

VCS®/VCSI™ User Guide

G-2012.09
September 2012

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Contents

1. Getting Started	
Simulator Support with Technologies	1-2
Setting Up the Simulator	1-4
Verifying Your System Configuration	1-4
Obtaining a License	1-5
Setting Up Your Environment	1-6
Setting Up Your C Compiler	1-8
Using the Simulator	1-8
Basic Usage Model	1-9
Default Time Unit and Time Precision	1-9
2. VCS Flow	
Compilation	2-2
Using vcs	2-3
Commonly Used Options	2-3
Simulation	2-8
Interactive Mode	2-8

Batch Mode	2-9
Commonly Used Runtime Options.	2-9
3. Modeling Your Design	
Avoiding Race Conditions	3-2
Using and Setting a Value at the Same Time	3-2
Setting a Value Twice at the Same Time	3-3
Flip-Flop Race Condition	3-4
Continuous Assignment Evaluation.	3-5
Counting Events.	3-6
Time Zero Race Conditions	3-7
Race Detection	3-8
The Dynamic Race Detection Tool.	3-8
Introduction to the Dynamic Race Detection Tool	3-8
Enabling Race Detection	3-12
The Race Detection Report	3-12
Post Processing the Report	3-15
Debugging Simulation Mismatches	3-17
The Static Race Detection Tool	3-20
Optimizing Testbenches for Debugging.	3-22
Conditional Compilation.	3-23
Enabling Debugging Features At Runtime.	3-24
Combining the Techniques	3-27
Avoiding the Debugging Problems From Port Coercion	3-28
Creating Models That Simulate Faster	3-29
Unaccelerated Data Types, Primitives, and Statements	3-30

Inferring Faster Simulating Sequential Devices	3-31
Modeling Faster always Blocks	3-35
Using Verilog 2001 Constructs.	3-36
Case Statement Behavior	3-38
Precedence in Text Macro Definitions	3-39
Memory Size Limits in the Simulator	3-39
Using Sparse Memory Models	3-40
Obtaining Scope Information.	3-41
Scope Format Specifications	3-41
Returning Information About the Scope.	3-44
Avoiding Circular Dependency	3-47
Designing With \$lsi_dumpports for Simulation and Test	3-49
Dealing With Unassigned Nets	3-49
Code Values at Time 0.	3-50
Cross Module Forces and No Instance Instantiation	3-51
Signal Value/Strength Codes	3-53
4. Compiling the Design	
Compiling or Elaborating the Design in Debug Mode	4-1
Compiling or Elaborating the Design in Optimized Mode	4-2
Key Compilation Features	4-3
Initializing Verilog Memories and Registers	4-3
Use Model	4-5
Overriding Parameters.	4-6

Checking for X and Z Values In Conditional Expressions	4-7
Enabling the Checking	4-8
Filtering Out False Negatives	4-9
VCS V2K Configurations and Libmaps	4-11
Library Mapping Files	4-12
Configurations	4-13
Hierarchical Configurations	4-17
The -top Compile-time Option	4-18
Limitations of Configurations	4-18
Evaluating the Active Events When Limiting the Exposure of Race Conditions	4-19
Lint Warning Message for Missing 'endcelldefine'	4-20
Error/Warning Message Control	4-24
Controlling Error Messages	4-26
Controlling Warning Messages	4-26
Controlling Lint Messages	4-28
Suppressing Lint, Warning, and Error Messages	4-29
Error Conditions and Messages That Cannot Be Disabled	4-29
Using Message Control Options Together	4-30
Message Control Examples	4-30
Obsolete Compile-Time Options for Controlling Messages	4-40
5. Simulating the Design	
Using DVE	5-2
Using UCLI	5-3
ucli2Proc Command	5-5
Options for Debugging Using DVE and UCLI	5-6

Key Runtime Features.....	5-8
Passing Values from the Runtime Command Line	5-8
Profiling the Simulation	5-9
CPU Time Views	5-10
Memory Usage Views	5-19
Save and Restart The Simulation	5-22
Save and Restart Example.....	5-23
Save and Restart File I/O.....	5-24
Save and Restart With Runtime Options	5-25
Specifying a Long Time Before Stopping The Simulation	5-26
How VCS Prevents Time 0 Race Conditions.....	5-28
 6. Diagnostics	
Using Diagnostics	6-2
Using -diag Option	6-2
Using Smartlog	6-3
Compile-time Diagnostics	6-5
Libconfig Diagnostics.....	6-5
Example	6-5
Timescale Diagnostics.....	6-8
Example	6-8
Runtime Diagnostics	6-12
Diagnostics for VPI PLI Applications	6-12
Keeping the UCLI/DVE Prompt Active After a Runtime Error	6-15
UCLI Use Model.....	6-15
DVE Use Model	6-17
UCLI Usage Example.....	6-19

Limitations	6-21
Diagnosing Quickthread Issues in SystemC	6-21
Quickthread Overruns Its Allocated Stack	6-22
Simulation Runs Out of Memory Due to Quickthread Stacks	6-23
Reducing or Turning Off Redzones	6-24
Post-processing Diagnostics	6-25
Using the vpduilt Utility to Generate Statistics	6-25
The vpduilt Utility Syntax	6-25
Options	6-26
7. VCS Multicore Technology	
Application Level Parallelism	
VCS Multicore Technology Options.....	7-2
Use Model for Assertion Simulation.....	7-4
Use Model for Toggle and Functional Coverage	7-4
Use Model for VPD Dumping.....	7-4
Running VCS Multicore Simulation	7-5
Assertion Simulation	7-5
Toggle Coverage	7-6
Functional Coverage	7-7
VPD File.....	7-9
Parallel SAIF	7-10
Customary SAIF System Function Entries.....	7-10
Enabling Parallel SAIF.....	7-11
Limitations	7-11

8. VPD, VCD, and EVCD Utilities

Advantages of VPD	8-2
Dumping a VPD File	8-3
Using System Tasks.	8-3
Enable and Disable Dumping.	8-4
Override the VPD Filename	8-7
Dump Multi-dimensional Arrays and Memories	8-8
Using \$vcdblplusmemorydump	8-17
Capture Delta Cycle Information	8-18
Dumping an EVCD File	8-19
Limitations	8-21
Post-processing Utilities	8-23
The vcdpost Utility	8-24
Scalarizing the Vector Signals	8-24
Uniquifying the Identifier Codes	8-25
The vcdpost Utility Syntax	8-26
The vcdiff Utility	8-27
The vcdiff Utility Syntax	8-27
The vcat Utility	8-35
The vcat Utility Syntax	8-35
Generating Source Files From VCD Files	8-39
Writing the Configuration File	8-40
The vcsplit Utility	8-45
The vcsplit Utility Syntax	8-45
The vcd2vpd Utility	8-48
Options for specifying EVCD options	8-50
The vpd2vcd Utility	8-50

The Command File Syntax	8-56
The vpdmerge Utility	8-60
The vpduilt Utility	8-63
9. Performance Tuning	
Compile-time Performance	9-2
Incremental Compilation	9-3
Compile Once and Run Many Times	9-4
Parallel Compilation	9-4
Runtime Performance	9-5
Using Radiant Technology	9-5
Compiling With Radiant Technology	9-5
Applying Radiant Technology to Parts of the Design	9-6
Improving Performance When Using PLIs	9-15
Usage Model	9-16
Impact on Performance	9-17
Obtaining VCS Consumption of CPU Resources	9-18
Use Model	9-18
Compile time	9-18
Simulation Time	9-19
10. Gate-level Simulation	
SDF Annotation	10-2
Using Unified SDF Feature	10-2
Using \$sdf_annotate System Task	10-3

Using -xlm Option for SDF Retain, Gate Pulse Propagation, and Gate Pulse Detection Warning	10-5
Using Optimistic Mode in SDF	10-5
Using Gate Pulse Propagation	10-6
Generating Warnings During Gate Pulses	10-7
Precompiling an SDF File	10-8
Creating the Precompiled Version of the SDF file	10-8
SDF Configuration File	10-9
Delay Objects and Constructs	10-10
SDF Configuration File Commands	10-11
approx_command.....	10-11
mtm_command.....	10-12
scale_command.....	10-13
SDF Example with Configuration File.....	10-14
Delays and Timing	10-17
Transport and Inertial Delays.....	10-17
Different Inertial Delay Implementations	10-19
Enabling Transport Delays.....	10-22
Pulse Control	10-23
Pulse Control with Transport Delays	10-25
Pulse Control with Inertial Delays.....	10-27
Specifying Pulse on Event or Detect Behavior.....	10-31
Specifying the Delay Mode	10-36
Using the Configuration File to Disable Timing	10-38
Using the timopt Timing Optimizer	10-38
Editing the timopt.cfg File	10-41
Editing Potential Sequential Device Entries.....	10-41

Editing Clock Signal Entries	10-42
Using Scan Simulation Optimizer	10-43
ScanOpt Config File Format	10-44
ScanOpt Assumptions	10-45
Negative Timing Checks	10-46
The Need for Negative Value Timing Checks	10-47
The \$setuphold Timing Check Extended Syntax	10-52
Negative Timing Checks for Asynchronous Controls	10-55
The \$recrem Timing Check Syntax	10-56
Enabling Negative Timing Checks	10-58
Other Timing Checks Using the Delayed Signals	10-59
Checking Conditions	10-63
Toggling the Notifier Register	10-64
SDF Back-annotation to Negative Timing Checks	10-65
How VCS Calculates Delays	10-66
Using Multiple Non-overlapping Violation Windows	10-68
11. Coverage	
Code Coverage	11-1
Functional Coverage	11-2
Options For Coverage Metrics	11-3
12. Using OpenVera Native Testbench	
Usage Model	12-3
Example	12-3
Usage Model	12-5

Using Template Generator	12-5
Example	12-6
Key Features	12-18
Multiple Program Support	12-18
Configuration File Model	12-19
Configuration File	12-19
Usage Model for Multiple Programs	12-20
NTB Options and the Configuration File	12-21
Separate Compilation of Testbench Files	12-23
Usage Model	12-24
Example	12-24
Class Dependency Source File Reordering	12-25
Circular Dependencies	12-26
Dependency-based Ordering in Encrypted Files	12-27
Using Encrypted Files	12-28
Functional Coverage	12-29
Using Reference Verification Methodology	12-29
Limitations	12-30
Performance Profiler	12-30
Enabling the NTB Profiler	12-31
Performance Profiler Example	12-31
13. Using SystemVerilog	
Usage Model	13-2
Using UVM With VCS	13-3
Update on UVM-1.0	13-4
Update on UVM-EA	13-4

Natively Compiling and Elaborating UVM-1.0	13-5
Natively Compiling and Elaborating UVM-1.1a	13-5
Compiling the External UVM Library	13-6
Using the -ntb_opts uvm Option.	13-7
Explicitly Specifying UVM Files and Arguments	13-7
Accessing HDL Registers Through UVM Backdoor.	13-8
Generating UVM Register Abstraction Layer Code	13-9
Recording UVM Transactions	13-10
UVM Template Generator (uvmgen)	13-11
Using Mixed VMM/UVM Libraries	13-12
Migrating from OVM to UVM	13-13
Where to Find UVM Examples.	13-14
Where to Find UVM Documentation	13-14
UVM-1.1a Documentation	13-14
UVM-1.0 Documentation	13-15
UVM-VMM Interop Documentation	13-15
Using VMM with VCS	13-15
Using OVM with VCS	13-16
Native Compilation and Elaboration of OVM 2.1.2	13-16
Compiling the External OVM Library	13-18
Using the -ntb_opts ovm Option.	13-18
Explicitly Specifying OVM Files and Arguments.	13-18
Recording OVM Transactions	13-19
Running Native OVM Code in Partition Compile Flow.	13-21
Debugging SystemVerilog Designs	13-23
Functional Coverage	13-23

Newly implemented SystemVerilog Constructs.....	13-25
Support for Aggregate Methods in Constraints Using the "with" Construct	13-25
Debugging During Initialization SystemVerilog Static Functions and Tasks in Module Definitions	13-26
Explicit External Constraint Blocks	13-30
Generate Constructs in Program Blocks	13-33
Error Condition for Using a Genvar Outside of its Generate Block	
13-35	
Randomizing Unpacked Structs.....	13-36
Using the Scope Randomize Method std::randomize() ..	13-37
Using the Class Randomize Method <code>randomize()</code> ..	13-41
Disabling and Re-enabling Randomization	13-44
Using In-line Random Variable Control	13-48
Limitation	13-52
Making <code>wait fork</code> Statements Compliant with the SV LRM....	13-52
Making <code>disable fork</code> Statements Compliant with the SV LRM	13-55
Recently Implemented SystemVerilog Constructs.....	13-56
The <code>std::randomize()</code> Function.....	13-57
SystemVerilog Bounded Queues.....	13-60
<code>wait()</code> Statement with a Static Class Member Variable.....	13-61
Parameters and Localparams in Classes	13-62
SystemVerilog Math Functions	13-62
Streaming Operators	13-63
Packing (Used on RHS)	13-63
Unpacking (Used on LHS)	13-64
Packing and Unpacking	13-64
Propagation and force Statement.....	13-64

Error Conditions	13-65
Structures with Streaming Operators	13-65
 Extensions to SystemVerilog	13-65
Unique/Priority Case/IF Final Semantic Enhancements	13-66
Using Unique/Priority Case/If with Always Block or Continuous Assign	13-67
Using Unique/Priority Inside a Function	13-70
System Tasks to Control Warning Messages	13-73
Single-Sized Packed Dimension Extension	13-74
Covariant Virtual Function Return Types	13-77
Self Instance of a Virtual Interface	13-78
UVM Example	13-80
Error Condition for Using a Genvar Outside of its Generate Block	13-81
 Exporting a SystemVerilog Package	13-82
Use Model	13-83
Backward Compatibility	13-85
 Using a Package in a SystemVerilog Module, Program, and Interface Header	13-86
 14. Aspect Oriented Extensions	
Aspect-Oriented Extensions in SV	14-3
Processing of AOE as a Precompilation Expansion	14-5
Weaving advice into the target method	14-10
Pre-compilation Expansion details	14-15
Precedence	14-16

15. Using Constraints

Inconsistent Constraints	15-2
Constraint Debug	15-3
Partition	15-4
Randomize Serial Number.....	15-6
Solver Trace.....	15-7
Constraint Profiler	15-12
Test Case Extraction	15-13
Using multiple +ntb_solver_debug arguments	15-15
Summary for +ntb_solver_debug.....	15-15
+ntb_solver_debug=serial	15-15
+ntb_solver_debug=trace.....	15-16
+ntb_solver_debug=profile.....	15-16
+ntb_solver_debug=extract	15-16
Constraint Debug Using DVE	15-16
Constraint Guard Error Suppression.....	15-17
Error Message Suppression Limitations	15-18
Flattening Nested Guard Expressions	15-18
Pushing Guard Expressions into Foreach Loops.....	15-19
Array and XMR Support in std::randomize()	15-20
Error Conditions	15-22
XMR Support in Constraints	15-22
XMR Function Calls in Constraints	15-24
State Variable Index in Constraints	15-25
Runtime Check for State Versus Random Variables	15-25

Array Index	15-26
Using Soft Constraints in SystemVerilog	15-26
Using Soft Constraints	15-27
Soft Constraint Prioritization	15-28
Within a Single Class	15-28
Soft Constraints Defined in Classes Instantiated as rand Members in Another Class	15-29
Soft Constraints Inheritance Between Classes	15-31
Soft Constraints in AOP Extensions to a Class	15-32
Soft Constraints in View Constraints Blocks	15-34
Discarding Lower-Priority Soft Constraints	15-34
Using DPI Function Calls in Constraints	15-36
Invoking Non-pure DPI Functions from Constraints	15-37
Using Foreach Loops Over Packed Dimensions in Constraints	15-41
Memories with Packed Dimensions	15-42
Single Packed Dimension	15-42
Multiple Packed Dimensions	15-42
MDAs with Packed Dimensions	15-43
Single Packed Dimension	15-43
Multiple Packed Dimensions	15-43
Just Packed Dimensions	15-43
The foreach Iterative Constraint for Packed Arrays	15-44
Randomized Objects in a Structure	15-46
16. Extensions for SystemVerilog Coverage	
Support for Reference Arguments in get_coverage()	16-1

get_inst_coverage() method	16-2
get_coverage() method	16-2
Functional Coverage Methodology Using the SystemVerilog C/C++ Interface.....	16-3
SystemVerilog Functional Coverage Flow	16-4
Covergroup Definition	16-6
SystemVerilog (Covergroup for C/C++): covg.sv	16-7
C Testbench: test.c.....	16-7
Approach #1: Passing Arguments by Reference	16-8
Approach #2: Passing Arguments by Value.....	16-8
Compile Flow	16-8
Runtime	16-9
C/C++ Functional Coverage API Specification	16-9
17. OpenVera-SystemVerilog Testbench Interoperability	
Scope of Interoperability	17-2
Importing OpenVera types into SystemVerilog	17-3
Data Type Mapping	17-6
Mailboxes and Semaphores	17-7
Events	17-9
Strings	17-9
Enumerated Types	17-10
Integers and Bit-Vectors	17-12
Arrays	17-13
Structs and Unions	17-15
Connecting to the Design	17-15

Mapping Modports to Virtual Ports	17-15
Virtual Modports	17-15
Importing Clocking Block Members into a Modport	17-16
Semantic Issues with Samples, Drives, and Expects	17-21
Notes to Remember	17-22
Blocking Functions in OpenVera	17-22
Constraints and Randomization	17-22
Functional Coverage	17-23
Usage Model	17-24
Limitations	17-25
18. Using SystemVerilog Assertions	
Using SVAs in the HDL Design	18-2
Using Standard Checker Library	18-2
Instantiating SVA Checkers in Verilog	18-3
Binding SVA to a Design	18-4
Inlining SVAs in the Verilog Design	18-5
Usage Model	18-6
Controlling SystemVerilog Assertions	18-6
Compilation and Runtime Options	18-7
Assertion Monitoring System Tasks	18-9
Using Assertion Categories	18-13
Using System Tasks	18-13
Using Attributes	18-16
Stopping and Restarting Assertions By Category	18-17
Viewing Results	18-27

Using a Report File	18-27
Enhanced Reporting for SystemVerilog Assertions in Functions	18-28
Introduction	18-28
Usage Model	18-30
Name Conflict Resolution	18-30
Checker and Generate Blocks	18-30
Controlling Assertion Failure Messages	18-31
Introduction	18-31
Options for Controlling Default Assertion Failure Messages .	18-32
Options to Control Termination of Simulation.	18-33
Option to Enable Compilation of OVA Case Pragmas	18-36
Enabling IEEE Std. 1800-2009 Compliant Features	18-37
Limitations	18-37
19. Using Property Specification Language	
Including PSL in the Design	19-1
Examples	19-2
Usage Model	19-2
Examples	19-3
Using SVA Options, SVA System Tasks, and OV Classes	19-4
Limitations	19-5
20. Using SystemC	
Overview	20-5

Verilog Design Containing Verilog Modules and SystemC Leaf Modules	
20-6	
Usage Model	20-7
Input Files Required.	20-8
Generating Verilog Wrappers for SystemC Modules	20-9
Supported Port Data Types	20-12
Example.	20-13
Compiling Interface Models with acc_user.h and vhpi_user.h	20-15
Controlling Time Scale and Resolution in a SystemC	20-16
Automatic adjustment of the time resolution	20-17
Setting time scale/resolution of Verilog kernel.	20-17
Setting time scale/resolution of SystemC kernel	20-18
Adding a Main Routine for Verilog-On-Top Designs	20-19
SNPS_REGISTER_SC_MAIN	20-20
SystemC Designs Containing Verilog Modules	20-21
Usage Model	20-22
Input Files Required.	20-23
Generating a SystemC Wrapper for Verilog Modules	20-24
Example.	20-26
Compilation Scheme	20-28
SNPS_REGISTER_SC_MODULE	20-31
SystemC Only Designs	20-31
Usage Model	20-32
Restrictions	20-33
Supported and Unsupported UCLI/DVE and CBug Features	20-34
Accessing Cross Module Hierarchy	20-35

Controlling TimeScale Resolution	20-36
Setting Timescale of SystemC Kernel	20-36
Automatic Adjustment of Time Resolution	20-37
Considerations for Export DPI Tasks.	20-38
Use syscan -export_DPI [function-name]	20-38
Use syscan -export_DPI [Verilog-file]	20-39
Use a Stubs File	20-41
Using options -Mlib and -Mdir	20-41
Specifying Runtime Options to the SystemC Simulation	20-42
Using a Port Mapping File	20-43
Automatic Creation of Portmap File	20-44
Using a Data Type Mapping File	20-45
Combining SystemC with Verilog Configurations	20-47
Verilog-on-top, SystemC	20-48
Compiling a Verilog/SystemC design	20-49
SystemC-on-top, Verilog	20-50
Compiling a SystemC/Verilog design	20-52
Limitations	20-52
Parameters	20-53
Parameters in Verilog	20-53
Parameters in SystemC	20-54
Verilog-on-Top, SystemC-down	20-54
SystemC-on-Top, Verilog	20-56
Namespace	20-57
Parameter specification as vcs elaboration arguments	20-57

Debug	20-58
Limitations	20-58
Debugging Mixed Simulations Using DVE or UCLI.....	20-58
Improved CBug Debugging Capabilities	20-60
Viewing sc_signal of User-defined struct in Waveform Window	20-60
Driver/Load Support for SystemC Designs in Post Processing	20-61
Transaction Level Interface	20-62
Interface Definition File	20-63
Generation of the TLI Adapters	20-67
Transaction Debug Output.	20-68
Instantiation and Binding	20-69
Supported Data Types of Formal Arguments.....	20-72
Miscellaneous	20-73
Delta-cycles.....	20-73
Using a Customized SystemC Installation.....	20-74
Compatibility with OSCI SystemC	20-77
Compiling Source Files	20-77
Using Posix threads or quickthreads.....	20-77
VCS Extensions to SystemC Library.....	20-78
Installing VG GNU Package	20-84
Static and Dynamic Linking	20-84
Static Linking in VCS	20-84
Dynamic Linking in VCS.....	20-85
Dynamic Linking in VCS.....	20-86

LD_LIBRARY_PATH Environment Variable	20-87
Limitations	20-87
Incremental Compile of SystemC Source Files.....	20-88
Full Build from Scratch.....	20-89
Full Incremental Build	20-90
Partial Build with Object Files	20-91
Partial Build with Shared Libraries.....	20-92
Updating the Shared Library	20-93
Using Different Libraries.....	20-93
Partial Build Invoked with vcs.....	20-94
Partial Build if Just One Shared Library is Updated	20-94
Adding or Deleting SC Source Files in Shared Library ..	20-95
Changing From a Shared Library Back to Object Files ..	20-95
Suppressing Automatic Dependency Checking.....	20-95
Restrictions	20-96
TLI Direct Access	20-96
Accessing SystemC Members from SystemVerilog.....	20-97
TLI Adaptor.....	20-97
Instantiating the TLI adaptor in SV.....	20-97
Direct Variable Access	20-98
Calling SystemC Member Function	20-98
Arguments of Type <code>char*</code> used in Blocking Member Functions 20-100	
Supported Data Types	20-100
SC_FIFO	20-103
Non-SystemC Classes	20-104
Sub-classes	20-105

Name Clashes	20-106
Error Handling	20-108
Compile Flow	20-108
Syntax of TLI File	20-109
Debug Flow	20-112
Accessing Struct or Class Members of a SystemC Module from SystemVerilog	20-113
Enhancements to TLI for Providing Access to SystemC/C++ Class Members from SystemVerilog.	20-114
Accessing Struct or Class Members of a SystemC Module Object from SystemVerilog.	20-114
Accessing Generic C++ Struct or Class	20-118
Extensions of TLI Input File	20-122
Invoking Pack or Unpack Adaptor Code Generation	20-123
Limitations	20-124
Accessing Verilog Variables from SystemC	20-124
Usage Model	20-124
Access Functions	20-125
Supported Data Types	20-126
Usage Example	20-127
Type Conversion Mechanism.	20-128
Accessing SystemVerilog Functions and Tasks from SystemC	20-130
Introduction.	20-131
Usage Model	20-131
Function Declaration Hierarchy	20-132
Passing Arguments	20-134
Supported Types	20-135
Usage Example	20-135
Compile Flow	20-137

Usage Guidelines	20-138
Limitations	20-139
Accessing SystemC Members from SystemVerilog Using the tli_get_<type> or tli_set_<type> Functions	20-140
Using the tli_get_<type> and tli_set_<type> Functions ..	20-140
Prototypes of tli_get_<type> and tli_set_<type> Functions	20-141
Supported Data Types	20-142
Member Variables	20-145
Type Conversion Mechanism.....	20-147
Compile Flow	20-149
Generating C++ Struct Definition from SystemVerilog Class Definition 20-151	
Use Model for Generating C++ Struct from SystemVerilog Class 20-152	
Data Type Conversion from SystemVerilog to C++	20-153
Example for Generating C++ Struct from SystemVerilog Class 20-154	
Limitations	20-155
Exchanging Data Between SystemVerilog and SystemC Using Byte Pack/Unpack	20-156
Use Model	20-157
Supported Data Types	20-158
Unsupported Data Types	20-158
Mapping of SystemC/C++ and SystemVerilog/VMM Data Types 20-159	
Usage Examples	20-164
Using the Pack Operator	20-164
Using Unpack Operator	20-165
Using Pack and Unpack Functions	20-165

Using Code Generator.....	20-168
Naming Convention	20-169
Input Files.....	20-169
Output Files	20-171
Supported Data types for Automatic Code Generation ..	20-172
Correcting the Generated Files	20-173
Compile Flow	20-174
Usage Example for Code Generator	20-175
 Using Direct Program Interface Based Communication	20-184
Limitations of Using DPI-based Communication Between Verilog and SystemC.....	20-185
 Improving VCS-SystemC Compilation Speed Using Precompiled C++ Headers.....	20-185
Introduction to Precompiled Header Files	20-186
Using Precompiled Header Files	20-186
Example to Use the Precompiled Header Files	20-188
Invoking the Creation of Precompiled Header Files.....	20-188
Limitations	20-189
Limitations of syscan -prec	20-190
Limitations of using -prec with path	20-191
Limitations of Sharing Precompiled Header Files	20-192
 Increasing Stack and Stack Guard Size	20-192
Increasing the Stack Size.....	20-193
Increasing the Stack Guard Size	20-194
Guidelines to Diagnose Stack Overrun	20-194
 Debugging SystemC Runtime Errors	20-195
Debugging SystemC Kernel Errors	20-196

Troubleshooting Your Elaboration Errors	20-196
Troubleshooting Your Runtime Errors	20-199
Function <code>cbug_stop_here()</code>	20-201
Limitations	20-203
Diagnosing Quickthread Issues	20-204
Using HDL and SystemC Sync Loops	20-204
The Coarse-Grained Sync Loop (<code>blocksync</code>)	20-204
The Fine-Grained Sync Loop (<code>deltasync</code>)	20-205
Run Time	20-205
Alignment of Delta Cycles	20-205
Example Syntax	20-206
Restrictions	20-206
Restrictions That No Longer Apply	20-207
Newsync is Now Default	20-207
Controlling Simulation Run From <code>sc_main</code>	20-208
Effect on <code>end_of_simulation</code> Callbacks	20-210
UCLI Save Restore Support for SystemC-on-top and Pure-SystemC 20-211	
SystemC with UCLI Save and Restore Use Model	20-212
SystemC with UCLI Save and Restore Coding Guidelines ..	20-212
Saving and Restoring Files During Save and Restore	20-214
Restoring the Saved Files from the Previous Saved Session	20-215
Limitations of UCLI Save Restore Support	20-215
Enabling Unified Hierarchy for VCS and SystemC	20-216
Using Unified Hierarchy Elaboration	20-216
Value Added by Option <code>--sysc=unihier</code>	20-219

Using the –sysc=show_sc_main Switch	20-220
SystemC Unified Hierarchy Flow Limitations	20-221
Aligning VMM and SystemC Messages	20-221
Introduction	20-222
Use Model	20-222
Changing Message Alignment Settings	20-223
Mapping SystemC to VMM Severities	20-225
Filtering Messages	20-225
Limitations	20-228
UVM Message Alignment	20-229
Enabling UVM Message Alignment	20-229
Accessing UVM Report Object of SystemC Instance	20-233
Introducing TLI Adapters	20-236
TLI Adapter Overview	20-236
SystemC Adapters	20-237
Global Package	20-237
User Package	20-239
Use Model	20-243
VMM Channel Interface (vmm_tlm_generic_payload)	20-243
VMM TLM Interface (vmm_tlm_generic_payload)	20-246
VMM Channel/TLM Interface (Other data type)	20-249
SV Interface Other Than vmm_channel/vmm_tlm	20-249
VMM Channel Interface Details	20-250
VMM TLM Interface Details	20-253
E	
xamples	20-257
Example-1	20-258

Example-2	20-262
Example-3	20-265
Example-4	20-267
Example-5	20-269
Example-6	20-273
Example-7	20-276
Example-8	20-278
Example-9	20-280
Example-10	20-283
Using VCS UVM TLI Adapters	20-287
Using the UVM TLI Adapters	20-287
UVM TLM Interface	20-287
UVM Analysis Interface	20-289
Handling Multiple Subscribers	20-291
UVM TLM Communication Examples	20-291
uvm_tlm_blocking Example	20-291
uvm_tlm_nonblocking Example	20-293
uvm_tlm_analysis Example	20-295
Modeling SystemC Designs with SCV	20-297
SCV Library in VCS	20-298
Use model	20-298
msglog Extensions for Transaction Recording with SCV in VCS	
20-299	
Use Model	20-299
Viewing SystemC <code>sc_report_handler</code> Messages from Log File	
20-300	

21. C Language Interface

Using PLI	21-2
Writing a PLI Application	21-2
Functions in a PLI Application	21-4
Header Files for PLI Applications.	21-5
PLI Table File	21-6
Syntax	21-6
Using the PLI Table File	21-18
Enabling ACC Capabilities.	21-19
Globally	21-19
Using the Configuration File	21-20
Selected ACC Capabilities	21-23
PLI Access to Ports of Celldefine and Library Modules	21-28
Example	21-28
Visualization in DVE	21-30
Using VPI Routines	21-31
Support for VPI Callbacks for Reasons <code>cbForce</code> and <code>cbRelease</code>	21-31
Support for the <code>vpi_register_systf</code> Routine.	21-32
Integrating a VPI Application With VCS.	21-33
PLI Table File for VPI Routines	21-35
Virtual Interface Debug Support.	21-35
Example	21-36
Limitations	21-39
Unimplemented VPI Routines	21-39
Diagnostics for VPIPLI Applications	21-41

Using DirectC	21-41
Using Direct C/C++ Function Calls	21-43
How C/C++ Functions Work in a Verilog Environment...	21-45
Declaring the C/C++ Function	21-46
Calling the C/C++ Function	21-52
Storing Vector Values in Machine Memory.....	21-54
Converting Strings	21-56
Avoiding a Naming Problem.....	21-59
Using Pass by Reference.....	21-60
Using Direct Access.....	21-61
Using the vc_hdrs.h File.....	21-68
Access Routines for Multi-Dimensional Arrays	21-69
Using Abstract Access.....	21-70
Using vc_handle.....	21-71
Using Access Routines	21-72
Summary of Access Routines	21-116
Enabling C/C++ Functions.....	21-121
Mixing Direct And Abstract Access	21-123
Specifying the DirectC.h File	21-123
Extended BNF for External Function Declarations	21-124
22. SAIF Support	
Using SAIF Files	22-2
SAIF System Tasks	22-2
The Flows to Generate a Backward SAIF File	22-5
Generating an SPDP Backward SAIF File.....	22-5
Generating a Non-SPDP Backward SAIF File.....	22-6

SAIF Support for Two-Dimensional Memories in v2k Designs	22-7
UCLI SAIF Dumping	22-7
Criteria for Choosing Signals for SAIF Dumping	22-8
23. Encrypting Source Files	
Using Compiler Directives or Pragmas	23-2
Example	23-3
Using Automatic Protection Options	23-5
24. Integrating VCS with Vera	
Setting Up Vera and VCS	24-2
Using Vera with VCS	24-3
Usage Model	24-4
25. Integrating VCS with HSIM	
Environment Setup	25-2
Usage Model	25-2
26. Integrating VCS with NanoSim	
Environment Setup	26-2
Usage Model	26-3
27. Integrating VCS with Specman	
Type Support	27-2

Usage Flow	27-3
Setting Up The Environment	27-3
Specman e Code Accessing Verilog	27-3
Using specrun and specview.	27-5
Adding Specman Objects To DVE.....	27-8
Version Checker for Specman.	27-10
Use Model	27-10
28. Integrating VCS with Denali	
Setting Up Denali Environment for VCS	28-1
Integrating Denali with VCS	28-2
Usage Model	28-2
Usage Model for Verilog Memory Models	28-2
Execute Denali Commands at UCLI Prompt	28-3
29. Integrating VCS with Debussy	
Using the Current Version of VCS with Novas 2010.07 Version .	29-1
Setting Up Debussy	29-2
Usage Model to Dump fsdb File.....	29-2
Using Verilog System Tasks.....	29-3
Using UCLI	29-3
Examples	29-4
30. Integrating VCS with XA	
Environment Setup	30-2

Usage Model	30-3
31. Integrating VCS with MVSIM Native Mode	
Introduction to MVSIM	31-1
MVSIM Native Mode in VCS	31-2
References	31-3
Appendix A. VCS Environment Variables	
Simulation Environment Variables	A-1
Optional Environment Variables	A-3
Appendix B. Compile-time Options	
Options for Accessing Verilog Libraries	B-4
Options for Incremental Compilation	B-6
Options for Help and Documentation	B-7
Options for SystemVerilog	B-8
Options for SystemVerilog Assertions	B-8
Options to Enable Compilation of OVA Case Pragmas	B-16
Options for Native Testbench	B-16
Options for Different Versions of Verilog	B-22
Options for Initializing Memories and Registers with Random Values B-23	
Options for Using Radiant Technology	B-24
Options for 64-bit Compilation	B-25
Options for Starting Simulation Right After Compilation	B-26
Options for Specifying Delays and SDF Files	B-26

Options for Compiling an SDF File	B-31
Options for Specify Blocks and Timing Checks	B-31
Options for Pulse Filtering	B-33
Options for Negative Timing Checks	B-34
Options for Profiling Your Design.	B-35
Options to Specify Source Files and Compile-time Options in a File B-36	
Options for Compiling Runtime Options into the Executable	B-37
Options for PLI Applications	B-37
Options to Enable the VCS DirectC Interface	B-41
Options for Flushing Certain Output Text File Buffers	B-41
Options for Simulating SWIFT VMC Models and SmartModels	B-42
Options for Controlling Messages	B-43
Options for Cell Definition	B-45
Options for Licensing	B-47
Options for Controlling the Linker	B-48
Options for Controlling the C Compiler	B-50
Options for Source Protection	B-52
Options for Mixed Analog/Digital Simulation	B-55
Options for Changing Parameter Values	B-56
Checking for X and Z Values in Conditional Expressions	B-56
Options for Detecting Race Conditions	B-56
Options to Specify the Time Scale.	B-57
Options for Overriding Parameters	B-59
General Options.	B-62
Specifying Directories for ‘include’ Searches	B-62

Enable the VCS/SystemC Cosimulation Interface	B-62
TetraMAX	B-63
Allow Inout Port Connection Width Mismatches.	B-63
Allow Zero or Negative Multiconcat Multiplier	B-63
Specifying a VCD File.	B-64
Enabling Dumping	B-64
Memories and Multi-Dimensional Arrays (MDAs)	B-64
Specifying a Log File	B-65
Changing Source File Identifiers to Upper Case	B-65
Defining a Text Macro.	B-66
Specifying the Name of the Executable File.	B-66
Returning The Platform Directory Name	B-66
Enable Loop Detect	B-67
Changing the Time Slot of Sequential UDP Output Evaluation	
B-67	
Gate-Level Performance	B-68
Option to Omit Compilation of Code Between Pragmas .	B-68

Appendix C. Simulation Options

Options for Simulating Native Testbenches	C-2
Options for SystemVerilog Assertions	C-10
Options to Control Termination of Simulation.	C-19
Options for Enabling and Disabling Specify Blocks	C-19
Options for Specifying When Simulation Stops	C-20
Options for Recording Output	C-20
Options for Controlling Messages	C-21
Options for VPD Files	C-22
Options for VCD Files	C-24

Options for Specifying Delays	C-25
Options for Flushing Certain Output Text File Buffers	C-27
Options for Licensing	C-28
Option to Specify User-Defined Runtime Options in a File	C-28
Option for Initializing Integer Data Type Variables at Runtime	C-29
General Options.	C-31
Viewing the Compile-Time Options	C-31
Recording Where ACC Capabilities are Used	C-32
Suppressing the \$stop System Task	C-32
Enabling User-defined Plusarg Options	C-32
Enabling Overriding the Timing of a SWIFT SmartModel.	C-32
Specifying acc_handle_simulated_net PLI Routine	C-33

Appendix D. Compiler Directives and System Tasks

Compiler Directives	D-1
Compiler Directives for Cell Definition	D-2
Compiler Directives for Setting Defaults	D-2
Compiler Directives for Macros	D-3
Compiler Directives for Delays.	D-5
Compiler Directives for Backannotating SDF Delay Values..	D-6
Compiler Directives for Source Protection.	D-6
Debugging Partially Encrypted Source Code.	D-7
Compiler Directives for Controlling Port Coercion	D-8
General Compiler Directives	D-8
Compiler Directive for Including a Source File	D-8
Compiler Directive for Setting the Time Scale	D-8
Compiler Directive for Specifying a Library	D-9

Compiler Directive for File Names and Line Numbers	D-10
Unimplemented Compiler Directives	D-10
System Tasks and Functions.	D-11
System Tasks for SystemVerilog Assertions Severity	D-11
System Tasks for SystemVerilog Assertions Control	D-11
System Tasks for SystemVerilog Assertions	D-12
System Tasks for VCD Files	D-13
System Tasks for LSI Certification VCD and EVCD Files	D-15
System Tasks for VPD Files.	D-18
System Tasks for SystemVerilog Assertions	D-26
System Tasks for Executing Operating System Commands	D-27
System Tasks for Log Files	D-28
System Tasks for Data Type Conversions	D-28
System Tasks for Displaying Information.	D-29
System Tasks for File I/O.	D-30
System Tasks for Loading Memories.	D-32
System Tasks for Time Scale.	D-33
System Tasks for Simulation Control.	D-34
System Tasks for Timing Checks.	D-34
Timing Checks for Clock and Control Signals	D-35
System Tasks for PLA Modeling	D-37
System Tasks for Stochastic Analysis	D-37
System Tasks for Simulation Time.	D-38
System Tasks for Probabilistic Distribution	D-39
System Tasks for Resetting VCS.	D-40
General System Tasks and Functions	D-40

Checks for a Plusarg	D-40
SDF Files	D-41
Counting the Drivers on a Net	D-41
Depositing Values.	D-41
Fast Processing Stimulus Patterns.	D-41
Saving and Restarting The Simulation State	D-42
Checking for X and Z Values in Conditional Expressions	D-42
Calculating Bus Widths	D-43
Displaying the Method Stack	D-44
IEEE Standard System Tasks Not Yet Implemented	D-46

Appendix E. PLI Access Routines

Access Routines for Reading and Writing to Memories	E-2
acc_setmem_int.	E-4
acc_getmem_int	E-5
acc_clearmem_int	E-6
Examples	E-6
acc_setmem_hexstr.	E-11
Examples	E-12
acc_getmem_hexstr	E-15
acc_setmem_bitstr.	E-16
acc_getmem_bitstr.	E-17
acc_handle_mem_by_fullname.	E-18
acc_readmem	E-18
Examples	E-19
acc_getmem_range.	E-21
acc_getmem_size	E-22

acc_getmem_word_int	E-23
acc_getmem_word_range	E-24
Access Routines for Multidimensional Arrays	E-24
tf_mdanodeinfo and tf_imdanodeinfo.	E-26
acc_get_mda_range	E-27
acc_get_mda_word_range()	E-29
acc_getmda_bitstr()	E-30
acc_setmda_bitstr()	E-31
Access Routines for Probabilistic Distribution	E-32
vcs_random	E-33
vcs_random_const_seed.	E-34
vcs_random_seed	E-34
vcs_dist_uniform	E-35
vcs_dist_normal.	E-35
vcs_dist_exponential	E-36
vcs_dist_poisson	E-37
Access Routines for Returning a Pointer to a Parameter Value .	E-37
acc_fetch_paramval_str.	E-38
Access Routines for Extended VCD Files	E-38
acc_lsi_dumpports_all	E-40
acc_lsi_dumpports_call	E-41
acc_lsi_dumpports_close.	E-43
acc_lsi_dumpports_flush	E-44
acc_lsi_dumpports_limit.	E-45
acc_lsi_dumpports_misc	E-46

acc_lsi_dumpports_off	E-47
acc_lsi_dumpports_on	E-48
acc_lsi_dumpports_setformat	E-50
acc_lsi_dumpports_vhdl_enable	E-51
Access Routines for Line Callbacks	E-52
acc_mod_lcb_add	E-53
acc_mod_lcb_del	E-55
acc_mod_lcb_enabled	E-57
acc_mod_lcb_fetch	E-57
acc_mod_lcb_fetch2	E-59
acc_mod_sfi_fetch	E-61
Access Routines for Source Protection	E-62
vcsSpClose	E-66
vcsSpEncodeOff	E-67
vcsSpEncodeOn	E-68
vcsSpEncoding	E-70
vcsSpGetFilePtr	E-71
vcsSpInitialize	E-72
vcsSpOvaDecodeLine	E-73
vcsSpOvaDisable	E-74
vcsSpOvaEnable	E-75
vcsSpSetDisplayMsgFlag	E-77
vcsSpSetFilePtr	E-77
vcsSpSetLibLicenseCode	E-78
vcsSpSetPliProtectionFlag	E-79
vcsSpWriteChar	E-80

vcsSpWriteString	E-81
Access Routine for Signal in a Generate Block.....	E-83
acc_object_of_type	E-83
VCS API Routines	E-83
Vcsinit()	E-84
VcsSimUntil()	E-84

1

Getting Started

VCS® is a high-performance, high-capacity Verilog® simulator that incorporates advanced, high-level abstraction verification technologies into a single open native platform.

VCS is a compiled code simulator. It enables you to analyze, compile, and simulate Verilog, SystemVerilog, OpenVera and SystemC design descriptions. It also provides you with a set of simulation and debugging features to validate your design. These features provide capabilities for source-level debugging and simulation result viewing.

VCS accelerates complete system verification by delivering the fastest and highest capacity Verilog simulation for RTL functional verification.

This chapter includes the following sections:

- “[Simulator Support with Technologies](#)”
- “[Setting Up the Simulator](#)”
- “[Using the Simulator](#)”
- “[Default Time Unit and Time Precision](#)”

Simulator Support with Technologies

VCS supports the following IEEE standards:

- The Verilog language as defined in the *Standard Verilog Hardware Description Language* (IEEE Std 1364).
- The IEEE Std 1800 language (with some exceptions) as defined in *SystemVerilog Language Reference Manual* for VCS/VCS MX.

In addition to its standard Verilog and SystemVerilog compilation and simulation capabilities, VCS includes the following integrated set of features and tools:

- SystemC - VCS / SystemC Co-simulation Interface enables VCS and the SystemC modeling environment to work together when simulating a system described in the Verilog and SystemC languages. For more information, refer to “[Using SystemC](#)” on page 1.
- Discovery Visualization Environment (DVE) — For more information, refer to “[Using DVE](#)” on page 2.
- Unified Command-line Interface (UCLI) — For more information, refer to “[Using UCLI](#)” on page 3.

- Built-In Coverage Metrics — a comprehensive built-in coverage analysis functionality that includes condition, toggle, line, finite-state-machine (FSM), path, and branch coverage. You can use coverage metrics to determine the quality of coverage of your verification test and focus on creating additional test cases. You only need to compile once to run both simulation and coverage analysis. For more information, refer to “[Coverage](#)” on page 1.
- DirectC Interface — this interface allows you to directly embed user-created C/C++ functions within your Verilog design description. This results in a significant improvement in ease-of-use and performance over existing PLI-based methods. VCS atomically recognizes C/C++ function calls and integrates them for simulation, thus eliminating the need to manually create PLI files.

VCS supports Synopsys DesignWare IPs, VCS Verification Library, VMC models, Vera, HSIM, and NanoSim. For information on integrating VCS with HSIM, refer to the HSIM-VCS DKI and HSIM-VCS-MX DKI Mixed-Signal Simulation Application Note. For information on integrating VCS with NanoSim, refer to the *Discovery AMS: Mixed-Signal Simulation User Guide* available in the NanoSim installation directory.

VCS can also be integrated with third-party tools such as Specman, Debussy, Denali, and other acceleration and emulation systems.

Setting Up the Simulator

This section outlines the basic steps for preparing to run VCS. It includes the following topics:

- “[Verifying Your System Configuration](#)”
 - “[Obtaining a License](#)”
 - “[Setting Up Your Environment](#)”
 - “[Setting Up Your C Compiler](#)”
-

Verifying Your System Configuration

You can use the `syschk.sh` script to check if your system and environment match the QSC requirements for a given release of a Synopsys product. The QSC (Qualified System Configurations) represents all system configurations maintained internally and tested by Synopsys.

To check whether the system you are on meets the QSC requirements, enter:

```
% syschk.sh
```

When you encounter any issue, run the script with tracing enabled to capture the output and contact Synopsys. To enable tracing, you can either uncomment the `set -x` line in the `syschk.sh` file or enter the following command:

```
% sh -x syschk.sh >& syschk.log
```

Use `syschk.sh -v` to generate a more verbose output stream including the exact path for various binaries used by the script, etc. For example:

```
% syschk.sh -v
```

Note:

If you copy the `syschk.sh` script to another location before using it, you must also copy the `syschk.dat` data file to the same directory.

You can also refer to the "Supported Platforms and Products" section of the VCS Release Notes for a list of supported platforms, and recommended C compiler and linker versions.

Obtaining a License

You must have a license to run VCS. To obtain a license, contact your local Synopsys Sales Representative. Your Sales Representative will need the hostid for your machine.

To start a new license, do the following:

1. Verify that your license file is functioning correctly:

```
% lmcksum -c license_file_pathname
```

Running this licensing utility ensures that the license file is not corrupt. You should see an "OK" for every INCREMENT statement in the license file.

Note:

The snpslmd platform binaries and accompanying FlexLM utilities are shipped separately and are not included with this distribution. You can download these binaries as part of the Synopsys Common Licensing (SCL) kit from the Synopsys Web Site at:

<http://www.synopsys.com/cgi-bin/ASP/sk/smartkeys.cgi>

2. Start the license server:

```
% lmgrd -c license_file_pathname -l logfile_pathname
```

3. Set the LM_LICENSE_FILE or SNPSLMD_LICENSE_FILE environment variable to point to the license file. For example:

```
% setenv LM_LICENSE_FILE /u/edatools/vcs/license.dat
```

or

```
% setenv SNPSLMD_LICENSE_FILE /u/edatools/vcs/  
license.dat
```

Note:

- You can use SNPSLMD_LICENSE_FILE environment variable to set licenses explicitly for Synopsys tools.
- If you set the SNPSLMD_LICENSE_FILE environment variable, then VCS ignores the LM_LICENSE_FILE environment variable.

Setting Up Your Environment

To run VCS, you need to set the following environment variables:

- \$VCS_HOME environment variable

Set the environment variable `VCS_HOME` to the path where VCS is installed as shown below:

```
% setenv VCS_HOME installation_path
```

- `$PATH` environment variable

Set your UNIX PATH variable to `$VCS_HOME/bin` as shown below:

```
% set path = ($VCS_HOME/bin $path)
```

OR

```
% setenv PATH $VCS_HOME/bin:$PATH
```

- `LM_LICENSE_FILE` or `SNPSLMD_LICENSE_FILE` environment variable:

Set the license variable `LM_LICENSE_FILE` or `SNPSLMD_LICENSE_FILE` to your license file as shown below:

```
% setenv LM_LICENSE_FILE Location_to_the_license_file
```

or

```
% setenv SNPSLMD_LICENSE_FILE /u/edatools/vcs/  
license.dat
```

Note:

- You can use `SNPSLMD_LICENSE_FILE` environment variable to set licenses explicitly for Synopsys tools.
- If you set the `SNPSLMD_LICENSE_FILE` environment variable, then VCS ignores the `LM_LICENSE_FILE` environment variable.

For additional information on environment variables, see [Appendix A, "VCS MX Environment Variables"](#).

Setting Up Your C Compiler

On Solaris VCS requires a C compiler to compile the intermediate files, and to link the executable file that you simulate. Solaris does not include a C compiler, therefore, you must purchase the C compiler for Solaris or use gcc. For Solaris, VCS assumes the C compiler is located in its default location (/usr/ccs/bin).

RHEL32, RHEL64 and IBM RS/6000 AIX platforms all include a C compiler, and VCS assumes the compiler is located in its default location (/usr/bin).

You can specify a different C compiler using the environment `vcs_cc` or the `-cc` compile-time option.

Using the Simulator

VCS uses the following steps to compile and simulate Verilog designs:

- Compiling the Design
- Simulating the Design

Compiling the Design

VCS provides you with the `vcs` executable to compile and elaborate the design. This executable compiles your design using the intermediate files in the design or work library, generates the object code, and statically links them to generate a binary simulation executable, `simv`. For more information, see [Chapter 2, "VCS MX Flow"](#).

Simulating the Design

Simulate your design by executing the binary simulation executable, `simv`. For more information, see [Chapter 2, "VCS MX Flow"](#).

Basic Usage Model

Compilation

```
% vcs [compile_options] Verilog_files
```

Simulation

```
% simv [run_options]
```

Default Time Unit and Time Precision

The default time unit is 1 ns.

The default time precision 1 ns.

2

VCS Flow

Simulating a design using VCS involves two basic steps:

- “[Compilation](#)”
- “[Simulation](#)”

VCS uses the same two steps to compile any design irrespective of the HDL, HVL, and other supported technologies used. For information on supported technologies, refer to “[Simulator Support with Technologies](#)” on page 2.

Compilation

Compiling is the first step to simulate your design. In this phase, VCS builds the instance hierarchy and generates a binary executable `simv`. This binary executable is later used for simulation.

In this phase, you can choose to compile the design either in optimized mode or in debug mode. Runtime performance of VCS is based on the mode you choose and the level of flexibility required during simulation. Synopsys recommends you use full-debug or partial-debug mode until the design correctness is achieved, and then switch to optimized mode.

In optimized mode, also called batch mode, VCS delivers the best compile-time and runtime performance for a design. You typically choose optimized mode to run regressions, or when you do not require extensive debug capabilities. For more information, see [“Compiling or Elaborating the Design in Optimized Mode”](#).

You compile the design in debug mode, also called interactive mode, when you are in the initial phase of your development cycle, or when you need more debug capabilities or tools to debug the design issues. In this mode, the performance will not be the best that VCS can deliver. However, using some of the compile-time options, you can compile your design in full-debug or partial-debug mode to get maximum performance in debug mode. For more information, see [“Compiling or Elaborating the Design in Debug Mode”](#).

Using vcs

The syntax to use vcs is shown below:

```
% vcs [compile_options] Verilog_files
```

Commonly Used Options

This section lists some of the commonly used vcs options. For a complete list of options, see the appendix on Compile-Time options.

Options for Help and Documentation

-h or -help

Lists descriptions of the most commonly used VCS compile and runtime options.

-doc

Displays the VCS documentation in your system's default web browser.

-ID

Returns useful information such as VCSversion and build date, VCScompiler version (same as VCS), and your work station name, platform, and host ID (used in licensing).

Options for Licensing

-licqueue

Tells VCS to wait for a network license if none is available.

Options for Accessing Verilog Libraries

-v *filename*

Specifies a Verilog library file. VCS looks in this file for definitions of the module and UDP instances that VCS found in your source code but for which it did not find the corresponding module or UDP definitions in your source code.

`-y directory`

Specifies a Verilog library directory. VCS looks in the source files in this directory for definitions of the module and UDP instances that VCS found in your source code but for which it did not find the corresponding module or UDP definitions in your source code. VCS looks in this directory for a file with the same name as the module or UDP identifier in the instance (not the instance name). If it finds this file, VCS looks in the file for the module or UDP definition to resolve the instance.

Note:

If you have multiple modules with the same name in different libraries, VCS selects the module defined in the library that is specified with the first `-y` option.

For example:

If `rev1/cell.v` and `rev2/cell.v` and `rev3/cell.v` all exist and define the module `cell()`, and you issue the following command:

```
% vcs -y rev1 -y rev2 -y rev3 +libext+.v top.v
```

VCS selects `cell.v` from `rev1`.

However, if the `top.v` file has a ``uselib` compiler directive as shown below:

```
//top.v
```

```
`uselib directory = /proj/libraries/rev3  
//rest of top module code  
//end top.v
```

...then `uselib takes priority. In this case, VCS will use rev3 / cell.v when you issue the following command:

```
% vcs -y rev1 -y rev2 +libext+.v top.v
```

Include the +libext compile-time option to specify the file name extension of the files you want VCS to look for in these directories.

+incdir+*directory*+

Specifies the directory or directories that VCS searches for include files used in the `include compiler directive. More than one directory may be specified when separated by the plus (+) character.

+libext+*extension*+

Specifies that VCS search only for files with the specified file name extensions in a library directory. You can specify more than one extension, separating the extensions with the plus (+) character. For example, +libext+.v+.V+ specifies searching for files with either the .v or .V extension in a library. The order in which you add file name extensions to this option does not specify an order in which VCS searches files in the library with these file name extensions.

+liborder

Specifies searching for module definitions for unresolved module instances through the remainder of the library where VCS finds the instance, then searching the next and then the next library on the vcs command line before searching in the first library on the command line.

Options for 64-bit Compilation

-full64

Enables compilation and simulation in 64-bit mode.

Option to Specify Files and Compile-time Options in a File

-file *filename*

Specifies a file containing a list of files and compile-time options.

Options for Discovery Visual Environment and UCLI

-gui

When used at compile time, always starts DVE at runtime.

For information on DVE, see the DVE User Guide. For information on UCLI, see the UCLI User Guide.

Options for Starting Simulation Right After Compilation

-R

Runs the executable file immediately after VCS links it together.

Options for Changing Parameter Values

-pvalue+*parameter_hierarchical_name*=*value*

Changes the specified parameter to the specified value.

-parameters *filename*

Changes parameters specified in the file to values specified in the file. The syntax for a line in the file is as follows:

assign *value* *path_to_parameter*

The path to the parameter is similar to a hierarchical name except that you use the forward slash character (/) instead of a period as the delimiter.

For more information on overriding parameters, see “[Overriding Generics and Parameters](#)”.

Options for Controlling Messages

-notice

Enables verbose diagnostic messages.

-q

Quiet mode; suppresses messages such as those about the C compiler VCS is using, the source files VCS is parsing, the top-level modules, or the specified timescale.

-V

Verbose mode; compiles verbosely. The compiler driver program prints the commands it executes as it runs the C compiler, assembler, and linker.

Specifying a Log File

-l *filename*

Specifies a file where VCS records compilation messages. If you also enter the **-R** option, VCS records messages from both compilation and simulation in the same file.

Defining a Text Macro

+define+macro=value+

Defines a text macro in your source code to a value or character string. You can test for this definition in your Verilog source code using the `ifdef compiler directive. If there are blank spaces in the character string then you must enclose it in quotation marks.

For example:

```
vcs design.v +define+USELIB="dir=dir1 dir=dir2"
```

The macro is used in a `uselib compiler directive:

```
'uselib 'USELIB libext+.v
```

Simulation

During compilation, using the intermediate files generated, VCS creates a binary executable, simv. You can use simv to run the simulation. Based on how you compile the design, you can run your simulation the following ways:

- Interactive mode
- Batch mode

For information on compiling the design, refer to the “[Compilation](#)” section.

Interactive Mode

You compile your design in interactive mode, also called debug mode, in the initial phase of your design cycle. In this phase, you require abilities to debug the design issues using a GUI or through the command line. To debug using a GUI, you can use the Discovery

Verification Environment (DVE), and to debug through the command-line interface, you can use the Unified Command-line Interface (UCLI).

Note:

To simulate the design in the interactive mode, you must compile the design using the `-debug` or `-debug_all` compile-time options. For information on compiling the design, refer to the “[Compilation](#)” section.

Batch Mode

You compile your design in batch mode, also called as optimized mode, when most of your design issues are resolved. In this phase, you will be more interested to achieve better performance to run regressions, and with minimum debug abilities.

Note:

The runtime performance reduces if you use `-debug` or `-debug_all`. Use these options only when you require runtime debug abilities.

The following command line simulates the design in batch mode:

```
% simv
```

Commonly Used Runtime Options

Use the following command line to simulate the design:

```
% executable [runtime_options]
```

By default, VCS generates the binary executable `simv`. However, you can use the compile-time option, `-o` with the `vcs` command line to generate the binary executable with the specified name.

For a complete list of options, see “[Simulation Options](#)” .

3

Modeling Your Design

Verilog coding style is the most important factor that affects the simulation performance of a design. How you write your design can make the difference between a fast error-free simulation, and one that suffers from race conditions and poor performance. This chapter describes some Verilog modeling techniques that will help your code designs simulate most efficiently with VCS.

This chapter includes the following topics:

- “[Avoiding Race Conditions](#)”
- “[Race Detection](#)”
- “[Optimizing Testbenches for Debugging](#)”
- “[Avoiding the Debugging Problems From Port Coercion](#)”
- “[Creating Models That Simulate Faster](#)”

- “Case Statement Behavior”
 - “Precedence in Text Macro Definitions”
 - “Memory Size Limits in the Simulator”
 - “Using Sparse Memory Models”
 - “Obtaining Scope Information”
 - “Avoiding Circular Dependency”
 - “Designing With \$lsi_dumpports for Simulation and Test”
-

Avoiding Race Conditions

A race condition is defined as a coding style for which there is more than one correct result. Since the output of the race condition is unpredictable, it can cause unexpected problems during simulation. It is easy to accidentally code race conditions in Verilog. For example, in *Digital Design with Verilog HDL* by Sternheim, Singh, and Trivedi, at least two of the examples provided with the book (adder and cachemem) have race conditions. VCS provides some tools for race detection.

Some common race conditions and ways of avoiding them are described in the following sections.

Using and Setting a Value at the Same Time

In this example, the two parallel blocks have no guaranteed ordering, so it is ambiguous whether the \$display statement will be executed.

```

module race;
    reg a;
    initial begin
        a = 0;
        #10 a = 1;
    end
    initial begin
        #10 if (a) $display("may not print");
    end
endmodule

```

The solution is to delay the `$display` statement with a `#0` delay:

```

initial begin
    #10 if (a)
        #0 $display("may not print");
end

```

You can also move it to the next time step with a non-zero delay.

Setting a Value Twice at the Same Time

In this example, the race condition occurs at time `10` because no ordering is guaranteed between the two parallel initial blocks.

```

module race;
    reg r1;
    initial #10 r1 = 0;
    initial #10 r1 = 1;
    initial
        #20 if (r1) $display("may not print");
endmodule

```

The solution is to stagger the assignments to register `r1` by finite time, so that the ordering of the assignments is guaranteed. Note that using the nonblocking assignment (`<=`) in both assignments to `r1` would not remove the race condition in this example.

Flip-Flop Race Condition

It is very common to have race conditions near latches or flip-flops. Here is one variant in which an intermediate node *a* between two flip-flops is set and sampled at the same time:

```
module test(out,in,clk);
    input in,clk;
    output out;
    wire a;
    dff dff0(a,in,clk);
    dff dff1(out,a,clk);
endmodule
module dff(q,d,clk);
    output q;
    input d,clk;
    reg q;
    always @(posedge clk)
        q = d; // race!
endmodule
```

The solution for this case is straightforward. Use the nonblocking assignment in the flip-flop to guarantee the order of assignments to the output of the instances of the flip-flop and sampling of that output. The change looks like this:

```
always @(posedge clk)
    q <= d; // ok
```

Or add a nonzero delay on the output of the flip-flop:

```
always @(posedge clk)
    q = #1 d; // ok
```

Or use a nonzero delay in addition to the nonblocking form:

```
always @(posedge clk)
```

```
q <= #1 d;      // ok
```

Note that the following change does not resolve the race condition:

```
always @(posedge clk)
#1 q = d;      // race!
```

The #1 delay simply shifts the original race by one time unit, so that the intermediate node is set and sampled one time unit *after* the posedge of clock, rather than *on* the posedge of clock. Avoid this coding style.

If you are modeling flip-flops using sequential UDPs (user-defined primitives), note that VCS evaluates the output terminals of sequential UDP (user-defined primitive) in the Active time slot of a simulation time. This can cause a race condition. The default behavior is required by the SystemVerilog LRM, IEEE Std 1800-2009. The `+udpsched` switch prevents these race conditions by changing the evaluation to the NBA time slot.

Continuous Assignment Evaluation

Continuous assignments with no delay are sometimes propagated earlier in VCS than in Verilog-XL. This is fully correct behavior, but exposes race conditions such as the one in the following code fragment:

```
assign x = y;
initial begin
    y = 1;
    #1
    y = 0;
    $display(x);
end
```

In VCS, this displays 0, while in Verilog-XL, it displays 1, because the assignment of the value to `x` races with the usage of that value by the `$display`.

Another example of this type of race condition is the following:

```
assign state0 = (state == 3'h0);
always @(posedge clk)
begin
    state = 0;
    if (state0)
        // do something
end
```

The modification of `state` may propagate to `state0` before the `if` statement, causing unexpected behavior. You can avoid this by using the nonblocking assignment to `state` in the procedural code as follows:

```
state <= 0;
if (state0)
    // do something
```

This guarantees that `state` is not updated until the end of the time step, that is, after the `if` statement has executed.

Counting Events

A different type of race condition occurs when code depends on the number of times events are triggered in the same time step. For instance, in the following example, if `A` and `B` change at the same time, it is unpredictable whether `count` is incremented once or twice:

```
always @(A or B)
```

```
count = count + 1;
```

Another form of this race condition is to toggle a register within the always block. If toggled once or twice, the result may be unexpected behavior.

The solution to this race condition is to make the code inside the always block insensitive to the number of times it is called.

Time Zero Race Conditions

The following race condition is subtle but very common:

```
always @(posedge clock)
    $display("May or may not display");
initial begin
    clock = 1;
    forever #50 clock = ~clock;
end
```

This is a race condition because the transition of clock to 1 (posedge) may happen before or after the event trigger (always @(posedge clock)) is established. Often the race is not evident in the simulation result because reset occurs at time zero.

The solution to this race condition is to guarantee that no transitions take place at time zero of any signals inside event triggers. Rewrite the clock driver in the above example as follows:

```
initial begin
    clock = 1'bx;
    #50 clock = 1'b0;
    forever #50 clock = ~clock;
end
```

Race Detection

VCS provides the following race detection tools:

- **Dynamic Race Detection Tool** - Finds the race conditions during simulation.
- **Static Race Detection Tool** - Finds the race conditions by analyzing source code during compilation.

The above two tools are described in the following sections:

- [The Dynamic Race Detection Tool](#)
- [The Static Race Detection Tool](#)

The Dynamic Race Detection Tool

This section consists of following topics:

- [Introduction to the Dynamic Race Detection Tool](#)
- [Enabling Race Detection](#)
- [The Race Detection Report](#)
- [Post Processing the Report](#)
- [Debugging Simulation Mismatches](#)

Introduction to the Dynamic Race Detection Tool

The dynamic race detection tool finds two basic types of race conditions during simulation:

- [Read - Write Race Condition](#)
- [Write - Write Race Condition](#)

Read - Write Race Condition

The Read - Write race condition occurs when both Read and Write on a signal take place at the same simulation time.

Example:

```
initial
#5 var1 = 0; // write operation on signal var1

initial
#5 var2 = var1; // read operation on signal var2
```

Read

Procedural assignment in any one of the always or initial block, or a continuous assignment samples the value of signal var1 to drive signal var2.

Write

Procedural assignment in another always or initial block, or another continuous assignment assigns a new value to signal var1.

In the above example, at the simulation time 5, there is both read and write operation on signal var1. When simulation time 5 is over, you do not know if signal var2 will have the value 0 or the previous value of signal var1.

Write - Write Race Condition

The Write - Write race condition occurs when multiple writes on a signal take place at the same simulation time.

Example:

```
initial  
#5 var1 = 0; // write operation on signal var1  
  
initial  
#5 var1 = 1; // write operation on signal var1
```

Write-Write

Value of the signal `var1` is non-deterministic when there are multiple concurrent procedural assignments on the same variable at the same simulation time.

In the above example, at simulation time 5, different initial blocks assign 0 and 1 to signal `var1`. When simulation time 5 is over, you do not know if `var1` signal value is 0 or 1.

Finding these race conditions is important because in Verilog simulation you cannot control the order of execution of statements in different always or initial blocks, or continuous assignments that execute at the same simulation time. This means that a race condition can produce different simulation results when you simulate a design with different, but both properly functioning Verilog simulators.

Even worse, a race condition can result in different simulation results with different versions of a particular simulator, or with different optimizations or performance features of the same version of a simulator.

Note:

`$dumpvars` can also expose races.

Also, sometimes modifications in one part of a design can cause hidden race conditions to surface even in unmodified parts of a design, thereby causing different simulation results from the unmodified part of the design.

The indications of a race condition are the following:

- When simulation results do not match when comparing simulators
- When design modifications cause inexplicable results
- When simulation results do not match between different simulation runs of the same simulator, when different versions or different optimization features of that simulator are used

Therefore, even when a Verilog design appears to be simulating correctly and you see the results you want, you should look for race conditions and remove them so that you will continue to see the same simulation results from an unrevised design well into the future. Also, you should look for race conditions while a design is in development.

VCS can help you find these race conditions by writing report files about the race conditions in your design.

VCS writes the reports at run time, but you should enable race detection at compile-time with a compile-time option.

The reports can be lengthy for large designs. You can post-process the report to generate another shorter report that is limited, for example, to only part of the design or to only between certain simulation times.

Enabling Race Detection

When you compile your design, you can enable race detection during simulation for your entire design or part of your design.

The `-race` compile-time option enables race detection for your entire design.

The `-racecd` compile-time option enables race detection for the part of your design that is enclosed between the `'race` and `'endrace` compiler directives.

Note:

The `-race` and `-racecd` compile-time options supports dynamic race detection for both pure Verilog and SystemVerilog data types.

The Race Detection Report

While VCS simulates your design, it writes race detection reports to the `race.out` and `race.unique.out` files.

The `race.out` file contains a line for all race conditions that it finds at all times throughout the simulation. If VCS executes two different statements in the same time step for several times, the `race.out` file contains a line for each of these times.

The `race.unique.out` file contains only lines for race conditions that are unique, and which have not been reported in a previous line.

Note:

The race.unique.out is automatically created by the PostRace.pl Perl script after the simulation. This script needs a perl5 interpreter. The first line of the script points to perl at a specific location, see "["Modifying the PostRace.pl Script"](#)". If that location at your site is not a perl5 interpreter, the script fails with syntax errors.

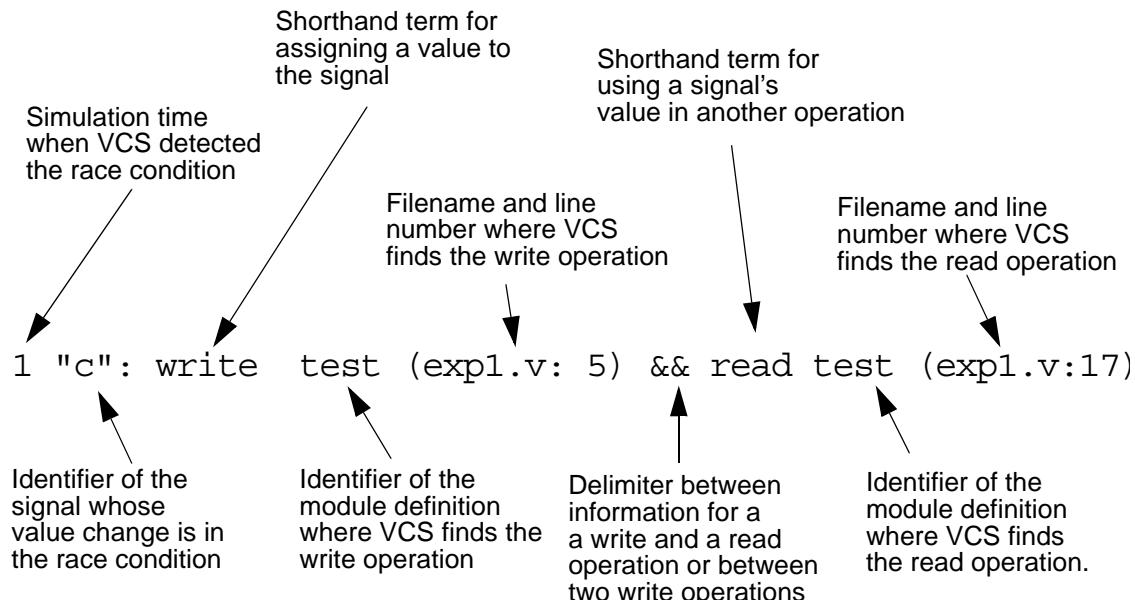
The report describes read-write and write-write race conditions. The following is an example of the contents of a small race.out file:

```
Synopsys Simulation VCS RACE REPORT

0 "c": write test (exp1.v: 5) && read test (exp1.v:23)
1 "a": write test (exp1.v: 16) && write test (exp1.v:10)
1 "c": write test (exp1.v: 5) && read test (exp1.v:17)

END RACE REPORT
```

The following explains a line in the race.out file:



The following is the source file, with line numbers added for this race condition report:

```
1. module test;
2. reg a,b,c,d;
3.
4. always @(a or b)
5. c = a & b;
6.
7. always
8. begin
9. a = 1;
10. #1 a = 0;
11. #2;
12. end
13.
14. always
15. begin
16. #1 a = 1;
17. d = b | c;
18. #2;
19. end
20.
21. initial
22. begin
23. $display("%m c = %b",c);
24. #2 $finish;
25. end
26. endmodule
```

As stipulated in `race.out`:

- At simulation time 0, there is a procedural assignment to reg `c` on line 5, and also `$display` system task displays the value of reg `c` on line 23.
- At simulation time 1, there is a procedural assignment to reg `a` on line 10 and another procedural assignment to reg `a` on line 16.

- Also, at simulation time 1, there is a procedural assignment to reg c on line 5, and the value of reg c is in an expression that is evaluated in a procedural assignment to another register on line 17.

Races of No Consequence

Sometimes race conditions exist, such as write-write race to a signal at the same simulation time, but the two statements that are assigning to the signal are assigning the same value. This is a race of no consequence, and the race tool indicates this with `**NC` at the end of the line for the race in the `race.out` file.

```

0 "r4": write test (nc1.v: 40) && write test
(nc1.v:44) **NC
20 "r4": write test (nc1.v: 40) && write test
(nc1.v:44) **NC
40 "r4": write test (nc1.v: 40) && write test
(nc1.v:44) **NC
60 "r4": write test (nc1.v: 40) && write test (nc1.v:44)
80 "r4": write test (nc1.v: 40) && write test
(nc1.v:44) **NC

```

Post Processing the Report

VCS comes with the `PostRace.pl` Perl script that you can use to post-process the `race.out` report to generate another report that contains a subset of the race conditions in the `race.out` file. You should include options on the command line for the `PostRace.pl` script to specify this subset. These options are as follows:

`-hier module_instance`

Specifies the hierarchical name of a module instance. The new report lists only the race conditions found in this instance and all module instances hierarchically under this instance.

-sig *signal*
Specifies the signal that you want to examine for race conditions. You can only specify one signal, and must not include a hierarchical name for the signal. If two signals in different module instances have the same identifier, the report lists race conditions for both signals.

-minmax *min max*
Specifies the minimum (or earliest) and the maximum (or latest) simulation time in the report.

-nozero
Omits race conditions that occur at simulation time 0.

-uniq
Omits race conditions that also occurred earlier in the simulation. The output is the same as the contents of the `race.unique.out` file.

-f *filename*
Specifies the name of the input file. Use this option if you have changed the name of the `race.out` file.

-o *filename*
The default name of the output file is `race.out.post`. If you want a different name, specify it with this option.

You can enter more than one of these options on the `PostRace.pl` command line.

If you enter an option more than once, the script uses the last of these multiple entries.

Unless you specify a different name with the `-o` option, the report generated by the `PostRace.pl` script is in the `race.out.post` file.

The following is an example of the command line:

```
PostRace.pl -minmax 80 250 -f mydesign.race.out -o  
mydesign.race.out.post
```

In this example, the output file is named `mydesign.race.out.post`, and reports the race conditions between 80 and 250 time units. The post-process file is named `mydesign.race.out`.

Modifying the PostRace.pl Script

The first line of the `PostRace.pl` Perl script is as follows:

```
#! /usr/local/bin/perl
```

If Perl is installed at a different location at your site, you must modify the first line of this script. This script needs a perl5 interpreter. You can find this script at the following location:

```
vcs_install_dir/bin/PostRace.pl
```

Debugging Simulation Mismatches

A design can contain several race conditions where many of them behave the same in different simulations, so they are not the cause of a simulation mismatch. For a simulation mismatch, you must find critical races. Critical races are the race conditions that cause the simulation mismatch. This section describes how to do this.

Add system tasks to generate VCD files to the source code of the simulations that mismatch. Recompile them with the `-race` or `-racecd` options and run the simulations again.

When you have two VCD files, find their differences with the `vcdiff` utility. This utility is located in the `vcs_install_dir/bin` directory. The command line for `vcdiff` is as follows:

```
vcdiff vcdfile1.dmp vcdfile2.dmp -options > output_filename
```

If you enter the `vcdiff` command without arguments, you see the usage information including the options.

Method 1: If the Number of Unique Race Conditions is Small

A unique race condition is a race condition that can occur several times during simulation, but only the first occurrence is reported in the `race.unique.out` file. If the number of lines in the `race.unique.out` file are smaller than the number of unique race conditions, then for each signal in the `race.unique.out` file:

1. Look in the output file from the `vcdiff` utility. If the signal values are different, you have found a critical write-write race condition.
2. If the signal values are not different, look for the signals that are assigned the value of this signal, or assigned expressions that include this signal (read operations).
3. If the values of these other signals are different at any point in the two simulations, note the simulation times of these differences on the other signals, and post-process the `race.out` file looking for race conditions in the first signal at around the simulation times of the value differences on the other signals. Specify simulation times before and after the time of these differences with the `-minmax` option. Enter:

```
PostRace.pl -sig first_signal -minmax time time2
```

If the `race.out.post` file contains the first signal, then it is a critical race condition, and must be corrected.

Method 2: If the Number of Unique Races is Large

If there are many lines in the `race.unique.out` file and a large number of unique race conditions, then the method of finding the critical race conditions is to do the following:

1. Look in the output file from the `vcldiff` utility for the simulation time of the first difference in simulation values.
2. Post-process the `race.out` file looking for races at the time of the first simulation value difference. Specify simulation times before and after the time of these differences with the `-minmax` option. Enter:

```
PostRace.pl -minmax time time2
```

3. For each signal in the resulting `race.out.post` file:
 - If the simulation values differ in the two simulations, then the race condition in the `race.out.post` file is a critical race condition.
 - If the simulation values are not different, check the signals that are assigned the value of this signal or assigned expressions that include this signal. If the values of these other signals are different, then the race condition in the `race.out.post` file is a critical race condition.

Method 3: An Alternative When the Number of Unique Race Conditions is Large

1. Look in the output file from the `vcldiff` utility for the simulation time of the first difference in simulation values.
2. For each signal that has a difference at this simulation time:

- a. Traverse the signal dependency backwards in the design until you find a signal whose values are same in both simulations.
- b. Look for a race condition on that signal at that time. Enter:

```
PostRace.pl -sig signal -minmax time time2
```

If there is a race condition at that time on that signal, then it is a critical race condition.

The Static Race Detection Tool

It is possible for a group of statements to combine and form a loop, so that the loop is executed once by VCS and more than once by other Verilog simulators. This is a race condition.

These situations arise when level-sensitive sensitivity lists (event controls which immediately follow the `always` keyword in an `always` block, and which do not contain the `posedge` or `negedge` keywords) and procedural assignment statements in the `always` blocks combine with other statements such as continuous assignment or module instantiation statements to form a potential loop. It is observed that these situations do not occur if the `always` blocks contain delays or other timing information, non-blocking assignment statements, or PLI calls through user-defined system tasks.

You can use the `+race=all` compile-time option to start the static race detection tool.

Note:

The `+race=all` compile-time option supports only pure Verilog constructs.

After compilation, the static race detection tool writes the file named `race.out.static` which reports the race conditions.

The following example shows an `always` block that combines with other statements to form a loop:

```
35      always @( A or C ) begin
36          D = C;
37          B = A;
38      end
39
40      assign C = B;
```

The `race.out.static` file from the compilation of this source code follows:

```
Race- [CLF] Combinational loop found
    "source.v", 35: The trigger 'C' of the always block
    can cause
        the following sequence of event(s) which can again
    trigger
        the always block.
    "source.v", 37: B = A;
    which triggers 'B'.
    "source.v", 40: assign C = B;
    which triggers 'C'.
```

Optimizing Testbenches for Debugging

Testbenches typically execute debugging features, for example, displaying text in certain situations as specified with the \$monitor or \$display system tasks. Another debugging feature, which is typically enabled in testbenches, is writing simulation history files during simulation so that you can view the results after simulation. Among other things, these simulation history files record the simulation times at which the signals in your design change value. These simulation history files can be either ASCII Value-Change-Dump (VCD) files that you can input into a number of third-party viewers, or binary VPD files that you can input into DVE. The \$dumpvars system task specifies writing a VCD file and the \$vcdpluson system task specifies writing a VPD file. You can also input a VCD file to DVE, which translates the VCD file to a VPD file and then displays the results from the new VPD file. For details on using DVE, see the *Discovery Visual Environment User Guide*.

Debugging features significantly slow down the simulation performance of any logic simulator including VCS. This is particularly true for operations that make VCS display text on the screen and even more so for operations that make VCS write information to a file. For this reason, you'll want to be selective about where in your design and where in the development cycle of your design you enable debugging features. The following sections describe a number of techniques that you can use to choose when debugging features are enabled.

Conditional Compilation

Use `ifdef, `else, and `endif compiler directives in your testbench to specify which system tasks you want to compile for debugging features. Then, when you compile the design with the +define compile-time option on the command line (or when the `define compiler directive appears in the source code), VCS will compile these tasks for debugging features. For example:

```
initial
begin
`ifdef postprocess
$vcpluspluson(0,design_1);
$vcplusplustraceon(design_1);
$vcplusplusdeltacycleon;
$vcplusplusglitchon;
`endif
end
```

In this case, the vcs command is as follows:

```
% vcs testbench.v design.v +define+postprocess
```

The system tasks in this initial block record several types of information in a VPD file. You can use the VPD file with DVE to post-process the design. In this particular case, the information is for all the signals in the design, so the performance cost is extensive. You would only want to do this early in the development cycle of the design when finding bugs is more important than simulation speed.

The command line includes the +define+postprocess compile-time option, which tells VCS to compile the design with these system tasks compiled into the testbench.

Later in the development cycle of the design, you can compile the design without the `+define+postprocess` compile-time option and VCS will not compile these system tasks into the testbench. Doing so enables VCS to simulate your design much faster.

Advantages and Disadvantages

The advantage of this technique is that simulation can run faster than if you enable debugging features at runtime. When you use conditional compilation, VCS has all the information it needs at compile-time.

The disadvantage of this technique is that you have to recompile the testbench to include these system tasks in the testbench, thus increasing the overall compilation time in the development cycle of your design.

Synopsys recommends that you consider this technique as a way to prevent these system tasks from inadvertently remaining compiled into the testbench, later in the development cycle, when you want faster performance.

Enabling Debugging Features At Runtime

Use the `$test$plusargs` system function in place of the `'ifdef` compiler directives. The `$test$plusargs` system function checks for a plusarg runtime option on the `simv` command line.

Note:

A plusarg option is an option that has a plus (+) symbol as a prefix.

An example of the `$test$plusargs` system function is as follows:

```
initial
```

```

if ($test$plusargs("postprocess"))
begin
$vcddpluson(0,design_1);
$vcddplustraceon(design_1);
$vcddplusdeltacycleon;
$vcddplusglitchon;
end

```

In this technique you do not include the `+define` compile-time argument on the `vcs` command line. Instead you compile the system tasks into the testbench and then enable the execution of the system tasks with the runtime argument to the `$test$plusargs` system function. Therefore, in this example, the `simv` command line is as follows:

```
% simv +postprocess
```

During simulation VCS writes the VPD file with all the information specified by these system tasks. Later you can execute another `simv` command line, without the `+postprocess` runtime option. As a result, VCS does not write the VPD file, and therefore runs faster.

There is a pitfall to this technique. This system function will match any plusarg that has the function's argument as a prefix. For example:

```

module top;
initial
begin
if ( $test$plusargs("a" ) )
    $display("\n<<< Now a >>>\n");
else if ( $test$plusargs("ab" ) )
    $display("\n<<< Now ab >>>\n");
else if ( $test$plusargs("abc" ) )
    $display("\n<<< Now abc >>>\n");
end
endmodule

```

No matter whether you enter the +a, +ab, or +abc plusarg, when you simulate the executable, VCS always displays the following:

```
<<< Now a >>>
```

To avoid this pitfall, enter the longest plusarg first. For example, you would revise the previous example as follows:

```
module top;
initial
begin
if ( $test$plusargs("abc") )
    $display("\n<<< Now abc >>>\n");
else if ( $test$plusargs("ab") )
    $display("\n<<< Now ab >>>\n");
else if ( $test$plusargs("a") )
    $display("\n<<< Now a >>>\n");
end
endmodule
```

Advantages and Disadvantages

The advantage to using this technique is that you do not have to recompile the testbench in order to stop VCS from writing the VPD file. This technique is something to consider using, particularly early in the development cycle of your design, when you are fixing a lot of bugs and already doing a lot of recompilation.

The disadvantages to this technique are considerable. Compiling these system tasks, or any system tasks that write to a file, into the testbench requires VCS to compile the `simv` executable so that it is possible for it to write the VPD file when the runtime option is included on the command line. This means that the simulation runs significantly slower than if you don't compile these system tasks into the testbench. This impact on performance remains even when you don't include the runtime option on the `simv` command line.

Using the `$test$plusargs` system function forces VCS to consider the worst case scenario — plusargs will be used at runtime — and VCS generates the `simv` executable with the corresponding overhead to prepare for these plusargs. The more fixed information VCS has at compile-time, the more VCS can optimize `simv` for efficient simulation. Alternatively, the more user control at runtime, the more overhead VCS has to add to `simv` to accept runtime options, and the less efficient the simulation.

For this reason Synopsys recommends that if you use this technique, you should plan to abandon it fairly early in the development cycle and switch to either the conditional compilation technique for writing simulation history files, or a combination of the two techniques.

Combining the Techniques

Some users find that they have the greatest amount of control over the advantages and disadvantages of these techniques when they combine them. Consider the following example:

```
`ifdef comppostprocess
initial
  if ($test$plusargs("runpostprocess"))
    begin
      $vcddpluson(0,design_1);
      $vcddplustraceon(design_1);
      $vcsplusdeltacycleon;
      $vcddplusglitchon;
    end
`endif
```

In this instance, both the `+define+comppostprocess` compile-time option and the `+runpostprocess` runtime option are required for VCS to write the VPD file. This technique allows you to avoid

recompiling just to prevent VCS from writing the file during the next simulation and also provides you with a way to recompile the testbench, later in the development cycle, to exclude these system tasks without first editing the source code for the testbench.

Avoiding the Debugging Problems From Port Coercion

The first Verilog simulator had a port collapsing algorithm that removed ports so it could simulate faster. In this simulator, you could still refer to a collapsed port, but inside the simulator, the port did not exist.

VCS mimics port collapsing so that an old, but reusable design, now simulated with VCS, will have the same simulation results. For this reason the default behavior of VCS is to “coerce” all ports to inout ports.

This port coercion can, for example, result in a value propagating up the design hierarchy out of a port you declared to be an input port and unexpectedly driving the signal connected to this input port. Port coercion, therefore, can cause debugging problems.

Port coercion also results in slower simulation, because with port coercion VCS must be prepared for bidirectional behavior of input and output ports as well as inout ports.

To avoid these debugging problems, and to increase simulation performance, do the following when writing new models:

1. If you need values to propagate in and out of a port, declare it as an inout port. If you don’t need this bidirectional behavior, declare it as an input or output port.

2. Compile the modules with these ports under the `noportcoerce compiler directive.
-

Creating Models That Simulate Faster

When modeling your design, for faster simulation use higher levels of abstraction. Behavioral and RTL models simulate much faster than gate and switch level models. This rule of thumb is not unique to VCS; it applies to all Verilog simulators and even all logic simulators in general.

What is unique to VCS are the acceleration algorithms that make behavioral and RTL models simulate even faster. In fact, VCS is particularly optimized for RTL models for which simulation performance is critical.

These acceleration algorithms work better for some designs than for others. Certain types of designs prevent VCS from applying some of these algorithms. This section describes the design styles that simulate faster or slower.

The acceleration algorithms apply to most data types and primitives and most types of statements but not all of them. This section also describes the data types, primitives, and types of statements that you should try to avoid.

VCS is optimized for simulating sequential devices. Under certain circumstances VCS infers that an `always` block is a sequential device and simulates the `always` block much faster. This section describes the coding guidelines you should follow to make VCS infer an `always` block as a sequential device.

When writing an `always` block, if you cannot follow the inferencing rules for a sequential device there are still things that you should keep in mind so that VCS simulates the `always` block faster. This section also describes the guidelines for coding faster simulating `always` blocks that VCS infers to be combinatorial instead of sequential devices.

