

Type **mixed** into the **Path:** field, then click **OK**. Now you're ready to compile the design.

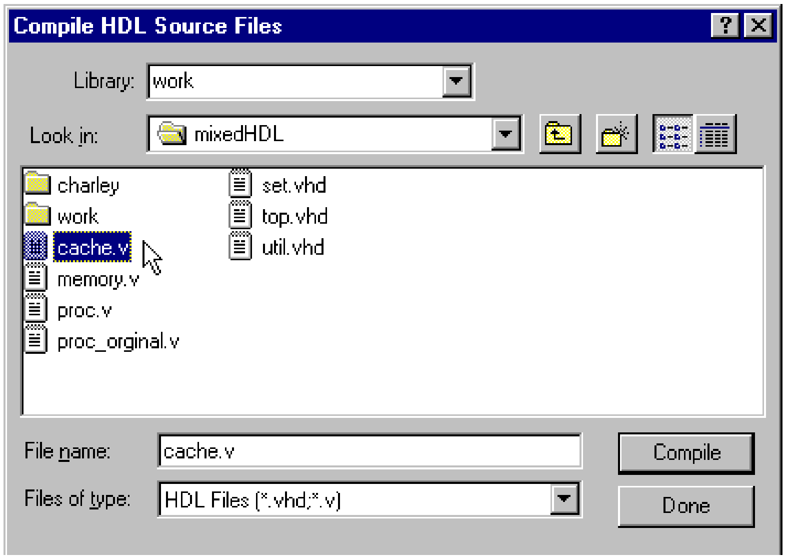
5 Compile the HDL files by selecting the **Compile** button on the toolbar:



(PROMPT: vlog cache.v memory.v proc.v)

(PROMPT: vcom util.vhd set.vhd top.vhd)

This opens the Compile HDL Source Files dialog box.



Library: work

Look in: mixedHDL

charley
work
cache.v
memory.v
proc.v
proc_orginal.v
set.vhd
top.vhd
util.vhd

File name: cache.v

Files of type: HDL Files (*.vhd;*.v)

A group of Verilog files can be compiled in any order. Note, however, in a mixed VHDL/Verilog design the Verilog files must be compiled before the VHDL files.

Compile the source, by double-clicking each of these Verilog files in the file list (this invokes the Verilog compiler, **vlog**):

- *cache.v*
- *memory.v*
- *proc.v*

6 Depending on the design, the compile order of VHDL files can be very specific. In the case of this lesson, the file *top.vhd* must be compiled last.

Stay in the Compile HDL Source Files dialog box and compile the VHDL files in this order (this invokes the VHDL compiler, **vcom**):

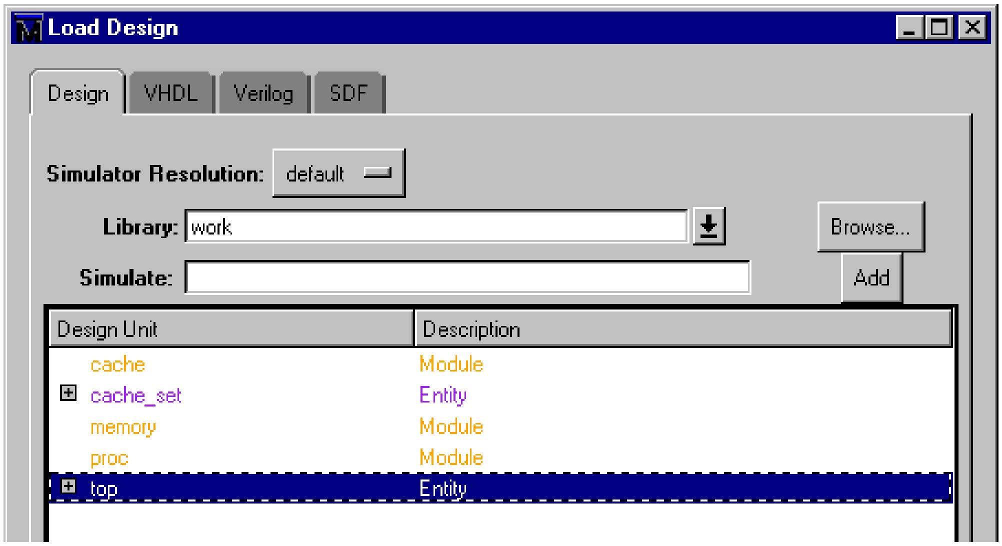
- *util.vhd*
- *set.vhd*
- *top.vhd*

Compiling is now complete, click **Done** to dismiss the dialog box.

7 Now it's time to simulate. Start the simulator by selecting the **Load Design** button from the Main toolbar:

(PROMPT: vsim top)

This returns the Load Design dialog box.



Simulator Resolution: default

Library: work

Simulate:

Design Unit	Description
cache	Module
⊞ cache_set	Entity
memory	Module
proc	Module
⊞ top	Entity

On the Design tab select the **top** entity and click **Load**.

8 From the Main menu select **View** > **All** to open all Model*Sim* windows.

(PROMPT: view *)

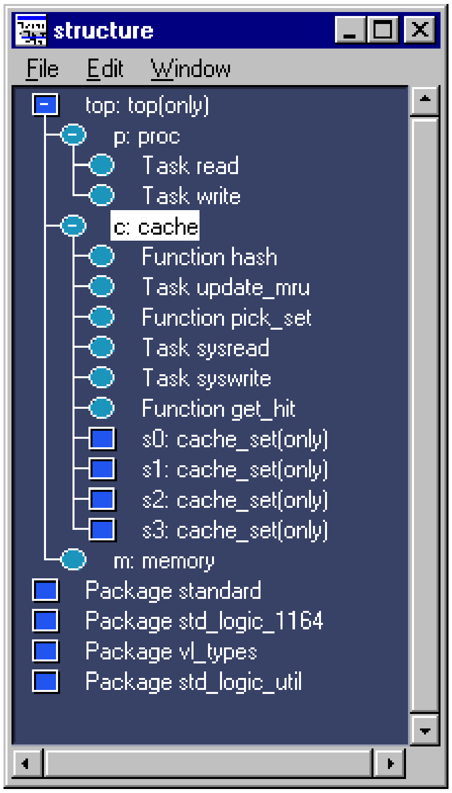
9 This time you will use the VSIM command line to add all of the HDL items in the region to the List and Wave windows:

```
add list *
add wave *
```

(Signals MENU: View > List > Signals in Region)
(Signals MENU: View > Wave > Signals in Region)

10 Take a look at the Structure window.

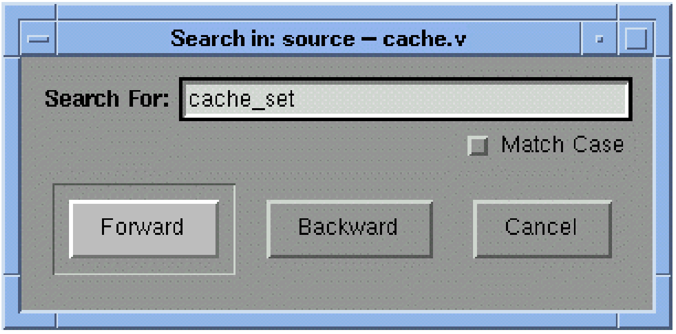
Notice the hierarchical mixture of VHDL and Verilog in the design. VHDL levels are indicated by a square “prefix”, while Verilog levels are indicated by a circle “prefix.” Try expanding (+) and contracting (-) the structure layers. You’ll find Verilog modules have been instantiated by VHDL architectures, and similar instantiations of VHDL items by Verilog.



Let’s take another look at the design.

11
In the Structure window, click on the Verilog module **c: cache**. The source code for the Verilog module is now shown in the Source window.

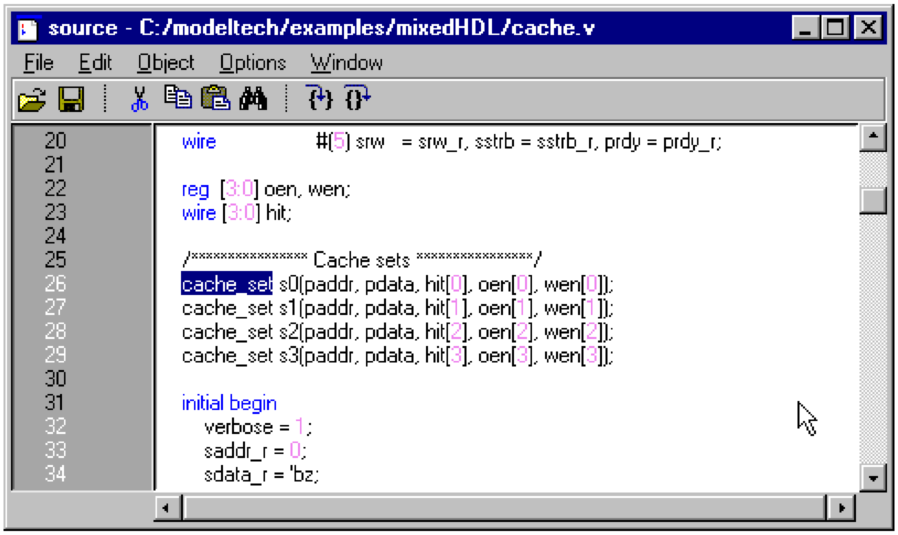
12 We'll use Model*Sim*'s Find/Search function to find the declaration of cache_set within *cache.v*. From the Source window menu select: **Edit** > **Find**; the Search dialog box is displayed.