Unaccelerated Data Types, Primitives, and Statements

VCS cannot accelerate certain data types and primitives. VCS also cannot accelerate certain types of statements. This section describes the data types, primitives, and types of statements that you should try to avoid.

Avoid Unaccelerated Data Types

VCS cannot accelerate certain data types. The following table lists these data types:

Data Type	Description in IEEE Std 1364-2001
time and realtime	Page 22
real	Page 22
named event	Page 138
trireg net	Page 26
integer array	Page 22

Avoid Unaccelerated Primitives

VCS cannot accelerate `tranif1`, `tranif0`, `rtranif1`, `rtranif0`, `tran`, and `rtran` switches. They are defined in IEEE Std 1364-2001 page 86.

Avoid Calls to User-defined Tasks or Functions Declared in Another Module

VCS cannot accelerate user-defined tasks or functions declared in another module. For example:

```
module bottom (x,y);  
.  
.  
.  
always @ y  
top.task_identifier(y,rb);  
endmodule
```

Avoid Strength Specifications in Continuous Assignment Statements

Omit strength specifications in continuous assignment statements. For example:

```
assign net1 = flag1;
```

Simulates faster than:

```
assign (strong1, pullo) net1= flag1;
```

Continuous assignment statements are described on IEEE 1364-2001 pages 69-70.

Inferring Faster Simulating Sequential Devices

VCS is optimized to simulate sequential devices. If VCS can infer that an always block behaves like a sequential device, VCS can simulate the always block much faster.

The IEEE Std 1364-2001 defines `always` constructs on page 149. Verilog users commonly use the term `always` block when referring to an `always` construct.

VCS can infer whether an `always` block is a combinatorial or sequential device. This section describes the basis on which VCS makes this inference.

Avoid Unaccelerated Statements

VCS does not infer an `always` block to be a sequential device if it contains any of the following statements:

Statement	Description in IEEE Std 1364-2001
<code>force</code> and <code>release</code> procedural statements	Page 126-127
<code>repeat</code> statements	Page 134-135, see the other looping statements on these pages and consider them as an alternative.
<code>wait</code> statements, also called level-sensitive event controls	Page 141
<code>disable</code> statements	Page 162-164
<code>fork-join</code> block statements, also called parallel blocks	Page 146-147

Using either blocking or nonblocking procedural assignment statements in the `always` block does not prevent VCS from inferring a sequential device, but in VCS blocking procedural assignment statements are more efficient.

Synopsys recommends zero delay nonblocking assignment statements to avoid race conditions.

IEEE Std 1364-2001 describes blocking and nonblocking procedural assignment statements on pages 119-124.

Place Task Enabling Statements in Their Own always Block and Use No Delays

IEEE Std 1364-2001 defines tasks and task enabling statements on pages 151-156.

VCS infers that an `always` block that contains a task enabling statement is a sequential device only when there are no delays in the task declaration.

All Sequential Controls Must Be in the Sensitivity List

To borrow a concept from VHDL, the sensitivity list for an `always` block is the event control that immediately follows the `always` keyword.

IEEE Std 1364-2001 defines event controls on page 138 and mentions sensitivity lists on page 139.

For correct inference, all sequential controls must be in the sensitivity list. The following code examples illustrate this rule:

- VCS does not infer the following DFF to be a sequential device:

```
always @ (d)
  @ (posedge clk) q <=d;
```

Even though `clk` is in an event control, it is not in the sensitivity list event control.

- VCS does not infer the following latch to be a sequential device:

```
always begin
  wait clk; q <= d; @ d;
```

```
end
```

There is no sensitivity list event control.

- VCS infers the following latch to be a sequential device:

```
always @ (clk or d)
  if (clk) q <= d;
```

The sequential controls, `clk` and `d`, are in the sensitivity list event control.

Avoid Level-sensitive Sensitivity Lists Whose Signals are Used “Completely”

VCS infers a combinational device instead of a sequential device if the following conditions are both met:

- The sensitivity list event control is level sensitive

A level sensitive event control does not contain the `posedge` or `negedge` keywords.

- The signals in the sensitivity list event control are used “completely” in the `always` block

Used “completely” means that there is a possible simulation event if the signal has a true or a false (`1` or `0`) value.

The following code examples illustrate this rule:

Example 1

VCS infers that the following `always` block is combinatorial, not sequential:

```
always @ (a or b)
  y = a or b
```

Here the sensitivity list event control is level sensitive and VCS assigns a value to `y` whether `a` or `b` are true or false.

Example 2

VCS also infers that the following `always` block is combinatorial, not sequential:

```
always @ (sel or a or b)
  if (sel)
    y=a;
  else
    y=b;
```

Here the sensitivity list event control is also level sensitive and VCS assigns a value to `y` whether `a`, `b`, or `sel` are true or false. Note that the `if-else` conditional statement uses signal `sel` completely, VCS executes an assignment statement whether `sel` is true or false.

Example 3

VCS infers that the following `always` block is sequential:

```
always @ (sel or a or b)
  if (sel)
    y=a;
```

In this instance, there is no simulation event when signal `sel` is false (0).

Modeling Faster `always` Blocks

Whether VCS infers an `always` block to be a sequential device or not, there are modeling techniques you should use for faster simulation.

Place All Signals Being Read in the Sensitivity List

The sensitivity list for an `always` block is the event control that immediately follows the `always` keyword. Place all nets and registers, whose values you are assigning to other registers, in the `always` block, and place all nets and registers, whose value changes trigger simulation events, in the sensitivity list control.

Use Blocking Procedural Assignment Statements

In VCS, blocking procedural assignment statements are more efficient.

Synopsys recommends zero delay nonblocking procedural assignment statements to avoid race conditions.

IEEE Std 1364-2001 describes blocking and nonblocking procedural assignment statements on pages 119-124.

Avoid force and release Procedural Statements

IEEE Std 1364-2001 defines these statements on pages 126-127. A few occurrences of these statements in combinatorial `always` blocks does not noticeably slow down simulation but their frequent use does lead to a performance cost.

Using Verilog 2001 Constructs

In G-2012.09 and newer releases, Verilog 2001 or V2K source code conforms to the Verilog IEEE Std 1364-2001 instead of the Verilog IEEE Std 1364-1995.

If your Verilog code contains a V2K keyword as an identifier, you can tell VCS not to recognize V2K keywords with the `-v95` compile time option, for example:

```
module cell (..., ...);
```

The module identifier `cell` is a keyword in Verilog 2001, so to use it as an identifier, include the `-v95` compile-time option.

The following table lists the implemented constructs in Std 1364-2001 and whether you need a compile-time option to use them.

Std 1364-2001 Construct	Default
comma separated event control expressions: <code>always @ (r1, r2, r3)</code>	yes
name-based parameter passing: <code>modname #(.param_name (value)) inst_name (sig1, ...);</code>	yes
ANSI-style port and argument lists: <code>module dev (output reg [7:0] out1, input wire [7:0] w1);</code>	yes
initialize a reg in its declaration: <code>reg [15:0] r2 = 0;</code>	yes
conditional compiler directives: <code>'ifndef</code> and <code>'elseif</code>	yes
disabling the default net data type: <code>'default_nettype</code>	yes
signed arithmetic extensions: <code>reg signed [7:0] r1;</code>	yes
file I/O system tasks: <code>\$fopen</code> <code>\$fsanf</code> <code>\$scanf</code> and more	yes
passing values from the runtime command line: <code>\$value\$plusarg</code> system function	yes
indexed part-selects: <code>reg1[8+:5]=5'b11111;</code>	yes
multi-dimensional arrays: <code>reg [7:0] r1 [3:0] [3:0];</code>	yes
maintaining file name and line number: <code>'line</code>	yes

Std 1364-2001 Construct	Default
implicit event control expression lists: always @*	yes
the power operator: r1=r2**r3;	yes
attributes: (* optimize_power=1 *)	yes
module dev (res,out,clk,data1,data2);	
generate statements	yes
localparam declarations	yes
Automatic tasks and functions task automatic t1();	requires the -sverilog compile-time option
constant functions	yes
localparam lp1 = const_func(p1);	
parameters with a bit range parameter bit [7:0] [31:0] P = {32'd1,32'd2,32'd3,32'd4,32'd5,32'd6,32'd7,32'd8};	requires the -sverilog compile-time option

Case Statement Behavior

The IEEE Std 1364-2001 standards for the Verilog language state that you can enter the question mark character (?) in place of the z character in casex and casez statements. The standard does not specify that you can also make this substitution in case statements and you might infer that this substitution is not allowed in case statements.

VCS, like other Verilog simulators, does not make this inference, and allows you to also substitute ? for z in case statements. If you do, remember that z does not stand for "don't care" in a case statement, like it does in a casez or casex statement. In a case statement z stands for the usual high impedance and therefore so does ?.

Precedence in Text Macro Definitions

In text macros, the line continuation character (\) has a higher precedence than the one line comment characters (//). This means that VCS can merge a subsequent line with the text in a one line comment, for example:

```
`define print_me_1 \
$display( "Hello 1" ); // just a comment \
$display( "I'm OK" );
```

VCS merges the second \$display system task with the comment on the previous line and does not display the text string I 'm OK.

Memory Size Limits in the Simulator

The bit width for a word or an element in a memory in VCS must be less than 0x100000 (or 2^{20} or 1,048,576) bits.

The number of elements or words (sometimes also called rows) in a memory in VCS must be less than 0x3FF_FFFE-1 (or $2^{30} - 2$ or 1,073,741,822) elements or words.

The total bit count of a memory (total number of elements * word size) must be less than $8 * (1024 * 1024 * 1024 - 2)$ or 8589934576.

Using Sparse Memory Models

If your design contains a large memory, the `simv` executable will need large amounts of machine memory to simulate it. However, if `/*sparse*/` is specified, the large memory will not occupy the IP space, so the above 2G-1 size limit (See “[Memory Size Limits in the Simulator](#)”) does not exist. The maximum memory size depends on address space size. If `/*sparse*/` is not specified, both full 64-bit and 32-bit VCS will have the same limitation (2G-1 size limit), because even with full 64-bit, VCS still uses 32-bit IP index in back-end and runtime. So, if the memory size exceeds 2G, simulation will have errors.

You use the `/*sparse*/` pragma or metacomment in the memory declaration to specify a sparse memory model. For example:

```
reg /*sparse*/ [31:0] pattern [0:10_000_000];
integer i, j;
initial
begin
    for (j=1; j<10_000; j=j+1)
        for (i=0; i<10_000_000; i=i+1_000)
            pattern[i] = i+j;
end
endmodule
```

In simulations, this memory model uses 4 MB of machine memory with the `/*sparse*/` pragma, 81 MB without it. There is a small runtime performance cost to sparse memory models: the simulation of the memory with the `/*sparse*/` pragma took 64 seconds, 56 seconds without it.

The larger the memory, and the fewer elements in the memory that your design reads or writes to, the more machine memory you will save by using this feature. It is intended for memories that contain at least a few MBs. If your design accesses 1% of its elements you could save 97% of machine memory. If your design accesses 50% of its elements, you save 25% of machine memory. Do not use this feature if your design accesses more than 50% of its elements because using the feature in these cases may lead to more memory consumption than not using it.

Note:

- Sparse memory models cannot be manipulated by PLI applications through `tf` calls (the `tf_nodeinfo` routine issues a warning for sparse memory and returns NULL for the memory handle).
- Sparse memory models cannot be used as a personality matrix in PLA system tasks.

Obtaining Scope Information

VCS has custom format specifications (IEEE Std 1364-2001 does not define these) for displaying scope information. It also has system functions for returning information about the current scope.

Scope Format Specifications

The IEEE Std 1364-2001 describes the `%m` format specification for system tasks for displaying information such as `$write` and `$display`. The `%m` specification tells VCS to display the hierarchical

name of the module instance that contains the system task. If the system task is in a scope lower than a module instance, it tells VCS to do the following:

- In named begin-end or fork-join blocks, it adds the block name to the hierarchical name.
- In user-defined tasks or functions, it considers the hierarchical name of the task declaration or function definition as the hierarchical name of the module instance.

VCS has the following additional format specifications for displaying scope information:

`%i`

Specifies the same as `%m` with the following difference: when in a user-defined task or function, the hierarchical name is the hierarchical name of the instance or named block containing the task enabling statement or function call, not the hierarchical name of the task or function declaration.

If the task enabling statement is in another user-defined task, the hierarchical name is the hierarchical name of the instance or named block containing the task enabling statement for this other user-defined task.

If the function call is in another user-defined function, the hierarchical name is the hierarchical name of the instance or named block containing the function call for this other user-defined function.

If the function call is in a user-defined task, the hierarchical name is the hierarchical name of the instance or named block containing the task enabling statement for this user-defined task.

`%-i`

Specifies that the hierarchical name is always of a module instance, not a named block or user-defined task or function. If the system task (such as `$write` and `$display`) is in:

- A named block — the hierarchical name is that of the module instance that contains the named block
- A user-defined task or function — the hierarchical name is that of the module instance containing the task enabling statement or function call

Note:

The `%i` and `%-i` format specifications are not supported with the `$monitor` system task.

The following commented code example shows what these format specifications do:

```
module top;
reg r1;

task my_task;
input taskin;
begin
$display("%m");           // displays "top.my_task"
$display("%i");           // displays "top.d1.named"
$display("%-i");          // displays "top.d1"
end
endtask

function my_func;
input taskin;
begin
$display("%m");           // displays "top.my_func"
$display("%i");           // displays "top.d1.named"
$display("%-i");          // displays "top.d1"
end
```

```

endfunction

dev1 d1 (r1);
endmodule

module dev1(inport);
input inport;

initial
begin:named
reg namedreg;
$display("%m"); // displays "top.d1.named"
$display("%i"); // displays "top.d1.named"
$display("%-i"); // displays "top.d1"
namedreg=1;
top.my_task(namedreg);
namedreg = top.my_func(namedreg);
end

endmodule

```

Returning Information About the Scope

The `$activeinst` system function returns information about the module instance that contains this system function. The `$activescope` system function returns information about the scope that contains the system function. This scope can be a module instance, a named block, a user-defined task, or a function in a module instance.

When VCS executes these system functions, it performs the following:

1. Stores the current scope in a temporary location.

2. If there are no arguments, it returns a pointer to the temporary location. Pointers are not used in Verilog but they are in DirectC applications.

The possible arguments are hierarchical names. If there are arguments, it compares them from left to right with the current scope. If an argument matches, the system function returns a 32-bit non-zero value. If none of the arguments match the current scope, the system function returns a 32-bit zero value.

The following example contains these system functions:

```
module top;
reg r1;
initial
r1=1;
dev1 d1(r1);
endmodule

module dev1(in);
input in;
always @ (posedge in)
begin:named
if ($activeinst("top.d0","top.d1"))
$display("%i");
if ($activescope("top.d0.block","top.d1.named"))
$display("%-i");
end
endmodule
```

The following is an example of a DirectC application that uses the \$activeinst system function:

```
extern void showInst(input bit[31:0]);  
  
module discriminator;  
task t;  
reg[31:0] r;  
begin  
    showInst($activeinst);  
    if($activeinst("top.c1", "top.c3"))  
    begin  
        r = $activeinst;  
        $display("for instance %i the pointer is %s", r ? "non-zero" : "zero");  
    end  
end  
endtask  
  
module child;  
initial discriminator.t;  
endmodule  
  
module top;  
child c1();  
child c2();  
child c3();  
child c4();  
endmodule
```

declaration of C function named showInst

\$activeinst system function without arguments passed to the C function

In task t, the following occurs:

1. The \$activeinst system function returns a pointer to the current scope, which is passed to the C function showInst. It is a pointer to a volatile or temporary char buffer containing the name of the instance.
2. A nested begin block executes only if the current scope is either top.c1 or top.c3.
3. VCS displays whether \$activeinst points to a zero or non-zero value.

The C code is as follows:

```
#include <stdio.h>

void showInst(unsigned str_arg)
{
    const char *str = (const char *)str_arg;
    printf("DirectC: [%s]\n", str);
}
```

Function `showInst` declares the `char` pointer `str` and assigns to it the value of its parameter, which is the pointer in `$activeinst` in the Verilog code. Then with a `printf` statement, it displays the hierarchical name that `str` is pointing to. Notice that the function begins the information it displays with `DirectC:` so that you can differentiate it from what VCS displays.

During simulation VCS and the C function display the following:

```
DirectC: [top.c1]
for instance top.c1 the pointer is non-zero
DirectC: [top.c2]
DirectC: [top.c3]
for instance top.c3 the pointer is non-zero
DirectC: [top.c4]
```

Avoiding Circular Dependency

The `$random` system function has an optional seed argument. You can use this argument to make the return value of this system function the assigned value in a continuous assignment, procedural continuous assignment, or force statement. For example:

```
assign out = $random(in);
```

```
initial
begin
  assign dr1 = $random(in);
  force dr2 = $random(in);
```

When you do this, you might set up a circular dependency between the seed value and the statement, resulting in an infinite loop and a simulation failure.

This circular dependency doesn't usually occur, but it can occur, so VCS displays a warning message when you use a seeded argument with these kinds of statements. This warning message is as follows:

```
Warning-[RWSI] $random() with a 'seed' input
$random in the following statement was called with a 'seed' input
This may cause an infinite loop and an eventual crash at runtime.
"exp1.v", 24: assign dr1 = $random(in);
```

The warning message ends with the source file name and line number of the statement, followed by the statement itself.

This possible circular dependency does not occur either when you use a seed argument and the return value is the assigned value in a procedural assignment statement, or when you do not use the seed argument in a continuous, procedural continuous, or `force` statement.

For example:

```
assign out = $random();

initial
begin
  assign dr1 = $random();
  force dr2 = $random();
  dr3 = $random(in);
```

These statements do not generate the warning message.

You can tell VCS not to display the warning message by using the `+warn=noRWSI` compile-time argument and option.

Designing With `$lsi_dumpports` for Simulation and Test

This section is intended to provide guidance when using `$lsi_dumpports` with Automatic Test Pattern Generation (ATPG) tools. Occasionally, ATPG tools strictly follow port direction and do not allow unidirectional ports to be driven from within the device. If you are not careful while writing the test fixture, the results of `$lsi_dumpports` causes problems for ATPG tools.

Note:

See “[Signal Value/Strength Codes](#)”. These are based on the TSSI Standard Events Format State Character set.

Dealing With Unassigned Nets

Consider the following example:

```
module test(A) ;
  input A;
  wire A;
  DUT DUT_1 (A);
  // assign A = 1'bz;
  initial
    $lsi_dumpports(DUT_1, "dump.out");
  endmodule

  module DUT(A) ;
    input A;
    wire A;
```

```

child child_1(A);
endmodule

module child(A);
input A;
wire Z,A,B;
and (Z,A,B);
endmodule

```

In this case, the top-level wire A is undriven at the top level. It is an input which goes to an input in DUT_1, then to an input in CHILD_1 and finally to an input of an AND gate in CHILD_1. When \$lsi_dumpports evaluates the drivers on port A of test.DUT_1, it finds no drivers on either side of port A of DUT_1, and therefore gives a code of F, tristate (input and output unconnected).

The designer actually meant for a code of Z to be returned, input tristated. To achieve this code, the input A needs to be assigned a value of z. This is achieved by removing the comment from the line, // assign A = 1'bz;, in the above code. Now, when the code is executed, VCS is able to identify that the wire A going into DUT_1 is being driven to a z. With the wire driven from the outside and not the inside, \$lsi_dumpports returns a code of Z.

Code Values at Time 0

Another issue can occur at time 0, before values have been assigned to ports as you intended. As a result, \$lsi_dumpports makes an evaluation for drivers when all of the users intended assignments haven't been made. To correct this situation, you need to advance simulation time just enough to have your assignments take place. This can be accomplished by adding a #1 before \$lsi_dumpports as follows:

```
initial
begin
#1 $lsi_dumpports(instance, "dump.out");
end
```

Cross Module Forces and No Instance Instantiation

In the following example there are two problems.

```
module test;
initial
begin
force top.u1.a = 1'b0;
$lsi_dumpports(top.u1, "dump.out");
end
endmodule

module top;
middle u1 (a);
endmodule

module middle(a);
input a;
wire b;
buf(b,a);
endmodule
```

First, there is no instance name specified for `$lsi_dumpports`. The syntax for `$lsi_dumpports` calls for an instance name. Since the user didn't instantiate module `top` in the test fixture, they are left specifying the MODULE name `top`. This will produce a warning message from VCS. Since `top` appears only once, that instance will be assumed.

The second problem comes from the cross-module reference (XMR) that the `force` command uses. Since the module `test` doesn't instantiate `top`, the example uses an XMR to force the desired

signal. The signal being forced is port `a` in instance `u1`. The problem here is that this force is done on the port from within the instance `u1`. The user expects this port `a` of `u1` to be an input, but when `$lsi_dumpports` evaluates the ports for the drivers, it finds that port `a` of instance `u1` is being driven from inside and therefore returns a code of `L`.

To correct these two problems, you need to instantiate `top` inside `test`, and drive the signal `a` from within `test`. This is done in the following way:

```
module test;
  wire a;
  initial
    begin
      force a = 1'b0;
      $lsi_dumpports(test.u0.u1, "dump.out2");
    end
    top u0 (a);
  endmodule

  module top(a);
    input a;
    middle u1 (a);
  endmodule

  module middle(a);
    input a;
    wire b;
    buf(b,a);
  endmodule
```

By using the method in this example, the port `a` of instance `u1` is driven from the outside, and when `$lsi_dumpports` checks for the drivers it reports a code of `D` as desired.

Signal Value/Strength Codes

The enhanced state character set is based on the TSSI Standard Events Format State Character set with additional expansion to include more unknown states. The supported character set is as follows:

Testbench Level (only z drivers from the DUT)

D	low
U	high
N	unknown
Z	tristate
d	low (2 or more test fixture drivers active)
u	high (2 or more test fixture drivers active)

DUT Level (only z drivers from the testbench)

L	low
H	high
X	unknown (don't care)
T	tristate
I	low (2 or more DUT drivers active)

Testbench Level (only z drivers from the DUT)

h	high (2 or more DUT drivers active)
---	-------------------------------------

Drivers Active on Both Levels

0	low (both input and output are active with 0 values)
1	high (both input and output are active with 1 values)
?	unknown
F	tristate (input and output unconnected)
A	unknown (input 0 and output unconnected)
a	unknown (input 0 and output X)
B	unknown (input 1 and output 0)
b	unknown (input 1 and output X)
C	unknown (input X and output 0)

c	unknown (input X and output 1)
f	unknown (input and output tristate)

3

Compiling the Design

This chapter describes the following sections:

- “Compiling or Elaborating the Design in Debug Mode”
- “Compiling or Elaborating the Design in Optimized Mode”
- “Key Compilation Features”

Compiling or Elaborating the Design in Debug Mode

Debug mode, also called interactive mode, is typically used (but not limited to):

- During your initial phase of the design, when you need to debug the design using debug tools like DVE, or UCLI.
- If you are using PLIs.

- If you use the UCLI commands to force a signal, to write into a registers/nets

VCS has the following compile-time options for debug mode:

-debug_pp, -debug, and -debug_all

The following examples show how to compile the design in full and partial debug modes.

Compiling the design in partial debug mode

```
% vcs -debug [compile_options] TOP.v
```

Compiling the design in full debug mode

```
% vcs -debug_all [compile_options] TOP.v
```

For information on DVE or UCLI, see the DVE User Guide and UCLI User Guide respectively.

Compiling or Elaborating the Design in Optimized Mode

Optimized mode is used when your design is fully-verified for design correctness, and is ready for regressions. VCS runtime performance is best in this mode when VCS optimizes a design.

For more information on performance, refer to the chapter entitled, [Chapter 8, "Performance Tuning"](#).

Note:

The runtime performance reduces if you use the -debug or -debug_all options. Use these options only when you require runtime debug capabilities.

Key Compilation Features

This section describes the following features in detail with a usage model and an example:

- “[Initializing Verilog Memories and Registers](#)”
- “[Overriding Parameters](#)”
- “[Checking for X and Z Values In Conditional Expressions](#)”
- “[VCS V2K Configurations and Libmaps](#)”
- “[Evaluating the Active Events When Limiting the Exposure of Race Conditions](#)”
- “[Lint Warning Message for Missing ‘endcelldefine’](#)”
- “[Error/Warning Message Control](#)”

Initializing Verilog Memories and Registers

You can use the following option to initialize all bits of your Verilog memories and registers:

`+vcs+initreg+random`

Initializes all state variables (`reg` data type), registers defined in sequential UDPs, and memories including MDAs (`reg` data type) in the design, to random logic 0 or 1, at time zero.

For more information on `+vcs+initreg+random` option, see [“Options for Initializing Memories and Registers with Random Values”](#).

Note:

This option allows you to initialize to specific value (0 or 1) or random value with specific seed at runtime. For more information on using this option at runtime, see “[Options for Initializing Memories and Registers with Random Values at Runtime](#)”.

Note:

`+vcs+initreg` options work only for the Verilog portion of the design.

The `+vcs+initreg` option initializes regular memories and multi-dimensional arrays of the `reg` data type also. For example:

```
reg [7:0] mem [7:0] [15:0];
```

The `+vcs+initreg` option does not initialize registers (variables) and multi-dimensional arrays of any other data type.

To prevent race conditions, avoid the following when you use these options:

- Assigning initial values to a `reg` in their declaration when the value you assign is not the same as the value specified with the `+vcs+initreg` option.

For example:

```
reg [7:0] r1=8'b01010101;
```

- Assigning values to regs or memory elements at simulation time 0 when the value you assign is not the same as the value specified with the `+vcs+initreg` option.

For example:

```
initial  
begin  
mem[1] [1]=8'b00000001;
```

Use Model

Compilation

```
% vcs +vcs+initreg+random [other_vcs_options] file1.v  
file2.v file3.v
```

Simulation

```
% simv +vcs+initreg+0|1|random|<seed> [simv_options]
```

For information on the `+vcs+initreg+0|1|random|<seed>` option, see [+vcs+initreg+random](#) and “[Options for Initializing Memories and Registers with Random Values at Runtime](#)” .

The `+vcs+initreg` feature helps in reducing the amount of time spent on initialization related issues in gate level simulations. At time 0, all (un-initialized) reg data types get the default value of X which is an undeterministic and unknown state of the design. This X can propagate during the simulation and can cause unexpected behavior in gate level simulations. You can use the `+vcs+initreg` feature to initialize all bits of Verilog memories and variables in the design.

Note:

This feature is targeted to initialize variable data types in gate level simulations (includes UDP variables). As such, initialization of variables in RTL constructs such as named blocks, structures, or in user-defined tasks/ or unctions is not supported.

Overriding Parameters

There are two compile-time options for changing parameter values from the vcs command line:

- -pvalue
- -parameters

You specify a parameter with the -pvalue option. It has the following syntax:

```
vcs -pvalue+hierarchical_name_of_parameter=value
```

For example:

```
vcs source.v -pvalue+test.d1.param1=33
```

You specify a file with the -parameters option. The file contains command lines for changing values. A line in the file has the following syntax:

```
assign value path_to_the_parameter
```

Here:

assign

 Keyword that starts a line in the file.

value

 New value of the parameter.

path_to_the_parameter

Hierarchical path to the parameter. This entry is similar to a Verilog hierarchical name except that you use forward slash characters (/), instead of periods, as the delimiters.

The following is an example of the contents of this file:

```
assign 33 test/d1/param1  
assign 27 test/d1/param2
```

Note:

The -parameters and -pvalue options do not work with a localparam or a specparam.

Checking for X and Z Values In Conditional Expressions

The -xzcheck compile-time option tells VCS to display a warning message when it evaluates a conditional expression and finds it to have an X or Z value.

A conditional expression is of the following types or statements:

- A conditional or if statement:

```
if (conditional_exp)  
    $display ("conditional_exp is true");
```

- A case statement:

```
case (conditional_exp)  
    1'b1: sig2=1;  
    1'b0: sig3=1;  
    1'bx: sig4=1;  
    1'bz: sig5=1;  
endcase
```

- A statement using the conditional operator:

```
reg1 = conditional_exp ? 1'b1 : 1'b0;
```

The following is an example of the warning message that VCS displays when it evaluates the conditional expression and finds it to have an X or Z value:

```
warning 'signal_name' within scope hier_name in file_name.v:  
line_number to x/z at time simulation_time
```

VCS displays this warning every time it evaluates the conditional expression to have an X or Z value, not just when the signal or signals in the expression transition to an X or Z value.

VCS does not display a warning message when a sub-expression has the value X or Z, but the conditional expression evaluates to a 1 or 0 value. For example:

```
r1 = 1'bz;  
r2 = 1'b1;  
if ( (r1 && r2) || 1'b1)  
    r3 = 1;
```

In this example, the conditional expression always evaluates to a value of 1. Therefore, VCS does not display a warning message.

Enabling the Checking

The `-xzcheck` compile-time option globally checks all the conditional expressions in the design and displays a warning message every time it evaluates a conditional expression to have an X or Z value. You can suppress or enable these warning messages on selected modules using `$xzcheckoff` and `$xzcheckon` system tasks. For more details on `$xzcheckoff` and `$xzcheckon` system tasks, see “[Checking for X and Z Values in Conditional Expressions](#)” on page 42.

The `-xzcheck` compile-time option has an optional argument to suppress the warning for glitches evaluating to `X` or `Z` value. Synopsys calls these glitches as false negatives. See “[Filtering Out False Negatives](#)” on page 9.

Filtering Out False Negatives

By default, if a signal in a conditional expression transitions to an `X` or `Z` value and then to 0 or 1 in the same simulation time step, VCS displays the warning.

Example 1

In this example, VCS displays the warning message when reg `r1` transitions from 0 to `X` to 1 during simulation time 1.

Example 3-1 False Negative Example

```
module test;
reg r1;

initial
begin
r1=1'b0;
#1 r1=1'bx;

#0 r1=1'b1;
end

always @ (r1)
begin
if (r1)
$display("\n r1 true at %0t\n",$time);
else
$display("\n r1 false at %0t\n",$time);
end
endmodule
```

Example 2

In this example, VCS displays the warning message when reg `r1` transitions from 1 to X during simulation time 1.

Example 3-2 False Negative Example

```
module test;
reg r1;

initial
begin
r1=1'b0;
#1 r1<=1'b1;
r1=1'bx;
end
always @ (r1)
begin
if (r1)
    $display("\n r1 true at %0t\n", $time);
else
    $display("\n r1 false at %0t\n", $time);
end

endmodule
```

If you consider these warning messages to be false negatives, use the `nofalseneg` argument to the `-xzcheck` option to suppress the messages.

For example:

```
% vcs -xzchecknofalseneg example.v
```

If you compile and simulate `example1` or `example2` with the `-xzcheck rcompilation` option, but without the `nofalseneg` argument, VCS displays the following warning about signal `r1` transitioning to an X or Z value:

```
r1 false at 0
Warning: 'r1' within scope test in source.v: 13 goes to x/
z at time 1

r1 false at 1

r1 true at 1
```

If you compile and simulate the examples shown earlier in this chapter, Example 1 or Example 2, with the `-xzcheck rcompilation` option and the `nofalseneg` argument, VCS does not display the warning message.

VCS V2K Configurations and Libmaps

Library mapping files are an alternative to the defacto standard way of specifying Verilog library directories and files with the `-v`, `-y`, and `+libext+ext` compile-time options and the `'uselib` compiler directive.

Configurations use the contents of library mapping files to specify what source code to use to resolve instances in other parts of your source code.

Library mapping and configurations are described in Std 1364-2001 IEEE Verilog Hardware Description Language. There is additional information on SystemVerilog in Std 1800-2009 IEEE Standard for SystemVerilog - Unified Hardware Design, Specification, and Verification Language.

It specifies that SystemVerilog interfaces can be assigned to logical libraries.

Library Mapping Files

A library mapping file enables you to specify logical libraries and assign source files to these libraries. You can specify one or more logical libraries in the library mapping file. If you specify more than one logical library, you are also specifying the search order VCS uses to resolve instances in your design.

The following is an example of the contents of a library mapping file:

```
library lib1 /net/design1/design1_1/*.v;  
library lib2 /net/design1/design1_2/*.v;
```

Note:

Path names can be absolute or relative to the current directory that contains the library mapping file.

In this example library mapping file, there are two logical libraries. VCS searches the source code assigned to `lib1` first to resolve module instances (or user-defined primitive or SystemVerilog interface instances) because that logical library is listed first in the library mapping file.

When you use a library mapping file, source files that are not assigned to a logical library in this file are assigned to the default logical library named `work`.

You specify the library mapping file with the `-libmap` during compilation.

Resolving ‘include’ Compiler Directives

The source file in a logical library might include the ‘`include`’ compiler directive. If so, you can include the `-incdir` option on the line in the library mapping file that declares the logical library, for example:

```
library gatelib /net/design1/gatelib/*.v -incdir /  
net/  
design1/spec1lib, /net/design1/spec2lib;
```

Note:

The `-incdir` option specified in the library mapping file overrides the `+incdir` option specified in the VCS command line.

Configurations

Verilog 2001 configurations are sets of rules that specify what source code is used for particular instances.

Verilog 2001 introduces the concept of configurations and it also introduces the concept of cells. A cell is like a VHDL design unit. A module definition is a type of cell, as is a user-defined primitive. Similarly, a configuration is also a cell. A SystemVerilog interface and testbench program block are also types of cells.

Configurations do the following:

- Specify a library search order for resolving cell instances (as does a library mapping file)
- Specifies overrides to the logical library search order for specified instances

- Specifies overrides to the logical library search order for all instances of specified cells

You can define a configuration in a library mapping file or in any type of Verilog source file outside the module definition .

Configurations can be mapped to a logical library just like any other type of cell.

Configuration Syntax

A configuration contains the following statements:

```
config config_identifier;
design [library_identifier.]cell_identifier;
config_rule_statement;
endconfig
```

Where:

config

Is the keyword that begins a configuration.

config_identifier

Is the name you enter for the configuration.

design

Is the keyword that starts a **design** statement for specifying the top of the design.

[library_identifier.]cell_identifier;

Specifies the top-level module (or top-level modules) in the design and the logical library for this module (modules).

config_rule_statement

Zero, one, or more of the following clauses: `default`, `instance`, or `cell`.

`endconfig`

Is the keyword that ends a configuration.

The default Clause

The `default` clause specifies the logical libraries in which to search to resolve a default cell instance. A default cell instance is an instance in the design that is not specified in a subsequent `instance` or `cell` clause in the configuration.

You specify these libraries with the `liblist` keyword. The following is an example of a `default` clause:

```
default liblist lib1 lib2;
```

This `default` clause specifies resolving default instances in the logical libraries names `lib1` and `lib 2`.

Note:

- Do not enter a comma (,) between logical libraries.
- The default logical library `work`, if not listed in the list of logical libraries, is appended to the list of logical libraries and VCS searches the source files in `work` last.

The instance Clause

The `instance` clause specifies something about a specific instance. What it specifies depends on the use of the `liblist` or `use` keywords:

`liblist`

Specifies the logical libraries to search to resolve the instance.

`use`

Specifies that the instance is an instance of the specified cell in the specified logical library.

The following are examples of `instance` clauses:

```
instance top.dev1 liblist lib1 lib2;
```

This `instance` clause tells VCS to resolve instance `top.dev1` with the cells assigned to logical libraries `lib1` and `lib2`;

```
instance top.dev1.gm1 use lib2.gizmult;
```

This `instance` clause tells VCS that `top.dev1.gm1` is an instance of the cell named `gizmult` in logical library `lib2`.

The cell Clause

A cell clause is similar to an `instance` clause except that it specifies something about all instances of a cell definition instead of specifying something about a particular instance. What it specifies depends on the use of the `liblist` or `use` keywords:

`liblist`

Specifies the logical libraries to search to resolve all instances of the cell.

`use`

The specified cell's definition is in the specified library.

Hierarchical Configurations

A design can have more than one configuration. You can, for example, define a configuration that specifies the source code you use in particular instances in a subhierarchy, then you can define a configuration for a higher level of the design.

Suppose, for example, a subhierarchy of a design was an eight-bit adder and you have RTL Verilog code describing the adder in a logical library named `rtllib` and you have gate-level code describing the adder in a logical library named `gatelib`. If, for example, you wanted the gate-level code used for the 0 (zero) bit of the adder and the RTL level code used for the other seven bits, the configuration might appear as:

```
config cfg1;
design aLib.eight_adder;
default liblist rtllib;
instance adder.fulladd0 liblist gatelib;
endconfig
```

Now, if you were going to instantiate this eight-bit adder eight times to make a 64-bit adder, you would use configuration `cfg1` for the first instance of the eight-bit adder, but not in any other instance. A configuration that would perform this function is as follows:

```
config cfg2;
design bLib.64_adder;
default liblist bLib;
instance top.64add0 use work.cfg1:config;
endconfig
```

The -top Compile-time Option

VCS has the `-top` compile-time option for specifying the configuration that describes the top-level configuration or module of the design, for example:

```
vcs -top top_cfg ...
```

If you have coded your design to have more than one top-level module, you can enter more than one `-top` option, or you can append arguments to the option using the plus delimiter. For example:

```
-top top_cfg+test+
```

Using the `-top` options tells VCS not to create extraneous top-level modules, that is, one that you don't specify.

Limitations of Configurations

In the current implementation, V2K configurations have the following limitations:

- You cannot specify source code for user-defined primitives in a configuration.
- The VPI functionality, described in section 13.6 "Displaying library binding information" in the Std 1364-2001 IEEE Verilog Hardware Description LRM, is not implemented.
-

Evaluating the Active Events When Limiting the Exposure of Race Conditions

VCS uses the `+evalorder` option to evaluate the active events when limiting the exposure of race conditions present in the design.

VCS divides the active events in the following categories:

- Combinational events: evaluates combinational logic such as gates, continuous assigns, and combinational UDPs.
- Behavioral events: evaluates behavioral logic such as always blocks, initial blocks, tasks, etc.

VCS first evaluates all the events in the combinational queue, and evaluates the events in the behavioral queue. If the behavioral events trigger more combinational events, VCS evaluates them only after the events in the behavioral queue are evaluated. This masks the race conditions happening at the boundaries of the combinational and behavioral parts of the design.

In this example, VCS without the `+evalorder` option will process the continuous assign statement after the statement `q = 0` or add it to the active events queue for later processing. Therefore, `$display` will show either 0 or X as the value of p.

```
module eval();
wire p;
reg q;
    assign p = q;
initial
begin
    #1 q = 0;
    $display("Value of p is %b", p);
end
endmodule
```

With the `+evalorder` option, VCS changes the scheduling of the continuous assignment to happen after all events in the initial block are done. Therefore, `$display` will always display the previous value of `p`, which is `x`.

Lint Warning Message for Missing ‘endcelldefine’

You can tell VCS to display a lint warning message if your Verilog or SystemVerilog code contains a `'celldefine` compiler directive without a corresponding `'endcelldefine` compiler directive and vice versa.

You enable this warning message with the `+lint=CDUB` VCS compile-time option . The CDUB argument stands for “compiler directives unbalanced.”

The examples in this section show the warning message and the source code that results in its display.

Example 3-3 Source Code with Missing ‘endcelldefine’

```
'celldefine  
module mod;  
endmodule
```

In this example there is no corresponding `'endcelldefine` compiler directive.

In VCS, if you enter the following vcs command line:

```
vcs exp1.v +lint=CDUB
```

VCS displays the following Lint warning message:

```
Lint- [CDUB] Compiler directive unbalanced
exp1.v, 1
    Unbalanced compiler directive is detected : `celldefine
    has no matching `endcelldefine.
    Please make sure that all directives are balanced.
```

The source code in [Example 3-4](#) does not display this warning message when you include the `+lint=CDUB`.

Example 3-4 Source Code with 'celldefine and 'endcelldefine

```
`celldefine
module mod;
endmodule
`endcelldefine
```

It doesn't display the warning message because there is an `'endcelldefine` compiler directive after the `'celldefine` compiler directive in the source code.

Instead of the `'endcelldefine` compiler directive you can substitute the `'resetall` compiler directive, as shown in [Example 3-5](#).

Example 3-5 Source Code with 'celldefine and 'resetall

```
`celldefine
module mod;
endmodule
`resetall
```

The source code in both [Example 3-4](#) and [Example 3-5](#) do not result in the warning message when you include the `+lint=CDUB` option.

Also with the `+lint=CDUB` option, if your source code contains an `'endcelldefine` compiler directive without the preceding and corresponding `'celldefine` compiler directive, you see a similar warning message.

Example 3-6 ‘endcelldefine Without a Preceding and Corresponding ‘celldefine

```
module mod;
endmodule
`endcelldefine
```

With the +lint=CDUB option, this source code results in the following lint warning message:

```
Lint- [CDUB] Compiler directive unbalanced
exp6.v, 3
    Unbalanced compiler directive is detected : `endcelldefine
    has no matching `celldefine.
    Please make sure that all directives are balanced.
```

With the +lint=CDUB option, it is not just that the number of `endcelldefine compiler directives must be equal to the number of `celldefine compiler directives. The `endcelldefine compiler directive must follow the `celldefine compiler directive before there is another `celldefine compiler directive.

Example 3-7 Equal Number of ‘celldefine and ‘endcelldefine But Not in the Required Sequence

```
`celldefine  \\ line 1
module mod;
endmodule

`celldefine
module schmodule;
endmodule

`endcelldefine

`endcelldefine \\ line 11
```

In [Example 3-7](#) the number of `celldefine compiler directives matches the number of `endcelldefine compiler directives, but they are not in a corresponding sequence, and so result in the following lint warning messages:

```
Lint- [CDUB] Compiler directive unbalanced
exp5.v, 1
    Unbalanced compiler directive is detected : `celldefine
    has no matching `endcelldefine.
    Please make sure that all directives are balanced.
```

```
Lint- [CDUB] Compiler directive unbalanced
exp5.v, 11
    Unbalanced compiler directive is detected : `endcelldefine
    has no matching `celldefine.
    Please make sure that all directives are balanced.
```

Limitation

The `celldefine/'endcelldefine compiler directives must be matched serially. Recursive `celldefine/'endcelldefine directives are not supported with the +lint=CDUB option and keyword argument, for example:

Example 3-8 Recursive 'celldefine/'endcelldefine compiler directives

```
'celldefine
'celldefine
module dev (....,...);
.
.
.
endmodule
`endcelldefine
`endcelldefine
```

[Example 3-8](#) shows redundant and unnecessary ‘celldefine and ‘endcelldefine compiler directives, but does not prevent compilation. The +lint=CDUB option and keyword argument triggers the Lint compiler directives unbalanced message when VCS reads another ‘celldefine directive before reading an ‘endcelldefine directive,

Error/Warning Message Control

This release includes the new -error and -suppress options, and revises the +lint and +warn options, to control error and warning messages. With them you can:

- disable the display of any lint, warning or error messages
- disable the display of specific messages
- limit the display of specific messages to a maximum number that you specify

See “[Obsolete Compile-Time Options for Controlling Messages](#)” for the options they replace.

To control the display of specific messages you will need the message ID. A messages ID is the character string in a messages between the square brackets [], as shown in [Figure 3-1](#).

Figure 3-1 Message IDs



```
Warning- [MFACF] Missing flag argument
Argument for flag 'verboseLevel' is missing in config statement, it will be
ignored.
Config file : error_id0_id1.cfg, starting at line 4.
```

The message ID in [Figure 3-1](#) is MFACF.

The new compile-time options for controlling messages and their syntax are as follows:

```
-error= [no] message_ID[:max_number], ... | none | all
-error=all,noWarn_ID|noLint_ID
+warn= [no] message_ID[:max_number], ... | none | all
+lint= [no] message_ID[:max_number], ... | none | all
-suppress [=message_ID, ...]
```

These compile-time options and their arguments are described in the following sections:

- [“Controlling Error Messages”](#)
- [“Controlling Lint Messages”](#)
- [“Suppressing Lint, Warning, and Error Messages”](#)
- [“Error Conditions and Messages That Cannot Be Disabled”](#)
- [“Using Message Control Options Together”](#)

Controlling Error Messages

You can control error messages with the `-error` option in the following ways:

- Limit the number of occurrences of an error message to a number you specify. You do so by specifying the message ID as an argument to the `-error` option along with the specified maximum number of occurrences.
- Disable the display of all error messages which are downgradable with the `none` argument .
- Enables the display of all error/warnings/lint messages with the `all` argument to the `-error` option. Warning/line will be upgraded to error and will be displayed.

Upgrading Lint and Warning Messages to Error Messages

If you enter the message ID for a warning or lint message as an argument to the `-error` option, VCS upgrades the condition causing the warning or lint message to an error condition and an error message.

Controlling Warning Messages

Like error messages, you can control warning messages with the `+warn` option in the following ways:

- Limit the number of occurrences of a warning message to a number you specify. You do so by specifying the message ID as an argument to the `+warn` option along with the specified maximum number of occurrences.

- Disable the display of a particular warning message by entering the keyword `no` as an argument and appending to this keyword the message ID, for example:

```
+warn=noTFIPC
```

This option disables the display of the error message with the TFIPC message ID.

Important:

Do not enter a maximum number of occurrences, even if 0, if also appending the `no` keyword to the message ID.

- Disable the display of all warning messages with the `none` argument to the `+warn` option.
- Enable the display of all warning messages with the `all` argument to the `+warn` option.

Upgrading Lint Messages to Warning Messages

Important:

- All lint/warning messages are suppressable. But only some of the error messages can be downgraded or suppressed.
- You cannot downgrade all error conditions and messages to a warning condition and message. Entering a message ID for an error message that can't be downgraded as an argument to the `+warn` option results in VCS ignoring the message ID and displaying a warning message similar to the following:

```
Warning- [CSMC] Cannot set message count
Failed to set display count for message id 'TFAFTC'
because cannot set count
for non-warning ID in '+warn' switch.
Specified count is ignored.
```

For an example of this warning see “[Example 4: An Error Message That Can’t Be Controlled](#)”.

This warning message was in response to the following +warn option:

```
+warn=TFAFTC:2
```

When TFATFC is the ID for the following error message:

```
Error- [TFAFTC] Too few arguments to function/task call  
tfatc_err.v, 9  
"wrFld4(.bus(1));"  
The above function/task call is not done with sufficient  
arguments.
```

Controlling Lint Messages

Like error and warning messages, you can control lint messages with the +lint option in the following ways:

- You can limit the number of occurrences of a lint message to a number you specify. You do so by specifying the message ID as an argument to the +lint option along with the specified maximum number of occurrences.

You can enter a maximum of 0 to disable any display of the message specified by the message ID, see “[Example 2: Reducing the number of lint messages](#)”.

Important:

Do not enter a maximum number of occurrences, even if 0, if also appending the no keyword to the message ID.

- Disable the display of all lint messages with the none argument to the +lint option.

- Enable the display of all lint messages with the `all` argument to the `+lint` option.

Important:

You cannot downgrade an error or warning condition and message to a lint condition and message.

Suppressing Lint, Warning, and Error Messages

The `-suppress` option suppresses lint, warning, and error messages. The `-supress` option with no argument should suppress all warnings/lint and downgradable error messages

If you enter a message ID argument, and the message is downgradable, VCS does not display that message. You can enter the ID for any lint, warning, or downgradable error message.

The `-suppress` option gives you a message control option that takes a higher precedence than the `-error`, `+warn`, or `+lint` options when you enter more than one of these options, see “[Using Message Control Options Together](#)” .

Error Conditions and Messages That Cannot Be Disabled

Some error conditions always terminate compilation without creating an executable and cannot be controlled or suppressed by the `-error` or `-suppress` options.

- syntax errors
- fatal error messages, those from error conditions that immediately halt compilation

Using Message Control Options Together

If you are entering more than one of these message control options, you will need to know their precedence when used together. The order of precedence is as follows, from highest to lowest:

1. The `-suppress` option with no arguments, suppresses all possible messages and cannot be overridden by another message control option.
2. The `none` argument has a higher precedence than specifying `all` or a message ID.
3. The order on the `vcs` command line

The following options and arguments have the same intrinsic precedence:

<code>-suppress=messageID</code>	
<code>-error=messageID:max</code>	<code>-error=all</code>
<code>+warn=essageID:max</code>	<code>+warn=all</code>
<code>+lint=essageID:max</code>	<code>+lint=all</code>

Because they have equal intrinsic precedence, the order on the `vcs` command line determines relative precedence, and so the first of these options on the command line has the least precedence and the last of these has the most.

Message Control Examples

The following examples show how to use these options.

Example 1: Reducing the number of warning messages

If we have small system verilog source file named as `diff_clk_wosvaext.sv` with the following content,

```
1 module top #(Pa = 1);
2 bit a , c, clk;
3 wand b1;
4 wand c1;
5
6 clocking cb2 @ (posedge clk);
7 endclocking
8
9 sequence S2();
10 @(cb2)
$past($past(a,, $stable($isunknown(1'bx),@(negedge
clk)),@(posedge clk)),,$sampled(a),@(negedge clk));
11 endsequence
12
13 property P1();
14 @(cb2 , posedge clk iff ($stable(b1,@(posedge clk)))
$stable($past(b1,,,@(posedge clk)),@(negedge clk));
15 endproperty
16
17 A1: assume property (@(S2)      S2 );
18 A2: assume property (@(S2) P1());
19 A3: assume property (@(cb2) disable iff ($stable(c1)) P1);
20 A4: assume property (@(cb2) disable
iff($sampled($past(c1,,@ (clk)))) first_match (S2));
21
22 sequence S3();
23 @(cb2) S2() ##1 @(negedge clk) $stable(b1 || $sampled(c1),
@(posedge clk));
24 endsequence
25
26 A5: cover property (@(S2) S3);
27 initial begin
28 a = 1;
29 repeat (20)
30 #5 clk = !clk;
31 end
32 endmodule
```

If we compile the above system Verilog file with following command,

```
vcs -sverilog diff_clk_wosvaext.sv
```

VCS displays following warning messages:

```
Warning- [SVA-LCDNAWPSC] Lead and property/sequence clocks differ  
diff_clk_wosvaext.sv, 17  
top  
    Leading clock of expression does not agree with property/  
    sequence clock.  
        Leading clock will be applied.  
        property/sequence clock: S2  
        leading clock: posedge clk
```

```
Warning- [SVA-LCDNAWPSC] Lead and property/sequence clocks differ  
diff_clk_wosvaext.sv, 18  
top  
    Leading clock of expression does not agree with property/  
    sequence clock.  
        Leading clock will be applied.  
        property/sequence clock: S2  
        leading clock: top.cb2,posedge clk iff $stable(b1,  
@(posedge clk) )
```

```
Warning- [SVA-LCDNAWPSC] Lead and property/sequence clocks differ  
diff_clk_wosvaext.sv, 19  
top  
    Leading clock of expression does not agree with property/  
    sequence clock.  
        Leading clock will be applied.  
        property/sequence clock: posedge clk  
        leading clock: top.cb2,posedge clk iff $stable(b1,  
@(posedge clk) )
```

```

Warning- [SVA-LCDNAWPSC] Lead and property/sequence clocks
differ
diff_clk_wosvaext.sv, 26
top
    Leading clock of expression does not agree with property/
    sequence clock.
        Leading clock will be applied.
            property/sequence clock: S2
            leading clock: posedge clk

```

VCS displays the same warning four times, if we want to control the number of warning messages, we can use the compile time option
`+warn=warn_ID:n...`

For example

```
vcs -sverilog +warn=SVA-LCDNAWPSC:1 diff_clk_wosvaext.sv
```

VCS limits the warning messages to one.

```

Warning- [SVA-LCDNAWPSC] Lead and property/sequence clocks
differ
diff_clk_wosvaext.sv, 17
top
    Leading clock of expression does not agree with property/
    sequence clock.
        Leading clock will be applied.
            property/sequence clock: S2
            leading clock: posedge clk

```

Example 2: Reducing the number of lint messages

If we have small SystemVerilog source file named as `top.sv` with the following content,

```

1 `celldefine
2 module sub;
3 endmodule
4
5 `celldefine

```

```
6 module sub1;
7 endmodule
8
9 `celldefine
10 module top;
11 sub inst();
12 sub1 inst1();
13 endmodule
```

By default all lint messages are disabled if we want to enable the lint message we need to use the compile time option `+lint=lint_ID`. For example:

```
vcs -sverilog +lint=CDUB top.sv
```

VCS displays the following lint messages during compilation.

```
Lint- [CDUB] Compiler directive unbalanced
top.sv, 1
    Unbalanced compiler directive is detected : `celldefine
has no matching
    `endcelldefine.
    Please make sure that all directives are balanced.
```

```
Lint- [CDUB] Compiler directive unbalanced
top.sv, 5
    Unbalanced compiler directive is detected : `celldefine
has no matching
    `endcelldefine.
    Please make sure that all directives are balanced.
```

```
Lint- [CDUB] Compiler directive unbalanced
top.sv, 9
    Unbalanced compiler directive is detected : `celldefine
has no matching
    `endcelldefine.
    Please make sure that all directives are balanced.
```

If we want to control the number of lint messages printed in the compile time we can use `+lint=lint_ID:n...`. For example:

```
vcs -sverilog +lint=CDUB:1 top.sv
```

Now VCS controls the number of lint messages printed to one:

```
Lint- [CDUB] Compiler directive unbalanced  
top.sv, 1  
    Unbalanced compiler directive is detected : `celldefine  
has no matching  
`endcelldefine.  
Please make sure that all directives are balanced
```

Example 3: Upgrading Multiple Warnings to One Error

If we had a Verilog file named tfpic.v with the following contents:

```
module top();  
wire a,b,c;  
child child_position_instance(a,b);  
child child_name_instance(.b(b));  
endmodule  
  
module child( input a, input b, input c);  
endmodule
```

Notice that module child has three input ports, but the module instantiation statements have only two or one port connection.

If we compile this source file without message control:

```
vcs tfpic.v
```

VCS displays the following during compilation:

```
Warning- [TFIPC] Too few instance port connections  
The following instance has fewer port connections than the  
module definition
```

```
"tfipc.v", 3: child child_position_instance(a, b);
```

Warning- [TFIPC] Too few instance port connections
The following instance has fewer port connections than the module definition

```
"tfipc.v", 4: child child_name_instance( .b (b));
```

Warning- [TFIPC] Too few instance port connections
The following instance has fewer port connections than the module definition

```
"tfipc.v", 4: child child_name_instance( .b (b));
```

If we recompile specifying that message ID TFIPC is upgraded to an error, and display this error message no more than once:

```
vcs tfpic.v -error=TFIPC:1
```

VCS displays:

Error- [TFIPC] Too few instance port connections
The following instance has fewer port connections than the module definition

```
"tfipc.v", 3: child child_position_instance(a, b);
```

```
1 error
```

Example 4: An Error Message That Can't Be Controlled

If we had a Verilog file named tfatf_err.v with the following contents:

```
module top;
    task wrFld4(input string fldName, input int bus = 0, input
    string fldName2);
        $display("In wrFld4");
    endtask
```

```

task wrFld4_2(input int bus = 0,input string fldName);
    $display("In wrFld4");
endtask
initial begin
    wrFld4(.bus(1));                                // this is line 9
    wrFld4(,1);                                     // 10
    wrFld4_2(.bus(1));                                // 11
end
endmodule

```

Task wrFld4 has three input ports. Task wrFld4_2 has two input ports, but the task enabling statements for them have only one connection.

VCS displays the following during compilation:

```

Error-[TFAFTC] Too few arguments to function/task call
tfatc_err.v, 9
"wrFld4(.bus(1));"
The above function/task call is not done with sufficient
arguments.

```

```

Error-[TFAFTC] Too few arguments to function/task call
tfatc_err.v, 10
"wrFld4(, 1);"
The above function/task call is not done with sufficient
arguments.

```

```

Error-[TFAFTC] Too few arguments to function/task call
tfatc_err.v, 10
top, "wrFld4(, 1);"
The above function/task call is not done with sufficient
arguments.

```

```

Error-[TFAFTC] Too few arguments to function/task call
tfatc_err.v, 11
top, "wrFld4_2(1);"

```

The above function/task call is not done with sufficient arguments.

The error message with the ID TFAFTC displays four times. If we recompile while specifying that this error message display only once:

```
vcs tfatc_err.v -sverilog -error=TFAFTC:1
```

VCS displays:

```
Warning- [CSMC] Cannot set message count  
Failed to set display count for message id 'TFAFTC' because  
it cannot be  
suppressed.  
Specified count is ignored.
```

```
Parsing design file 'tfatc_err.v'
```

```
Error- [TFAFTC] Too few arguments to function/task call  
tfatc_err.v, 9  
"wrFld4(.bus(1));"  
The above function/task call is not done with sufficient  
arguments.
```

```
Error- [TFAFTC] Too few arguments to function/task call  
tfatc_err.v, 10  
"wrFld4(, 1);"  
The above function/task call is not done with sufficient  
arguments.
```

```
Error- [TFAFTC] Too few arguments to function/task call  
tfatc_err.v, 10  
top, "wrFld4(, 1);"  
The above function/task call is not done with sufficient  
arguments.
```

```
Error- [TFAFTC] Too few arguments to function/task call
```

```

tfatc_err.v, 11
top, "wrFld4_2(1);"
    The above function/task call is not done with sufficient
arguments.

1 warning
4 errors

```

None of the error messages are disabled and there is a warning saying that VCS can't limit the display of the message.

Example 5: Syntax Using the -suppress option

If we have SystemVerilog file `example.sv` with the following content:

```

1 module top;
2 wire [5:0]data;
3 longint result,result1,result2,result3,result4;
4 assign data = 6'h2345;
5 initial
6 begin
7 result = $clog2(4294967296);      //2 ** 32
8 result4 = $clog2(2147483648);      //2 ** 31
9 result3 = $clog2(1073741824);      //2 ** 30
10 result1=2**16;
11 result2=result1*result1;
12 $display("clog: %0d result2 %0d \n",result,result2);
13 $display("clog3: %0d \n",result3);
14 $display("clog43: %0d \n",result4);
15 end
16 endmodule

```

If we compile this file normally:

```
vcs -sverilog exmaple.sv
```

VCS display following warning messages:

```
Warning- [TMBIN] Too many bits in Based Number
example.sv, 4
The specified width is '6' bits, actually got '16' bits.
The offending number is : '2345'.
```

```
Warning- [DCTL] Decimal constant too large
example.sv, 7
Decimal constant is too large to be handled in compilation.
Absolute value 4294967296 should be smaller than
2147483648.
```

```
Warning- [DCTL] Decimal constant too large
example.sv, 8
Decimal constant is too large to be handled in compilation.
Absolute value 2147483648 should be smaller than
2147483648.
```

If we are using -suppress option with the command line all warning messages will suppressed.

For example if we are using:

```
vcs -sverilog -suppress example.sv
```

The -suppress option suppresses all warning/lint/downgradable error messages.

Obsolete Compile-Time Options for Controlling Messages

The +vcs+error compile-time option is replaced by the -error option. In this release using +vcs+error results in the following warning:

```
Warning- [RNME_OPT] Renamed option found
Option '+vcs+error' has been renamed to '-error'. Future
```

releases of VCS may not accept '+vcs+error'.

Similarly, the -no_error compile-time option is obsolete and using it results in the following error message:

```
Warning- [OBSLFLGS] Obsolete flag(s) used
The flag(s) '-no_error' is(are) obsolete and will not be
supported after
this release. Please use '-error=no<ID>' instead.
Please contact vcs_support@synopsys.com or call VCS
Customer Support at
1-800-VERILOG for any questions about obsolete switches.
```

4

Simulating the Design

This chapter describes the following:

- “Using DVE”
- “Using UCLI”
- “Key Runtime Features”

As described in the section “[Simulation](#)” on page 18, you can simulate your design in either interactive or batch mode. To simulate your design in interactive mode, you need to use DVE or UCLI. To simulate your design in batch mode, refer to the section entitled, “[Batch Mode](#)” on page 19.

Using DVE

DVE provides you with a graphical user interface to debug your design. Using DVE, you can debug the design in interactive mode or in post-processing mode. You must use the same version of VCS and DVE to ensure problem-free debugging of your simulation.

In the interactive mode, apart from running the simulation, DVE allows you to do the following:

- View waveforms
- Trace Drivers and loads
- Schematic and Path Schematic view
- Compare waveforms
- Execute UCLI/Tcl commands
- Set line, time, event, etc breakpoints
- Perform line stepping

However, in post-processing mode, a VPD/VCD/EVCD file is created during simulation, and you use DVE to:

- View waveforms
- Trace Drivers and loads
- Schematic and Path Schematic view
- Compare waveforms

Use the following command to invoke the simulation in interactive mode using DVE:

```
% simv -gui
```

Use the following command to invoke DVE in post-processing mode:

```
% dve -vpd [VPD/EVCD_filename]
```

Note:

The interactive mode of DVE is not supported, when you are running VCS slave mode simulation.

For information on generating a VPD/EVCD dump file, see “[VPD, VCD, and EVCD Utilities](#)” on page 1.

For more information on using DVE, click this link [Discovery Visual Environment User Guide](#) if you are using the VCS Online Documentation.

If you are using the PDF interface, click this link [dve_ug.pdf](#) to view the DVE User Guide PDF document.

Using UCLI

Unified Command-line Interface (UCLI) provides a common set of commands for interactive simulation. UCLI is the default command-line interface for batch mode debugging in VCS .

UCLI commands are based on Tcl, therefore you can use any Tcl command with UCLI. You can also write Tcl procedures and execute them at the UCLI prompt. Using UCLI commands, you can do the following:

- Control the simulation
- Dump a VPD file

- Save/Restore the simulation state
- Force/Release a signal
- Debug the design using breakpoints, scope/thread information, built-in macros

UCLI commands are built based on Tcl. Therefore, you can execute any Tcl command or procedures at the UCLI prompt. This provides you with more flexibility to debug the design in interactive mode. The following command starts the simulation from the UCLI prompt:

```
% simv [simv_options] -ucli
```

When you execute the above command, VCS takes you to the UCLI command prompt. To invoke UCLI, ensure that you specify the `-debug_pp`, `-debug`, or `-debug_all` options during compilationelaboration. You can then use the `-ucli` option at runtime to enter the UCLI prompt at time 0 as shown:

```
% simv -ucli
ucli%
```

At the ucli prompt, you can execute any UCLI command to debug or run the simulation. You also can specify the list of required UCLI commands in a file, and source it to the UCLI prompt or specify the file as an argument to the runtime option, `-do`, as shown below:

```
% simv -ucli
ucli% source file.cmds

% simv -ucli -do file.cmds
```

Note:

UCLI is not supported when you are running VCS slave mode simulation.

Note:

You can use the `-ucli` flag at runtime even if you have NOT used some form of `-debug` switches during compilation. This is called a "mini UCLI" feature, where full power of Tcl is now provided with just `run` and `quit` UCLI commands.

Note the following behavioral changes when UCLI is the default command-line interface:

- The `-s` switch is no longer allowed in `simv`.
- If you are unable to migrate the flow to use UCLI instead of CLI, contact VCS Support.
- Command line flags, such as `simv -i` or `-do`, only accept UCLI commands.
- Interrupting the simulation using `Ctrl+C` takes you to UCLI prompt by default for debugging your designs.
- `ucli>"Include file options (-i or -do) expects a UCLI script by default.`

```
%> simv -ucli -i ucli_script.inc
```

- The `-R` feature in VCS will continue to take you to the old CLI/MX UI, unless you explicitly add `-ucli` as well to VCS command line.

ucli2Proc Command

There are a few scenarios after UCLI became the default command line interface, which may require using of the `-ucli2Proc` switch:

- In SystemC designs, you need to add the `-ucli2Proc` command if you want to call 'cbug' in batch mode (ucli). VCS issues a warning message if you do not add this command.
- When you issue a `restore` command inside a `-i/-do/source`, you need to pass the `-ucli2Proc`. This situation is only applicable when there are commands following the `restore` commands that need to be executed in the `do` script.
- Any usage of `start/restart/finish/config "endofsim"` from UCLI needs the `-ucli2Proc` command.

For more information about UCLI, click the link [Unified Command-line Interface \(UCLI\)](#) if you are using the VCS Online Documentation.

If you are using the PDF interface, click the link [ucli_ug.pdf](#) to view the UCLI User Guide PDF document.

Options for Debugging Using DVE and UCLI

`-debug_pp`

Gives best performance with the ability to generate the VPD/VCD file for post-process debug. It is the recommended option for post-process debug.

It enables read/write access and callbacks to design nets, memory callback, assertion debug, VCS DKI, and VPI routine usage. You can also run interactive simulation when the design is compiled with this option, but certain capabilities are not enabled. It does not provide force net and reg capabilities. Set value and time breakpoints are permissible, but line breakpoints cannot be set.

`-debug`

Gives average performance and debug visibility/control i.e more visibility/control than `-debug_pp` and better performance than `-debug_all`. It provides force net and reg capabilities in addition to all capabilities of the `-debug_pp` option. Similar to the `-debug_pp` option, with the `-debug` option also you can set value and time breakpoints, but not line breakpoints.

`-debug_all`

Gives the most visibility/control and you can use this option typically for debugging with interactive simulation. This option provides the same capabilities as the `-debug` option, in addition it adds simulation line stepping and allows you to track the simulation line-by-line and setting breakpoints within the source code. With this option, you can set all types of breakpoints (line, time, value, event etc).

`-ucli`

Forces runtime to go into UCLI mode, by default.

`-gui`

When used at compile time, starts DVE at runtime.

`+vpdfile+filename`

Specifies the name of the generated VPD file. You can also use this option for post-processing where it specifies the name of the VPD file.

`+vpdfilesizex+number_in_MB`

Specifies a size for the vpd file. When the vpd file reaches this size, VCS closes this file and opens a new one with the same size.

Key Runtime Features

Key runtime features includes:

- “Passing Values from the Runtime Command Line”
- “Profiling the Simulation”
- “Save and Restart The Simulation”
- “Specifying a Long Time Before Stopping The Simulation”
- “How VCS Prevents Time 0 Race Conditions”

Passing Values from the Runtime Command Line

The `$value$plusargs` system function can pass a value to a signal from the `simv` runtime command line using a plusarg. The syntax is as follows:

```
integer = $value$plusargs("plusarg_format",signalname);
```

The `plusarg_format` argument specifies a user-defined runtime option for passing a value to the specified signal. It specifies the text of the option and the radix of the value that you pass to the signal.

The following code example contains this system function:

```
module valueplusargs;
reg [31:0] r1;
```

```

integer status;

initial
begin
$monitor("r1=%0d at %0t",r1,$time);
#1 r1=0;
#1 status=$value$plusargs("r1=%d",r1);
end
endmodule

```

If you enter the following `simv` command line:

```
% simv +r1=10
```

The `$monitor` system task displays the following:

```

r1=x at 0
r1=0 at 1
r1=10 at 2

```

Profiling the Simulation

If you include the `+prof` compile-time option when you compile your design, VCS generates the `vcs.prof` file during simulation. This file contains a profile of the simulation in terms of the CPU time and memory that it uses.

For CPU time it reports the following:

- The percentage of CPU time used by the VCS kernel, the design, the SystemVerilog testbench program block, cosimulation applications using either the DPI or PLI, and the time spent writing a VCD or VPD file.
- The module instances in the hierarchy that use the most CPU time

- The module definitions whose instances use the most CPU time
- The Verilog constructs in those instances that use the most CPU time

For memory usage it reports the following:

- The amount of memory and the percentage of memory used by the VCS kernel, the design, the SystemVerilog testbench program block, cosimulation applications using either the DPI or PLI, and the time spent writing a VCD or VPD file.
- The amount of memory and the percentage of memory that each module definition uses.

You can use this information to see where in your design you might be able to modify your code for faster simulation performance.

The profile data in the `vcs.prof` file is organized into a number of “views” of the simulation. The `vcs.prof` file starts with views on CPU time, followed by views on memory usage.

Note:

The current profiler and the `+prof` compile-time option will be replaced by the unified profiler and the `-simprofile` compile-time option in the next release of VCS. The unified profiler is now an LCA feature, see [The Unified Simulation Profiler](#).

CPU Time Views

The views on CPU time are as follows:

- [“The Top-level View”](#)
- [“The Module View”](#)

- “The Program View”
- “The Instance View”
- “The Program to Construct Mapping View”
- “The Top-level Construct View”
- “The Construct View Across Design”

The Top-level View

This view displays how much CPU time was used by:

- Any PLI application that executes along with VCS.
- VCS for writing VCD and VPD files.
- VCS for internal operations that can't be attributed to any part of your design.
- The Verilog modules in your design.
- A SystemVerilog testbench program block, if used.

Example 4-1 Top-level View

TOP-LEVEL VIEW	
TYPE	%Totaltime
DPI	0.00
PLI	0.00
VCD	0.00
KERNEL	29.06
MODULES	51.87
PROGRAMS	21.17
PROGRAM GC	1.64

In this example, there is no PLI application and VCS does not write a VCD or VPD file. VCS used 51.87% of the CPU time to simulate the design, 21.94% for a testbench program, and 29.06% for internal operations, such as scheduling, that VCS cannot attribute to any part of the design. The designation KERNEL is for these internal operations. PROGRAM GC is for the garbage collector.

The designation VCD is for the simulation time used by the callback mechanisms inside VCS for writing either VCD or VPD files.

If there was CPU time used by a PLI application, you could use a tool such as gprof or Quantify to profile the PLI application.

The Module View

This view displays the module definitions whose instances use the most CPU time. It does not list module definitions whose module instances collectively use less than 0.5% of the CPU time.

Example 4-2 Module View

MODULE VIEW				
Module(index)		%Totaltime	No of Instances	Definition
FD2	(1)	62.17	10000	/u/design/design.v:142.
EN	(2)	8.73	1000	/u/design/design.v:131.

In this example, there are two module definitions whose instances collectively used a significant amount of CPU time, modules FD2 and EN.

The profile data for module FD2 is as follows:

- FD2 has an index number of 1. Other views that show the hierarchical names of module instances use this index number. The index number associates a module instance with a module definition because module identifiers do not necessarily resemble the hierarchical names of their instances.
- The instances of module FD2 used 62.17% of the CPU time.
- There are 10,000 instances of module FD2. The number of instances is a way to assess the CPU time used by these instances. For example, as in this case, a high CPU time with a correspondingly high number of instances tells you that each instance isn't using very much CPU time.
- The module header, the first line of the module definition, is in source file `design.v` on line 142.

The Program View

The program view displays the simulation time used by the testbench program, the number of instances, and the line number where it starts in its source file.

Example 4-3 Program View

PROGRAM VIEW			
Program(index)	%Totaltime	No of Instances	Definition
test	(1) 21.17	1	/u/design/test.sv:25.

The Module to Construct Mapping View

This view displays the CPU time used by different types of Verilog constructs in each module definition in the module view. The following lists the different types of Verilog constructs:

- always constructs (commonly called always blocks)
- initial constructs (commonly called initial blocks)
- module path delays in specify blocks
- timing check system tasks in specify blocks
- combinational logic including gates or built-in primitives and continuous assignment statements
- user-defined tasks
- user-defined functions
- module instance ports
- user-defined primitives (UDPs)
- Any Verilog code protected by encryption

Ports use simulation time particularly when there are expressions in port connection lists such as bit or part selects and concatenation operators.

This view has separate sections for the Verilog constructs for each module definition in the module view.

Example 4-4 Module to Construct Mapping View

=====			
MODULE TO CONSTRUCT MAPPING			
=====			
<hr/>			
1. FD2			
<hr/>			
Construct type	%Totaltime	%Moduletime	LineNo
Always	27.44	44.14	design.v : 150-160.
Module Path	23.17	37.26	design.v : 165-166.

```
Timing Check      11.56      18.60      design.v : 167-168.
```

```
2. EN
-----
Construct type    %Totaltime    %Moduletime    LineNo
-----
Combinational     8.73         100.00       design.v: 137.
```

For each construct the view reports the percentage of “Totaltime” and “Moduletime”.

%Totaltime

The percentage of the total CPU time that was used by this construct.

%Moduletime

Each module in the design uses a certain amount of CPU time. This percentage is the fraction of the module’s CPU time that was used by the construct.

In the section for module FD2:

- An always block in this module definition used 27.44% of the TOTAL CPU time. Of all the CPU time consumed by all instances of the FD2 module, 44.14% is spent on this construct (44.14% of 62.17% = 27.44%). The always block is in source file design.v between lines 150 and 160.

If there were another always block in module FD2 that used more than 0.5% of the CPU time, there would be another line in this section for it, beginning with the `always` keyword.

- The module path delays in this module used 23.17% of the TOTAL CPU time. Of all the CPU time consumed by all instances of the FD2 module, 37.26% is spent on this construct. These module path delays can be found on lines 165-166 of the `design.v` source file.
- The timing check system tasks in this module used 11.56% of the TOTAL CPU time. Of all the CPU time consumed by all instances of the FD2 module, 18.60% is spent on this construct. These timing check system tasks can be found on lines 167-168 of the `design.v` source file.

In the section for module EN, a construct classified as Combinational used 8.73 of the total CPU time. 100% of the CPU time used by all instances of EN were used for this combinational construct.

No initial blocks, user-defined functions, or user-defined tasks, ports, UDPs, or encrypted code in the design used more than 0.5% of the CPU time. If there were, there would be a separate line for each of these types of constructs.

The Instance View

This view displays the module instances that use the most CPU time. An instance must use more than 0.5% of the CPU time to be entered in this view.

Example 4-5 Instance View

```
=====
           INSTANCE VIEW
=====
Instance          %Totaltime
-----
test.lfsr1000_1.lfsr100_1.lfsr10_1.lfsr_1.en_
1             ( 2    )      0.73
-----
```

In this example, there is only one instance that uses more than 0.5% of the CPU time.

This instance's hierarchical name is
test.lfsr1000_1.lfsr100_1.lfsr10_1.lfsr_1.en_1.
(Long hierarchical names wrap to the next line.)

The instance's index number is 2, indicating an instance of module EN, which had an index of 2 in the module view.

This instance used 0.73% of the CPU time.

No instance of module FD2 is listed here, so no individual instance of FD2 used more than 0.5% of the CPU time.

Note:

It is very common for no instances to appear in the instance view. This happens when many instances use some of the simulation time, but none use more than 0.5% of the total simulation time.

The Program to Construct Mapping View

The program to construct mapping view lists the testbench constructs that use the most simulation time and list the percentage of the total simulation they use, and the percentage of the program's simulation time each type of construct uses. It also lists the source file and line number of the constructs declaration.

Example 4-6 Program to Construct Mapping View

```
=====
PROGRAM TO CONSTRUCT MAPPING
=====
```

```
1. test
```

Construct	Construct type	%Totaltime	%Programtime	LineNo
name1::name2	Program Task	2.85	13.45	/u/design/vmm.sv : 12668-12901.
var	queue.var	2.64	12.45	/u/design/vmm.sv : 14551-14558.
name3::name4	Program Function	0.99	4.67	/u/design/vmm.sv : 13890-14215.

The Top-level Construct View

This view shows you the CPU time used by different types of constructs throughout the design.

Example 4-7 Top-level Construct View

TOP-LEVEL CONSTRUCT VIEW	
Construct	%Totaltime
Combinational	28.14
Task	16.58
Program Task	9.87
Always	6.52
Program Function	5.82
queue.size	2.64
Port	2.01
Object new	1.92
Initial	0.89
Program Thread	0.79
Function	0.76
queue.name	0.09
queue.name	0.05

The Construct View Across Design

This view displays the module or program definitions that contain a type of construct that used more than 0.5% of the CPU time. There are separate sections for each type of construct and each section contains a list of the modules or programs that contain that type of construct.

Example 4-8 Top-level Construct View

CONSTRUCT VIEW ACROSS DESIGN	
<hr/>	
1. Always	
<hr/>	
Module	%TotalTime
FD2	27.44
<hr/>	
2. Module Path	
<hr/>	
Module	%TotalTime
FD2	23.17
<hr/>	
3. Timing Check	
<hr/>	
Module	%TotalTime
FD2	11.56
<hr/>	
4. Combinational	
<hr/>	
Module	%TotalTime
EN	8.73
<hr/>	

Memory Usage Views

The views on memory usage are as follows:

- Top-level View
- Module View
- “[The Program View](#)”

The Top-level View

This view displays how much memory was used by:

- Any PLI or DPI application that executes along with VCS
- VCS for writing VCD and VPD files
- VCS for internal operations (known as the kernel) that can't be attributed to any part of your design
- The Verilog modules in your design
- A SystemVerilog testbench program block, if used

Example 4-9 Top-level View

```
=====
//      Simulation memory:      2054242 bytes
=====

=====
                         TOP-LEVEL VIEW
=====
          TYPE        Memory    %Totalmemory
-----
          DPI           0         0.00
          PLI           0         0.00
          VCD           0         0.00
          KERNEL       890408      43.34
          MODULES      1163834     56.66
          PROGRAMS      0         0.00
-----//
```

Just before the top-level view, VCS writes the total amount of memory used by the simulation. In this example, it is 2054242 bytes.

In this example, there is no DPI or PLI application and VCS does not write a VCD or VPD file.

VCS used 1163834 bytes of memory and 56.66% of the total memory to simulate the design.

VCS used 890408 bytes of memory and 43.34% of the total memory for internal operations, such as scheduling, that can't be attributed to any part of the design. The designation KERNEL is for these internal operations.

The designation VCD is for the simulation time used by the callback mechanisms inside VCS for writing either VCD or VPD files.

The Module View

The module view shows the amount of memory used, and the percentage of memory used, by each module definition.

Example 4-10 Top-level View

=====					
MODULE VIEW					
Module(index)	Memory	%Totalmemory	No of Instances	Definition	
bigmem	(1) 1048704	51.05	2	expl.v:16.	
bigtime	(2) 115030	5.60	2	expl.v:61.	
test	(3) 100	0.00	1	expl.v:1.	

=====

In this example, the instances of module `bigmem` used 1048704 bytes of memory, 51.05% of the total memory used. The instances of module `bigtime` used 115030 bytes of memory, 5.6% of the total memory used.

The Program View

The program view displays the amount of memory used, and the percentage of memory used, by each testbench program.

Example 4-11 Program View

PROGRAM VIEW				
Program(index)	Memory	%Totalmemory	No of Instances	Definition
test	(1) 4459091	18.74	1	/u/design/test.sv:25.

Save and Restart The Simulation

VCS provides a save and restart feature using `$save` and `$restart` system tasks. These system tasks allows you to save the checkpoints of the simulation at arbitrary times. The resulting checkpoint files can be executed at a later time, causing simulation to resume at the point immediately following the save.

Note:

Save and Restart using `$save` and `$restart` system task is for designs having both DUT and the testbench in Verilog HDL. You can also use the UCLI `save` and `restart` feature. For more information, see the *Unified Command-line Interface User Guide*, available in the online HTML documentation system.

Benefits of save and restart include:

- Regular checkpoints for interactively debugging problems found during long batch runs
- Use of plusargs to start action such as `$dumpvars` on restart

- Execution of common simulation system tasks such as \$reset just once in a regression

Restrictions of save and restart include:

- Requires extra Verilog code to manage the save and restart
- Must duplicate start-up code if handling plusargs on restart
- File I/O suspend and resume in PLI applications must be given special consideration

Save and Restart Example

[Example 4-12](#) illustrates the basic functionality of save and restart.

The \$save call does not execute a save immediately, but schedules the checkpoint save at the end of the current simulation time just before events scheduled with #0 are processed. Therefore, events delayed with #0 are the first to be processed upon restart.

Example 4-12 Save and Restart Example

```
% cat test.v
module simple_restart;
initial begin
    #10
    $display("one");
    $save("test.chk");
    $display("two");
    #0 // make the following occur at restart
    $display("three");
    #10
    $display("four");
end
endmodule
```

Now compile the example source file:

```
% vcs test.v
```

Now run the simulation:

```
% simv
```

VCS displays the following:

```
one
two
$save: Creating test.chk from current state of simv...
three
four
```

To restart the simulation from the state saved in the check file, enter:

```
% simv -r test.chk
```

VCS displays the following:

```
Restart of a saved simulation
three
four
```

Save and Restart File I/O

VCS remembers the files you opened via \$fopen and reopens them when you restart the simulation. If no file with the old file name exists, VCS opens a new file with the old file name. If a file exists having the same name and length at the time you saved the old file, then VCS appends further output to that file. Otherwise, VCS attempts to open a file with a file name equal to the old file name plus the suffix .N. If a file with this name already exists, VCS exits with an error.

If your simulation contains PLI routines that do file I/O, the routines must detect both the save and restart events, closing and reopening files as needed. You can detect save and restart calls using `misctf` callbacks with reasons `reason_save` and `reason_restart`.

When running the saved checkpoint file, be sure to rename it so that further `$save` calls do not overwrite the binary you are running. There is no way from within the Verilog source code to determine if you are in a previously saved and restarted simulation, therefore, you cannot suppress the `$save` calls in a restarted binary.

Save and Restart With Runtime Options

If your simulation behavior depends on the existence of runtime `plusargs` or any other runtime action (such as reading a vector file), be aware that the restarted simulation uses the values from the original run unless you add special code to process runtime events after the restart action. Depending on the complexity of your environment and your usage of the save and restart feature, this can be a significant task.

For example, if you load a memory image with `$loadmemb` at the beginning of the simulation and want to be able to restart from a checkpoint with a different memory image, you must add Verilog code to load the memory image after every `$save` call. This ensures that at the beginning of any restart the correct memory image is loaded before simulation begins. A reasonable way to manage this is to create a task to handle processing arguments, and call this task at the start of execution, and after each save.

The following example illustrates this in greater detail. The first run optimizes simulation speed by omitting the +dump flag. If a bug is found, the latest checkpoint file is run with the +dump flag to enable signal dumping.

```
// file test.v
module dumpvars();
task processargs;
    begin
        if ($test$plusargs("dump")) begin
            $dumpvars;
        end
    end
end task
//normal start comes here
initial begin
    processargs;
end
// checkpoint every 1000 time units
always
    #1000 begin
        // save some old restarts
        $system("mv -f save.1 save.2");
        $system("mv -f save save.1");
        $save("save");
        #0 processargs;
    end
endmodule
// The design itself here
module top();
    ....
endmodule
```

Specifying a Long Time Before Stopping The Simulation

You can use the `+vcs+stop+time` runtime option to specify the simulation time when VCS halts simulation. This works if the *time* value you specify is less than 2^{32} or 4,294,967,296. You can also use the `+vcs+finish+time` runtime option to specify when VCS either halts or ends simulation, provided that the time value is less than 2^{32} .

For *time* values greater than 2^{32} , you must follow a special procedure that uses two arguments with the `+vcs+stop` or `+vcs+finish` runtime options, as shown below:

```
+vcs+stop+<first argument>+<second argument>  
+vcs+finish+<first argument>+<second argument>
```

This procedure is as follows:

For example, if you want a time value of 10,000,000,000 (10 billion):

1. Divide the large *time* value by 2^{32} .

In this example:

$$\frac{10,000,000,000}{4,294,967,296} = 2.33$$

2. Narrow down this quotient to the nearest whole number. This whole number is the second argument.

In this example, you would narrow down to 2.

3. Multiply 2^{32} with the second argument (that is, 2), and then subtract the obtained result from the large time value (that is, subtract 2×2^{32} from the large time value), as shown below:

$10,000,000,000 - (2^*4,294,967,296) = (1,410,065,408)$

This difference is the first argument.

You now have the first and second argument. Therefore, in this example, to specify stopping simulation at time 10,000,00,000, you would enter the following runtime option:

```
+vcs+stop+1410065408+2
```

VCS can do some of this work for you by using the following source code:

```
module wide_time;
  time wide;
  initial
  begin
    wide = 64'd10_000_000_000;
    $display("Hi=%0d, Lo=%0d", wide[63:32], wide[31:0]);
  end
endmodule
```

VCS displays:

```
Hi=2, Lo=1410065408
```

How VCS Prevents Time 0 Race Conditions

At simulation time 0, VCS always executes the always blocks where any of the signals in the event control expression, that follows the always keyword (the sensitivity list), initializes at time 0.

For example, consider the following code:

```
module top;
```

```

reg rst;
wire w1,w2;
initial
rst=1;
bottom bottom1 (rst,w1,w2);
endmodule

module bottom (rst,q1,q2);
output q1,q2;
input rst;
reg rq1,rq2;

assign q1=rq1;
assign q2=rq2;

always @ rst
begin
rq1=1'b0;
rq2=1'b0;
$display("This always block executed!");
end
endmodule

```

With other Verilog simulators there are two possibilities at time 0:

- The simulator executes the initial block first, initializing `reg rst`, then the simulator evaluates the event control sensitivity list for the `always` block and executes the `always` block because the simulator initialized `rst`.

The simulator evaluates the event control sensitivity list for the `always` block, and so far, `reg rst` has not changed value during this time step, therefore, the simulator does not execute the `always` block. Then the simulator executes the `initial` block and initializes `rst`. When this occurs, the simulator does not re-evaluate the event control sensitivity list for the `always` block.

5

Diagnostics

This chapter covers various diagnostic tools and provides instructions on how to use these tools.

The following tasks are covered in this chapter:

- “Using Diagnostics” on page 2
- “Compile-time Diagnostics” on page 5
- “Runtime Diagnostics” on page 12
- “Post-processing Diagnostics” on page 25

Using Diagnostics

This section describes the following topics:

- “[Using -diag Option](#)”
 - “[Using Smartlog](#)”
-

Using -diag Option

Use the `-diag` option to enable the libconfig/timescale diagnostic messages at compile-time and VPI/VHPI diagnostic messages at runtime. The `-diag` option supports compile-time diagnostics on the `vcs` command-line and runtime diagnostics on the `simv` command-line.

Syntax

Below is the syntax of the `-diag` option:

```
-diag <diag_arg>[,diag_arg] [,diag_arg] ..
```

Where, `diag_arg` is a diagnostic argument. [Table 5-1](#) lists the supported diagnostic arguments.