Search For: cache_set

□ Match Case

In the **Search For:** field type **cache_set** and click **Forward**. The cache_set declaration is now displayed in the Source window.

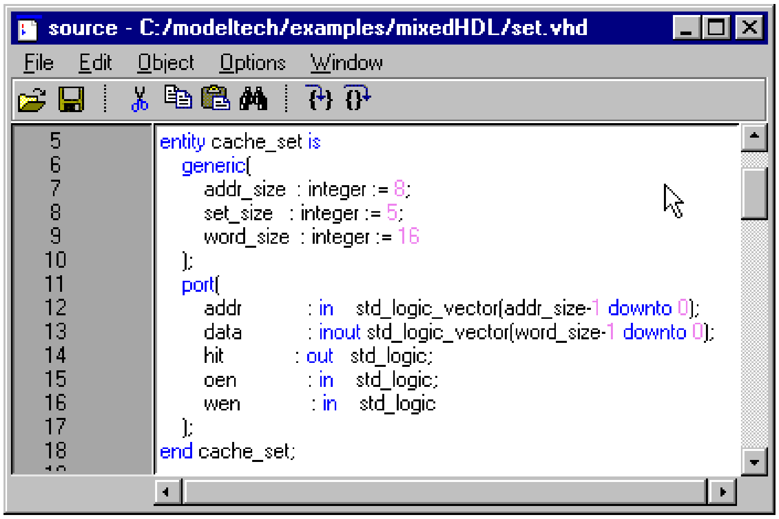


```
wire              #(5) srw   = srw_r, sstrb = sstrb_r, prdy = prdy_r;

reg  [3:0] oen, wen;
wire [3:0] hit;

/**************** Cache sets ****************/
cache_set s0(paddr, pdata, hit[0], oen[0], wen[0]);
cache_set s1(paddr, pdata, hit[1], oen[1], wen[1]);
cache_set s2(paddr, pdata, hit[2], oen[2], wen[2]);
cache_set s3(paddr, pdata, hit[3], oen[3], wen[3]);

initial begin
   verbose = 1;
   saddr_r = 0;
   sdata_r = 'bz;
```

Note that the declaration of cache_set is a VHDL entity instantiated within the Verilog file *cache.v.*

13 Now click on the line **"s0: cache_set(only)"** in the Structure window.

The Source window now shows the VHDL code for the cache_set entity.



```
entity cache_set is
   generic(
      addr_size  : integer := 8;
      set_size   : integer := 5;
      word_size  : integer := 16
   );
   port(
      addr        : in    std_logic_vector(addr_size-1 downto 0);
      data        : inout std_logic_vector(word_size-1 downto 0);
      hit         : out   std_logic;
      oen         : in    std_logic;
      wen         : in    std_logic
   );
end cache_set;
```

Before you quit, try experimenting with some of the commands you've learned from Lesson 1. Note that in this design, "clk" is already driven, so you won't need to use the **force** command.

14 When you're ready to quit simulating, enter the command:

```
quit -force
```

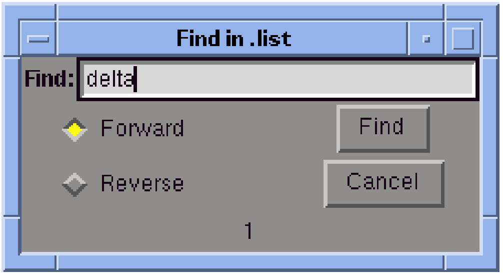
Finding names, and searching for values

You can easily locate HDL item names and values within Model*Sim*’s windows. Start any of the lesson simulations to try out the Find and Search functions illustrated below.

Finding items by name in tree windows

You can find HDL item names with the **Edit > Find** menu selection in these windows:
List, Process, Signals, Source, Structure, Variables, and Wave windows.

Select **Edit > Find** to bring up the Find dialog box (List window version shown).



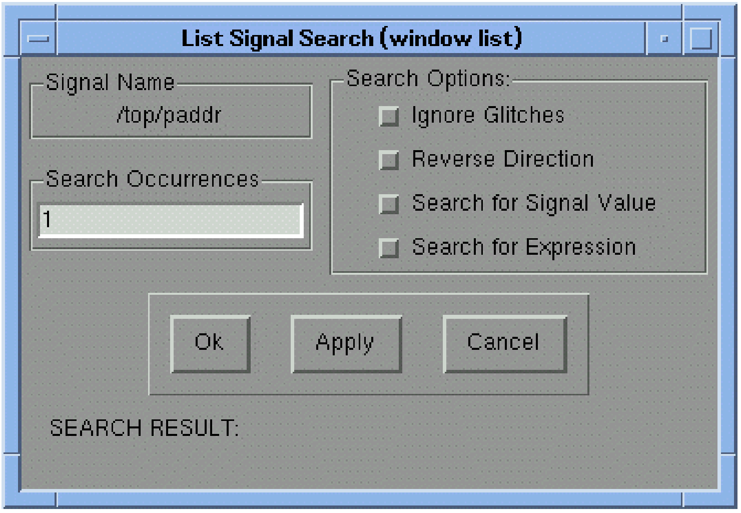
Find: delta

● Forward
○ Reverse

Enter an item label and **Find** it by searching **Forward** (right) or **Reverse** (left) through the window display.

Searching for item values in the List and Wave windows

You can search for HDL item values in the List, and Wave windows. Select **Edit > Search** from the window’s menu to bring up the Signal Search dialog box (List window version shown).



List Signal Search (window list)

Signal Name: /top/paddr

Search Occurrences: 1

Search Options:

□ Ignore Glitches

□ Reverse Direction

□ Search for Signal Value

□ Search for Expression

SEARCH RESULT:

The **List Signal Search** dialog box includes these options:

You can locate values for the **Signal Name: <item_label>** shown at the top of the dialog box. The search is based on these options (multiple **Search Options** may be selected):

- **Search Options: Ignore Glitches**
  Ignore zero width glitches in VHDL signals and Verilog nets.
- **Search Options: Reverse Direction**
  Search the list from bottom to top.
- **Search Options: Search for Signal Value**
  Activates the **Search Value** field; search for the value specified in the **Search Value** field, otherwise just look for transitions.
- **Search Options: Search for Expression**
  Activates the **Search Expression** field and the **Use Expression Builder** button; searches for the expression specified in the Search Expression field evaluating to a boolean true.

  The expression may involve more than one signal but is limited to signals logged in the List window. Expressions may include constants, variables, and DO files. If no expression is specified, the search will give an error.

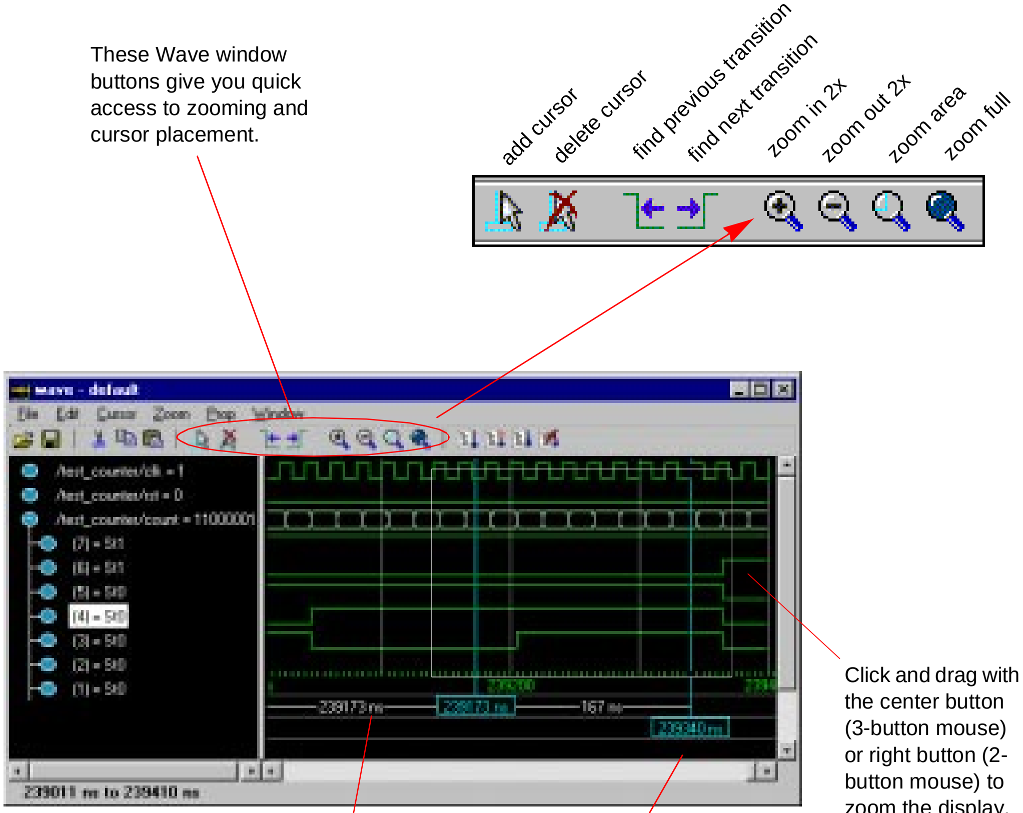
  See the *ModelSim EE/PLUS Reference Manual* for more information on expression syntax and the use of the Expression Builder.