Table 5-1 Supported Diagnostic Arguments

Argument	Use Model	Description
libconfig	vcs -diag libconfig	Enables the library binding diagnostics. For more information, see “ Libconfig Diagnostics ”.
timescale	vcs -diag timescale	Enables timescale diagnostics. For more information, see “ Timescale Diagnostics ”.
vpi	simv -diag vpi	Enables VPI diagnostics. For more information, see “ Diagnostics for VPI PLI Applications ”.
all	vcs -diag all	Enables the libconfig and timescale diagnostics.
	simv -diag all	Enables the vpi diagnostics.
help	vcs -diag help simv -diag help	Displays the following help message: Usage for -diag flag: -diag <option>,<option>,... Options: all Enable all diagnostics help Display this message libconfig Library binding diagnostics (compile time) timescale Timescale diagnostics (compile time) vpi VPI diagnostics (simulation time) vhpi VHPI diagnostics (simulation time)

Using Smartlog

DVE Smartlog provides log analysis (diagnostic information) for each line in the log file. It takes the compile log and simulation log created by VCS and summarizes the data into reports. Smartlog provides the diagnostic information in a separate log file known as a smartlog file. Following are the main features of Smartlog:

- Hyperlink the log occurrences to the Source View
- Highlights the words, namely, Error, Warning, and so on, in different colors
- Displays the selected message within a blue rectangle

For more information, refer to the [*Using Smartlog*](#) section of the *Discovery Visual Environment User Guide* category in the VCS Online Documentation.

Compile-time Diagnostics

This section describes the following topics:

- “Libconfig Diagnostics”
 - “Timescale Diagnostics”
-

Libconfig Diagnostics

You can use the `libconfig` option, as shown below, to enable libconfig diagnostics:

```
vcs -diag libconfig
```

This option provides the library binding diagnostics at compile-time. It generates physical mappings of user-defined libraries and the default work library specified by VCS.

For each VHDL/Verilog instance, this option generates the instance name, location, binding rule, and entity-architecture pair/module to which it is bound.

Example

Consider the following test case:

```
leaf.vhd
=====
entity leaf is
end entity leaf;

architecture behv of leaf is
begin
```

```

end architecture;

mid.vhd
=====
entity mid is
end entity mid;

architecture behv of mid is
  component leaf
    end component leaf;
begin
  a0:          leaf;
end architecture;

top.v
=====
module top();
  mid inst1 ();
endmodule

```

Perform the following commands:

```

vhdlan leaf.vhd -work lib1
vhdlan mid.vhd -work lib1
vlogan top.v -work lib2
vcs top -diag libconfig -l log

```

Following is the output:

```

Setup library mapping:
  DEFAULT : /remote/vtghome13/diag./work/
  LIB1 : /remote/vtghome13/diag./lib/
  LIB2 : /remote/vtghome13/diag./lib/
Work logical library name set to 'DEFAULT'.
Default library search order:
  DEFAULT
  LIB1

```

```

instance: LIB1.top
          "/remote/vtghome13/diag/top.v", 1
rule: Top Module
module: LIB1.top
          "/remote/vtghome13/diag/top.v", 1

Top Level Modules:
top
instance: top.inst1
          "/remote/vtghome13/diag/top.v", 3
rule: Direct Instantiation
entity: LIB1.MID
          "/remote/vtghome13/diag/mid.vhd", 3
architecture: BEHV
          "/remote/vtghome13/diag/mid.vhd", 6

instance: top.inst1.A0
          "/remote/vtghome13/diag/mid.vhd", 10
rule: Default Binding
entity: LIB1.LEAF
          "/remote/vtghome13/diag/leaf.vhd", 4
architecture: BEHV
          "/remote/vtghome13/diag/leaf.vhd", 7

```

Note:

- If VCS option **-l** is specified, the output is dumped into the corresponding text log file.
- If VCS option **-sml** is also specified, smart log output will also be dumped into the corresponding smart log file. For more information, refer to the [Using Smartlog](#) section of the *Discovery Visual Environment User Guide* category in the VCS Online Documentation.

Timescale Diagnostics

You can use the `timescale` option, as shown below, to enable timescale diagnostics:

```
vcs -diag timescale
```

This option generates timescale diagnostic message for each module during VCS elaboration phase.

This allows you to understand how VCS has scaled delays in its design, and helps to quickly identify, localize and fix the timescale issues.

Note:

- The output will be printed on the `STDOUT` by default.
- If VCS option `-l` is specified, the output is dumped into the corresponding text log file.
- If VCS option `-sml` is also specified, smart log information will also be dumped into the corresponding smart log file. For more information, refer to the [Using Smartlog](#) section of the *Discovery Visual Environment User Guide* category in the VCS Online Documentation.

Example

Example 1: Module has `timescale

Consider the following test case `test.v`, which contains module `test` with ``timescale as 1ns/1ns`:

```
`timescale 1ns/1ns
module test;
```

```
initial  
$printtimescale;  
endmodule
```

Enabling timescale diagnostics at elaboration time using -diag timescale:

```
vcs test.v -diag timescale
```

Following is the output:

```
Parsing design file 'test.v'  
Top Level Modules:  
    test  
TimeScale is 1ns/1ns  
module 'test' gets time unit '1ns' from source code '/remote/  
vgscratch7/timescale_diag/tests/cft/sva_bind/l1_svbs/  
Source/test.v', 1  
module 'test' gets time precision '1ns' from source code '/  
remote/vgscratch7/timescale_diag/tests/cft/sva_bind/  
l1_svbs/Source/test.v', 1  
Starting vcs inline pass...  
1 module and 0 UDP read.  
recompiling module test  
if [ -x ..//simv ]; then chmod -x ..//simv; fi  
g++ -o ..//simv -melf_i386 -m32 -Wl,-whole-archive -  
Wl,-no-whole-archive _vcsobj_1_1.o 5NrI_d.o  
...  
..//simv up to date
```

From the above output, you can figure out which module gets what timescale at elaboration, and also the reason why and from where the module got that timescale.

```
module 'test' gets time unit '1ns' from source code '/remote/  
vgscratch7/timescale_diag/tests/cft/sva_bind/l1_svbs/  
Source/test.v', 1  
module 'test' gets time precision '1ns' from source code '/  
remote/vgscratch7/timescale_diag/tests/cft/sva_bind/  
l1_svbs/Source/test.v', 1
```

In the above example, as mentioned `timescale 1ns/1ns on line# 1, so module has got the timeunit of 1ns and timeprecision of 1ns.

Example 2: Passing -timescale from vcs command-line

Consider the following testcase test.v:

```
module test;
initial
$printtimescale;
endmodule
```

Perform the following command:

```
vcs test.v -diag timescale -timescale=1ns/1ns
```

Following is the output:

```
Parsing design file test.v
Top Level Modules:
    test
TimeScale is 1ns/1ns
module 'test' gets time unit '1ns' from vcs command option
module 'test' gets time precision '1ns' from vcs command
option
Starting vcs inline pass...
1 module and 0 UDP read.
recompiling module test
if [ -x ..//simv ]; then chmod -x ..//simv; fi
g++ -o ..//simv -melf_i386 -m32      -Wl,-whole-archive      -
-Wl,-no-whole-archive _vcsobj_1_1.o  5NrI_d.o
...
..//simv up to date
```

In the below command, you are passing timescale at elaboration using the -timescale option.

```
vcs test.v -diag timescale -timescale=1ns/1ns
```

So the diagnostics message printed on the output is:

```
module 'test' gets time unit '1ns' from vcs command option
module 'test' gets time precision '1ns' from vcs command
option
```

Runtime Diagnostics

This section describes the following topics:

- “[Diagnostics for VPI PLI Applications](#)”
 - “[Keeping the UCLI/DVE Prompt Active After a Runtime Error](#)”
 - “[Diagnosing Quickthread Issues in SystemC](#)”
-

Diagnostics for VPI PLI Applications

As per LRM, VPI remain silent when an error occurs. The application checks for error status to report an error. If error detection mechanisms are not in place, the C code of the application must be modified and recompiled. In addition, you may need to recompile the HDL code, if required.

However, you can use the following new runtime diagnostic option to make the PLI application to report errors without code modification:

- `-diag vpi`

Furthermore, reporting provides you the information related to the HDL code context, where applicable, to help fix problems with a faster turnaround time.

Note:

- If VCS option `-l` is specified, the output is dumped into the corresponding text log file.

- If VCS option `-sml` is also specified, smart log information will also be dumped into the corresponding smart log file. For more information, refer to the [Using Smartlog](#) section of the *Discovery Visual Environment User Guide* category in the VCS Online Documentation.

For example, consider the following test case `tokens.v`:

Example 5-1 tokens.v

```

module top;
    reg r;

    initial begin
        #5;
        $putValue("sys_top.rst", 1'b1);

        #1 $finish;
    end
endmodule

module sys_top;
    wire rst;

    assign db.A = rst;
endmodule

module db;

    wire Y;
    wire A;

    my_buf b1(Y, A);

    initial begin
    end
endmodule

module my_buf(Y, A);
    output Y;

```

```
input      A;  
  
buf #5 (Y, A);  
endmodule
```

Compile the tokens.v code shown in [Example 5-1](#), as follows:

```
% vcs -sverilog +vpi -P value.tab value.c tokens.v
```

Run the tokens.v code, as follows:

```
simv -diag vpi
```

Here, the user application tries to write a value on the sys_top.rst signal, but there is no write permission enabled on sys_top. So VPI generates an error message and prints the HDL information, as follows:

```
Error-[VPI-WPNEN] VPI put value error  
At time 5, in PLI routine called from tokens.v, 6  
In vpi_put_value call, write permission not enabled.  
Please add capability 'wn' to signal 'sys_top.rst' of module 'sys_top'.  
Please refer to the VCS User Guide, Section 'Specifying ACC Capabilities  
PLI functions' in the chapter 'Using PLI' for further details.  
  
At time 5, in the PLI application '$putValue' called from tokens.v, 6:  
    vpiSeverity - vpiError  
    PLI Routine - vpi_put_value  
    Reference Object - rst  
    Reference Scope - sys_top  
    Reference vpiType - vpiNet  
    Path - /remote/us01/home17/[REDACTED]/12-09/VPI_EM/tokens.v, 14  
    Delay Propagation Method - 1
```

Keeping the UCLI/DVE Prompt Active After a Runtime Error

VCS now allows you to debug an unexpected error condition by not exiting and keeping active the UCLI or DVE prompt for debugging commands.

In previous releases, when there was a runtime error condition the simulation exited. Starting this release the DVE or UCLI command prompt remains active when there is an error condition, allowing you to examine the current simulation state (the simulation stack, variable values, and so on) so you can debug the error condition.

UCLI Use Model

If simv is executed from the UCLI, follow the below steps to enable this feature:

1. Specify the following UCLI configuration command in a Tcl file (see [Example 5-3](#)) or in `$HOME/.synopsys_ucli_prefs.tcl` file:

```
config -onfail enable [failure_type]
```

Where the `failure_type` is optional. It allows you to specify the failure type. [Table 5-1](#) lists the types of failures which are normally observed during an unexpected runtime error.

Table 5-2 Types of Failures

Failure Type	Failure Description
sysfault	Assertion or signal (including segfault)
{error <regex>}	Error for which the tag matches regex. The tag of an error can be seen in the error message (Error-[TAG]).
fatal	Fatal error for which VCS currently dumps a stack trace.
all	All failures (default)

Note:

- You can divide configuration of onfail into multiple configuration commands.
- You can use the config -onfail disable configuration command to disable this feature.

Example

The following command enables you to catch for system faults, DT.* errors, and NOA errors:

```
config -onfail enable sysfault {error DT.*}
{error NOA}
```

You can also specify the above command as three different configuration commands:

```
config -onfail enable sysfault
config -onfail enable {error DT.*}
config -onfail enable {error NOA}
```

2. Use the following UCLI command to get a UCLI prompt when a runtime error occurs:

```
% simv -ucli -i file_name.tcl
```

or

```
simv -ucli
```

```
ucli% do file_name.tcl
```

Where *file_name.tcl* is the Tcl file that contains the config -onfail enable command and run script (see [Example 5-3](#)).

Note:

You must run the simulation using the `run` command by specifying it in a Tcl file. You can also specify the `config -onfail enable` command in the same Tcl file, but instead, if you use `simv -ucli` at the UNIX prompt to run the simulation, then UCLI exits when there is a failure.

Automating User Actions on Failure

You can create the `onfail` routine to automate some actions (like printing specific message, collecting data into a file, and so on) when an unexpected crash happens during runtime. You can create this routine in your script or in the `.synopsys_ucli_prefs.tcl` file.

If you declare this routine, and the `onfail` configuration is enabled, then `simv` will call the `onfail` routine before going into the UCLI prompt. If you do not want to go into the UCLI prompt, you can call the UCLI `exit` command from that routine.

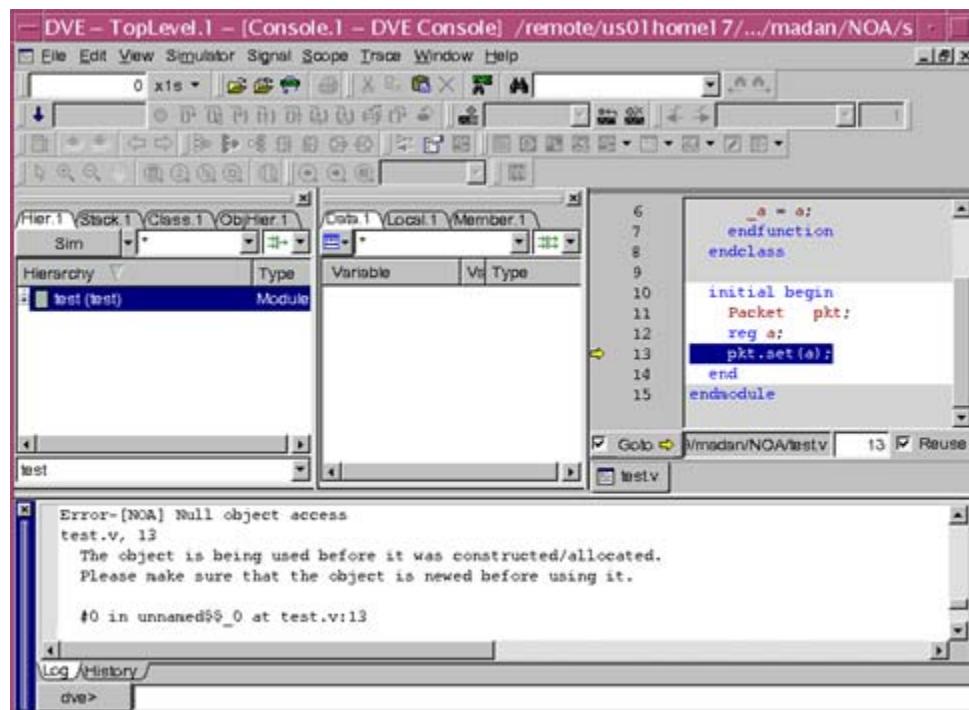
DVE Use Model

By default, DVE enables the `onfail` configuration on all types of failures.

DVE systematically enables the onfail config on all error types. In previous versions, if there is error or failure, simv stops, and many DVE functionalities like expand hierarchy, show data for a given module (if not already loaded before the simv crash), create schematic, do not work, especially when DVE is running with the preference option “Use simulation as design debug library in interactive.”

From this version, If you enable the onfail config, simv stays active and continue to respond to DVE queries. Therefore, all the features mentioned in the previous paragraph continue to work. Also, DVE shows the location of the error with the simulation pointer (yellow arrow in the source view), and the stack pane shows the current HDL stack. You can use value annotation to obtain signal values in order to debug the issue.

Figure 5-1 The DVE Prompt After a Runtime Error



UCLI Usage Example

Consider the following test case `test.v`. This code causes simv to exit during simulation:

Example 5-2 UCLI Prompt on Error Test Case (test.v)

```
module test;
    class Packet;
        int _a;

        function void set (int a);
            _a = a;
        endfunction
    endclass

    initial begin
        Packet pkt;
        reg a;
        pkt.set(a);
    end
endmodule
```

Compile the `test.v` file:

```
% vcs -sverilog -debug_all test.v
```

If you run the above test case using the `simv -ucli` command, then VCS generates the following NOA error message:

Figure 5-2 NOA Error Message

```
Error-[NOA] Null object access
test.v, 13
The object is being used before it was constructed/allocated.
Please make sure that the object is newed before using it.

#0 in unnamed$$_0 at test.v:13
#1 in test

          V C S   S i m u l a t i o n   R e p o r t
Time: 0
CPU Time:      0.790 seconds;           Data structure size:   0.0Mb
Mon Jan 23 02:59:51 2012
```

Create the following Tcl file to catch the above error and analyze it inside an `onfail` routine:

Example 5-3 Tcl File (test.tcl)

```
onfail {
    set err_msg "Stopped in "
    append err_msg [scope]
    puts $err_msg
}
config -onfail enable {error NOA}
run
```

Run the `test.tcl` file using the following command to keep the UCLI prompt active after the NOA error, as shown in [Figure 5-3](#):

```
simv -ucli -i test.tcl
```

Figure 5-3 Viewing the UCLI Prompt After Failure

```
ucli% config -onfail enable {error NOA}
ucli% run

Error-[NOA] Null object access
test.v, 13
The object is being used before it was constructed/allocated.
Please make sure that the object is newed before using it.

#0 in unnamed$$_0 at test.v:13
#1 in test

file test.tcl, line 7: System Fault
Stopped in test

Pause in file test.tcl, line 7
pause% █
```

The onfail routine is executed after the NOA error is generated.

Limitations

- You cannot specify an onfail routine to be executed on error in DVE.

Diagnosing Quickthread Issues in SystemC

VCS is now equipped with a better mechanism to report VCS runtime crashes caused by certain problems with quickthreads used during VCS runtime. You will get clear feedback as to what went wrong and which thread is causing the crash thereby enabling you to take specific action to circumvent the issue.

Note: VCS reports these error messages for the DPI crashes also, not just SystemC.

VCS reports these runtime crashes in the following two scenarios:

- A quickthread overruns its allocated stack
- Simulation runs out of memory due to quickthread stacks

Note: The default stack size has been changed from 60KB to 1MB while the default stackguard size has been changed from 4KB to 16KB from this release onwards.

Quickthread Overruns Its Allocated Stack

If a quickthread overruns its allocated stack, then it will probably try to read/write into its redzone. This causes an SEGV with the following diagnostic message. Here is an example:

Error - [VCS-QTHREAD-OVERRUN] Stack of quickthread maybe too small

The simulation received a fatal segmentation violation signal SEGV and will end, because it accessed protected stack guard memory. This memory belongs to the thread 'top.ref_model_0.cpu.ALU'. It is likely, but not certain that a stack overflow in this thread caused the segmentation violation (SEGV). It may also be caused by a different, unknown problem and the quickthread is not related.

The suspected quickthread belongs to SystemC domain. Its stack has a size of 60 K bytes and is located from address '0x800a00000' to '0x800a0efff'.

Its redzone has a size of 4 K bytes and is located from address '0x800a0f000' to '0x800a0ffff'.

The SEGV happened at address '0x800a0f004' which is 5 bytes into the redzone.

Increase the stack size for this thread and check whether this solves the problem. This can be done by calling the `stack_size()` method within the SC_CTOR. Alternatively, start the simulation with '`simv -sysc=stacksize:10M`'. See the VCS user guide, chapter SystemC for more information.

A similar message will be printed if the redzone belongs to the stack of a DPI thread.

Limitations

The VCS-QTHREAD-OVERRUN diagnostic applies only to quickthreads. It is not available if you use POSIX threads in SystemC by defining environment `SYSC_USE_PTHREADS`.

Simulation Runs Out of Memory Due to Quickthread Stacks

Each quickthread allocates memory for its stack. Simv may run out of memory due to this. When allocation of memory for a SystemC stack of a quickthread fails, a message like the following is printed:

```
Error- [SC-VCS-QTHREAD-ALLOC] Thread memory allocation failed
      The creation of thread 'top.sc_thread_04' in the SystemC
      domain failed
      because its stack of 64MB could not be allocated. Currently,
      149MB stack
      memory are allocated by 95 threads.

      Details about stack allocation:
      (sorted by size in decreasing order)
      32MB total (31.9MB stack + 19.9KB guard) in
      SystemC:top.sc_thread_05
      16MB total (15.9MB stack + 19.9KB guard) in
      SystemC:top.sc_thread_06
      8.01MB total (7.99MB stack + 19.9KB guard) in
      SystemC:top.sc_thread_07
      (~50 lines removed, we show approx. 50..60 stack frames
      , ordered by size, largest first)
      ... (truncated) ...
      Total: 149MB qthread stack memory used in 95 threads.

      If this was a 32 bit simulation, consider a 64 bit
      simulation. You can also
      decrease the stack size for other threads. This can be
      done by calling the
      stack_size() method within the SCCTOR. Alternatively,
      start the simulation
```

with e.g. 'simv -sysc=stacksize:500k'. See the VCS user guide, chapter Using SystemC for more information.

Reducing or Turning Off Redzones

You can decrease the number of redzones or turn them off altogether in case if the number of quickthreads you are using is exceedingly large. For instance, if the quickthreads are reaching the limit set in your OS, then some of the operations may fail. To avoid such a situation, you may want to decrease the number of the redzones or turn them off completely. Though the diagnostic support will not be there when a particular thread overruns its stack, you would still increase the chances of running your simulation without any issues.

You can use the following environment variable to either decrease the number of redzones or turn them off completely. To decrease the number of redzones, you must set the following environment variable to a value greater than 2000 and less than 30000. For example:

```
setenv SNPS_VCS_SYSC_RESERVED_MAP_COUNT 10000
```

Setting the above environment variable to a value higher than 30000 will turn off the redzones completely.

Post-processing Diagnostics

This section describes the following topic:

- “[Using the vpdutil Utility to Generate Statistics](#)”

Using the vpdutil Utility to Generate Statistics

The vpdutil utility generates statistics about the data in the vpd file. The utility takes a single vpd file as input. You can specify options to this utility to query at design, module, instance, and node levels.

This utility supports time ranges and input lists for query on more than one object. Output will be in ascii to stdout with option to redirect to an output file.

The vpdutil Utility Syntax

The syntax of the vpdutil utility is as follows:

```
vpdutil <input_vpd_file>
    [-help]
    [-vc_info]
    [-tree [-lvl <level>] [-source]]
    [-vc_info_detail]
    [-info]
    [-design]
    [-find_forces]
    [-start <Time> -end <Time>]
    [-find_glitches]
    [output_file_name]
```

Options

`-h/help`

Displays the options to be used with the vpdui application.

`output_file_name`

Writes the output of vpdui application to a file instead of stdout.

Options for VPD File Information

`-info`

Prints the basic information present in the header of vpd file.

Options for Design Information

`-design`

Prints statistics about static design hierarchy in vpd.

`-tree`

Prints the full hierarchy tree in the vcd-like (not vcd compatible) format.

`-lvl <level>`

Print the tree with the hierarchy depth=level.

`-source`

Prints source file/line data to tree.

Options for Value Change Information

`-vc_info`

Displays information for the value changes information with number of dump off events, force events, glitch events, and repeat count events.

-vc_info_detail

Prints the detailed value change summary statistics about given vpd file.

-find_forces

Displays forces on node and the times when forces occurred.

-start <Time> -end <Time>

Enables the collection of value change data between start time to end time.

-find_glitches

Print the list of nodes with glitches and the time when glitches occurred, if the glitch capturing was enabled during the simulation.

6

VCS Multicore Technology Application Level Parallelism

VCS Multicore Technology takes advantage of the computing power of multiple processors in one machine to improve simulation turnaround time.

Use the following VCS Multicore Technology options in a simulation:

- Assertion simulation
- Toggle coverage
- Multicore functional coverage
- VPD dumping
- SAIF dumping

VCS Multicore Technology Options

You use the VCS `-parallel` option to invoke parallel compilation. The syntax is:

```
vcs filename(s).v -parallel [ +multicore_option(s) ]  
[ -parallel+show_features ] [-o multicore_executable_name]  
[ vcs-options ]
```

These options and properties are as follows:

`-parallel`

When used without VCS Multicore options, `-parallel` enables all VCS Multicore Technology options. When used with VCS Multicore options, `-parallel` enables only those option specified.

This option is available at compile-time only.

`fc [=NCONS]`

This compile-time option enables multicore Functional Coverage, and with `NCONS` specifies the number of PFC consumers. `NCONS` can be changed at run time. For example,

```
vcs -parallel+fc ...  
vcs -parallel+fc=3 ...
```

`+sva [=NCONS]`

This compile-time option enables multicore SVA, and with `NCONS` specifies the number of multicore SVA consumers. `NCONS` can be changed at run time.

`+saif`

Enables SAIF file dumping, see “[Parallel SAIF](#)” .

+tgl [=NCONS]

Enables multicore Toggle Coverage, and specifies the number of multicore toggle coverage consumers. To enable the use of the same executable for both serial and parallel runs, use this option at runtime.

NCONS specifies the number of multicore SVA consumers. For ALP, NCONS can be changed at run time.

+vpd [=NCONS]

Enables multicore VCD+ Dumping. NCONS specifies the number of multicore SVA consumers. For ALP, NCONS can be changed at run time

[-o *multicore_executable_name*]

Using the VCS -o option to specify the simulation executable binary filename allows work on multiple simultaneous VCS Multicore compiles and runs. VCS Multicore-specific data is stored in a directory *executable_name.pdaidir*. The default path name is *simv.pdaidir*.

Note:

If [NCONS] is not specified, the default is 1 client. For ALP, NCONS can be changed at run time.

-parallel+show_features

Displays enabled VCS Multicore features. Note that you must enter the -parallel option with +show_features

Examples:

-parallel+vpd is equal to -parallel+vpd=1
-parallel+tgl is equal to -parallel+tgl=1

VCS Multicore option examples:

```
vcs -parallel+fc .... -o psimv
vcs -parallel+vpd+fc -parallel+tgl -o par_simv ....
```

```
vcs -parallel+design=part.cfg+sva ....
```

Use Model for Assertion Simulation

1. Run VCS Multicore compilation specifying the `sva` option.
 2. Run VCS Multicore simulation.
-

Use Model for Toggle and Functional Coverage

1. Run VCS Multicore compilation specifying the VCS Multicore `tgl` option and coverage metric options for toggle coverage, and/or the VCS Multicore `fc` option for functional coverage. You can optionally specify the number of consumers for each.
 2. Run the simulation to generate coverage results.
 3. Generate coverage result reports.
-

Use Model for VPD Dumping

1. Run VCS Multicore compilation specifying the `vpd` option.
2. Run the simulation to generate the VPD file.

Running VCS Multicore Simulation

VCS Multicore Technology takes advantage of the computing power of multiple processors to improve simulation turnaround time

You can generate results for one of all the following VCS Multicore Technology options in a simulation:

- Assertion simulation
- Toggle coverage
- Functional coverage
- VPD file generation

Assertion Simulation

You can process only assertion level results or assertion level results along with other VCS Multicore options.

1. Compile using the VCS Multicore `-parallel` option, the assertion compilation option or options, and other VCS Multicore and VCS options.

```
vcs filename(s).v -parallel+ [sva [=NCONS] ]  
[-ntb_opts] [ multicore_options vcs_options ]
```

2. Run the simulation with VCS and VCS Multicore run-time options.

```
simv
```

Toggle Coverage

Generate results for only toggle coverage or toggle coverage along with other results by compiling the design with VCS Multicore options that include the `+tgl` option and VCS coverage metrics options. You can use the `+count` option to report total executed transactions. After generating coverage results, you can examine them using the Unified Report Generator.

Note:

To enable the use of the same executable for both serial and parallel runs, use this option at runtime.

`tgl [+count]`

Report total executed transactions.

1. Compile using the VCS Multicore `-parallel` option, coverage option or options, and other VCS Multicore and VCS options.

```
vcs filename(s).v -parallel+tgl[=NCONS] -cm tgl  
[multicore_options] [vcs_options]
```

2. Run the simulation to generate coverage results.

```
simv -vdb tgl [vcs_options]
```

3. Generate coverage result reports:

```
urg -dir coverage_directory.vdb urg_options
```

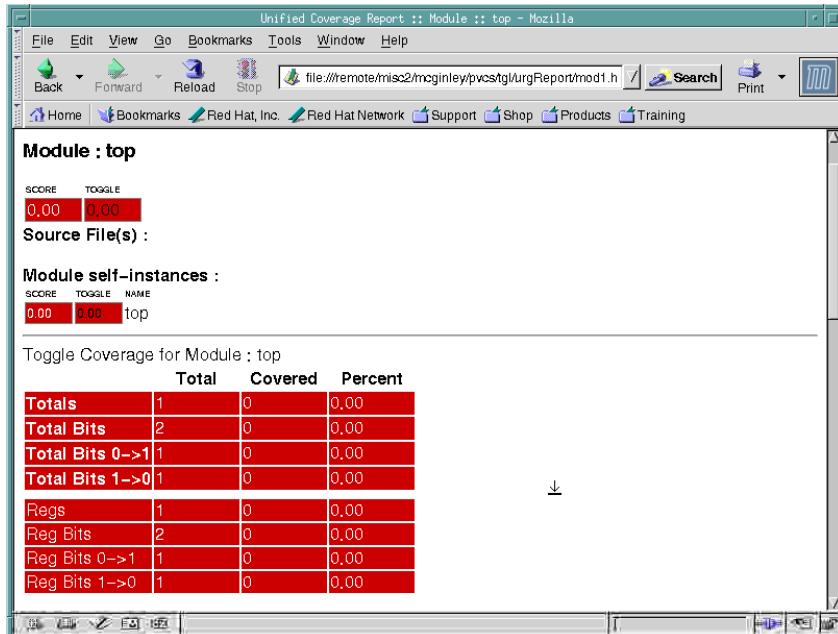
Example

In this example, toggle coverage results only are generated and the URG report is produced in the default HTML format.

```
% vcs -cm_tgl mda -q -cm_dir pragmaTest1.vdb -cm tgl -  
sverilog -parallel+tgl=2 pragmaTest1.v  
% simv -vdb tgl
```

```
% urg -dir pragmaTest1.vdb
```

Results can then be examined in your default browser.



Functional Coverage

Generate results for only functional coverage or functional coverage along with other results by compiling the design with VCS Multicore options that include the `+fc` option and VCS coverage metrics options. After generating coverage results, you can examine them using the Unified Report Generator.

1. Compile using the VCS Multicore `-parallel` option, coverage option or options, and other VCS Multicore and VCS options.

```
vcs filename(s).v -sverilog -parallel+fc [=NCONS]  
[parallel_vcs_options] [vcs_options]
```

2. Run the simulation to generate coverage results.

```
simv
```

3. Generate coverage result reports:

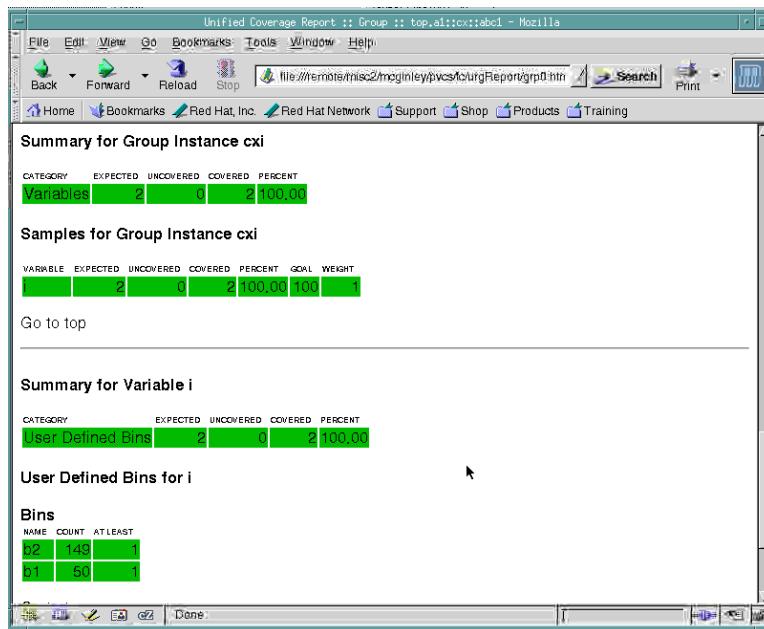
```
urg -dir coverage_directory.vdb urg_options
```

Example

In this example, functional coverage results only are generated and the URG report is produced in the default HTML format.

```
% vcs iemIntf.v -sverilog -parallel+fc=2  
% simv -covg_cont_on_error  
% $urg -dir simv.vdb  
% cat urgReport/gr*  
%
```

Results can then be examined in your default browser.



VPD File

You can enable VCS Multicore VPD+ Dumping and specify the number of VCS Multicore VPD+ consumers using the VCS Multicore `vpd` option. To enable the use of the same executable for both serial and parallel runs, use this option at runtime.

Note:

When used with multiple consumers, VPD file size blow up might be an issue. Use `-parallel+vpd_buffer=<N>`, where N=256, 512 etc.

1. Compile using the VCS Multicore `-parallel` option with the `vpd [=NCONS]` option, and other VCS Multicore and VCS options.

```
vcs filename(s).v -debug_pp -parallel+vpd [=NCONS]  
[multicore_options] [vcs_options]
```

2. Run the simulation.

```
simv
```

You can post-process the results with the generated +VPD database.

Example

In this example, a VPD+ file with three specified consumers is generated.

```
% vcs -debug_pp -parallel+vpd=3 design.v  
% simv
```

Parallel SAIF

SAIF is Switching Activity Interchange Format, a file format for Power Compiler. VCS writes or dumps SAIF files for it.

Parallel SAIF is a feature to improve runtime performance. Parallel SAIF uses the VCS Multicore Application Level Parallelism (ALP) capability for multicore machines. In it Parallel SAIF uses a consumer or slave process to write or dump SAIF files while the simulation is run by the producer or master process.

Serial SAIF dumping, that is having VCS write SAIF files without using the advantage of a multiple processor machine, is of course still supported.

You specify Parallel SAIF with the `-parallel+saif` compile-time or runtime option.

Customary SAIF System Function Entries

Like in serial SAIF, Parallel SAIF first requires you to enter the following system functions in your Verilog code:

```
$set_toggle_region  
$toggle_start  
$toggle_reset  
$toggle_stop  
$toggle_report
```

```
$set_gate_level_monitoring
```

Forward SAIF file read mode is not supported in Parallel SAIF so do not enter the following system functions:

```
$read_lib_saif
```

```
$read_rtl_saif
```

Enabling Parallel SAIF

You enable Parallel SAIF with the `-parallel+saif=1` or just `-parallel+saif` compile-time or runtime option.

If you enabled Parallel SAIF at compile-time and want to disable it at runtime, you can do so with the `-parallel+saif=0` runtime option.

Limitations

Parallel SAIF has the following limitations:

- Parallel SAIF is not implemented for VCS Multicore Design Level Parallelism (DLP).
- Parallel SAIF only works with one consumer or slave process, so for example specifying more than one slave process such as entering `-parallel+saif=2` results in an error condition.
- SAIF file read mode is not implemented for Parallel SAIF.

- Multiple \$toggle_start system tasks are not supported in Parallel SAIF. Only full dump mode is supported, which is one \$toggle_start and \$toggle_stop system task. Entering multiple \$toggle_start system tasks in Parallel SAIF is an error condition.

7

VPD, VCD, and EVCD Utilities

This chapter describes the following:

- “Advantages of VPD”
- “Dumping a VPD File”
- “Dump Multi-dimensional Arrays and Memories”
- “Dumping an EVCD File”
- “Post-processing Utilities”

VCS allows you to save your simulation history in the following formats:

- Value Change Dumping (VCD)

VCD is the IEEE Standard for Verilog designs. You can save your simulation history in VCD format by using the `$dumpvars` Verilog system task.

- VCDPlus Dumping (VPD)

VPD is a Synopsys proprietary dumping technology. VPD has many advantages over the standard VCD ASCII format. See “[Advantages of VPD](#)” for more information. To dump a VPD file, use the `$vcdplus` Verilog system task. See “[Dumping a VPD File](#)” for more information.

- Extended VCD (EVCD)

EVCD dumps only the port information of your design. See “[Dumping an EVCD File](#)” for more information.

VCS also provides several post-processing utilities to:

- Convert VPD to VCD
- Convert VCD to VPD
- Merge VPD Files

Advantages of VPD

VPD offers the following significant advantages over the standard VCD ASCII format:

- Provides a compressed binary format that dramatically reduces the file size as compared to VCD and other proprietary file formats.
- The VPD compressed binary format dramatically reduces the signal load time.
- Allows data collection for signals or scopes to be turned on and off during a simulation run, therefore, dramatically improving simulation runtime and file size.

- Can save source statement execution data. This allows instant replay of source execution in the DVE Source Window.

To optimize VCS performance and VPD file size, consider the size of the design, the RAM memory capacity of your workstation, swap space, disk storage limits, and the methodology used in the project.

Dumping a VPD File

You can save your simulation history in VPD format in the following ways:

- “[Using System Tasks](#)” - For Verilog designs.
 - “[Using UCLI](#)” - For VHDL, Verilog, and mixed designs.
 - “[Using DVE](#)” See the *Discovery Visual Environment User Guide*.
-

Using System Tasks

VCS provides Verilog system tasks to:

- “[Enable and Disable Dumping](#)”
- “[Override the VPD Filename](#)”
- “[Dump Multi-dimensional Arrays and Memories](#)”
- “[Capture Delta Cycle Information](#)”

Enable and Disable Dumping

You can use the Verilog system task `$vcdpluson` and `$vcdplusoff` to enable and disable dumping the simulation history in VPD format.

Note:

The default VPD filename is `vcdplus.vpd`. However, you can use `$vcdplusfile` to override the default filename, see [“Override the VPD Filename”](#).

\$vcdpluson

The following displays the syntax for `$vcdpluson`:

```
$vcdpluson (level/"LVL=integer", scope*, signal*) ;
```

Usage:

level | LVL=integer_variable

Specifies the number of hierarchy scope levels to descend to record signal value changes (a zero value records all scope instances to the end of the hierarchy; the default is zero).

You can also specify the number of hierarchy scope levels using "LVL=*integer_variable*". In this example, the *integer_variable* specifies the level to descend to record signal value changes.

scope

Specifies the name of the scope in which to record signal value changes (the default is all).

```
signal
```

Specifies the name of the signal in which to record signal value changes (the default is all).

Note:

In the syntax, * indicates that the argument can have a list of more than one value (for scopes or signals).

Example 1: Record all signal value changes.

```
'timescale 1ns/1ns
module test ();
...
initial
$vcpluson;
...
endmodule
```

When you simulate the above example, VCS saves the simulation history of the whole design in `vcpluson.vpd`. For information on the use model to simulate the design, see “[Basic Usage Model](#)” on page [17](#).

Example 2: Record signal value changes for scope `test.risc1.alureg` and all levels below it.

```
'timescale 1ns/1ns
module test ();
...
risc1 risc(...);
initial
$vcpluson(test.risc1.alureg);
...

```

```
endmodule
```

When you simulate the previous example, VCS saves the simulation history of the instance `alureg`, and all instances below `alureg` in `vcdplus.vpd`.

\$vcdplusoff

The `$vcdplusoff` task stops recording the signal value changes for specified scopes or signals.

The following displays the syntax for `vcdplusoff`:

```
$vcdplusoff (level | "LVL=integer", scope*, signal*) ;
```

Example 1: Turn recording off.

```
'timescale 1ns/1ns
module test ();
...
initial
begin
    $vcdpluson; // Enable Dumping
    #5 $vcdplusoff; //Disable Dumping after 5ns
    ...
end
...
endmodule
```

The above example, enables dumping at 0ns, and disables dumping after 5ns.

Example 2: Stop recording signal value changes for scope `test.risc1.alu1`.

```
'timescale 1ns/1ns
module test ();
...
initial
begin
```

```

$vcddpluson; // Enable Dumping
$vcddplusoff(test.risc1.alu1); //Does not dump signal value
                                //changes in test.risc1.alu1
...
end
...
endmodule

```

The above example, enables dumping on the entire design. However, \$vcddplusoff disables dumping the instance alu1 and instances below alu1.

Note:

If multiple \$vcddpluson commands cause a given signal to be saved, the signal will continue to be saved until an equivalent number of \$vcddplusoff commands are applied to the signal.

Override the VPD Filename

By default, \$vcddpluson writes the simulation history in the vcdplus.vpd file. However, you can override the default filename by using the system task \$vcddplusfile, as shown below:

```

$vcddplusfile ("filename.vpd");
$vcddpluson();

```

Note:

You must use \$vcddpluson after specifying \$vcddplusfile, as shown above, to override the default filename.

Example:

```

'timescale 1ns/1ns
module test ();
...
initial
begin

```

```

$vcddplusfile("my.vpd"); //Dumps signal value changes
                           //in my.vpd
$vcddpluson; // Enable Dumping
...
end
...
endmodule

```

The above example writes the signal value changes of the whole design in `my.vpd`.

Dump Multi-dimensional Arrays and Memories

This section describes system tasks and functions that provide visibility into multi-dimensional arrays (MDAs).

There are two ways to view MDA data:

- The first method, which uses the `$vcddplusmemon` and `$vcddplusmemoff` system tasks, records data each time an MDA has a data change.

Note:

You should use the compilation option `+memcbk` to use these system tasks.

- The second method, which uses the `$vcddplusmemorydump` system task, stores data only when the task is called.

Syntax for Specifying MDAs

Use the following syntax to specify MDAs using the `$vcddplusmemon`, `$vcddplusmemoff`, and `$vcddplusmemorydump` system tasks:

system_task(Mda [, dim1Lsb [, dim1Rsb [, dim2Lsb [, dim2Rsb

```
[, ... dimNLsb [, dimNRsb] ]]]] );
```

Usage:

`system_task`

Name of the system task (required). It can be `$vcdplusmemon`, `$vcdplusmemoff`, or `$vcdplusmemorydump`.

`Mda`

Name of the MDA to be recorded. It must not be a part select. If there are no other arguments, then all elements of the MDA are recorded to the VPD file.

`dim1Lsb`

Name of the variable that contains the left bound of the first dimension. This is an optional argument. If there are no other arguments, then all elements under this single index of this dimension are recorded.

`dim1Rsb`

Name of the variable that contains the right bound of the first dimension. This is an optional argument.

Note:

The `dim1Lsb` and `dim1Rsb` arguments specify the range of the first dimension to be recorded. If there are no other arguments, then all elements under this range of addresses within the first dimension are recorded.

`dim2Lsb`

This is an optional argument with the same functionality as `dim1Lsb`, but refers to the second dimension.

`dim2Rsb`

This is an optional argument with the same functionality as `dim1Rsb`, but refers to the second dimension.

`dimNLsb`

This is an optional argument that specifies the left bound of the N th dimension.

`dimNRsb`

This is an optional argument that specifies the right bound of the N th dimension.

Note that MDA system tasks can take 0 or more arguments, with the following caveats:

- No arguments: The whole design is traversed and all memories and MDAs are recorded.

Note that this process may cause significant memory usage, and simulation drag.

- One argument: If the object is a scope instance, all memories/MDAs contained in that scope instance and its children will be recorded. If the object is a memory/MDA, that object will be recorded.

Examples

This section provides examples and graphical representations of various MDA and memory declarations using the `$vcdplusmemon` and `$vcdplusmemoff` tasks.

In this example, `mem01` is a three-dimensional array. It has $3 \times 3 \times 3$ (27) locations; each location is 8 bits in length, as shown in [Figure 7-1](#).

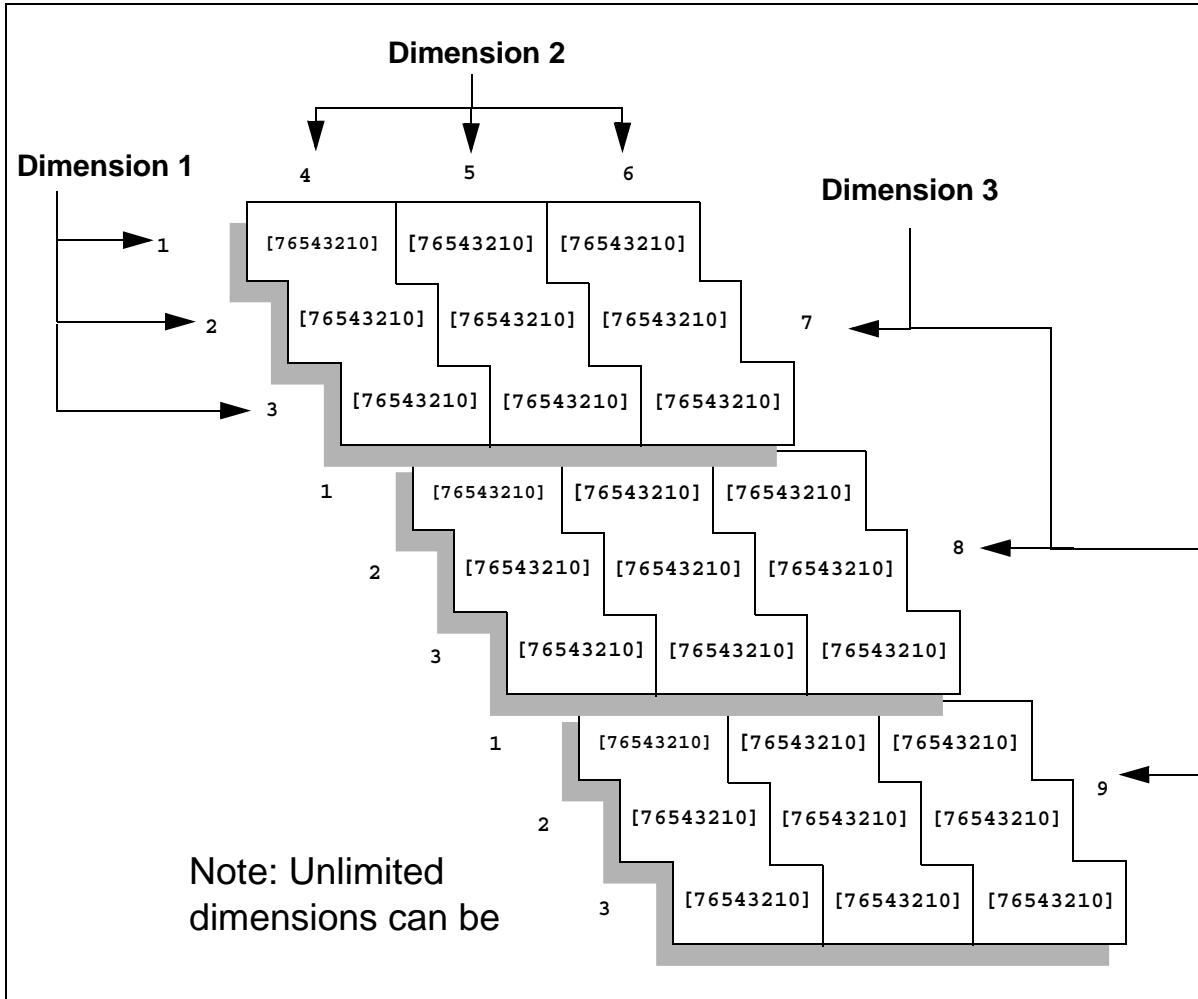
```
module tb();
...
reg [3:0] addr1L, addr1R, addr2L, addr2R, addr3L, addr3R;
reg [7:0] mem01 [1:3] [4:6] [7:9]
...
endmodule
```

Example 1: To dump all elements to the VPD File

```
module test();
...
initial
$vcplusmemon( mem01 );
    // Records all elements of mem01 to the VPD file.
...
endmodule
```

In the above example, `$vcplusmemon` dumps the entire `mem01` MDA.

Figure 7-1 `reg [7:0] mem01 [1:3] [4:6] [7:9]`

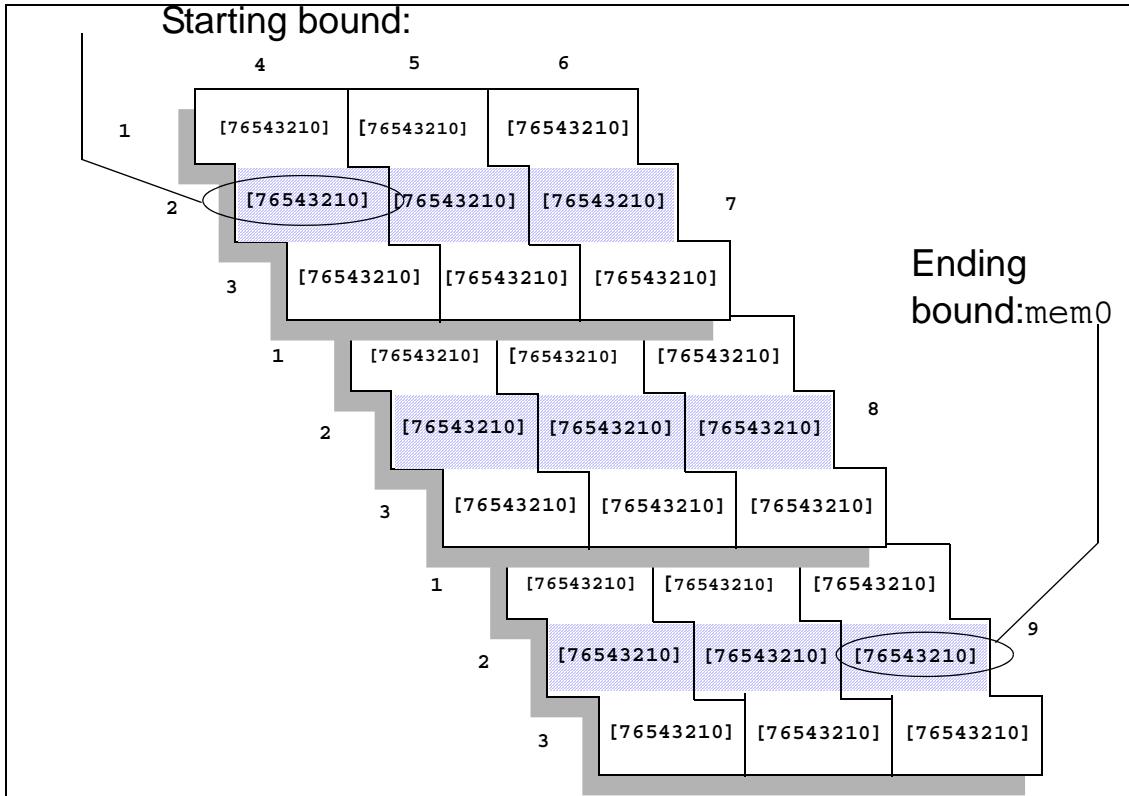


Example 2: Removed variable 'addr1L' and replaced it with constant in the system task

```
module test();
...
initial
begin
    $vcplusmemon( mem01, 2);
    // Records elements mem01[2][4][7] through mem01[2][6][9]
    ...
end
...
endmodule
```

The elements highlighted by the  in the following Figure 7-2, illustrate this example.

Figure 7-2 \$vcplusmemon (mem01, addr1L)

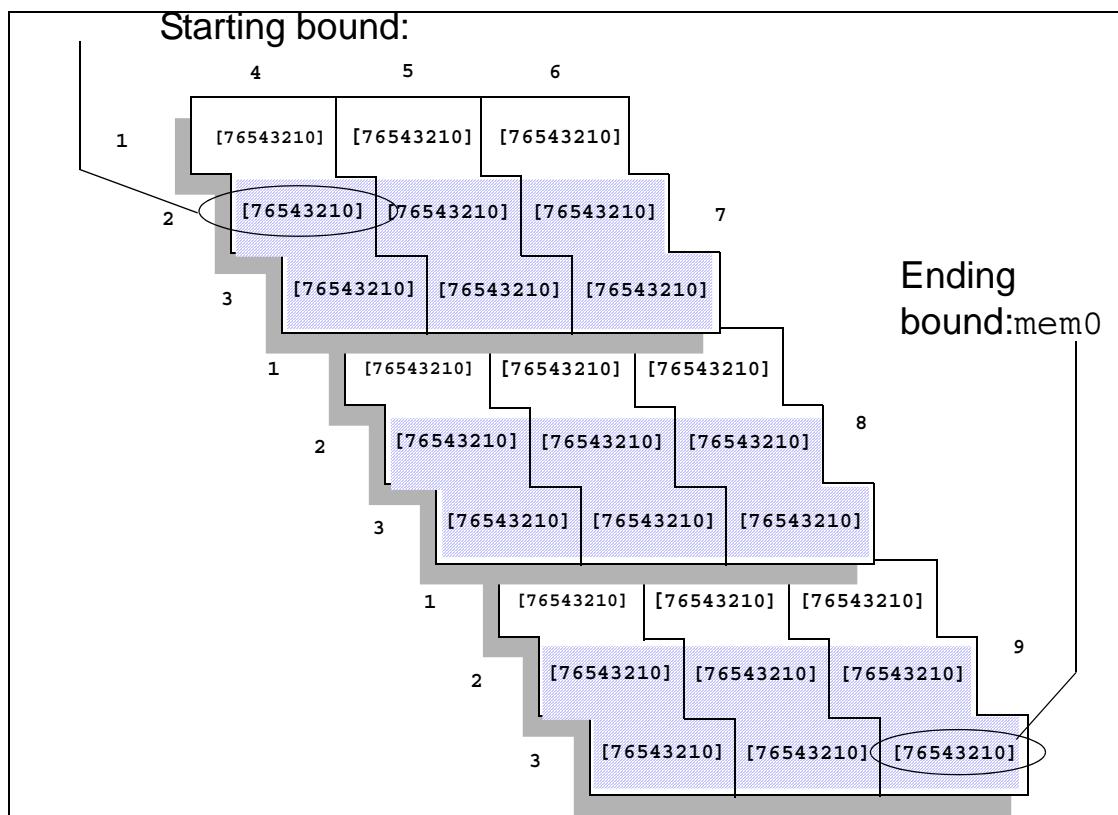


Example 3: Removed variable 'addr1L','addr1R' and replaced them with constants in the system task

```
module test();
...
initial
begin
    $vcplusmemon( mem01, 2, 3);
    // Records elements mem01[2] [4] [7] through mem01[3] [6] [9]
    ...
end
..
endmodule
```

The elements highlighted by the  in the following Figure 7-3, illustrate this example.

Figure 7-3 \$vcplusmemon(mem01, addr1L, addr1R)



Example 4: Removed variable 'addr1L', 'addr1R', 'addr2L' and replaced them with constants in the system task

```
module test();
...
initial
begin
    $vcplusmemon( mem01, 2, 2, 5 );
    // Records elements mem01[2] [5] [7] through mem01[2] [5] [9]
    ...
end
```

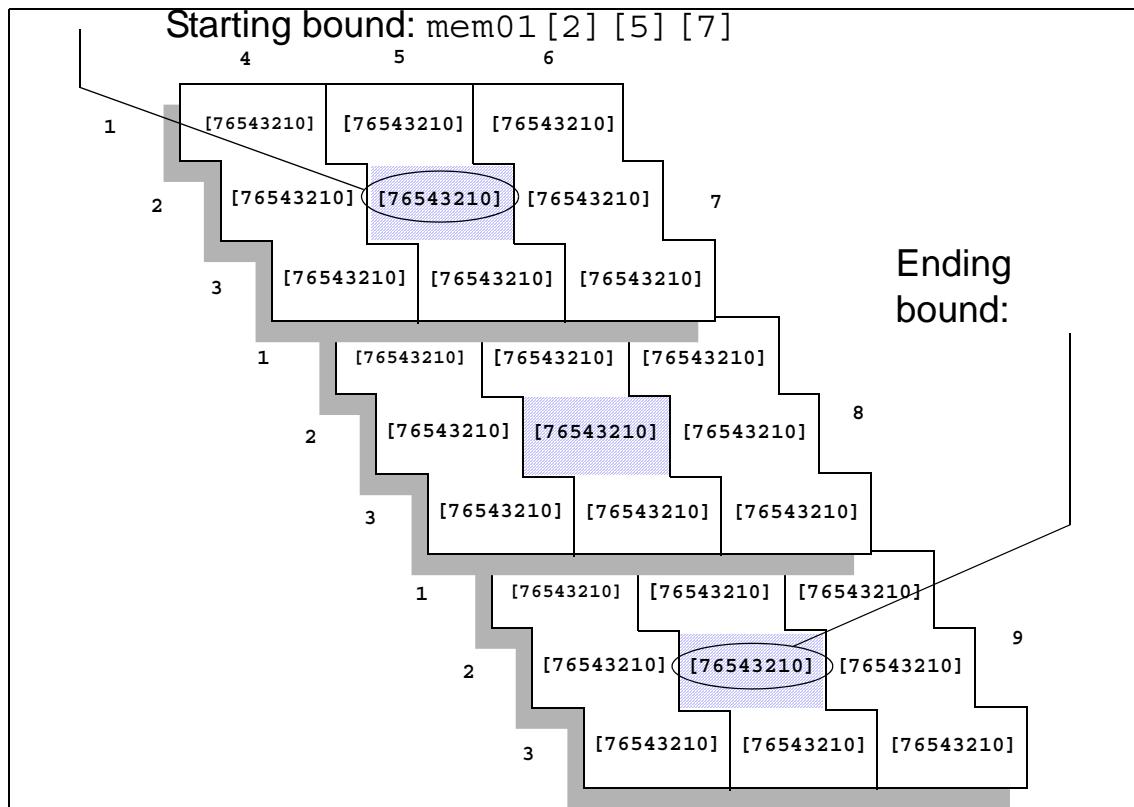
```

...
endmodule

```

The elements highlighted by the  in the following Figure 7-4, illustrate this example.

Figure 7-4 \$vcplusmemon(mem01, addr1L, addr1R, addr2L)



**Example 5: Removed variable
'addr1L','addr1R','addr2L','addr2R','addr3L','addr3R' and
replaced them with constants in the system task**

```

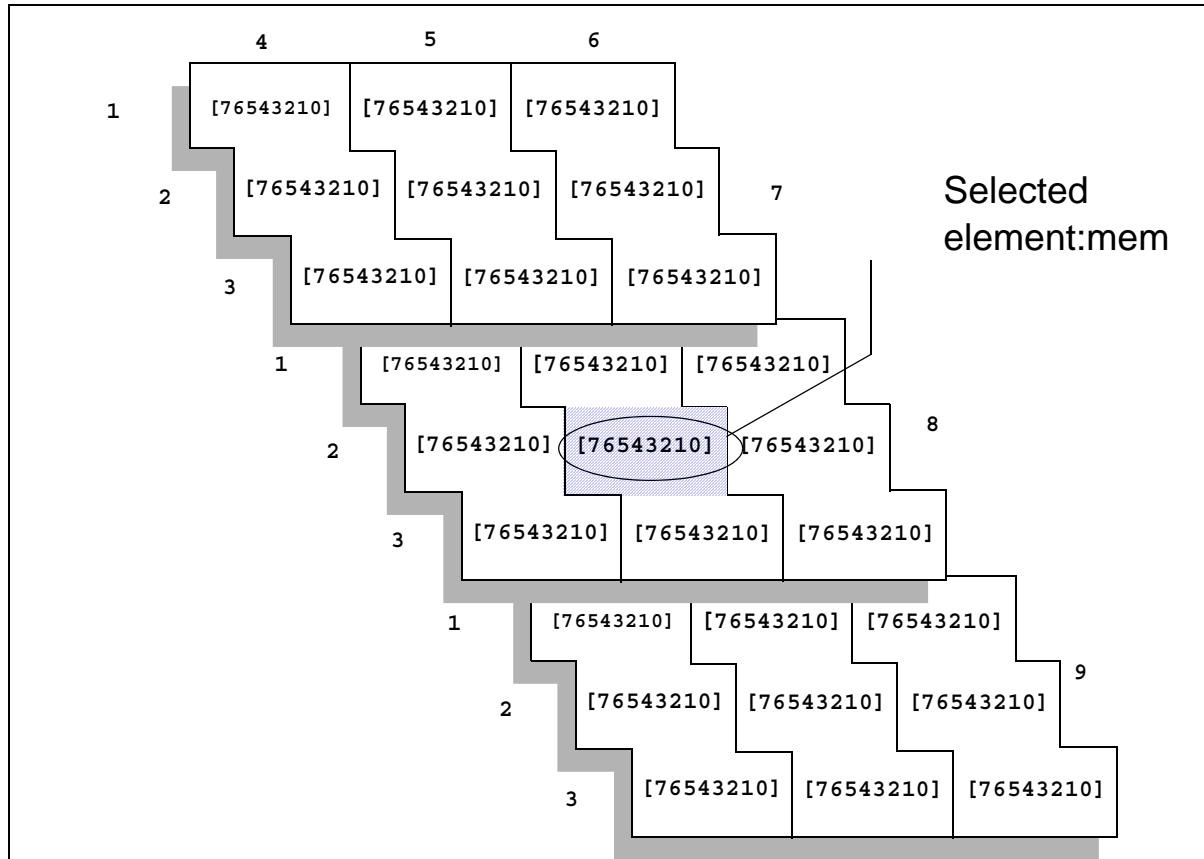
module test();
...
initial
begin
    $vcplusmemon( mem01, 2, 2, 5, 5, 8, 8 );

```

```
// Either command records element mem01[2] [5] [8]
...
end
...
endmodule
```

The elements highlighted by the  in the following [Figure 7-5](#) illustrate this example.

Figure 7-5 `$vcdplusmemon(mem01, addr1L, addr1R, addr2L, addr2R, addr3L, addr3R)`



Using `$vcdplusmemorydump`

The `$vcdplusmemorydump` task dumps a snapshot of memory locations. When the function is called, the current contents of the specified range of memory locations are recorded (dumped).

You can specify to dump the complete set of multi-dimensional array elements only once. You can specify multiple element subsets of an array using multiple `$vcdplusmemorydump` commands, but they must occur in the same simulation time. In subsequent simulation

times, `$vcplusmemorydump` commands must use the initial set of array elements or a subset of those elements. Dumping elements outside the initial specifications results in a warning message.

Capture Delta Cycle Information

You can use the following VPD system tasks to capture and display delta cycle information in the Waveform Window.

\$vcplusdeltacycleon

The `$vcplusdeltacycleon` task enables reporting of delta cycle information from the Verilog source code. It must be followed by the appropriate `$vcpluson`/`$vcplusoff` tasks.

Glitch detection is automatically turned on when VCS executes `$vcplusdeltacycleon` unless you have previously used `$vcplusglitchon/off`. Once you use `$vcplusglitchon/off`, DVE allows you explicit control of glitch detection.

Syntax:

```
$vcplusdeltacycleon;
```

Note:

Delta cycle collection can start only at the beginning of a time sample. The `$vcplusdeltacycleon` task must precede the `$vcpluson` command to ensure that delta cycle collection will start at the beginning of the time sample.

\$vcplusdeltacycleoff

The `$vcplusdeltacycleoff` task turns off reporting of delta cycle information starting at the next sample time.

Glitch detection is automatically turned off when VCS executes \$vcdplusdeltacycleoff unless you have previously used \$vcdplusglitchon/off. Once you use \$vcdplusglitchon/off, DVE allows you explicit control of glitch detection.

Syntax:

```
$vcdplusdeltacycleoff;
```

Dumping an EVCD File

EVCD dumps the signal value changes of the ports at the specified module instance. You can dump an EVCD file, using the following system tasks:

```
$lsi_dumpports
```

For LSI certification of your design, this system task specifies recording a simulation history file that contains the transition times and values of the ports in a module instance.

This simulation history file for LSI certification contains more information than the VCD file specified by the \$dumpvars system task. The information in this file includes strength levels and whether the test fixture module (test bench) or the Device Under Test (the specified module instance or DUT) is driving a signal's value.

Syntax:

```
$lsi_dumpports(module_instance, "filename");
```

Example:

```
$lsi_dumpports(top.middle1, "dumpports.dmp");
```

Instead, if you would prefer to have the `$lsi_dumpports` system task generate an extended VCD (EVCD) file, include the `+dumpports+ieee` runtime option.

```
$dumpports
```

Creates an EVCD file as specified in IEEE Standard 1364-2001 pages 339-340. You can, for example, input a EVCD file into TetraMAX for fault simulation. EVCD files are similar to the simulation history files generated by the `$lsi_dumpports` system task for LSI certification, but there are differences in the internal statements in the file. Further, the EVCD format is a proposed IEEE standard format whereas the format of the LSI certification file is specified by LSI.

Syntax:

```
$dumpports(module_instance, [module_instance,] "filename") ;
```

Example:

```
$dumpports(top.middle1, "dumpports.evcd");
```

If your source code contains a `$dumpports` system task and you want it to generate simulation history files for LSI certification, include the `+dumpports+lsi` runtime option.

Limitations

Following are the limitations for EVCD dumping using `$dumpports` or UCLI command `dump -type EVCD`:

Unsupported Port Types

- For Verilog DUT:
 - Ports can only be of type Verilog-2001. SystemVerilog type ports are not allowed. VCS generates a warning message, if it finds any unsupported port type.
 - SystemVerilog complex types (including MDAs, dynamic arrays, associative arrays, queues, and so on) are not supported, and not legal in LRM. Interface or virtual interface is not supported.
- For ports connected to CCN (`tran/rtran`) directly or hierarchically:
 - They are only supported with `$dumpports` in the Verilog source, and must be known at compile-time. They are not supported with `dump -type EVCD` UCLI command.
 -

Unsupported DUT Types

- DUT cannot be SV program, interface, SystemC, Spice, or Verilog-A.

Unsupported Driver Types

- Since `tran` gates divide a net into different segments, the EVCD behavior might be different in presence of XMR drivers.

- `$deposit`, `force -deposit` (UCLI command) associated with EVCD port is not supported. They are not true drivers, and LRM is silent about the intended behavior.
- If drivers of port are in encrypted region, they are ignored.
- Drivers through virtual interface/nested interface and so on, are not supported.
- High-conn logical expressions are not supported.

SystemC Support

- Each SystemC module is treated like a Verilog shell, and multiple drivers cannot be detected inside SystemC.
- SystemC is not supported as a DUT.

Note:

- All forces will be considered as TB regardless of where the force is applied from (TB, DUT, or UCLI).
- EVCD port associated with SDF timing may not be properly handled. LRM does not specify how the delay has to be handled for various scenarios (whether to add delay on driver side for EVCD and so on).

In case of SDF, value is not same for different net segments of the same net (there is a delay) and whether they should be treated as same net or different net for EVCD purpose. Current behavior is all net segments are treated as part of the same net, all drivers are reported, and driver value change is reported as it occurs in core simulation.

Post-processing Utilities

VCS provides you with the following utilities to process VCD and VPD files. You can use these utilities to perform the following conversions:

- VPD file to a VCD file
- VCD file to a VPD file
- Merge a VPD file

Note:

All utilities are available in `$VCS_HOME/bin`.

This section describes these utilities in the following sections:

- “[The vcdpost Utility](#)”
- “[The vcdiff Utility](#)”
- “[The vcat Utility](#)”
- “[The vcsplit Utility](#)”
- “[The vcd2vpd Utility](#)”
- “[The vpd2vcd Utility](#)”
- “[The vpdmerge Utility](#)”
- “[The vpduil Utility](#)”

The vcdpost Utility

You use the vcdpost utility to generate an alternative VCD file that has the following characteristics:

- Contains value change and transition times for each bit of a vector net or register, recorded as a separate signal. This is called “scalarizing” the vector signals in the VCD file.
- Avoids sharing the same VCD identifier code with more than one net or register. This is called “uniquifying” the identifier codes.

Scalarizing the Vector Signals

The VCD format does not support a mechanism to dump part of a vector. For this reason, if you enter a bit select or a part select for a net or register as an argument to the \$dumpvars system task, VCS records value changes and transition times for the entire net or register in the VCD file. For example, if you enter the following in your source code:

```
$dumpvars(1,mid1.out1[0]);
```

In this example, mid1.out1[0] is a bit select of a signal because you need to examine the transition times and value changes of this bit. VCS however writes a VCD file that contains the following:

```
$var wire 8 ! out1 [7:0] $end
```

Therefore, all the value changes and simulation times for signal out1 are for the entire signal and not just for the 0 bit.

The vcdpost utility can create an alternative VCD file that defines a separate \$var section for each bit of the vector signal. The results are as follows:

```
$var wire 8 ! out1 [7] $end
$var wire 8 " out1 [6] $end
$var wire 8 # out1 [5] $end
$var wire 8 $ out1 [4] $end
$var wire 8 % out1 [3] $end
$var wire 8 & out1 [2] $end
$var wire 8 ' out1 [1] $end
$var wire 8 ( out1 [0] $end
```

What this means is that the new VCD file contains value changes and simulation times for each bit.

Uniquifying the Identifier Codes

In certain circumstances, to enable better performance, VCS assigns the same VCD file identifier code to more than one net or register, if these nets or registers have the same value throughout the simulation. For example:

```
$var wire 1 ! ramsel_0_0 $end
$var wire 1 ! ramsel_0_1 $end
$var wire 1 ! ramsel_1_0 $end
$var wire 1 ! ramsel_1_1 $end
```

In this example, VCS assigns the ! identifier code to more than one net.

Some back-end tools from other vendors fail when you input such a VCD file. You can use the vcdpost utility to create an alternative VCD file in which the identifier codes for all nets and registers, including those instances without value changes, are unique. For example:

```
$var wire 1 ! ramsel_0_0 $end
$var wire 1 " ramsel_0_1 $end
$var wire 1 # ramsel_1_0 $end
$var wire 1 $ ramsel_1_1 $end
```

The vcdpost Utility Syntax

The syntax for the vcdpost utility is as follows:

vcdpost [+scalar] [+unique] *input_VCD_file* *output_VCD_file*

Usage:

+scalar

Specifies creating separate `$var` sections for each bit in a vector signal. This option is the default option and you include it on the command line when you also include the `+unique` option and want to create a VCD file that both scalarizes the vector nets and uniquifies the identifier codes.

+unique

Specifies uniquifying the identifier codes. When you include this option without the `+scalar` option, `vcdpost` uniquifies the identifier codes without scalarizing the vector signals.

input_VCD_file

The name of the VCD file created by VCS.

output_VCD_file

The name of the alternative VCD file created by the `vcdpost` utility.

The vcdiff Utility

The vcdiff utility compares two dump files and reports any differences it finds. The dump file can be of type VCD, EVCD or a VPD.

Note:

The vcdiff utility cannot compare dump files of different type.

Dump files consist of two sections:

- A header section that reflects the hierarchy (or some subset) of the design that was used to create the dump file.
- A value change section, which contains all of the value changes (and times when those value changes occurred) for all of the signals referenced in the header.

The vcdiff utility always performs two diffs. First, it compares the header sections and reports any signals/scopes that are present in one dump file but are absent in the other.

The second diff compares the value change sections of the dump files, for signals that appear in both dump files. The

utility determines value change differences based on the final value of the signal in a time step.

The vcdiff Utility Syntax

The syntax of the vcdiff utility is as follows:

```
vcdiff first_dump_file second_dump_file
[-noabsentsig] [-absentsigscope scope] [-absentsigiserror]
[-allabsentsig] [-absentfile filename] [-matchtypes] [-
```

```
ignorecase]
[-min time] [-max time] [-scope instance] [-level
level_number]
[-include filename] [-ignore filename] [-strobe time1 time2]
[-prestrobe] [-synch signal] [-synch0 signal] [-synch1
signal]
[-when expression] [-xzmatch] [-noxzmatchat0]
[-compare01xz] [-xumatch] [-xdmatch] [-zdmatch] [-zwmatch]
[-showmasters] [-allsigdiffs] [-wrapsize size]
[-limitdiffs number] [-ignorewires] [-ignorereggs]
[ingorereals]
[-ignorefunctaskvars] [-ignoretiming units] [-
ignorestrength]
[-geninclude [filename]] [-spikes]
```

Options for Specifying Scope/Signal Hierarchy

The following options control how the `vcdiff` utility compares the header sections of the dump files:

-noabsentsig

Does not report any signals that are present in one dump file but are absent in the other.

-absentsigscope [scope]

Reports only absent signals in the given scope.

-absentfile [file]

Prints the full path names of all absent scopes/signals to the given file, as opposed to stdout.

-absentsigiserror

If this option is present and there are any absent signals in either dump file, then `vcdiff` returns an error status upon completion even if it doesn't detect any value change differences. If this option is not present, absent signals do not cause an error.

-allabsentsig

Reports all absent signals. If this option is not present, by default, `vcdiff` reports only the first 10 absent signals.

-ignorecase

Ignores the case of scope/signal names when looking for absent signals. In effect, it converts all signal/scope names to uppercase before comparison.

-matchtypes

Reports mismatches in signal data types between the two dump files.

Options for Specifying Scope(s) to be Value Change Diffed

By default, `vcdiff` compares the value changes for all signals that appear in both dump files. The following options limit value change comparisons to specific scopes.

-scope [scope]

Changes the top-level scope to be value change diffed from the top of the design to the indicated scope. Note, all child scopes/signals of the indicated scope will be diffed unless modified by the `-level` option (below).

-level N

Limits the depth of scope for which value change diffing occurs. For example, if `-level 1` is the only command-line option, then `vcdiff` diffs the value changes of only the signals in the top-level scope in the dump file.

-include [file]

Reports value change diffs only for those signals/scopes given in the specified file. The file contains a set of full path specifications of signals and/or scopes, one per line.

-ignore [file]

Removes any signals/scopes contained in the given file from value change differencing. The file contains a set of full path specifications of signals and/or scopes, one per line.

Note:

The vcdiff utility applies the **-scope** / **-level** options first. It then applies the **-include** option to the remaining scopes/signals, and finally applies the **-ignore** option.

Options for Specifying When to Perform Value Change Differencing

The following options limit when vcdiff detects value change differences:

-min time

Specifies the starting time (in simulation units) when value change differencing is to begin (by default, time 0).

-max time

Specifies the stopping time (in simulation units) when value change differencing will end. By default, this occurs at the latest time found in either dump file.

-strobe first_time delta_time

Only checks for differences when the strobe is true. The strobe is true at `first_time` (in simulation units) and then every `delta_time` increment thereafter.

-prestroke

Used in conjunction with **-strobe**, tells **vcdiff** to look for differences just before the strobe is true.

-when expression

Reports differences only when the given **when** expression is true. Initially this expression can consist only of scalar signals, combined with **and**, **or**, **xor**, **xnor**, **and not** operators and employ parentheses to group these expressions. You must fully specify the complete path (from root) for all signals used in expressions. Note, operators may be either Verilog style (**&**, **|**, **^**, **~^**, **~**) or VHDL (**and**, **or**, **xor**, **xnor**, **not**).

-synch signal

Checks for differences only when the given signal changes value. In effect, the given signal is a "clock" for value change differencing, where diffs are only checked for on transitions (any) of this signal.

-synch0 signal

As **-sync** (above) except that it checks for diffs when the given signal transitions to '0'.

-synch1

As **-sync** (above) except that it checks for diffs only when the given signal transitions to '1'.

Note:

The **-max**, **-min** and **-when** options must all be true in order for **vcdiff** to report a value change difference.

Options for Filtering Differences

The following options filter out value change differences that are detected under certain circumstances. For the most part, these options are additive.

-ignoretiming time

Ignores the value change when the same signal in one of the VCD files has a different value from the same signal in the other VCD file for less than the specified time. This is to filter out signals that have only slightly different transition times in the two VCD files. The `vcdiff` utility reports a change when there is a transition to a different value in one of the VCD files and then a transition back to a matching value in that same file.

-ignorereg

Does not report value change differences on signals that are of type register.

-ignorewire

Does not report value change differences on signals that are of type wire.

-ignorereal

Does not report value change differences on signals that are of type real.

-ignorefunctaskvars

Does not report value change differences on signals that are function or task variables.

-ignorestrength (EVCD only)

EVCD files contain a richer set of signal strength and directional information than VCD or even VPD files. This option ignores the strength portion of a signal value when checking for differences.

-compare01xz (EVCD only)

Converts all signal state information to equivalent 4-state values (0, 1, x, z) before difference comparison is made (EVCD files only). Also ignores the strength information.

-xzmatch

Equates x and z values.

-xumatch (9-state VPD file only)

Equates x and u (uninitialized) values.

-xdmatch (9-state VPD file only)

Equates x and d (dontcare) values.

-zdmatch (9-state VPD file only)

Equates z and d (dontcare) values.

-zwmatch (9-state VPD file only)

Equates z and w (weak 1) values. In conjunction with -xzmatch (above), this option causes x and z value to be equated at all times EXCEPT time 0.

Options for Specifying Output Format

The following options change how value change differences are reported.

-allsigdiffs

By default, vcdiff only shows the first difference for a given signal. This option reports all diffs for a signal until the maximum number of diffs is reported (see `-limitdiffs`).

`-wrapsize columns`

Wraps the output of vectors longer than the given size to the next line. By default, this value is 64.

`-showmasters` (VCD, EVCD files only)

Shows collapsed net masters. VCS can split a collapsed net into several sub-nets when this has a performance benefit. This option reports the master signals when the master signals (first signal defined on a net) are different in the two dump files.

`-limitdiffs number_of_diffs`

By default, vcdiff stops after the first 50 diffs are reported. This option overrides that default. Setting this value to 0 causes vcdiff to report all diffs.

`-geninclude filename`

Produces a separate file of the given name in addition to the standard vcdiff output. This file contains a list of signals that have at least one value change difference. The format of the file is one signal per line. Each signal name is a full path name. You can use this file as input to the vcat tool with vcat's `-include` option.

`-spikes`

A spike is defined as a signal that changes multiple times in a single time step. This option annotates with #'s the value change differences detected when the signal spikes (glitches). It keeps and reports a total count of such diffs.

The vcat Utility

The format of a VCD or a EVCD file, although a text file, is written to be read by software and not by human designers. VCS includes the vcat utility to enable you to more easily understand the information contained in a VCD file.

The vcat Utility Syntax

The vcat utility has the following syntax:

```
vcat VCD_filename [-deltaTime] [-raw] [-min time] [-max time]
[-scope instance_name] [-level level_number]
[-include filename] [-ignore filename] [-spikes] [-noalpha]
[-wrapsize size] [-showmasters] [-showdefs] [-showcodes]
[-stdin] [-vgen]
```

Here:

-deltaTime

Specifies writing simulation times as the interval since the last value change rather than the absolute simulation time of the signal transition. Without -deltaTime a vcat output looks like this:

```
--- TEST_top.TEST.U4._G002 ---
0      x
33     0
20000  1
30000  x
30030  z
50030  x
50033  1
60000  0
70000  x
70030  z
```

With `-deltaTime` a vcat output looks like this:

```
--- TEST_top.TEST.U4._G002 ---
0      x
33     0
19967  1
10000  x
30     z
20000  x
3      1
9967   0
10000  x
30     z
```

`-raw`

Displays “raw” value changed data, organized by simulation time, rather than signal name.

`-min time`

Specifies a start simulation time from which vcat begins to display data.

`-max time`

Specifies an end simulation time up to which vcat displays data.

`-scope instance_name`

Specifies a module instance. The vcat utility displays data for all signals in the instance and all signals hierarchically under this instance.

`-level level_number`

Specifies the number of hierarchical levels for which vcat displays data. The starting point is either the top-level module or the module instance you specify with the `-scope` option.

-include *filename*

Specifies a file that contains a list of module instances and signals. The vcat utility only displays data for these signals or the signals in these module instances.

-ignore *filename*

Specifies a file that contains a list of module instances and signals. However, the vcat utility does NOT display data for these signals or the signals in these module instances.

-spikes

Indicates all zero-time transitions with the >> symbol in the leftmost column. In addition, prints a summary of the total number of spikes seen at the end of the vcat output. The following is an example of the new output:

```
--- DF_test.logic.I_348.N_1 ---
    0      x
    100    0
    120    1
>>120   0
    4000   1
    12000  0
    20000  1

Spikes detected:  5
```

-noalpha

By default vcat displays signals within a module instance in alphabetical order. This option disables this ordering.

-wrapsize *size*

Specifies value displays for wide vector signals, how many bits to display on a line before wrapping to the next line.

-showmasters

Specifies showing collapsed net masters.

-showdefs

Specifies displaying signals but not their value changes or the simulation time of these value changes.

-showcodes

Specifies displaying the signal's VCD file identifier code.

-stdin

Enables you to use standard input, such as piping the VCD file into vcat, instead of specifying the filename.

-vgen

Generates from a VCD file two types of source files for a module instance: one that models how the design applies stimulus to the instance, and the other that models how the instance applies stimulus to the rest of the design. See “[Generating Source Files From VCD Files](#)” on page 39.

The following is an example of the output from the vcat utility:

```
vcat exp1.vcd

exp1.vcd: scopes:6 signals:12 value-changes:13

--- top.mid1.in1 ---
0 1

--- top.mid1.in2 ---
0 xxxxxxxx
10000 00000000
```

```

--- top.mid1.midr1 ---
0 x
2000 1

--- top.mid1.midr2 ---
0 x
2000 1

```

In this output, for example, you see that signal `top.mid1.midr1` at time 0 had a value of `x` and at simulation time 2000 (as specified by the `$timescale` section of the VCD file, which VCS derives from the time precision argument of the `'timescale` compiler directive) this signal transitioned to 1.

Generating Source Files From VCD Files

The `vcat` utility can generate Verilog and VHDL source files that are one of the following:

- A module definition that succinctly models how a module instance is driven by a design, that is, a concise testbench module that instantiates the specified instance and applies stimulus to that instance the way the entire design does. This is called testbench generation.
- A module definition that mimics the behavior of the specified instance to the rest of the design, that is, it has the same output ports as the instance and in this module definition the values from the VCD file are directly assigned to these output ports. This is called module generation.

Note:

The `vcat` utility can only generate these source files for instances of module definitions that do not have inout ports.

Testbench generation enables you to focus on a module instance, applying the same stimulus as the design does, but at faster simulation because the testbench is far more concise than the entire design. You can substitute module definitions at different levels of abstraction and use vcdiff to compare the results.

Module generation enables you to use much faster simulating “canned” modules for a part of the design to enable the faster simulation of other parts of the design that need investigation.

The name of the generated source file from testbench generation begins with testbench followed by the module and instance names in the hierarchical name of the module instance, separated by underscores. For example `testbench_top_ad1.v`.

Similarly, the name of the generated source file from module generation begins with `moduleGeneration` followed by the module and instance names in the hierarchical name of the module instance, separated by underscores. For example `moduleGeneration_top_ad1.v`.

You enable vcat to generate these files by doing the following:

1. Writing a configuration file.
2. Running vcat with the `-vgen` command-line option.

Writing the Configuration File

The configuration file is named `vgen.cfg` by default and vcat looks for it in the current directory. This file needs three types of information specified in the following order:

1. The hierarchical name of the module instance.

2. Specification of testbench generation with the keyword `testbench` or specification of module generation with the keyword `moduleGeneration`.
3. The module header and the port declarations from the module definition of the module instance.

You can use Verilog comments in the configuration file.

The following is an example of a configuration file:

Example 7-1 Configuration File

```
top.ad1
testbench
//moduleGeneration
module adder (out,in1,in2);
input in1,in2;
output [1:0] out;
```

You can use a different name and location for the configuration file. In order to do this, you must enter it as an argument to the `-vgen` option. For example:

```
vcat filename.vcd -vgen /u/design1/vgen2.cfg
```

Example 7-2 Source Code

Consider the following source code:

```
module top;
reg r1,r2;
wire int1,int2;
wire [1:0] result;

initial
begin
$dumpfile("exp3.vcd");
$dumpvars(0,top.pa1,top.ad1);
```

```

#0  r1=0;
#10 r2=0;
#10 r1=1;
#10 r2=1;
#10 r1=0;
#10 r2=0;
#10 r1=1;
#10 r2=1;
#10 r1=0;
#10 r2=0;
#10 r1=1;
#10 r2=1;
#10 r1=0;
#10 r2=0;
#100 $finish;
end

passer pa1 (int1,int2,r1,r2);
adder ad1 (result,int1,int2);
endmodule

module passer (out1,out2,in1,in2);
input in1,in2;
output out1,out2;

assign out1=in1;
assign out2=in2;
endmodule

module adder (out,in1,in2);
input in1,in2;
output [1:0] out;

reg r1,r2;
reg [1:0] sum;

always @ (in1 or in2)
begin
r1=in1;
r2=in2;
sum=r1+r2;
end

```

```
assign out=sum;  
endmodule
```

Notice that the stimulus from the testbench module named `test` propagates through an instance of a module named `passer` before it propagates to an instance of a module named `adder`. The `vcat` utility can generate a testbench module to stimulate the instance of `adder` in the same exact way but in a more concise and therefore faster simulating module.

If we use the sample `vgen.cfg` configuration file in [Example 7-1](#) and enter the following command line:

```
vcat filename.vcd -vgen
```

The generated source file, `testbench_top_ad1.v`, is as follows:

```
module tbench_adder ;  
wire [1:0] out ;  
reg in2 ;  
reg in1 ;  
initial #131 $finish;  
initial $dumpvars;  
initial begin  
#0 in2 = 1'bx;  
#10 in2 = 1'b0;  
#20 in2 = 1'b1;  
#20 in2 = 1'b0;  
#20 in2 = 1'b1;  
#20 in2 = 1'b0;  
#20 in2 = 1'b1;  
#20 in2 = 1'b0;  
end  
initial begin  
in1 = 1'b0;  
forever #20 in1 = ~in1 ;  
end
```

```
adder ad1 (out,in1,in2);  
endmodule
```

This source file uses significantly less code to apply the same stimulus with the instance of module `passer` omitted.

If we revise the `vgen.cfg` file to have `vcat` perform module generation, the generated source file, `moduleGeneration_top_ad1.v`, is as follows:

```
module adder (out,in1,in2) ;  
input in2 ;  
input in1 ;  
output [1:0] out ;  
reg [1:0] out ;  
initial begin  
    #0 out = 2'bxx;  
    #10 out = 2'b00;  
    #10 out = 2'b01;  
    #10 out = 2'b10;  
    #10 out = 2'b01;  
    #10 out = 2'b00;  
    #10 out = 2'b01;  
    #10 out = 2'b10;  
    #10 out = 2'b01;  
    #10 out = 2'b00;  
    #10 out = 2'b01;  
    #10 out = 2'b10;  
    #10 out = 2'b01;  
    #10 out = 2'b00;  
end  
endmodule
```

Notice that the input ports are stubbed and the values from the VCD file are assigned directly to the output port.