- **Search Occurrences**
  You can search for the n-th transition or the n-th match on value; **Search Occurrences** indicates the number of transitions or matches for which to search.
- **Search Value**
  Valid only if **Use signal value** is selected; specifies the search value; must be formatted in the same radix as displayed.

The result of your search is indicated at the bottom of the dialog box.

Using the Wave window

This practice involves the use of Wave window time cursors, zooming the waveform display, and Wave window keyboard shortcuts. Any of the previous lesson simulations may be used with this practice.



These Wave window buttons give you quick access to zooming and cursor placement.

Click and drag with the center button (3-button mouse) or right button (2-button mouse) to zoom the display.

interval measurement

selected cursor is bold

Using time cursors in the Wave window

When the Wave window is first drawn, there is one cursor located at time zero. Clicking anywhere in the waveform display brings that cursor to the mouse location.You can add additional cursors to the waveform pane with the **Cursor >**

Add Cursor menu selection (or the Add Cursor button shown below). The selected cursor is drawn as a solid line; all other cursors are drawn with dotted lines. Remove cursors by selecting them and choosing using the **Cursor > Delete Cursor** menu selection (or the Delete Cursor button shown below).

Add Cursor add a cursor to the center of the waveform window	**Delete Cursor** delete the selected cursor from the window

Finding a cursor

The cursor value (on the **Goto** list) corresponds to the simulation time of that cursor. Choose a specific cursor view with **Cursor > Goto** menu selection.

Making cursor measurements

Each cursor is displayed with a time box showing the precise simulation time at the bottom. When you have more than one cursor, each time box appears in a separate track at the bottom of the display. VSIM also adds a delta measurement showing the time difference between the two cursor positions.

If you click in the waveform display, the cursor closest to the mouse position is selected and then moved to the mouse position. Another way to position multiple cursors is to use the mouse in the time box tracks at the bottom of the display. Clicking anywhere in a track selects that cursor and brings it to the mouse position.

The cursors are designed to snap to the closest wave edge to the left on the waveform that the mouse pointer is positioned over. You can control the snap distance from "Wave category" in the dialog box available from the Wave window **Prop > Display Props** menu selection.

You can position a cursor without snapping by dragging in the area below the waveforms.

You can also move cursors to the next transition of a signal with these toolbar buttons:

Find Previous Transition locate the previous signal value change for the selected signal	**Find Next Transition** locate the next signal value change for the selected signal

Zooming - changing the waveform display range

Zooming lets you change the simulation range in the windowpane display. You can zoom with either the **Zoom** menu, toolbar buttons, mouse, keyboard, or VSIM commands.

Using the Zoom menu

You can use the Wave window menu bar, or call up a **Zoom** menu window with the right mouse button in the right windowpane. The menu options include:

- **Zoom Full**
  Redraws the display to show the entire simulation from time 0 to the current simulation time.
- **Zoom In**
  Zooms in by a factor of two, increasing the resolution and decreasing the visible range horizontally, cropping the view on the right. The starting time is held static.
- **Zoom Out**
  Zooms out by a factor of two, decreasing the resolution and increasing the visible range horizontally, extending the view on the right. The starting time is held static.
- **Zoom Last**
  Restores the display to where it was before the last zoom operation.
- **Zoom Range**
  Brings up a dialog box that allows you to enter the beginning and ending times for a range of time units to be displayed.