The vcsplit Utility

The vcsplit utility generates a VCD, EVCD, or VPD file that contains a selected subset of value changes found in a given input VCD, EVCD, or VPD file (the output file has the same type as the input file). You can select the scopes/signals to be included in the generated file either via a command-line argument, or a separate "include" file.

The vcsplit Utility Syntax

The vcsplit utility has the following syntax:

```
vcsplit [-o output_file] [-scope selected_scope_or_signal]
[-include include_file] [-min min_time] [-max max_time]
[-level n] [-ignore ignore_file] input_file [-v] [-h]
```

Here:

-o *output_file*

Specifies the name of the new VCD/EVCD/VPD file to be generated. If *output_file* is not specified, vcsplit creates the file with the default name `vcsplit.vcd`.

-scope *selected_scope_or_signal*

Specifies a signal or scope whose value changes are to be included in the output file. If a scope name is given, then all signals and sub-scopes in that scope are included.

-include *include_file*

Specifies the name of an include file that contains a list of signals/ scopes whose value changes are to be included in the output file.

The include file must contain one scope or signal per line. Each presented scope/signal must be found in the input VCD, EVCD, or VPD file. If the file contains a scope, and separately, also contains a signal in that scope, vcsplit includes all the signals in that scope, and issues a warning.

Note:

If you use both `-include` and `-scope` options, vcsplit uses all the signals and scopes indicated.

input_file

Specifies the VCD, EVCD, or VPD file to be used as input.

Note:

If the input file is either VCD or EVCD, and it is not specified, vcsplit takes its input from stdin. The vcsplit utility has this stdin option for VCD and EVCD files so that you can pipe the output of gunzip to this tool. If you try to pipe a VPD file through stdin, vcsplit exits with an error message.

-min *min_time*

Specifies the time to begin the scan.

-max *max_time*

Specifies the time to stop the scan.

-ignore *ignore_file*

Specifies the name of the file that contains a list of signals/scopes whose value changes are to be ignored in the output file.

If you specify neither `include_file` nor `selected_scope_or_signal`, then `vcsplit` includes all the value changes in the output file except the signals/scopes in the `ignore_file`.

If you specify an `include_file` and/or a `selected_scope_or_signal`, `vcsplit` includes all value changes of those signals/scopes that are present in the `include_file` and the `selected_scope_or_signal` but absent in `ignore_file` in the output file. If the `ignore_file` contains a scope, `vcsplit` ignores all the signals and the scopes in this scope.

-level *n*

Reports only *n* levels hierarchy from top or scope. If you specify neither `include_file` nor `selected_scope_or_signal`, `vcsplit` computes *n* from the top level of the design. Otherwise, it computes *n* from the highest scope included.

-v

Displays the current version message.

-h

Displays a help message explaining usage of the `vcsplit` utility.

Note:

In general, any command-line error (such as illegal arguments) that VCS detects causes `vcsplit` to issue an error message and exit with an error status. Specifically:

- If there are any errors in the `-scope` argument or in the include file (such as a listing a signal or scope name that does not exist in the input file), VCS issues an error message, and `vcsplit` exits with an error status.
- If VCS detects an error while parsing the input file, it reports an error, and `vcsplit` exits with an error status.
- If you do not provide either a `-scope`, `-include` or `-ignore` option, VCS issues an error message, and `vcsplit` exits with an error status.

Limitations

- MDAs are not supported.
- Bit/part selection for a variable is not supported. If this usage is detected, the vector will be regarded as all bits are specified.

The vcd2vpd Utility

The `vcd2vpd` utility converts a VCD file generated using `$dumpvars` or UCLI dump commands to a VPD file.

The syntax is as shown below:

```
vcd2vpd [-bmin_buffer_size] [-fmax_output_filesize] [-h]
[-m] [-q] [+glitchon] [+nocompress] [+nocurrentvalue]
[+bitrangenospace] [+vpdnoreadopt] [+dut+dut_sufix]
[+tf+tf_sufix] vcd_file vpd_file
```

Usage:

`-b<min_buffer_size>`

Minimum buffer size in KB used to store Value Change Data before writing it to disk.

-f<max_output_filesize>

Maximum output file size in KB. Wrap around occurs if the specified file size is reached.

-h

Translate hierarchy information only.

-m

Give translation metrics during translation.

-q

Suppress printing of copyright and other informational messages.

+deltacycle

Add delta cycle information to each signal value change.

+glitchon

Add glitch event detection data.

+nocompress

Turn data compression off.

+nocurrentvalue

Do not include object's current value at the beginning of each VCB.

+bitrangenospace

Support non-standard VCD files that do not have white space between a variable identifier and its bit range.

`+vpdnoreadopt`

Turn off read optimization format.

Options for specifying EVCD options

`+dut+dut_sufix`

Modifies the string identifier for the Device Under Test (DUT) half of the split signal. Default is "DUT".

`+tf+tf_sufix`

Modifies the string identifier for the Test-Fixture half of the split signal. Default is "TF".

`+indexlast`

Appends the bit index of a vector bit as the last element of the name.

`vcd_file`

Specify the vcd filename or use "-" to indicate VCD data to be read from stdin.

`vpd_file`

Specify the VPD file name. You can also specify the path and the filename of the VPD file, otherwise, the VPD file will be generated with the specified name in the current working directory.

The `vpd2vcd` Utility

The `vpd2vcd` utility converts a VPD file generated using the system task `$vcdpluson` or UCLI dump commands to a VCD or EVCD file.

The syntax is as shown below:

```
vpd2vcf [-h] [-q] [-s] [-x] [-x1rm] [+zerodelayglitchfilter]
[+morevhdl] [+start+value] [+end+value] [+splitpacked]
[+dumpports+instance] [-f cmd_filename] vpd_file vcd_file
```

Here:

-h

Translate hierarchy information only.

-q

Suppress the copyright and other informational messages.

-s

Allow sign extension for vectors. Reduces the file size of the generated *vcd_file*.

-x

Expand vector variables to full length when displaying \$dumpoff value blocks.

-x1rm

Convert uppercase VHDL objects to lowercase.

+zerodelayglitchfilter

Zero delay glitch filtering for multiple value changes within the same time unit.

+morevhdl

Translates the VHDL types of both directly mappable and those that are not directly mappable to verilog types.

Note:

This switch may create a non-standard VCD file.

+start+time

Translate the value changes starting after the specified start time.

+end+time

Translate the value changes ending before the specified end time.

Note:

Specify both start time and end time to translate the value changes occurring between start and end time.

+dumports+instance

Generate an EVCD file for the specified module instance. If the path to the specified instance contains escaped identifiers, then the full path must be enclosed in single quotes.

-f *cmd_filename*

Specify a command file containing commands to limit the design converted to VCD or EVCD. See the “[The Command File Syntax](#)” section for more information.

+splitpacked

Use this option to change the way packed structs and arrays are reported in the output VCD file. It does the following:

- Treats a packed structure the same as an unpacked structure and dumps the value changes of each field.

Consider the following example:

```

typedef logic [1:0] t_vec;

typedef struct packed {
    t_vec f_vec_b;
} t_ps_b;

module test();
    t_ps_b var_ps_b;
endmodule

```

The VCD file created in the previous example is as follows:

```

$scope module test $end
$scope fork var_ps_b $end
$var reg 2 ! f_vec_b [1:0] $end
$upscope $end
$upscope $end

```

- Treats a packed MDA as an unpacked MDA except for the inner most dimensions.

Consider the following example:

```

typedef logic [1:0] t_vec;

module test();
    t_vec [3:2] var_vec;
endmodule

```

The VCD file created in the previous example is as follows:

```

$scope module test $end
$var reg      2 %      var_vec[3]  [1:0] $end
$var reg      2 &      var_vec[2]  [1:0] $end
$upscope $end

```

- Expands all packed arrays defined in a packed struct.

Consider the following example:

```

typedef logic [1:0] t_vec;

typedef struct packed {
    t_vec f_vec;
    t_vec [3:2][1:0] f_vec_array;
} t_ps;

module test();
    t_ps var_ps;
endmodule

```

The VCD file created in the previous example is as follows:

```

$scope module test $end
$scope fork var_ps $end
$var reg      2 '   f_vec [1:0] $end
$var reg      2 (   f_vec_array[3][1] [1:0] $end
$var reg      2 )   f_vec_array[3][0] [1:0] $end
$var reg      2 *   f_vec_array[2][1] [1:0] $end
$var reg      2 +   f_vec_array[2][0] [1:0] $end
$upscope $end
$upscope $end

```

- Expands all dimensions of a packed array defined in a packed struct.

Consider the following example:

```

typedef logic [1:0] t_vec;

typedef struct packed {
    t_vec f_vec;
    t_vec [3:2][1:0] f_vec_array;
} t_ps;

module test();
    t_ps [1:0] var_paps;
endmodule

```

The VCD file created in the previous example is as follows:

```

$scope module test $end
$scope fork var_paps[1] $end
$var reg      2 '   f_vec [1:0] $end
$var reg      2 (   f_vec_array[3][1] [1:0] $end
$var reg      2 )   f_vec_array[3][0] [1:0] $end
$var reg      2 *   f_vec_array[2][1] [1:0] $end
$var reg      2 +   f_vec_array[2][0] [1:0] $end
$upscope $end
$scope fork var_paps[0] $end
$var reg      2 ,   f_vec [1:0] $end
$var reg      2 -   f_vec_array[3][1] [1:0] $end
$var reg      2 .   f_vec_array[3][0] [1:0] $end
$var reg      2 /   f_vec_array[2][1] [1:0] $end
$var reg      2 0   f_vec_array[2][0] [1:0] $end
$upscope $end
$upscope $end

```

- Expands and prints the value of each member of a packed union.

Consider the following example:

```

module testit;

typedef logic [1:0] t_vec;

typedef union packed {
    t_vec f_vec;
    struct packed {
        logic f_a;
        logic f_b;
    } f_ps;
} t_pu_v;
typedef union packed {
    struct packed {
        logic f_a;
        logic f_b;
    } f_ps;
    t_vec f_vec;
} t_pu_s;

```

```

t_pu_v var_pu_v;
t_pu_s var_pu_s;
endmodule

```

The VCD file created in the previous example is as follows:

```

$scope module testit $end
$scope fork var_pu_v $end
$var reg      2 -    f_vec [1:0] $end
$scope fork f_ps $end
$var reg      1 .    f_a $end
$var reg      1 /    f_b $end
$upscope $end
$upscope $end
$scope fork var_pu_s $end
$scope fork f_ps $end
$var reg      1 0    f_a $end
$var reg      1 1    f_b $end
$upscope $end
$var reg      2 2    f_vec [1:0] $end
$upscope $end
$upscope $end

```

The Command File Syntax

Using a command file, you can generate:

- A VCD file for the whole design or for the specified instances.
- Only the port information for the specified instances.
- An EVCD file for the specified instances.

Note the following before writing a command file:

- All commands must start as the first word in the line, and the arguments for these commands should be written in the same line. For example:

```
dumpvars 1 adder4
```

- All comments must start with “//”. For example:

```
//Add your comment here  
dumpvars 1 adder4
```

- All comments written after a command, must be preceded by a space. For example:

```
dumpvars 1 adder4 //can write your comment here
```

A command file can contain the following commands:

```
dumpports instance [instance1 instance2 . . .]
```

Specify an instance for which an EVCD file has to be generated. You can generate an EVCD file for more than one instance by specifying the instance names separated by a space. You can also specify multiple `dumpports` commands in the same command file.

```
dumpvars [level] [instance instance1 instance2 . . .]
```

Specify an instance for which a VCD file has to be generated. [*level*] is a numeric value indicating the number of levels to traverse down the specified instance. If not specified, or if the value specified is "0", then all the instances under the specified instance will be dumped.

You can generate a VCD file for more than one instance by specifying the instance names separated by a space. You can also specify multiple `dumpvars` commands in the same command file.

If this command is not specified or the command has no arguments, then a VCD file will be generated for the whole design.

```
dumpvcdports [level] instance [instance1 instance2  
....]
```

Specify an instance whose port values are dumped to a VCD file. [level] is a numeric value indicating the number of levels to traverse down the specified instance. If not specified, or if the value specified is "0", then the port values of all the instances under the specified instance will be dumped.

You can generate a dump file for more than one instance by specifying the instance names separated by a space. You can also specify multiple `dumpvcdports` commands in the same command file.

Note:

`dumpvcdports` splits the inout ports of type wire into two separate variables:

- one shows the value change information driven into the port. VCS adds a suffix `_DUT` to the basename of this variable.
- the other variable shows the value change information driven out of the port. VCS adds a suffix `_TB` to the basename of this variable.

```
dutsuffix DUT_suffix
```

Specify a string to change the suffix added to the variable name that shows the value change date driven out of the inout port. The default value is `_DUT`. The suffix can also be enclosed within double quotes.

`tbsuffix TB_suffix`

Specify a string to change the suffix added to the variable name that shows the value change date driven into the inout port. The default value is `_TB`. The suffix can also be enclosed within double quotes.

`starttime start_time`

Specify the start time to start dumping the value change data to the VCD file. If this command is not specified, the start time will be the start time of the VPD file.

Note:

Only one `+start` command is allowed in a command file.

`endtime end_time`

Specify the end time to stop dumping the value change data to the VCD file. If this command is not specified, the end time will be the end time of the VPD file.

Note:

Only one `+end` command is allowed in a command file, and must be equal to or greater than the start time.

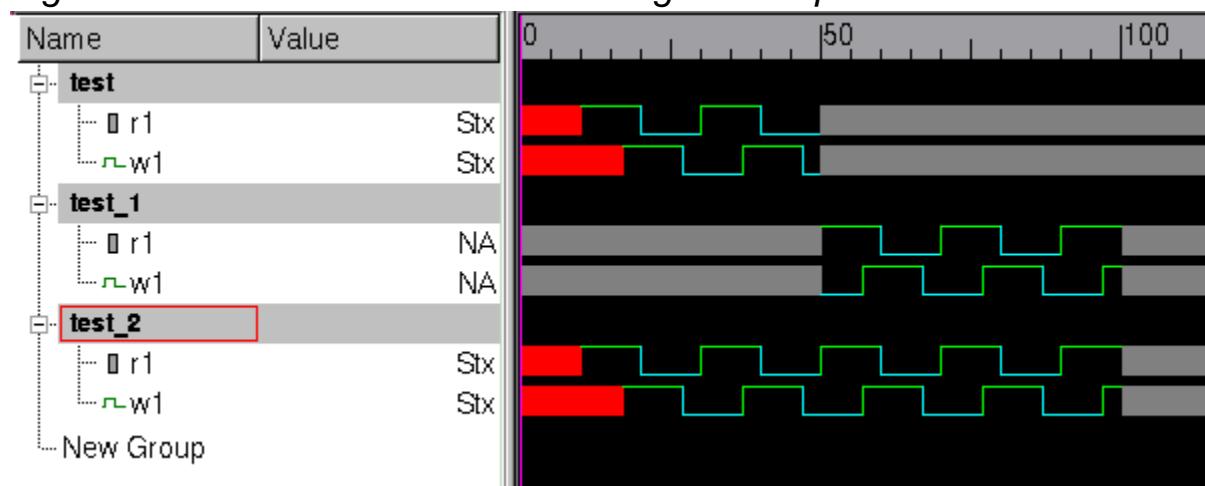
Limitations

- `dumpports` is mutually exclusive with either the `dumpvars` or `dumpvcdports` commands. The reason for this is that `dumpports` generates an EVCD file while both `dumpvars` and `dumpvcdports` generates standard VCD files.
- Escaped identifiers must include the trailing space.
- Any error parsing the file will cause the translation to terminate.

The vpdmerge Utility

Using the vpdmerge utility, you can merge different VPD files storing simulation history data for different simulation times, or parts of the design hierarchy into one large VPD file. For example in the DVE Wave view in [Figure 7-6](#), there are three signal groups for the same signals in different VPD files.

Figure 7-6 DVE Wave Window with Signal Groups from Different VPD Files



Signal group `test` is from a VPD file from the first half of a simulation, signal group `test_1` is from a VPD file for the second half of a simulation, and signal group `test_2` is from the merged VPD file.

The syntax is as shown below:

```
vpdmerge [-h] [-q] [-hier] [-v] -o merged_VPD_filename  
input_VPD_filename input_VPD_filename ...
```

Usage:

`-h`

Displays a list of the valid options and their purpose.

-o *merged_VPD_filenames*

Specifies the name of the output merged VPD file. This option is required.

-q

Specifies quiet mode, disables the display of most output to the terminal.

-hier

Specifies that you are merging VPD files for different parts of the design, instead of the default condition, without this option, which is merging VPD files from different simulation times.

-v

Specifies verbose mode, enables the display of warning and error messages.

Restrictions

The vpdmerge utility includes the following restrictions:

- To read the merged VPD file, DVE must have the same or later version than that of the vpdmerge utility.
- VCS must have written the input VPD files on the same platform as the vpdmerge utility.
- The input VPD files cannot contain delta cycle data (different values for a signal during the same time step).
- The input VPD files cannot contain named events.
- The merged line stepping data does not always accurately replay scope changes within a time step.

- If you are merging VPD files from different parts of the design, using the `-hier` option, the VPD files must be used for distinctly different parts of the design, they cannot contain information for the same scope.
- You cannot use the `vpdmerge` option on two vpd files, which are created based on timing, for both timing & hierarchy (using the `-hier` option) based merging.

Limitations

The verbose option `-v` may not display error or warning messages in the following scenarios:

- If the reference signal completely or coincidentally overlaps the compared signal.
- During hierarchy merging, if the design object already exists in the merged file.

During hierarchy merging, the `-hier` option may not display error or warning messages in the following scenarios.

- If the start and end times of the two dump files are the same.
- If the datatype of the hierarchical signal in the dump files do not match.

Value Conflicts

If the `vpdmerge` utility encounters conflicting values for the same signal, with the same hierarchical name, in different input VPD files, it does the following when writing the merged VPD file:

- If the signals have the same end time, `vpdmerge` uses the values from the first input VPD file that you entered on the command line.

- If the signals have different end times, vpdmerge uses the values for the signal with the greatest end time.

In cases where there are value conflicts, the `-v` option displays messages about these conflicts.

The vpdutil Utility

The vpdutil utility generates statistics about the data in the vpd file. The utility takes a single vpd file as input. You can specify options to this utility to query at design, module, instance, and node levels.

This utility supports time ranges and input lists for query on more than one object. Output will be in ascii to stdout with option to redirect to an output file.

For more information, see [“Using the vpdutil Utility to Generate Statistics”](#).

8

Performance Tuning

VCS delivers the best performance during both compile-time and runtime by reducing the size of the simulation executable, and the amount of memory consumed for compilation and simulation. By default, it is optimized for the following types of designs:

- Designs with many layers of hierarchy
- Gate-level designs
- Structural RTL-level designs - Using libraries where the cells are RTL-level code
- Designs with extensive use of timing such as delays, timing checks, and SDF back annotation, particularly to INTERCONNECT delays

However, depending on the phase of your design cycle, you can fine-tune VCS for a better compile-time and runtime performance.

This chapter describes the following sections:

- **Compile-time Performance**

Compile-time performance plays a very important role when you are in the initial phase of your design development cycle. In this phase, you may want to modify and recompile the design to observe the behavior. Since, this phase involves lot many recompiling cycles, achieving a faster compilation is important. For additional information, see the section entitled, “[Compile-time Performance](#)” .

- **Runtime Performance**

Runtime performance is important in regression phase or in the final phase of the design development cycle. For additional information, see the section entitled, “[Runtime Performance](#)” .

- **Obtaining VCS Consumption of CPU Resources**

You can now capture the CPU resource statistics for compilation and simulation using the switch -reportstats. For more information, see “[Obtaining VCS Consumption of CPU Resources](#)”

Compile-time Performance

You can improve compile-time performance in the following ways:

- “[Incremental Compilation](#)”
- “[Compile Once and Run Many Times](#)” “[Parallel Compilation](#)”

Incremental Compilation

During compilation, VCS builds the design hierarchy. By default, when you recompile the design, VCS compiles only those design units that have changed since the last compilation. This is called incremental compilation.

The incremental compilation feature is the default in VCS. It triggers recompilation of design units under the following conditions:

- Changes in the command-line options.
- Change in the target of a hierarchical reference.
- Change in the ports of a design unit.
- Change in the functional behavior of the design.
- Change in a compile-time constant such as a parameter.

The following conditions do not cause VCS to recompile a module:

- Change of time stamp of any source file.
- Change in file name or grouping of modules in any source file.
- Unrelated change in the same source file.
- Nonfunctional changes such as comments or white space.

Compile Once and Run Many Times

The VCS usage model is devised in such a way that you can create a single binary executable and execute it many times avoiding the elaboration step for all but the first run. For information on the VCS usage model, see “[Using the Simulator](#)” on page 16.

For example, you can use this feature in the following scenarios:

- Use VCS runtime features, like passing values at runtime, to modify the design, and simulate it without re-compiling. For information on runtime features, see [Chapter 4, "Simulating the Design"](#).
- Run the same test with different seeds.
- Create a softlink of the executable and the .daidir or .db.dir directory in a different directory, to run multiple simulations in parallel.

Parallel Compilation

You can improve the compile-time performance by specifying the number of parallel processes VCS can launch for the native code generation phase of the compilation. You should specify this using the compile-time option `-j [no_of_processes]`, as shown below:

```
% vcs -j [no_of_processes] [options] top_entity/module/  
config
```

For example, the following command line will fork off two parallel processes to generate a binary executable:

```
% vcs -j2 top
```

Runtime Performance

VCS runtime performance is based on the following:

- Coding Style (see [Chapter 3, "Modeling Your Design"](#)).
- Access to the internals of your design at runtime, using PLIs, UCLI, debugging using GUI, dumping waveforms etc.

This section describes the following to improve the runtime performance:

- [“Using Radiant Technology”](#)
- [“Improving Performance When Using PLIs”](#)

Using Radiant Technology

VCS Radiant Technology applies performance optimizations to the Verilog portion of your design while VCS compiles your Verilog source code. These Radiant optimizations improve the simulation performance of all types of designs from behavioral, RTL to gate-level designs. Radiant Technology particularly improves the performance of functional simulations where there are no timing specifications or when delays are distributed to gates and assignment statements.

Compiling With Radiant Technology

Radiant Technology optimizations are not enabled by default. You enable them using the compile-time options:

`+rad`

Specifies using Radiant Technology

`+optconfigfile`

Optional. Specifies applying Radiant Technology optimizations to part of the design using a configuration file as described below:

Applying Radiant Technology to Parts of the Design

The configuration file enables you to apply Radiant optimizations selectively to different parts of your design. You can enable or disable Radiant optimizations for all instances of a module, specific instances of a module, or specific signals.

You specify the configuration file with the `+optconfigfile` compile-time option. For example:

`+optconfigfile+file_name`

Note:

The configuration file is a general purpose file that has other purposes, such as specifying ACC write capabilities. Therefore, to enable Radiant Technology optimizations with a configuration file, you must also include the `+rad` compile-time option.

The Configuration File Syntax

The configuration file contains one or more statements that set Radiant optimization attributes, such as enabling or disabling optimization on a type of design object, such as a module definition, a module instance, or a signal.

The syntax of each type of statement is as follows:

```
module {list_of_module_identifiers} {list_of_attributes};  
or
```

```
instance  
{list_of_module_identifiers_and_hierarchical_names}  
{list_of_attributes};
```

or

```
tree [(depth)] {list_of_module_identifiers}  
{list_of_attributes};
```

Usage:

module

Keyword that specifies that the attributes in this statement apply to all instances of each module in the list, specified by module identifier.

list_of_module_identifiers

A comma separated list of module identifiers enclosed in curly braces: { }

list_of_attributes

A comma separated list of Radiant optimization attributes enclosed in curly braces: { }

instance

Keyword that specifies that the attributes in this statement apply to:

- All instances of each module in the list specified by module identifier.

- All module instances in the list specified by their hierarchical names.
- The individual signals in the list specified by their hierarchical names.

`list_of_module_identifiers_and_hierarchical_names`

A comma separated list of module identifiers, hierarchical names of module instances, or signals enclosed in curly braces:
`{ }`

Note:

Follow the Verilog syntax for signal names and hierarchical names of module instances.

`tree`

Keyword that specifies that the attributes in this statement apply to all instances of the modules in the list, specified by module identifier, and also apply to all module instances hierarchically under these module instances.

`depth`

An integer that specifies how far down the module hierarchy, from the specified modules, you want to apply Radiant optimization attributes. You can specify a negative value. A negative value specifies descending to the leaf level and counting up levels of the hierarchy to apply these attributes. This specification is optional. Enclose this specification in parentheses: `()`

The valid Radiant optimization attributes are as follows:

`noOpt`

Disables Radiant optimizations on the module instance or signal.

`noPortOpt`

Prevents port optimizations such as optimizing away unused ports on a module instance.

`Opt`

Enables all possible Radiant optimizations on the module instance or signal.

`PortOpt`

Enables port optimizations such as optimizing away unused ports on a module instance.

Statements can use more than one line and must end with a semicolon.

Verilog style comments characters `/* comment */` and `// comment` can be used in the configuration file.

Configuration File Statement Examples

The following are examples of statements in a configuration file.

module statement example

```
module {mod1, mod2, mod3} {noOpt, PortOpt};
```

This module statement example disables Radiant optimizations for all instances of modules `mod1`, `mod2`, and `mod3`, with the exception of port optimizations.

multiple module statement example

```
module {mod1, mod2} {noOpt};  
module {mod1} {Opt};
```

In this example, the first module statement disables radiant optimizations for all instances of modules mod1 and mod2 and then the second module statement enables Radiant optimizations for all instances of module mod1. VCS processes statements in the order in which they appear in the configuration file so the enabling of optimizations for instances of module mod1 in the second statement overrides the first statement.

instance statement example

```
instance {mod1} {noOpt};
```

In this example, mod1 is a module identifier so the statement disables Radiant optimizations for all instances of mod1. This statement is the equivalent of:

```
module {mod1} {noOpt};
```

module and instance statement example

```
module {mod1} {noOpt};  
instance {mod1.mod2_inst1.mod3_inst1,  
mod1.mod2_inst1.reg_a} {noOpt};
```

In this example, the module statement disables Radiant optimizations for all instances of module mod1.

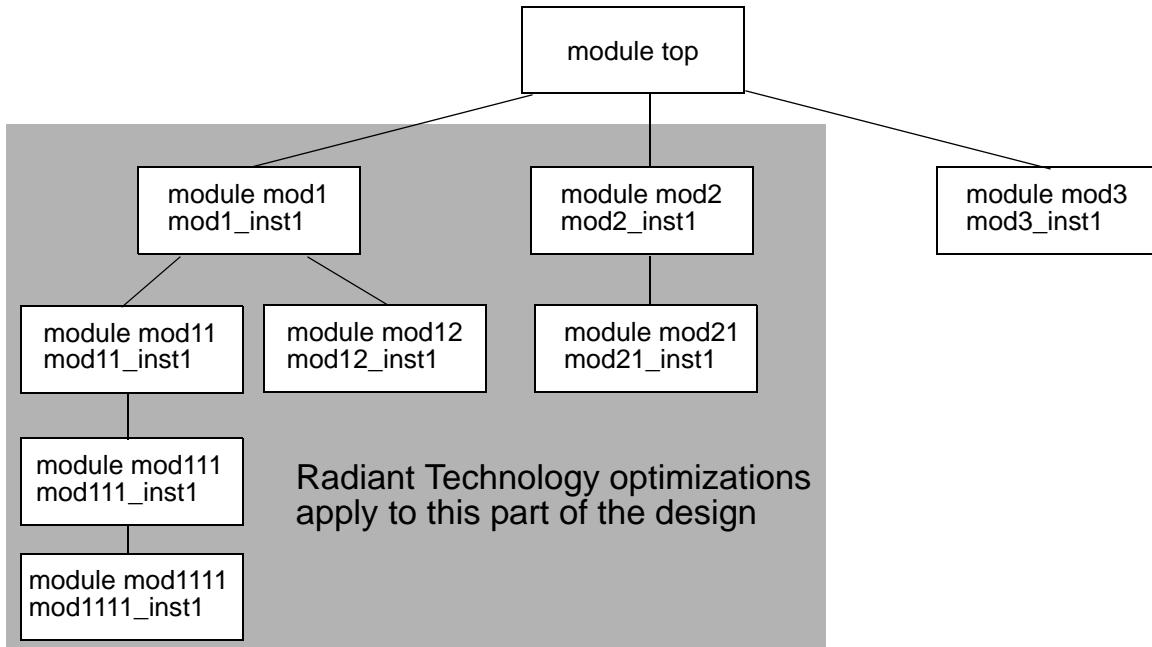
The instance statement disables Radiant optimizations for the following:

- Hierarchical instance mod1.mod2_inst1.mod3_inst1
- Hierarchical signal mod1.mod2_inst1.reg_a

first tree statement example

```
tree {mod1,mod2} {Opt};
```

This example is for a design with the following module hierarchy:

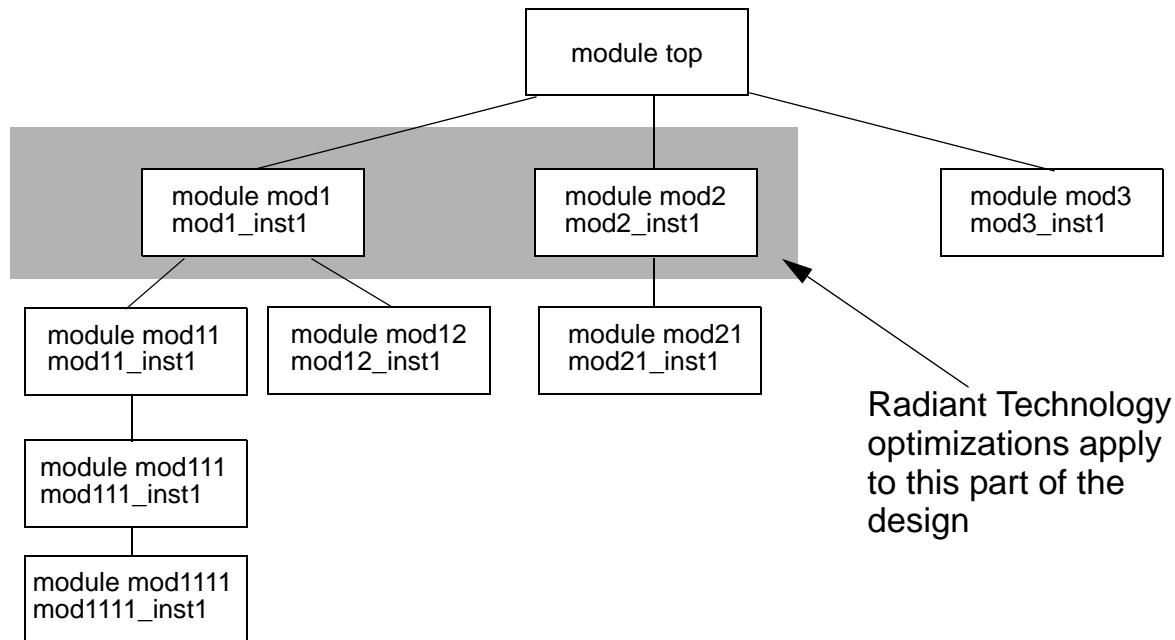


The statement enables Radiant Technology optimizations for the instances of modules `mod1` and `mod2` and for all the module instances hierarchically under these instances.

second tree statement example

```
tree (0) {mod1,mod2} {Opt};
```

This modification of the previous tree statement includes a depth specification. A depth of 0 means that the attributes apply no further down the hierarchy than the instances of the specified modules, mod1 and mod2.



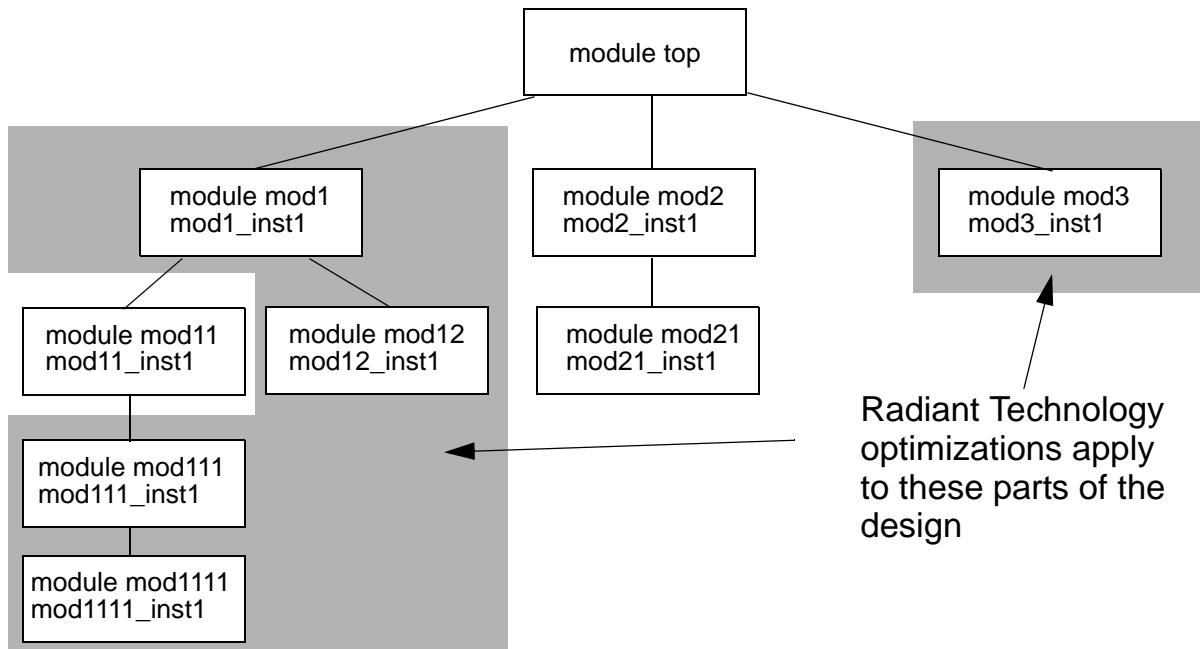
A tree statement with a depth of 0 is the equivalent of a module statement.

third tree statement example

You can specify a negative value for the depth value. If you do this, specify ascending the hierarchy from the leaf level. For example:

```
tree (-2) {mod1, mod3} {Opt};
```

This statement specifies looking down the module hierarchy under the instances of modules `mod1` and `mod3` to the leaf level and counting up from there. (Leaf level module instances contain no module instantiation statements.)



In this example, the instances of `mod111`, `mod12`, and `mod3` are at a depth of -1 and the instances of `mod111` and `mod1` are at a depth of -2. The attributes do not apply to the instance of `mod11` because it is at a depth of -3.

fourth tree statement example

You can disable Radiant optimizations at the leaf level under specified modules. For example:

```
tree(-1) {mod1, mod2} {noOpt};
```

This example disables optimizations at the leaf level, the instances of modules `mod1111`, `mod12`, and `mod21`, under the instances of modules `mod1` and `mod2`.

Known Limitations

Radiant Technology is not applicable to all simulation situations. Some features of VCS are not available when you use Radiant Technology.

These limitations are:

- Back-annotating SDF Files

You cannot use Radiant Technology if your design back-annotates delay values from either a compiled or an ASCII SDF file at runtime.

- SystemVerilog

Radiant Technology does not work with SystemVerilog design construct code. For example, structures and unions, new types of always blocks, interfaces, or things defined in \$root.

The only SystemVerilog constructs that work with Radiant Technology are SystemVerilog assertions that refer to signals with Verilog-2001 data types, not the new data types in SystemVerilog.

Potential Differences in Coverage Metrics

VCS supports coverage metrics with Radiant Technology and you can enter both the `+rad` and `-cm` compile-time options. However, Synopsys does not recommend comparing coverage between two simulation runs when only one simulation was compiled for Radiant Technology.

The Radiant Technology optimizations, though not changing the simulation results, can change the coverage results.

Compilation Performance With Radiant Technology

Using Radiant Technology incurs longer incremental compile times because the analysis performed by Radiant Technology occurs every time you recompile the design even when only a few modules have changed. However, VCS only performs the code generation phase on the parts of the design that have actually changed. Therefore, the incremental compile times are longer when you use Radiant Technology but shorter than a full recompilation of the design.

Improving Performance When Using PLIs

As mentioned earlier, the runtime performance is reduced when you have PLIs accessing the design. In some cases, you may have ACC capabilities enabled on all the modules in the design, including those which actually do not require them. These scenarios will unnecessarily reduce the runtime performance. Ideally the performance can be improved if you are able to control the access rights of the PLIs. However, this may not be possible in many situations. In this situation, you can use the `+vcs+learn+pli` runtime option.

`+vcs+learn+pli` tells VCS to write a new tab file with the ACC capabilities enabled on the modules/scopes which actually need them during runtime. Now, during recompile, along with your original tab file, you can pass the new tab file using the compile-time option, `+applylearn+ [tabfile]`, so that the next simulation will have a better runtime. Therefore, this is a two-step process:

- Using the runtime option `+vcs+learn+pli`
- Using the compilation option `+applylearn+ [tabfile]` during recompile. You do not have to reanalyze the files in this step.

The usage model and an example is shown below:

Usage Model

Step1: Using the runtime option `+vcs+learn+pli`.

Compilation

```
% vcs [vcs_options] Verilog_files
```

Simulation

```
% simv [sim_options] +vcs+learn+pli
```

Step2: Using the compilation option `+applylearn+ [tabfile]`.

Compilation

```
% vcs [vcs_options] +applylearn+ [tabfile] Verilog_files
```

Simulation

```
% simv [sim_options]
```

Impact on Performance

Options like `-debug_pp`, `-debug`, and `-debug_all` disable VCS optimizations and also impact the performance. The `-debug_pp` option has less performance impact than the `-debug` or `-debug_all` options. The following table describes these options and their performance impact:

Table 8-1 Performance Impact of `-debug_pp`, `-debug`, and `-debug_all`

Options	Description
<code>-debug_pp</code>	Use this option to generate a dump file. You can also use this option to invoke UCLI and DVE with some limitations. This has less performance impact when compared to <code>-debug</code> or <code>-debug_all</code> .
<code>-debug</code>	Use this option if you want to use the <code>force</code> command at the UCLI prompt, and for more debug capabilities.
<code>-debug_all</code>	This option enables all debug capabilities, and therefore will have a huge performance impact.

See the section “[Compiling or Elaborating the Design in Debug Mode](#)” on page 1 for more information.

Note that using extensive user interface commands, like `force` or `release` at runtime, will have a huge impact on the performance.

To improve the performance, Synopsys recommends you to convert these user interface commands to HDL files and to compile and simulate them along with the design.

Contact Synopsys Support Center (vcs_support@synopsys.com) or your Synopsys Application Consultant for further assistance.

Obtaining VCS Consumption of CPU Resources

You can now capture the CPU resource statistics for compilation and simulation using the switch -reportstats.

Use Model

You can specify this option at compile time as well as runtime or both depending on your requirement.

For example:

```
%vcs -reportstats  
or  
%simv -reportstats
```

Note: This option is supported only on RHEL32 and RHEL64 platforms. If you attempt to use this option on other platforms, VCS issues a warning and then continues.

When you specify this option at compile time, VCS prints out the following information.

Compile time

```
Compilation Performance Summary  
=====  
vcs started at : Sat Nov 12 11:02:38 2011  
Elapsed time : 4 sec  
CPU Time : 3.0 sec  
Virtual memory size : 361.7 MB  
Resident set size : 141.7 MB  
Shared memory size : 79.7 MB  
Private memory size : 62.1 MB  
Major page faults : 0  
=====
```

The details of the above report are as follows:

- VCS start time
- Elapsed real time: wall clock time from VCS start to VCS end.
- CPU time: Accumulated user time + system time from all processes spawned from VCS.
- Peak virtual memory size summarized from all the contributing processes at specific time points.
- Sum of resident set size from all the contributing processes at specific time points.
- Sum of shared memory from all the contributing processes at specific time points.
- Sum of Private memory from all the contributing processes at specific time points.
- Major fault accumulated from all processes spawned from VCS.

Simulation Time

Specifying this option at compile time and runtime, VCS prints out both the compile time and simulation time data:

Simulation time sample report data

```
Simulation Performance Summary
=====
Simulation started at : Sat Nov 12 11:02:43 2011
Elapsed Time           : 1 sec
CPU Time               : 0.1 sec
Virtual memory size   : 152.2 MB
Resident set size     : 106.5 MB
Shared memory size    : 21.2 MB
```

```
Private memory size      : 85.3 MB
Major page faults        : 0
=====
```

If you specify the option only runtime and not at compile time, VCS prints only runtime data at runtime.

9

Gate-level Simulation

This chapter contains the following sections:

- “SDF Annotation”
- “Precompiling an SDF File”
- “SDF Configuration File”
- “Delays and Timing”
- “Using the Configuration File to Disable Timing”
- “Using the timopt Timing Optimizer”
- “Using Scan Simulation Optimizer”
- “Negative Timing Checks”

SDF Annotation

The OVI Standard Delay File (SDF) specification provides a standard ASCII file format for representing and applying delay information. VCS supports the OVI versions 1.0, 1.1, 2.0, 2.1, and 3.0 of this specification.

In the SDF format a tool can specify intrinsic delays, interconnect delays, port delays, timing checks, timing constraints, and pulse control (PATHPULSE).

When VCS reads an SDF file it “back-annotates” delay values to the design, that is, it adds delay values or changes the delay values specified in the source files.

Following are ways to back-annotate the delays specified in the SDF file:

- “Using Unified SDF Feature”
- “Using \$sdf_annotate System Task”
- “Using -xlrn Option for SDF Retain, Gate Pulse Propagation, and Gate Pulse Detection Warning”

Using Unified SDF Feature

Unified SDF feature allows you to back-annotate the SDF delays using the following compile-time option:

```
-sdf min|typ|max:instance_name:file.sdf
```

Compilation% vcs -sdf min|typ|max:*instance_name*:*file.sdf* \
 [compile_options]

Simulation

```
% simv [run_options]
```

For more information, see “[Options for Specifying Delays and SDF Files](#)”

Using \$sdf_annotate System Task

You can use the `$sdf_annotate` system task to back-annotate delay values from an SDF file to your Verilog design.

The syntax for the `$sdf_annotate` system task is as follows:

```
$sdf_annotate ("sdf_file" [, module_instance]
[, "sdf_configfile"] [, "sdf_logfile"] [, "mtm_spec"]
[, "scale_factors"] [, "scale_type"]);
```

Where:

`"sdf_file"`

Specifies the path to the SDF file.

`module_instance`

Specifies the scope where back-annotation starts. The default is the scope of the module instance that calls `$sdf_annotate`.

`"sdf_configfile"`

Specifies the SDF configuration file. For more information on the SDF configuration file, refer to the “[SDF Configuration File](#)” section.

"sdf_logfile"

Specifies the SDF log file to which VCS sends error messages and warnings. By default, VCS displays no more than ten warning and ten error messages about back-annotation and writes no more than that in the log file you specify with the *-l* option. However, if you specify an SDF log file with this argument, the SDF log file receives all messages about back-annotation. You can also use the *+sdfverbose* runtime option to enable the display of all back-annotation messages.

"mtm_spec"

Specifies which delay values of min:typ:max triplets VCS back-annotates. Specify "MINIMUM", "TYPICAL", "MAXIMUM" or "TOOL_CONTROL" (default).

"scale_factors"

Specifies the multiplier for the minimum, typical and maximum components of delay triplets. It is a colon separated string of three positive, real numbers "1.0:1.0:1.0" by default.

"scale_type"

Specifies the delay value from each triplet in the SDF file for use before scaling. Possible values: "FROM_TYPICAL", "FROM_MIMINUM", "FROM_MAXIMUM", "FROM_MT" (default).

The usage model to simulate a design using *\$sdf_annotate* is the same as the basic usage model as shown below:

Compilation

```
% vcs [elab_options] top_cfg/entity/module
```

Simulation

```
% simv [run_options]
```

See “[Options for Specifying Delays and SDF Files](#)” on page 20.

Using -xlm Option for SDF Retain, Gate Pulse Propagation, and Gate Pulse Detection Warning

The following sections explain how to use the new features added under the `-xlm` option:

- “[Using Optimistic Mode in SDF](#)”
- “[Using Gate Pulse Propagation](#)”
- “[Generating Warnings During Gate Pulses](#)”

Using Optimistic Mode in SDF

Currently, when you use the `-sdfretain` option, SDF retain is visible whenever there is a change in related inputs.

When you specify the `-sdfretain` option with `-xlm alt_retain`, SDF retain is visible only when there is a change in the output. This new behavior is called optimistic mode. For example, consider the following Verilog code:

```
and u(qout,d1,d2);  
  
specify  
    (d1 => qout) = (10); //RETAIN (6)  
    (d2 => qout) = (10);  
endspecify
```

The corresponding SDF entry is:

```
(IOPATH d1 qout (RETAIN (6))(10) )
(IOPATH d2 qout (10) )
```

The default output for the above example is:

```
time= 10 , d1=0,d2=0, qout=0
time= 100 , d1=1,d2=0, qout=0
time= 106 , d1=1,d2=0, qout=x // since input d1 change at
100, VCS propagate "x" to qout
time= 110 , d1=1,d2=0, qout=0
= 200 , d1=0,d2=0, qout=0
time= 206 , d1=0,d2=0, qout=x // since input d1 change at
200, VCS propagate "x" to qout
time= 210 , d1=0,d2=0, qout=0
time= 300 , d1=0,d2=1, qout=0
time= 400 , d1=1,d2=1, qout=0
time= 406 , d1=1,d2=1, qout=x
time= 410 , d1=1,d2=1, qout=1
```

The output using the `-xlrn alt_retain` option (new behavior) is:

```
time= 10 , d1=0,d2=0, qout=0
time= 100 , d1=1,d2=0, qout=0 // since there is no logic
change on "qout", no retain "x" seen
time= 200 , d1=0,d2=0, qout=0
time= 300 , d1=0,d2=1, qout=0
time= 400 , d1=1,d2=1, qout=0
time= 406 , d1=1,d2=1, qout=x // since there is logic change
on "qout", retain "x" propagated
time= 410 , d1=1,d2=1, qout=1
```

Using Gate Pulse Propagation

Using the `-xlrn gd_pulseprop` option, VCS always propagates a gate pulse, even when the pulse width is equal to the gate delay. For example, consider the following Verilog code:

```

module dut(qout,dinA,dinB);
output qout;
input dinA;
input dinB;

xor #10 inst(qout,dinA,dinB);

endmodule

```

Under the `-xlrn gd_pulseprop` option, if the pulse width on a gate is equal to the gate delay, VCS always propagates the pulse as shown below:

```

0 qout=x, dinA=1 dinB=1
10 qout=0, dinA=0 dinB=1
20 qout=1, dinA=0 dinB=0
30 qout=0, dinA=0 dinB=1
40 qout=1, dinA=0 dinB=0
50 qout=0, dinA=0 dinB=0

```

Generating Warnings During Gate Pulses

Using the `-xlrn gd_pulsegarn` option, VCS generates a warning when it detects that the width of a pulse is identical to the gate delay. For example, consider the following Verilog code:

```

module dut(qout,dinA,dinB);
output qout;
input dinA;
input dinB;

xor #10 inst(qout,dinA,dinB);
endmodule

```

Under the `-xlrn gd_pulsegarn` option, if the pulse width on a gate is equal to the gate delay, VCS generates the following warning message:

```
0 qout=x, dinA=1 dinB=1

Warning- [PWIWGD] Pulse Width Identical With Gate Delay
verilogfile.v, 42
top.mid_inst.dut_inst
At time 10, pulse width identical with gate delay "10" is
detected

10 qout=0, dinA=0 dinB=1

20 qout=1, dinA=0 dinB=0
```

Precompiling an SDF File

Whenever you compile your design, if your design backannotates SDF data, VCS parses either the ASCII text SDF file or the precompiled version of the ASCII text SDF file that VCS can make from the original ASCII text SDF file. VCS does this even if the SDF file is unchanged and already compiled into a binary version by a previous compilation, and even when you are using incremental compilation and the parts of the design backannotated by the SDF file are unchanged.

VCS can parse the precompiled SDF file much faster than it can parse the ASCII text SDF file, so for large SDF files it's a good idea to have VCS create a precompiled version of the SDF file.

Creating the Precompiled Version of the SDF file

To create the precompiled version of the SDF file, include the `+csdf+precompile` option on the vcs command line.

By default, the `+csdf+precompile` option creates the precompiled SDF file in the same directory as the ASCII text SDF file and differentiates the precompiled version by appending "`_c`" to its extension. For example, if the `/u/design/sdf` directory contains a `design1.sdf` file, using the `+csdf+precompile` option creates the precompiled version of the file named `design1.sdf_c` in the `/u/design/sdf` directory.

After you have created the precompiled version of the SDF file, you no longer need to include the `+csdf+precompile` option on the vcs command line unless there is a change in the SDF file.

Continuing to include it, however, such as in a script that you run every time you compile your design, would have no effect when the precompiled version is newer than the ASCII text SDF file, but would create a new precompiled version of the SDF file whenever the ASCII text SDF file changes. Therefore this option is intended to be used in scripts for compiling your design.

When you recompile your design, VCS finds the precompiled SDF file in the same directory as the SDF file specified in the `$sdf_annotate` system task. You can also specify the precompiled SDF file in the `$sdf_annotate` system task. The `+csdf+precompile` option also supports zipped SDF.

SDF Configuration File

You can use the configuration file to control the following on a module type basis, as well as a global basis:

- min:typ:max selection
- Scaling

- MIPD (module-input-delay) approximation policy for cases of ‘overlapping’ annotations to the same input port.

Additionally, there is a mapping command you can use to redirect the target of `IOPATH` and `TIMINGCHECK` statements from the scope of the `INSTANCE` to a specific `IOPATH` or `TIMINGCHECK` in its sub hierarchy for all instances of a specified module type.

Delay Objects and Constructs

The mapping from SDF statements to simulation objects in VCS is fixed, as shown in [Table 9-1](#).

Table 9-1 VCS Simulation Delay Objects/Constructs

	SDF Constructs	VCS Simulation Object
Delays		
	PATHPULSE	module path pulse delay
	GLOBALPATHPULSE	module path pulse reject/error delay
	IOPATH	module path delay
	PORT	module input port delay
	INTERCONNECT	module input port delay or, intermodule path delay when +multisource_int_delays specified
	NETDELAY	module input port delay
	DEVICE	primitive and module path delay
Timing-checks		
	SETUP	\$setup timing-check limit
	HOLD	\$hold timing-check limit
	SETUPHOLD	\$setup and \$hold timing-check limit
	RECOVERY	\$recovery timing-check limit

Table 9-1 VCS Simulation Delay Objects/Constructs

SDF Constructs	VCS Simulation Object
SKEW	\$skew timing-check limit
WIDTH	\$width timing-check limit
PERIOD	\$period timing-check limit
NOCHANGE	ignored
PATHCONSTRAINT	ignored
SUM	ignored
DIFF	ignored
SKEWCONSTRAINT	ignored

SDF Configuration File Commands

This section explains the following commands used in SDF configuration files, with syntax and examples.

- [approx_command](#)
- [mtm_command](#)
- [scale_command](#)

approx_command

The `INTERCONNECT_MPID` keyword selects the INTERCONNECT delays in the SDF file that are mapped to MIPDs in VCS. It can specify one of the following to VCS:

`MINIMUM`

Annotates, to the MIPD for the input or inout port instance, the shortest delay of all the INTERCONNECT delay value entries in the SDF file that specify a connection to the input or inout port.

MAXIMUM

Annotates, to the MIPD for the input or inout port instance, the longest delay of all the INTERCONNECT delay value entries in the SDF file that specify a connection to the input or inout port.

AVERAGE

Annotates, to the MIPD for the input or inout port instance, the average delay of all the INTERCONNECT delay value entries in the SDF file that specify a connection to the input or inout port.

LAST

Annotates, to the MIPD for the input or inout port instance, the delays in the last INTERCONNECT entry in the SDF file that specifies a connection to the input or inout port.

The default approximation is MAXIMUM.

Syntax:

```
INTERCONNECT_MIPD = MINIMUM | MAXIMUM | AVERAGE | LAST;
```

Example:

```
INTERCONNECT_MIPD=LAST;
```

mtm_command

Annotates the minimum, typical, or maximum delay value. Specifies one of the following keywords:

MINIMUM

Annotates the minimum delay value

TYPICAL

Annotates the typical delay value

MAXIMUM

Annotates the maximum delay value

TOOL_CONTROL

Delay value is determined by the command line options of the Verilog tool (+mindelays, +typdelays, or +maxdelays)

The default for min_typ_max is TOOL_CONTROL.

Syntax:

```
MTM = MINIMUM | TYPICAL | MAXIMUM | TOOL_CONTROL;
```

Example:

```
MTM=MAXIMUM;
```

scale_command

- **SCALE_FACTORS** - Set of three real number multipliers that scale the timing information in the SDF file to the minimum, typical, and maximum timing information that is backannotated to the Verilog tool. The multipliers each represent a positive real number, for example 1.6:1.4:1.2
- **SCALE_TYPE** - Selects one of the following keywords to scale the timing specification in the SDF file to the minimum, typical, and maximum timing that is backannotated to the Verilog tool:

FROM_MINIMUM

Scales from the minimum timing specification in the SDF file.

FROM_TYPICAL

Scales from the typical timing specification in the SDF file.

FROM_MAXIMUM

Scales from the maximum timing specification in the SDF file.

`FROM_MM`

Scales directly from the minimum, typical, and maximum timing specifications in the SDF file.

Syntax:

```
SCALE_FACTORS = number : number : number;
SCALE_TYPE = FROM_MINIMUM | FROM_TYPICAL | FROM_MAXIMUM |
FROM_MM;
```

Example:

```
SCALE_FACTORS=100:0:9;
SCALE_TYPE=FROM_MM;
SCALE_FACTORS=1.1:2.1:3.1;
SCALE_TYPE=FROM_MINIMUM;
```

SDF Example with Configuration File

The following example uses the VCS SDF configuration file `sdf.cfg`:

```
// test.v - test sdf annotation
`timescale 1ns/1ps
module test;
initial begin
    $sdf_annotate("./test.sdf",test, "./sdf.cfg",,,);
end
wire out1,out2;
wire w1,w2;
reg in;
reg ctrl,ctrlw;
sub Y (w1,w2,in,in,ctrl,ctrl);
sub W (out1,out2,w1,w2,ctrlw,ctrlw);
initial begin
    $display(" i c ww oo");
    $display("ttt n t 12 12");
    $monitor($realtime,,,in,,ctrl,,w1,w2,,out1,out2);
end
initial begin
    ctrl = 0;// enable
```

```

ctrlw = 0;
in = 1'bx; //stabilize at x;
#100 in = 1; // x-1
#100 ctrl = 1; // 1-z
#100 ctrl = 0; // z-1
#100 in = 0; // 1-0
#100 ctrl = 1; // 0-z
#100 ctrl = 0; // z-0
#100 in = 1'bx; // 0-x
#100 ctrl = 1; // x-z
#100 ctrl = 0; // z-x
#100 in = 0; // x-0
#100 in = 1; // 0-1
#100 in = 1'bx; // 1-x
end
endmodule
`celldefine
module sub(o1,o2,i1,i2,c1,c2);
output o1,o2;
input i1,i2;
input c1,c2;
bufif0 Z(o1,i1,c1);
bufif0 (o2,i2,c2);
specify
    (i1,c1 *> o1) = (1,2,3,4,5,6);
    // 01 = 1, 10 = 2, 0z = 3, z1 = 4, 1z = 5, z0 = 6
    if (i2==1'b1) (i2,c2 *> o2) = (7,8,9,10,11,12);
    // 01 = 7, 10 = 8, z1 = 10, 1z = 11, z0 = 12
endspecify
subsub X ();
endmodule
`endcelldefine
module subsub(oa,ob,ib,ia);
input ia,ib;output oa,ob;
specify
    (ia *> oa) = 99.99;
    (ib *> ob) = 2.99;
endspecify
endmodule

SDF File: test.sdf
(DELAYFILE

```

```

(SDFVERSION "3.0")
(DESIGN "sdftest")
(DATE "July 14, 1997")
(VENDOR "Synopsys")
(PROGRAM "manual")
(VERSION "4.0")
(DIVIDER .)
(VOLTAGE )
(PROCESS "")
(TEMPERATURE )
(TIMESCALE 1 ns)
(CELL (CELLTYPE "sub")
(INSTANCE *)
(DELAY (ABSOLUTE
(IOPATH i1 o1
(10:11:12) (13:14:15) (16:17:18) (19:20:21) (22:23:24) (25:26:2
7)))
(COND (i2==1) (IOPATH i2 o2
(10:11:12) (13:14:15) (16:17:18) (19:20:21) (22:23:24) (25:26:2
7)))
)))
)
)
)

SDF Configuration File: sdf.cfg
PATHPULSE=IGNORE;
INTERCONNECT_MIPD=MAXIMUM;
MTM=TOOL_CONTROL;
SCALE_FACTORS=100:0:9;
SCALE_TYPE=FROM_MTM;
MTM = TYPICAL;
SCALE_TYPE=FROM_MINIMUM;
SCALE_FACTORS=1.1:2.1:3.1;

MODULE sub {
SCALE_TYPE=FROM_MTM;
SCALE_FACTORS=1:2:3;
MTM=MINIMUM;
MAP_INNER = X;
(i1 *> o1) = IGNORE;
(i1 *> o1) = ADD { (ia *> oa); }
(i1 *> o1) = ADD { (ib *> ob); }
if (i2==1) (i2 *> o2) = ADD { (ib *> ob); }
}

```

}

Delays and Timing

This section describes the following topics:

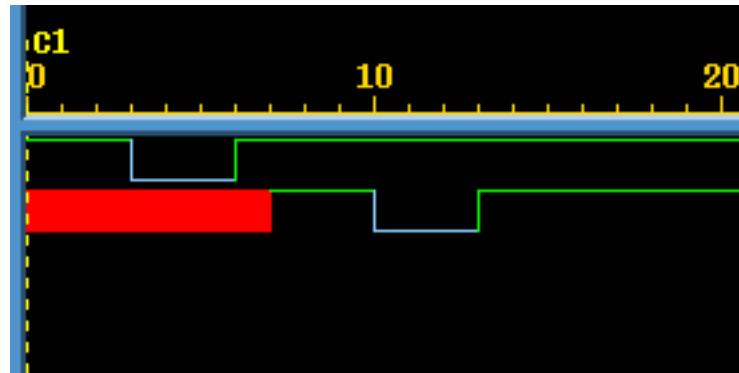
- “Transport and Inertial Delays”
 - “Pulse Control”
 - “Specifying the Delay Mode”
-

Transport and Inertial Delays

Delays can be categorized into transport and inertial delays.

Transport delays allow all pulses that are narrower than the delay to propagate through. For example, [Figure 9-1](#) shows the waveforms for an input and output port of a module that models a buffer with a module path delay of seven time units between these ports. The waveform on top is that of the input port and the waveform underneath is that of the output port. In this example, you have enabled transport delays for module path delays and specified that a pulse three time units wide can propagate through. For an explanation on how this is done, see “[Enabling Transport Delays](#)” on page 22 and “[Pulse Control](#)” on page 23.

Figure 9-1 Transport Delay Waveforms

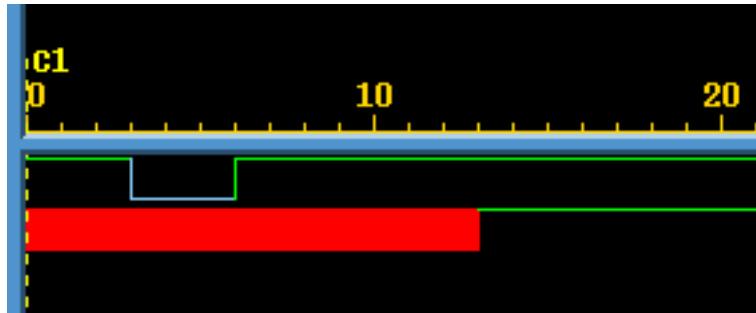


At time 0, a pulse three time units wide begins on the input port. This pulse is narrower than the module path delay of seven time units, but this pulse propagates through the module and appears on the output port after seven time units. Similarly, another narrow pulse begins on the input port at time 3 and it also appears on the output port seven time units later.

You can apply transport delays on all module path delays and all SDF INTERCONNECT delays back-annotated to a net from an SDF file. For more information on SDF back-annotation, see “[SDF Annotation](#)” .

Inertial delays, in contrast, filter out all pulses that are narrower than the delay. [Figure 9-2](#) shows the waveforms for the same input and output ports when you have not enabled transport delays for module path delays.

Figure 9-2 Inertial Delay Waveforms



The pulse that begins at time 0 that is three time units wide does not propagate to the output port because it is narrower than the seven time unit module path delay. Neither does the narrow pulse that begins at time 3. Note that the wide pulse that begins at time 6 does propagate to the output port.

Gates, switches, MIPDs, and continuous assignments only have inertial delays, which are the default type of delay for module path delays and INTERCONNECT delays back-annotated from an SDF file to a net.

Different Inertial Delay Implementations

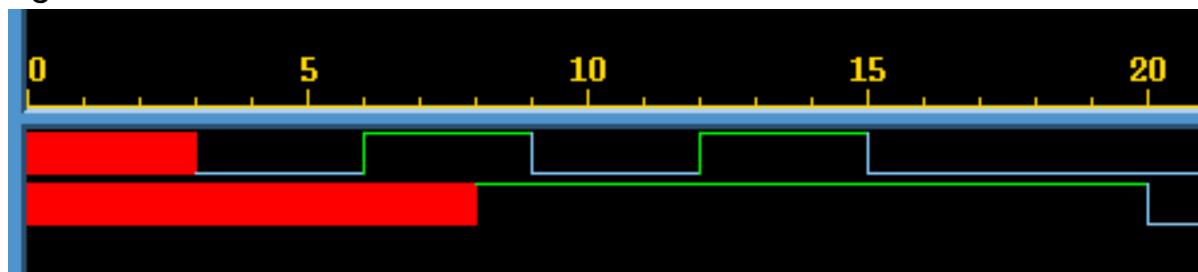
For compatibility with the earlier generation of Verilog simulators, inertial delays have two different implementations, one for primitives (gates, switches and UDPs), continuous assignments, and MIPDs (Module Input Port Delays) and the other for module path delays and INTERCONNECT delays back-annotated from an SDF file to a net. For more details on SDF back-annotation, see “[SDF Annotation](#)” . There is also a third implementation that is for module path and INTERCONNECT delays and pulse control, see “[Pulse Control](#)” on page 23.

Inertial Delays for Primitives, Continuous Assignments, and MIPDs

Both implementations were devised to filter out narrow pulses but the one for primitives, continuous assignments, and MIPDs can produce unexpected results. For example, [Figure 9-3](#) shows the waveforms for nets connected to the input and output terminals of a buf gate with a delay of five time units.

In this implementation there can never be more than one scheduled event on an output terminal. To filter out narrow pulses, the trailing edge of a pulse can alter the value change but not the transition time of the event scheduled by the leading edge of the pulse if the event has not yet occurred.

Figure 9-3 Gate Terminal Waveforms



In the example illustrated in [Figure 9-3](#), the following occurs:

1. At time 3 the input terminal changes to 0. This is the leading edge of a three time unit wide pulse. This event schedules a value change to 0 on the output terminal at time 8 because there is a #5 delay specification for the gate.
2. At time 6 the input terminal toggles to 1. This implementation keeps the scheduled transition on the output terminal at time 8 but alters the value change to a value of 1.

3. At time 8 the output terminal transitions to 1. This transition might be unexpected because all pulses on the input have been narrower than the delay, but this is how this implementation works. There is now no event scheduled on the output and a new event can now be scheduled.
4. At time 9 the input terminal toggles to 0 and the implementation schedules a transition of the output to 0 at time 14.
5. At time 12 the input terminal toggles to 1 and the value change scheduled on the output at time 14 changes to a 1.
6. At time 14 the output is already 1 so there is no value change. The narrow pulse on the input between time 9 and 12 is filtered out. This implementation was devised for these narrow pulses. There is now no event scheduled for the output.
7. At time 15 the input toggles to 0 and this schedules the output to toggle to 0 at time 20.

Inertial Delays for Module Path Delays and INTERCONNECT Delays

The implementation of inertial delays for module path delays and SDF INTERCONNECT delays is as follows: if the event scheduled by the leading edge of a pulse is scheduled for a later simulation time, or in other words, has not yet occurred, then the event scheduled by the trailing edge at the end of the specified delay and at a new simulation time, replaces the event scheduled by the leading edge. All narrow pulses are filtered out.

Note:

- SDF INTERCONNECT delays follow this implementation if you include the `+multisource_int_delays` compile-time option. If you do not include this option, VCS uses an MIPD to model the SDF INTERCONNECT delay and the delay uses the inertial delay implementation for MIPDs.
- VCS enables more complex and flexible pulse control processing when you include the `+pulse_e/number` and `+pulse_r/number` options. See “[Pulse Control](#)” on page 23.

Enabling Transport Delays

Transport delays are never the default delay.

You can specify transport delays on module path delays with the `+transport_path_delays` compile-time option. For this option to work, you must also include the `+pulse_e/number` and `+pulse_r/number` compile-time options. See “[Pulse Control](#)” on page 23.

You can specify transport delays on a net to which you back-annotate SDF INTERCONNECT delays with the `+transport_int_delays` compile-time option. For this option to work, you must also include the `+pulse_int_e/number` and `+pulse_int_r/number` compile-time options. See “[Pulse Control](#)” on page 23.

The `+pulse_e/number`, `+pulse_r/number`, `+pulse_int_e/number`, and `+pulse_int_r/number` options define specific thresholds for pulse width, which allow you to tell VCS to filter out only some of the pulses and let the other pulses through. See “[Pulse Control](#)” on page 23.

Pulse Control

So far we've seen that with pulses narrower than a module path or INTERCONNECT delay, you have the option of filtering all of them out by using the default inertial delay or allowing all of them to propagate through, by specifying transport delays. VCS also provides a third option - pulse control. With pulse control you can:

- Allow pulses that are slightly narrower than the delay to propagate through.
- Have VCS replace even narrower pulses with an `x` value pulse on the output and display a warning message.
- Have VCS then filter out and ignore pulses that are even narrower than the ones for which it propagates an `x` value pulse and displays an error message.

You specify pulse control with the `+pulse_e/number` and `+pulse_r/number` compile-time options for module path delays and the `+pulse_int_e/number` and `+pulse_int_r/number` compile-time options for INTERCONNECT delays.

The `+pulse_e/number` option's `number` argument specifies a percentage of the module path delay. VCS replaces pulses whose widths that are narrower than the specified percentage of the delay with an `x` value pulse on the output or inout port and displays a warning message.

Similarly, the `+pulse_int_e/number` option's `number` argument specifies a percentage of the INTERCONNECT delay. VCS replaces pulses whose widths are narrower than the specified percentage of the delay with an `x` value pulse on the inout or output port instance that is the load of the net to which you back-annotated the INTERCONNECT delay. It also displays a warning message.

The `+pulse_r/number` option's *number* argument also specifies a percentage of the module path delay. VCS filters out the pulses whose widths are narrower than the specified percentage of the delay. With these pulses there is no warning message; VCS simply ignores these pulses.

Similarly, the `+pulse_int_r/number` option's *number* argument specifies a percentage of the INTERCONNECT delay. VCS filters out pulses whose widths are narrower than the specified percentage of the delay. There is no warning message with these pulses.

You can use pulse control with transport delays (see “[Pulse Control with Transport Delays](#)” on page 25) or inertial delays (see “[Pulse Control with Inertial Delays](#)” on page 27).

When a pulse is narrow enough for VCS to display a warning message and propagate an x value pulse, you can set VCS to do one of the following:

- Place the starting edge of the x value pulse on the output, as soon as it detects that the pulse is sufficiently narrow, by including the `+pulse_on_detect` compile-time option.
- Place the starting edge on the output at the time when the rising or falling edge of the narrow pulse would have propagated to the output. This is the default behavior.

See “[Specifying Pulse on Event or Detect Behavior](#)” on page 31.

Also when a pulse is sufficiently narrow to display a warning message and propagate an x value pulse, you can have VCS propagate the x value pulse but disable the display of the warning message with the `+no_pulse_msg` runtime option.

Pulse Control with Transport Delays

You specify transport delays for module path delays with the `+transport_path_delays`, `+pulse_e/number`, and `+pulse_r/number` options. You must include all three of these options.

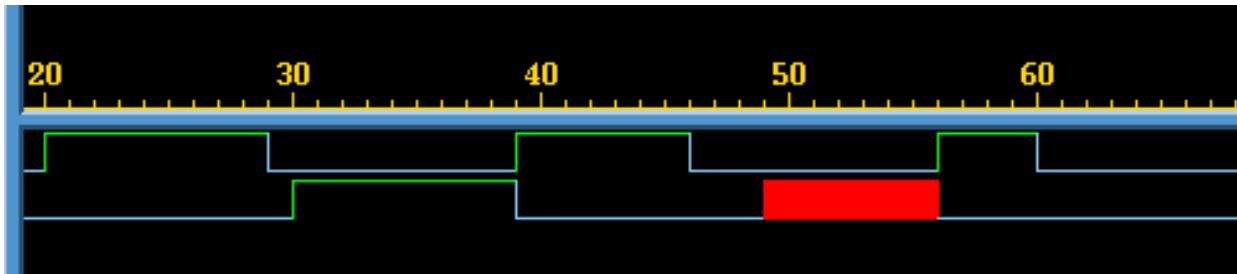
You specify transport delays for INTERCONNECT delays on nets with the `+transport_int_delays`, `+pulse_int_e/number`, and `+pulse_int_r/number` options. You must include all three of these options.

If you want VCS to propagate all pulses, no matter how narrow, specify a 0 percentage. For example, if you want VCS to replace pulses that are narrower than 80% of the delay with an x value pulse (and display a warning message) and filter out pulses that are narrower than 50% of the delay, enter the `+pulse_e/80` and `+pulse_r/50` or `+pulse_int_e/80` and `+pulse_int_r/50` compile-time options.

[Figure 9-4](#) shows the waveforms for the input and output ports for an instance of a module that models a buffer with a ten time unit module path delay. The `vcs` command line contains the following compile-time options:

```
+transport_path_delays +pulse_e/80 +pulse_r/50
```

Figure 9-4 Pulse Control with Transport Delays



In the example illustrated in [Figure 9-4](#) the following occurs:

1. At time 20, the input port toggles to 1.
2. At time 29, the input port toggles to 0 ending a nine time unit wide value 1 pulse on the input port.
3. At time 30, the output port toggles to 1. The nine time unit wide value 1 pulse that began at time 20 on the input port is propagating to the output port because we have enabled transport delays and nine time units is more than 80% of the ten time unit module path delay.
4. At time 39, the input port toggles to 1 ending a ten time unit wide value 0 pulse. Also, at time 39 the output port toggles to 0. The ten time unit wide value 0 pulse that began at time 29 on the input port is propagating to the output port.
5. At time 46, the input port toggles to 0 ending a seven time unit wide value 1 pulse.
6. At time 49, the output port transitions to x. The seven time unit wide value 1 pulse that began at time 39 on the input port has propagated to the output port, but VCS has replaced it with an x value pulse because seven time units is less than 80% of the module path delay. VCS issues a warning message in this case.

7. At time 56, the input port toggles to 1 ending a ten time unit wide value 0 pulse. Also, at time 56, the output port toggles to 0. The ten time unit wide value 0 pulse that began at time 46 on the input port is propagating to the output port.
8. At time 60, the input port toggles to 0 ending a four time unit wide value 1 pulse. Four time units is less than 50% of the module path delay, therefore, VCS filters out this pulse and no indication of it appears on the output port.

Pulse Control with Inertial Delays

You can enter the `+pulse_e/number` and `+pulse_r/number` or `+pulse_int_e/number` and `+pulse_int_r/number` options without the `+transport_path_delays` or `+transport_int_delays` options. If you do this, you are specifying pulse control for inertial delays on module path delays and INTERCONNECT delays.

There is a special implementation of inertial delays with pulse control for module path delays and INTERCONNECT delays. In this implementation, value changes on the input can schedule two events on the output.

The first of these two scheduled events always causes a change on the output. The type of value change on the output is determined by the following:

- If the first event is scheduled by the leading edge of a pulse whose width is equal to or wider than the percentage specified by the `+pulse_e/number` option, the value change on the input propagates to the output.

- If the pulse is not wider than the percentage specified by the `+pulse_e/number` option, but is wider than the percentage specified by the `+pulse_r/number` option, the value change is replaced by an x value.
- If the pulse is not wider than the percentage specified by the `+pulse_r/number` option, the pulse is filtered out.

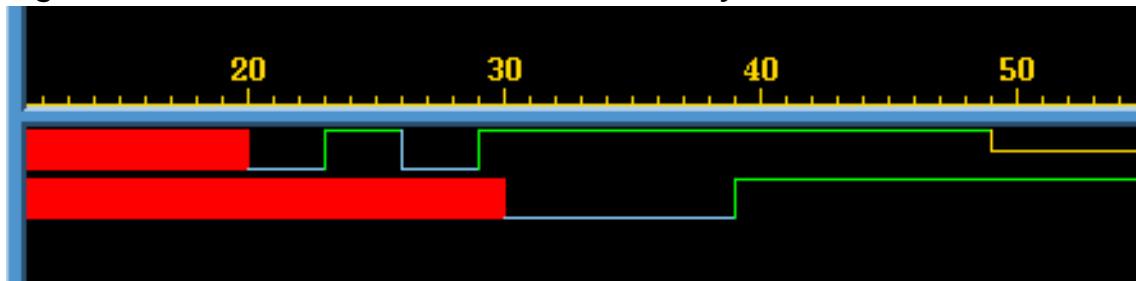
The second scheduled event is always tentative. If another event occurs on the input before the first event occurs on the output, that additional event on the input cancels the second scheduled event and schedules a new second event.

[Figure 9-5](#) shows the waveforms for the input and output ports for an instance of a module that models a buffer with a ten time unit module path delay. The `vcs` command line contains the following compile-time options:

```
+pulse_e/0 +pulse_r/0
```

In this example, specifying 0 percentages means that the trailing edge of all pulses can change the second scheduled event on the output. Specifying 0 does not mean that all pulses propagate to the output because this implementation has its own way of filtering out short pulses.

Figure 9-5 Pulse Control with Inertial Delays



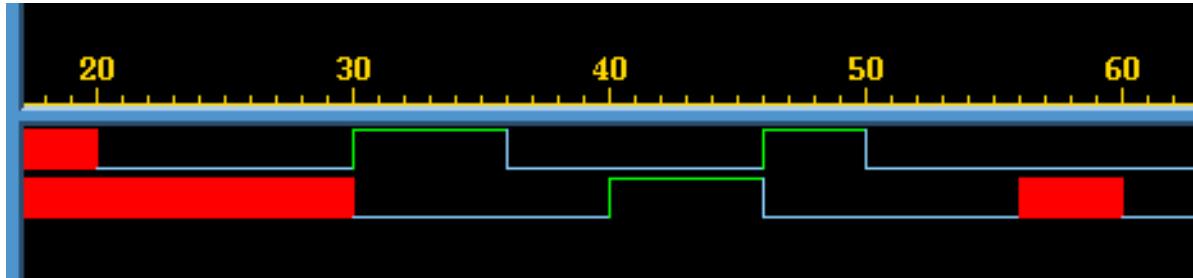
In the example illustrated in [Figure 9-5](#) the following occurs:

1. At time 20, the input port transitions to 0. This schedules a transition to 0 on the output port at time 30, ten time units later as specified by the module path delay. This is the first scheduled event on the output port. This event is not tentative, it will occur.
2. At time 23, the input port toggles to 1. This schedules a transition to 1 on the output port at time 33. This is the second scheduled event on the output port. This event is tentative.
3. At time 26, the input port toggles to 0. This cancels the current scheduled second event and replaces it by scheduling a transition to 0 at time 36. The first scheduled event is a transition to 0 at time 30 so the new second scheduled event isn't really a transition on the output port. This is how this implementation filters out narrow pulses.
4. At time 29, the input port toggles to 1. This cancels the current scheduled second event and replaces it by scheduling a transition to 1 at time 39.
5. At time 30, the output port transitions to 0. The second scheduled event on the output becomes the first scheduled event and is therefore no longer tentative.
6. At time 39, the output port toggles to 1.

Typically, however, you will want to specify that VCS replace or reject certain narrow pulses. [Figure 9-6](#) shows the waveforms for the input and output ports for an instance of the same module with a ten time unit module path delay. The `vcs` command line contains the following compile-time options:

```
+pulse_e/60 +pulse_r/40
```

Figure 9-6 Pulse Control with Inertial Delays and a Narrow Pulses



In the example illustrated in [Figure 9-6](#) the following occurs:

1. At simulation time 20, the input port transitions to 0. This schedules the first event on the output port, a transition to 0 at time 30.
2. At simulation time 30, the input port toggles to 1. This schedules the output port to toggle to 1 at time 40. Also, at simulation time 30, the output port transitions to 0. It doesn't matter which of these events happened first. At the end of this time there is only one scheduled event on the output.
3. At simulation time 36, the input port toggles to 0. This is the trailing edge of a six time unit wide value 1 pulse. The pulse is equal to the width specified with the `+pulse_e/60` option so VCS schedules a second event on the output, a value change to 0 on the output at time 46.
4. At simulation time 40, the output toggles to 1 so now there is only one event scheduled on the output, the value change to 0 at time 46.
5. At simulation time 46, the input toggles to 1 scheduling a transition to 1 at time 56 on the output. Also at time 46, the output toggles to 0. There is now only one event scheduled on the output.

6. At time 50, input port toggles to 0. This is the trailing edge of a four time unit wide value 1 pulse. The pulse is not equal to the width specified with the `+pulse_e/60` option, but is equal to the width specified with the `+pulse_r/40` option, therefore, VCS changes the first scheduled event from a change to 1 to a change to X at time 56 and schedules a second event on the output, a transition to 0 at time 60.
7. At time 56, the output transitions to X and VCS issues a warning message.
8. At time 60, the output transitions to 0.

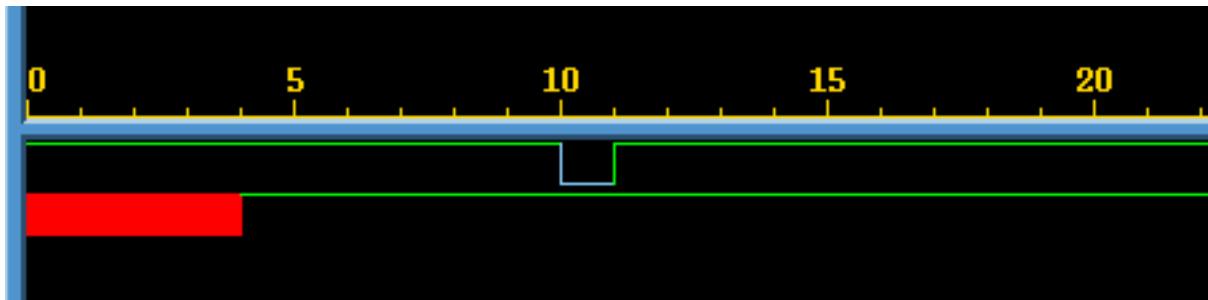
Pulse control sometimes blurs the distinction between inertial and transport delays. In this example, the results would have been the same if you also included the `+transport_path_delays` option.

Specifying Pulse on Event or Detect Behavior

Asymmetric delays, such as different rise and fall times for a module path delay, can cause schedule cancellation problems for pulses. These problems persist when you specify transport delay and can persist for a wide range of percentages that you specify for the pulse control options.

For example, for a module that models a buffer, if you specify a rise time of 4 and a fall time of 6 for a module path delay, a narrow value 0 pulse can cause scheduling problems, as illustrated in [Figure 9-7](#).

Figure 9-7 Asymmetric Delays and Scheduling Problems



In this example, you include the `+pulse_e/100` and `+pulse_r/0` options. The scheduling problem is that the leading edge of the pulse on the input, at time 10, schedules a transition to 0 on the output at time 16; but the trailing edge, at time 11, schedules a transition to 1 on the output at time 15.

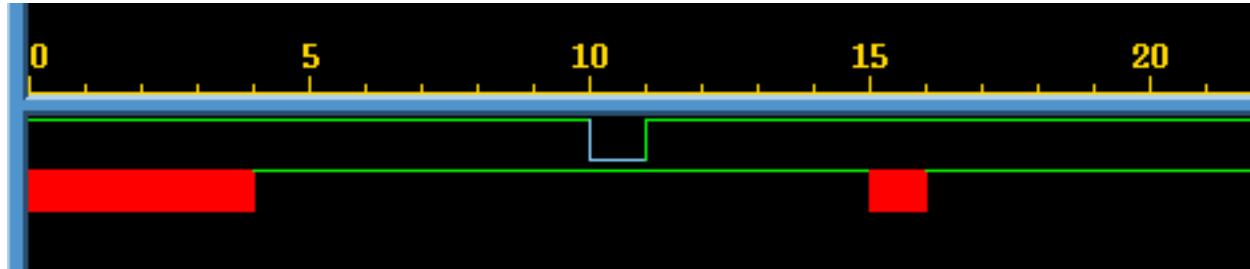
Obviously, the output has to end up with a value of 1 so VCS can't allow the events scheduled at time 15 and 16 to occur in sequence; if it did, the output would end up with a value of 0. This problem persists when you enable transport delays and whenever the percentage specified in the `+pulse_r/number` option is low enough to enable the pulse to propagate through the module.

To circumvent this problem, when a later event on the input schedules an event on the output that is earlier than the event scheduled by the previous event on the input, VCS cancels both events on the output.

This ensures that the output ends up with the proper value, but what it doesn't do is indicate that something happened on the output between times 15 and 16. You might want to see an error message and an X value pulse on the output indicating there was an undefined event on the output between these simulation times. You see this message and the X value pulse if you include the `+pulse_on_event` compile-time option, specifying pulse on event behavior, as illustrated in [Figure 9-8](#). Pulse on event behavior calls

for an X value pulse on the output after the delay and when there are asymmetrical delays scheduling events on the output that would be canceled by VCS , to output an X value pulse between those events instead.

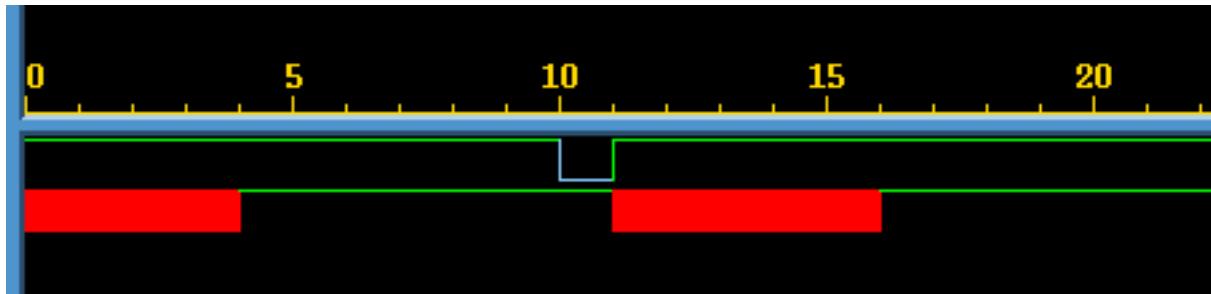
Figure 9-8 Using +pulse_on_event



In most cases where the `+pulse_e/number` and `+pulse_r/number` options already create X value pulses on the output, also including the `+pulse_on_event` option to specify pulse on event behavior will make no change on the output.

Pulse on detect behavior, specified by the `+pulse_on_detect` compile-time option, displays the leading edge of the X value pulse on the output as soon as events on the input, controlled by the `+pulse_e/number` and `+pulse_r/number` options, schedule an X value pulse to appear on the output. Pulse on detect behavior differs from pulse on event behavior in that it calls for the X value pulse to begin before the delay elapses. [Figure 9-9](#) illustrates pulse on detect behavior.

Figure 9-9 Using +pulse_on_detect



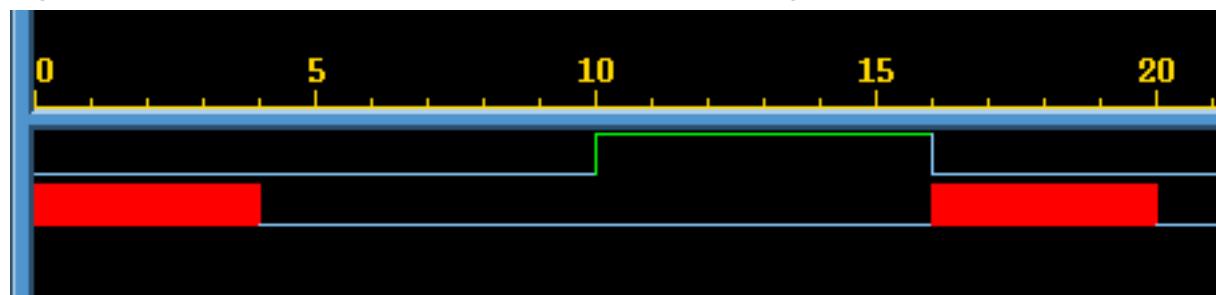
In this example, by including the `+pulse_on_detect` option, VCS causes the leading edge of the X value pulse on the output to begin at time 11 because of an unusual event that occurred on the output between times 15 and 16 because of the rise at simulation time 11.

Using pulse on detect behavior can also show you when VCS has scheduled multiple events for the same simulation time on the output by starting the leading edge of an X value pulse on the output as soon as VCS has scheduled the second event.

For example, a module that models a buffer has a rise time module path delay of 10 time units and a fall time module path delay of 4 time units.

[Figure 9-10](#) shows the waveforms for the input and output port when you include the `+pulse_on_detect` option.

Figure 9-10 Pulse on Detect Behavior Showing Multiple Transitions



In the example illustrated in [Figure 9-10](#) the following occurs:

1. At simulation time 0 the input port transitions to 0 scheduling the first event on the output, a transition to 0 at time 4.
2. At time 4 the output transitions to 0.
3. At time 10 the input transitions to 1 scheduling a transition to 1 on the output at time 20.
4. At time 16 the input toggles to 0 scheduling a second event on the output at time 20, a transition to 0. This event also is the trailing edge of a six time unit wide value 1 pulse so the first event changes to a transition to X. There is more than one event for different value changes on the output at time 20, so VCS begins the leading edge of the X value pulse on the output at this time.
5. At time 20 the output toggles to 0, the second scheduled event at this time.

If you did not include the `+pulse_on_detect` option, or substituted the `+pulse_on_event` option, you would not see the X value pulse on the output between times 16 and 20.

Pulse on detect behavior does not just show you when asymmetrical delays schedule multiple events on the output. Other kinds of events can cause multiple events on the output at the same simulation time, such as different transition times on two input ports and different module path delays from these input ports to the output port. Pulse on detect behavior would show you an X value pulse on the output starting when the second event was scheduled on the output port.

Specifying the Delay Mode

It is possible for a module definition to include module path delay that does not equal the cumulative delay specifications in primitive instances and continuous assignment statements in that path.

[Example 9-1](#) shows such a conflict.

Example 9-1 Conflicting Delay Modes

```
'timescale 1 ns / 1 ns
module design (out,in);
output out;
input in;
wire int1,int2;

assign #4 out=int2;

buf #3 buf2 (int2,int1),
      buf1 (int1,in);

specify
  (in => out) = 7;
endspecify
endmodule
```

In [Example 9-1](#), the module path delay is seven time units, but the delay specifications distributed along that path add up to ten time units.

If you include the `+delay_mode_path` compile-time option, VCS ignores the delay specifications in the primitive instantiation and continuous assignment statements and uses only the module path delay. In [Example 9-1](#), it would use the seven time unit delay for propagating signal values through the module.

If you include the `+delay_mode_distributed` compile-time option, VCS ignores the module path delays and uses the delay in the delay specifications in the primitive instantiation and continuous assignment statements. In [Example 9-1](#), it uses the ten time unit delay for propagating signal values through the module.

There are other modes that you can specify:

- If you include the `+delay_mode_unit` compile-time option, VCS ignores the module path delays and changes the delay specification in all primitive instantiation and continuous assignment statements to the shortest time precision argument of all the `'timescale` compiler directives in the source code. (The default time unit and time precision argument of the `'timescale` compiler directive is 1 s). In [Example 9-1](#) the `'timescale` compiler directive has a precision argument of 1 ns. VCS might use this 1 ns as the delay, but if the module definition is used in a larger design and there is another `'timescale` compiler directive in the source code with a finer precision argument, then VCS uses the finer precision argument.
- If you include the `+delay_mode_zero` compile-time option, VCS changes all delay specifications and module path delays to zero.
- If you include none of the compile-time options described in this section, when, as in [Example 9-1](#), the module path delay does not equal the distributed delays along the path, VCS uses the longer of the two.

Using the Configuration File to Disable Timing

You can use the VCS configuration file to disable module path delays, specify blocks, and timing checks for module instances that you specify as well as all instances of module definitions that you specify. You use the instance, module, and tree statements to do this just as you do for applying Radiant Technology. See “[The Configuration File Syntax](#)” on page 7 for details on how to do this. The attribute keywords for timing are as follows:

`noIopath`

Specifies disabling the module path delays in the specified module instances.

`noSpecify`

Specifies disabling the specify blocks in the specified module instances.

`noTiming`

Specifies disabling the timing checks in the specified module instances.

Using the `timopt` Timing Optimizer

The `timopt` timing optimizer can yield large speedups for full-timing gate-level designs. The `timopt` timing optimizer makes its optimizations based on the clock signals and sequential devices that it identifies in the design. `timopt` is particularly useful when you use SDF files because SDF files can't be used with Radiant Technology (+rad).

You enable `timopt` with the `+timopt+clock_period` compile-time option, where the argument is the shortest clock period (or clock cycle) of the clock signals in your design. For example:

```
+timopt+100ns
```

This options specifies that the shortest clock period is 100ns.

`timopt` first displays the number of sequential devices that it finds in the design and the number of these sequential devices to which it might be able to apply optimizations. For example:

```
Total Sequential Elements : 2001
Total Sequential Elements 2001, Optimizable 2001
```

`timopt` then displays the percentage of identified sequential devices to which it can actually apply optimizations followed by messages about the optimization process.

```
TIMOPT optimized 75 percent of the design
Starting TIMOPT Delay optimizations
Done TIMOPT Delay Optimizations
DONE TIMOPT
```

The next step is to simulate the design and see if the optimizations applied by `timopt` produce a satisfactory increase in performance. If you are not satisfied there are additional steps that you can take to get more optimizations from `timopt`.

If `timopt` was able to identify all the clock signals and all the sequential devices with an absolute certainty it simply applies its optimizations. If `timopt` is uncertain about a number of clock signals and sequential devices then you can use the following process to maximize `timopt` optimizations:

1. `timopt` writes a configuration file named `timopt.cfg` in the current directory that lists the signals and sequential devices that it finds questionable.
2. You review and edit this file, validating that the signals in the file are, or are not, clock signals and that the module definitions in it are, or are not, sequential devices. If you do not need to make any changes in the file, go to step 5. If you do make changes, go to step 3.
3. Compile your design again with the `+timopt+clock_period` compile-time option.

`timopt` will make the additional optimizations that it did not make, because it was unsure of the signals and sequential devices in the `timopt.cfg` file that it wrote during the first compilation.

4. Look at the `timopt.cfg` file again:
 - If `timopt` wrote no new entries for potential clock signals or sequential devices, go to step 5.
 - If `timopt` wrote new entries, but you make no changes to the new entries, go to step 5.
 - If you make modifications to the new entries, return to step 3.
5. `timopt` does not need to look for any more clock signals and it can assume that the `timopt.cfg` file correctly specifies clock signal and sequential devices. At this point, it just needs to apply the latest optimizations. Compile your design one more time, including the `+timopt` compile-time option, but without its `+clock_period` argument.

6. You now simulate your design using `timopt` optimizations. `timopt` monitors the simulation and makes its optimizations based on its analysis of the design and information in the `timopt.cfg` file. During simulation, if it finds that its assumptions are incorrect, for example the clock period for a clock signal is incorrect, or there is a port for asynchronous control on a module for a sequential device, `timopt` displays a warning message similar to the following:

```
+ Timopt Warning: for clock testbench.clockgen..clk:  
TimePeriod 50ns      Expected 100ns
```

Editing the `timopt.cfg` File

When editing the `timopt.cfg` file, first edit the potential sequential device entries. Edit the potential clock signal only when you have made no changes to the entries for sequential devices.

Editing Potential Sequential Device Entries

The following is an example of sequential devices that `timopt` was not sure of:

```
// POTENTIAL SEQUENTIAL CELLS  
// flop {jknpn} { , } ;  
// flop {jknpc} { , } ;  
// flop {tfnpsc} { , } ;
```

You can remove the comment marks for the module definitions that are, in fact, model sequential devices and which provide the clock port, clock polarity, and optionally asynchronous ports.

A modified list might look like the following:

```
flop { jknpn } { CP, true } ;
```

```
flop { jknpc } { CP, true, CLN};  
flop { tfnpsc } { CP, true, CLN};
```

In this example, CP is the clock port and the keyword `true` indicates that the sequential device is triggered on the posedge of the clock port and CLN is an asynchronous port.

If you uncomment any of these module definitions, then `timopt` might identify additional clock signals that drive these sequential devices. To enable `timopt` to do this:

1. Remove the clock signal entries from the `timopt.cfg` file.
2. Recompile the design with the same `+timopt+clock_period` compile-time option.

`timopt` will write new clock signal entries in the `timopt.cfg` file.

Editing Clock Signal Entries

The following is an example of the clock signal entries:

```
clock {  
    // test.badClock , // 1  
    test.goodClock // 2000  
} {100ns};
```

These clock signals have a period of `100ns` or longer. This time value comes from the `+clock_period` argument that you added to the `+timopt` compile-time option when you first compiled the design. The entry for the signal `test.badClock` is commented out because it connects to a small percentage of the sequential devices in the design. In this instance, it is only 1 of the 2001 sequential devices that it identified in the design. The entry for the signal

`test.goodClock` is not commented out because it connects to a large percentage of the sequential devices. In this instance, it is 2000 of the 2001 sequential devices in the design.

If a commented out clock signal is a clock signal that you want `timopt` to use when it optimizes the design in a subsequent compilation, then remove the comment characters preceding the signal's hierarchical name.

Using Scan Simulation Optimizer

The Scan Simulation Optimizer (ScanOpt) yields large speed-ups when used with Serial Scan DFT simulations. The optimizations are done based on the scan cells that are identified in the design. This optimization is applicable only on the Serial Scan DFT designs, using scan flops built with the MUX-FLOP combination.

This optimization can be enabled by using the

`-scanopt=<clock_period>` compile-time option, where the `clock_period` argument is the shortest clock period (or clock cycle) of the clock signals in the design. For example, you must use `-scanopt=100ns` for a shortest clock period of 100ns.

The optimizer applies its optimization after the scan flops in the design are identified. There is an option for providing all the scan flops in the design through a configuration file `scanopt.cfg` in the current directory. This can be used if the optimizer fails to identify the scan flops, thereby not producing a satisfactory performance improvement.

For example, for a design with shortest clock period of 100ns, you can supply the list of scan flops in the file `scanopt.cfg` using the format specified in the following section, and then use the following compile-time option.

```
-scanopt=100ns, cfg
```

This enables the optimizer to pick up the scan flops specified in the configuration file and use for its optimization.

The optimizer also determines the length of the scan chain(s) on its own. If there are multiple scan chains, the minimal scan length is chosen for optimizations.

ScanOpt Config File Format

The following format must be used for specifying a scan flop:

```
BEGIN_FLOP      <scan_cell_name>
    BEGIN_PORT
        Q_PORT   <q_port_name>
        [QN_PORT <qn_port_name>]
        D_PORT   <d_port_name>
        TI_PORT  <ti_port_name>
        TE_PORT  <te_port_name>
    END_PORT
END_FLOP
```

The section between `BEGIN_FLOP` and `END_FLOP` corresponds to one particular scan flop. The field `<scan_cell_name>` corresponds to the name of scan flop (scan cell). Multiple sections can be used to specify multiple scan flops.

The section between `BEGIN_PORT` and `END_PORT` corresponds to ports of the scan flop. Specifying `Q_PORT`, `D_PORT`, `TI_PORT`, and `TE_PORT` are mandatory, whereas `QN_PORT` could be optional.

ScanOpt Assumptions

Combinational Path Delays

By default, the optimizer assumes that the worst case delay for any combinational path in the design is not more than **five times** the shortest clock period and applies the optimizations. The following banner is printed at the compile time to indicate this assumption to you:

*“ScanOpt assumes that no combinational path has worst-case delay more than 5 clock period. Please use,
"-scanopt=<clock_period>,cdel=<overriding_value>” to override the assumed value”*

For example, for a design with shortest clock period of 100ns, if the default value of 5 is to be overridden with a value of 10, you can use the following compile-time option.

```
- scanopt=100ns , cdel=10
```

Length of Test Cycles

The optimizer assumes that the simulation remains in the test mode for at least the scan chain length times the shortest clock period. Any violation of this assumption is automatically detected during the simulation, and the following error message is displayed quitting the simulation.

“Error: Simulation has been aborted due to fatal violation of ScanOpt assumptions. Please refer to the documentation for more details. To get around this error, please rerun simulation with “-noscanopt” switch”

For example, if the inferred length of scan chain in the design is 5000 and the short clock period is 100ns, then the Test enable signal(s) should remain in test mode for at least 500000ns (that is, 5000 * 100ns).

Note:

The `-noscanopt` option can be used at runtime, thereby avoiding re-compilation of the design.

Negative Timing Checks

Negative timing checks are either `$setuphold` timing checks with negative setup or hold limits, or `$recrem` timing checks with negative recovery or removal limits.

This following sections describe their purpose, how they work, and how to use them:

- “The Need for Negative Value Timing Checks”
- “The `$setuphold` Timing Check Extended Syntax”
- “The `$recrem` Timing Check Syntax”
- “Enabling Negative Timing Checks”
- “Checking Conditions”
- “Toggling the Notifier Register”
- “SDF Back-annotation to Negative Timing Checks”
- “How VCS Calculates Delays”
- “Using Multiple Non-overlapping Violation Windows”

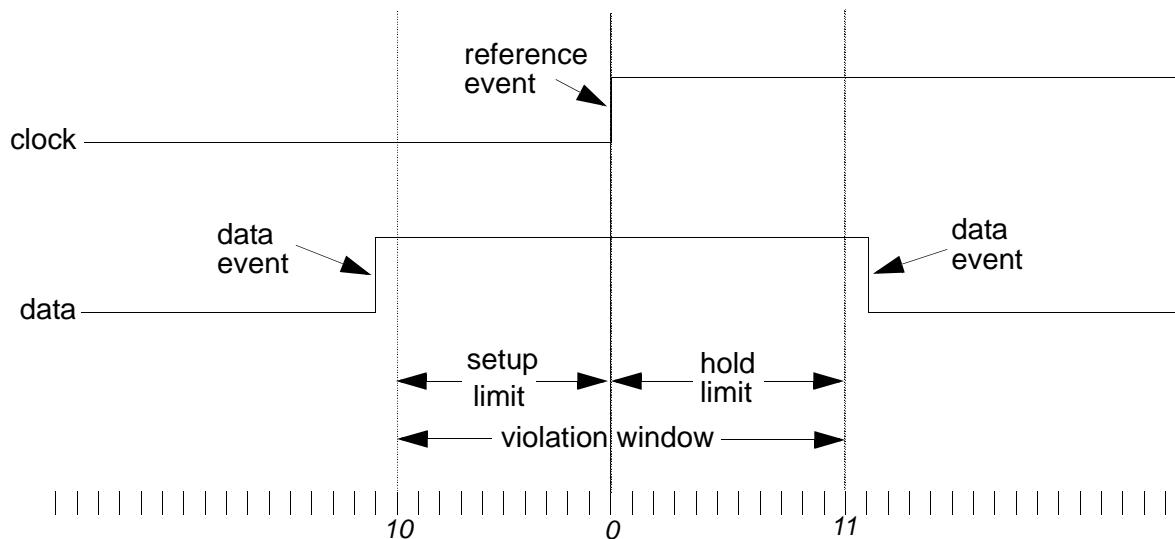
The Need for Negative Value Timing Checks

The `$setuphold` timing check defines a timing violation window of a specified amount of simulation time before and after a reference event, such as a transition on some other signal, for example, a clock signal, in which a data signal must remain constant. A transition on the data signal, called a data event, during the specified window is a timing violation. For example:

```
$setuphold (posedge clock, data, 10, 11, notifyreg);
```

In this example, VCS reports the timing violation if there is a transition on signal `data` less than 10 time units before, or less than 11 time units after, a rising edge on signal `clock`. When there is a timing violation, VCS toggles a notify register, in this example, `notifyreg`. You could use this toggling of a notify register to output an `x` value from a device, such as a sequential flop, when there is a timing violation.

Figure 9-11 Positive Setup and Hold Limits



In this example, both the setup and hold limits have positive values. When this occurs, the violation window straddles the reference event.

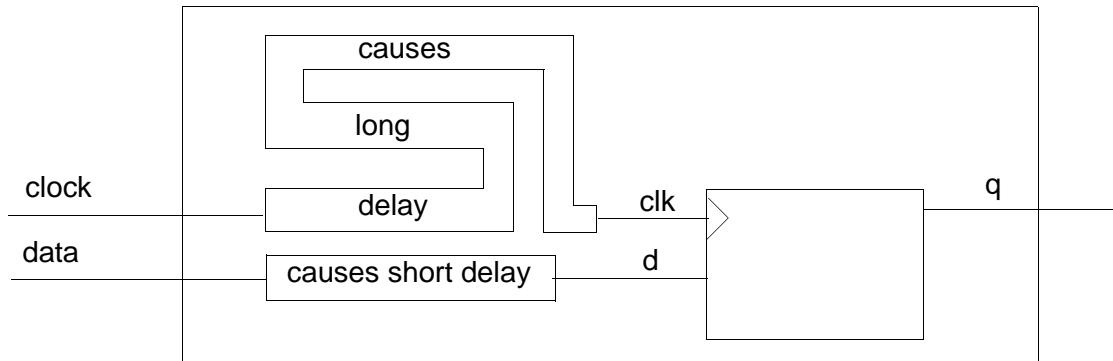
There are cases where the violation window cannot straddle the reference event at the inputs of an ASIC cell. Such a case occurs when:

- The data event takes longer than the reference event to propagate to a sequential device in the cell
- Timing must be accurate at the sequential device
- You need to check for timing violations at the cell boundary

It also occurs when the opposite is true, that is, when the reference event takes longer than the data event to propagate to the sequential device.

When this happens, use the `$setuphold` timing check in the top-level module of the cell to look for timing violations when signal values propagate to that sequential device. In this case, you need to use negative setup or hold limits in the `$setuphold` timing check.

Figure 9-12 ASIC Cell with Long Propagation Delays on Reference Events

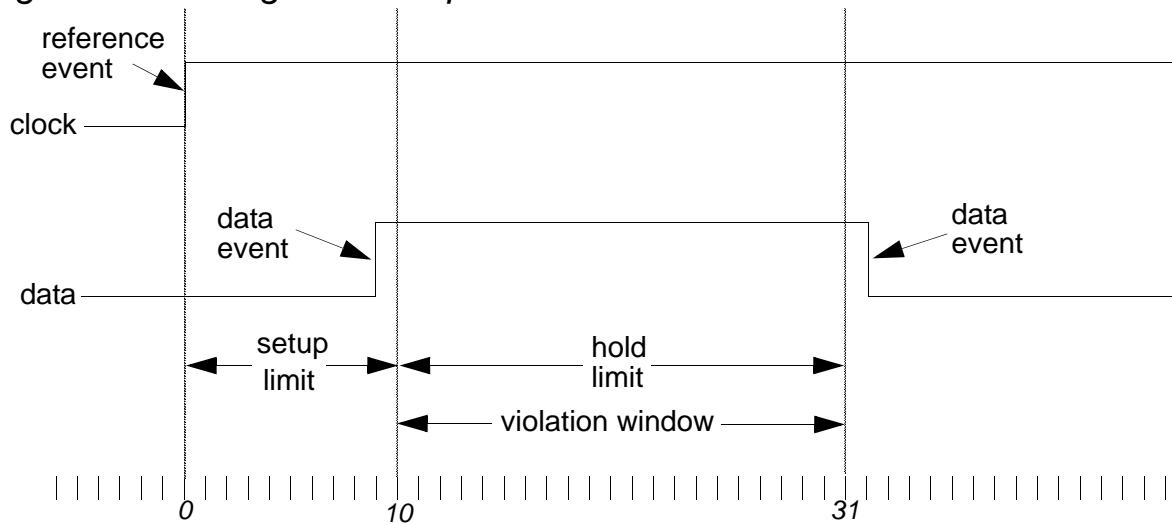


When this occurs, the violation window shifts at the cell boundary so that it no longer straddles the reference event. It shifts to the right when there are longer propagation delays on the reference event. This right shift requires a negative setup limit:

```
$setuphold (posedge clock, data, -10, 31, notifyreg);
```

[Figure 9-13](#) illustrates this scenario.

Figure 9-13 Negative Setup Limit



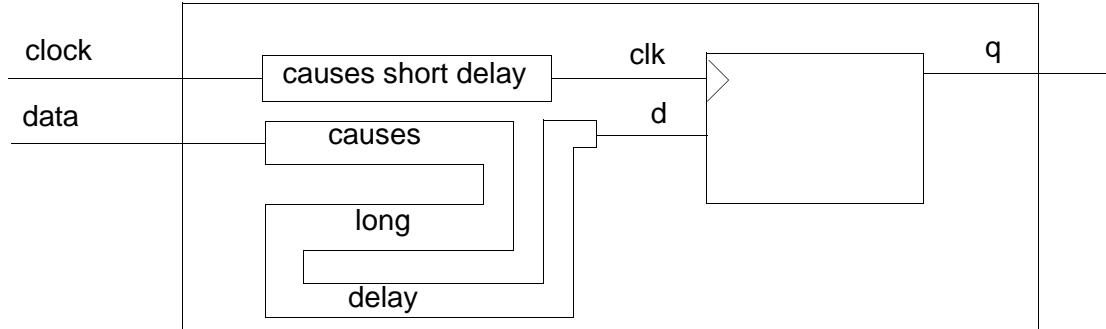
In this example, the `$setupHold` timing check is in the specify block of the top-level module of the cell. It specifies that there is a timing violation if there is a data event between 10 and 31 time units after the reference event on the cell boundary.

This is giving the reference event a “head start” at the cell boundary, anticipating that the delays on the reference event will allow the data events to “catch up” at the sequential device inside the cell.

Note:

When you specify a negative setup limit, its value must be less than the hold limit.

Figure 9-14 ASIC Cell with Long Propagation Delays on Data Events

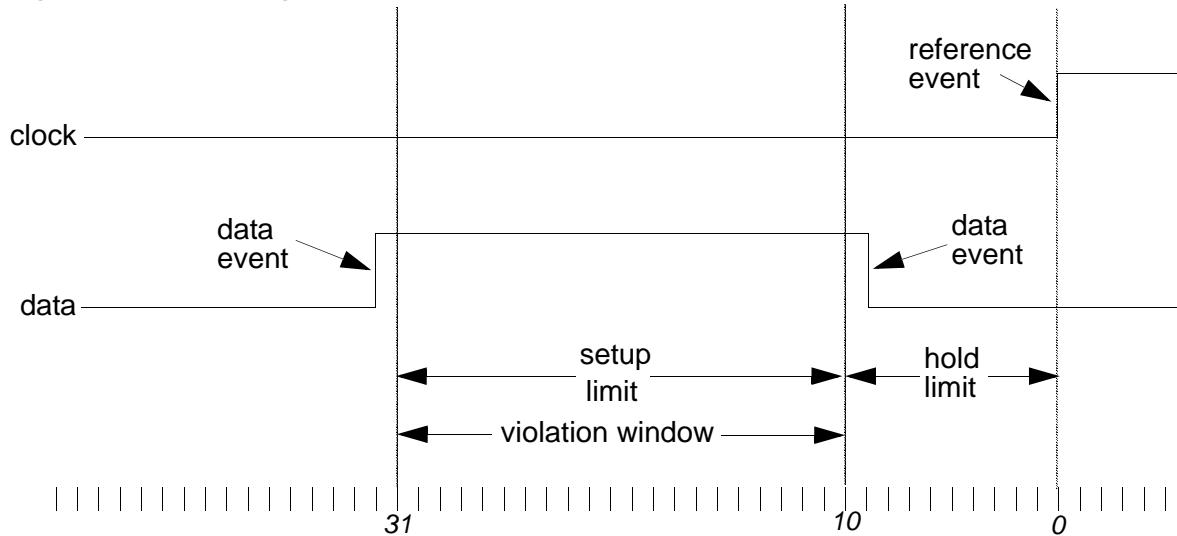


The violation window shifts to the left when there are longer propagation delays on the data event. This left shift requires a negative hold limit:

```
$setuphold (posedge clock, data, 31, -10, notifyreg);
```

[Figure 9-15](#) illustrates this scenario.

Figure 9-15 Negative Hold Limit



In this example, the `$setuphold` timing check is in the specify block of the top-level module of the cell. It specifies that there is a timing violation if there is a data event between 31 and 10 time units before the reference event on the cell boundary.

This is giving the data events a “head start” at the cell boundary, anticipating that the delays on the data events will allow the reference event to “catch up” at the sequential device inside the cell.

Note:

When you specify a negative hold limit, its value must be less than the setup limit.

To implement negative timing checks, VCS creates delayed versions of the signals that carry the reference and data events and an alternative violation window where the window straddles the delayed reference event.

You can specify the names of the delayed versions by using the extended syntax of the `$setuphold` system task, or by allowing VCS to name them internally.

The extended syntax also allows you to specify expressions for additional conditions that must be true for a timing violation to occur.

The `$setuphold` Timing Check Extended Syntax

The `$setuphold` timing check has the following extended syntax:

```
$setuphold(reference_event, data_event, setup_limit,  
hold_limit, notifier, [timestamp_cond, timecheck_cond,  
delayed_reference_signal, delayed_data_signal]);
```

The following additional arguments are optional:

`timestamp_cond`

This argument specifies the condition which determines whether or not VCS reports a timing violation.

In the setup phase of a `$setuphold` timing check, VCS records or “stamps” the time of a data event internally so that when a reference event occurs, it can compare the times of these events to see if there is a setup timing violation. If the condition specified by this argument is false, VCS does not record or “stamp” the data event so there cannot be a setup timing violation.

Similarly, in the hold phase of a `$setuphold` timing check, VCS records or “stamps” the time of a reference event internally so that when a data event occurs, it can compare the times of these events to see if there is a hold timing violation. If the condition specified by this argument is false, VCS does not record or “stamp” the reference event so there cannot be a hold timing violation.

`timecheck_cond`

This argument specifies the condition which determines whether or not VCS reports a timing violation.

In the setup phase of a `$setuphold` timing check, VCS compares or “checks” the time of the reference event with the time of the data event to see if there is a setup timing violation. If the condition specified by this argument is false, VCS does not make this comparison and so there is no setup timing violation.

Similarly, in the hold phase of a `$setuphold` timing check, VCS compares or “checks” the time of a data event with the time of a reference event to see if there is a hold timing violation. If the condition specified by this argument is false, VCS does not make this comparison and so there is no hold timing violation.

`delayed_reference_signal`

The name of the delayed version of the reference signal.

```
delayed_data_signal
```

The name of the delayed version of the data signal.

The following example demonstrates how to use the extended syntax:

```
$setuphold(ref, data, -4, 10, notifrl, stampreg==1, , d_ref,  
          d_data);
```

In this example, the *timestamp_cond* argument specifies that reg stampreg must equal 1 for VCS to “stamp” or record the times of data events in the setup phase or “stamp” the times of reference events in the hold phase. If this condition is not met, and stamping does not occur, VCS will not find timing violations no matter what the time is for these events. Also in the example, the delayed versions of the reference and data signals are named *d_ref* and *d_data*.

You can use these delayed signal versions of the signals to drive sequential devices in your cell model. For example:

```
module DFF(D,RST,CLK,Q);  
  input D,RST,CLK;  
  output Q;  
  reg notifier;  
  DFF_UDP d2(Q,dCLK,dD,dRST,notifier);  
  specify  
    (D => Q) = 20;  
    (CLK => Q) = 20;  
    $setuphold(posedge CLK,D,-5,10,notifier,,,dCLK,dD);  
    $setuphold(posedge CLK,RST,-8,12,notifier,,,dCLK,  
              dRST);  
  endspecify  
endmodule  
  
primitive DFF_UDP(q,clk,data,rst,notifier);  
  output q; reg q;  
  input data,clk,rst,notifier;
```

```

table
// clock  data rst   notifier state q
// -----
r    0     0      ?     : ?   : 0 ;
r    1     0      ?     : ?   : 1 ;
f    ?     0      ?     : ?   : - ;
?    ?     r      ?     : ?   : 0 ;
?    *     ?      ?     : ?   : - ;
?    ?     ?      *     : ?   : x ;
endtable
endprimitive

```

In this example, the DFF_UDP user-defined primitive is driven by the delayed signals dClk, dD, dRST, and the notifier reg.

Negative Timing Checks for Asynchronous Controls

The \$recrm timing check is used for checking how close asynchronous control signal transitions are to clock signals. Similar to the setup and hold limits in \$setuphold timing checks, the \$recrm timing check has recovery and removal limits. The recovery limit specifies how much time must elapse after a control signal toggles from its active state before there is an active clock edge. The removal limit specifies how much time must elapse after an active clock edge before the control signal can toggle from its active state.

In the same way a reference signal, such as a clock signal and data signal can have different propagation delays from the cell boundary to a sequential device inside the cell, there can be different propagation delays between the clock signal and the control signal. For this reason, there can be negative recovery and removal limits in the \$recrm timing check.

The \$recrem Timing Check Syntax

The \$recrem timing check syntax is very similar to the extended syntax for \$setuphold:

```
$recrem(reference_event, data_event, recovery_limit,  
removal_limit, notifier, [timestamp_cond, timecheck_cond,  
delayed_reference_signal, delayed_data_signal]);
```

`reference_event`

Typically the reference event is the active edge on a control signal, such as a clear signal. Specify the active edge with the `posedge` or `negedge` keyword.

`data_event`

Typically, the data event occurs on a clock signal. Specify the active edge on this signal with the `posedge` or `negedge` keyword.

`recovery_limit`

Specifies how much time must elapse after a control signal, such as a clear signal toggles from its active state (the reference event), before there is an active clock edge (the data event).

`removal_limit`

Specifies how much time must elapse after an active clock edge (the data event), before the control signal can toggle from its active state (the reference event).

`notifier`

A register whose value VCS toggles when there is a timing violation.

`timestamp_cond`

This argument specifies the condition which determines whether or not VCS reports a timing violation.

In the recovery phase of a `$recrem` timing check, VCS records or “stamps” the time of a reference event internally so that when a data event occurs it can compare the times of these events to see if there is a recovery timing violation. If the condition specified by this argument is false, VCS does not record or “stamp” the reference event so there cannot be a recovery timing violation.

Similarly, in the removal phase of a `$recrem` timing check, VCS records or “stamps” the time of a data event internally so that when a reference event occurs, it can compare the times of these events to see if there is a removal timing violation. If the condition specified by this argument is false, VCS does not record or “stamp” the data event so there cannot be a removal timing violation.

`timecheck_cond`

This argument specifies the condition which determines whether or not VCS reports a timing violation.

In the recovery phase of a `$recrem` timing check, VCS compares or “checks” the time of the data event with the time of the reference event to see if there is a recovery timing violation. If the condition specified by this argument is false, VCS does not make this comparison and so there is no recovery timing violation.

Similarly, in the removal phase of a \$recrm timing check, VCS compares or “checks” the time of a reference event with the time of a data event to see if there is a removal timing violation. If the condition specified by this argument is false, VCS does not make this comparison and so there is no removal timing violation.

`delayed_reference_signal`

The name of the delayed version of the reference signal, typically a control signal.

`delayed_data_signal`

The name of the delayed version of the data signal, typically a clock signal.

Enabling Negative Timing Checks

To use a negative timing check you must include the `+neg_tchk` compile-time option when you compile your design. If you omit this option, VCS changes all negative limits to 0.

If you include the `+no_notifier` compile-time option with the `+neg_tchk` option, you only disable notifier toggling. VCS still creates the delayed versions of the reference and data signals and displays timing violation messages.

Conversely, if you include the `+no_tchk_msg` compile-time option with the `+neg_tchk` option, you only disable timing violation messages. VCS still creates the delayed versions of the reference and data signals and toggles notifier regs when there are timing violations.

If you include the `+neg_tchk` compile-time option but also include the `+notimingcheck` or `+nospecify` compile-time options, VCS does not compile the `$setuphold` and `$recrem` timing checks into the `simv` executable. However, it does create the signals that you specified in the `delayed_reference_signal` and `delayed_data_signal` arguments, and you can use these to drive sequential devices in the cell. Note that there is no delay on these "delayed" arguments and they have the same transition times as the signals specified in the `reference_event` and `data_event` arguments.

Similarly, if you include the `+neg_tchk` compile-time option and then include the `+notimingcheck` runtime option instead of the compile-time option, you disable the `$setuphold` and `$recrem` timing checks that VCS compiled into the executable. At compile time, VCS creates the signals that you specified in the `delayed_reference_signal` and `delayed_data_signal` arguments, and you can use them to drive sequential devices in the cell, but the `+notimingcheck` runtime option disables the delay on these "delayed" versions.

Other Timing Checks Using the Delayed Signals

When you enable negative timing limits in the `$setuphold` and `$recrem` timing checks, and have VCS create delayed versions of the data and reference signals, by default the other timing checks also use the delayed versions of these signals. You can prevent the other timing checks from doing this with the `+old_ntc` compile-time option.

Having the other timing checks use the delayed versions of these signals is particularly useful when the other timing checks use a notifier register to change the output of the sequential element to x.

Example 9-2 Notifier Register Example for Delayed Reference and Data Signals

```
`timescale 1ns/1ns

module top;
    reg clk, d;
    reg rst;
    wire q;

    dff dff1(q, clk, d, rst);

    initial begin
        $monitor($time,,clk,,d,,q);
        rst = 0; clk = 0; d = 0;
        #100 clk = 1;
        #100 clk = 0;
        #10 d = 1;
        #90 clk = 1;
        #1 clk = 0; // width violation
        #100 $finish;
    end
endmodule

module dff(q, clk, d, rst);
    output q;
    input clk, d, rst;
    reg notif;

    DFF_UDP(q, d_clk, d_d, d_rst, notif);

    specify
        $setuphold(posedge clk, d, -10, 20, notif, , , d_clk,
                   d_d);
        $setuphold(posedge clk, rst, 10, 10, notif, , , d_clk,
                   d_rst);
        $width(posedge clk, 5, 0, notif);
    endspecify
endmodule
```

```

primitive DFF_UDP(q,data,clk,rst,notifier);
output q; reg q;
input data,clk,rst,notifier;

table
// clock  data rst   notifier state q
// -----
    r      0      0      ?      : ? : 0 ;
    r      1      0      ?      : ? : 1 ;
    f      ?      0      ?      : ? : - ;
    ?      ?      r      ?      : ? : 0 ;
    ?      *      ?      ?      : ? : - ;
    ?      ?      ?      *      : ? : x ;
endtable
endprimitive

```

In this example, if you include the `+neg_tchk` compile-time option, the `$width` timing check uses the delayed version of signal `clk`, named `d_clk`, and the following sequence of events occurs:

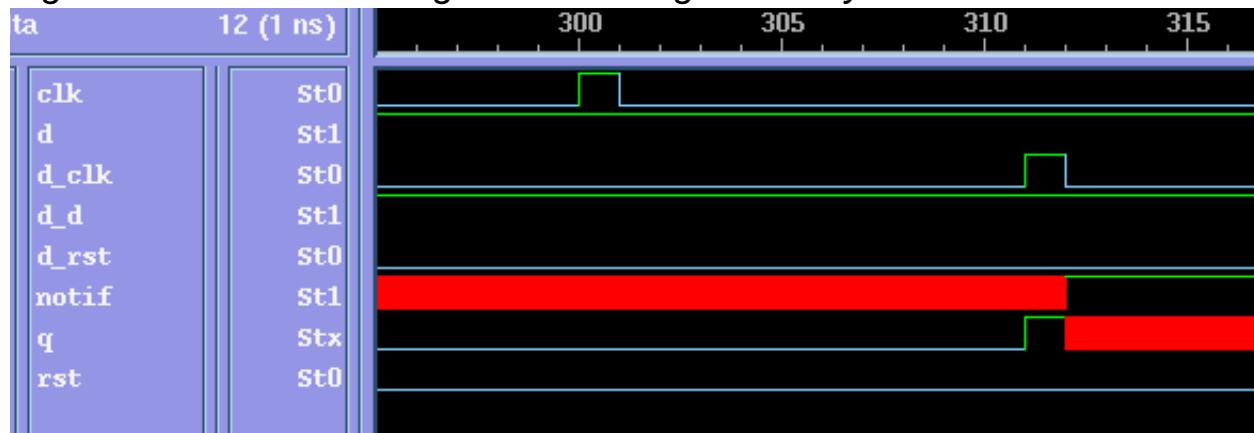
1. At time 311, the delayed version of the clock transitions to 1, causing output `q` to toggle to 1.
2. At time 312, the narrow pulse on the clock causes a width violation:

```
"test1.v", 31: Timing violation in top.dff1
$width( posedge clk:300,    : 301, limit: 5);
```

The timing violation message looks like it occurs at time 301, but you do not see it until time 312.

3. Also at time 312, `reg notif` toggles from `x` to 1. This changes output `q` from 1 to `x`. There are no subsequent changes on output `q`.

Figure 9-16 Other Timing Checks Using the Delayed Versions

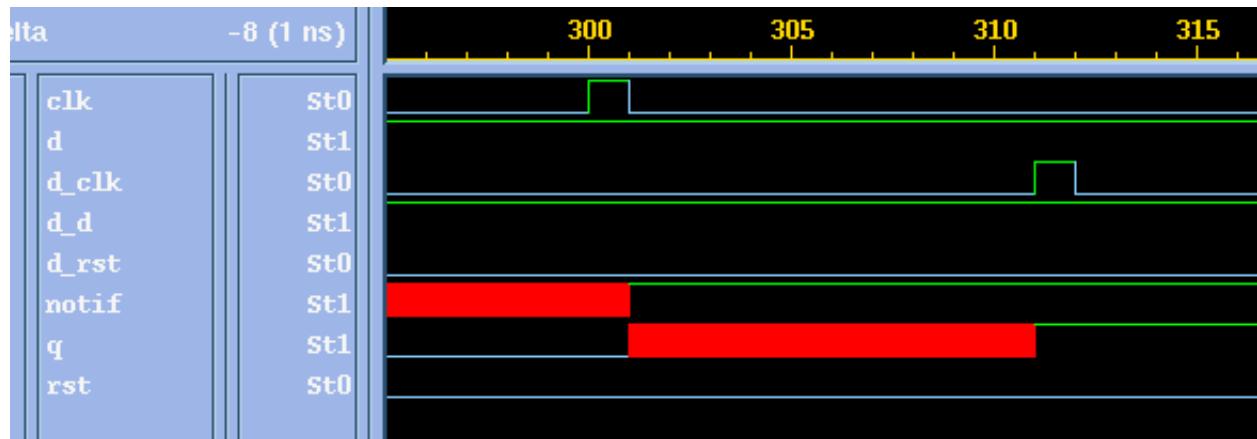


If you include both the `+neg_tchk` and `+old_ntc` compile-time options, the `$width` timing check does not use the delayed version of signal `clk`, causing the following sequence of events to occur:

1. At time 301, the narrow pulse on signal `clk` causes a width violation:


```
"test1.v", 31: Timing violation in top.dff1
$width( posedge clk:300,    : 301, limit: 5);
```
2. Also at time 301, the notifier reg named `notif` toggles from `X` to `1`. In turn, this changes the output `q` of the user-defined primitive `DFF_UDP` and module instance `dff1` from `0` to `X`.
3. At time 311, the delayed version of signal `clk`, named `d_clk`, reaches the user-defined primitive `DFF_UDP`, thereby changing the output `q` to `1`, erasing the `X` value on this output.

Figure 9-17 Other Timing Checks Not Using the Delayed Versions



The timing violation, as represented by the `x` value, is lost to the design. If a module path delay that is greater than ten time units was used for the module instance, the `x` value would not appear on the output at all.

For this reason, Synopsys does not recommend using the `+old_ntc` compile-time option. It exists only for unforeseen circumstances.

Checking Conditions

VCS evaluates the expressions in the `timestamp_cond` and `timecheck_cond` arguments either when there is a value change on the original reference and data signals at the cell boundary, or when the value changes propagate from the delayed versions of these signals at the sequential device inside the cell. It decides when to evaluate the expressions depending on which signals are the operands in these expressions. Note the following:

- If the operands in these expressions are neither the original nor the delayed versions of the reference or data signals, and if these operands are signals that do not change value between value changes on the original reference and data signals and their delayed versions, then it does not matter when VCS evaluates these expressions.
- If the operands in these expressions are delayed versions of the original reference and data signals, then you want VCS to evaluate these expressions when there are value changes on the delayed versions of the reference and data signals. VCS does this by default.
- If the operands in these expressions are the original reference and data signals and not the delayed versions, then you want VCS to evaluate these expressions when there are value changes on the original reference and data signals. To specify evaluating these expressions when the original reference and data signals change value, include the +NTC2 compile-time option.

Toggling the Notifier Register

VCS waits for a timing violation to occur on the delayed versions of the reference and data signals before toggling the notifier register. Toggling means the following value changes:

- X to 0
- 0 to 1
- 1 to 0

VCS does not change the value of the notifier register if you have assigned a Z value to it.

SDF Back-annotation to Negative Timing Checks

You can back-annotate negative setup and hold limits from SDF files to `$setuphold` timing checks and negative recovery and removal limits from SDF files to `$recrem` timing checks, if the following conditions are met:

- You included the arguments for the names of the delayed reference and data signals in the timing checks.
- You compiled your design with the `+neg_tchk` compile-time option.
- For all `$setuphold` timing checks, the positive setup or hold limit is greater than the negative setup or hold limit.
- For all `$recrem` timing checks, the positive recovery or removal limit is greater than the negative recovery or removal limit.

As documented in the OVI SDF3.0 specification:

- TIMINGCHECK statements in the SDF file back-annotate timing checks in the model which match the edge and condition arguments in the SDF statement.
- If the SDF statement specifies SCOND or CCOND expressions, they must match the corresponding `timestamp_cond` or `timecheck_cond` in the timing check declaration for back-annotation to occur.
- If there is no SCOND or CCOND expressions in the SDF statement, all timing checks that otherwise match are back-annotated.

How VCS Calculates Delays

This section describes how VCS calculates the delays of the delayed versions of reference and data signals. It does not describe how you use negative timing checks; it is supplemental material intended for users who would like to read more about how negative timing checks work in VCS.

VCS uses the limits you specify in the `$setuphold` or `$recrem` timing check to calculate the delays on the delayed versions of the reference and data signals. For example:

```
$setuphold(posedge clock,data,-10,20, , , , del_clock,  
           del_data);
```

This specifies that the propagation delays on the reference event (a rising edge on signal clock), are more than 10 but less than 20 time units more than the propagation delays on the data event (any transition on signal data).

So when VCS creates the delayed signals, `del_clock` and `del_data`, and the alternative violation window that straddles a rising edge on `del_clock`, VCS uses the following relationship:

$$20 > (\text{delay on } \text{del_clock} - \text{delay on } \text{del_data}) > 10$$

There is no reason to make the delays on either of these delayed signals any longer than they have to be so the delay on `del_data` is 0 and the delay on `del_clock` is 11. Any delay on `del_clock` between 11 and 19 time units would report a timing violation for the `$setuphold` timing check.

Multiple timing checks, that share reference or data events, and specified delayed signal names, can define a set of delay relationships. For example:

```
$setuphold(posedge CP,D,-10,20, notifier, , ,
           del_CP, del_D);
$setuphold(posedge CP,TI,20,-10, notifier, , ,
           del_CP, del_TI);
$setuphold(posedge CP,TE,-4,8,  notifier, , ,
           del_CP, del_TE);
```

In this example:

- The first `$setuphold` timing check specifies the delay on `del_CP` is more than 10 but less than 20 time units more than the delay on `del_D`.
- The second `$setuphold` timing check specifies the delay on `del_TI` is more than 10 but less than 20 time units more than the delay on `del_CP`.
- The third `$setuphold` timing check specifies the delay on `del_CP` is more than 4 but less than 8 time units more than the delay on `del_TE`.

Therefore:

- The delay on `del_D` is 0 because its delay does not have to be more than any other delayed signal.
- The delay on `del_CP` is 11 because it must be more than 10 time units more than the 0 delay on `del_D`.

- The delay on `del_TE` is 4 because the delay on `del_CP` is 11. The 11 makes the possible delay on `del_TE` larger than 3, but less than 7. The delay cannot be 3 or less, because the delay on `del_CP` is less than 8 time units more than the delay on `del_TE`. VCS makes the delay 4 because it always uses the shortest possible delay.
- The delay on `del_TI` is 22 because it must be more than 10 time units more than the 11 delay on `del_CP`.

In unusual and rare circumstances, multiple `$setuphold` and `$recrem` timing checks, including those that have no negative limits, can make the delays on the delayed versions of these signals mutually exclusive. When this happens, VCS repeats the following procedure until the signals are no longer mutually exclusive:

1. Sets one negative limit to 0.
2. Recalculates the delays of the delayed signals.

Using Multiple Non-overlapping Violation Windows

The `+overlap` compile-time option enables accurate simulation of multiple violation windows for the same two signals when the following conditions occur:

- The violation windows are specified with negative delay values that are back-annotated from an SDF file.
- The violation windows do not converge or overlap.

When these conditions are met, the default behavior of VCS is to replace the negative delay values with zeros so that the violation windows overlap. Consider the following code example:

```

'timescale 1ns/1ns
module top;
reg in1, clk;
wire out1;

FD1 fd1_1 (.d(in1), .cp(clk), .q(out1) );

initial
begin
    $sdf_annotate("overlap1.sdf");
in1 = 0;
#45 in1=1;
end

initial
begin
    clk=0;
#50 clk = 1;
#50 clk = 0;
end
endmodule

module FD1 (d, cp, q);
input d, cp;
output q;
wire q;
reg notifier;
reg q_reg;

always @(posedge cp)
q_reg = d;

assign q = q_reg;

specify
    $setuphold( posedge cp, negedge d, 40, 30, notifier);
    $setuphold( posedge cp, posedge d, 20, 10, notifier);
endspecify
endmodule

```

The SDF file contains the following to back-annotate negative delay values:

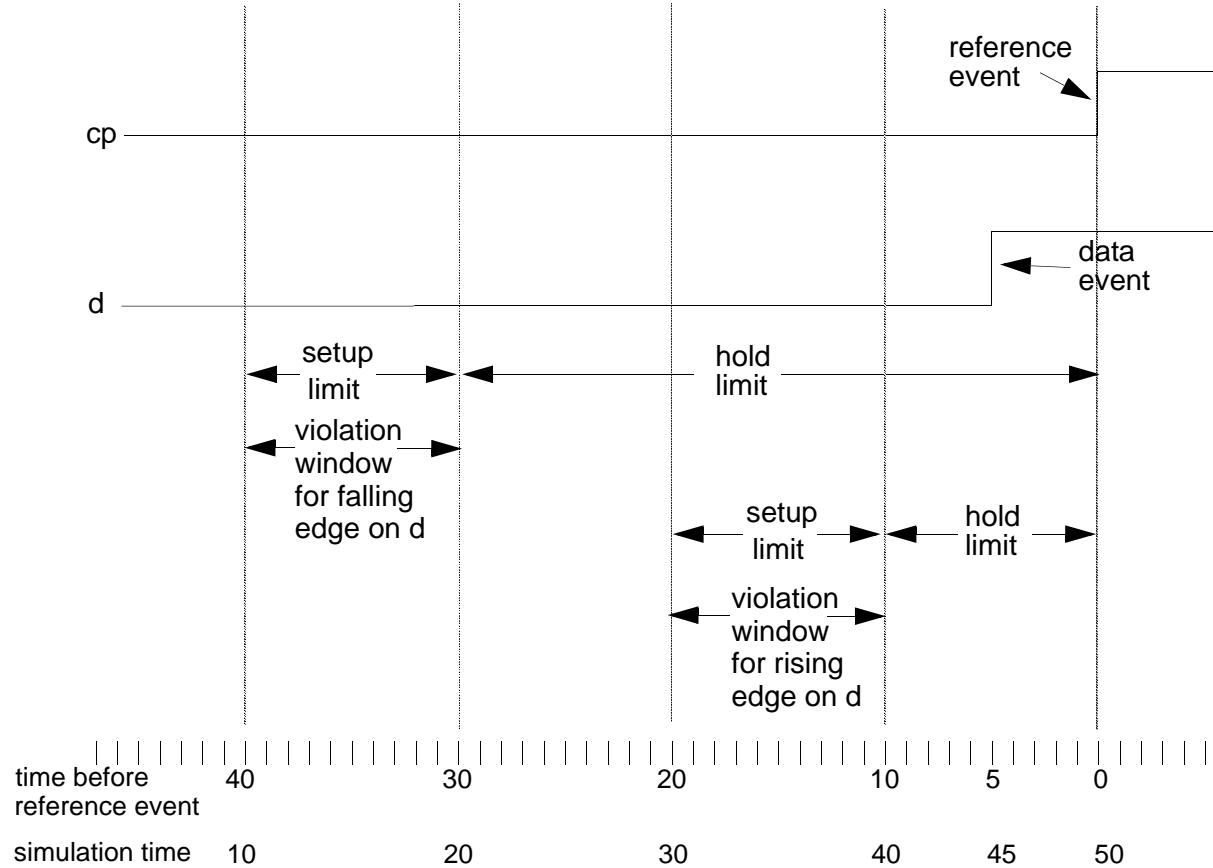
```
(CELL
  (CELLTYPE "FD1")
  (INSTANCE top.fd1_1)
  (TIMINGCHECK
    (SETUPHOLD (negedge d) (posedge cp) (40) (-30))
    (SETUPHOLD (posedge d) (posedge cp) (20) (-10))
  )
)
```

So the timing checks are now:

```
$setuphold( posedge cp, negedge d, 40, -30, notifier);
$setuphold( posedge cp, posedge d, 20, -10, notifier);
```

The violation windows and the transitions that occur on signals `top.fd1_1.cp` and `top.fd1_1.d` are shown in [Figure 9-18](#).

Figure 9-18 Non-Overlapping Violation Windows



The `$setuphold` timing checks now specify:

- A violation window for a falling edge on signal *d* between 40 and 30 time units before a rising edge on signal *cp*
- A violation window for a rising edge on signal *d* between 20 and 10 time units before a rising edge on signal *cp*

The testbench module `top` applies stimulus so that the following transitions occur:

1. A rising edge on signal *d* at time 45
2. A rising edge on signal *cp* at time 50

The rising edge on signal d at time 45 is not inside the violation window for a rising edge on signal d. If you include the +overlap compile-time option, you will not see a timing violation. This behavior is desired because there is no transition in the violation windows so VCS should not display a timing violation.

The +overlap option tells VCS not to change the violation windows, just like it would if the windows overlapped.

If you omit the +overlap option, VCS does what Verilog simulators traditionally do, which is both pessimistic and inaccurate:

1. During compilation, VCS replaces the -30 and -10 negative delay values in the \$setuphold timing checks with 0 values. It displays the following warning:

```
Warning: Negative Timing Check delays did not converge,  
Setting minimum constraint to zero and using approximation  
solution (  
"sourcefile", line_number_of_second_timing_check)
```

VCS alters the violation windows:

- For the falling edge, the window starts 40 time units before the reference event and ends at the reference event.
- For the rising edge, the window starts 20 time units before the reference event and also ends at the reference event.

VCS alters the windows so that they overlap or converge.

2. During simulation, at time 50 (reference event), VCS displays the timing violation message:

```
"sourcefile.v", line_number_of_second_timing_check:  
Timing violation in top.fd1_1  
    $setuphold( posedge cp:50 posedge d:45, limits (20,0)  
);
```

The rising edge on signal d is in the altered violation window for a rising edge on d that starts 20 time units *before* the reference event and now ends *at* the reference event. The rising edge on signal d occurs five time units before the reference event.

10

Coverage

VCS monitors the execution of the HDL code during simulation. The verification engineers can determine which part of the code has not been tested yet so that they can focus their efforts on those areas to achieve 100% coverage. VCS offers two coverage techniques to test your HDL code. Code coverage and Functional coverage.

Code Coverage

The following coverage metrics are classified as code coverage:

- Line Coverage — This metric measures statements in your HDL code that have been executed in the simulation.

- Toggle Coverage — This metric measures the bits of logic that have toggled during simulation. A toggle simply means that a bit changes from 0 to 1 or from 1 to 0. It is one of the oldest metrics of coverage in hardware design and can be used at both the register transfer level (RTL) and gate level.
- Condition Coverage — This metric measures how the variables or sub-expressions in the conditional statements are evaluated during simulation. It can find the errors in the conditional statements that cannot be found by other coverage analysis.
- Branch Coverage — This metric measures the coverage of expressions and case statements that affect the control flow (such as the if-statement and while-statement) of the HDL. It focuses on the decision points that affect the control flow of the HDL execution.
- FSM Coverage — This metric verifies that every legal state of the state machine has been visited and that every transition between states has been covered.

For more information about coverage technology and how you can generate the coverage information for your design, click the link [Coverage Technology User Guide](#) if you are using the VCS Online Documentation.

If you are using the PDF interface, click this link [cov_ug.pdf](#) to view the Coverage Technology User Guide PDF documentation.

Functional Coverage

Functional coverage checks the overall functionality of the implementation. To perform functional coverage, you must define the coverage points for the functions to be covered in the DUT. VCS

supports both NTB and SystemVerilog covergroup model. Covergroups are specified by the user. They allow the system to monitor values and transitions for variables and signals. They also enable cross coverage between variables and signals.

For more information about NTB or SystemVerilog functional coverage models, see the VCS Native Testbench Language Reference Manual or the VCS SystemVerilog Language Reference Manual respectively in the Testbench category in the VCS Online Documentation.

Options For Coverage Metrics

`-cm line|cond|fsm|tgl|branch|assert`

Specifies compiling for the specified type or types of coverage. The argument specifies the types of coverage:

`line`

Compile for line or statement coverage.

`cond`

Compile for condition coverage.

`fsm`

Compile for FSM coverage.

`tgl`

Compile for toggle coverage.

`branch`

Compile for branch coverage

assert

Compile for SystemVerilog assertion coverage.

For more information on Coverage options, click the link [Coverage Technology Reference Manual](#) if you are using the VCS Online Documentation.

If you are using the PDF interface, click the link [cov_ref.pdf](#) to view the Coverage Technology Reference Manual PDF documentation.

12

Using OpenVera Native Testbench

OpenVera Native Testbench is a high-performance, single-kernel technology in VCS that enables:

- Native compilation of testbenches written in OpenVera and in SystemVerilog.
- Simulation of these testbenches along with the designs.

This technology provides a unified design and verification environment in VCS for significantly improving overall design and verification productivity. Native Testbench is uniquely geared towards efficiently catching hard-to-find bugs early in the design cycle, enabling not only completing functional validation of designs with the desired degree of confidence, but also achieving this goal in the shortest time possible.

Native Testbench is built around the preferred methodology of keeping the testbench and its development separate from the design. This approach facilitates development, debug, maintenance and reusability of the testbench, as well as ensuring a smooth synthesis flow for your design by keeping it clean of all testbench code. Further, you have the choice of either compiling your testbench along with your design or separate from it. The latter choice not only saves you from unnecessary recompilations of your design, it also enables you to develop and maintain multiple testbenches for your design.

This chapter describes the high-level, object-oriented verification language of OpenVera, which enables you to write your testbench in a straightforward, elegant and clear manner and at a high level essential for a better understanding of and control over the design validation process. Further, OpenVera assimilates and extends the best features found in C++ and Java along with syntax that is a natural extension of the hardware description languages. Adopting and using OpenVera, therefore, means a disciplined and systematic testbench structure that is easy to develop, debug, understand, maintain and reuse.

Thus, the high-performance of Native Testbench technology, together with the unique combination of the features and strengths of OpenVera, can yield a dramatic improvement in your productivity, especially when your designs become very large and complex.

This chapter includes the following topics:

- “Usage Model”
- “Key Features”

Usage Model

As any other VCS applications, the usage model to simulate OpenVera testbench includes the following steps:

Compilation

```
% vcs [ntb_options] [compile_options] file1.vr file2.vr  
      file3.v file4.v
```

Simulation

```
% simv [run_options]
```

Example

In this example, we have an interface file, a Verilog design `arb.v`, OpenVera testbench `arb.vr`, all instantiated in a Verilog top file, `arb.test_top.v`.

```
//Interface  
#ifndef INC_ARB_IF_VRH  
#define INC_ARB_IF_VRH  
  
interface arb {  
    input clk CLOCK;  
    output [1:0] request OUTPUT_EDGE OUTPUT_SKEW;  
    output reset OUTPUT_EDGE OUTPUT_SKEW;  
    input [1:0] grant INPUT_EDGE INPUT_SKEW;  
} // end of interface arb  
  
#endif  
  
//Verilog module: arb.v  
module arb ( clk, reset, request, grant) ;  
    input [1:0] request ;
```

```

        output [1:0] grant ;
        input   reset ;
        input   clk ;

parameter IDLE = 2, GRANT0 = 0, GRANT1 = 1;

reg  last_winner ;
reg  winner ;
reg [1:0] grant ;
reg [1:0] next_grant ;

reg [1:0] state, nxState;

...
endmodule

//OpenVera Testbench: arb.vr

#define OUTPUT_EDGE PHOLD
#define OUTPUT_SKEW #1
#define INPUT_SKEW #-1
#define INPUT_EDGE PSAMPLE
#include <veraDefines.vrh>

#include "arb.if.vrh"

program arb_test
{ // start of top block

...
}

// end of program arb_test

```

Note:

You can find the complete example in the following path:

```
$VCS_HOME/doc/examples/testbench/ov/Tutorial/  
arb
```

Usage Model

Compilation

```
% vcs -ntb arb.v arb.vr arb.test_top.v
```

Simulation

```
% simv
```

Using Template Generator

To ease the process of writing a testbench in OpenVera, VCS provides you with a testbench template generator.

Use the following command to invoke the template generator on a Verilog design unit:

```
% ntb_template -t design_module_name [-c clock] design_file\  
[-vcs vcs_compile-time_options]
```

Where:

-t *design_module_name*

Specifies the top-level design module name.

design_file

Name of the design file.

-c

Specifies the clock input of the design.

`-template`

Can be omitted.

`-program`

Optional. Use it to specify program name.

`-simcycle`

Optional. Use this to override the default cycle value of 100.

`-vcs vcs_compile-time_options`

Optional. Use it to supply a VCS compile-time option. Multiple `-vcs vcs_compile-time_options` options can be used to specify multiple options. Use this option only for Verilog on top designs.

Example

An example SRAM model is used in this demonstration of using the template generator to develop a testbench environment.

For details on the OpenVera verification language, refer to the *OpenVera Language Reference Manual: Native Testbench*.

Design Description

The design is an SRAM whose RTL Verilog model is in the file `sram.v`. It has four ports:

- `ce_N` (chip enable)
- `rdWr_N` (read/write enable)
- `ramAddr` (address)
- `ramData` (data)

Example 12-1 RTL Verilog Model of SRAM in sram.v

```
module sram(ce_N, rdWr_N, ramAddr, ramData) ;  
  
    input ce_N, rdWr_N;  
    input [5:0] ramAddr;  
    inout [7:0] ramData;  
    wire [7:0] ramData;  
    reg [7:0] chip[63:0];  
  
    assign #5 ramData = (~ce_N & rdWr_N) ? chip[ramAddr] :  
        8'bzzzzzzz;  
  
    always @(ce_N or rdWr_N)  
    begin  
        if(~ce_N && ~rdWr_N)  
            #3 chip[ramAddr] = ramData;  
    end  
endmodule
```

During a read operation, when `ce_N` is driven low and `rdWr_N` is driven high, `ramData` is continuously driven from inside the SRAM with the value stored in the SRAM memory element specified by `ramAddr`. During a write operation, when both `ce_N` and `rdWr_N` are driven low, the value driven on `ramData` from outside the SRAM is stored in the SRAM memory element specified by `ramAddr`. At all other times, `ce_N` is driven high, and as a result, `ramData` gets continuously driven from inside the SRAM with the high-impedance value `Z`.

Generating the Testbench Template, the Interface, and the Top-level Verilog Module from the Design

As previously mentioned, Native Testbench provides a template generator to start the process of constructing a testbench. The template generator is invoked on `sram.v` as shown below:

```
% ntb_template -t sram sram.v
```

Where:

- The `-t` option is followed with the top-level design module name, which is `sram`, in this case.
- `sram` is the name of the module.
- `sram.v` is the name of the file containing the top-level design module.
- If the design uses a clock input, then the `-c` option is to be used and followed with the name of the clock input. Doing so provides a clock input derived from the system-clock for the interface and the design. In this example, there is no clock input required by the design.

Template generator generates the following files:

- `sram.vr.tmp`
- `sram.if.vrh`
- `sram.test_top.v`

sram.vr.tmp

This is the template for testbench development. The following is an example, based on the `sram.v` file of the output of the previous command line:

```
//sram.vr.tmp
#define OUTPUT_EDGE PHOLD
#define OUTPUT_SKEW #1
#define INPUT_SKEW #-1
#define INPUT_EDGE PSAMPLE
#include <veraDefines.vrh>

// define interfaces, and verilog_node here if necessary
```

```

#include "sram.if.vrh"

// define ports, binds here if necessary

// declare external tasks/classes/functions here if
//necessary

// declare verilog_tasks here if necessary

// declare class typedefs here if necessary

program sram_test
{ // start of top block

    // define global variables here if necessary

    // Start of sram_test

    // Type your test program here:

    //
    // Example of drive:
    // @1 sram.ce_N = 0 ;
    //
    //
    // Example of expect:
    // @1,100 sram.example_output == 0 ;
    //

} // end of program sram_test

// define tasks/classes/functions here if necessary

```

sram.if.vrh

This is the interface file which provides the basic connectivity between your testbench signals and your design's ports and/or internal nodes. All signals going back and forth between the

testbench and the design go through this interface. The following is the `sram.if.vrh` file which results from the previous command line:

```
//sram.if.vrh
#ifndef INC_SRAM_IF_VRH
#define INC_SRAM_IF_VRH
interface sram {
    output           ce_N      OUTPUT_EDGE OUTPUT_SKew;
    output           rdWr_N   OUTPUT_EDGE OUTPUT_SKew;
    output [5:0]     ramAddr  OUTPUT_EDGE OUTPUT_SKew;
    inout [7:0]      ramData  INPUT_EDGE  INPUT_SKew
OUTPUT_EDGE OUTPUT_SKew;
} // end of interface sram

#endif
```

Notice that, for example, the direction of `ce_N` is now "output" instead of "input". The signal direction specified in the interface is from the point of view of the testbench and not the DUT.

This file must be modified to include the clock input.

sram.test_top.v

This is the top-level Verilog module that contains the testbench instance, the design instance, and the system-clock. The system clock can also provide the clock input for both the interface and the design. The following is the `sram.test_top.v` file that results from the previous command line:

```
//sram.test_top.v
module sram_test_top;
    parameter simulation_cycle = 100;

    reg SystemClock;

    wire ce_N;
```

```

    wire          rdWr_N;
    wire [5:0]     ramAddr;
    wire [7:0]     ramData;
`ifdef SYNOPSYS_NTB
    sram_test vshell(
        .SystemClock (SystemClock),
        .\sram.ce_N (ce_N),
        .\sram.rdWr_N      (rdWr_N),
        .\sram.ramAddr     (ramAddr),
        .\sram.ramData     (ramData)
    );
`else

    vera_shell vshell(
        .SystemClock (SystemClock),
        .sram_ce_N   (ce_N),
        .sram_rdWr_N (rdWr_N),
        .sram_ramAddr (ramAddr),
        .sram_ramData (ramData)
    );
`endif

`ifdef emu
/* DUT is in emulator, so not instantiated here */
`else
    sram dut(
        .ce_N       (ce_N),
        .rdWr_N     (rdWr_N),
        .ramAddr    (ramAddr),
        .ramData    (ramData)
    );
`endif

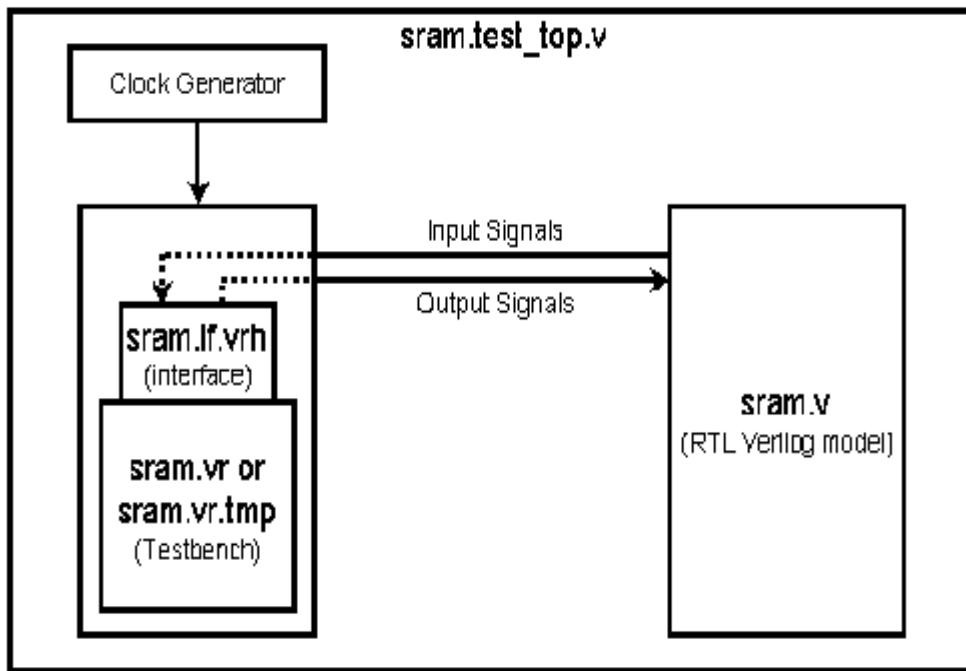
initial begin
    SystemClock = 0;
    forever begin
        #(simulation_cycle/2)
            SystemClock = ~SystemClock;
    end
end
end

endmodule

```

[Figure 12-1](#) shows how the three generated files and the design connect and fit in with each other in the final configuration.

Figure 12-1 Testbench and Design Configuration



Testbench Development and Description

Your generated testbench template, `sram.vr.tmp`, contains a list of macro definitions for the interface, include statements for the interface file and the library containing predefined tasks and functions, comments indicating where to define or declare the various parts of the testbench, and the skeleton program shell that will contain the main testbench constructs. Starting with this template, you can develop a testbench for the SRAM and rename it `sram.vr`. An example testbench is shown in [Example 12-2](#).

Example 12-2 Example testbench for SRAM, sram.vr

```
// macro definitions for Interface signal types and skews
```

```

#define OUTPUT_EDGE PHOLD      // for specifying posedge-drive type
#define OUTPUT_SKEW #1        // for specifying drive skew
#define INPUT_SKEW #-1        // for specifying sample skew
#define INPUT_EDGE PSAMPLE    // for specifying posedge-sample type

#include <veraDefines.vrh>   // include the library of predefined
                             // functions and tasks
#include "sram.if.vrh"       // include the Interface file

program sram_test {          // start of program sram_test

reg [5:0] address = 6'b00_0001; // declare, initialize address (for
                               // driving ramAddr during Write and
                               // Read)
reg [7:0] rand_bits;         // declare rand_bits (for driving
                           // ramData during Write)
reg [7:0] data_result;       // declare data_result (for receiving
                           // ramData during Read)

@(posedge sram.clk);
rand_bits = random();        // move to the first posedge of clock
                            // initialize rand_bits with a random
                            // value using the random() function

@1 sram.ramAddr = address;   // move to the next posedge of clock,
                            // drive ramAddr with the value of
                            // address
sram.ce_N = 1'b1;            // disable SRAM by driving ce_N high
sram.ramData = rand_bits;    // drive ramData with rand_bits and
                           // keep it ready for a Write
sram.rdWr_N = 1'b0;          // drive rdWr_N low and keep it ready
                            // for a Write

@1 sram.ce_N = 1'b0;         // move to the next posedge of clock,
                            // and enable a SRAM Write by driving
                            // ce_N low
printf("Cycle: %d Time: %d \n", get_cycle(), get_time(0));
printf("The SRAM is being written at ramAddr: %b Data written: %b \n",
      address, sram.ramData);

@1 sram.ce_N = 1'b1;          // move to the next posedge of clock,
                            // disable SRAM by driving ce_N high
sram.rdWr_N = 1'b1;           // drive rdWr_N high and keep it ready
                            // for a Read
sram.ramData = 8'bzzzz_zzzz;  // drive a high-impedance value on
                            // ramData

@1 sram.ce_N = 1'b0;          // move to the next posedge of clock,
                            // enable a SRAM Read by driving ce_N

```

```

        // low

@1 sram.ce_N = 1'b1;                      // move to the next posedge of clock,
                                            // disable SRAM by driving ce_N high
data_result = sram.ramData;                 // sample ramData and receive the data
                                            // from SRAM in data_result
printf("Cycle: %d Time: %d\n",get_cycle(), get_time(0));
printf("The SRAM is being read    at ramAddr: %b Data read   : %b \n", address,
data_result);

} // end of program sram_test

```

The main body of the testbench is the program, which is named `sram_test`. The program contains three data declarations of type `reg` in the beginning. It then moves execution through a Write operation first and then a Read operation. The memory element of the SRAM written to and read from is `6'b 00_0001`. The correct functioning of the SRAM implies data that is stored in a memory element during a Write operation must be the same as that which is received from the memory element during a Read operation later. The example testbench only demonstrates how any memory element can be functionally validated. For complete functional validation of the SRAM, the testbench would need further development to cover all memory elements from `6'b00_0000` to `6b'11_1111`.

Interface Description

The generated `if.vrh` file has to be modified to include the clock input. The modified interface is shown in [Example 12-3](#).

Interface for SRAM, `sram.if.vrh`

Example 12-3

```

#ifndef INC_SRAM_IF_VRH
#define INC_SRAM_IF_VRH

interface sram {

```

```

    input          clk      CLOCK; // add clock
    output         ce_N    OUTPUT_EDGE OUTPUT_SKew;
    output         rdWr_N  OUTPUT_EDGE OUTPUT_SKew;
    output [5:0]   ramAddr OUTPUT_EDGE OUTPUT_SKew;
    inout [7:0]   ramData INPUT_EDGE  OUTPUT_EDGE OUTPUT_SKew;
} // end of interface sram
#endif

```

The interface consists of signals that are either driven as outputs into the design or sampled as inputs from the design. The clock input, `clk`, is derived from the system clock in the top-level Verilog module.

Top-level Verilog Module Description

The generated top-level module has been modified to include the clock input for the interface and eliminate code that was not relevant. The clock input is derived from the system clock. [Example 12-4](#) shows the modified top-level Verilog module for the SRAM.

Example 12-4 Top-level Verilog Module, sram.test_top.v

```

module sram_test_top;
    parameter simulation_cycle = 100;
    reg           SystemClock;
    wire          ce_N;
    wire          rdWr_N;
    wire [5:0]    ramAddr;
    wire [7:0]    ramData;
    wire          clk = SystemClock; /* Add this line. Interface
                                      clock input derived from the system clock*/

`ifdef SYNOPSYS_NTB
sram_test vshell(
    .SystemClock (SystemClock),
    .\sram.clk(clk),
    .\sram.ce_N (ce_N),
    .\sram.rdWr_N        (rdWr_N),
    .\sram.ramAddr       (ramAddr),
    .\sram.ramData        (ramData)
);
`else

```

```

vera_shell vshell(
    .SystemClock (SystemClock),
    .sram_ce_N   (ce_N),
    .sram_rdWr_N (rdWr_N),
    .sram_ramAddr (ramAddr),
    .sram_ramData (ramData)
);
`endif

// design instance
sram dut(
    .ce_N      (ce_N),
    .rdWr_N    (rdWr_N),
    .ramAddr   (ramAddr),
    .ramData   (ramData)
);

// system-clock generator
initial begin
    SystemClock = 0;
    forever begin
        #(simulation_cycle/2)
        SystemClock = ~SystemClock;
    end
end
end

endmodule

```

The top-level Verilog module contains the following:

- The system clock, `SystemClock`. The system clock is contained in the port list of the testbench instance.
- The declaration of the interface clock input, `clk`, and its derivation from the system clock.

- The testbench instance, `vshell`. The module name for the instance must be the name of the testbench program, `sram_test`. The instance name can be something you choose. The ports of the testbench instance, other than the system clock, refer to the interface signals. The period in the port names separates the interface name from the signal name. A backslash is appended to the period in each port name because periods are not normally allowed in port names.
- The design instance, `dut`.

Compiling Testbench With the Design And Running

The VCS command line for compiling both your example testbench and design is the following:

Compilation

```
% vcs -ntb sram.v sram.test_top.v sram.vr
```

Simulation

```
% simv
```

You will find the simulation output to be the following:

```
Cycle: 3 Time: 250
The SRAM is being written at ramAddr: 000001 with ramData:
10101100
Cycle: 6 Time: 550
The SRAM is being read at ramAddr: 000001 its ramData is:
10101100
$finish at simulation time 550
V C S   S i m u l a t i o n   R e p o r t
```

Key Features

VCS supports the following features for OpenVera testbench:

- “Multiple Program Support”
- “Separate Compilation of Testbench Files”
- “Class Dependency Source File Reordering”
- “Using Encrypted Files”
- “Functional Coverage”
- “Using Reference Verification Methodology”
- “Performance Profiler”

Multiple Program Support

Multiple program support enables multiple testbenches to run in parallel. This is useful when testbenches model stand-alone components (for example, Verification IP (VIP) or work from a previous project). Because components are independent, direct communication between them except through signals is undesirable. For example, UART and CPU models would communicate only through their respective interfaces, and not via the testbench. Thus, multiple program support allows the use of stand-alone components without requiring knowledge of the code for each component, or requiring modifications to your own testbench.

Configuration File Model

The configuration file that you create, specifies file dependencies for OpenVera programs.

Specify the configuration file as an argument to `-ntb_opts` as shown in the following usage model:

```
% vcs -ntb -ntb -ntb_opts  
config=configfileVerilog_and_OV_files
```

Configuration File

The configuration file contains the program construct.

The program keyword is followed by the OpenVera program file (`.vr` file) containing the testbench program and all the OpenVera program files needed for this program. For example:

```
//configuration file  
program  
    main1.vr  
    main1_dep1.vr  
    main1_dep2.vr  
    ...  
    main1_depN.vr  
    [NTB_options ]  
  
program  
    main2.vr  
    main2_dep1.vr  
    main2_dep2.vr  
    ...  
    main2_depN.vr  
    [NTB_options ]  
  
program  
    mainN.vr
```

```
mainN_dep1.vr  
mainN_dep2.vr  
...  
mainN_depN.vr  
[NTB_options ]
```

In this example, `main1.vr`, `main2.vr` and `mainN` files each contain a program. The other files contain items such as definitions of functions, classes, tasks and so on needed by the program files. For example, the `main1_dep1.vr`, `main1_dep2.vr` `main1_depN.vr` files contain definitions relevant to `main1.vr`. Files `main2_dep1.v`, `main2_dep2.vr` ... `main2_depN.vr` contain definitions relevant to `main2.vr`, and so forth.

Usage Model for Multiple Programs

You can specify programs and related support files with multiple programs in two different ways:

1. Specifying all OpenVera programs in the configuration file
2. Specifying one OpenVera program on the command line, and the rest in the configuration file

Note:

- Specifying multiple OpenVera files containing the program construct at the VCS command prompt is an error.
- If you specify one program at the VCS command line and if any support files are missing from the command line, VCS issues an error.

Specifying all OpenVera programs in the configuration file

When there are two or more program files listed in the configuration file, the VCS command line is:

```
% vcs -ntb -ntb_opts config=configfile
```

The configuration file, could be:

```
program main1.vr -ntb_define ONE  
program main2.vr -ntb_incdir /usr/vera/include
```

Specifying one OpenVera program on the command line, and the rest in the configuration file

You can specify one program in the configuration file and the other program file at the command prompt.

```
% vcs -ntb -ntb_opts config=configfile main2.vr
```

The configuration file used in this example is:

```
program main1.vr
```

In the previous example, `main1.vr` is specified in the configuration file and `main2.vr` is specified on the command line along with the files needed by `main2.vr`.

NTB Options and the Configuration File

The configuration file supports different OpenVera programs with different NTB options such as '`include`', '`define`', or '`timescale`'. For example, if there are three OpenVera programs `p1.vr`, `p2.vr` and `p3.vr`, and `p1.vr` requires the `-ntb_define VERA1` runtime option, and `p2.vr` should run with `-ntb_incdir /usr/vera/include` option, specify these options in the configuration file:

```
program p1.vr -ntb_define VERA1  
program p2.vr -ntb_incdir /usr/vera/include
```

and specify the command line as follows.

```
% vcs -ntb -ntb_opts config=configfile p3.vr
```

Any NTB options mentioned at the command prompt, in addition to the configuration file, are applicable to all OpenVera programs.

In the configuration file, you may specify the NTB options in one line separated by spaces, or on multiple lines.

```
program file1.vr -ntb_opts no_file_by_file_pp
```

Some NTB options specific for OpenVera code compilation, such as `-ntb_cmp` and `-ntb_vl`, affect the VCS flow after the options are applied. If these options are specified in the configuration file, they are ignored.

The following options are allowed for multiple program use.

- `-ntb_define macro`
- `-ntb_incdir directory`
- `-ntb_opts no_file_by_file_pp`
- `-ntb_opts tb_timescale=value`
- `-ntb_opts dep_check`
- `-ntb_opts print_deps`
- `-ntb_opts use_sigprop`
- `-ntb_opts vera_portname`

See the appendix on “Compile-time Options” or “Elaboration Options” for descriptions of the these options.

Separate Compilation of Testbench Files

This section describes how to compile your testbench separately from your design and then load it on simv (compiled design executable) at runtime. Separate compilation of testbench files allows you to:

- Keep one or many testbenches compiled and ready and then choose which testbench to load when running a simulation.
- Save time by recompiling only the testbench after making changes to it and then running simv with the recompiled testbench.
- Save time in cases where changes to the design do not require changes to the testbench by recompiling only the design after making changes to it and then running simv with the previously compiled testbench.

Separate compilation of the testbench generates two files:

- The compiled testbench in a shared object file, `libtb.so`. This shared object file is the one to be loaded on simv at runtime.
- A Verilog shell file (`.vshell`) that contains the testbench shell module. Since the testbench instance in the top-level Verilog module now refers to this shell module, the shell file has to be compiled along with the design and the top-level Verilog module. The loaded shared object testbench file is automatically invoked by the shell module during simulation.

The following steps demonstrate a typical flow involving separate compilation of the testbench:

1. Compile the testbench in VCS to generate the shared object (`libtb.so`) file containing the compiled testbench and the Verilog testbench shell file.

2. Compile the HDL along with the top-level Verilog module and the testbench shell (.vshell) file to generate the executable simv.
3. Load the testbench on simv at runtime.

Important:

The following `ntb_opts` options must be used for both steps of the compilation (the testbench compilation and the design compilation):

```
-ntb_opts use_sigprop
-ntb_opts dw_vip
-ntb_opts aop
```

Usage Model

Testbench Compilation

```
% vcs -ntb_cmp [other_ntb_options] file1.vr file2.vr
```

Compilation

```
% vcs -ntb_vl [ntb_options] [compile_options]
file1.vr file2.vr file3.v file4.v
```

Simulation

```
% simv +ntb_load=PATH/libtb.so [run_options]
```

PATH is the directory where the `libtb.so` and `.vshell` files are created. You can specify *PATH* by using the `-ntb_spath` option while compiling the testbench.

Example

Design files: `top.v` `mid.v`, `bot.v`

Testbench file: `tb.vr`

```
% vcs -ntbmx_cmp -timescale=1ns/1ps tb.vr  
  
% vcs -ntb_vl -timescale=1ns/1ps top.v mid.v bot.v  
  
% simv +ntb_load=./libtb.so
```

Class Dependency Source File Reordering

In order to ease transitioning of legacy code from Vera's make-based single-file compilation scheme to VCS-NTB, where all source files have to be specified on the command line, VCS provides a way of instructing the compiler to reorder Vera files in such a way that class declarations are in topological order (that is, base classes precede derived classes).

In Vera, where files are compiled one-by-one, and extensive use of header files is a must, the structure of file inclusions makes it very likely that the combined source text has class declarations in topological order.

If specifying a command line like the following leads to problems (error messages related to classes), adding the analysis option `-ntb_opts dep_check` to the command line directs the compiler to activate analysis of Vera files and process them in topological order with regard to class derivation relationships.

```
% vcs -ntb *.vr
```

By default, files are processed in the order specified (or wildcard-expanded by the shell). This is a global option, and affects all Vera input files, including those preceding it, and those named in `-f file.list`.

When using the option `-ntb_opts print_deps` in addition to `-ntb_opts dep_check` with vcs, the reordered list of source files is printed on standard output. This could be used, for example, to establish a baseline for further testbench development.

For example, assume the following files and declarations:

```
b.vr: class Base {integer i;}  
d.vr: class Derived extends Base {integer j;}  
p.vr: program test {Derived d = new;}
```

File `d.vr` depends on file `b.vr`, since it contains a class derived from a class in `b.vr`, whereas `p.vr` depends on neither, despite containing a reference to a class declared in the former. The `p.vr` file does not participate in inheritance relationships. The effect of dependency ordering is to properly order the files `b.vr` and `d.vr`, while leaving files without class inheritance relationships alone.

The following command lines result in reordered sequences.

```
% vcs -ntb -ntb_opts dep_check d.vr b.vr p.vr  
% vcs -ntb -ntb_opts dep_check p.vr d.vr b.vr
```

The first command line yields the order `b.vr d.vr p.vr`, while the second line yields, `p.vr b.vr d.vr`.

Circular Dependencies

With some programming styles, source files can appear to have circular inheritance dependencies in spite of correct inheritance trees being cycle-free. This can happen, for example, in the following scenario:

```
a.vr: class Base_A {...}  
      class Derived_B extends Base_B {...}
```

```
b.vr: class Base_B {...}
      class Derived_A extends Base_A {...}
```

In this example, classes are derived from base classes that are in the other file, respectively, or more generally, when the inheritance relationships project onto a loop among the files. This is, however, an abnormality that should not occur in good programming styles. VCS will detect and report the loop, and will use a heuristic to break it. This may not lead to successful compilation, in which case you can use the `-ntb_opts print_deps` option to generate a starting point for manual resolution; however, if possible, the code should be rewritten.

Dependency-based Ordering in Encrypted Files

As encrypted files are intended to be mostly self-contained library modules that the testbench builds upon, they are excluded from reordering regardless of dependencies (these files should not exist in unencrypted code). VCS splits Vera input files into those that are encrypted or declared as such by having the `.vrp` or `.vrhp` file extension or as specified using the `-ntb_vipext` option, and others. Only the latter unencrypted files are subject to dependency-based reordering, and encrypted files are prefixed to them.

Note:

The `-ntb_opts dep_check` compile-time option specifically resolves dependencies involving classes and enums. That is, we only consider definitions and declarations of classes and enums. Other constructs such as ports, interfaces, tasks and functions are not currently supported for dependency check.

Using Encrypted Files

VCS NTB allows distributors of Verification IP (Intellectual Property) to make testbench modules available in encrypted form. This enables the IP vendors to protect their source code from reverse-engineering. Encrypted testbench IP is regular OpenVera code, and is not subject to special processing other than to protect the source code from inspection in the debugger, through the PLI, or otherwise.

Encrypted code files provided on the command line are detected by VCS, and are combined into one preprocessing unit that is preprocessed separately from unencrypted files, and is for itself, always preprocessed in `-ntb_opts no_file_by_file_pp` mode. The preprocessed result of encrypted code is prefixed to preprocessed unencrypted code.

VCS only detects encrypted files on the command line (including `-f` option files), and does not descend into include hierarchies. While the generally recommended usage methodology is to separate encrypted from unencrypted code, and not include encrypted files in unencrypted files, encrypted files can be included in unencrypted files if the latter are marked as encrypted-mode by naming them with extensions `.vrp`, `.vrhp`, or additional extensions specified using the `-ntb_vipext` option. This implies that the extensions are considered OpenVera extensions similar to using `-ntb_fileext` for unencrypted files. This causes those files and everything they include to be preprocessed in encrypted mode.

Functional Coverage

The VCS implementation of OpenVera supports the `covergroup` construct. For more information about the covergroup and other functional coverage model, see the section "Functional Coverage Groups" in the VCS OpenVera Language Reference Manual.

Using Reference Verification Methodology

VCS supports the use of Reference Verification Methodology (RVM) for implementing testbenches as part of a scalable verification architecture.

The usage model for using RVM with VCS is:

Compilation

```
% vcs -ntb -ntb_opts rvm [ntb_options] [compile_options]  
file1.vr file2.vr file3.v file4.v
```

Simulation

```
% simv [run_options]
```

For details on the use of RVM, see the *Reference Verification Methodology User Guide*. Though the manual descriptions refer to Vera, NTB uses a subset of the OpenVera language and all language specific descriptions apply to NTB.

Differences between the usage of NTB and Vera are:

- NTB does not require header files (`.vrh`) as described in the *Reference Verification Methodology User Guide* chapter "Coding and Compilation."

- NTB parses all testbench files in a single compilation.
- The VCS command-line option `-ntb_opts rvm` must be used with NTB.

Limitations

- The handshake configuration of notifier is not supported (since there is no handshake for triggers-syncs in NTB).
- RVM enhancements for assertion support in Vera 6.2.10 and later are not supported for NTB.
- If there are multiple consumers and producers, there is no guarantee of fairness in reads from channels, etc.

Performance Profiler

The NTB Performance Profiler aids in writing more efficient OpenVera code. When performance profiling is turned on, NTB tracks:

- The time spent in each function, task and program
- The time spent in the HDL simulator and in testbench internal
- Predefined methods
- OpenVera fork join block
- Predefined procedures
- Testbench garbage collection

Enabling the NTB Profiler

The VCS profiler has been enhanced to support NTB. The `+prof` option enables the profiling of OpenVera NTB constructs and is used in the `vcs` command line. For example:

```
% vcs +prof [ntb_options] [compile_options] Verilog_files
```

The NTB profile report is dumped in the `vcs.prof` log file.

Note:

The current profiler and the `+prof` compile-time option will be replaced by the unified profiler and the `-simprofile` compile-time option in the next release of VCS. The unified profiler is now an LCA feature, see [The Unified Simulation Profiler](#).