Zooming with the toolbar buttons

These zoom buttons are available on the toolbar:

🔍	**Zoom in 2x** zoom in by a factor of two from the current view	🔍	**Zoom area** use the cursor to outline a zoom area
🔍	**Zoom out 2x** zoom out by a factor of two from current view	🔍	**Zoom Full** zoom out to view the full range of the simulation from time 0 to the current time

Zooming with the mouse

To zoom with the mouse, position the mouse cursor to the left side of the desired zoom interval, press the middle mouse button (3 button mouse), or right button (2 button mouse), and while continuing to press, drag to the right and then release at the right side of the desired zoom interval.

Zooming keyboard shortcuts

See "Wave window keyboard shortcuts" (p157) for a complete list of Wave window keyboard shortcuts.

Zooming with VSIM commands

The**.wave.tree zoomfull** provides the same function as the **Zoom** > **Zoom Full** menu selection and the **.wave.tree zoomrange** provides the same function as the **Zoom** > **Zoom Range** menu selection.

Use this syntax with the **.wave.tree zoomrange** command:

Syntax

```
.wave.tree zoomrange f1 f2
```

Arguments

`f1 f2`
Sets the waveform display to zoom from time f1 to f2, where f1 and f2 are floating point numbers.

Wave window keyboard shortcuts

Using the following keys when the mouse cursor is within the Wave window will cause the indicated actions:

Key	Action
i I or +	zoom in
o O or -	zoom out
f or F	zoom full
l or L	zoom last
r or R	zoom range
<arrow up>	scroll waveform display up
<arrow down>	scroll waveform display down
<arrow left>	scroll waveform display left
<arrow right>	scroll waveform display right
<page up>	scroll waveform display up by page
<page down>	scroll waveform display down by page
<tab>	searches forward (right) to the next transition on the selected signal
<shift-tab>	searches backward (left) to the previous transition on the selected signal
<Control-f>	opens the find dialog box; search within the specified field in the wave-name pane for text strings

Continuing with Model*Sim* EE

More information on Model*Sim* commands, functions and techniques for use can be found in the following locations:

- **Model*Sim* EE/PLUS Reference Manual**
  an Adobe Acrobat (.pdf) version of our reference manual is available in the *<install_dir>/<modelsim_dir>/docs* directory after installation
- **Tips and Techniques appendix of the Model*Sim* reference manual**
- **technote text files installed with Model*Sim***
  located in the *<install_dir>/<modelsim_dir>/docs/technotes* directory, or select **Help > technotes** from the Main window Help menu
- **Tcl man pages (the basis of Model*Sim*'s GUI)**
  select **Help > Tcl man pages** from the Main window Help menu

A - Technical Support, Updates, and Licensing

Technical support - by telephone

Mentor Graphics customers In North America

For customers who purchased products from Mentor Graphics in North America, and are under a current support contract, technical telephone support is available from the central SupportCenter by calling toll-free 1-800-547-4303. The coverage window is from 6:00am to 5:30pm Pacific Time. All coverage is provided Monday through Friday, excluding Mentor Graphics holidays.

The more preliminary information customers can supply about a problem or issue at the beginning of the reporting process, the sooner the Software Support Engineer (SSE) can supply a solution or workaround. Information of most help to the SSE includes accurate operating system and software version numbers, the steps leading to the problem or crash, the first few lines of a traceback, and problem sections of the Procedural Interface code.

Mentor Graphics customers outside North America

For customers who purchased products from Mentor Graphics outside of North America, should contact their local support organization. A list of local Mentor Graphics SupportCenters outside North America can be found at supportnetweb.mentorg.com under "Connections", then "International Directory".

Model Technology customers worldwide

For customers who purchased from Model Technology, please contact Model Technology via the support line at 1-503-641-1340 from 8:00 AM to 5:00 PM Pacific Time. Be sure to have your server hostID or hardware security key authorization number handy.