Performance Profiler Example

The NTB performance profiler is illustrated here by means of a simple example. The program, `MyTest`, calls an OpenVera task entitled `MyPack`, and a DPI task entitled `DPI_call`, together in a loop 20 times. The profiler reports the relative portion of the runtime that each consumes.

```
//OpenVera: dpi.vr
#include <vera_defines.vrh>

// declare DPI tasks
import "DPI" function void DPI_call(integer a, integer b);

class A {
    packed rand integer i;
}

task MyPack(integer k) {
    bit[31:0] arr[];
}
```

```

        integer result, index, left,right;
A a = new;
a.i = k;
index = 0;
left = 0;

right = 0;
result = 0;
result = a.pack(arr,index,left,right,0);
}

program MyTest
{
    integer k = 0, j = 0;
repeat (20)
{
    fork
    {
        for (j = 0; j < 200; j++)
        {
            k = k + 1;
            MyPack(k);
        }
    }
    {
        for(j = 1; j < 100000; j++)
        k++;
        DPI_call(1, 2);
    }
join all
}

//C-file: dpi.c
#include <svdpi.h>

static int tmp;
static void do_activity(int j)
{

```

```

int i;

for( i = 0; i < 200000; i++ )
{
    tmp ^= j + i;
}
void DPI_call(int a, int b)
{
    int i;

    for( i = 0; i < 1000; i++ )
    {
        i +=b;
        i *=a;
        do_activity( i );
    }
}

```

The usage model to simulate this design is shown below:

Compilation

```
% vcs +prof -ntb dpi.vr dpi.c
```

Simulation

```
% simv
```

Example 12-5 Log File (vcs.prof)

```
//      Synopsys VCS Y-2006.06-SP1-5
//      Simulation profile: vcs.prof
//      Simulation Time:      18.640 seconds

=====
          TOP LEVEL VIEW
=====
          TYPE      %Totaltime
-----
            DPI      97.98
            PLI      0.00
```

VCD	0.00
KERNEL	0.00
MODULES	0.00
PROGRAMS	1.90
PROGRAM GC	0.11
ASSERTION KERNEL	0.00

Reporting limit is 0.50%

MODULE VIEW

(index)	Module	%Totaltime	No of Instances	Definition
---------	--------	------------	-----------------	------------

PROGRAM VIEW

Program(index)	%Totaltime	No of Instances	Definition
----------------	------------	-----------------	------------

MyTest_p	(1)	1.90	dpi.vr:26.
----------	-----	------	------------

INSTANCE VIEW

Instance	%Totaltime
----------	------------

MyTest	1.90
--------	------

PROGRAM TO CONSTRUCT MAPPING

1. MyTest_p

Construct	Construct type	%Totaltime	%Programtime	LineNo
-----------	----------------	------------	--------------	--------

Fork	Program Thread	0.90	47.06	dpi.vr : 39-43.
A::pack	Object Pack	0.84	44.12	dpi.vr : 23.
MyPack	Program Task	0.17	8.82	dpi.vr : 11-23.

=====

TOP-LEVEL CONSTRUCT VIEW

=====

Construct	%Totaltime
Program Thread	0.90
Object Pack	0.84
Program Task	0.17

=====

CONSTRUCT VIEW ACROSS DESIGN

=====

1. Program Thread

Program	%TotalTime
MyTest_p	0.90

2. Object Pack

Program	%TotalTime
MyTest_p	0.84

3. Program Task

Program	%TotalTime

```

=====
//      Simulation memory:      6316085 bytes

=====
TOP LEVEL VIEW
=====

```

TYPE	Memory	%Totalmemory
DPI	2068	0.03
PLI	0	0.00
VCD	0	0.00
KERNEL	1638725	25.95
MODULES	0	0.00
PROGRAMS	9349992	148.03

```

=====
PROGRAM VIEW
=====

```

Program(index)	Memory	%Totalmemory	No of Instances	Definition
MyTest_p	(1) 9349992	148.03	2	dpi.vr:26.

```

*****End of vcs.prof*****

```

The `vcs.prof` log file shown in Example 13-7 provides the following information:

- The DPI function in `dpi.c` consumed 97.98% of the total time.

Fork	Program Thread	0.90	47.06	dpi.vr : 39-43.
A::pack	Object Pack	0.84	44.12	dpi.vr : 23
MyPack	Program Task	0.17	8.82	dpi.vr : 11-23

- The fork-join block defined in `test.vr : 39-43` consumed 0.90% of the total time.

- The predefined class method, `pack()`, invoked at `test.vr:23` consumed 0.84% of the total time.
- The task `MyPack()` defined at `test.vr:11:23` consumed 0.17% of the total time.

The time reported for construct is the exclusive time consumed by the construct itself. Time spent in dependants is not reported.

11

Using SystemVerilog

VCS supports the SystemVerilog language as defined in the IEEE 1800-2009 standard. For information on SystemVerilog constructs, see the *SystemVerilog Language Reference Manual*.

This chapter describes the following:

- “Usage Model”
- “Using UVM With VCS”
- “Using VMM with VCS”
- “Using OVM with VCS”
- “Debugging SystemVerilog Designs”
- “Functional Coverage”
- “Newly implemented SystemVerilog Constructs”

- “Extensions to SystemVerilog”
- “Error Condition for Using a Genvar Outside of its Generate Block” on page 81
- “Exporting a SystemVerilog Package” on page 82
- “Using a Package in a SystemVerilog Module, Program, and Interface Header” on page 86

For SystemVerilog assertions, see Chapter 17, "Using SystemVerilog Assertions".

Usage Model

The usage model to compile and simulate your design with SystemVerilog files is as follows:

Compilation

```
% vcs -sverilog [compile_options] Verilog_files
```

Simulation

```
% simv [simv_options]
```

To analyze SV files, use the option `-sverilog` with `vcs` as shown in the above usage model.

Using UVM With VCS

This version of VCS provides native support for both UVM-1.1a and UVM-1.0. These libraries are located in:

- \$VCS_HOME/etc/uvm-1.1
- \$VCS_HOME/etc/uvm-1.0

UVM 1.1 is now replaced with UVM 1.1a, which is the default. You can load UVM 1.1a by:

- Using the `-ntb_opts uvm` option
- Explicitly specifying the `-ntb_opts uvm-1.1` option

The following sections explain your options for using UVM with VCS:

- “[Update on UVM-1.0](#)” on page 4
- “[Update on UVM-EA](#)” on page 4
- “[Natively Compiling and Elaborating UVM-1.0](#)” on page 5
- “[Natively Compiling and Elaborating UVM-1.1a](#)” on page 5
- “[Compiling the External UVM Library](#)” on page 6
- “[Accessing HDL Registers Through UVM Backdoor](#)” on page 8
- “[Generating UVM Register Abstraction Layer Code](#)” on page 9
- “[Recording UVM Transactions](#)” on page 10
- “[UVM Template Generator \(uvmgen\)](#)” on page 11
- “[Using Mixed VMM/UVM Libraries](#)” on page 12

- “Migrating from OVM to UVM” on page 13
 - “Where to Find UVM Examples” on page 14
 - “Where to Find UVM Documentation” on page 14
-

Update on UVM-1.0

Starting with this release, you can load UVM-1.0 using the
-ntb_opts uvm-1.0 option.

In the E-2011.03 version of VCS, the UVM-1.0 library is the default.
In F-2011.12 and in this version, the UVM-1.1 library is the default..
In this version, the UVM-1.1 library is the default.

Note:

You may see some differences in results when changing UVM libraries. However, you don't need any code changes to comply with UVM-1.1.

Update on UVM-EA

Starting with this release, UVM-EA is not natively available. If you use the -ntb_opts uvm-ea option, VCS generates an error message. In that case, you can edit your source code to comply with UVM-1.0 or UVM-1.1a.

As an alternative, you can continue to use the UVM-EA library by downloading the UVM-EA installation from Accellera and using the +includer option to point to that installation.

Natively Compiling and Elaborating UVM-1.0

You can compile and elaborate SystemVerilog code which extends from UVM-1.0 base classes using the following command:

```
% vcs -sverilog -ntb_opts uvm-1.0 [compile_options] \
<user source files using UVM>
```

For a mixed-HDL or UUM (unified use model) environment, compile UVM-1.0 with vlogan using the following commands:

```
% vlogan -ntb_opts uvm-1.0 [compile_options]
// no source files here!

% vlogan -ntb_opts uvm-1.0 [compile_options] \
<user source files using UVM>
```

Note:

Complete the first step before using the subsequent command. The first vlogan call compiles the UVM library. This is without any user source files specified.

Elaborate the design as follows:

```
% vcs top [elab_options] -ntb_opts uvm-1.0 <top module>
```

Natively Compiling and Elaborating UVM-1.1a

You can compile and elaborate SystemVerilog code which extends from UVM-1.1a base classes by using the following command:

```
% vcs -sverilog -ntb_opts uvm [compile_options] \
<user source files using UVM>
```

For a mixed-HDL or UVM environment, compile UVM-1.1a with vlogan using the following command:

```
% vlogan -ntb_opts uvm [compile_options]
// no source files here!

% vlogan -ntb_opts uvm [compile_options] \
<user source files using UVM>
```

Note:

- Complete the first step that compiles the UVM library before using the subsequent command. The first vlogan call compiles the UVM library. This is without any user source files specified.
- In specific cases, the subsequent vlogan command might error out with Error-[UM] Undefined Macro. In this scenario you must explicitly add `include uvm_macros.svh to the file getting this error.

Elaborate the design as follows:

```
% vcs -ntb_opts uvm [elab_options] <top module>
```

Using the -ntb_opts uvm option is the same as specifying the version explicitly using the -ntb_opts uvm-1.1 option. However, it is best to specify the version explicitly, because later versions of UVM might carry the default UVM library.

Compiling the External UVM Library

If you want to use a UVM version from Accellera in place of the UVM-1.1a version shipped with VCS, follow either of these procedures:

- “[Using the -ntb_opts uvm Option](#)”

- “Explicitly Specifying UVM Files and Arguments”

Using the -ntb_opts uvm Option

When you set the VCS_UVM_HOME environment variable to specify a UVM library directory, VCS uses this location even if the -ntb_opts uvm option is used. For example:

```
% setenv VCS_UVM_HOME /<path_to_uvm_library>/myuvm1.1

% vcs -sverilog -ntb_opts uvm [compile_options] \
<user source files using UVM>
```

This is also supported for the UUM flow and using vlogan.

Specifying External uvm_dpi.cc Source

When using -ntb_opts uvm, the uvm_dpi.cc is picked up from the UVM installation inside the VCS installation. However, you might want to use the custom UVM DPI files instead of the ones shipped with the UVM library.

Explicitly Specifying UVM Files and Arguments

The following example shows how to compile and elaborate the UVM extended code by explicitly specifying the UVM files and arguments:

```
% vcs -sverilog +incdir+${UVM_HOME} \
      ${UVM_HOME}/uvm_pkg.sv \
      ${UVM_HOME}/dpi/uvm_dpi.cc \
      -CFLAGS -DVCS \
      [compile_options] \
      <user source files using UVM>
```

For a mixed-HDL or UVM environment, compile with `vlogan` using the following command:

```
% vlogan -sverilog +incdir+${UVM_HOME} \
${UVM_HOME}/uvm_pkg.sv

% vlogan -sverilog +incdir+${UVM_HOME} \
<user source files using UVM>
```

Elaborate the design as follows:

```
% vcs [elab_options] \
${UVM_HOME}/dpi/uvm_dpi.cc <top module> \
-CFLAGS -DVCS
```

Note:

`${UVM_HOME}` should point to your UVM release path. It can also point to `${VCS_HOME}/etc/uvm-1.1`.

Accessing HDL Registers Through UVM Backdoor

If you are using tests that need to access HDL registers through the default UVM register backdoor mechanism, add the `-debug_pp` switch to your command line:

```
% vcs -sverilog -debug_pp -ntb_opts uvm \
[compile_options] <user source files using UVM>
```

Note:

The `debug_pp` switch may affect simulation performance. Therefore, you should use the `pli_learn` capability to improve the HDL access. For more information, see the *VCS User Guide*.

To simulate, use the following command:

```
% simv +UVM_TESTNAME=<your_uvm_test> [simv_options]
```

If you use the `-b` option with `ralgen`, the `-debug_pp` switch is not required and the HDL backdoor is enabled through cross-module references instead of VPI. This provides better performance.

Generating UVM Register Abstraction Layer Code

VCS ships a utility called `ralgen`. Given a description of the available registers and memories in a design, `ralgen` automatically generates the UVM RAL abstraction model for these registers and memories. The description of these registers and memories can be in RALF format or in the IPXACT schema.

To generate a register model from a RALF file, use the following command:

```
% ralgen [options] -t <topname> -uvm <filename.ralf>
```

Here, `filename.ralf` is the name of the RALF input file and `topname` is the top block or system name in the RALF file.

To generate a register model from an IPXACT file, you use a two-step flow. The first step is to generate RALF from IPXACT as follows:

```
% ralgen -ipxact2ralf <input_file>
```

The second step is the same as the one described above. For more information, see the *UVM RAL Generator User Guide*.

Recording UVM Transactions

UVM has additional features that allow you to take advantage of VCS transaction recording and DVE transaction debugging capabilities. These features are available with both the UVM-1.0 and UVM-1.1a libraries.

To turn on UVM transaction recording, you need to use a compile-time flag for UVM-1.0. No compile-time flag is needed for UVM-1.1a. Then you enable recording using a runtime flag. The transaction and report recordings are stored in the simulation VPD file.

To compile your UVM-1.0 code, add the
+define+UVM_TR_RECORD statement to your vcs or vlogan command line as shown below:

```
% vcs -sverilog -ntb_opts uvm-1.0 \
+define+UVM_TR_RECORD [compile_options]
```

To compile your UVM-1.1a code, no compile-time flag is needed.

```
% vcs -sverilog -ntb_opts uvm-1.1 [compile_options]
```

To simulate, use +UVM_TR_RECORD to turn on transaction recording and use +UVM_LOG_RECORD to turn on recording of UVM report log messages:

```
% simv +UVM_TESTNAME=<your_uvm_test> +UVM_TR_RECORD \
+UVM_LOG_RECORD [simv_options]
```

You can then use DVE to debug the transactions and messages. This is supported for both interactive and post-process debug. The recorded streams with transactions and report logs are available in the VMM/UVM folder of the transaction browser.

Note:

If you used the `UVM_TR_RECORD` feature with a previous version of VCS, then you should remove the `set_config_int("*", "recording_detail", UVM_FULL)` statement from your UVM code, because it is no longer required.

UVM Template Generator (uvmgen)

`uvmgen` is a template generator for creating robust and extensible UVM-compliant environments. The primary purpose of `uvmgen` is to minimize the VIP and environment development cycle by providing detailed templates for developing UVM-compliant verification environments. You can also use `uvmgen` to quickly understand how different UVM base classes can be used in different contexts. This is possible because the templates use a rich set of the latest UVM features to ensure the appropriate base classes and their features are picked up optimally.

In addition, `uvmgen` can be used to generate both individual templates and complete UVM environments.

`uvmgen` is a part of the VCS installation. It can be invoked by,

```
uvmgen [-L libdir] [-X] [-o fname] [-O]
```

where,

-L: Takes user-defined library for template generation

-X: Excludes standard template library

-o: Generates templates in specified file

-O: Overwrites if file already exists

-q: Quick mode to generate complete environment

For more information, see the *UVM Template Generator (uvmgen) User Guide*.

Using Mixed VMM/UVM Libraries

For interoperability reasons (using UVM components in a VMM environment and vice versa), VCS allows you to load the VMM and UVM libraries simultaneously, along with the VMM/UVM interop kit.

The VMM-1.2/UVM-1.0 interop kit is located in:

- \$VCS_HOME/etc/uvm-1.0/uvm_vmm_pkg.sv
- \$VCS_HOME/etc/uvm-1.1/uvm_vmm_pkg.sv

This works with both UVM-1.0 and UVM-1.1a.

You can load mixed VMM-1.2 and UVM-1.0/1.1a by using a combination of the following VCS switches:

- -ntb_opts uvm[-1.0/1.1]+rvm

-or-

- -ntb_opts rvm+uvm[-1.0/1.1]

-ntb_opts uvm[-1.0/1.1]+rvm is supported for both the mixed-HDL and UUM flows:

```
% vcs ... -ntb_opts uvm+rvm ...
```

```
% vlogan ... -ntb_opts uvm+rvm ...
```

You can turn off the automatic inclusion of uvm_vmm_pkg.sv using
+define+NO_VMM_UVM_INTEROP.

By default, the mixed environment is driven by a VMM top timeline.
However, you can define a UVM top using +define+UVM_ON_TOP.

The UVM-1.0/1.1a VMM-1.2 interop kit examples are located in
\$VCS_HOME/doc/examples/uvm_vmm_interop_kit.

Note:

In this version of VCS, the UVM-EA and VMM-1.2 interop kit is no longer included. If you need either one of these kits, contact vcs_support@synopsys.com.

Migrating from OVM to UVM

To convert your OVM code to UVM, you can use a script stored in \${VCS_HOME}/bin/OVM_UVM_Rename.pl. This script makes the migration process easy.

Note:

This process is simple for SystemVerilog code that extends from OVM 2.1.1 onward.

Use the following command to convert your OVM code to UVM code:

```
% OVM_UVM_Rename.pl
```

This script hierarchically changes all occurrences of "ovm_" to "uvm_" for files with .v, .vh, .sv, and .svh extensions.

Change the simulation command line by replacing OVM_TESTNAME with UVM_TESTNAME.

Note:

Some additional work is required for the base classes that differ between OVM and UVM. For example, you may need to modify callbacks, some global function names, arguments, etc.

Where to Find UVM Examples

The UVM-1.1a interop examples are located in:

`$VCS_HOME/doc/examples/uvm.`

The UVM-VMM interop examples are located in:

`$VCS_HOME/doc/examples/uvm_vmm_interop_kit.`

Where to Find UVM Documentation

The UVM-1.1a, UVM-1.0, and UVM-VMM interop documentation is available in the following locations.

UVM-1.1a Documentation

The PDF version of the *UVM-1.1a User Guide* is located in
`$VCS_HOME/doc/UserGuide/pdf/uvm_users_guide_1.1.pdf.`

The PDF version of the *UVM-1.1a Reference Guide* is located in
`$VCS_HOME/doc/UserGuide/pdf/UVM_Class_Reference_1.1.pdf.`

UVM-1.0 Documentation

The PDF version of the *UVM-1.0 Reference Guide* is located in
\$VCS_HOME/doc/UserGuide/pdf/
UVM_Class_Reference_Manual_1.0.pdf.

The PDF version of the *UVM-1.0 User Guide* is located in
\$VCS_HOME/doc/UserGuide/pdf/uvm_users_guide_1.0.pdf

UVM-VMM Interop Documentation

The unified HTML version of the *UVM-VMM Interop Reference Guide* is accessible from the VCS or VCS MX installation at
[\\$VCS_HOME/doc/UserGuide/userguide_html/uvm_vmm/html/index.html](#).

Using VMM with VCS

The usage model to use VMM with VCS is as follows:

Compilation

```
% vcs -sverilog -ntb_opts rvm [compile_options]  
Verilog_files
```

Simulation

```
% simv [simv_options]
```

To analyze SV files using VMM, use the option
-sverilog and -ntb_opts rvm with vcs as shown in the above
usage model.

For more information on VMM, refer to the *Verification Methodology Manual for SystemVerilog*.

Using OVM with VCS

VCS provides native support for OVM 2.1.2. The libraries are located in:

```
$VCS_HOME/etc/ovm
```

Native Compilation and Elaboration of OVM 2.1.2

You can compile and elaborate SystemVerilog code which extends from OVM 2.1.2 base classes by using the following command:

```
% vcs -sverilog -ntb_opts ovm [compile_options] \  
<user source files using OVM>
```

When you natively compile and elaborate the OVM code, you do not have to explicitly include OVM source files in user code as they would get parsed by default.

In the G-2012.09 version of VCS, the OVM 2.1.2 library is default.

For a mixed-HDL or UUM environment, compile OVM 2.1.2 with vlogan using the following command:

```
% vlogan -ntb_opts ovm [compile_options]  
// no source files here!  
% vlogan -ntb_opts ovm -sverilog [compile_options] \  
<user source files using OVM>
```

Note:

- Complete the first step that compiles the OVM library before using the subsequent command. The first vlogan call compiles the OVM library, which does not contain any user source files.
- In specific cases, the subsequent vlogan command might error out with Error- [UM] Undefined macro. In this scenario, explicitly add `include "ovm_macros.svh" to the file encountering this error.

Elaborate the design as follows:

```
% vcs -ntb_opts ovm [elab_options] <top module>
% simv +OVM_TESTNAME=<ovm testname> <simv options>
```

Using -ntb_opts ovm option is same as specifying the version by explicitly using -ntb_opts ovm-2.1.2 option.

In some cases, if you have explicitly included "ovm.svh" then the OVM source code is recompiled in subsequent vlogan command. To avoid re-compilation, you need to add +define+OVM_SVH in subsequent vlogan commands.

```
% vlogan -ntb_opts ovm [compile_options]
// no source files here!
```

```
% vlogan -ntb_opts ovm -sverilog +define+OVM_SVH
[compile_options] \<user source files using OVM>
```

In cases where `include "ovm_pkg.sv" is present in the user code, recompilation of the OVM source code is required. To avoid this, you need to pass +define+OVM_PKG_SV in the subsequent vlogan commands.

```
% vlogan -ntb_opts ovm [compile_options]
// no source files here!
```

```
% vlogan -ntb_opts ovm -sverilog +define+OVM_PKG_SV
[compile_options] \<user source files using OVM>
```

Compiling the External OVM Library

If you want to use an OVM version from Accellera in place of the OVM 2.1.2 version shipped with VCS, use one of the following procedures:

- Using the `-ntb_opts ovm` option
- Explicitly specifying OVM files and arguments

Using the `-ntb_opts ovm` Option

When you set the `VCS_OVM_HOME` environment variable to specify a OVM library directory, VCS uses this location even if the `-ntb_opts ovm` option is used. For example,

```
% setenv VCS_OVM_HOME /<path_to_ovm_library>/myOVM-2.1.2  
% vcs -sverilog -ntb_opts ovm [compile_options] \  
<user source files using OVM>
```

This is also supported for the UUM flow and for using vlogan.

Explicitly Specifying OVM Files and Arguments

The following example shows how to compile and elaborate the OVM extended code by explicitly specifying the OVM files and arguments:

```
% vcs -sverilog +incdir+${OVM_HOME} \  
 ${OVM_HOME}/ovm_pkg.sv \  
 [compile_options] \  
 <user source files using OVM>
```

For a mixed-HDL or UUM environment, compile with vlogan using the following command:

```
% vlogan -sverilog +incdir+${OVM_HOME} \
${OVM_HOME}/ovm_pkg.sv

% vlogan -sverilog +incdir+${OVM_HOME} \
<user source files using OVM>
```

Note: \${OVM_HOME} should point to your OVM release path. It can also point to \${VCS_HOME}/etc/ovm-2.1.2

Recording OVM Transactions

The OVM version shipped with VCS has additional features that allows you to take advantage of VCS and DVE's transaction recording and debugging capabilities.

To turn on OVM transaction recording, you need to use a specific compile-time flag for OVM or use any of the -debug flags with VCS in the two step flow and then enable recording using a different runtime flag. The transaction and report recordings are stored in the simulation VPD file. -PP can be provided instead of -debug flags if only post process debug is desired.

To compile your OVM code, add -debug/_pp/_all flag to your VCS command.

For three step flow, you need to provide +define+OVM_VCS_RECORD to the first vlogan command line as shown below along with any of the -debug flags with VCS.

Two step flow:

```
% vcs -sverilog -ntb_opts ovm -debug[_pp/all] \
[compile_options]
```

In UUM flow:

```
% vlogan -ntb_opts ovm
+define+OVM_VCS_RECORD [compile_options]
// no source files here!

% vlogan -ntb_opts ovm [compile_options] \
<user source files using OVM>
```

Note:

- Complete the first step that compiles the OVM library before using the subsequent command. The first vlogan call compiles the OVM library. Define `OVM_VCS_RECORD` at this step to enable transaction recording which is without any specified user source files.
- In specific cases, the subsequent vlogan command might error out with `Error- [UM] Undefined macro`. In this scenario, you must explicitly add ``include "ovm_macros.svh"` to the file getting this error.

Elaborate the design as follows:

```
% vcs -ntb_opts ovm [elab_options] <top module> -debug [_all/
_pp]
```

To simulate, use `+OVM_TR_RECORD` to turn on transaction recording and use `+OVM_LOG_RECORD` to turn on recording of OVM report log messages:

```
% simv +OVM_TESTNAME=<my_ovm_testname> +OVM_TR_RECORD \
+OVM_LOG_RECORD [simv_options]
```

You can then use DVE to debug the transactions and log messages. This is supported for both interactive and post-process debug. The recorded streams with transactions and report logs are available in the VMM/OVM folder of the transaction browser.

Running Native OVM Code in Partition Compile Flow

Partition compile flow allows you to create various partitions and compile the code in partitions. The OVM code can also be used in this flow.

You need to identify the block of the design that needs modifications. Specify the identified block as partition. Create a top config file and compile the code `-partcomp` to enable the partition compile.

To enable the partition compile flow, use vlogan and VCS commands as shown.

```
% vlogan -sverilog -ntb_opts ovm [compile_options]
// no source files here!

% vlogan -sverilog -ntb_opts ovm [compile_options] \
<user source files using OVM>

% vlogan -sverilog topcfg.v
```

Note:

- Complete the first step that compiles the OVM library before using the subsequent command. The first vlogan call compiles the OVM library, which is without any specified user source files.
- In specific cases, the subsequent vlogan command might error out with Error- [UM] Undefined macro. In this scenario, you must explicitly add ``include "ovm_macros.svh"` to the file encountering this error.
- The top config file should have the partitions based on either the instance or the module. The start and end of the file will be config and endconfig.

Example of top config file:

```
config topcfg;
    design work.top;
    partition package work.ovm_pkg;
    instance router_test_top.top_io use work.router_io;
    instance router_test_top.tb use work.test;
    partition instance router_test_top.tb ;
    instance router_test_top.dut use work.router;
    partition instance router_test_top.dut ;
    default liblist  work;
endconfig
```

Elaborate the design as follows:

```
% vcs -ntb_opts ovm -sverilog -partcomp <top_config_name>
[elab_options]

% simv +OVM_TESTNAME=<my_ovm_testname> [simv options]
```

To turn on OVM transaction recording in the partition compile flow, you need to use the same options as in the UUM flow.

Debugging SystemVerilog Designs

VCS provides UCLI commands to perform the following tasks to debug a design:

Task	Related UCLI commands are...
Line stepping	step next run
Thread debugging	step thread
Setting breakpoints	stop run
Mailbox related information	show
Semaphore related information	show

For detailed information on the UCLI commands, see the UCLI User Guide.

Functional Coverage

The VCS implementation of SystemVerilog supports the `covergroup` construct, which you specify as the user. These constructs allow the system to monitor values and transitions for variables and signals. They also enable cross coverage between variables and signals.

If you have covergroups in your design, VCS collects the coverage data during simulation and generates a database, `simv.vdb`. Once you have `simv.vdb`, you can use the Unified Report Generator to generate text or HTML reports. For more information about

covergroups, see the *VCS SystemVerilog LRM*. For more information about functional coverage generated in VCS, see the *Coverage Technology User Guide*.

Newly implemented SystemVerilog Constructs

VCS has implemented the following SystemVerilog constructs in this release:

- “[Support for Aggregate Methods in Constraints Using the “with” Construct](#)”
- “[Debugging During Initialization SystemVerilog Static Functions and Tasks in Module Definitions](#)”
- “[Explicit External Constraint Blocks](#)”
- “[Generate Constructs in Program Blocks](#)”
- “[Error Condition for Using a Genvar Outside of its Generate Block](#)” on page 35
- “[Randomizing Unpacked Structs](#)”
- “[Making wait fork Statements Compliant with the SV LRM](#)”
- “[Making disable fork Statements Compliant with the SV LRM](#)”

Support for Aggregate Methods in Constraints Using the “with” Construct

Aggregate methods in constraint blocks using the `with` construct have two variants, as shown in the following code example:

```
byte arr[3] = { 10, 20, 30 };  
class C;  
    rand int x1;  
    rand int x2;  
    rand int x3;  
    rand int x4;
```

```

constraint cons {
    // Newly implemented variant
    x1 == arr.sum() with (item * item);
    x2 == arr.sum(x) with (x + x);

    // Previously implemented variant
    // Supported in older releases
    x3 == arr.sum() with (arr[item.index] * arr[item.index]);
    x4 == arr.sum(x) with (arr[x.index] + arr[x.index]);
}
endclass

```

The first variant is implemented in this release.

For a discussion and examples of aggregate methods in constraints using the `with` construct, see IEEE Std 1800-2009, section 7.12.4 “Iterator index querying.”

As specified in the standard, the entire `with` expression must be in parentheses.

Debugging During Initialization SystemVerilog Static Functions and Tasks in Module Definitions

You can tell VCS to enable UCLI debugging when initialization begins for static SystemVerilog tasks and functions in module definitions with the `-ucli=init` runtime option and keyword argument.

This debugging capability enables you to do, among other things, to set breakpoints during initialization.

If you omit the `=init` keyword argument and just enter the `-ucli` runtime option, the UCLI begins after initialization and you can't debug inside static initialization routines during initialization.

Note:

- Debugging static SystemVerilog tasks and functions in program blocks during initialization does not require the `=init` keyword argument.
- This feature does not apply to SystemC code.

When you enable this debugging VCS displays the following prompt indicating that the UCLI is in the initialization phase:

```
init%
```

When initialization ends the UCLI returns to its usual prompt:

```
ucli%
```

During the initialization the `run` UCLI command with the `0` argument (`run 0`), or the `-nba` or `-delta` options runs VCS until initialization ends. As usual, after initialization, the `run 0` command and argument runs the simulation until the end of the current simulation time.

During initialization the following restrictions apply:

- UCLI commands that alter the simulation state, such as a `force` command, create an error condition.
- Attaching or configuring Cbug, or in other ways enabling C, C++, or SystemC debugging during initialization is an error condition.
- The following UCLI commands are not allowed during initialization:

session management commands: save and restore

signal and variable commands: force, release, and call

The signal value and memory dump specification commands:
memory -read/-write and dump

The coverage commands: coverage and assertion

Example

If we have the following small code example:

```
module mod1;
  class C;
    static int I=F();
    static function int F();
      logic log1;
      begin
        log1 = 1;
        $display("%m log1=%0b",log1);
        $display("In function F");
        F = 10;
      end
    endfunction
  endclass
endmodule
```

If we simulate this example, with just the -ucli runtime option, we see the following:

```
Command: simv -ucli
Chronologic VCS simulator copyright 1991-year
Contains Synopsys proprietary information.
Compiler version version-number; Runtime version version-number;
simulation-start-date-time
mod1.\C::F log1=1
In function F
```

```
V C S      S i m u l a t i o n      R e p o r t  
Time: 0  
CPU Time:      0.510 seconds;      Data structure size:  0.0Mb  
simulation-ends-day-date-time
```

VCS executed the \$display tasks right away and the simulation immediately ran to completion.

If we simulate this example, with just the -ucli=init runtime option and keyword argument, we see the following:

```
Command: simv -ucli=init  
Chronologic VCS simulator copyright 1991-year  
Contains Synopsys proprietary information.  
Compiler version version-number; Runtime version version-number  
simulation-start-date-time  
init%
```

Notice that VCS has not executed the \$display system tasks yet and the prompt is init%.

We can set a breakpoint, for example:

```
init% stop -in \C::F  
1
```

We ran then attempt to run through the initialization phase:

```
init% run 0  
  
Stop point #1 @ 0 s;  
init%
```

The breakpoint halts VCS.

If we run the simulation up to the end of the initialization phase with the run 0 UCLI command again, we see the following:

```
init% run 0
mod1.\C::F log1=1
In function F
ucli%
```

Now VCS executes the \$display system tasks and changes the prompt to ucli%.

Explicit External Constraint Blocks

External constraint blocks are constraint blocks, also called the constraint bodies, that are outside of a class, and at the same hierarchical level of that class. You enable them with external constraint prototypes in the class.

There are two forms of external constraint prototypes:

- explicit — where you include the `extern` keyword in the prototype.
- implicit — where you omit the `extern` keyword in the prototype.

The explicit form is implemented in this release.

The following code example shows these two forms of external constraint prototypes.

```
class Class1;
    rand int int1,int2;
    constraint imp_ext_cnstr_proto1;           // implicit form
    extern constraint exp_ext_cnstr_proto2;     // explicit form
    ...
endclass
```

The external constraint block, or body, for these prototypes must be at the same hierarchical level as the class and follow the class definition.

The following are external constraint blocks or bodies for these external constraint prototypes:

```
constraint Class1::imp_ext_cnstr_proto1 {
    int1 inside {0, [3:5], [7:31]};}
constraint Class1::exp_ext_cnstr_proto2 {
    int2 dist {100 := 1, 101 := 2};}
```

Besides the `extern` keyword, the difference between the implicit and explicit forms is how VCS responds when the external constraint block or body for a prototype is missing:

- With the implicit form, VCS handles a missing external constraint block as an empty constraint block. This is not an error condition and VCS just outputs a warning message, for example:

```
Warning-[BCNACMBP] Missing constraint definition
doc_example.sv, 6
prog, "constraint imp_ext_cnstr_proto1;"
    The constraint imp_ext_cnstr_proto1 declared in the
    class Class1 is not defined.
Provide a definition of the constraint body
imp_ext_cnstr_proto1 or remove the constraint declaration
imp_ext_cnstr_proto1 from the class declaration Class1.
```

An empty constraint block would be the same as the following:

```
constraint imp_ext_cnstr_proto1 { };
```

With a missing external constraint block for the implicit form, because it is not an error condition, VCS continues to compile or elaborate and generates the simv executable. If you don't notice the warning message you might expect to see the missing constraint block constraining the values of the random variables.

- With the explicit form, a missing external constraint block is an error condition, for example:

```
Error- [SV_MEECD] Missing explicit external constraint def
doc_example.sv, 7
prog, "constraint exp_ext_cnstr_proto2;"  
The explicit external constraint 'exp_ext_cnstr_proto2'  
declared in the class 'Class1' is not defined.  
Provide a definition of the constraint body  
'exp_ext_cnstr_proto2' or remove the explicit external  
constraint declaration 'exp_ext_cnstr_proto2' from the  
class declaration 'Class1'.
```

With a missing external constraint block for the explicit form, because it is an error condition, VCS does not compile or elaborate.

Using an Empty Constraint Block

You can use the implicit form of a constraint prototype, without the corresponding constraint block, in a subclass to remove a constraint from a base class, for example:

```
module top;
class C;
rand int x;
constraint protoc_1 { x < 5; }
constraint protoc_2 { x > 3; }
endclass

class CD extends C;
rand int y;
constraint protoc_1; // removing this constraint in
```

```

        // this subclass
constraint protoCD_1 { x < 6; } // applying a new constraint
                                // on x
endclass

C ci = new;
CD cdi = new;
int res1;
int res2;

initial begin
repeat (20) begin
    res1 = ci.randomize();    // here x can have value 4 only
    res2 = cdi.randomize();  // here x can have values 4 and 5
    if ((res1 == 1) && (res2 == 1))
        $display("niru>> ci.x=%d  cdi.x=%d",ci.x, cdi.x);
end
end

endmodule

```

The Explicit Form in Previous Releases

In previous releases the explicit form was an error condition and VCS displayed the following:

```

Error-[SE] Syntax error
Following verilog source has syntax error :
"doc_example.sv", 7: token is 'constraint'
extern constraint exp_ext_cnstr_proto2;
                                         ^
System verilog keyword 'constraint' is not expected
to be used in this context.

```

Generate Constructs in Program Blocks

Generate constructs are now supported in program blocks, not just in modules.

These constructs are described in The Verilog LRM, IEEE Std 1364-2005 in the following sections:

12.4 Generate constructs

12.4.1 Loop generate constructs

12.4.2 Conditional generate constructs

The following are examples of these constructs in a program block:

```
program prog;
...
generate
    reg reg1;
endgenerate

if (1) logic log1;

genvar gv1;
for(gv1=1; gv1<10; gv1++) logic log2;

case (param1)
    0 : logic log3;
    ...
endcase

endprogram
```

The first is a generate region, specified with the `generate` and `endgenerate` keywords inside a program block:

```
generate
    reg reg1;
endgenerate
```

The second is a conditional generate construct with the `if` keyword:

```
if (1) logic log1;
```

The third is a generate loop variable declared with the `genvar` keyword, followed by a `for` loop for that variable:

```
genvar gv1;
for(gv1=1; gv1<10; gv1++) logic log2;
```

The fourth is a generate case construct:

```
case (param1)
  0 : logic log3;
  ...
endcase
```

In previous releases these constructs would have resulted in the following error messages:

```
Error- [NYI] Not Yet Implemented
source_filename, line_number
Feature is not yet supported: Generate Block inside Program
```

```
Error- [NYI] Not Yet Implemented
source_filename, line_number
Feature is not yet supported: Generate Variable declaration
inside Program
```

Error Condition for Using a Genvar Outside of its Generate Block

A genvar variable declared in local scope of a generate block, that is used outside that block is an error condition starting from VCS2011.12-FCS release. The following code example shows this error condition:

```
module test;
generate
```

```

        for (genvar i = 0; i < 1; i++)
            begin
                a1: assert final (1);
            end
    endgenerate
generate
    for (i = 0; i < 1; i++)
        begin
            a1: assert final (1);
        end
endgenerate
endmodule

```

Compiling this example with the following command line:

```
vcs generate.sv -sverilog -assert svaext
```

Results in the following error message:

```

Error-[IND] Identifier not declared
generate.sv, 9
    Identifier 'i' has not been declared yet. If this error
is not expected,
    please check if you have set `default_nettype to none.

1 error

```

This error condition was ignored in previous releases.

To fix this error please declare `genvar i` in module scope.

Randomizing Unpacked Structs

You can now randomize members of an unpacked struct. You can do this in the following ways:

- use the scope randomize method `std::randomize()`

- use the class randomize method `randomize()`

You can also:

- disable and re-enable randomization in an unpacked struct with the `rand_mode()` method.
- use in-line random variable control to specify the randomized variables with an argument to the `randomize()` method.

Using the Scope Randomize Method `std::randomize()`

The following example illustrates using this method:

*Example 11-1 First Example of the Scope Randomize Method
`std::randomize()`*

```
module test();

typedef struct {
    bit [1:0] b1;
    integer i1;
} ST1;

ST1 st1;

initial
repeat (4)
begin
    std::randomize(st1);
    #10 $display("\n\n\t at %0t",$time);
        $display("\t st1.b1 is %0d",st1.b1);
        $display("\t st1.i1 is %0d",st1.i1);
end

endmodule
```

This example randomizes struct instance `st1`. The `$display` system tasks display the following:

```
at 10
st1.b1 is 2
st1.i1 is 1474208060
```

```
at 20
st1.b1 is 1
st1.i1 is 816460770
```

```
at 30
st1.b1 is 3
st1.i1 is -1179418145
```

```
at 40
st1.b1 is 0
st1.i1 is -719881993
```

In the previous version of VCS, this example would result in the following error messages at compile-time:

```
Error-[UARC] Unsupported argument to randomize call
doc_ex1.sv, 13
"st1"
    Arg #1 of std::randomize "st1" is unsupported unpacked
    struct or array of unpacked struct
```

```
Error-[SV-FNYI] Feature not yet implemented
doc_ex1.sv, 13
    SystemVerilog feature not yet implemented. unpacked
    structure(s) in system function calls Expression:
    std::randomize(st1)
```

Here is another code example that randomizes members of an unpacked struct and uses constraints:

*Example 11-2 Second Example of the Scope Randomize Method
std::randomize()*

```
module test;
    typedef struct {
        rand byte aa;
        byte bb;
    } ST;

    ST st;
    bit [3:0] c;

    initial begin
        std::randomize(st.bb);      // std randomization on a
                                     // struct member
        std::randomize(st) with { st.aa > 10; };
                                     // support st.aa in with block
        std::randomize(c,st) with { st.aa > c; };
        $display("\n\n\t at %0t",$time);
        $display("\t st.aa is %0d",st.aa);
        $display("\t st.bb is %0d",st.bb);
        $display("\t bit c is %0d",c);
    end
endmodule
```

The \$display system tasks display the following:

```
at 0
st.aa is 121
st.bb is -9
bit c is 0
```

*Example 11-3 Third Example of the Scope Randomize Method
std::randomize()*

```
module test;
    typedef struct {
        byte a0;
        byte b0;
    } ST0;
    typedef struct {
```

```

        byte aa;
        ST0 st0;
    } ST_NONE;

typedef struct {
    rand byte aa;
    byte bb;
} ST_PART;

typedef struct {
    rand byte aa;
    randc byte bb;
} ST_ALL;

ST_NONE st;
ST_PART st1;
ST_ALL st2;

initial begin
    repeat (5) begin
        // random variables: st.aa st.st0.a0 st.st0.b0
        std::randomize(st);

        // random variables: st1.aa st.bb
        std::randomize(st1) with {st1.aa>st1.bb;};

        // random variables: st2.aa st2.bb
        std::randomize(st2);

        $display("st %p",st);
        $display("st1 %p",st1);
        $display("st2 %p",st2);
    end
end

endmodule

```

This example randomizes unpacked struct instance st1. The \$display system tasks display the following:

```
st '{aa:54, st0:{a0:60, b0:125}}
```

```

st1 '{aa:-125, bb:-126}
st2 '{aa:-9, bb:-90}
st '{aa:27, st0:'{a0:-75, b0:-6}}
st1 '{aa:-37, bb:-47}
st2 '{aa:-106, bb:49}
st '{aa:-60, st0:'{a0:-86, b0:-60}}
st1 '{aa:-71, bb:-103}
st2 '{aa:-120, bb:-15}
st '{aa:44, st0:'{a0:-50, b0:5}}
st1 '{aa:-69, bb:-96}
st2 '{aa:96, bb:95}
st '{aa:122, st0:'{a0:-94, b0:-16}}
st1 '{aa:-2, bb:-63}
st2 '{aa:18, bb:-12}

```

Using the Class Randomize Method `randomize()`

The following example illustrates using this method.

Example 11-4 The Class Randomize Method `randomize()`

```

module test();

typedef struct {
    rand bit [1:0] b1;
    rand integer i1;
} ST1;

class CC;
    rand ST1 st1;
endclass

CC cc = new;

initial
repeat (4)
begin
    cc.randomize();
#10 $display("\n\n\t at %0t",$time);
    $display("\t cc.st1.b1 is %0d",cc.st1.b1);
    $display("\t cc.st1.i1 is %0d",cc.st1.i1);

```

```
    end  
  
endmodule
```

This example randomizes instance cc of class CC that contains unpacked struct ST. The \$display system tasks display the following:

```
at 10  
cc.st1.b1 is 3  
cc.st1.i1 is -1241023056
```

```
at 20  
cc.st1.b1 is 3  
cc.st1.i1 is -1877783293
```

```
at 30  
cc.st1.b1 is 1  
cc.st1.i1 is 629780255
```

```
at 40  
cc.st1.b1 is 3  
cc.st1.i1 is 469272579
```

In the previous version of VCS, this example would result in the following error messages at compile-time:

```
Error-[SV-RISNYI] Rand in Struct Not Yet Implemented  
doc_ex2.sv, 4  
The qualifier 'rand' was seen in a struct. This is not yet  
supported.  
Please remove the 'rand' declaration.
```

```
Error-[SV-RISNYI] Rand in Struct Not Yet Implemented  
doc_ex2.sv, 5  
The qualifier 'rand' was seen in a struct. This is not yet
```

```
supported.  
Please remove the 'rand' declaration.  
2 errors
```

Here is another code example:

Example 11-5 Another Example of the Class Randomize Method randomize()

```
module test;  
  
typedef struct {  
    bit[3:0] c;  
    randc bit[1:0] d;  
} ST0;  
  
typedef struct {  
    rand bit[5:0] a;  
    rand bit[5:0] b;  
    rand ST0 st0;  
    bit [5:0] e;  
} ST;  
  
class CC;  
    rand ST st;  
endclass  
  
CC cc = new;  
  
initial begin  
repeat (10) begin  
    // random variables: cc.st.a cc.st.b and cc.st.st0.d  
    // state variables: cc.st.e and cc.st.st0.c  
    cc.randomize() with { st.a<10 ; st.b>10; st.a+st.b==64; };  
  
    $display("st %p",cc.st);  
end  
end  
  
endmodule
```

This example randomizes class instance `cc` according to the constraint that follows the `with` keyword. The `$display` system task displays the following:

```
st '{a:'h7, b:'h39, st0:{c:'h0, d:'h0}, e:'h0}
st '{a:'h8, b:'h38, st0:{c:'h0, d:'h1}, e:'h0}
st '{a:'h1, b:'h3f, st0:{c:'h0, d:'h3}, e:'h0}
st '{a:'h1, b:'h3f, st0:{c:'h0, d:'h2}, e:'h0}
st '{a:'h1, b:'h3f, st0:{c:'h0, d:'h0}, e:'h0}
st '{a:'h8, b:'h38, st0:{c:'h0, d:'h1}, e:'h0}
st '{a:'h9, b:'h37, st0:{c:'h0, d:'h2}, e:'h0}
st '{a:'h9, b:'h37, st0:{c:'h0, d:'h3}, e:'h0}
st '{a:'h7, b:'h39, st0:{c:'h0, d:'h3}, e:'h0}
st '{a:'h8, b:'h38, st0:{c:'h0, d:'h1}, e:'h0}
```

Disabling and Re-enabling Randomization

You can disable and re-enable randomization in an unpacked struct with the `rand_mode()` method.

Example 11-6 Disabling and Re-enabling Randomization with the rand_mode() Method

```
module test();

typedef struct {
    rand integer i1;
} ST1;

class CC;
    rand ST1 st1;
endclass

CC cc = new;

initial
repeat (10)
begin
```

```

cc.randomize();
#10 $display("\n\t at %0t",$time);
    $display("\t cc.st1.i1 is %0d",cc.st1.i1);
end

initial
begin
#55 cc.rand_mode(0);
#20 cc.rand_mode(1);
end

endmodule

```

In this example the `rand_mode()` method, with its arguments, disables and re-enables randomization in class instance `cc`. The `$display` system tasks display the following:

```

at 10
cc.st1.i1 is -902462825

at 20
cc.st1.i1 is -1241023056

at 30
cc.st1.i1 is 69704603

at 40
cc.st1.i1 is -1877783293

at 50
cc.st1.i1 is -795611063

at 60
cc.st1.i1 is 629780255

at 70
cc.st1.i1 is 629780255

at 80
cc.st1.i1 is 629780255

```

```

at 90
cc.st1.i1 is 1347943271

at 100
cc.st1.i1 is 469272579

```

In this example randomization is disabled at simulation time 55 and re-enabled at simulation time 75, enabling new random values at simulation time 90.

In the previous version of VCS, this example would result in the following error messages at compile-time:

```

Error-[SV-RISNYI] Rand in Struct Not Yet Implemented
doc_ex3.sv, 4
    The qualifier 'rand' was seen in a struct. This is not yet
    supported.

    Please remove the 'rand' declaration.

```

1 error

Here is another code example:

Example 11-7 Another Example of Disabling and Re-enabling Randomization with the rand_mode() Method

```

module test;

typedef struct {
    bit[3:0] c;
    randc bit[1:0] d;
} ST0;

typedef struct {
    rand bit[5:0] a;
    rand bit[5:0] b;
    rand ST0 st0;
    bit [5:0] e;
} ST;

```

```

class CC;
    rand ST st;
    rand bit[2:0]  n1;
endclass

CC cc = new;

initial
begin
    cc.st.rand_mode(0);
    repeat (10)
        begin
            // random variables: cc.n1
            // state variables: all members of cc.st
            cc.randomize();
            $display("turn off st %p , cc.n1 %b",
                     cc.st,cc.n1);
        end
    cc.st.rand_mode(1);
    cc.st.st0.rand_mode(0);
    repeat (10)
        begin
            // random variables: cc.n1 cc.st.a cc.st.b
            // state variables: cc.st.e cc.st.st0.c cc.st.st0.d
            cc.randomize();
            $display("turn off st.st0 %p , cc.n1 %b",
                     cc.st,cc.n1);
        end
    cc.st.st0.rand_mode(1);
end

endmodule

```

In this example the `rand_mode()` method disables randomization in unpacked struct instance `cc.st.st0` and then re-enables it. The `$display` system tasks displays the following:

```

turn off st '{a:'h0, b:'h0, st0:{c:'h0, d:'h0}, e:'h0} , cc.n1 111
turn off st '{a:'h0, b:'h0, st0:{c:'h0, d:'h0}, e:'h0} , cc.n1 000
turn off st '{a:'h0, b:'h0, st0:{c:'h0, d:'h0}, e:'h0} , cc.n1 011
turn off st '{a:'h0, b:'h0, st0:{c:'h0, d:'h0}, e:'h0} , cc.n1 011

```

```

turn off st '{a:'h0, b:'h0, st0:'{c:'h0, d:'h0}, e:'h0} , cc.n1 001
turn off st '{a:'h0, b:'h0, st0:'{c:'h0, d:'h0}, e:'h0} , cc.n1 111
turn off st '{a:'h0, b:'h0, st0:'{c:'h0, d:'h0}, e:'h0} , cc.n1 111
turn off st '{a:'h0, b:'h0, st0:'{c:'h0, d:'h0}, e:'h0} , cc.n1 011
turn off st '{a:'h0, b:'h0, st0:'{c:'h0, d:'h0}, e:'h0} , cc.n1 001
turn off st '{a:'h0, b:'h0, st0:'{c:'h0, d:'h0}, e:'h0} , cc.n1 100
turn off st.st0 '{a:'h39, b:'h17, st0:'{c:'h0, d:'h0}, e:'h0} , cc.n1 010
turn off st.st0 '{a:'h26, b:'h1f, st0:'{c:'h0, d:'h0}, e:'h0} , cc.n1 001
turn off st.st0 '{a:'h9, b:'h3, st0:'{c:'h0, d:'h0}, e:'h0} , cc.n1 010
turn off st.st0 '{a:'h23, b:'he, st0:'{c:'h0, d:'h0}, e:'h0} , cc.n1 101
turn off st.st0 '{a:'h21, b:'h18, st0:'{c:'h0, d:'h0}, e:'h0} , cc.n1 000
turn off st.st0 '{a:'h34, b:'h1d, st0:'{c:'h0, d:'h0}, e:'h0} , cc.n1 001
turn off st.st0 '{a:'h2f, b:'h27, st0:'{c:'h0, d:'h0}, e:'h0} , cc.n1 011
turn off st.st0 '{a:'h2f, b:'h17, st0:'{c:'h0, d:'h0}, e:'h0} , cc.n1 100
turn off st.st0 '{a:'hd, b:'h34, st0:'{c:'h0, d:'h0}, e:'h0} , cc.n1 010
turn off st.st0 '{a:'h27, b:'h11, st0:'{c:'h0, d:'h0}, e:'h0} , cc.n1 010

```

Using In-line Random Variable Control

The following example illustrates using in-line random variable control to specify the randomized variables with an argument to the `randomize()` method.

Example 11-8 In-line Random Variable Control

```

module test();

typedef struct {
    rand integer i1;
} ST1;

typedef struct {
    rand integer i1;
} ST2;

class CC;
    rand ST1 st1;
    rand ST2 st2;
endclass

CC cc = new;

initial

```

```

begin
#10 cc.randomize();
$display("\n\t at sim time %0t",$time);
$display("\t cc.st1.i1 is %0d",cc.st1.i1);
$display("\t cc.st2.i1 is %0d",cc.st2.i1);
#10 cc.randomize(st1);
$display("\n\t at sim time %0t",$time);
$display("\t cc.st1.i1 is %0d",cc.st1.i1);
$display("\t cc.st2.i1 is %0d",cc.st2.i1);
#10 cc.randomize(null);
$display("\n\t at sim time %0t",$time);
$display("\t cc.st1.i1 is %0d",cc.st1.i1);
$display("\t cc.st2.i1 is %0d",cc.st2.i1);
#10 cc.randomize(st2);
$display("\n\t at sim time %0t",$time);
$display("\t cc.st1.i1 is %0d",cc.st1.i1);
$display("\t cc.st2.i1 is %0d",cc.st2.i1);
end

endmodule

```

This example supplies the `randomize()` method with arguments for unpacked struct instances `st1` and `st2` and the `null` keyword.

1. At simulation time 20 randomization is limited to `st1`.
2. At simulation time 30 randomization is turned off.
3. At simulation time 40 randomization is limited to `st2`.

The `$display` system tasks displays the following:

```

at sim time 10
cc.st1.i1 is -902462825
cc.st2.i1 is -1241023056

at sim time 20
cc.st1.i1 is 69704603
cc.st2.i1 is -1241023056

```

```
at sim time 30
cc.st1.i1 is 69704603
cc.st2.i1 is -1241023056
```

```
at sim time 40
cc.st1.i1 is 69704603
cc.st2.i1 is -1877783293
```

At simulation 20 a new random value is in st1 but not st2.

At simulation time 30 there are no new random values.

At simulation time 40 a new random value is in st2 but not st1.

In the previous version of VCS, this example would result in the following error messages at compile-time:

```
Error-[SV-RISNYI] Rand in Struct Not Yet Implemented
doc_ex4.sv, 4
The qualifier 'rand' was seen in a struct. This is not yet
supported.
Please remove the 'rand' declaration.
```

```
Error-[SV-RISNYI] Rand in Struct Not Yet Implemented
doc_ex4.sv, 8
The qualifier 'rand' was seen in a struct. This is not yet
supported.
Please remove the 'rand' declaration.
```

2 errors

Here is another code example:

Example 11-9 Another Example of In-line Random Variable Control

```
module test;

typedef struct {
    bit[3:0] c;
    randc bit[1:0] d;
```

```

} ST0;

typedef struct {
    rand bit[5:0] a;
    rand bit[5:0] b;
    rand ST0 st0;
    bit [5:0] e;
}ST;

class CC;
    ST st;
    rand bit[2:0] n1;
endclass

CC cc = new;

initial begin
    // random variables: cc.n1
    // state variables: all members of cc.st
repeat (5) begin
    cc.randomize();
    $display("default st %p , cc.n1 %b",cc.st,cc.n1);
end

    // random variables: cc.st.a cc.st.b cc.st.st0.d
    // state variables: cc.n1 cc.st.e cc.st.st0.c
repeat (5) begin
    cc.randomize(st);
    $display("inline st %p , cc.n1 %b",cc.st,cc.n1);
end

end
endmodule

```

In this example the `randomize()` method is called without an argument and then with the `st` struct instance argument. The `$display` system tasks display the following:

```

default st '{a:'h0, b:'h0, st0:{c:'h0, d:'h0}, e:'h0} , cc.n1 111
default st '{a:'h0, b:'h0, st0:{c:'h0, d:'h0}, e:'h0} , cc.n1 000
default st '{a:'h0, b:'h0, st0:{c:'h0, d:'h0}, e:'h0} , cc.n1 011

```

```

default st '{a:'h0, b:'h0, st0:{c:'h0, d:'h0}, e:'h0} , cc.n1 011
default st '{a:'h0, b:'h0, st0:{c:'h0, d:'h0}, e:'h0} , cc.n1 001
inline st '{a:'h1f, b:'h27, st0:{c:'h0, d:'h0}, e:'h0} , cc.n1 001
inline st '{a:'h11, b:'h34, st0:{c:'h0, d:'h1}, e:'h0} , cc.n1 001
inline st '{a:'h17, b:'h2a, st0:{c:'h0, d:'h2}, e:'h0} , cc.n1 001
inline st '{a:'h1f, b:'h9, st0:{c:'h0, d:'h3}, e:'h0} , cc.n1 001
inline st '{a:'h3, b:'h12, st0:{c:'h0, d:'h3}, e:'h0} , cc.n1 001

```

VCS executes the second \$display system task after it executes the randomize() method with the st argument.

Limitation

Random class objects as members of an unpacked struct are not yet implemented (NYI), for example:

```

module test;

class CC0;
    rand int a;
endclass

typedef struct {
    rand bit[5:0] a;
    rand bit[5:0] b;
    rand CC0 cc0;      // this is not allowed in this release
}ST;

endmodule

```

Making wait fork Statements Compliant with the SV LRM

You specify making wait fork statements compliant with the SV LRM with the -ntb_opts sv_dwfork compile-time option and keyword argument.

The IEEE Std 1800-2009 standard LRM for SystemVerilog states the following about wait fork statements:

“The `wait fork` statement blocks process execution flow until all immediate child subprocesses (processes created by the current process, excluding their descendants) have completed their execution.”

For backwards compatibility reasons, by default, VCS blocks the process execution flow until all child subprocesses, not just the immediate child subprocesses, have completed their execution. It also waits only for those processes that are created by the current task or process that contains the `wait fork` statement.

You can specify that VCS be compliant with the standard and block process execution flow only for immediate child subprocesses and wait for processes created by the current process (even if the `wait fork` is contained within a task) with the `-ntb_opts sv_dwfork` compile-time option and keyword argument.

The following code example shows the difference in behavior for `wait fork`.

```
program A;
task t1();
    #1 $display($time,, " T1_1 \n");
endtask
task t2();
    fork
        #1 $display($time,, " T2_1 \n");
        #9 $display($time,, " T2_2 \n");
    join_any
endtask
task disp();
    fork
        t1();
        t2();
    join_any
    wait fork;
    $display($time,, "After Wait fork");

```

```

endtask
initial begin
  fork
    #1 $display($time,, " Initial Thread 1 \n");
    #5 $display($time,, " Initial Thread 2 \n");
  join_any
  disp();
end
endprogram

```

VCS by default waits for the execution of:

```
#9 $display($time,, " T2_2 \n");
```

It executes this line at simulation time 10, even though the fork for this \$display system task is not an immediate child subprocess of task disp().

The \$display system tasks, by default, displays the following:

```

1 Initial Thread 1
2 T1_1
2 T2_1
5 Initial Thread 2
10 T2_2
10 After Wait fork

```

If you include the `-ntb_opts sv_dwfork` compile-time option and keyword argument, the \$display system tasks displays the following:

```

1 Initial Thread 1
2 T1_1
2 T2_1
5 Initial Thread 2
5 After Wait fork

```

Making disable fork Statements Compliant with the SV LRM

You also specify making `disable fork` statements compliant with the SV LRM with the `-ntb_opts sv_dwfork` compile-time option and keyword argument.

The IEEE Std 1800-2009 standard LRM for SystemVerilog states the following about `disable fork` statements:

“The `disable fork` statement terminates all active descendants (subprocesses) of the calling process.”

For backwards compatibility reasons, by default, VCS terminates only those processes that are created by the current task or process that contains the `disable fork`.

You can specify that VCS be compliant with the standard and terminate all the processes that are created by the process that contains the `disable fork` (even if the `disable fork` is contained within a task) with the `-ntb_opts sv_dwfork` compile-time option and keyword argument.

The following code example shows the difference in behavior for `disable fork`.

```
program A;
task disp();
    fork
        #1 $display($time,, "disp_T1");
        #2 $display($time,, "disp_T2");
    join_any
    disable fork;
    $display($time,, "After disable fork");
endtask
initial begin
```

```

fork
    #1 $display($time,, " Initial Thread 1 \n");
    #5 $display($time,, " Initial Thread 2 \n");
join_any
disp();
#10 $display($time,, "End");
end
endprogram

```

By default, disable fork does not disable the fork in the process, but only disables the fork in the task in which it is present, to give the output:

```

1 Initial Thread 1
2 disp_T1
2 After disable fork
5 Initial Thread 2
12 End

```

With the -ntb_opts sv_dwfork option, disable fork disables the fork in the process also, giving the output:

```

1 Initial Thread 1
2 disp_T1
2 After disable fork
12 End

```

Recently Implemented SystemVerilog Constructs

VCS MX has implemented the following SystemVerilog constructs in recent releases:

- “[The std::randomize\(\) Function](#)”
- “[SystemVerilog Bounded Queues](#)”

- “[wait\(\) Statement with a Static Class Member Variable](#)”
 - “[Parameters and Localparams in Classes](#)”
 - “[SystemVerilog Math Functions](#)”
 - “[Streaming Operators](#)”
-

The std::randomize() Function

The `randomize()` function randomizes variables that are not class members.

Syntax

```
[std::] randomize(variable-identifier-list)  
    [with constraint-block]
```

Description

SystemVerilog defines extensive randomization methods and operators for class members. Most modeling methodologies recommend the use of classes for randomization. However, there are situations where the data to be randomized is not available in a class. SystemVerilog provides the `std::randomize()` function to randomize variables that are not class members.

The `std::randomize()` function can be used in the following scopes:

- module
- function
- task

- class method

Arguments to `std::randomize()` can be of integral types including:

- integer
- bit vector
- enumerated type

Object handles and strings cannot be used as arguments to `std::randomize()`.

The variables passed to `std::randomize()` must be visible in the scope where the function is called. Cross-module references are not allowed as arguments to the `std::randomize()` function.

All constraint expressions currently available with `obj.randomize()` in VCS can be used as constraints in the *constraint-block*.

Only constraints specified in the constraint block are honored. Any rand mode specified on the class members is ignored when `std::randomize()` is called with the given class member.

The `pre_randomize()` and `post-randomize()` tasks are not called when `std::randomize()` is used within a class member function.

The “`std::`” prefix must be explicitly specified for the `randomize()` call.

The `std::randomize()` function is supported in VCS. Files containing `std::randomize()` calls can be compiled with `vlogan`.

The function using `std::randomize()` can be declared in a task inside a package that can be imported into modules and programs.

Example

```
module M;
    bit[11:0] addr;
    integer data;

    function bit genAddrData();
        bit success;
        success = std::randomize(addr, data);
        return success;
    endfunction

    function bit genConstrainedAddrData();
        bit success;
        success = std::randomize(addr, data)
            with {addr > 1000; addr + data < 20000;};
        return success;
    endfunction

endmodule
```

The `genAddrData` function uses `std::randomize(addr, data)` to assign random values to `addr` and `data` variables. The `std::randomize()` function randomizes any variables that are visible in the scope.

The `getConstrainedAddrData()` function uses `std::randomize(addr, data)` to assign random values to `addr` and `data` variables. In this case there is an additional constraint given to the call, which is that `addr` is greater than 1,000 and `addr+data` is less than 20,000.

SystemVerilog Bounded Queues

A bounded queue is a queue limited to a fixed number of items, for example:

```
bit q[$:255] ;
```

a bit queue whose maximum size is 257 bits

```
int q[$:5000] ;
```

an int queue whose maximum size is 50001

This section explains the how bounded queues work in certain operations.

```
q1 = q2 ;
```

This is a bounded queue assignment. VCS copies the items in q2 into q1 until q1 is full or until all the items in q2 are copied into q1. The bound number of items in the queues remain as you declared them.

```
q.push_front(new_item)
```

If adding a new item to the front of a full bounded queue, VCS deletes the last item in the back of the queue.

```
q.push_back(new_item)
```

If the bounded queue is full, a new item can't be added to the back of the queue and the queue remains the same.

```
q1 === q2
```

A bounded queue comparison behaves the same as an unbounded queue, the bound sizes should be the same when the two bounded queues are equal.

Limitation for SystemVerilog Bounded Queues

Bounded queues are not supported in constraints.

wait() Statement with a Static Class Member Variable

A wait statement with a static class member variable is now supported. The following is an example:

```
class foo;
    static bit is_true = 0;
    task my_task();
        fork
            begin
                #20;
                is_true = 1;
            end
            begin
                wait(is_true == 1);
                $display("%0d: is_true is now %0d", $time, is_true);
            end
        join
    endtask: my_task
endclass: foo

program automatic main;
    foo foo_i;
    initial begin
        foo_i = new();
        foo_i.my_task();
    end
endprogram: main
```

Parameters and Localparams in Classes

You can include parameters and localparams in classes, for example:

```
class cls;
    localparam int Lp = 10;
    parameter int P = 5;
endclass
```

SystemVerilog Math Functions

Verilog defines math functions that behave the same as their corresponding math functions in C. These functions are as follows:

\$ln(x)	Natural logarithm
\$log10(x)	Decimal logarithm
\$exp(x)	Exponential
\$sqrt(x)	Square root
\$pow(x,y)	$x^{**}y$
\$floor(x)	Floor
\$ceil(x)	Ceiling
\$sin(x)	Sine
\$cos(x)	Cosine
\$tan(x)	Tangent
\$asin(x)	Arc-sine
\$acos(x)	Arc-cosine
\$atan(x)	Arc-tangent
\$atan2(x,y)	Arc-tangent of x/y
\$hypot(x,y)	$\sqrt{x^2+y^2}$
\$sinh(x)	Hyperbolic sine

<code>\$cosh(x)</code>	Hyperbolic cosine
<code>\$tanh(x)</code>	Hyperbolic tangent
<code>\$asinh(x)</code>	Arc-hyperbolic sine
<code>\$acosh(x)</code>	Arc-hyperbolic cosine
<code>\$atanh(x)</code>	Arc-hyperbolic tangent
<code>\$clog2(n)</code>	Ceiling of log base 2 of n (as integer)

Streaming Operators

Streaming operators can be applied to any bit-stream data types consists of the following:

- Any integral, packed, or string type
- Unpacked arrays, structures, or class of the above types
- Dynamically sized arrays (dynamic, associative, or queues) of any of the above types

Packing (Used on RHS)

Primitive Operation

```
expr_target = { >> | << slice{expr_1, expr_2, ..., expr_n} }
```

The `expr_target` and `expr_i` can be any primary expressions of any streamed data types.

The slice determines the size of each block measured in bits. If specified, it may be either a constant integral expression, or a simple type.

The `<<` or `>>` determines the order in which blocks of data are streamed.

Streaming Concatenation

```
expr_target = {>>slice1 {expr1, expr2, {<< slice2{expr3,  
expr4}}}}
```

Unpacking (Used on LHS)

Primitive operation

```
{>>|<< slice{expr_1, expr_2, ..., expr_n } } = expr_src;
```

If the unpacked operation includes unbounded dynamically sized types, the process is greedy. The first dynamically sized items is resized to accept all the available data (excluding subsequent fixed sized items) in the stream; any remaining dynamically sized items are left empty.

Streaming Concatenation

```
{>>slice1 {expr1, expr2, {<< slice2{expr3, expr4}}}} =  
expr_src;
```

Packing and Unpacking

```
{>>|<< slice_target{target_1, target_2, ..., target_n } } =  
{>>|<< slice_src{src_1, src_2, ..., src_n }};
```

Propagation and force Statement

Any operand (either dynamic or not) in the stream can be propagated and forced/released correctly.

Error Conditions

- Compile time error for associative arrays as assignment target
- Run time error for Any null class handles in packing and unpacking operations

Structures with Streaming Operators

Although the whole structure is not allowed in the stream, any structure members, sub structures excluded, could be used as an operand of both packing and unpacking operations.

For example:

```
s1 = {>>{expr_1, expr_2, ..., expr_n}} //invalid  
s1.data = {>>{expr_1, expr_2, expr_n}}//valid
```

Extensions to SystemVerilog

This section contains descriptions of Synopsys enhancements to SystemVerilog. This section contains the following topics:

- “Unique/Priority Case/IF Final Semantic Enhancements”
- “Single-Sized Packed Dimension Extension”
- “Covariant Virtual Function Return Types”
- “Self Instance of a Virtual Interface”

Unique/Priority Case/IF Final Semantic Enhancements

The behavior of the compliance checking keywords `unique` and `priority` for `case` and for `if...else if...else` selection statements as defined in the IEEE 1800-2009 LRM section named “*Conditional if-else statement*” in some cases can cause spurious warnings when used inside a module’s continuous assignment or `always` block. By default, VCS will evaluate compliance with `unique` or `priority` on every update to the selection statement input.

To force `unique` and `priority` to evaluate compliance only on the stable and final value of the selection input at the end of a simulation timestep, VCS now provides a compile time switch `-x1rm uniq_prior_final`.

This can be useful, for example, when `always_comb` might trigger several times within a simulation time slot while its input values are getting stabilized. The `case` statements can get executed several times during same time slot if it is valid for combinational blocks. While going through intermediate transitions, the `case` statement might get values that violate the `unique` or `priority` property and cause VCS to report multiple runtime warnings. When it is undesirable to receive intermediate warnings, compile time option ‘`-x1rm uniq_prior_final`’ can be used to evaluate compliance for only the final stable value of the input.

Using Unique/Priority Case/If with Always Block or Continuous Assign

-x1rm uniq_prior_final behavior only applies to the use of unique and priority keywords when selection statements are used inside a module's continuous assignment or always block. The switch is not applicable for program block or initial block of code.

The following two examples illustrate this behavior:

Example 11-10 unique case statement at the same timestep

```
//test.sv:  
module top;  
reg cond;  
bit [7:0] a = 0,b, v1, v2;  
always_comb begin  
    if (cond) begin  
        unique case (a)  
            v1: begin b = 0; $display(" Executing Case  
                           with cond value 1 "); end  
            v2: begin b = 1; $display(" Executing Case  
                           with cond value 1 "); end  
        endcase  
    end  
    else begin  
        unique case (a)  
            v1: begin b = 0; $display(" Executing Case  
                           with cond value 0 "); end  
            v2: begin b = 1; $display(" Executing Case  
                           with cond value 0 "); end  
        endcase  
    end  
end  
  
initial begin  
#1 cond = 1;  
a=a+4; v1=4; v2=4;  
$display("\n TIME %0d ns : cond value %0b, a value %0d",
```

```

        $time, cond, a);
#0 cond = 0;
a=a+1; v1++; v2++;
$display("\n TIME %0d ns: cond value %0b, a value %0d",
        $time, cond, a);
end
endmodule

```

Simulation output without '-x1rm uniq_prior_final':

```

%> vcs -sverilog test.sv -R

Executing Case with condition value 0
RT Warning: More than one conditions match in 'unique case'
statement.
    "unique_case.sv", line 12, for top.
    Line    13 &    14 are overlapping at time      0.
Executing Case with cond value 0
RT Warning: More than one conditions match in 'unique case'
statement.
    "unique_case.sv", line 12, for top.
    Line    13 &    14 are overlapping at time      0.

TIME 1 ns : cond value 1, a value 4
Executing Case with cond value 1
RT Warning: More than one conditions match in 'unique case'
statement.
    "unique_case.sv", line 6, for top.
    Line    7 &    8 are overlapping at time      1.

TIME 1 ns: cond value 0, a value 5
Executing Case with cond value 0
RT Warning: More than one conditions match in 'unique case'
statement.
    "unique_case.sv", line 12, for top.
    Line    13 &    14 are overlapping at time      1.

```

Simulation output with ' -xlrn uniq_prior_final' compile time switch:

```
%> vcs -sverilog test.sv -xlrn uniq_prior_final -R
Executing Case with cond value 0:
RT Warning: More than one conditions match in 'unique case'
statement.
    "unique_case.sv", line 12, for top.
    Line      13 &      14 are overlapping at time      0.

TIME 1 ns : cond value 1, a value 4
Executing Case with cond value 1

TIME 1 ns: cond value 0, a value 5
Executing Case with cond value 0
RT Warning: More than one conditions match in 'unique case'
statement.
    "unique_case.sv", line 12, for top.
    Line      13 &      14 are overlapping at time      1.
```

Example 11-11 unique if inside always_comb

```
//test.sv
module top;
reg cond;
bit [7:0] a = 0,b;
always_comb begin

unique if (a == 0 || a == 1) $display ("A is 0 or 1");
else if (a == 2) $display ("A is 2");

end

initial begin
#100;
a = 1;
#100 a = 2;
#100 a = 3;
#0 a++;
#0 a++;
#0 a++;
#10 $finish;
```

```
end  
endmodule
```

Simulation output without '-x1rm':

```
%> vcs -sverilog test.sv -R  
  
A is 0 or 1  
A is 0 or 1  
A is 0 or 1  
A is 2  
RT Warning: No condition matches in 'unique if' statement.  
    "unique_if.sv", line 5, for top, at time 300.  
RT Warning: No condition matches in 'unique if' statement.  
    "unique_if.sv", line 5, for top, at time 300.  
RT Warning: No condition matches in 'unique if' statement.  
    "unique_if.sv", line 5, for top, at time 300.  
RT Warning: No condition matches in 'unique if' statement.  
    "unique_if.sv", line 5, for top, at time 300.  
$finish called from file "unique_if.sv", line 17.
```

Simulation output with '-x1rm uniq_prior_final':

```
%> vcs -sverilog test.sv -x1rm uniq_prior_final -R  
  
A is 0 or 1  
A is 0 or 1  
A is 0 or 1  
A is 2  
RT Warning: No condition matches in 'unique if' statement.  
    "unique_if.sv", line 5, for top, at time 300.  
$finish called from file "unique_if.sv", line 17.
```

Using Unique/Priority Inside a Function

With the new enhancement, if unique/priority case statement is used inside a function, VCS not only points to the current case statement but also provides a complete stack trace of where the function is called. The following example illustrate this behavior:

Example 11-12 unique case used with nested loop inside function

```
//test.sv
module top;
    int i,j;
    reg [1:0] [2:0] a, b, c;
    bit flag;

    function foo;
        for (int i=0; i<2; i++)
            for (int j=0; j<3; j++)
                unique case (a[i][j])
                    0: b[i][j] = 1'b0;
                    1: b[i][j] = c[i][j];
                endcase
    endfunction : foo

    always_comb begin
        for(i=0; i<4; i++) begin
            if (i==2)
                foo();
        end
    end

    initial begin
        a = 6'b00x011;
    end

endmodule : top
```

Simulation output without ‘-x1rm’ option:

```
%> vcs -sverilog test.sv -R
```

```
RT Warning: No condition matches in 'unique case' statement.
"unique_case_inside_func.sv", line 8, for top.foo, at time 0.
```

```
RT Warning: No condition matches in 'unique case' statement.
"unique_case_inside_func.sv", line 8, for top.foo, at time 0.
```

Simulation output with '-xlrn uniq_prior_final':

```
%> vcs -sverilog test.sv -xlrn uniq_prior_final -R  
  
RT Warning: No condition matches in 'unique case' statement.  
  
"unique_case_inside_func.sv", line 8, for top.foo, at time 0.  
#0 in foo      at unique_case_inside_func.sv:8  
#1 in loop with j= 0      at unique_case_inside_func.sv:7  
#2 in loop with i= 1      at unique_case_inside_func.sv:6  
#3 in top      at unique_case_inside_func.sv:16  
#4 in loop with i= 2      at unique_case_inside_func.sv:14
```

Note:

The following limitations must be noted while using '-xlrn uniq_prior_final' feature for loop indices:

- It must be written in `for` statement. The `while` and `do...while` are not supported.
- The loop bounds must be compile-time constants.
 - `for(i= lsb; i<msb; i++)`
 - Here, `lsb` and `msb` must be compile-time constant, or will become constant when upper loops get unrolled.
 - No other drivers of the loop variable must be in the loop body.

VCS also supports `unique/prior final` in a `for` loop that can not be unrolled at compile time. For example, if you have a `for` loop whose range could not be determined at compile-time and if there are errors during the last evaluation of such a `for` loop, VCS still reports the error. However, loop index information will not be provided. Even if multiple failures occur in different iterations, VCS reports only the last one.

Important:

Use unique/priority case/if statement only inside always block, continuous assign, or inside a function. If you use it in other places, the final semantic will be ignored.

System Tasks to Control Warning Messages

Two system tasks `$uniq_prior_checkon` and `$uniq_prior_checkoff` will enable you to switch on/off runtime warning messages for unique/priority if/case statements. The following example illustrates the use model of these tasks to ignore violations:

Example 11-13 System tasks to control warning messages

```
//test.sv
module m;
    bit sel, v1, v2;

//Disable this initial block to display all RT warning
messages
initial
begin
    $display($time, " Priority checker OFF\n");
    $uniq_prior_checkoff();
    #1;
    $display($time, " Priority checker ON\n");
    $uniq_prior_checkon();
end

initial
begin
//violation with this set of values (warning disabled)
    sel = 1'b1;
    v1 = 1'b1;
    v2 = 1'b1;
    #1;
//violation with this set of values (warning enabled)
    sel = 1'b0;
```

```

v1 = 1'b0;
v2 = 1'b0;
#1;
end
always_comb begin
unique case(sel)
  v1: $display($time, " Hello");
  v2: $display($time, " World");
endcase
end
endmodule

```

Simulation Output:

```

%> vcs -sverilog test.sv -R

0 Priority checker OFF
0 Hello
0 Hello
1 Priority checker ON
1 Hello
RT Warning: More than one conditions match in 'unique case'
statement.
"system_task_control_warning.sv", line 28, for m.
Line 29 & 30 are overlapping at time 1.

```

Single-Sized Packed Dimension Extension

VCS has implemented an extension to a single-sized packed dimension SystemVerilog signals and Multi-Dimensional Arrays (MDAs). This section provides examples of using this extension for a single-sized packed dimension and explains how VCS expands the single size.

You can use the extension for these basic data types: `bit`, `reg`, and `wire` (using other basic data types with this extension is an error condition) The following is an example:

```
bit [4] a;
```

VCS expands the packed dimension [4] into [0:3].

For packed MDAs, for example:

```
bit [4] [4] a;
```

VCS expands the packed dimensions [4] [4] into [0:3] [0:3].

You can use this extension in several ways. The following is an example of using this extension in a user defined type:

```
typedef reg [8] DREG;
```

The following is an example of using this extension in a structure, union, and enumerated type:

```
struct packed {
    DREG [20] [20] arr4;
} [2] [2] st1;
union packed {
    DBIT [20] [20] arr5;
} [2] [2] un1;
enum logic [8] { IDLE, XX=8'bxxxxxxxxx, S1=8'bzzzzzzzz,
S2=8'hff } arr3;
```

The following is an example of a user-defined structure and union with a packed memory or MDA:

```
typedef bit [2] [24] DBIT;
typedef reg [2] [24] DREG;
typedef struct packed {
    DBIT [20] [20] arr1;
} ST;
ST [2] [2] st;
```

```
typedef union packed {
    DREG [20] [20] arr2;
} UN;

UN [2] [2] un;
```

You can also use this extension for specifying module ports, for example:

```
module mux2( input wire [3] a,
              input wire [3] b,
              output logic [3] y);
```

You can use this extension in the parameter list of a user-defined function or task, for example:

```
function automatic integer factorial (input [32] operand);
```

You can use this extension in the definition of a parameter, for example:

```
parameter reg [2] [2] [2] p2 = 8;
```

Error Conditions

The following are error conditions for this extension:

- Using the dollar sign (\$) as the size, for example:

```
reg [8:$] a;
reg [$] b;
```

- Using basic data types other than `bit`, `reg`, and `wire`, for example:

```
typedef shortint [8] DREG;
```

Covariant Virtual Function Return Types

VCS supports, as an extension to SystemVerilog, covariant virtual function return types.

A covariant return type allows overriding a superclass method with a return type that is a derived type of the superclass method's return type. Covariant return types minimize the need for dynamic casts (upcasting or downcasting).

Example 11-14 Sample code for covariant function return types

```
class Base;
    virtual function Base clone();
        Base b = new this;
        return b;
    endfunction
endclass

class Derived extends Base;
    virtual function Derived clone();
        Derived d = new this;
        return d;
    endfunction
endclass
```

Without covariant types, the signature of the `Derived::clone()` above would have to be the same as in the `Base` class, like the following:

```
class Derived extends Base;
    virtual function Base clone();
        Derived d = new this;
        return d;
    endfunction
endclass
```

This would lead to code like the following for users of the class:

```

Derived d = new;
Base b = d.clone();    // automatic down-cast to Base
Derived d2;
if(!$cast(d2, b)) begin
    b = null;
    $error(...); // some exception
end

```

Instead, with covariant return types, the code is simplified to:

```

Derived d = new;
Derived d2 = d.clone();

```

Self Instance of a Virtual Interface

You can create a self instance of a virtual interface that points to itself when it is initialized, for example:

```

interface intf;
    int data1;
    int data2;
    virtual intf vi;
    initial
        vi = interface::self();
endinterface

module top;
    intf i0();
    initial #1 i0.vi.data1 = 100;
    always @(i0.data1)
        $display("trigger success");
endmodule

```

In this example the virtual interface named `vi` is initialized with the expression:

```
vi = interface::self();
```

The `interface::self()` expression enables you provide a string variable that is effectively the `%m` format specification of the interface instance that VCS MX returns for assignment to the virtual interface variable. You use the `interface::self()` expression to initialize virtual interface variables in methodologies like UVM and VMM. It enables you to write components that are configurable with a string is the `%m` of the virtual interface that the component drives or monitors.

The expression `interface::self()` must be entered precisely, otherwise it is a syntax error. Also notice the required delay (in this case #1) in the initialization of virtual interface `vi`. This delay is required to prevent a race condition.

This implementation is in accordance with the SystemVerilog IEEE STD 1800-2009 section 9.7 Fine-grain process control which specifies:

“The `self()` function returns a handle to the current process, that is, a handle to the process making the call.”

SVA-bind is supported with self instances of virtual interfaces.

Note:

A self instance of a virtual interface is not supported in Partition Compile.

The following conditions are required for a self instance of a virtual interface:

- The self instance must be defined in the scope.
- The virtual interface type in the interface declaration must be the same as the interface that includes itself.

- Within an interface, you can only use the virtual `interface::self()` expression can be used in a context that is valid for initializing a virtual interface. Any other use of the `interface::self()` expression results in a compilation error.
- Within an interface, the virtual `interface::self()` expression in a context that is valid for initializing a virtual interface. Any other use of the `interface::self()` expression results in a compilation error.

UVM Example

The following is an example of a self instance of a virtual interface:

```
/* interface definition */
interface bus_if; //ports.
//signal declaration.

```
initial begin
 uvm_resource_db#(virtual bus_if)::set("*",
 $sformatf("%m"), interface::self());
end
endinterface

/* instantiated bus interface in design. */
//Add "bus()" to module called "top".
bind top bus_if bus();

/*Example config_db usage: */
if(!uvm_config_db#(virtual bus_if)::get(this, "",
 "top.bus", bus))
 `uvm_error("TESTERROR", "no bus interface available");
else
 'uvm_info("build", "got bus_if", UVM_LOW)
```

OR

```

/*Example resource_db usage: */
if(!uvm_resource_db#(virtual
bus_if)::read_by_type(get_full_name(), bus, this))
 `uvm_error("TESTERROR", "no bus interface available");
else
 'uvm_info("build", "got bus_if", UVM_LOW)

```

## Error Condition for Using a Genvar Outside of its Generate Block

Declaring a genvar variable in the local scope of a generate block, and then using this genvar variable (in statements that read or write to this variable) outside of that block, is an error condition starting from VCS2011.12-FCS release.

The following code example shows this error condition:

```

module test;
generate
 for (genvar i = 0; i < 1; i++)
 begin
 a1: assert final (1);
 end
endgenerate
generate
 for (i = 0; i < 1; i++)
 begin
 a1: assert final (1);
 end
endgenerate
endmodule

```

In this code example the genvar variable named *i* is:

1. declared in the first generate block

2. used in the first generate block (initialized, evaluated, and incremented)
3. also used in the same way in the second generate block

Compiling this example with the following command line:

```
vcs generate.sv -sverilog -assert svaext
```

Results in the following error message:

```
Error-[IND] Identifier not declared
generate.sv, 9
Identifier 'i' has not been declared yet. If this error
is not expected,
please check if you have set `default_nettype to none.

1 error
```

This error condition was ignored in previous releases.

To fix this error in this example declare `genvar i` in the module scope.

## Exporting a SystemVerilog Package

VCS has an alternative implementation of how it exports SystemVerilog packages. This implementation is less optimistic and is more rigidly compliant with the SystemVerilog IEEE Std 1800-2009 standard. You enable this implementation with the `-sv_package_export` compile-time option or `vlogan` option.

In this implementation, declarations imported into a package are not visible by way of subsequent imports of that package.

Package export declarations allow a package to specify those imported declarations to be made visible in subsequent imports.

There are three forms of export declarations:

```
export pkg::name;
```

This both imports and exports the explicit *name* from the specified package named *pkg*.

```
export pkg::*;
```

This exports all names imported from package *pkg* into the current package. Those imports can be by name reference or by named export directive.

```
export *::*;
```

Exports all names imported from any packages into the current package. Those imports can be by name reference or by named export directive. An export directive *\* :: \** must match at least one import directive

Unlike package import directives, package export directives *can only* occur at *package scope*, and cannot occur in \$unit.

---

## Use Model

This package export functionality is implemented under the `-sv_package_export` compile-time option or `vlogan` option.

For VCS the command lines are as follows:

```
vcs -sverilog -sv_package_export other_options source_files
```

```
simv runtime_options
```

You can also enable the package export functionality with a `synopsys_sim.setup` option:

```
SV_PACKAGE_EXPORT=TRUE | FALSE
```

The `TRUE` argument enables this functionality.

The `-sv_package_export` compile-time or `vlog` analysis option takes precedence over the `SV_PACKAGE_EXPORT=FALSE` `synopsys_sim.setup` option.

The following example illustrates the package export functionality:

*Example 11-15 The Package Import Functionality Example 1*

```
package p1;
 int x, y;
endpackage
package p2;
 import p1::x;
 export p1::*;

 endpackage
 exports p1::x as the variable
 named x
 p1::x and p2::x are the same
 declaration

package p3;
 import p1::*;
 import p2::*;
 export p2::*;
 int q = x;
 endpackage
 p1::x and q are made available
 from p3
 Although p1::y is a candidate
 for import, it is not actually imported
 since it is not referenced.