Technical support - electronic support services

Mentor Graphics customers

Mentor Graphics Customer Support offers a SupportNet-Email server for North American and European companies that lets customers find product information or submit service requests (call logs) to the SupportCenter 24 hours a day, 365 days a year. The server will return a call log number within minutes. SSEs follow up on the call logs submitted through SupportNet-Email using the same process as if a customer had phoned the SupportCenter. For more information about using the SupportNet-Email server, send a blank e-mail message to the following address: support_net@mentorg.com.

Additionally, customers can open call logs or search the Mentor TechNote database of solutions to try to find the answers to their questions by logging onto Mentor Graphics' Customer Support web home page at http://supportnetweb.mentorg.com.

To establish a SupportNet account for your site (both a site-based SupportNet-Web account and a user-based SupportNet Email account), please submit the following information: name, phone number, fax number, email address, company name, site ID. Within one business day, you will be provided with the account information for new registrations.

While all customers worldwide are invited to obtain a SupportNet-Web site login, the SupportNet-Email services are currently limited to customers who receive support from Mentor support offices in North America or Europe. If you receive support from Mentor offices outside of North America or Europe, please contact your local field office to obtain assistance for a technical-support issue.

Model Technology customers

Support questions may be submitted through the Model Technology web site at: www.model.com. Model Technology customers may also email test cases to support@model.com; please provide the following information, in this format, in the body of your email message:

- Your name:
  Company:
  Email address (if different from message address):
  Telephone:
  FAX (optional):
- Model*Sim* product (EE or PE, and VHDL, VLOG, or PLUS):

- Model*Sim* Version:
  (Use the Help About dialog box with Windows; type **vcom** for UNIX workstations.)
- Host operating system version:
- PC hardware security key authorization number:
- Host ID of license server for workstations:
- Description of the problem (please include the exact wording of any error messages):

Technical support - other channels

For customers who purchased Model*Sim* as part of a bundled product from an OEM or VAR, support is available at the following:

- **Annapolis Microsystems**
  email: wftech@annapmicro.com
  telephone: 1-410-841-2514
  web site: http://www.annapmicro.com
- **Exemplar Logic**
  email: support@exemplar.com
  telephone: 1-510-789-3333
  web site: http://www.exemplar.com
- **Hewlett Packard EEsof**
  email: hpeesof_support@hp.com
  telephone: 1-800-HPEESOF (1-800-473-3763)
  web site: http://www.hp.com/go/hpeesof
- **Synplicity**
  email: support@synplicity.com
  telephone: 1-408-617-6000
  web site: http://www.synplicity.com

Updates

Mentor customers: getting the latest version via FTP

You can ftp the latest EE or PE version of the software from the SupportNet site at ftp://supportnet.mentorg.com/pub/mentortech/modeltech/. Instructions are there as well. A valid license file from Mentor Graphics is needed to uncompress the Model*Sim* EE files. A password from Model Technology is required to uncompress the Model*Sim* PE files. Contact license@model.com if you are a current PE customer and need a password.

Model Technology customers: getting the latest version via FTP

You can ftp the latest version of the software from the web site at ftp://ftp.model.com. Instructions are there as well. A valid license file from Model Technology is needed to uncompress the Model*Sim* EE files. A password from Model Technology is needed to uncompress the Model*Sim* PE files. Contact license@model.com if you are a current PE customer and need a password.

Licenses - Model*Sim* EE

Where to obtain your license

Mentor Graphics customers must contact Mentor Graphics for Model*Sim* EE licensing. All other customers may obtain Model*Sim* EE licenses from Model Technology. Please contact Model Technology at license@model.com.

If you have trouble with licensing

Contact your normal technical support channel:

- Technical support - by telephone (p159)
- Technical support - electronic support services (p160)
- Technical support - other channels (p161)

All customers: Model*Sim* EE licensing

Model*Sim* EE uses Globetrotter's FLEXlm license manager and files. Globetrotter FLEXlm license files contain lines that can be referred to by the word that appears first on the line. Each kind of line has a specific purpose and there are many more kinds of lines that MTI does not use.

A *license.dat* file example

```
SERVER hostname 11111111 1650
DAEMON modeltech ./modeltech ./options
FEATURE vcom modeltech 1998.080 31-aug-98 1 \
0C944D8F0C79B02EF5CF ck=117
FEATURE vsim modeltech 1998.080 31-aug-98 1 \
FCB4FD0F2A635C20E5CF ck=128
FEATURE vlog modeltech 1998.080 31-aug-98 1 \
0C944D9F176CA773E889 ck=10
FEATURE vsim-vlog modeltech 1998.080 31-aug-98 1 \
FCB41D9FC43C87567DBC ck=116

FEATURE hdlcom modeltech 1998.080 31-aug-98 1 \
4C94EDFF6A00858BC8F2 ck=93
FEATURE hdlsim modeltech 1998.080 31-aug-98 1 \
4CF48DDF6A6EA59BCEF2 ck=89
# NOTE: You can edit the hostname on the SERVER line (1st arg),
#       the port address on the SERVER line (3rd arg), the paths
#       to the daemon and options files on the DAEMON line
#       (2nd and 3rd args), or any right-half of a string (b)
#       of the form a=b where (a) is all lowercase. (For example,
#       xxx in vendor_info="xxx" can be changed).
#       Any other changes will invalidate this license.
```

A Globetrotter FLEXlm license file contains information about the license server, the daemon required to authorize the feature, and a line for each product feature you are authorized to execute.

The first line is a SERVER line; it spells out which computer on the network is the license server. The license server is a network resource that will manage the features for all users of ModelSim products. The SERVER line includes the server's hostname, hostID (a unique serial number), and a socket number. The hostname and socket number may be changed in a license file, but any change to the hostID will invalidate the license. If the host is a Windows machine, the hostID is the FLEXid security key number, and will take the alpha-numeric form: 7-xxxxxxxx.

If you need to find the unique server ID, use one of these UNIX commands: for Sun, **hostid**; for HP, **/etc/lanscan**; for IBM RISC/6000: **uname -m**. On a Windows machine, use the FLEXlm license manager control panel.

A DAEMON line specifies the name of the license daemon and the locations of the daemon and options files it will use. This is the full path to the modeltech daemon. In the example file, the UNIX "./" means "look in the current directory". This is the directory in which the server was started. If the server is to be started from another directory, the full path to the *modeltech* and *options* files would need to be added to this line. For example,

```
DAEMON modeltech /usr/mti5.2/sunos5/modeltech \
/usr/mti5.2/sunos5/options
```

A FEATURE line describes how many licenses ("tokens") are available; it contains the feature name, daemon required, most current build date authorized to run, token expiration date, number of tokens for the feature, license code, and a checksum. The features are:

vcom is a VHDL compilation feature

vsim is a VHDL simulation feature

vlog is a Verilog compilation feature

vsim-vlog is a Verilog simulation feature

When a VHDL design is compiled, a **vcom** token is used. When a Verilog design is compiled, a **vlog** token is used. When a VHDL design is simulated, a **vsim** token is used. When a Verilog design is simulated,
vsim-vlog is used. This is why two people running different single-language designs can work at the same time with one ModelSim PLUS product. When a design with both languages is run, one of each token is checked out.

With ModelSim EE/LNL, **hdl** FEATURE lines are added. With LNL (language-neutral licensing), either VHDL or Verilog - but not both - can be used. The hdl FEATURE lines are shown in the example:

hdlcom is a compilation feature used with either VHDL or Verilog

hdlsim is a simulation feature used with either language

Notice the FEATURE lines. If a line is too long for the email program, a backslash ("\") appears at the end of the line. A UNIX system reads that as "whatever you read on the next line belongs on this line". So never edit out the "\" when you are transcribing a license file. Never put another character after it either.

All the important lines end in checksums. FLEXlm will let you know if you mistyped something when transcribing the license files because the checksum will not match the line's contents.
(GLOBEtrotter has a utility that will report any checksum errors in a file. Use this command: **lmchksum <license.file>**)

Lines that start with "#" are comments.

If you want to learn more about the tools that license ModelSim, read the license manager appendix in the ModelSim reference manual, and visit GLOBEtrotter at http://www.globetrotter.com/home.htm.

All customers: maintenance renewals and EE licenses

When maintenance is renewed, a new license file that incorporates the new maintenance expiration date will be automatically sent to you. If maintenance is not renewed, the current license file will still permit the use of any version of the software built before the maintenance expired until the stop date is reached.

All customers: license transfers and server changes

Model Technology and Mentor Graphics both charge a fee for server changes or license transfers. Contact sales@model.com for more information from Model Technology, or contact your local Mentor Graphics sales office for Mentor Graphics purchases.

Online References

The Model Technology web site includes links to many EDA information sources. Check the links below for the most current information.

Books and publications

model.com/support/tnbooksvhd.html

Partners

model.com/partners/index.html

Training partners

model.com/support/training.html

Index

Thank you for purchasing ModelSim!

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