 Since p1::y is not imported, it is not
 made available by the export
```

---

## Backward Compatibility

VCS presently implicitly exports all names imported into a package, so those symbols can then be referenced through the scope of the importing package. This is referred to as "chained imports", but it is not a IEEE 1800-2009 standard. With the implementation of export package support, using `-sv_package_export`, chained imports will no longer be allowed, VCS would only export the required set of names/symbols.

In a future release, the export package support will be enabled by default. The chained import behavior would be allowed only under a backwards compatibility switch, for a limited time.

### *Example 11-16 The Package Import Functionality Example 2*

```
package p1;
 int x = 11;
 int y = 22;
endpackage

package p2;
 import p1::*;

 import p1::y; // Explicit import, no other reference required
 task t;
 $display(x);
 endtask

```

import p1::x

In default mode , `x` is exported from `p2`. Either of the following are required with the new export package functionality enabled with `-sv_package_export`:

```

// export p1::x, p1::y; ← doesn't require reference to x/y
// export p1::*; ←
// export *::*; ← require reference to x in p2

endpackage

module m;
 import p2::*;
 initial $display(x); ← chained import of p1::x through p2
 initial $display(y); ← chained import of p1::y through p2
endmodule

```

## Using a Package in a SystemVerilog Module, Program, and Interface Header

Importing from a package to a module, program, or interface by including the package in the module, program, or interface header is now implemented.

This technique of importing from a package is described in the SystemVerilog LRM IEEE Std 1800-2009 in the section named “26.4 Using packages in module headers” in clause “26 Packages.”

The primary purpose of this syntax and usage is to enable you to import names in the parameter list or port list, without importing the package into the enclosing scope (\$unit).

To illustrate this technique we import from a package into a module definition and then into a program definition, as shown in [Example 11-17](#) and [Example 11-18](#). This technique is also implemented for importing from a package to an interface.

*Example 11-17 Importing a Package in a Module Header*

```
package my_pkg;
 typedef reg [3:0] my_type1;
 typedef int my_type2;
endpackage

module my_module import my_pkg::*;
 (input my_type1 a, output my_type2 z);
M
endmodule
```

In [Example 11-17](#) the design objects declared in package my\_pkg are imported into module my\_module with the `import` keyword followed by the name of the package. We use the wildcard `*` (asterisk) to specify importing all design objects in the package.

In previous release this example results in the following error messages:

```
Error- [NYI-NS] Not Yet Implemented
The following feature is not yet supported: import in
module/interface/program header
```

```
Error- [SE] Syntax error
Following verilog source has syntax error :
"ex1.sv", 6: token is 'my_pkg'
module my_module import my_pkg::*;
^
```

2 errors

[Example 11-18](#) shows importing from packages in a program header.

*Example 11-18 Importing Packages in a Program Header*

```
package pack1;
 typedef struct {
```

```

 real r1;
 } struct1;
 typedef enum bit {H,T} bool_sds;
endpackage:pack1

package pack3;
 integer int1=0;
endpackage: pack3

program prog1 import pack1::struct1,pack3::*;
 (output out1,out2);
M
endprogram: prog1

```

The header of program prog1 includes the keyword `import` followed by the packages pack1 and pack3. We import structure struct1 from pack1 into program prog1, then using the wildcard \* (asterisk) import all the design objects in pack3 into the program.

In previous release this example results in the following error messages:

```

Error-[NYI-NS] Not Yet Implemented
The following feature is not yet supported: import in
module/interface/program header

```

```

Error-[SE] Syntax error
Following verilog source has syntax error :
"complx.sv", 16: token is 'pack1'
program prog1 import pack1::struct1,pack3::*;
^

```

2 errors

# 13

## Aspect Oriented Extensions

---

Aspect-Oriented Programming (AOP) methodology complements the OOP methodology using a construct called aspect or an aspect-oriented extension (AOE) that can affect the behavior of a class or multiple classes. In AOP methodology, the terms “aspect” and “aspect-oriented extension” are used interchangeably.

Aspect oriented extensions in SV allow testbench engineers to design testcase more efficiently, using fewer lines of code.

AOP addresses issues or concerns that prove difficult to solve when using Object-Oriented Programming (OOP) tow write constrained-random test benches.

Such concerns include:

1. Context-sensitive behavior.
2. Unanticipated extensions.

### 3. Multi-object protocols.

In AOP these issues are termed cross-cutting concerns as they cut across the typical divisions of responsibility in a given programming model.

In OOP, the natural unit of modularity is the class. Some of the cross cutting concerns, such as "Multi-object protocols", cut across multiple classes and are not easy to solve using the OOP methodology. AOP is a way of modularizing such cross-cutting concerns. AOP extends the functionality of existing OOP derived classes and uses the notion of aspect as a natural unit of modularity. Behavior that affects multiple classes can be encapsulated in aspects to form reusable modules. As potential benefits of AOP are achieved better in a language where an aspect unit can affect behavior of multiple classes and therefore can modularize the behavior that affects multiple classes, AOP ability in SV language is currently limited in the sense that an aspect extension affects the behavior of only a single class. It is useful nonetheless, enabling test engineers to design code that efficiently addresses concerns "Context-sensitive behavior" and "Unanticipated extensions".

AOP is used in conjunction with object-oriented programming. By compartmentalizing code containing aspects, cross-cutting concerns become easy to deal with. Aspects of a system can be changed, inserted or removed at compile time, and become reusable.

It is important to understand that the overall verification environment should be assembled using OOP to retain encapsulation and protection. NTB's Aspect-Oriented Extensions should be used only for constrained-random test specifications with the aim of minimizing code.

SV's Aspect-Oriented Extensions should not be used to:

- Code base classes and class libraries
- Debug, trace or monitor unknown or inaccessible classes
- Insert new code to fix an existing problem

For information on the creation and refinement of verification test benches, see the *Reference Verification Methodology User Guide*.

---

## **Aspect-Oriented Extensions in SV**

In SV, AOP is supported by a set of directives and constructs that need to be processed before compilation. Therefore, an SV program with these Aspect oriented directives and constructs would need to be processed as per the definition of these directives and constructs in SV to generate an equivalent SV program that is devoid of aspect extensions, and consists of traditional SV. Conceptually, AOP is implemented as pre-compilation expansion of code.

This chapter explains how AOE in SV are directives to SV compiler as to how the pre-compilation expansion of code needs to be performed.

In SV, an aspect extension for a class can be defined in any scope where the class is visible, except for within another aspect extension. That is, aspect extensions can not be nested.

An aspect oriented extension in SV is defined using a new top-level *extends directive*. Terms aspect and “extends directive” have been used interchangeably throughout the document. Normally, a class is extended through derivation, but an extends directive defines modifications to a pre-existing class by doing *in-place* extension of the class. *in-place* extension modifies the definition of a class by adding new member fields and member methods, and changing the

behavior of earlier defined class methods, without creating any new subclass(es). That is, SV's Aspect-Oriented Extensions change the original class definition without creating subclasses. These changes affect all instances of the original class that was extended by AOEs.

An extends directive for a class defines a scope in SV language. Within this scope exist the items that modify the class definition. These items within an extends directive for a class can be divided into the following three categories.

- Introduction

Declaration of a new property, or the definition of a new method, a new constraint, or a new coverage group within the extends directive scope adds (or *introduces*) the new symbol into the original class definition as a new member. Such declaration/definition is called an *introduction*.

- Advice

An *advice* is a construct to specify code that affects the behavior of a member method of the class by *weaving* the specified code into the member method definition. This is explained in more detail later. The advice item is said to be an advice *to* the affected member method.

- Hide list:

Some items within an extends directive, such as a virtual method introduction, or an advice to virtual method may not be permissible within the extends directive scope depending upon the *hide permissions* at the place where the item is defined. A *hide list* is a construct whose placement and arguments within the extends directive scope controls the hide permissions. There could be multiple hide lists within an extends directive.

---

## Processing of AOE as a Precompilation Expansion

As a precompilation expansion, AOE code is processed by VCS to modify the class definitions that it extends as per the directives in AOE.

A *symbol* is a valid identifier in a program. Classes and class methods are symbols that can be affected by AOE. AOE code is processed which involves adding of introductions and *weaving* of advices in and around the affected symbols. Weaving is performed before actual compilation (and thereby before symbol resolution), therefore, under certain conditions, introduced symbols with the same identifier as some already visible symbol, can *hide* the already visible symbols. This is explained in more detail in [Section , “hide\\_list details,” on page 13-30](#). The preprocessed input program, now devoid of AOE, is then compiled.

Syntax:

```
extends_directive ::=
 extends extends_identifier
(class_identifier) [dominate_list];
 extends_item_list
 endextends

dominate_list ::=
 dominates(extends_identifier
{,extends_identifier});

extends_item_list ::=
 extends_item {extends_item}

extends_item ::=
 class_item
 | advice
 | hide_list
```

```

class_item ::=
 class_property
 | class_method
 | class_constraint
 | class_coverage
 | enum_defn

advice ::= placement procedure

placement ::=
 before
 | after
 | around

procedure ::=
 | optional_method_specifiers task
 task_identifier(list_of_task_proto_formals);
 | optional_method_specifiers function
function_type
function_identifier(list_of_function_proto_formals)
endfunction

advice_code ::= [stmt] {stmt}

stmt ::= statement
 | proceed ;

hide_list ::=
 hide([hide_item {,hide_item}]);

hide_item ::=
 // Empty
 | virtuals
 | rules

```

The symbols in boldface are keywords and their syntax are as follows:

**extends\_identifier**

Name of the aspect extension.

`class_identifier`

Name of the class that is being extended by the `extends` directive.

`dominate_list`

Specifies extensions that are *dominated* by the current directive. Domination defines the *precedence* between code woven by multiple extensions into the same scope. One extension can dominate one or more of the other extensions. In such a case, you must use a comma-separated list of `extends` identifiers.

```
dominates(extends_identifier
{,extends_identifier});
```

A dominated extension is assigned lower precedence than an extension that dominates it. Precedence among aspects extensions of a class determines the order in which introductions defined in the aspects are added to the class definition. It also determines the order in which advices defined in the aspects are *woven* into the class method definitions thus affecting the behavior of a class method. Rules for determination of precedence among aspects are explained later in “[Precedence” on page 16](#).

`class_property`

Refers to an item that can be parsed as a property of a class.

`class_method`

Refers to an item that can be parsed as a class method.

`class_constraint`

Refers to an item that can be parsed as a class constraint.

`class_coverage`

Refers to an item that can be parsed as a coverage\_group in a class.

`advice_code`

Specifies to a block of statements.

`statement`

Is an SV statement.

`procedure_prototype`

A full prototype of the target procedure. Prototypes enable the advice code to reference the formal arguments of the procedure.

`opt_method_specifiers`

Refers to a combination of protection level specifier (local, or protected), virtual method specifier (virtual), and the static method specifier (static) for the method.

`task_identifier`

Name of the task.

`function_identifier`

Name of the function.

`function_type`

Data type of the return value of the function.

`list_of_task_proto_formals`

List of formal arguments to the task.

`list_of_function_proto_formals`

List of formal arguments to the function.

`placement`

Specifies the position at which the advice code within the advice is *woven* into the *target method* definition. Target method is either the class method, or some other new method that was created as part of the process of *weaving*, which is a part of pre-compilation expansion of code. The overall details of the process of “weaving” are explained in [Pre-compilation Expansion details](#). The placement element could be any of the keywords, *before*, *after*, or *around*, and the advices with these placement elements are referred to as ***before*** advice, ***after*** advice and ***around*** advice, respectively.

`proceed statement`

The proceed keyword specifies an SV statement that can be used within advice code. A proceed statement is valid only within an around block and only a single proceed statement can be used inside the *advice code block* of an around advice. It cannot be used in a before advice block or an after advice block. The proceed statement is optional.

`hide_list`

Specifies the permission(s) for introductions to hide a symbol, and/or permission(s) for advices to modify local and protected methods. It is explained in detail in [Section , “hide\\_list details,” on page 13-30](#).

## Weaving advice into the target method

The target method is either the class method, or some other new method that was created as part of the process of *weaving*. “Weaving” of all advices in the input program comprises several steps of *weaving of an advice into the target method*. Weaving of an advice into its target method involves the following.

A new method is created with the same method prototype as the target method and with the advice code block as the code block of the new method. This method is referred to as the *advice method*.

The following table shows the rest of the steps involved in weaving of the advice for each type of placement element (*before*, *after*, and *around*).

*Table 13-1 Placement Elements*

| Element | Description                                                                                                                                                                                                                                                                                                                                                                 |
|---------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| before  | Inserts a new method-call statement that calls an advice method. The statement is inserted as the first statement to be executed before any other statements.                                                                                                                                                                                                               |
| after   | Creates a new method A with the target method prototype, with its first statement being a call to the target method. Second statement with A is a new method call statement that calls the advice method. All the instances in the input program where the target method is called are replaced by newly created method calls to A. A is replaced as the new target method. |
| around  | All the instances in the input program where the target method is called are replaced by newly created method calls to the advice method.                                                                                                                                                                                                                                   |

Within an extends directive, you can specify only one advice can be specified for a given placement element and a given method. For example, an extends directive may contain a maximum of one before, one after, and one around advice each for a class method *Packet::foo* of a class *Packet*, but it may not contain two before advices for the *Packet::foo*.

### *Example 13-1 **before** Advice*

Target method:

```
class packet;
 task myTask();
 $display("Executing original code\n");
 endtask
```

```
endclass
```

Advice:

```
before task myTask () ;
 $display("Before in aoe1\n");
endtask
```

Weaving of the advice in the target method yields the following.

```
task myTask();
 mytask_before();
 $display("Executing original code\n");
endtask

task mytask_before ();
 $display("Before in aoe1\n");
endtask
```

Note that the SV language does not impose any restrictions on the names of newly created methods during pre-compilation expansion, such as *mytask\_before*. Compilers can adopt any naming conventions such methods that are created as a result of the *weaving* process.

### *Example 13-2 after Advice*

Target method:

```
class packet;
 task myTask();
 $display("Executing original code\n");
 endtask
endclass
```

Advice:

```
after task myTask ();
 $display("Before in aoe1\n");
endtask
```

Weaving of the advice in the target method yields the following.

```
task myTask_newTarget();
 myTask();
 myTask_after();
endtask

task myTask();
 $display("Executing original code\n");
endtask

task myTask_after ();
 $display("After in aoel\n");
endtask
```

As a result of weaving, all the method calls to myTask() in the input program code are replaced by method calls to myTask\_newTarget(). Also, myTask\_newTarget replaces myTask as the target method for myTask().

### *Example 13-3   **around** Advice*

Target method:

```
class packet;
 task myTask();
 $display("Executing original code\n");
 endtask
endclass
```

Advice:

```
around task myTask ();
 $display("Around in aoel\n");
endtask
```

Weaving of the advice in the target method yields the following.

```

task myTask_around();
 $display("Around in aoel\n");
endtask

task myTask();
 $display("Executing original code\n");
endtask

```

As a result of weaving, all the method calls to `myTask()` in the input program code are replaced by method calls to `myTask_around()`. Also, `myTask_around()` replaces `myTask()` as the target method for `myTask()`.

During weaving of an *around* advice that contains a *proceed* statement, the *proceed* statement is replaced by a method call to the target method.

#### *Example 13-4    **around** Advice with **proceed***

Target method:

```

class packet;
 task myTask();
 $display("Executing original code\n");
 endtask
endclass

```

Advice:

```

around task myTask ();
 proceed;
 $display("Around in aoel\n");
endtask

```

Weaving of the advice in the target method yields:

```

task myTask_around();
 myTask();

```

```

 $display("Around in aoe1\n");
endtask

task myTask();
 $display("Executing original code\n");
endtask

```

As a result of weaving, all the method calls to myTask() in the input program code are replaced by method calls to myTask\_around(). The proceed statement in the around code is replaced with a call to the target method myTask(). Also, myTask\_around replaces myTask as the target method for myTask().

---

## Pre-compilation Expansion details

Pre-compilation expansion of a program containing AOE code is done in the following order:

1. Preprocessing and parsing of all input code.
2. Identification of the symbols, such as methods and classes affected by extensions.
3. The precedence order of aspect extensions (and thereby introductions and advices) for each class is established.
4. Addition of introductions to their respective classes as class members in their order of precedence. Whether an introduction can or can not override or hide a symbol with the same name that is visible in the scope of the original class definition, is dependent on certain rules related to the hide\_list parameter. For a detailed explanation, see “[hide\\_list details](#)” on page 13-30.
5. Weaving of all advices in the input program are weaved into their respective class methods as per the precedence order.

These steps are described in more detail in the following sections.

## Precedence

Precedence is specified through the *dominate\_list* (see “[dominate\\_list](#)” on page 7) There is no default precedence across files; if precedence is not specified, the tool is free to weave code in any order. Within a file, dominance established by dominate\_lists always overrides precedence established by the order in which extends directives are coded. Only when the precedence is not established after analyzing the dominate lists of directives, is the order of coding used to define the order of precedence.

Within an extends directive there is an inherent precedence between advices. Advices that are defined later in the directive have higher precedence than those defined earlier.

Precedence does not change the order between adding of introductions and weaving of advices in the code. Precedence defines the order in which introductions to a class are added to the class, and the order in which advices to methods belonging to a class are woven into the class methods.

### *Example 13-5 Precedence Using **dominates***

```
// Beginning of file test.sv
class packet;
 // Other member fields/methods
 //...

 task send();
 $display("Sending data\n");
 endtask
endclass

program top ;
```

```

initial begin
 packet p;
 p = new();
 p.send();
end
endprogram

extends aspect_1(packet) dominates (aspect_2, aspect_3);

 after task send(); // Advice 1
 $display("Aspect_1: send advice after\n");
 endtask
endextends

extends aspect_2(packet);

 after task send() ; // Advice 2
 $display("Aspect_2: send advice after\n");
 endtask
endextends

extends aspect_3(packet);

 around task send(); // Advice 3
 $display("Aspect_3: Begin send advice around\n");
 proceed;
 $display("Aspect_3: End send advice around\n");
 endtask

 before task send(); // Advice 4
 $display("Aspect_3: send advice before\n");
 endtask
endextends

// End of file test.sv

```

In [Example 13-5](#), multiple aspect extensions for a class named *packet* are defined in a single SV file. As specified in the dominating list of *aspect\_1*, *aspect\_1* dominates both *aspect\_2* and *aspect\_3*.

As per the dominating lists of the aspect extensions, there is no precedence order established between `aspect_2` and `aspect_3`, and since `aspect_3` is coded later in `Input.vr` than `aspect_2`, `aspect_3` has higher precedence than `aspect_2`. Therefore, the precedence of these aspect extensions in the decreasing order of precedence is:

{`aspect_1`, `aspect_3`, `aspect_2`}

This implies that the advice(s) within `aspect_2` have lower precedence than advice(s) within `aspect_3`, and advice(s) within `aspect_3` have lower precedence than advice(s) within `aspect_1`. Therefore, `advice 2` has lower precedence than `advice 3` and `advice 4`. Both `advice 3` and `advice 4` have lower precedence than `advice 1`. Between `advice 3` and `advice 4`, `advice 4` has higher precedence as it is defined later than `advice 3`. That puts the order of advices in the increasing order of precedence as:

{2, 3, 4, 1}.

## **Adding of Introductions**

*Target scope* refers to the scope of the class definition that is being extended by an aspect. Introductions in an aspect are appended as new members at the end of its target scope. If an extension A has precedence over extension B, the symbols introduced by A are appended first.

Within an aspect extension, symbols introduced by the extension are appended to the target scope in the order they appear in the extension.

There are certain rules according to which an introduction symbol with the same identifier name as a symbol that is visible in the target scope, may or may not be allowed as an introduction. These rules are discussed later in the chapter.

## Weaving of advices

An input program may contain several aspect extensions for any or each of the different class definitions in the program. Weaving of advices needs to be carried out for each class method for which an advice is specified.

Weaving of advices in the input program consists of weaving of advices into each such class method. Weaving of advices into a class method A is unrelated to weaving of advices into a different class method B, and therefore weaving of advices to various class methods can be done in any ordering of the class methods.

For weaving of advices into a class method, all the advices pertaining to the class method are identified and ordered in the order of increasing precedence in a list L. This is the order in which these advices are woven into the class method thereby affecting the run-time behavior of the method. The advices in list L are woven in the class method as per the following steps. Target method is initialized to the class method.

- a. Advice A that has the lowest precedence in L is woven into the target method as explained earlier. Note that the target method may either be the class method or some other method newly created during the weaving process.
- b. Advice A is deleted from list L.
- c. The next advice on list L is woven into the target method. This continues until all the advices on the list have been woven into list L.

It would become apparent from the example provided later in this section how the order of precedence of advices for a class method affects how advices are woven into their target method and thus the relative order of execution of advice code blocks. Before and after advices within an aspect to a target method are unrelated to each other in the sense that their relative precedence to each other does not affect their relative order of execution when a method call to the target method is executed. The before advice's code block executes before the target method code block, and the after advice code block executes after the target method code block. When an around advice is used with a before or after advice in the same aspect, code weaving depends upon their precedence with respect to each other. Depending upon the precedence of the around advice with respect to other advices in the aspect for the same target method, the around advice either may be woven before all or some of the other advices, or may be woven after all of the other advices.

As an example, weaving of advices 1, 2, 3, 4 specified in aspect extensions in [Example 13-5](#) leads to the expansion of code in the following manner. Advices are woven in the order of increasing precedence {2, 3, 4, 1} as explained earlier.

#### *Example 13-6 After Weaving Advice-2 of Class **packet***

```
// Beginning of file test.sv

program top ;
 packet p;
 p = new();
 p.send_Created_a();
endprogram

class packet;
 ...
 // Other member fields/methods
 ...
 task send();
 p$display("Sending data\n");
 endtask
endclass
```

```

 endtask

 task send_Created_a();
 send();
 send_after_Created_b();
 endtask

 task send_after_Created_b();
 $display("Aspect_2: send advice after\n");
 endtask

 endclass

extends aspect_1(packet) dominates (aspect_2, aspect_3);
 after task send(); // Advice 1
 $display("Aspect_1: send advice after\n");
 endtask
endextends

extends aspect_3(packet);
 around task send(); // Advice 3
 $display("Aspect_3: Begin send advice around\n");
 proceed;
 $display("Aspect_3: End send advice around\n");
 endtask

 before task send(); // Advice 4
 $display("Aspect_3: send advice before\n");
 endtask
endextends

// End of file test.sv

```

This [Example 13-6](#) shows what the input program looks like after weaving advice 2 into the class method. Two new methods *send\_Created\_a* and *send\_after\_Created\_b* are created in the process and the instances of method call to the target method *packet::send* are modified, such that the code block from advice 2 executes after the code block of the target method *packet::send*.

### *Example 13-7 After Weaving Advice-3 of Class **packet***

```

// Beginning of file test.sv

program top;

```

```

 packet p;
 p = new();
 p.send_around_Created_c();
endprogram

class packet;
 ...
 // Other member fields/methods
 ...
 task send();
 $display("Sending data\n");
 endtask

 task send_Created_a();
 send();
 send_after_Created_b();
 endtask

 task send_after_Created_b();
 $display("Aspect_2: send advice after\n");
 endtask

 task send_around_Created_c();
 $display("Aspect_3: Begin send advice around\n");
 send_Created_a();
 $display("Aspect_3: End send advice around\n");
 endtask
endclass

extends aspect_1(packet) dominates (aspect_2, aspect_3);
 after task send(); // Advice 1
 $display("Aspect_1: send advice after\n");
 endtask
endextends

extends aspect_3(packet);
 before task send(); // Advice 4
 $display("Aspect_3: send advice before\n");
 endtask
endextends

// End of file test.sv

```

This [Example 13-7](#) shows what the input program looks like after weaving advice 3 into the class method. A new method *send\_around\_Created\_c* is created in this step and the instances of

method call to the target method `packet::send_Created_a` are modified, such that the code block from *advice 3* executes *around* the code block of method `packet::send_Created_a`. Also note that the `proceed` statement from the advice code block is replaced by a call to `send_Created_a`. At the end of this step, `send_around_Created_c` becomes the new target method for weaving of further advices to `packet::send`.

### *Example 13-8 After Weaving Advice-4 of Class **packet***

```
// Beginning of file test.sv

program top;
 packet p;
 p = new();
 p.send_around_Created_c();
endprogram

class packet;
 ...
 // Other member fields/methods
 ...
 task send();
 $display("Sending data\n");
 endtask

 task send_Created_a();
 send();
 send_after_Created_b();
 endtask

 task send_after_Created_b();
 $display("Aspect_2: send advice after\n");
 endtask

 task send_around_Created_c();
 send_before_Created_d();
 $display("Aspect_3: Begin send advice around\n");
 send_after_Created_a();
 $display("Aspect_3: End send advice around\n");
 endtask

 task send_before_Created_d();
 $display("Aspect_3: send advice before\n");
 endtask
```

```

 endtask
endclass

extends aspect_1(packet) dominates (aspect_2, aspect_3);
 after task send(); // Advice 1
 $display("Aspect_1: send advice after\n");
 endtask
endextends

// End of file test.sv

```

This [Example 13-8](#) shows what the input program looks like after weaving advice 4 into the class method. A new method *send\_before\_Created\_d* is created in this step and a call to it is added as the first statement in the target method *packet::send\_around\_Created\_c*. Also note that the outcome would have been different if *advice 4* (before advice) was defined earlier than *advice 3* (around advice) within *aspect\_3*, as that would have affected the order of precedence of *advice 3* and *advice*. In that scenario the *advice 3* (around advice) would have weaved around the code block from *advice 4* (before advice), unlike the current outcome.

### *Example 13-9 After Weaving all{2,3,4,1} Advices of Class **packet***

```

// Beginning of file test.sv

program top;
 packet p;
 p = new();
 p.send_Created_f();
endprogram

class packet;
 ...
 // Other member fields/methods
 ...
 task send();
 $display("Sending data\n");
 endtask

 task send_Created_a();

```

```

 send();
 send_Created_b();
 endtask

 task send_after_Created_b();
 $display("Aspect_2: send advice after\n");
 endtask

 task send_around_Created_c();
 send_before_Created_d();
 $display("Aspect_3: Begin send advice around\n");
 send_after_Created_a();
 $display("Aspect_3: End send advice around\n");
 endtask

 task send_before_Created_d();
 $display("Aspect_3: send advice before\n");
 endtask
 task send_after_Created_e();
 $display("Aspect_1: send advice after\n");
 endtask

 task send_Created_f();
 send_around_Created_c();
 send_after_Created_e()
 endtask
endclass

// End of file test.sv

```

This [Example 13-9](#) shows the input program after weaving of all four advices {2, 3, 4, 1}. New methods *send\_after\_Created\_e* and *send\_Created\_f* are created in the last step of weaving and the instances of method call to *packet::send\_around\_Created\_c* were replaced by method call to *packet::send\_Created\_f*.

When executed, output of this program is:

```

Aspect_3: send advice before
Aspect_3: Begin send advice around
Sending data
Aspect_2: send advice after
Aspect_3: End send advice around
Aspect_1: send advice after

```

### *Example 13-10 Around Advice With **dominates**-I*

```
// Begin file test.sv
class foo;
 int i;

 task myTask();
 $display("Executing original code\n");
 endtask
endclass

extends aoe1 (foo) dominates(aoe2);
 around task myTask();
 proceed;
 $display("around in aoe1\n");
 endtask
endextends

extends aoe2 (foo);
 around task myTask();
 proceed;
 $display("around in aoe2\n");
 endtask
endextends

program top;
 foo f;

 initial begin
 f = new();
 f.myTask();
 end
endprogram

// End file test.sv
```

When aoe1 **dominates** aoe2, as in func1, the output when the program is executed is:

```
Executing original code
around in aoe2
around in aoe1
```

*Example 13-11 Around Advice with **dominates**-II*

```
// Begin file test.sv
class foo;
 int i;
 task myTask();
 $display("Executing original code\n");
 endtask
endclass

extends aoe1 (foo);
 around task myTask();
 proceed;
 $display("around in aoe1\n");
 endtask
endextends

extends aoe2 (foo) dominates (aoe1);
 around task myTask();
 proceed;
 $display("around in aoe2\n");
 endtask
endextends

program top;
 foo f;

 initial begin
 f = new();
 f.myTask();
 end
endprogram
// End file test.sv
```

On the other hand, when aoe2 dominates aoe1 as in this [Example 13-11](#), the output is:

```
Executing original code
around in aoe1
around in aoe2
```

## **Symbol Resolution Details:**

As introductions and advices defined within extends directives are pre-processed as a pre-compilation expansion of the input program, the pre-processing occurs earlier than final symbol resolution stage within a compiler. Therefore, it is possible for AOE code to reference symbols that were added to the original class definition using AOE. Because advices are woven after introductions have been added to the class definitions, advices can be specified for introduced member methods and can reference introduced symbols.

An advice to a class method can access and modify the member fields and methods of the class object to which the class method belongs. An advice to a class function can access and modify the variable that stores the return value of the function.

Furthermore, members of the original class definition can also reference symbols introduced by aspect extensions using the extern declarations (?). Extern declarations can also be used to reference symbols introduced by an aspect extension to a class in some other aspect extension code that extends the same class.

An introduction that has the same identifier as a symbol that is already defined in the target scope as a member property or member method is not permitted.

## **Examples:**

### *Example 13-12 **before** Advice on Class Task*

```
// Begin file test.sv
class packet;
 task foo(integer x); //Formal argument is "x"
 $display("x=%0d\n", x);
 endtask
endclass
```

```

extends myaspect(packet);
 // Make packet::foo always print: "x=99"
 before task foo(integer x);
 x = 99; //force every call to foo to use x=99
 endtask
endextends

program top;
 packet p;

 initial begin
 p = new();
 p.foo(100);
 end
endprogram
// End file test.sv

```

The `extends` directive in [Example 13-12](#) sets the `x` parameter inside the `foo()` task to 99 before the original code inside of `foo()` executes. Actual argument to `foo()` is not affected, and is not set unless passed-by-reference using `ref`.

### *Example 13-13 after Advice on Class Function*

```

// Begin file test.sv
class packet ;
 function integer bar();
 bar = 5;
 $display("Point 1: Value = %d\n", bar);
 endfunction
endclass

extends myaspect(packet);
 after function integer bar();
 $display("Point 2: Value = %d\n", bar);
 bar = bar + 1; // Stmt A
 $display("Point 3: Value = %d\n", bar);
 endfunction
endextends

program top ;

```

```

packet p;

initial begin
 p = new();
 $display("Output is: %d\n", p.bar());
end
endprogram

// End file test.sv

```

An advice to a function can access and modify the variable that stores the return value of the function as shown in [Example 13-13](#), in this example a call to *packet::bar* returns 6 instead of 5 as the final return value is set by the *Stmt A* in the advice code block.

When executed, the output of the program code is:

```

Point 1: Value = 5
Point 2: Value = 5
Point 3: Value = 6
Output is: 6

```

### **hide\_list details**

The *hide\_list* item of an *extends\_directive* specifies the permission(s) for introductions to hide symbols, and/or advice to modify local and protected methods. By default, an introduction does not have permission to hide symbols that were previously visible in the target scope, and it is an error for an extension to introduce a symbol that hides a global or super-class symbol.

The *hide\_list* option contains a comma-separated list of options such as:

- The *virtuals* option permits the hiding (that is, overriding) of virtual methods defined in a super class. Virtual methods are the only symbols that may be hidden; global, and file-local tasks and functions may not be hidden. Furthermore, all introduced methods must have the same virtual modifier as their overridden super-class and overriding sub-class methods.
- The *rules* option permits the extension to suspend access rules and to specify advice that changes protected and local virtual methods; by default, extensions cannot change protected and local virtual methods.
- An empty option list removes all permissions, that is, it resets permissions to default.

In [Example 13-14](#), the *print* method introduced by the *extends* directive hides the *print* method in the super class.

#### *Example 13-14 Change Permission Using **hide virtuals***

```

class pbase;
 virtual task print();
 $display("I'm pbase\n");
 endtask
endclass

class packet extends pbase;
 task foo();
 $display(); //Call the print task
 endtask
endclass

extends myaspect(packet);
 hide(virtuals); // Allows permissions to
 // hide pbase::print task

 virtual task print();
 $display("I.m packet\n.");
 endtask
endextends

```

```

program test;
 packet tr;
 pbase base;

 initial begin
 tr = new();
 tr.print();
 base = tr;
 base.print();
 end
endprogram

```

As explained earlier, there are two types of hide permissions:

- a. Permission to hide virtual methods defined in a super class (option `virtuals`) is referred to as *virtuals-permission*. An aspect item is either an introduction, an advice, or a hide list within an aspect. If at an aspect item within an aspect, such permission is granted, then the *virtuals-permission* is said to be *on* or the *status* of *virtuals-permission* is said to be *on* at that aspect item and at all the aspect items following that, until a hide list that forfeits the permission is encountered. If *virtuals-permission* is not *on* or the *status* of *virtuals-permission* is not *on* at an aspect item, then the *virtuals-permission* at that item is said to be *off* or the *status* of *virtuals-permission* at that item is said to be *off*
- b. Permission to suspend access rules and to specify advice that changes protected and local virtual methods (option "rules") is referred to as *rules-permission*. If within an aspect, at an aspect item, such permission is granted, then the *rules-permission* is said to be *on* or the *status* of *rules-permission* is said to be *on* at that aspect item and at all the aspect items following that, until a hide list that forfeits the permission is encountered. If *rules-permission* is not *on* or the *status* of *rules-permission* is not *on* at an aspect item, then the *rules-permission* at that item is said to be *off* or the *status* of *rules-permission* at that item is said to be *off*.

Permission for one of the above types of hide permissions does not affect the other. Status of rules-permission and hide-permission varies with the position of an aspect item within the aspect. Multiple hide\_list(s) may appear in the extension. In an aspect, whether an introduction or an advice that can be affected by hide permissions is permitted to be defined at a given position within the aspect extension is determined by the status of the relevant hide permission at the position. A hide\_list at a given position in an aspect can change the status of rules-permission and/or virtuals-permission at that position and all following aspect items until any hide permission status is changed again in that aspect using hide\_list.

**Example 13-15** illustrates how the two hide permissions can change at different aspect items within an aspect extension.

### *Example 13-15 Hide Permissions*

```
class pbase;
 virtual task print1();
 $display("pbase::print1\n");
 endtask

 virtual task print2();
 $display("pbase::print2\n");
 endtask
endclass

class packet extends pbase;
 task foo();
 rules_test();
 endtask

 local virtual task rules_test();
 $display("Rules-permission example\n");
 endtask
endclass

extends myaspect(packet);
```

```

 // At this point within the myaspect scope,
 // virtuals-permission and rules-permission are both off.
 hide(virtuals); // Grants virtuals-permission

 // virtuals-permission is on at this point within aspect,
 // and therefore can define print1 method introduction.
 virtual task print1();
 $display("packet::print1\n.");
 endtask

 hide(); // virtuals-permission is forfeited

 hide(rules); // Grants rules-permission

 // Following advice permitted as rules-permission is on
 // before local virtual task rules_test();
 $display("Advice to Rules-permission example\n");
 endtask

 hide(virtuals); // Grants virtuals-permission

 // virtuals-permission is on at this point within aspect,
 // and therefore can define print2 method introduction.
 virtual task print2();
 $display("packet::print2\n.");
 endtask
 endextends

 program test;
 packet tr;

 initial begin
 tr = new();
 tr.print1();
 tr.foo();
 tr.print2();
 end
 endprogram

```

## Examples

Introducing new members into a class:

[Example 13-16](#) shows how AOE can be used to introduce new members into a class definition. *myaspect* adds a new property, constraint, coverage group, and method to the *packet* class.

### *Example 13-16 Introducing New Member*

```
class packet;
 rand bit[31:0] hdr_len;
endclass

extends myaspect(packet);
 integer sending_port;
 event cg_trigger;

 constraint con2 {
 hdr_len == 4;
 }

 covergroup cov2 @(cg_trigger);
 coverpoint sending_port;
 endgroup

 task print_sender();
 $display("Sending port = %0d\n", sending_port);
 endtask
endextends

program test;
 packet tr;

 initial begin
 tr = new();
 void'(tr.randomize());
 tr.sending_port = 1;
 tr.print_sender();
 -> tr.cg_trigger;
 end
```

```
endprogram
```

As mentioned earlier, new members that are introduced should not have the same name as a symbol that is already defined in the class scope. So, AOE defined in the manner shown in [Example 13-17](#) will not be allowed, as the aspect *myaspect* defines *x* as one of the introductions when the symbol *x* is already defined in class *foo*.

#### *Example 13-17 Non-permissible Introduction*

```
class foo;
 rand integer myfield;
 integer x;
endclass

extends myaspect(foo);
integer x;

constraint con1 {
 myfield == 4;
}
endextends

program test;
foo tr;

initial begin
 tr = new();
 $display("Non-permissible introduction error....!");
 void'(tr.randomize());
end
endprogram
```

#### Examples of advice code

In [Example 13-18](#), the `extends` directive adds advices to the `packet::send` method.

### *Example 13-18 before-after Advices*

```
// Begin file test.sv
class packet;
 task send();
 $display("Sending data\n.");
 endtask
endclass

extends myaspect(packet);
 before task send();
 $display("Before sending packet\n");
 endtask

 after task send();
 $display("After sending packet\n");
 endtask
endextends

program test;
 packet p;

 initial begin
 p = new();
 p.send();
 end
endprogram

// End file test.sv
```

When [Example 13-18](#) is executed, the output is:

```
Before sending packet
Sending data
After sending packet
```

In [Example 13-19](#), extends directive myaspect adds advice to turn off constraint c1 before each call to the `foo::pre_randomize` method.

### *Example 13-19 Turn-off Constraint Using **before** Advice*

```
class foo;
 rand integer myfield;

 constraint c1 {
 myfield == 4;
 }
endclass

extends myaspect(foo);

before function void pre_randomize();
 c1.constraint_mode(0);
endfunction
endextends

program test;
 foo tr;

 initial begin
 tr = new();
 void'(tr.randomize());
 $display("myfield value = %d, constraint mode OFF (!= 4) !", tr.myfield);
 end
endprogram
```

In [Example 13-20](#), extends directive myaspect adds advice to set a property named valid to 0 after each call to the `foo::post_randomize` method.

### *Example 13-20 Change Property Value After **post-randomize()***

```
class foo;
 integer valid;
 rand integer myfield;

 constraint c1 {
 myfield inside { [0:6] };
 }

```

```

endclass

extends myaspect(foo);
 after function void post_randomize();
 if (myfield > 6)
 valid = 0;
 else
 valid = 1;
 endfunction
endextends

program test;
 foo tr;

 initial begin
 tr = new();
 void'(tr.randomize());
 $display("valid = %0d ", tr.valid);
 end
endprogram

```

**Example 13-21** shows an aspect extension that defines an around advice for the class method packet::send. When the code in example is compiled and run, the around advice code is executed instead of original packet::send code.

#### *Example 13-21 Changing Test Functionality Using **around** Advice*

```

// Begin file test.sv
class packet;
 integer len;
 task setLen(integer i);
 len = i;
 endtask

 task send();
 $display("Sending data\n.");
 endtask
endclass

program test;

```

```

packet p;

initial begin
 p = new();
 p.setLen(5000);
 p.send();
 p.setLen(10000);
 p.send();
end
endprogram

extends myaspect(packet);
around task send();
 if (len < 8000)
 proceed;
 else
 $display("Dropping packet\n");
endtask
endextends

// End file test.sv

```

This [Example 13-21](#) also demonstrates how the around advice code can reference properties such as len in the packet object p. When executed the output of the above example is,

```

Sending data
Dropping packet

```

# 14

## Using Constraints

---

This chapter explains VCS support for the following constraints features:

- “Inconsistent Constraints” on page 2
- “Constraint Debug” on page 3
- “Constraint Debug Using DVE” on page 16
- “Constraint Guard Error Suppression” on page 17
- “Array and XMR Support in std::randomize()” on page 20
- “XMR Support in Constraints” on page 22
- “State Variable Index in Constraints” on page 25
- “Using Soft Constraints in SystemVerilog” on page 26
- “Using DPI Function Calls in Constraints” on page 36

- “Using Foreach Loops Over Packed Dimensions in Constraints” on page 41
  - “Randomized Objects in a Structure” on page 46
- 

## Inconsistent Constraints

VCS correctly identifies inconsistent constraints while trying to find the minimal set causing the inconsistency. VCS supports two options to find inconsistent constraints: binary search and linear search. You can use two new options to set larger timeout values. The default timeout values for each iteration of the constraint solver are 100 seconds for the binary search and 10 seconds for the linear search. You can set larger timeout values in seconds. For example:

```
simv +ntb_binary_debug_solver_cpu_limit=200
simv +ntb_linear_debug_solver_cpu_limit=20
```

Note:

If the constraint solver timeout value is too low, VCS may not be able to find the minimal set of conflicting constraints. If the solver timeout value is too high, performance may degrade while finding a conflict. Therefore, setting optimal timeout values is important.

Inconsistent constraints are non-fatal by default. VCS continues to run after a constraint failure. Use the `+ntb_stop_on_constraint_solver_error=0|1` option, where `1` enables stop on first error and `0` disables stop on first error to control how VCS handles these inconsistencies. For example, to make VCS stop the simulation on the first constraint failure, use the following command line:

```
simv +ntb_stop_on_constraint_solver_error=1
```

When VCS detects inconsistent constraints, the default printing mode only displays the failure subset. For example:

The solver failed when solving following set of constraints

```
rand integer y; // rand_mode = ON
rand integer z; // rand_mode = ON
rand integer x; // rand_mode = ON
constraint c // (from this) (constraint_mode = ON)
{
 (x < 1) ;
 (x in { 3 , 5 , 7 : 11 }) ;
}
```

You can use the

+ntb\_enable\_solver\_trace\_on\_failure=0|1|2|3 runtime option as follows:

- 0 Print a one-line failure message with no details.
- 1 Print only the failure subset (this is the default).
- 2 Print the entire constraint problem and failure subset.
- 3 Print only the failure problem. This is useful when the solver fails to determine the minimum subset.

---

## Constraint Debug

Generally, there are two kinds of constraint debug scenarios. In the first scenario, VCS solves the random variables but the user wishes to get a better understanding how the random variables are solved. This is about debugging the solved values. In the second scenario, VCS either times out when solving or solves after a long time. This is about performance debug.

The following sections describe the VCS features that can help with these kinds of constraint debug.

- “Partition” on page 4
  - “Randomize Serial Number” on page 6
  - “Solver Trace” on page 7
  - “Test Case Extraction” on page 13
  - “Using multiple +ntb\_solver\_debug arguments ” on page 15
  - “Summary for +ntb\_solver\_debug” on page 15
- 

## Partition

Whether it is `std::randomize` or the randomization of a class object, it generally involves one or more state and random variables. Constraints are used to describe relationships that between these variables. An important concept of constrained randomization is the notion of partitions. In other words, a randomize call is partitioned into one or more smaller constraint problems to solve. At run time, VCS groups all the related random variables involved in each randomization into one or more partitions. If there are no constraints between two random variables, they are not solved in the same partition. Here is an example to illustrate this concept:

```
class myClass;
 rand int x;
 rand int y;
 rand int z;
 rand byte a;
 rand byte b;
 bit c;
 constraint m {
 x > z;
```

```

 c -> a == b;
 }
constraint n {
 y > 0;
}

myClass obj = new;
obj.randomize(); // 1st randomize() call
obj.randomize() with {x!=y;}; // 2nd randomize() call

```

For the first randomize call, the following constraints are used to solve the five random variables: x, y, z, a, and b and VCS creates three partitions for these random variables.

```

x > z; // from the constraint block m
c -> a == b; // from the constraint block m
y > 0; // from the constraint block n

```

The random variables x and z are grouped in one partition because of a constraint ( $x > z$ ) relating the two together.

The random variables a and b are grouped in another partition because of the constraint ( $c -> a == b$ ).

There are no constraints between y and any other random variable. So y is on a third partition of its own.

Because the random variables from different partitions are not constrained together, they do not have to be solved in any particular order.

For the second `randomize()` call, a new constraint is added in the inline constraint (that is `randomize()` with). Here are the four constraints for the same 5 random variables.

```
x > z; // from the constraint block m
c -> a == b; // from the constraint block m
y > 0; // from the constraint block n
x != y; // from the inline constraint
// - randomize() with ..
```

For this second randomize call, two partitions are created.

The first partition has the random variables: x, y, and z because the following constraints relate all three together:  $(x > z)$ ,  $(y > 0)$ , and  $(x \neq y)$ .

The second partition has the random variables a and b because of the  $(c \rightarrow a == b)$  constraint.

---

## Randomize Serial Number

Each randomization in a simulation is assigned a serial number starting with 1. For example, if there are ten randomize calls (`std::randomize` or randomization of class objects) in a simulation, they are numbered from 1 to 10.

By default, the randomize serial numbers are not printed at run time. To display the randomize serial numbers during simulation, you need to run the simulation with the `+ntb_solver_debug=serial` option.

```
simv +ntb_solver_debug=serial
```

After each randomization completes, VCS prints the randomize serial number along with some run time and memory data for the `randomize()` call.

Using a randomize serial number provides a mechanism to focus the constraint debug on a specific `randomize()` call. If the randomize serial number is used together with the partition number, it is the specified partition within the specified randomize call that becomes the focus for the constraint debug.

To specify the  $n^{\text{th}}$  partition of the  $m^{\text{th}}$  randomize call, the notation `m.n` is used.

---

## Solver Trace

To get more insight to how VCS solves a randomize call, you can enable solver trace reporting by using the `+ntb_solver_debug=trace` runtime option. Here is an example of the solver trace:

```
// Part.sv
class C;
 rand byte x, y, z, m, n, p, q;

 constraint imply {
 x > 3 -> y > p; // C1
 z < bigadd (x, q); // C2
 n != 0; // C3
 }

 function byte bigadd (byte a, b);
 return (a + b);
 endfunction

endclass

program automatic test;
 C obj = new;
 initial begin
 repeat (5) begin
 obj.randomize() with { m == z; }; // C4
 end
 end
endprogram
```

```
 end
 end
endprogram
```

For this example, let us determine the partitions that will be created by the solver.

The SystemVerilog LRM mandates that function arguments must be solved first in order to compute the function that is used to constraint other random variables. In other words, separate partitions must be created for (x, q) and then for z.

- The constraint expression C1 relates the random variables, x, y, p together. So they are solved together in one partition.
- The constraint expression C2 using function call in constraint requires that z is solved in a different partition from x and q.
- Since the random variable q is not related to any other random variables, q is solved in a partition on its own.
- Similarly, the random variable n is not related to any other random variables, n is solved in another partition on its own.
- The constraint expression C4 is an inline constraint relating the two random variables, m and z, together. Therefore, m and z will be solved together in one partition.
- Given the above descriptions, you can see four partitions will be created.
  - Partition 1 to solve x, y, p together
  - Partition 2 to solve n alone
  - Partition 3 to solve q alone
  - Partition 4 to solve z and m together

To compile and run this example and enable solver trace for the third randomize call:

```
vcs -sverilog part.sv
simv +ntb_solver_debug=trace +ntb_solver_debug_filter=3
```

Part of the solver trace will show the partition information. Here is a part of the solver trace from the command above.

```
=====
SOLVING constraints
At file part.sv, line 20, serial 3

Rng state is:
01x0z11xzx11zx1xz0zx100zxzzz0zxzzzzzzzzzzzzzzzzzz
xxzxxz
Virtual class C, Static class C

...
Solving Partition 1 (mode = 2)

rand bit signed [7:0] y; // rand_mode = ON
rand bit signed [7:0] p; // rand_mode = ON
rand bit signed [7:0] x; // rand_mode = ON

...

Solving Partition 2 (mode = 2)

rand bit signed [7:0] n; // rand_mode = ON

...

Solving Partition 3 (mode = 2)

rand bit signed [7:0] q; // rand_mode = ON

...
```

```
Solving Partition 4 (mode = 2)

bit signed [7:0] fv_3 /* this .C::bigadd(x , q) */ = -127;
rand bit signed [7:0] z; // rand_mode = ON
rand bit signed [7:0] m; // rand_mode = ON
```

It is required to specify the `randomize()` call(s) and/or partitions(s) to report the solver trace details. For example:

The following command reports the solver trace for the second `randomize()` call and all partitions within this `randomize()` call of the simulation.

```
simv +ntb_solver_debug=trace +ntb_solver_debug_filter=2
```

The following command reports the solver trace for the third partition of the fifth `randomize()` call of the simulation.

```
simv +ntb_solver_debug=trace +ntb_solver_debug_filter=5.3
```

If the solver trace is to be enabled for multiple `randomize` calls, you can specify the list of random serial and, optionally, partition numbers in a comma separated list for the `+ntb_solver_debug_filter` option. For example: the following command reports the solver traces for the following `randomize()` calls and their partitions:

- Serial number 2, all partitions of this second `randomize()` call
- Serial number 5, just the third partition of this fifth `randomize()` call
- Serial number 10, all partitions of this tenth `randomize()` call
- Serial number 15, just the 30th partition of this 15<sup>th</sup> `randomize()` call.

```
simv +ntb_solver_debug=trace \
+ntb_solver_debug_filter=2,5.3,10,15.30
```

The following command reports the solver traces for the `randomize()` calls or partitions listed in a text file, for example if `serial_trace.txt` is the file name.

```
simv +ntb_solver_debug=trace \
+ntb_solver_debug_filter=file:serial_trace.txt
```

The following command reports the solver traces for all `randomize()` calls in the simulation. Be aware that this may produce a lot of data if there are many `randomize()` calls in the simulation.

```
simv +ntb_solver_debug=trace +ntb_solver_debug_filter=all
```

or

```
simv +ntb_solver_debug=trace_all
```

The `+ntb_solver_debug_filter` is not needed on the second `simv` command line.

Note:

Reporting solver traces for all `randomize()` calls can generate very large data files. Using the `+ntb_solver_debug=trace` and `+ntb_solver_debug_filter=serial_num|file` options and arguments limit the solver trace reports to the one(s) on which you want to focus the constraint debug.

Constraint debugging capability is also in DVE, including a similar solver trace capability to understand the details of a `randomize()` call and many graphical user interface features, such as cross probing, search, and filters to make debugging constraints faster and easier. For more information see the *DVE User Guide*.

---

## Constraint Profiler

To debug any performance related issues, profiling is required to identify the top consumers of time/memory. VCS provides a constraint profiler feature that can be enabled by using the `+ntb_solver_debug=profile` runtime option and keyword argument.

```
simv +ntb_solver_debug=profile
```

This `simv` command line runs the simulation and collects runtime and memory data on each of the `randomize()` calls in the simulation. The randomize calls/partitions that take the most time and memory will be listed out in a constraint profile report in the file `simv.cst/html/profile.xml`, where `simv` is the name of the simulation executable.

To view the constraint profile report in `simv.cst/html/profile.xml`, open the file with the Firefox or Chrome web browser. Viewing this file in Internet Explorer on Windows is not supported.

The random serial numbers for the randomize calls and/or partitions that take the most time are listed in the `simv.cst/serial2trace.txt` file.

Note:

The unified profiler also does constraint profiling. The Unified profiler is an LCA feature, for more information see the *VCS/VCSI LCA Features* book.

---

## Test Case Extraction

The solver trace shows the list of variables and constraints for each of the partitions. By wrapping this data inside a SystemVerilog class in a program block, you can create a standalone test case to compile and simulate to shorten the debug time. If you wishes to try different things to better understand the solver behavior and or to fix the constraint issue, you can do it on this extracted test case instead of the original design to save compile and run time.

To enable test case extraction, you can enable solver trace reporting by using the `+ntb_solver_debug=extract` runtime option and keyword argument. You must specify the specific `randomize()` call(s) to extract the test cases for using the `+ntb_solver_debug_filter` option.

For example, test case extraction is enabled for the second `randomize` call, that is `randomize serial number = 2`:

```
simv +ntb_solver_debug=extract +ntb_solver_debug_filter=2
```

This extracts a test case for each of the partitions of the `randomize()` call. Extracted test cases are saved in the `simv.cst/testcases` directory, where `simv` is the name of the simulation executable. The extracted test cases follow this naming convention:

```
extracted_r_serial#_p_partition#.sv
```

Once extracted, you can follow the commands below to compile and run the standalone test case. For example, to simulate the extracted test case for the third partition of the second `randomize()` call of the original design:

```
cd simv.cst/testcases
vcs -sverilog extracted_r_2_p_3.sv -R
```

Similar to reporting solver traces for a single partition or for multiple `randomize()` calls and their partitions, you can enable test case extraction for these too. For example:

```
simv +ntb_solver_debug=extract \
+ntb_solver_debug_filter=5.3

simv +ntb_solver_debug=extract \
+ntb_solver_debug_filter=2,5.3,10,15.30

simv +ntb_solver_debug=extract \
+ntb_solver_debug_filter=file:serial_trace.txt
```

**Note:**

You can only extract test cases from a partition. If VCS fails before any partition is created, test case extraction does not work.

When VCS encounters a `randomize()` call that has no solution or has constraint inconsistencies, VCS MX automatically extracts a test for it and saves the extracted test case using the following naming convention:

```
simv.cst/testcases/
extracted_r_serial#_p_partition#_inconsistency.sv
```

When VCS fails to solve a `randomize()` call due to solver time outs, test case extraction is also automatically enabled for it and VCS saves the extracted test case using the following naming convention:

```
simv.cst/testcases/
extracted_r_serial#_p_partition#_timeout.sv
```

---

## Using multiple +ntb\_solver\_debug arguments

To use multiple `+ntb_solver_debug` arguments such as `serial`, `trace`, `extract`, and `profile`, you can use pluses (+) to combine them, for example:

```
simv +ntb_solver_debug=serial+trace+extract \
+ntb_solver_debug_filter=3,4
```

---

## Summary for +ntb\_solver\_debug

The runtime option `+ntb_solver_debug` provides you with many constraint debug features to debug constraints in batch mode.

### **+ntb\_solver\_debug=serial**

The serial number assignment to the randomizations in a simulation provides a method to identify the `randomize()` calls to be debugged next. Once identified, you can use this runtime option with appropriate arguments to report the trace and extract test cases. The constraint profiler also uses the same identification method to provide feedback to you which specific `randomize()` calls to optimize for best performance improvements.

### **+ntb\_solver\_debug=trace**

This enables solver trace reporting for the specified `randomize()` calls. This helps the user to understand how VCS solves the random variables for given `randomize` calls. The `+ntb_solver_debug_filter` option is required to specify a list of `randomize()` calls for which to enable the solver trace.

### **+ntb\_solver\_debug=profile**

This enables constraint profiling for the simulation at runtime. The profile report provides important information to you which `randomize` calls should be targeted for improving constraint performance to bring down the total simulation run time or memory.

### **+ntb\_solver\_debug=extract**

This enables test case extraction for the specified `randomize` calls. This creates standalone test cases for you to compile and run outside of the original design. This should help quicker turnaround time to experiment possible fixes as it is faster to compile and run a smaller test case. The `+ntb_solver_debug_filter` option is required to specify a list of `randomize` calls for which to enable test case extraction.

---

## **Constraint Debug Using DVE**

Constraint debug is supported in DVE. Please refer to *DVE User Guide* for more details.

---

## Constraint Guard Error Suppression

If a guard expression is false, and if there are no other errors during randomization, VCS suppresses errors in the implied expressions of guard constraints. For example, here is a sample error message that VCS now suppresses:

```
Error-[CNST-NPE] Constraint null pointer error
test_guard.sv, 27
 Accessing null pointer obj.x in constraints.
 Please make sure variable obj.x is allocated.
```

Guarded constraints are defined in the SystemVerilog LRM (section 13.4; especially sections 13.4.5, 13.4.6, and 13.4.12).

The VCS constraint solver does not distinguish between implication (LRM section 13.4.5) and `if-else` constraints (LRM section 13.4.6). They are equivalent representations in the VCS constraint solver. We call them guarded constraints in this document.

Hence, the two formats shown in [Example 14-1](#) are equivalent inside the VCS constraint solver.

### *Example 14-1 Guarded Expressions*

```
if (a | b | c)
{
 obj.x == 10;
}
```

-or-

```
(a | b | c) -> (obj.x == 10);
```

In [Example 14-1](#), the expression inside the `if` condition (or the left side of the implication operator) is the guard expression. The remaining part of the expression (the right side of the implication operator) is the implied expression.

Note:

If there are other types of errors or conflicts, VCS does not guarantee suppression of those errors in the implied expression of the guard constraint.

The LRM says that the implication operator (or the `if-else` statement) should be at the top level of each constraint. Therefore, a constraint may have at most one guard (or one implication operator).

---

## Error Message Suppression Limitations

The constraint guard error message suppression feature has some limitations, as explained in the following sections:

- “[Flattening Nested Guard Expressions](#)” on page 18
- “[Pushing Guard Expressions into Foreach Loops](#)” on page 19

## Flattening Nested Guard Expressions

If there are multiple nested guards for a constraint, VCS combines them into one guard. For example, given the following code:

```
if (a)
{
 if (b)
 {
 if (c)
```

```

 {
 obj.x == 10;
 }
}

```

VCS flattens the guard expression into the following equivalent code:

```

if (a && b && c)
{
 obj.x == 10;
}

```

In the above example, if `a` is false, and `b` has an error (for example, a null address error), VCS still generates the error message.

## **Pushing Guard Expressions into Foreach Loops**

VCS pushes constraint guards into foreach loops. For example, if you have:

```

if (a | b | c)
{
 foreach (array[i])
 {
 array[i].obj.x == 10;
 }
}

```

VCS transforms it into the following equivalent code:

```

foreach (array[i])
{
 if (a | b | c)
 {
 array[i].obj.x == 10;
 }
}

```

In the above example, if `a | b | c` is false, and `array` has an error (for example, a null address error), VCS still generates the error message.

---

## Array and XMR Support in `std::randomize()`

VCS allows you to use cross-module references (XMRs) in class constraints and inline constraints, in all applicable contexts. Here, XMR means a variable with static storage (anything accessed as a global variable).

VCS `std::randomize()` support allow the use of arrays and cross-module references (XMRs) as arguments.

VCS supports all types of arrays:

- fixed-size arrays
- associative arrays
- dynamic arrays
- multidimensional arrays
- smart queues

Note:

VCS does not support multidimensional, variable-sized arrays.

Array elements are also supported as arguments to `std::randomize()`.

VCS supports all types of XMRs:

- class XMRs
- package XMRs
- interface XMRs
- module XMRs
- static variable XMRs
- any combination of the above

You can use arrays, array elements, and XMRs as arguments to `std::randomize()`.

## Syntax

```
integer fa[3];
success= std::randomize(fa);
success= std::randomize(fa[2]);
success= std::randomize(pkg::xmr);
```

## Example

```
module test;
integer i, success;
integer fa[3];
initial
begin
 foreach(fa[i]) $display("%d %d\n", i, fa[i]);
 success = std::randomize(fa);
 foreach(fa[i]) $display("%d %d\n", i, fa[i]);
end
endmodule
```

When `std::randomize()` is called, VCS ignores any rand mode specified on class member arrays or array elements that are used as arguments. This is consistent with how `std::randomize()` is

specified in the SystemVerilog LRM. This means that for purposes of `std::randomize()` calls, all arguments have rand mode ON, and none of them are randc.

## Error Conditions

If you specify an argument to a `std::randomize()` array element which is outside the range of the array, VCS prints the following error message:

```
Error-[CNST-VOAE] Constraint variable outside array error
```

Random variables are not allowed as part of an array index.

If you specify an XMR argument in a `std::randomize()` call, and that XMR that cannot be resolved, VCS prints an error message.

---

## XMR Support in Constraints

You can use XMRs in class constraints and inlined constraints. You can refer to XMR variables directly or by specifying the full hierarchical name, where appropriate. You can use XMRs for all data types, including scalars, enums, arrays, and class objects.

VCS supports all types of XMRs:

- class XMRs
- package XMRs
- interface XMRs
- module XMRs

- static variable XMRs
- any combination of the above

## Syntax

```
constraint general
{
 varxmr1 == 3;
 pkg::varxmr2 == 4;
}

c.randomize with { a.b == 5; }
```

## Examples

Here is an example of a module XMR:

```
// xmr from module
module mod1;
 int x = 10;
class cls1;
 rand int i1 [3:0];
 rand int i2;
constraint constr
{
 foreach(i1[a]) i1[a] == mod1.x;
}
endclass

cls1 c1 = new();
initial
begin
 c1.randomize() with {i2 == mod1.x + 5;};
end
endmodule
```

Here is an example of a package XMR:

```
package pkg;
 typedef enum {WEAK,STRONG} STRENGTH;
```

```

class C;
 static rand STRENGTH stren;
endclass

pkg::C inst = new;
endpackage

module test;
 import pkg::*;
 initial
 begin
 inst.randomize() with {pkg::C::stren == STRONG;};
 $display("%d", pkg::C::stren);
 end
endmodule

```

## Functional Clarifications

XMR resolution in constraints (that is, choosing to which variable VCS binds an XMR variable) is consistent with XMR resolution in procedural SystemVerilog code. VCS first tries to resolve an XMR reference in the local scope. If the variable is not found in the local scope, VCS searches for it in the immediate upper enclosing scope, and so on, until it finds the variable.

If you specify an XMR variable that cannot be resolved in any parent scopes of the constraint/scope where it is used, VCS errors out and prints an error message.

## XMR Function Calls in Constraints

VCS supports XMR function calls in class constraints, inlined constraints, and `std::randomize`. You can refer to XMR functions with or without specifying the full hierarchical name. XMR functions can return and have as arguments all supported data types, including scalar data types, enums, arrays, and class objects.

---

## State Variable Index in Constraints

VCS supports the use of state variables as array indexes in constraints and inline constraints, in all applicable contexts. These state variables must evaluate to the same type required by the index type of the array to which they are addressed.

Note:

String-type state variables in array indexes are not supported.

VCS supports the set of expressions (operators and constructs) that also work with loop variables as array indices in constraints. The set of supported expressions is restricted in the sense that they must evaluate in the constraint framework.

---

## Runtime Check for State Versus Random Variables

VCS supports state variables for array indexes, but not random variables, so the tool performs runtime checks for the randomness of the variable. The randomness may be affected if the variable is aliased (due to object hierarchy, module hierarchy, or XMR). When this runtime check finds a random variable being used as an array index, the tool issues an error message.

To differentiate random versus state variables, VCS uses the following scheme:

- For `randomize` with a list of arguments (`std::randomize` or `obj.randomize`), variables or objects in the argument list are considered to be random. Variables or objects outside the list (and not aliased by the random objects) are considered to be state variables.

- For randomize without a list of arguments (`obj.randomize`) variables declared as non-random, or declared as random but with rand mode OFF, are considered to be state variables.
- 

## Array Index

The variable (or supported expression) used for an array index must be an integral data type. If the value of the expression or the state variable evaluates out of bounds, comes to a negative index value, references a non-existent array member, or contains X or Z, VCS issues a runtime error message.

---

## Using Soft Constraints in SystemVerilog

Input stimulus randomization in SystemVerilog is controlled by user-specified constraints. If there is a conflict between two or more constraints, the randomization fails.

To solve this problem, you can use soft constraints. Soft constraints are constraints that VCS disables if they conflict with other constraints.

VCS use a deterministic, priority-based mechanism to disable soft constraints. When there is a constraint conflict, VCS disables any soft constraints in reverse order of priority (that is, the lowest priority soft constraint is disabled first) until the conflict is resolved. The following sections explain how to use soft constraints with VCS:

- “[Using Soft Constraints](#)” on page 27
- “[Soft Constraint Prioritization](#)” on page 28

- “Soft Constraints Defined in Classes Instantiated as rand Members in Another Class” on page 29
  - “Soft Constraints Inheritance Between Classes” on page 31
  - “Soft Constraints in AOP Extensions to a Class” on page 32
  - “Soft Constraints in View Constraints Blocks” on page 34
  - “Discarding Lower-Priority Soft Constraints” on page 34
- 

## Using Soft Constraints

Use the `soft` keyword to identify soft constraints. Constraints not defined as soft constraints are hard constraints. [Example 14-2](#) shows a soft constraint.

### *Example 14-2 Soft Constraint*

```
class A;
 rand int x;
constraint c1 {
 soft x > 2; // soft constraint
}
endclass
```

[Example 14-3](#) shows a hard constraint.

### *Example 14-3 Hard Constraint*

```
class A;
 rand int x;
constraint c1 {
 x > 2; // hard constraint
}
endclass
```

---

## Soft Constraint Prioritization

VCS determines the priorities of soft constraints according to the set of rules described in this section. In general, VCS assigns increasing priorities to soft constraints as they climb the following list:

- Class parents in the inheritance graph
- Class members
- Soft constraints in the class itself
- Soft constraints in any `extends` blocks applied to a class

In this schema, soft constraints in any `extends` blocks applied to a class are assigned the highest priority.

In this documentation, we use the following notation to describe the priority of a given soft constraint (SC):

`priority(SCx)`

If the following is true:

`priority(SC2) > priority(SC1)`

then VCS disables constraint SC1 before constraint SC2 when there is a conflict.

## Within a Single Class

VCS assigns soft constraints declared within a class increasing priority by order of declaration. Soft constraints that appear later in the class body have higher priority than soft constraints that appear earlier in the class body.

For example, in [Example 14-4](#), priority(SC2) > priority(SC1).

*Example 14-4 SC2 Higher Priority than SC1*

```
class A;
 rand int x;
constraint c1 {
 soft x > 10; // SC1
 soft x > 5; // SC2
}
endclass
```

In [Example 14-5](#), priority(SC2) > priority(SC1).

*Example 14-5 SC2 Higher Priority than SC1*

```
class A;
 rand int x;
constraint c1 {
 soft x > 10; // SC1
}
constraint c2 {
 soft x > 5; // SC2
}
endclass
```

---

## Soft Constraints Defined in Classes Instantiated as rand Members in Another Class

VCS assigns soft constraints declared within rand members of classes increasing priority by order of member declaration. In [Example 14-6 on page 30](#), the soft constraints contributed by C.objB are higher priority than the soft constraints contributed by C.objA because C.objB is declared after C.objA within class C.

[Example 14-6 on page 30](#) also shows why some soft constraints are dropped, instead of honored, because of the relative priorities assigned to soft constraints:

- // objC.x = 4 because SC6 is honored.
- // objC.objA.x = 4 because priority(SC4) > priority(SC1).

Here, SC4 is honored and SC1 is dropped. If SC1 were not dropped, it would have caused a conflict because objA.x cannot be 4 (objC.x in SC4) and 2 (SC1) at the same time.

- // objC.objB.x = 5 because priority(SC5) > priority(SC3) > priority(SC2).

Here, SC5 is honored and SC3 is dropped (otherwise, SC3 would conflict with SC5). SC2 is honored because it does not conflict with SC5. By honoring SC2, objC.objB.x = 5.

#### *Example 14-6 SC3 Higher Priority than SC2 and SC1*

```
class A;
 rand int x;
 constraint c1 { soft x == 2; } // SC1
endclass

class B;
 rand int x;
 constraint c2 { soft x == 5; } // SC2
 constraint c3 { soft x == 3; } // SC3
endclass

class C;
 rand int x;
 rand A objA;
 rand B objB;
 constraint c4 { soft x == objA.x; } // SC4
 constraint c5 { soft objA.x < objB.x; } // SC5
 constraint c6 { soft x == 4; } // SC6
```

```

function
 new(); objA = new; objB = new;
endfunction
endclass

program test;
 C objC;
 initial begin
 objC = new;
 objC.randomize();
 $display(objC.x); // should print "4"
 $display(objC.objA.x); // should print "4"
 $display(objC.objB.x); // should print "5"
 end
endprogram

```

For array members where objects are allocated prior to randomization, priorities are assigned in increasing order by position in the array, where soft constraints in element N have lower priority than soft constraints in element N+1.

For array members where the objects are allocated during randomization, all soft constraints in allocated objects and their base classes and member classes have the same priority.

## Soft Constraints Inheritance Between Classes

Soft constraints in an inherited class have a higher priority than soft constraints in its base class. For example, in [Example 14-7](#), priority(SC2) > priority(SC1).

### *Example 14-7 SC2 Higher Priority than SC1*

```

class A;
 rand int x;
 constraint c1 {
 soft x > 2; // SC1

```

```

 }
endclass

class B extends A;
 constraint c1 {
 soft x > 3; // SC2
 }
endclass

```

---

## Soft Constraints in AOP Extensions to a Class

VCS assigns soft constraints added to a class through an `extends` construct higher priority than soft constraints already in the class. For example, in [Example 14-8](#), `priority(SC2) > priority(SC1)`.

### *Example 14-8 SC2 Higher Priority than SC1*

```

class A;
 rand int x;
 constraint c1 {
 soft x > 2; // SC1
 }
endclass

extends A_aop1(A);
 constraint c2 {
 soft x > 3; // SC2
 }
endextends

```

VCS assigns priorities to multiple soft constraints in a single `extends` block in the same manner as in a class.

By default, VCS assigns `extends` blocks appearing later in a given file higher priority than those appearing earlier. The prioritization between `extends` blocks in different files depends on compilation order.

You can explicitly define priorities between `extends` blocks using the `dominates` keyword. If `extends` block A is described as explicitly dominating `extends` block B, then the constraints in A have higher priority than those in B. For example, in [Example 14-9](#), `priority(SC5) > priority(SC4) > priority(SC3) > priority(SC2) > priority(SC1)`.

*Example 14-9 SC5 Higher Priority than SC1*

```
class A;
 rand int x;
 constraint c1 {
 soft x > 2; // SC1
 }
endclass

extends A_aop2(A) dominates (A_aop1);
constraint c3 {
 soft x > 4; // SC3
}
constraint c4 {
 soft x == 5; // SC4
}
endextends

extends A_aop4(A);
constraint c5 {
 soft x == 5; // SC5
}
endextends

extends A_aop1(A);
constraint c2 {
 soft x > 3; // SC2
}
endextends
```

---

## Soft Constraints in View Constraints Blocks

VCS assigns soft constraints within a view constraint block increasing priority by order of declaration. Soft constraints that appear later have higher priority than those that appear earlier. For example, in [Example 14-10](#), priority(SC3) > priority(SC2) > priority(SC1).

### *Example 14-10 SC3 Higher Priority than SC1*

```
class A;
 rand int a;
 rand int b;
 constraint c1 {
 soft a == 2; // SC1
 }
endclass

A objA;
objA.randomize () with {
 soft a > 2; // SC2
 soft b == 1; // SC3
}
```

---

## Discarding Lower-Priority Soft Constraints

You can use a disable soft constraint to discard lower-priority soft constraints, even when they are not in conflict with other constraints (see [Example 14-11](#)).

### *Example 14-11 Discarding Lower-Priority Soft Constraints*

```
class A;
rand int x;
constraint A1 {soft x == 3;}
constraint A2 {disable soft x;} // discard soft constraints
constraint A3 {soft x inside {1, 2};}
```

```

endclass
initial begin
A a= new();
a.randomize();
end

```

In [Example 14-11](#), constraint A2 tells the solver to discard all soft constraints of lower priority on random variable x. This results in constraint A1 being discarded. Now, only the last constraint (A3) needs to be honored. This example results in random variable x taking the values 1 and 2.

A disable soft constraint causes lower-priority soft constraints to be discarded even when they are not in conflict with other constraints. This feature allows you to introduce fresh soft constraints which replace default values specified in preceding soft constraints (see [Example 14-12](#)).

#### *Example 14-12 Specifying Fresh Soft Constraints*

```

class B;
rand int x;
constraint B1 {soft x == 5;}
constraint B2 {disable soft x; soft x dist {5, 8};}
endclass
initial begin
B b = new();
b.randomize();
end

```

In [Example 14-12](#), the disable soft constraint preceding the soft dist in block B2 causes the lower-priority constraint on variable x in block B1 to be discarded. Now, the solver assigns the values 5 and 8 to x with equal distribution (the result from the fresh constraint: soft x dist {5, 8}).

Compare the behavior of [Example 14-12](#) with [Example 14-13](#), where the disable soft constraint is omitted.

### *Example 14-13 Specifying Additional Soft Constraints*

```
class B;
rand int x;
constraint B1 {soft x == 5;}
constraint B3 {soft x dist {5, 8};}
endclass
initial begin
B b = new();
b.randomize();
end
```

In [Example 14-13](#), the soft dist constraint in block B3 can be satisfied with a value of 5, so the solver assigns x the value 5. If you want the distribution weights of a soft dist constraint to be satisfied regardless of the presence of lower-priority soft constraints, you should first use a disable soft to discard those lower-priority soft constraints.

---

## Using DPI Function Calls in Constraints

VCS supports calling DPI functions directly from constraints. These DPI function calls must be pure and cannot have any side effects, as per the SystemVerilog LRM (Section 18.5.11 of Std. 1800-2009). For more information on DPI function call contexts (pure and non-pure), see Section 35 of the SystemVerilog LRM.

Following are some examples of valid import DPI function declarations that you can call from constraints:

```
import "DPI-C" pure function int func1();
import "DPI-C" pure function int func2(int a, int b);
```

[Example 14-14](#) shows a pure DPI function in C.

*Example 14-14 Pure DPI Function in C*

```
#include <svdpi.h>

int dpi_func (int a, int b) {
 return (a+b); // Result depends solely on its inputs.
}
```

[Example 14-15](#) shows how to call a pure DPI function from constraints.

*Example 14-15 Invoking a Pure DPI Function from Constraints*

```
import "DPI-C" pure function int dpi_func(int a, int b);
class C;
 rand int ii;
 constraint cstr {
 ii == dpi_func(10, 20);
 }
endclass

program tb;
initial begin
 C cc;
 cc = new;
 cc.randomize();
end
endprogram
```

---

## Invoking Non-pure DPI Functions from Constraints

VCS issues an error message when it detects a call to any context DPI function or other import DPI function for which the context is not specified or the import property is not specified as `pure`. VCS issues

this error even if the DPI function actually has no side effects. To prevent this kind of error, explicitly mark the DPI function import declaration with the `pure` keyword.

For example, running [Example 14-16](#) with the C code shown in [Example 14-14 on page 37](#) results in an error because the import DPI function is not explicitly marked as `pure`.

*Example 14-16 Invoking a DPI Function Not Marked pure from Constraints.*

```
import "DPI-C" function int dpi_func(int a, int b);
// Error: Only functions explicitly marked as
// pure can be called from constraints

class C;
 rand int ii;
 constraint cstr {
 ii == dpi_func(10, 20);
 }
endclass

program tb;
initial begin
 C cc;
 cc = new;
 cc.randomize();
end
endprogram
```

Similarly, running [Example 14-17](#) with the C code shown in [Example 14-14 on page 37](#) results in an error because context import DPI functions cannot be called from constraints.

*Example 14-17 Invoking a context DPI Function from Constraints*

```
import "DPI-C" context function int dpi_func(int a, int b);

// Error: Calling 'context' DPI function
// from constraint is illegal.
```

```

class C;
 rand int ii;
 constraint cstr {
 ii == dpi_func(10, 20);
 }
endclass

program tb;
initial begin
 C cc;
 cc = new;
 cc.randomize();
end
endprogram

```

Calling an import DPI function that is explicitly marked `pure` (as shown in [Example 14-14 on page 37](#)) has undefined behavior if the actual implementation of the function does things that are not pure, such as:

- Calling DPI exported functions/tasks.
- Accessing SystemVerilog data objects other than the function's actual arguments (for example, via VPI calls).

For example, [Example 14-18](#) has undefined behavior (and may even cause a crash).

#### *Example 14-18 Non-pure DPI Function in C*

```

#include <stdio.h>
#include <stdlib.h>
#include "svdpi.h"

int readValueOfFile(char * file) {
 int result = 0;
 char * buf = NULL;
 FILE * fp = fopen(file, "r");

 // Read the content of the file in 'buf' here...

```

```

 ...
 if (buf) return strlen(buf);
 else return 0;
}

int dpi_func () {

 char * str = getenv("ENV_VAL_OF_A");
 int a = str ? atoi(str) : -1;
 int b = readValueOfFile("/some/file");
 int c;

 svScope scp = svGetScopeFromName("$unit");
 if (scp == NULL) {
 fprintf(stderr, "FATAL: Cannot set scope to $unit\n");
 exit(-1);
 }
 svSetScope(scp);

 c = export_dpi_func();
 return (a+b+c);
}

```

[Example 14-19](#) shows a DPI function marked `pure` that is actually doing non-pure activities. This results in an error.

#### *Example 14-19 DPI Function Marked `pure` but Non-pure Activities*

```

import "DPI-C" pure function int dpi_func();
export "DPI-C" function export_dpi_func;

function int export_dpi_func();
 return 10;
endfunction

class C;
 rand int ii;
 constraint cstr {
 ii == dpi_func();
 }

```

```
endclass

program tb;
initial begin
 C cc;
 cc = new;
 cc.randomize();
end
endprogram
```

So make sure that DPI functions called from constraints explicitly use the `pure` keyword. Also make sure that the DPI function corresponding foreign language implementation is indeed pure (that is, has no side effects).

---

## Using Foreach Loops Over Packed Dimensions in Constraints

VCS supports foreach loops over the following kinds of packed dimensions in constraints:

- “[Memories with Packed Dimensions](#)” on page 42
- “[MDAs with Packed Dimensions](#)” on page 43

You do not need to set any special compilation or runtime switches to make this work. VCS supports foreach loop variables for entirely packed dimensions of an array. For more information, see the section “[The foreach Iterative Constraint for Packed Arrays](#)” on page 44.

---

## Memories with Packed Dimensions

You can use foreach loops over memories with single or multiple packed dimensions, as shown in the following examples.

### Single Packed Dimension

```
class C;
 rand bit [5:2] arr [2];
 constraint Cons {
 foreach(arr[i,j]) {
 arr[i][j] == 1;
 }
 }
endclass
```

### Multiple Packed Dimensions

```
class C;
 rand bit [3:1][5:2] arr [2];
 constraint Cons {
 foreach(arr[i,j,k]) {
 arr[i][j][k] == 1;
 }
 }
endclass
```

---

## MDAs with Packed Dimensions

You can use foreach loops over MDAs with single or multiple packed dimensions, as shown in the following examples.

### Single Packed Dimension

```
class C;
 rand bit [5:2] arr [2][3];
 constraint Cons {
 foreach(arr[i,j,k]) {
 arr[i][j][k] == 1;
 }
 }
endclass
```

### Multiple Packed Dimensions

```
class C;
 rand bit [-1:1][5:2] arr [2][3];
 constraint Cons {
 foreach(arr[i,j,k,l]) {
 arr[i][j][k][l] == 1;
 }
 }
endclass
```

### Just Packed Dimensions

```
class C;
rand bit [5:2] arr1;
rand bit [-1:0][5:2] arr2;
constraint Cons1 {
foreach(arr1[i]) {
arr1[i] == 1;
}
}
```

```

Constraint Cons2 {
 foreach(arr2[i,j]) {
 arr2[i][j] == 1;
 }
}
endclass

```

VCS does not create implicit constraints that guarantee the array indexed by the variable (or expression) is valid. You must properly constrain or set the variable value so that the array is correctly addressed.

VCS also supports associative array indices. The indexes of these arrays may be integral data types or strings if the associative array is string-indexed. However, you cannot use expressions for associative arrays.

## **The `foreach` Iterative Constraint for Packed Arrays**

VCS has implemented `foreach` loop variables for entirely packed dimensions of an array in the constraint context.

In previous releases up to 2011.12-2, a `foreach` loop for the dimensions of a multi-dimensional array in the constraint context required that at least one of the dimensions be unpacked. That restriction is removed, a multi-dimensional packed array in the constraint context is now fully supported.

The following code example illustrates this implementation.

### *Example 14-20 The foreach Iterative Constraint for Packed Arrays*

```
program prog;
 class my_class;
 rand reg [2] [2] [2] [2] arr;
 constraint constr {
 foreach (arr[i,j,k,l]) {
 (i==0) -> arr [i] [j] [k] [l] == 1;
 (i==1) -> arr [i] [j] [k] [l] == 0;
 }
 }
 endclass
endprogram
```



all dimensions packed

In previous releases at least one of the dimensions of MDA array needed to be unpacked.

This code example results in the following error message in previous releases:

```
Error- [NYI-UFAIFE] NYI constraint: packed dimensions
doc_ex.sv,9
prog, "this.arr"
 arr has only packed dimensions and no unpacked dimensions.
 Foreach over packed dimensions is supported if the object
has at least one
 unpacked dimension.

1 error
```

Starting with release F-2011.12-3 and G-2012.09, entirely packed arrays in the constraint context are not an error condition and do not result in this error message.

---

## Randomized Objects in a Structure

VCS has implemented randomized objects in a structure. The following code example illustrates this implementation.

*Example 14-21 Randomized Object in a Structure*

```
program test;

 class packet;
 randc int addr = 1;
 int crc;
 rand byte data [] = {1,2,3,4};
 endclass
 class packet_test;
 typedef struct {
 rand packet p1; ← randomized object
 } header; in a structure
 header hd;
 endclass

 function new();
 this.hd.p1 = new;
 endfunction

 endclass

 packet_test pt = new;

 initial begin
 pt.randomize(hd);
 end
endprogram
```

In previous releases declaring this class in a structure with the `rand` type-modifier keyword resulted in the following error message:

```
Error- [SV-NYI-CRUDST] Rand class object under structure
code_ex_rand_struct.sv, 10
"p1"
Rand class objects which defined under structure is not
yet supported.
1 error
```

This code example compiles and runs without any errors since rand class objects inside a structure are implemented.

# 15

## Extensions for SystemVerilog Coverage

---

The extensions for SystemVerilog coverage include the following:

- “Support for Reference Arguments in `get_coverage()`”
- “Functional Coverage Methodology Using the SystemVerilog C/C++ Interface”

---

### Support for Reference Arguments in `get_coverage()`

The Systemverilog LRM provides several pre-defined methods for every covergroup, coverpoint, or cross. See “Predefined Coverage Methods” in Clause 18 of the *SystemVerilog Language Reference Manual for VCS/VCS MX* for information. Two of these pre-defined methods, `get_coverage()` and `get_inst_coverage()`, support optional arguments.

You can use the `get_coverage()` and `get_inst_coverage()` predefined methods to query on coverage during the simulation run, so that you can react to the coverage statistics dynamically.

The `get_coverage()` and `get_inst_coverage()` methods both accept, as optional arguments, a pair of integer values passed by reference.

---

### **get\_inst\_coverage() method**

When the optional arguments are entered with the method in coverpoint scope or cross scope, the `get_inst_coverage()` method assigns to the first argument the value of the covered bins, and assigns to the second argument the number of bins for the given coverage item. These two values correspond to the numerator and the denominator used for calculating the coverage score (before scaling by 100).

In covergroup scope, the `get_inst_coverage()` method assigns to the first argument the weighted sum of coverpoint and cross coverage, rounded to the nearest integer, and assigns to the second argument the sum of the weights of the coverpoint or cross items.

---

### **get\_coverage() method**

The numerator and denominator assigned by the `get_coverage()` method depend on the scope.

In covergroup scope, `get_coverage()` assigns to its first argument the weighted sum of the coverage of merged coverpoints and crosses.

In coverpoint or cross scope the first argument to `get_coverage()` is assigned the number of covered bins in the merged coverpoint or cross, and the second argument is assigned the total number of bins.

In all cases, weighted sums are rounded to the nearest integer and the second argument is set to the sum of weights.

---

## Functional Coverage Methodology Using the SystemVerilog C/C++ Interface

This section describes a SystemVerilog-based functional coverage flow. The flow supports functional coverage features—data collection, reporting, merging, grading, analysis, GUI, and so on.

The SystemVerilog functional coverage flow has the following features:

- Performs RTL coverage using covergroups and cover properties.
- Performs C coverage using covergroups.
- Integrates easily with the existing testbench environment.
- Provides coverage analysis capabilities — reporting, grading merging, and GUI.
- Has no negative impact on RTL simulation performance.

Functional coverage is very important in verifying correct functionality of a design. SystemVerilog natively supports functional coverage in RTL code.

However, because C/C++ code is now commonly used in a design (with PLI, DPI, DirectC, and so on), there is no systematic approach to verify the functionality of C/C++.

The SystemVerilog C/C++ interface feature provides an application programming interface (API) so that C/C++ code can use the SystemVerilog functional coverage infrastructure to verify its coverage.

**Note:**

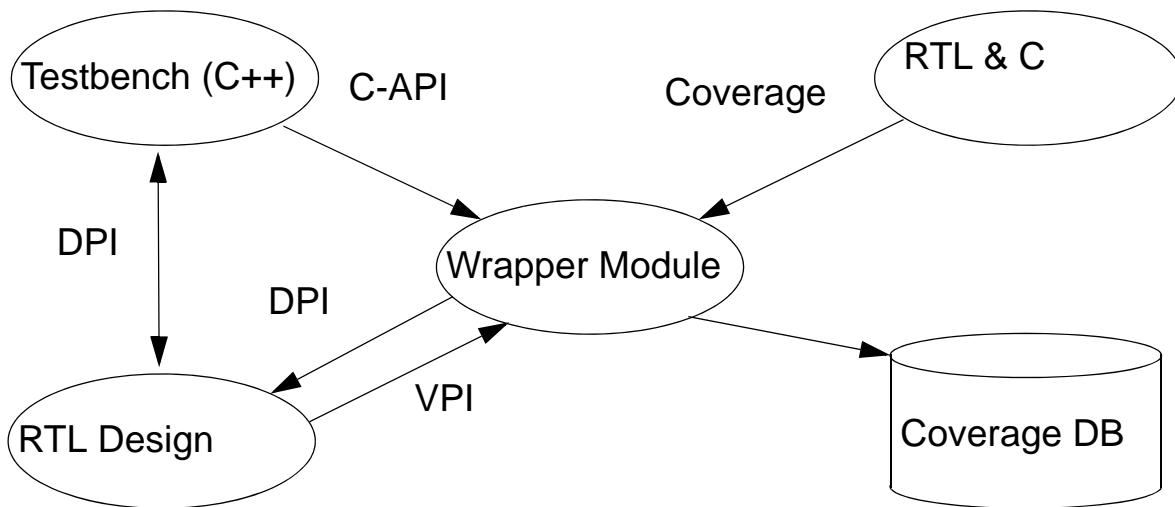
When you use the SystemVerilog C/C++ interface feature, you need include the header file `svCovgAPI.h`.

---

## **SystemVerilog Functional Coverage Flow**

[Figure 15-1](#) illustrates the functional coverage flow:

Figure 15-1 SystemVerilog C/C++ Functional Coverage Flow



DPI is the SystemVerilog Direct Programming Interface. See “SystemVerilog DPI” in the *SystemVerilog Language Reference Manual* for VCS/VCS MX for details and examples of using DPI.

VPI is the Verilog Procedural Interface. See “SystemVerilog VPI Object Model” in the *SystemVerilog Language Reference Manual* for VCS/VCS MX for information about using VPI with SystemVerilog.

Covergroups are defined in SystemVerilog, and then they are used to track the functional coverage of C/C++ code through the C-API (C Application Programming Interface). There are two major parts to C/C++ functional coverage interface:

- Covergroup(s)
- The C/C++ testbench using those covergroups

---

## Covergroup Definition

The following section lists the covergroup limitations for C/C++ functional coverage. Covergroups

- Cannot have a sampling clock.
- Must be declared in \$unit.
- Cannot be inside another scope (for example, modules, programs, and so on).
- Must not be instantiated anywhere in else SystemVerilog code.
- Arguments can only be in int, enum (base type int), and bit vector types. The SystemVerilog-to-C data-type mapping is compliant with DPI. [Table 15-1](#) shows the mapping of the supported types:

*Table 15-1 SystemVerilog-to-C Data-Type Mapping by DPI*

| SystemVerilog | C             |
|---------------|---------------|
| int           | int           |
| bit           | unsigned char |
| bit [m:n]     | svBitVec32    |
| enum int      | int           |

- Definitions must appear in files that are separate from the DUT because the definitions are compiled separately with the VCS command-line option -c\_covg.

After you define the covergroups, compile them with -c\_covg (that is, -c\_covg <covergroup\_file>). If you have multiple covergroup files, you must precede each of them with the -c\_covg option (that is, -c\_covg <cov\_file1> -c\_covg <cov\_file2> ...).

The options `-sverilog` and `+vpi` are also needed when compiling with `-c_covg`.

After compiling the covergroups to be used with C/C++, the C-API allows for the allocation of covergroup handles, manual triggering of the covergroup sample, and the ability to de-instance and free the previously declared covergroup handle.

The following is a list of the C-API functions:

- `svCovgNew / svCovgNew2`
- `svCovgSample / svCovgSample2`
- `svCovgDelete`

Detailed specifications for these functions appear in “[C/C++ Functional Coverage API Specification](#)” .

The following examples demonstrate the use model.

## SystemVerilog (Covergroup for C/C++): covg.sv

```
cp: coverpoint count {
 bins b = {data};
 ...
}
endgroup
```

## C Testbench: test.c

```
int my_c_testbench ()
{
 svCovgHandle cgh;
 // C variables
 int data;
 int count;
```

## Approach #1: Passing Arguments by Reference

```
// Create a covergroup instance; pass data as a value
// parameter and count as a reference parameter;
// coverage handle remembers references
cgh = svCovgNew("cg", "cg_inst", SV_SAMPLE_REF, data,
&count);

// Sample stored references
svCovgSample(cgh); // sampling by the stored reference
...

// Delete covergroup instance
svCovgDelete(cgh);
```

## Approach #2: Passing Arguments by Value

```
// Create a covergroup instance; pass data and count as
// value parameters
cgh = svCovgNew("cg", "cg_inst", SV_SAMPLE_VAL, data,
count);

// Sample values passed for covergroup ref arguments
svCovgSample(cgh, count); // sampling the value of count
...

// Delete covergroup instance
svCovgDelete(cgh);
```

## Compile Flow

Compile the coverage model (`covg.sv`) using `-c_covg` together with the design and the C testbench

This step assumes that you invoke the C testbench from the design `dut.sv` through some C interface (for example, DPI, PLI, and so on). For example:

```
vcs -sverilog dut.sv test.c -c_covg +vpi covg.sv
```

## Runtime

At runtime (executing `simv`), the functional coverage data is collected and stored in the coverage database.

---

## C/C++ Functional Coverage API Specification

This section gives detailed specifications for the C/C++ functional coverage C-API.

**`svCovgHandle svCovgNew (char* cgName, char* ciName, int refType, args ...);`**

**`svCovgHandle svCovgNew2 (char* cgName, char* ciName, int refType, va_list v);`**

### Parameters

*cgName*

Covergroup name.

*ciName*

Covergroup instance name (should be unique).

*refType*

`SV_SAMPLE_REF` or `SV_SAMPLE_VAL`.

*args...*

A variable number of arguments for creating a new covergroup instance.

*vl*

Represents a C predefined data structure (`va_list`) for maintaining a list of arguments.

## Description

Create a covergroup instance using the covergroup and instance names. If no error, return `svCovgHandle`, otherwise return NULL. The C variable sampling type (either reference or value) is specified using `refType`. The sampling type is stored in `svCovgHandle`. The `svCovgNew2` function is similar to `svCovgNew` except that you provide it with a `va_list`, instead of a variable number of arguments (represented by "...") to `svCovgNew`.

For value sampling, pass values for non-reference and reference arguments in the order specified in the covergroup declaration, and set `refType` to `SV_SAMPLE_VAL`.

For reference sampling, pass values for non-reference arguments and addresses for reference arguments in the order specified in the covergroup declaration. References must remain valid during the life of the covergroup instance. Set `refType` to `SV_SAMPLE_REF`.

Type checking is not performed for arguments. It is your responsibility to pass correct values and addresses.

**int svCovgSample(svCovgHandle *ch*, args ...);**

**int svCovgSample2(svCovgHandle *ch*, va\_list *vl*);**

## Parameters

*ch*

Handle to a covergroup instance created by `svCovgNew()`.

*args*

A variable number of arguments for sampling a covergroup by value, if `refType = SV_SAMPLE_VAL` in `svCovgNew()`.

*vl*

Represents a C predefined data structure (`va_list`) for maintaining a list of arguments.

## Description

Sample a covergroup instance using the sampling style stored in `svCovgHandle` and return 1 (TRUE) if no error, otherwise return 0 (FALSE). The `svCovgSample2` function is similar to `svCovgSample` except that you provide a `va_list`, instead of a variable number of arguments (represented by "..."), to `svCovgSample`.

For value sampling, provide values for reference arguments in the order specified in the covergroup declaration. Type checking is not performed for value arguments. It is your responsibility to pass correct values.

For reference sampling, use stored addresses for reference arguments in `svCovgHandle`.

**int svCovgDelete(svCovgHandle *ch*);**

## Parameters

*ch*

Handle to a covergroup instance created by `svCovgNew()` (or `svCovgNew2`).

## **Description**

Delete a covergroup instance and return 1 (TRUE) if no error, otherwise return 0 (FALSE).

# 16

## OpenVera-SystemVerilog Testbench Interoperability

---

The primary purpose of OpenVera-SystemVerilog interoperability in VCS Native Testbench is to enable you to reuse OpenVera classes in new SystemVerilog code without rewriting OpenVera code into SystemVerilog.

This chapter describes:

- “[Scope of Interoperability](#)”
- “[Importing OpenVera types into SystemVerilog](#)”

Using the SystemVerilog package import syntax to import OpenVera data types and constructs into SystemVerilog.

- “Data Type Mapping”

The automatic mapping of data types between the two languages as well as the limitations of this mapping (some data types cannot be directly mapped).

- “Connecting to the Design”

Mapping of SystemVerilog modports to OpenVera where they can be used as OpenVera virtual ports.

- “Notes to Remember”

- “Usage Model”

- “Limitations”

---

## Scope of Interoperability

The scope of OpenVera-SystemVerilog interoperability in VCS Native Testbench is as follows:

- Classes defined in OpenVera can be used directly or extended in SystemVerilog testbenches.
- Program blocks must be coded in SystemVerilog. The SystemVerilog interface can include constructs like modports and clocking blocks to communicate with the design.
- OpenVera code must not contain program blocks, bind statements, or predefined methods. It can contain classes, enums, ports, interfaces, tasks, and functions.

- OpenVera code can use virtual ports for sampling, driving, or waiting on design signals that are connected to the SystemVerilog testbench.

## Importing OpenVera types into SystemVerilog

OpenVera has two user-defined types: enums and classes. These types can be imported into SystemVerilog by using the SystemVerilog package import syntax:

```
import OpenVera::openvera_class_name;
import OpenVera::openvera_enum_name;
```

Allows one to use `openvera_class_name` in SystemVerilog code in the same way as a SystemVerilog class. This includes the ability to:

- Create objects of type `openvera_class_name`
- Access or use properties and types defined in `openvera_class_name` or its base classes
- Invoke methods (virtual and non-virtual) defined in `openvera_class_name` or its base classes
- Extend `openvera_class_name` to SV classes

However, this does not import the names of base classes of `openvera_class_name` into SystemVerilog (that requires an explicit import). For example:

```
// OpenVera
 class Base {
 .
 .
 }
```

```

 .
 .
 .
 }
 virtual task (arguments) {
 .
 .
 .
 }
class Derived extends Base {
 virtual task vfoo(arguments) {
 .
 .
 .
 }
}

// SystemVerilog
import OpenVera::Derived;
Derived d = new; // OK
initial begin
 d.foo(); // OK (Base::foo automatically
 // imported)
 d.vfoo(); // OK
end
Base b = new; // not OK (don't know that Base is a
 // class name)

```

The previous example would be valid if you add the following line before the first usage of the name Base.

```
import OpenVera::Base;
```

Continuing with the previous example, SystemVerilog code can extend an OpenVera class as shown below:

```
// SystemVerilog
import OpenVera::Base;
```

```

class SVDerived extends Base;
 virtual task vmt()
 begin
 .
 .
 .
 end
 endtask
endclass

```

**Note:**

- If a derived class redefines a base class method, the arguments of the derived class method must exactly match the arguments of the base class method.
- Explicit import of each data type from OpenVera can be avoided by a single `import OpenVera::*;`

```

// OpenVera
 class Base {
 integer i;
 .
 .
 .
 }
 class wrappedBase {
 public Base myBase;
 }
// SystemVerilog
 import OpenVera::wrappedBase;
 class extendedWrappedBase extends wrappedBase;
 .
 .
 .
 endclass

```

In this example, `myBase.i` can be used to refer to this member of `Base` from the SV side. However, if SV also needs to use objects of type `Base`, then you must include:

```
import OpenVera::Base;
```

---

## Data Type Mapping

This section describes how various data types in SystemVerilog are mapped to OpenVera and vice-versa:

- *Direct mapping:* Many data types have a direct mapping in the other language and no conversion of data representation is required. In such cases, we say that the OpenVera type is equivalent to the SystemVerilog type.
- *Implicit conversion:* In other cases, VCS performs implicit type conversion. The rules of inter-language implicit type conversion follows the implicit type conversion rules specified in SystemVerilog LRM. To apply SystemVerilog rules to OpenVera, the OpenVera type must be first mapped to its equivalent SystemVerilog type. For example, there is no direct mapping between OpenVera `reg` and SystemVerilog `bit`. But `reg` in OpenVera can be directly mapped to `logic` in SystemVerilog. Then the same implicit conversion rules between SystemVerilog `logic` and SystemVerilog `bit` can be applied to OpenVera `reg` and SystemVerilog `bit`.
- *Explicit translation:* In the case of mailboxes and semaphores, the translation must be explicitly performed by the user. This is because in OpenVera, mailboxes and semaphores are represented by `integer` *ids* and VCS cannot reliably determine if an `integer` value represents a mailbox *id*.

---

## Mailboxes and Semaphores

Mailboxes and semaphores are referenced using object handles in SystemVerilog whereas in OpenVera they are referenced using integral *ids*.

VCS supports the mapping of mailboxes between the two languages.

For example, consider a mailbox created in SystemVerilog. To use it in OpenVera, you need to get the *id* for the mailbox somehow. The `get_id()` function, available as a VCS extension to SV, returns this value:

```
function int mailbox::get_id();
```

It will be used as follows:

```
// SystemVerilog
mailbox mbox = new;
int id;
.
.
.
id = mbox.get_id();
.
.
.
foo.vera_method(id);

// OpenVera
class Foo {
.
.
.
task vera_method(integer id) {
```

```

.
.
void = mailbox_put(data_type mailbox_id,
 data_type variable);
}
}

```

Once OpenVera gets an *id* for a mailbox/semaphore it can save it into any `integer` type variable. Note that however if `get_id` is invoked for a mailbox, the mailbox can no longer be garbage collected because VCS has no way of knowing when the mailbox ceases to be in use.

Typed mailboxes (currently not supported), when they are supported in SystemVerilog can be passed to OpenVera code using the same method as untyped mailboxes above. However, if the OpenVera code attempts to put an object of incompatible type into a typed mailbox, a simulation error will result.

Bounded mailboxes (currently not supported), when they are supported in SystemVerilog can be passed to OpenVera code using the same method as above. OpenVera code trying to do `mailbox_put` into a full mailbox will result in a simulation error.

To use an OpenVera mailbox in SystemVerilog, you need to get a handle to the mailbox object using a system function call. The system function `$get_mailbox` returns this handle:

```
function mailbox $get_mailbox(int id);
```

It will be used as follows:

```
// SystemVerilog
.
.
.
```

```
mailbox mbox;
int id = foo.vera_method(); // vera_method returns an
 // OpenVera mailbox id
mbox = $get_mailbox(id);
```

Analogous extensions are available for semaphores:

```
function int semaphore::get_id();
function semaphore $get_semaphore(int id);
```

---

## Events

The OpenVera event data type is equivalent to the SystemVerilog event data type. Events from either language can be passed (as method arguments or return values) to the other language without any conversion. The operations performed on events in a given language are determined by the language syntax:

An event variable can be used in OpenVera in `sync` and `trigger`. An event variable `event1` can be used in SystemVerilog as follows:

```
event1.triggered //event1 triggered state property
->event1 //trigger event1
@(event1) //wait for event1
```

---

## Strings

OpenVera and SystemVerilog strings are equivalent. Strings from either language can be passed (as method arguments or return values) to the other language without any conversion. In OpenVera, `null` is the default value for a `string`. In SystemVerilog, the default

value is the empty string (""). It is illegal to assign null to a string in SystemVerilog. Currently, NTB-OV treats "" and null as distinct constants (equality fails).

---

## Enumerated Types

SystemVerilog enumerated types have arbitrary base types and are not generally compatible with OpenVera enumerated types. A SystemVerilog enumerated type will be implicitly converted to the base type of the enum (an integral type) and then the bit-vector conversion rules (section 2.5) are applied to convert to an OpenVera type. This is illustrated in the following example:

```
// SystemVerilog
typedef reg [7:0] formal_t; // SV type equivalent to
 // 'reg [7:0]' in OV
typedef enum reg [7:0] { red = 8'hff, blue = 8'hfe,
 green = 8'hfd } color;
// Note: the base type of color is 'reg [7:0]'
typedef enum bit [1:0] { high = 2'b11, med = 2'b01,
 low = 2'b00 } level;
color c;
level d = high;
Foo foo;
...
foo.vera_method(c); // OK: formal_t'(c) is passed to
 // vera_method.
foo.vera_method(d); // OK: formal_t'(d) is passed to
 // vera_method.
 // If d == high, then 8'b00000011 is
 // passed to vera_method.

// OpenVera
class Foo {
 ...
 task vera_method(reg [7:0] r) {
 ...
 }
}
```

The above data type conversion does not involve a conversion in data representation. An enum can be passed by reference to OpenVera code but the formal argument of the OpenVera method must exactly match the enum base type (for example: 2-to-4 value conversion, sign conversion, padding or truncation are not allowed for arguments passed by reference; they are OK for arguments passed by value).

Enumerated types with 2-value base types will be implicitly converted to the appropriate 4-state type (of the same bit length). See the discussion in 2.5 on the conversion of bit vector types.

OpenVera enum types can be imported to SystemVerilog using the following syntax:

```
import OpenVera::openvera_enum_name;
```

It will be used as follows:

```
// OpenVera
 enum OpCode { Add, Sub, Mul };

// System Verilog
 import OpenVera::OpCode;
 OpCode x = OpenVera::Add;

// or the enum label can be imported and then used
// without OpenVera::

 import OpenVera::Add;
 OpCode y = Add;
```

Note: SystemVerilog enum methods such as next, prev and name can be used on imported OpenVera enums.

Enums contained within OV classes are illustrated in the following example:

```

class OVclass{
 enum Opcode {Add, Sub, Mul};
}

import OpenVera::OVclass;
OVclass::Opcode SVvar;
SVvar=OVclass::Add;

```

---

## **Integers and Bit-Vectors**

The mapping between SystemVerilog and OpenVera integral types are shown in the following table:

| <b>SystemVerilog</b> | <b>OpenVera</b>    | <b>2/4 or 4/2 value conversion?</b> | <b>Change in sign?</b> |
|----------------------|--------------------|-------------------------------------|------------------------|
| integer              | integer            | N<br>(equivalent types)             | N (Both signed)        |
| byte                 | reg [7:0]          | Y                                   | Y                      |
| shortint             | reg [15:0]         | Y                                   | Y                      |
| int                  | integer            | Y                                   | N (Both signed)        |
| longint              | reg [63:0]         | Y                                   | Y                      |
| logic [m:n]          | reg [abs(m-n)+1:0] | N<br>(equivalent types)             | N (Both unsigned)      |
| bit [m:n]            | reg [abs(m-n)+1:0] | Y                                   | N (Both unsigned)      |
| time                 | reg [63:0]         | Y                                   | N (Both unsigned)      |

### **Note:**

If a value or sign conversion is needed between the actual and formal arguments of a task or function, then the argument cannot be passed by reference.

---

## Arrays

Arrays can be passed as arguments to tasks and functions from SystemVerilog to OpenVera and vice-versa. The formal and actual array arguments must have equivalent element types, the same number of dimensions with corresponding dimensions of the same length. These rules follow the SystemVerilog LRM.

- A SystemVerilog fixed array dimension of the form  $[m:n]$  is directly mapped to  $[\text{abs}(m-n)+1]$  in OpenVera.
- An OpenVera fixed array dimension of the form  $[m]$  is directly mapped to  $[m]$  in SystemVerilog.

Rules for equivalency of other (non-fixed) types of arrays are as follows:

- A dynamic array (or Smart queue) in OpenVera is directly mapped to a SystemVerilog dynamic array if their element types are equivalent (can be directly mapped).
- An OpenVera associative array with unspecified key type (for example `integer a []`) is equivalent to a SystemVerilog associative array with key type `reg [63:0]` provided the element types are equivalent.
- An OpenVera associative array with `string` key type is equivalent to a SystemVerilog associative array with `string` key type provided the element types are equivalent.

Other types of SystemVerilog associative arrays have no equivalent in OpenVera and hence they cannot be passed across the language boundary.

Some examples of compatibility are described in the following table:

| OpenVera        | SystemVerilog          | Compatibility |
|-----------------|------------------------|---------------|
| integer a[10]   | integer b[11:2]        | Yes           |
| integer a[10]   | int b[11:2]            | No            |
| reg [11:0] a[5] | logic [3:0] [2:0] b[5] | Yes           |

A 2-valued array type in SystemVerilog cannot be directly mapped to a 4-valued array in OpenVera. However, a cast may be performed as follows:

```
// OpenVera
 class Foo {
 .
 .
 .
 task vera_method(integer array[5]) {
 .
 .
 .
 .
 }
 }
// SystemVerilog
 int array[5];
 typedef integer array_t[5];
 import OpenVera::Foo;
 Foo f;
 .
 .
 .
 f.vera_method(array); // Error: type mismatch
 f.vera_method((array_t')array)); // OK
 .
 .
 .
```

---

## Structs and Unions

Unpacked structs/unions cannot be passed as arguments to OpenVera methods. Packed structs/unions can be passed as arguments to OpenVera: they will be implicitly converted to bit vectors of the same width.

```
packed struct { . . . } s in SystemVerilog is mapped to
reg [m:0] r in OpenVera where m == $bits(s).
```

Analogous mapping applies to unions.

---

## Connecting to the Design

---

### Mapping Modports to Virtual Ports

This section relies on the following extensions to SystemVerilog supported in VCS.

### Virtual Modports

VCS supports a *reference* to a modport in an interface to be declared using the following syntax.

```
virtual interface_name.modport_name virtual_modport_name;
```

For example:

```
interface IFC;
 wire a, b;
 modport mp (input a, output b);
endinterface
```

```

IFC i();
virtual IFC.mp vmp;
.
.
.
vmp = i.mp;

```

## Importing Clocking Block Members into a Modport

VCS allows a reference to a clocking block member to be made by omitting the clocking block name.

For example, in SystemVerilog a clocking block is used in a modport as follows:

```

interface IFC(input clk);
 wire a, b;
 clocking cb @(posedge clk);
 input a;
 input b;
 endclocking
 modport mp (clocking cb);
endinterface

program mpg(IFC ifc);
.
.
.
virtual IFC.mp vmp;
.
.
.
vmp = i.mp;
@(vmp.cb.a); // here we need to specify cb explicitly
.
endprogram
module top();
.

```

```

 IFC ifc(clk); // use this to connect to DUT and TB
 mpg mpg(ifc);
 dut dut(...);

 .
 .

endmodule

```

VCS supports the following extensions that allow the clocking block name to be omitted from vmp.cb.a.

```

// Example-1
interface IFC(input clk);
 wire a, b;
 clocking cb @(posedge clk);
 input a;
 input b;
 endclocking
 modport mp (import cb.a, import cb.b);
endinterface

program mpg(IFC ifc);
 .
 .
 .
 virtual IFC.mp vmp;
 .
 .
 .
 vmp = i.mp;
 @(vmp.a); // cb can be omitted; 'cb.a' is
 // imported into the modport

endprogram
module top();
 .
 .
 .
 IFC ifc(clk); // use this to connect to DUT and TB
 mpg mpg(ifc);
 dut dut(...);
 .

```

```

endmodule

// Example-2
interface IFC(input clk);
 wire a, b;
 bit clk;
 clocking cb @(posedge clk);
 input a;
 input b;
 endclocking
 modport mp (import cb.*); // All members of cb
 // are imported.
 // Equivalent to the
 // modport in
 // Example-1.
endinterface

program mpg(IFC ifc);
 .
 .
 .
 IFC i(clk);
 .
 .
 .
 virtual IFC.mp vmp;
 .
 .
 .
 vmp = i.mp;
 @(vmp.a); // cb can be omitted;
 //'cb.a' is imported into the modport
endprogram

module top();

```

```
endmodule
```

A SystemVerilog modport can be implicitly converted to an OpenVera virtual port provided the following conditions are satisfied:

- The modport and the virtual port have the same number of members.
- Each member of the modport converted to a virtual port must either be: (1) a clocking block, or (2) imported from a clocking block using the `import` syntax above.
- For different modports to be implicitly converted to the same virtual port, the corresponding members of the modports (in the order in which they appear in the modport declaration) be of bit lengths. If the members of a clocking block are imported into the modport using the `cb.*` syntax, where `cb` is a clocking block, then the order of those members in the modport is determined by their declaration order in `cb`.

## Example

```
// OpenVera
port P {
 clk;
 a;
 b;
}

class Foo {
 P p;
 task new(P p_) {
 p = p_;
 }

 task foo() {
 .
 .
 .
 }
}
```

```

 @(p.$clk) ;

 .
 variable = p.$b;
 p.$a = variable;
 .
 .
 .

 }

}

// SystemVerilog
interface IFC(input clk);
 wire a;
 wire b;

 clocking clk_cb @(clk);
 input #0 clk;
 endclocking

 clocking cb @ (posedge clk);
 output a;
 input b;
 endclocking

modport mp (import clk_cb.* , import cb.*); // modport
// can aggregate signals from multiple clocking blocks.

endinterface: IFC

program mpg(IFC ifc);
 import OpenVera::Foo;
 .

 .
 virtual IFC.mp vmp = ifc.mp;
 Foo f = new(vmp); // clocking event of ifc.cb mapped to
 // $clk in port P
 // ifc.cb.a mapped to $a in port P
 // ifc.cb.b mapped to $b in port P
 .
 f.foo();
 .

```

```

.
endprogram

module top();
.

IFC ifc(clk); // use this to connect to DUT and TB
mpg mpg(ifc);
dut dut(...);

.

endmodule

```

**Note:**

In the above example, you can also directly pass the `vmp` modport from an interface instance:

```
Foo f = new(ifc.mp);
```

## Semantic Issues with Samples, Drives, and Expects

When OpenVera code wants to sample a DUT signal through a virtual port (or interface), if the current time is not at the relevant clock edge, the current thread is suspended until that clock edge occurs and then the value is sampled. NTB-OV implements this behavior by default. On the other hand, in SystemVerilog, sampling never blocks and the value that was sampled at the most recent edge of the clock is used. Analogous differences exist for drives and expects.

---

## Notes to Remember

### Blocking Functions in OpenVera

When a SystemVerilog function calls a virtual function that may resolve to a blocking OpenVera function at runtime, the compiler cannot determine with certainty if the SystemVerilog function will block. VCS issues a warning at compile time and let the SystemVerilog function block at runtime.

Besides killing descendant processes in the same language domain, `terminate` invoked from OpenVera will also kill descendant processes in SystemVerilog. Similarly, `disable fork` invoked from SystemVerilog will also kill descendant processes in OpenVera. `wait_child` will also wait for SystemVerilog descendant processes and `wait fork` will also wait for OpenVera descendant processes.

### Constraints and Randomization

- SystemVerilog code can call `randomize()` on objects of an OpenVera class type.
- In SystemVerilog code, SystemVerilog syntax must be used to turn off/on constraint blocks or randomization of specific `rand` variables (even for OpenVera classes).
- Random stability will be maintained across the language domain.

```
//OV
class OVclass{
 rand integer ri;
 constraint cnst{...}
}
```

```
//SV
OVclass obj=new();
SVclass Svobj=new();
SVobj.randomize();
obj.randomize() with
{obj.ri==SVobj.var;};
```

## Functional Coverage

There are some differences in functional coverage semantics between OpenVera and SystemVerilog. These differences are currently being eliminated by changing OpenVera semantics to conform to SystemVerilog. In interoperability mode, `coverage_group` in OpenVera and `covergroup` in SystemVerilog will have the same (SystemVerilog) semantics. Non-embedded coverage group can be imported from Vera to SystemVerilog using the package `import` syntax (similar to classes).

Coverage reports will be unified and keywords such as `coverpoint`, `bins` will be used from SystemVerilog instead of OpenVera keywords.

Here is an example of usage of coverage groups across the language boundary:

```
// OpenVera
class A
{
 B b;
 coverage_group cg {
 sample x(b.c);
 sample y(b.d);
 cross cc1(x, y);
 sample_event = @(posedge CLOCK);
 }
 task new() {
 b = new;
 }
}
```

```

// SystemVerilog

import OpenVera::A;

initial begin
 A obj = new;
 obj.cg.option.at_least = 2;
 obj.cg.option.comment = "this should work";
 @(posedge CLOCK);
 $display("coverage=%f", obj.cg.get_coverage());
end

```

---

## Usage Model

Any `define from the OV code will be visible in SV once they are explicitly included.

Note:

OV #define must be rewritten as `define for ease of migration to SV.

## Compilation

```
% vcs [compile_options] -sverilog -ntb_opts interop
[other_NTB_options] file4.sv file5.vr file2.v file1.v
```

## Simulation

```
% simv [simv_options]
```

Note:

- If RVM class libs are used in the OV code, use -ntb\_opts rvm with vlog command line.
- Using -ntb\_opts interop -ntb\_opts rvm with vcs, automatically translates rvm\_ macros in OV package to vmm\_ equivalents.

---

## Limitations

- Classes extended/defined in SystemVerilog cannot be instantiated by OpenVera. OpenVera verification IP will need to be compiled with the NTB syntax and semantic restrictions. These restrictions are detailed in the *Native Testbench Coding Guide*, included in the VCS release.
- SystemVerilog contains several data types that are not supported in OpenVera including real, unpacked-structures, and unpacked-unions. OpenVera cannot access any variables or class data members of these types. A compiler error will occur if the OpenVera code attempts to access the undefined SystemVerilog data member. This does not prevent SystemVerilog passing an object to OpenVera, and then receiving it back again, with the unsupported data items unchanged.
- When using VMM RVM Interoperability, you should only register VMM or RVM scenarios with a generator in the same language. You can instantiate an OpenVera scenario in a SystemVerilog scenario, but only a SystemVerilog scenario can be registered with a SystemVerilog generator. You cannot register OpenVera Multi-Stream Scenarios on a SystemVerilog Multi-Stream Scenario Generator (MSSG).

# 17

## Using SystemVerilog Assertions

---

Using SystemVerilog Assertions (SVA) you can specify how you expect a design to behave and have VCS display messages when the design does not behave as specified.

```
assert property (@(posedge clk) req |-> ##2 ack)
 else $display ("ACK failed to follow the request);
```

The above example displays, "ACK failed to follow the request", if ACK is not high two clock cycles after req is high. This example is a very simple assertion. For more information on how to write assertions, refer to Chapter 17 of *SystemVerilog Language Reference Manual*.

VCS allows you to:

- Control the SVAs
- Enable or Disable SVAs

- Control the simulation based on the assertion results

This chapter describes the following:

- “Using SVAs in the HDL Design”
- “Controlling SystemVerilog Assertions”
- “Viewing Results”
- “Enhanced Reporting for SystemVerilog Assertions in Functions”
- “Controlling Assertion Failure Messages”

Note:

Synopsys recommends you to use the gcc compiler for Solaris platform.

---

## Using SVAs in the HDL Design

You can instantiate SVAs in your HDL design in the following ways:

- “Using Standard Checker Library”
- “Binding SVA to a Design”
- “Inlining SVAs in the Verilog Design”

---

## Using Standard Checker Library

VCS provides you SVA checkers, which can be directly instantiated in your Verilog source files. You can find these SVA checkers files in \$VCS\_HOME/packages/sva directory.

This section describes the usage model to compile and simulate the design with SVA checkers. For more information on SVA checker libraries and list of available checkers, see the *SystemVerilog Assertions Checker Library Reference Manual*.

## Instantiating SVA Checkers in Verilog

You can instantiate SVA checkers in your Verilog source just like instantiating any other Verilog module. For example, to instantiate the checker `assert_always`, specify:

```
module my_verilog();
 ...
 assert_always always_inst (.clk(clk), .reset(rst),
 .test_expr(test_expr));
 ...
endmodule
```

The usage model to simulate the design with SVA checkers is as follows:

### Compilation

```
% vcs [vcs_options] -sverilog +define+ASSERT_ON \
+incdir+$VCS_HOME/packages/sva -y $VCS_HOME/packages/sva \
+libext+.v \
Verilog_source_files
```

### Simulation

```
% simv [simv_options]
```

For more information on SVA checker libraries and a list of available checkers, see the *SystemVerilog Assertions Checker Library Reference Manual*.

---

## Binding SVA to a Design

Using bind statements to bind SVAs to your Verilog design is another way to use SVAs. The advantage is, bind statements allow you to bind SVAs to Verilog designs without modifying or editing your design files.

The bind statement syntax is as follows:

```
bind inst_name/module SVA_module #[SVA_parameters]
SVA_inst_name [SVA_ports]
```

The bind statement for Verilog targets can be used anywhere within your Verilog source file. For example:

```
//Verilog file
module dev (...);
...
endmodule

bind dev dev_checker dc1 (.clk(clk), .a(a), .b(b));
```

As shown in the above example, the bind statement is specified in the same Verilog file.

The usage model to simulate the design is as shown below:

### Compilation

```
% vcs -sverilog [compile_options] Verilog_files
```

### Simulation

```
% simv [run_options]
```

---

## Inlining SVAs in the Verilog Design

For Verilog designs, you can write SVAs as part of the code or within pragmas as shown in the following example:

### Example 1: Writing Assertions as a part of the code

```
module dut(...);

 ...

sequence s1;
@(posedge clk) sig1 ##[1:3] sig2;
endsequence

...

endmodule
```

### Example 2: Writing Assertions using SVA pragmas (/sv pragma)

```
module dut(...);

 ...

//sv_pragma sequence s1;
//sv_pragma @(posedge clk) sig1 ##[1:3] sig2;
//sv_pragma endsequence

/*sv_pragma
sequence s2;
 @(posedge clk) sig3 ##[1:3] sig4;
endsequence
*/
...

endmodule
```

As shown in Example 2, you can use SVA pragmas as //sv pragma at the beginning of all SVA lines, or you can use the following to mark a block of code as SVA code:

```
/* sv pragma
sequence s2;
 @(posedge clk) sig3 ##[1:3] sig4;
endsequence
*/
```

## Usage Model

The usage model to compile and simulate the designs having inlined assertions is as follows:

Note:

If you have your assertions inlined using //sv pragma, use the analysis option -sv pragma as shown above.

## Compilation

```
% vcs -sva_pragma [compile_options] Verilog_files
```

## Simulation

```
% simv [run_options]
```

---

# Controlling SystemVerilog Assertions

SVAs can be controlled or monitored using:

- “Compilation and Runtime Options”
- “Assertion Monitoring System Tasks”
- “Using Assertion Categories”

---

## Compilation and Runtime Options

VCS provides various compilation options to perform the following tasks:

- If you want to control assertions at runtime, use the `-assert enable_diag` option at compile time.
- To enable `-assert hier=<file_name>` at runtime, use the `-assert enable_hier` option at compile time.

Note:

The `-assert quiet` and `-assert report=<file_name>` options do not require the use of the `-assert enable_hier` or `-assert enable_diag` options at compile time.

- To enable dumping assertion information in a VPD file, use the `-assert dve` option. This option also allows you to view assertion information in the assertion pane in DVE (for more information, see the *DVE User Guide*.)
- To disable all SVAs in the design, use the `-assert disable` compilation option. To disable only the SVAs specified in a file, use the `-assert disable_file=<file_name>` compilation option.
- To disable assertion coverage, use the `-assert disable_cover` compilation option. By default, when you use the `-cm assert` option, VCS enables monitoring your assertions for coverage, and writes an assertion coverage database during simulation.
- To disable property checks (that is, `assert` and `assume` directives) and retain assertion coverage (that is, `cover` directives), use `-assert disable_assert` at compile-time.

- Disable dumping of SVA information in the VPD file

You can use the `-assert dumpoff` option to disable the dumping of SVA information to the VPD file during simulation (for additional information, see “[Options for SystemVerilog Assertions](#)” on page 7).

Following are the tasks VCS allows you to do during the runtime:

- Terminate simulation after certain number of assertion failures

You can use either the `-assert finish_maxfail=N` or `-assert global_finish_maxfail=N` runtime option to terminate the simulation if the number of failures for any assertion reaches  $N$  or if the total number of failures from all SVAs reaches  $N$ , respectively.

- Show both passing and failing assertions

By default, VCS reports only failures. However, you can use the `-assert success` option to enable reporting of successful matches, and successes on `cover` statements, in addition to failures.

- Limit the maximum number of successes reported

You can use the `-assert maxsuccesses=N` option to limit the total number of reported successes to  $N$ .

- Disable the display of messages when assertions fail

You can use the `-assert quiet` option to disable the display of messages when assertions fail.

- Enable or disable assertions during runtime

You can use the `-assert hier=file_name` option to enable or disable the list of assertions in the specified file.

- Generate a report file

You can use the `-assert report=file_name` option to generate a report file with the specified name. For additional information, see “[Options for SystemVerilog Assertions](#)” on page [7](#).

You can enter more than one keyword, using the plus + separator. For example:

```
% vcs -assert maxfail=10+maxsuccess=20+success ...
```

However, you cannot combine the elaboration assert arguments and runtime assert arguments. Both should be specified separately as shown below:

```
% vcs -assert disable+dumpoff
 -assert maxfail=10+maxsuccess=20+success ...
```

---

## Assertion Monitoring System Tasks

For monitoring SystemVerilog assertions we have developed the following new system tasks:

```
$assert_monitor
$assert_monitor_off
$assert_monitor_on
```

Note:

Enter these system tasks in an initial block. Do not enter these system tasks in an always block.

The `$assert_monitor` system task is analogous to the standard `$monitor` system task in that it continually monitors specified assertions and displays what is happening with them (you can have it only display on the next clock of the assertion). The syntax is as follows:

```
$assert_monitor([0|1,] assertion_identifier...) ;
```

Where:

0

Specifies reporting on the assertion if it is active (VCS is checking for its properties) and for the rest of the simulation reporting on the assertion or assertions, whenever they start.

1

Specifies reporting on the assertion or assertions only once, the next time they start.

If you specify neither 0 or 1, the default is 0.

*assertion\_identifier*...

A comma separated list of assertions. If one of these assertions is not declared in the module definition containing this system task, specify it by its hierarchical name.

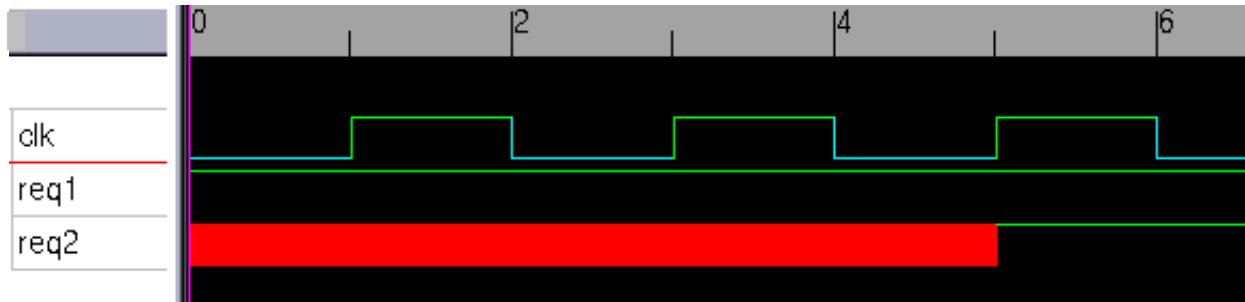
Consider the following assertion:

```
property p1;
 @ (posedge clk) (req1 ##[1:5] req2) ;
endproperty

a1: assert property(p1) ;
```

For property `p1` in assertion `a1`, a clock tick is a rising edge on signal `clk`. When there is a clock tick VCS checks to see if signal `req1` is true, and then to see if signal `req2` is true at any of the next five clock ticks.

In this example simulation, signal `clk` initializes to 0 and toggles every 1 ns, so the clock ticks at 1 ns, 3 ns, 5 ns and so on.



A typical display of this system task is as follows:

```
Assertion test.a1 ['design.v' 27] :
5ns: tracing "test.a1" started at 5ns:
 attempt starting found: req1 looking for: req2 or
 any
5ns: tracing "test.a1" started at 3ns:
 trace: req1 ##1 any looking for: req2 or any
 failed: req1 ##1 req2
5ns: tracing "test.a1" started at 1ns:
 trace: req1 ##1 any[* 2] looking for: req2 or any
 failed: req1 ##1 any ##1 req2
```

Breaking this display into smaller chunks:

```
Assertion test.a1 ['design.v' 27] :
```

The display is about the assertion with the hierarchical name `test.a1`. It is in the source file named `design.v` and declared on line 27.

```
5ns: tracing "test.a1" started at 5ns:
 attempt starting found: req1 looking for: req2 or
 any
```

At simulation time, 5 ns VCS is tracing test.a1. An attempt at the assertion started at 5 ns. At this time, VCS found req1 to be true and is looking to see if req2 is true one to five clock ticks after 5 ns. Signal req2 doesn't have to be true on the next clock tick, so req2 not being true is okay on the next clock tick; that's what looking for "or any" means, anything else than req2 being true.

```
5ns: tracing "test.a1" started at 3ns:
 trace: req1 ##1 any looking for: req2 or any
 failed: req1 ##1 req2
```

The attempt at the assertion also started at 3 ns. At that time, VCS found req1 to be true at 3 ns and it is looking for req2 to be true some time later. The assertion "failed" in that req2 was not true one clock tick later. This is not a true failure of the assertion at 3 ns, it can still succeed in two more clock ticks, but it didn't succeed at 5 ns.

```
5ns: tracing "test.a1" started at 1ns:
 trace: req1 ##1 any[* 2] looking for: req2 or any
 failed: req1 ##1 any ##1 req2
```

The attempt at the assertion also started at 1 ns. [\* is the repeat operator. ##1 any[\* 2 ] means that after one clock tick, anything can happen, repeated twice. So the second line here says that req1 was true at 1 ns, anything happened after a clock tick after 1 ns (3 ns) and again after another clock tick (5 ns) and VCS is now looking for req2 to be true or anything else could happen. The third line here says the assertion "failed" two clock ticks (5 ns) after req1 was found to be true at 1 ns.

The `$assert_monitor_off` and `$assert_monitor_on` system tasks turn off and on the display from the `$assert_monitor` system task, just like the `$monitoroff` and `$monitoron` system turn off and on the display from the `$monitor` system task.

---

## Using Assertion Categories

You can categorize assertions and then enable and disable them by category. There are two ways to categorize assertions:

- [Using System Tasks](#)
  - [Using OpenVera System Tasks](#)
  - [Using Assertion System Tasks](#)
- [Using Attributes](#)
- [Stopping and Restarting Assertions By Category](#)
  - [Starting and Stopping Assertions Using OpenVera System Tasks](#)
  - [Starting and Stopping Assertions Using Assertion System Tasks](#)

After you categorize assertions you can use these categories to stop and restart assertions.

## Using System Tasks

VCS has a number of system tasks and functions for assertions. These system tasks do the following:

- Set a category for an assertion

- Return the category of an assertion

## Using OpenVera System Tasks

These system tasks are as follows:

```
$ova_set_category("assertion_full_hier_name",
category)
```

or

```
$ova_set_category(assertion_full_hier_name,
category)
```

System task that sets the category level attributes of an assertion.  
The category level is an unsigned integer from 0 to  $2^{24} - 1$ .

Note:

These string arguments, such as the full hierarchical name of an assertion, can be enclosed in quotation marks or not. This is true when using these system tasks with SVA. They must be in quotation marks when using them with OVA.

```
$ova_get_category("assertion_full_hier_name")
```

or

```
$ova_get_category(assertion_full_hier_name)
```

System function that returns an unsigned integer for the category.

## Using Assertion System Tasks

You can use the following assertion system tasks to set the category and severity attributes of assertions:

```
$assert_set_severity("assertion_full_hier_name", severity)
```

Sets the severity level attributes of an assertion. The severity level is an unsigned integer from 0 to 255.

```
$assert_set_category("assertion_full_hier_name", category)
```

Sets the category level attributes of an assertion. The category level is an unsigned integer from 0 to  $2^{24} - 1$ .

You can use the following system tasks to retrieve the category and severity attributes of assertions:

```
$assert_get_severity("assertion_full_hier_name")
```

Returns the severity of action for an assertion failure.

```
$assert_get_category("assertion_full_hier_name")
```

Returns an unsigned integer for the category.

After specifying these system tasks and functions, you can start or stop the monitoring of assertions based upon their specified category or severity. For details on starting and stopping assertions, see [“Stopping and Restarting Assertions By Category”](#).

Note:

VCS also supports use of OpenVera system tasks and functions to categorize assertions namely:

```
$ova_set_category, $ova_get_category
```

The use model is identical to the assertion tasks.

## Using Attributes

You can prefix an attribute in front of an `assert` statement to specify the category of the assertion. The attribute must begin with the category name and specify an integer value, for example:

```
(* category=1 *) a1: assert property (p1);
(* category=2 *) a2: assert property (s1);
```

The value you specify can be an unsigned integer from 0 to  $2^{24} - 1$ , or a constant expression that evaluates to 0 to  $2^{24} - 1$ .

You can use a parameter, localparam, or genvar in these attributes. For example:

```
parameter p=1;
localparam l=2;
. . .
(* category=p+1 *) a1: assert property (p1);
(* category=l *) a2: assert property (s1);

genvar g;
generate
for (g=0; g<1; g=g+1)
begin:loop
(* category=g *) a3: assert property (s2);
end
endgenerate
```

Note:

In a generate statement the category value cannot be an expression, the attribute in the following example is invalid:

```
genvar g;
generate
```

```

for (g=0; g<1; g=g+1)
begin:loop
(* category=g+1 *) a3: assert property (s2);
end
endgenerate

```

If you use a parameter for a category value, the parameter value can be overwritten in a module instantiation statement.

You can use these attributes to assign categories to both named and unnamed assertions. For example:

```

(* category=p+1 *) a1: assert property (p1);
(* category=l *) assert property (s1);

```

The attribute is retained in a tokens.v file when you use the -Xman=0x4 compile-time option and keyword argument.

## **Stopping and Restarting Assertions By Category**

The are assertions system tasks for starting and stopping assertions. These system tasks are as follows:

### **Starting and Stopping Assertions Using OpenVera System Tasks**

`$ova_category_start(category)`

System task that starts all assertions associated with the specified *category*.

`$ova_category_stop(category)`

System task that stops all assertions associated with the specified *category*.

## **Using Mask Values To Stop And Restart Assertions**

There are system tasks for both OpenVera and SystemVerilog assertions that allow you to use a mask to determine if a category of assertions should be stopped or restarted. These system tasks are `$ova_category_stop` and `$ova_category_start`. They have matching syntax.

```
$ova_category_stop(categoryValue,
maskValue[,globalDirective]);
```

Where:

*categoryValue*

Because there is a *maskValue* argument, this argument is now the result of an anding operation between the assertion categories and the *maskValue* argument. If the result matches this value, these categories stop. As seen in “[Stopping and Restarting Assertions By Category](#)”, without the *maskValue* argument, this argument is the value you specified in `$ova_set_category` system tasks or `category` attribute.

*maskValue*

A value that is logically anded with the category of the assertion. If the result of this and operation matches the *categoryValue*, VCS stops monitoring the assertion.

*globalDirective*

Can be either of the following values:

0

Enables an `$ova_category_start` system task, that does not have a *globalDirective* argument, to restart the assertions stopped with this system task.

1

Prevents an `$ova_category_start` system task that does not have a `globalDirective` argument from restarting the assertions stopped with this system task.

```
$ova_category_start (categoryValue,
 maskValue[, globalDirective]);
```

Where:

`categoryValue`

Because there is a `maskValue` argument, this argument now is the result of an anding operation between the assertion categories and the `maskValue` argument. If the result matches this value, these categories start. As seen in [“Stopping and Restarting Assertions By Category”](#), without the `maskValue` argument, this argument is the value you specified in `$ova_set_category` system tasks or `category` attribute.

`maskValue`

A value that is logically anded with the category of the assertion. If the result of this and operation matches the `categoryValue`, VCS starts monitoring the assertion.

`globalDirective`

Can be either of the following values:

0

Enables an `$ova_category_stop` system task, that does not have a `globalDirective` argument, to stop the assertions started with this system task.

1

Prevents an `$ova_category_stop` system task that does not have a `globalDirective` argument from stopping the assertions started with this system task.

## Examples

This first example stops the odd numbered categories:

```
$ova_set_category(top.d1.a1,1);
$ova_set_category(top.d1.a2,2);
$ova_set_category(top.d1.a3,3);
$ova_set_category(top.d1.a4,4);

.
.
.
.

$ova_category_stop(1,'h1');
```

The categories are masked with the `maskValue` argument and compared with the `categoryValue` argument:

|            | bits | categoryValue |          |
|------------|------|---------------|----------|
| category 1 | 001  |               |          |
| maskValue  | 1    |               |          |
| result     | 1    | 1             | match    |
| <hr/>      |      |               |          |
| category 2 | 010  |               |          |
| maskValue  | 1    |               |          |
| result     | 0    | 1             | no match |
| <hr/>      |      |               |          |
| category 3 | 011  |               |          |
| maskValue  | 1    |               |          |
| result     | 1    | 1             | match    |

|            |     |   |          |
|------------|-----|---|----------|
| category 4 | 100 |   |          |
| maskValue  | 1   |   |          |
| result     | 0   | 1 | no match |

1. VCS looks at the least significant bit of each category and logically ands that LSB to the *maskValue* argument, which is 1.
2. The results of these anding operations, 1 or true for categories 1 and 3, and 0 or false for categories 2 and 4, is compared to the *categoryValue*, which is 1, there is a match for categories 1 and 3.
3. VCS stops the odd numbered categories.

This additional example uses the *globalDirective* argument:

```
$sova_set_category(top.d1.a1,1);
$sova_set_category(top.d1.a2,2);
$sova_set_category(top.d1.a3,3);
$sova_set_category(top.d1.a4,4);
.
.
.
$sova_category_stop(1,'h1,0);
$sova_category_stop(0,'h1,1);
.
.
.
$sova_category_start(1,'h1);
$sova_category_start(0,'h1);
```

In this example:

1. The two \$ova\_category\_stop system tasks first stop the odd numbered assertions and then the even numbered ones. The first \$ova\_category\_stop system task has a *globalDirective* argument that is 0, the second has a *globalDirective* argument that is 1.

2. The first \$ova\_category\_start system task can restart the odd numbered assertions, but the second \$ova\_category\_start system task cannot start the even numbered assertions.

## Starting and Stopping Assertions Using Assertion System Tasks

There are assertions system tasks for starting and stopping assertions. These system tasks are as follows:

### Stopping Assertions by Category or Severity

```
$assert_category_stop(categoryValue,
[maskValue[,globalDirective]]);
```

Stops all assertions associated with the specified category.

```
$assert_severity_stop(severityValue,
[maskValue[,globalDirective]]);
```

Stops all assertions associated with the specified severity level.

where,

*categoryValue*

Since there is a *maskValue* argument, it is now the result of an anding operation between the assertion categories and the *maskValue* argument. If the result matches this value, these categories stop. Without the *maskValue* argument, this argument is the value you specify in \$assert\_set\_category system tasks or category attributes.

*maskValue*

A value that is logically anded with the category of the assertion. If the result of this and operation matches the *categoryValue*, VCS stops monitoring the assertion.

*globalDirective*

Can be either of the following values:

0

Enables an `$assert_category_start` system task that does not have a *globalDirective* argument, to restart the assertions stopped with this system task.

1

Prevents an `$assert_category_start` system task that does not have a *globalDirective* argument from restarting the assertions stopped with this system task.

## Starting Assertions by Category or Severity

```
$assert_category_start(categoryValue,
[maskValue[,globalDirective]]);
```

Starts all assertions associated with the specified category.

```
$assert_severity_start(severityValue,
[maskValue[,globalDirective]]);
```

Starts all assertions associated with the specified severity level. The severity level is an unsigned integer from 0 to 255.

where,

*categoryValue*

Since there is a *maskValue* argument, this argument is the result of an anding operation between the assertion categories and the *maskValue* argument. If the result matches this value, these categories start. Without the *maskValue* argument, this argument is the value you specify in `$assert_set_category` system tasks or `category` attributes.

#### *maskValue*

A value that is logically anded with the category of the assertion. If the result of this and operation matches the *categoryValue*, VCS starts monitoring the assertion.

#### *globalDirective*

Can be either of the following values:

0

Enables an `$assert_category_stop` system task (that does not have a *globalDirective* argument) to stop the assertions started with this system task.

1

Prevents an `$assert_category_stop` system task that does not have a *globalDirective* argument from stopping the assertions started with this system task.

### **Example Showing How to Use MaskValue**

#### [Example 17-1](#) stops the odd numbered categories

*Example 17-1 MaskValue Numbering:*

```
$assert_set_category(top.d1.a1,1);
$assert_set_category(top.d1.a2,2);
```

```

$assert_set_category(top.d1.a3,3);
$assert_set_category(top.d1.a4,4);

.

.

.

$assert_category_stop(1,'h1);

```

The categories are masked with the *maskValue* argument and compared with the *categoryValue* argument as shown in the following table.

|           | bits | categoryValue |          |
|-----------|------|---------------|----------|
| category  | 1    |               |          |
| maskValue | 1    |               |          |
| result    | 1    | 1             | match    |
| category  | 2    | 010           |          |
| maskValue | 1    |               |          |
| result    | 0    | 1             | no match |
| category  | 3    | 011           |          |
| maskValue | 1    |               |          |
| result    | 1    | 1             | match    |
| category  | 4    | 100           |          |
| maskValue | 1    |               |          |
| result    | 0    | 1             | no match |

1. VCS logically ands the category value to the *maskValue* argument, which is 1.
2. The result of the and operation is true for categories 1 and 3 as per the calculation shown above. The result is false for categories 2 and 4.

- VCS stops all the assertions which result in a true match with the and operation.

[Example 17-2](#) uses the `globalDirective` argument.

### *Example 17-2 Mask Value with Global Directive*

```
$assert_set_category(top.d1.a1,1);
$assert_set_category(top.d1.a2,2);
$assert_set_category(top.d1.a3,3);
$assert_set_category(top.d1.a4,4);
.
.
$assert_category_stop(1,'h1,1);
$assert_category_start(0,'h1);
```

The assertions that are stopped or started with `globalDirective` value 1, cannot be restarted or stopped with a call to `$assert_category_start`, without using the `globalDirective` argument. The above code cannot restart assertions.

The assertions can only be restarted with a call to `$assert_category_start` with `globalDirective`, as follows:

```
$assert_category_start(1,'h1,1);
```

or

```
$assert_category_start(1,'h1,0);
```

Note:

VCS also supports use of OpenVera system tasks and functions to categorize assertions namely:

```
$ova_set_category, $ova_get_category
```

The use model is identical to the assertion tasks.

---

## Viewing Results

By default, VCS reports only assertion of the failures. However, you can use the `-assert success` runtime option to report both pass and failures.

Assertion results can be viewed:

- Using a Report File
- Using DVE

For information on viewing assertions in DVE, refer to the "*Using the Assertion Pane*" chapter, in the DVE user guide.

---

## Using a Report File

Using the `-assert report=file_name` option, you can create an assertion report file. VCS writes all SVA messages to the specified file.

Assertion attempts generate messages with the following format:

| File and line with the assertion | Full hierarchical name of the assertion | Start time        | Status (succeeded at ..., failed at ..., not finished) |
|----------------------------------|-----------------------------------------|-------------------|--------------------------------------------------------|
| "design.v", 157: top.cnt_in.a2:  | started at 22100ns                      | failed at 22700ns |                                                        |

Offending ' (busData == mem[\$past(busAddr, 3)])'

Expression that failed (only with failure of check assertions)

---

# Enhanced Reporting for SystemVerilog Assertions in Functions

This section describes an efficient reporting convention for functions containing assertions in the following topics:

- “Introduction”
- “Usage Model”
- “Name Conflict Resolution”
- “Checker and Generate Blocks”

---

## Introduction

In earlier releases, when assertions were present inside functions, assertion path names were reported based on the position of the function call in the source file. For example, consider the following code:

```
module top;
bit b, a1, a2, a3, a4, a5;
function bit myfunc(input bit k);
 $display("FUNC name: %m");
 AF: assert #0(k && !k);
 return !k;
endfunction

always_comb a1=myfunc(b);
always_comb begin: A
 begin: B
 a2=myfunc(b);
 begin a3=myfunc(!b); end
 end
end
end
```

```

always_comb begin
 a4=myfunc(b);
 a5=myfunc(!b);
end
endmodule

```

If you run this code, it generates the following output:

```

"top.v", 5: top.\top.v_18_myfunc.AF : started
"top.v", 5: top.\top.v_17_myfunc.AF : started
"top.v", 5: top.\top.v_13_myfunc.AF : started
"top.v", 5: top.\top.v_12_myfunc.AF : started
"top.v", 5: top.\top.v_9_myfunc.AF : started

```

But the problem with this type of naming convention is, when code changes, the output of the simulation also changes. To overcome this limitation, a new naming convention is implemented under the `-assert funchier` compile-time option. This new naming convention is implemented as follows:

- Function names are generated based on the named blocks under which the functions are called. Each function name is appended with an index (index=0, 1, 2, 3...), where index 0 is given to the first function call, index 1 is given to the second function call, and so on.
- For unnamed blocks, the function name is based on the closest named block.
- If there is no named scope around the function call, then a module scope is used as a named block with an empty name.
- Each assertion status reporting message contains the file name and line number of the function caller.

---

## Usage Model

Use the `-assert funchier` option to enable the new function naming convention, as shown in the following command:

```
% vcs -sverilog -assert funchier+svaext
```

If you run the above code using this command, it generates the following output:

```
"top.v", 5: top.myfunc_2.AF ("top.v", 18): started
"top.v", 5: top.myfunc_1.AF ("top.v", 17): started
"top.v", 5: top.\A.B.myfunc_1.AF ("top.v", 13): started ...
"top.v", 5: top.\A.B.myfunc_0.AF ("top.v", 12): started
"top.v", 5: top.myfunc_0.AF ("top.v", 9): started
```

---

## Name Conflict Resolution

When a function name generated with the new naming convention conflicts with an existing block or identifier name in that scope, then the suffix index is incremented until the conflict is resolved.

---

## Checker and Generate Blocks

When a function is present inside a checker, the generated name of that function contains the checker name appended to all named blocks and identifiers in that checker.

Similarly, when a function is present inside a generate block, the generated name of that function contains the generated block name appended to all named blocks and identifiers in that generate block.

---

# Controlling Assertion Failure Messages

This section describes the mechanism for controlling failure messages for SystemVerilog Assertions (SVA), OpenVera Assertions (OVA), Property Specification Language (PSL) assertions, and OVA case checks.

This section contains the following topics:

- “[Introduction](#)”
- “[Options for Controlling Default Assertion Failure Messages](#)”
- “[Options to Control Termination of Simulation](#)”
- “[Option to Enable Compilation of OVA Case Pragmas](#)”

---

## Introduction

Earlier releases did not provide the flexibility to control the display of default messages for assertion (SVA, OVA, or PSL) failures, based on the presence of an action block (for SVA) or a user message (for OVA and PSL). Also, there was no control over whether these assertion failures contributed to the failure counts for

```
-assert [global_]finish_maxfail, or affected simulation if
$ova_[severity|category]_action(<severity_or_category>,
"finish") was specified.
```

You can now use the options described in the following topics to enable additional controls on failure messages, and to terminate the simulation and compilation of OVA case pragmas.

---

## Options for Controlling Default Assertion Failure Messages

You can use the following runtime options to control the default assertion failure messages:

`-assert no_default_msg [=SVA | OVA | PSL]`

Disables the display of default failure messages for SVA assertions that contain a fail action block, and OVA and PSL assertions that contain user messages.

The default failure messages are displayed for:

- SVA assertions without fail action blocks
- PSL and OVA assertions that do not contain user messages

When used without arguments, this option affects SVA, OVA, and PSL assertions. You can use an optional argument with this option to specify the class of assertions that should be affected.

### Note:

The `-assert quiet` and `-assert report` options override the `-assert no_default_msg` option. That is, if you use either of these options along with `-assert no_default_msg`, then the latter has no effect.

The `-assert no_default_msg=SVA` option affects only SVA.

The `-assert no_default_msg=OVA` and `-assert no_default_msg=PSL` options affect both OVA and PSL assertions, but not SVA.

In addition to the default message, an extra message is displayed by default, for PSL assertions that have a severity (info, warning, error, or fatal) associated with them. This message is considered as a user message, and no default message is displayed, if you use the `-assert no_default_msg [=PSL]` option.

## Example

Consider the following assertion:

```
As1: assert property (@(posedge clk) P1) else
$info("As1 fails");
```

By default, VCS displays the following information for each assertion failure:

```
"sva_test.v", 15: top.As1: started at 5s failed at 5s
Offending 'a'
Info: "sva_test.v", 15: top.As1: at time 5
As1 fails
```

If you use the `-assert no_default_msg` option at runtime, it disables the default message, and displays only the user message, as shown below:

```
Info: "sva_test.v", 15: top.As1: at time 5
As1 fails
```

---

## Options to Control Termination of Simulation

You can use the following runtime options to control the termination of simulation:

`-assert no_fatal_action`

Excludes failures on SVA assertions with fail action blocks for computation of failure count in the `-assert [global_] finish_maxfail=N` runtime option. This option also excludes failures of these assertions for termination of simulation, if you use the following command:

```
$ova_[severity|category]_action(<severity_or_category>, "finish")
```

**Note:**

This option does not affect OVA case violations and OVA or PSL assertions, with or without user messages.

Specifying `$fatal()` in the fail action block of an SVA assertion or in a fatal severity associated with a PSL assertion, results in termination of simulation irrespective of whether this option is used or not.

This option is useful when you want to exclude failures of assertions having fail action blocks, from adding up to the global failure count, for the `-assert [global]_finish_maxfail=N` option.

## **Example**

Consider the following assertion:

```
As1: assert property (@(posedge clk) P1) else
$info("As1 fails");
```

If you use the `-assert global_finish_maxfail=1` option at runtime, then the simulation terminates at the first `As1` assertion failure. Now, if you use `-assert global_finish_maxfail=1 -assert no_fatal_action` at runtime, then the failure of assertion `As1` does not cause the simulation to terminate.

`-ova_enable_case_maxfail`

Includes OVA case violations in computation of global failure count for the `-assert global_finish_maxfail=N` option.

Note:

The `-assert finish_maxfail=N` option does not include OVA case violations. This option maintains a per-assertion failure count for termination of simulation.

## Example

Consider an OVA case pragma, as shown in the following code, to check the case statements for full case violations:

```
reg [2:0] mda[31:0][31:0];
//ova full_case on;
initial begin
 for(i = 31; i >= 0; i = i - 1) begin
 for(j = 0; j <= 31; j = j + 1) begin
 case(mda[i][j])
 1: begin
 testdetect[i][j] = 1'b1;
 end
 endcase
 #1;
 end
 end
end
```

The above code violates full case check. Therefore, case violations are displayed as follows:

```
Select expression value when violation happened for last iteration : 3'b000
Ova [0]: "ova_case_full.v", 20: Full case violation at time 9 in a
Failed in iteration: [31] [9]
```

By default, these violations are not considered in the failure count for the `-assert global_finish_maxfail=N` option. But if you use the `-ova_enable_case_maxfail` option at runtime, then the case violations are added in the failure count.

---

## Option to Enable Compilation of OVA Case Pragmas

You can use the following compile-time option to enable compilation of OVA case pragmas:

`-ova_enable_case`

Enables the compilation of OVA case pragmas only, when used without `-Xova` or `-ova_inline`. All inlined OVA assertion pragmas are ignored.

Note:

- `Xova` or `-ova_inline` is the superset of the `-ova_enable_case` option. They are used to compile both the case pragmas and assertions.

## Example

Consider the following code:

```
//ova parallel_case on;
```

```

//ova full_case on; /* case pragma*/
always @(negedge clock)
 case (opcode)
//ova check_bool (alu_out>10, "ddd", negedge clock); /* assertion pragma */
 3'h0: alu_out = accum;
 3'h1: alu_out = accum;
 3'h2: alu_out = accum + data;
 3'h3: alu_out = accum & data;
 3'h4: alu_out = accum ^ data;
 3'h5: alu_out = data;
 3'h6: alu_out = accum;
 endcase

```

The above code contains both OVA case pragmas and assertions. This option ignores the OVA assertion pragmas, and compiles only the case pragmas.

## Enabling IEEE Std. 1800-2009 Compliant Features

You must use the `-assert svaext` compile-time option to enable the new IEEE Std. 1800-2009 compliant SVA features.

### Limitations

- In VCS, strong and weak properties are not distinguished in terms of their reporting at the end of simulation. In all cases, if a property evaluation attempt did not complete evaluation, it will be reported as "unfinished evaluation attempt", and allows you to decide whether it is a failure or success.
- Checker declaration are allowed in unit scope only.
- Bind construct with checkers are not supported.

Limitations on debug support are as follows:

- Use `-assert dve` at compile/elab to enable debug for assertions. While basic debug support is available with this release, assertion tracing in DVE not supported completely. DVE provides information such as: `start_time`, `end_time` for every attempt and statistics for every assertion/cover. DVE also groups all signals involved in an assertion on tracing an attempt. However the extra "hints" that are provided for SVA constructs are not available for new constructs as of now.
- UCLI support for new assertions is not supported.

# 18

## Using Property Specification Language

---

VCS supports the Simple Subset of the IEEE 1850 Property Specification Language (PSL) standard. Refer to Section 4.4.4 of the *IEEE 1850 PSL LRM* for the subset definition.

You can use PSL along with SystemVerilog Assertions (SVA), SVA options, SVA system tasks, and OpenVera (OV) classes.

---

### Including PSL in the Design

You can include PSL in your design in any of the following ways:

- Inlining the PSL using the `//psl` or `/*psl */` pragmas in Verilog and SystemVerilog.
- Specifying the PSL in an external file using a verification unit (`vunit`).

---

## Examples

The following example shows how to inline PSL in Verilog using the //psl and /\*psl \*/ pragmas.

```
module mod;
 ...
 // psl a1: assert always {r1; r2; r3} @(posedge clk);
 /* psl
 A2: assert always {a;b} @(posedge clk);
 ...
 */
endmodule
```

The following example shows how to use vunit to include PSL in the design.

```
vunit vunit1 (verilog_mod)
{
 a1: assert always {r1; r2; r3} @(posedge clk);
}
```

---

## Usage Model

If you inline the PSL code, you must compile it with the -psl option.

If you use vunit, you must compile the file that contains the vunit with the -pslfile option. You do not need to use this option if the file has the .psl extension.

### Compilation

```
% vcs -psl [vcs_options] Verilog_files
```

## Simulation

```
% simv
```

---

## Examples

To simulate the PSL code inlined in a Verilog file (`test.v`), execute the following commands:

```
% vcs -psl test.v
% simv
```

To simulate the `vunit` specified in an external file with the `.psl` extension (`checker.psl`), execute the following commands:

```
% vcs dev.v checker.psl
% simv
```

To simulate the `vunit` specified in an external file without the `.psl` extension (`checker.txt`), execute the following commands:

```
% vcs dev.v -pslfile checker.txt
% simv
```

To simulate both the PSL code inlined in a Verilog file (`test.v`), and the `vunit` specified in an external file (`checker.psl` or `checker.txt`), execute the following commands:

```
% vcs -psl -test.v checker.psl
% simv
```

or

```
% vcs -psl -test.v -pslfile checker.txt
% simv
```

---

## Using SVA Options, SVA System Tasks, and OV Classes

VCS enables you to use all assertion options with SVA, PSL, and OVA. For example, to enable PSL coverage and debug assertions while compiling the PSL code, execute the following commands:

```
% vcs -psl -cm assert -debug -assert enable_diag test
% simv -cm assert -assert success
```

For information on all assertion options, see Appendix B, Compile Time Options.

You can control PSL assertions in any of the following ways:

- Using the \$asserton, \$assertoff, or \$assertkill SVA system tasks.
- Using NTB-OpenVera assert classes.

Note that VCS treats the assume PSL directive as the assert PSL directive.

Discovery Visual Environment (DVE) supports PSL assertions. The PSL assertion information displayed by VCS is similar to SystemVerilog assertions.

---

## Limitations

The VCS implementation of PSL has the following limitations:

- VCS does not support binding `vunit` to an instance of a module or entity.
- VCS does not support the following data types in your PSL code -- `shortreal`, `real`, `realtime`, associative arrays, and dynamic arrays.
- VCS does not support the `union` operator and union expressions in your PSL code.
- Clock expressions have the following limitations:
  - You must not include the `rose()` and `fell()` built-in functions.
  - You must not include endpoint instances.
- Endpoint declarations must have a clocked SERE with either a clock expression or default clock declaration.
- VCS does not support the `%for` and `%if` macros.
- VCS supports only the `always` and `never` FL invariance operators in top-level properties. Ensure that you do not instantiate top-level properties in other properties.
- VCS supports all LTL operators, except `sync_abort` and `async_abort`. You can apply the abort operator only to the top property.
- VCS does not support the `assume_guarantee`, `restrict`, and `restrict_guarantee` PSL directives.

# 19

## Using SystemC

---

The VCS SystemC Co-simulation Interface enables VCS and the SystemC modeling environment to work together when simulating a system described in the Verilog and SystemC languages.

VCS contains a built-in SystemC simulator that is compatible with OSCI SystemC 2.2 (IEEE 1666).

You also have the option of installing the OSCI SystemC simulator and having VCS run it to co-simulate using the interface. See “[Using a Customized SystemC Installation](#)” on page 74.

With the interface, you can use the most appropriate modeling language for each part of the system, and verify the correctness of the design. For example, the VCS SystemC Co-simulation Interface allows you to:

- Use a SystemC module as a reference model for the Verilog RTL design under test in your testbench

- Verify a Verilog netlist after synthesis with the original SystemC testbench
- Write test benches in SystemC to check the correctness of Verilog designs
- Import legacy Verilog IP into a SystemC description
- Import third-party Verilog IP into a SystemC description
- Export SystemC IP into a Verilog environment when only a few of the design blocks are implemented in SystemC
- Use SystemC to provide stimulus to your design

The VCS /SystemC Co-simulation Interface creates the necessary infrastructure to co-simulate SystemC models with Verilog models. The infrastructure consists of the required build files and any generated wrapper or stimulus code. VCS writes these files in subdirectories in the `./csrc` directory. To use the interface, you don't need to do anything to these files.

During co-simulation, the VCS /SystemC Co-simulation Interface is responsible for:

- Synchronizing the SystemC kernel and VCS
- Exchanging data between the two environments

Note:

- The unified profiler (an LCA feature) can report CPU time profile information about the SystemC part or parts of a design. See the chapter in the LCA features documentaion.
- There are examples of Verilog instantiated in SystemC and SystemC instantiated in Verilog in the `$VCS_HOME/doc/examples/systemc` directory.

- The interface supports the following compilers:
  - RH4, RH5, suse10, suse11: gcc 3.4.6, gcc 4.2.2 and gcc 4.5.2 (default) compilers
  - Solaris/SPARC (sparcOS5, sparc32): gcc 3.3.2. However, sparc64 is not supported
  - Solaris/AMD64 (X86sol, x86sol64): gcc 4.2.2
- The VCS / SystemC Co-simulation Interface supports 32-bit, as well as 64-bit (VCS flag -full64) simulation.
- The gcc 4.5.2, gcc 4.2.2, gcc 3.4.6 compilers along with a matching set of GNU tools are available on the Synopsys FTP server for download. For more information, e-mail [vcs\\_support@synopsys.com](mailto:vcs_support@synopsys.com).

This chapter describes the following sections:

- “Overview”
- “Verilog Design Containing Verilog Modules and SystemC Leaf Modules”
- “SystemC Designs Containing Verilog Modules”
- “SystemC Only Designs”
- “Considerations for Export DPI Tasks”
- “Specifying Runtime Options to the SystemC Simulation”
- “Using a Port Mapping File”
- “Using a Data Type Mapping File”
- “Combining SystemC with Verilog Configurations”
- “Parameters”

- “Debugging Mixed Simulations Using DVE or UCLI”
- “Transaction Level Interface”
- “Delta-cycles”
- “Using a Customized SystemC Installation”
- “Using Posix threads or quickthreads”
- “VCS Extensions to SystemC Library”
- “Installing VG GNU Package”
- “Static and Dynamic Linking”
- “Limitations”
- “Incremental Compile of SystemC Source Files”
- “TLI Direct Access”
- “Aligning VMM and SystemC Messages”
- “Exchanging Data Between SystemVerilog and SystemC Using Byte Pack/Unpack”
- “Using Direct Program Interface Based Communication”
- “Improving VCS-SystemC Compilation Speed Using Precompiled C++ Headers”
- “Increasing Stack and Stack Guard Size”
- Debugging SystemC Runtime Errors
- “Using HDL and SystemC Sync Loops”
- “Controlling Simulation Run From sc\_main”

- “UCLI Save Restore Support for SystemC-on-top and Pure-SystemC”
- “Enabling Unified Hierarchy for VCS and SystemC”
- “Aligning VMM and SystemC Messages”
- “UVM Message Alignment”
- “Introducing TLI Adapters”
- “Using VCS UVM TLI Adapters”
- Modeling SystemC Designs with SCV
- Viewing SystemC `sc_report_handler` Messages from Log File

---

## Overview

VCS /SystemC Co-simulation Interface supports the following topologies:

- Verilog designs containing SystemC modules

In this topology, you have a Verilog testbench and instances of SystemC and Verilog. You can also have many other SystemC modules in the design. To instantiate a SystemC module in your Verilog design, create a Verilog wrapper and instantiate the wrapper in your Verilog testbench. You can use the `syscan` utility to create a Verilog wrapper for your SystemC module. To see the usage model and an example, refer to the section entitled, “[Verilog Design Containing Verilog Modules and SystemC Leaf Modules](#)”.

- SystemC designs containing Verilog modules

In this topology, you have a SystemC testbench and instances of Verilog. You can also have many other SystemC modules in the design. To instantiate a Verilog design in your SystemC module, create a SystemC wrapper and instantiate the wrapper in your SystemC module. You can use the `vlogan` executable to create a SystemC wrapper for your Verilog design units. To see the usage model and an example, refer to the section entitled, “[SystemC Designs Containing Verilog Modules](#)”.

For information on limitations, see “[Limitations](#)”.

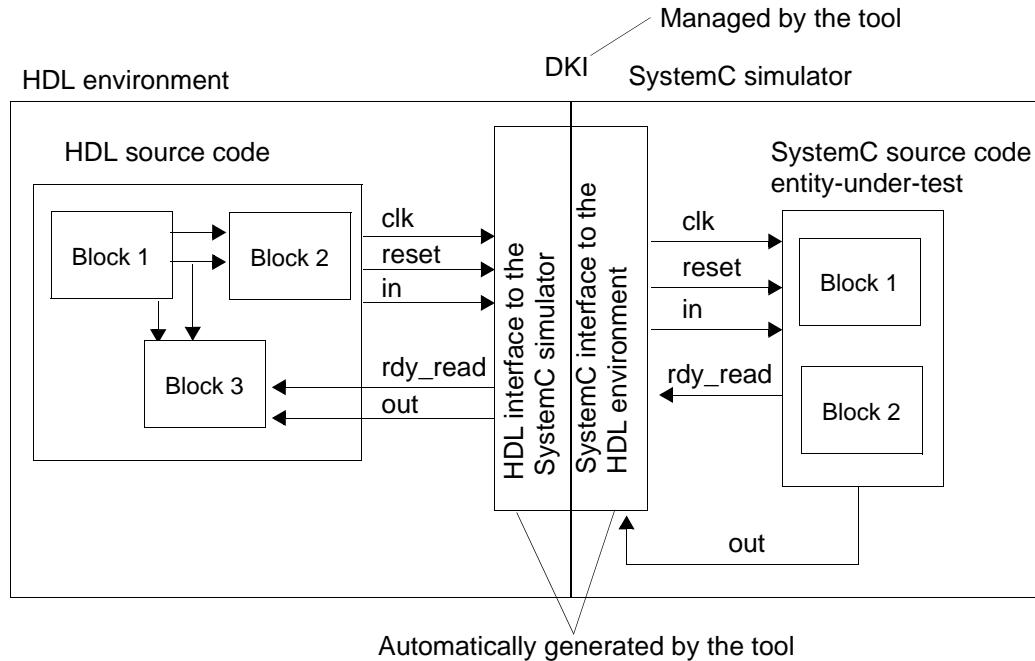
---

## Verilog Design Containing Verilog Modules and SystemC Leaf Modules

To co-simulate a Verilog design that contains SystemC and Verilog modules, you need to create a Verilog wrapper for the SystemC module, which directly interacts with the Verilog design. You can instantiate your SystemC modules in the Verilog module just like instantiating any other Verilog module. For additional information, see “[Example](#)” on page 13. The ports of the created Verilog wrapper are connected to signals that are attached to the ports of the corresponding SystemC modules.

[Figure 19-1](#) illustrates VCS DKI communication.

*Figure 19-1 VCS DKI Communication of a Verilog Design Containing SystemC Modules*




---

## Usage Model

The usage model to simulate a design having a Verilog testbench with SystemC and Verilog instances involves the following steps:

1. Wrapper Generation
2. Compilation
3. Simulation

### Wrapper Generation

```
% syscan [options] file1.cpp:sc_module_name
```

For additional information, see “[Generating Verilog Wrappers for SystemC Modules](#)”.

## Compilation

```
% vcs -sysc [compile_options] file1.v file2.v
```

## Simulation

```
% simv [runtime_options]
```

---

## Input Files Required

To run a co-simulation with a Verilog design containing SystemC instances, you need to provide the following files:

- SystemC source code
  - You can directly write the entity-under-test source code or generate it with other tools
  - Any other C or C++ code for the design
- Verilog source code (.v extensions) including:
  - Verilog wrapper for your SystemC module (see “[Generating Verilog Wrappers for SystemC Modules](#)”)
  - Any other Verilog source files for the design
- An optional port mapping file. If you do not provide this file, the interface uses the default port mapping definition. For details of the port mapping file, see “[Using a Port Mapping File](#)” on page 43.
- An optional data type mapping file. If you don’t write a data type mapping file, the interface uses the default one in the VCS installation. For details of the data type mapping files, see “[Using a Data Type Mapping File](#)” on page 45.

## Generating Verilog Wrappers for SystemC Modules

You use the `syscan` utility to generate the wrapper and interface files for co-simulation. This utility creates the `csrc` directory in the current directory. The `syscan` utility writes the wrapper and interface files in subdirectories in the `./csrc` directory.

The syntax for the `syscan` command line is as follows:

```
syscan [options] filename[:modulename]
[filename[:modulename]] *
```

Where:

*filename*[:*modulename*] [*filename*[:*modulename*]] \*

Specifies all the SystemC files in the design. There is no limit to the number of files.

Include :*modulename*, for those SystemC modules which are directly instantiated in your Verilog design. If :*modulename* is omitted, the `.cpp` files are compiled and added to the design's database so the final `vcs` command is able to bring together all the modules in the design. You do not need to add `-I$VCS_HOME/include` or `-I$SYSTEMC/include`.

[*options*]

These can be any of the following:

`-cflags "flags"`

Passes flags to the C++ compiler.

`-cpp path_to_the_compiler`

Specifies the location of the C++ compiler. If you do specify this option, VCS uses the following compilers by default:

- RH4, RH5, suse10, suse11 : g++
- SunOS : CC (native Sun compiler)

Note:

- See the VCS *Release Notes* for details on all supported compiler versions.

`-full64`

Enables compilation and simulation in 64-bit mode.

`-debug_all`

Prepares SystemC source files for interactive debugging. Along with `-debug_all`, use the `-g` compiler flag.

`-port port_mapping_file`

Specifies a port mapping file. See “[Using a Port Mapping File](#)” on page 43.

`-Mdir=directory_path`

Specifies an alternate directory for 'csrc'.

`-help | -h`

Displays the syntax, options, and examples of the `syscan` command.

`-v`

Displays the version number.

`-o name`

The `syscan` utility uses the specified `name` instead of the module name as the name of the model. Do not enter this option when you have multiple modules on the command line. Doing so results in an error condition.

`-V`

Displays code generation and build details. Use this option if you encounter errors, or are interested in the flow that builds the design.

`i`

`-f filename`

Specifies a file containing one or more `filename [ :modulename]` entries, as if these entries were on the command line.

`-verilog`

Generates wrapper for the specified language. `-verilog` is the default.

`-t1m2`

Add to the compiler call `include` directives for header files of the TLM 2.0.1 installation (located at `$VCS_HOME/etc/systemc/tlm`). These `include` directories have precedence over other `include` directories specified with `syscan -cflags "-I/my/tlm2/include"`.

Note:

You do not specify the data type mapping file on the command line. For detailed information, see “[Using a Data Type Mapping File](#)” on page 45.

The following example generates a Verilog wrapper:

```
syscan -cflags "-g" sc_add.cpp:sc_add
```

---

## Supported Port Data Types

SystemC types are restricted to the `sc_clock`, `sc_bit`, `sc_bv`, `sc_logic`, `sc_lv`, `sc_int`, `sc_uint`, `sc_bigint`, and `sc_bignum` data types. Native C/C++ types are restricted to the `uint`, `uchar`, `ushort`, `int`, `bool`, `short`, `char`, `long` and `ulong` types.

Verilog ports are restricted to `bit`, `bit-vector` and `signed bit-vector` types.

In-out ports that cross the co-simulation boundary between SystemC and Verilog must observe the following restrictions:

- SystemC port types must be `sc_inout_rv<>` or `sc_inout_resolved` and must be connected to signals of type `sc_signal_rv<>` or `sc_signal_resolved`.
- Verilog port types must be `bit_vector` or `bit`.
- You need to create a port mapping file, as described in “[Using a Port Mapping File](#)” on page 43, to specify the SystemC port data types as `sc_lv` (for a vector port) or `sc_logic` (for a scalar port).

---

## Example

In this example, you have a Verilog testbench, a SystemC module, stimulus, and a Verilog module, display.

```
// SYSTEMC MODULE: stimulus
#include <systemc.h>
#include "stimulus.h"

void stimulus::entry() {

 cycle++;
 // sending some reset values
 if (cycle<25) {
 reset.write(SC_LOGIC_1);
 input_valid.write(SC_LOGIC_0);
 } else {
 reset.write(SC_LOGIC_0);
 input_valid.write(SC_LOGIC_0);
 // sending normal mode values
 if (cycle%60==0) {
 input_valid.write(SC_LOGIC_1);
 sample.write(send_value1.to_int());
 printf("Stimuli : %d\n", send_value1.to_int());
 send_value1++;
 }
 }
}
```

```

//Verilog module: display
module display (output_data_ready, result);
 input output_data_ready;
 input [31:0] result;
 integer counter;

 ...

endmodule

//Verilog testbench: tb
module testbench ();

parameter PERIOD = 20;

reg clock;
wire reset;
wire input_valid;
wire [31:0] sample;
wire output_data_ready;
wire [31:0] result;

// Stimulus is the SystemC model.
stimulus stimulus1(.sample(sample),
 .input_valid(input_valid),
 .reset(reset),
 .clk(clock));

// Display is the Verilog model.
display display1(.output_data_ready(output_data_ready),
 .result(result));

...

endmodule

```

**Note:**

You can find the same example with a run script in the  
`$VCS_HOME/doc/examples/systemc/` directory.

The usage model for the above example is shown below:

## Wrapper Generation

```
% syscan stimulus.cpp:stimulus
```

For additional information, see “[Generating Verilog Wrappers for SystemC Modules](#)”.

## Compilation

```
% vcs -sysc tb.v display.v
```

## Simulation

```
% simv
```

---

## Compiling Interface Models with `acc_user.h` and `vhpi_user.h`

Header file `acc_user.h` is provided by VCS and contains many `#define` macros and type definitions. Some of these definitions, for example ‘`#define bool int`’, may conflict with C++ class definitions in user code. Similarly, header file `vhpi_user.h` is also provided by VCS and may also conflict with C++ class definitions in user code.

SystemC/HDL interface models require to make at least some of these definitions visible in order to compile the internal interface code. The amount of definitions can be controlled when `syscan` is called. Three use models are available.

**Use Model 1:** Only a minimal subset of definitions from `acc_user.h` and `vhi_user.h` are made visible. Invoke `syscan` as follows:

```
syscan A.cpp:A -cflags -DSYSC_ACC_USER=0
```

Chances for a clash of those definitions with user C++ classes are minimal. Note that it is neither possible to include `acc_user.h` nor `vhpi_user.h` in the user C++ source code.

Use model 2: All definitions from `acc_user.h` (and `vhpi_user.h` if a VHDL interface is created) are made visible, except the following macros ("`#define`") : `bool`, `true`, `TRUE`, `false`, `FALSE`, `global`, `exfunc`, `local`, `null`. Invoke syscan as follows:

```
syscan A.cpp:A -cflags -DSYSC_ACC_USER=1
```

The user code can include header files `acc_user.h` or `vhpi_user.h` whereby the macros mentioned above are `#undef`'ed in some situations.

Use model 3: All definitions from `acc_user.h` (and `vhpi_user.h` if a VHDL interface is created) are made visible. Only macro "bool" is not visible. Invoke syscan as follows:

```
syscan A.cpp:A -cflags
```

or

```
syscan A.cpp:A -cflags -DSYSC_ACC_USER=2
```

The user code can include header files `acc_user.h` or `vhpi_user.h`, all definitions including the macros mentioned above are visible.

---

## Controlling Time Scale and Resolution in a SystemC

The SystemC runtime kernel has a time scale and time resolution that can be controlled by the user with functions

`sc_set_time_resolution()` and

`sc_set_default_time_unit()`. The default setting for time scale is 10 ns, default for time resolution is 10 ps.

The Verilog runtime kernel also has a time scale and time resolution. This time scale/resolution is different and independent from the time scale/resolution of SystemC.

If the time scale/resolution is not identical, then a warning will be printed during the start of the simulation. The difference may slow down the simulation, may lead to wrong simulation results, or even make the simulation be "stuck" at one time point and not progressing. It is therefore highly recommended to ensure that time scale and resolution from both kernels have the same settings. The following sections explain how to do this.

## **Automatic adjustment of the time resolution**

When the time resolution of SystemC and HDL differs, the overall time resolution must be the finest of both. This can be set automatically by the elaboration option `-sysc=adjust_timeres` of vcs. This option determines the finest resolution used in both domains, and sets it to be the finest of the simulator. That can result that either the HDL side or the SystemC side is adjusted.

When it is not possible to adjust the time resolution, due to a user constraint, then an error is printed, and no simulator is created.

## **Setting time scale/resolution of Verilog kernel**

There are several ways how the time scale and resolution of a Verilog or mixed Verilog is determined. For more information on time scale and resolution, see "[Controlling Time Scale and Resolution in a SystemC](#)" on page 16.

The most convenient way to ensure that Verilog and SystemC use the same time scale/resolution is using the VCS "-timescale=1ns/1ps" command line option. Example:

```
vcs ... -sysc ... -timescale=1ns/1ps ...
```

This will force the Verilog kernel to have the same values as the default values from the SystemC kernel. If this is not possible (for example, because you need a higher resolution in a Verilog module), then change the default values of the SystemC kernel as shown in the next section.

## **Setting time scale/resolution of SystemC kernel**

The default time scale of a systemC kernel is 1 ns, and the default time resolution is 1 ps. These default values are NOT affected by the VCS -timescale option.

To control the time resolution of the SystemC kernel, create a static global object that initializes the timing requirements for the module. This can be a separate file that is included as one of the .cpp files for the design. Choose a value that matches the time scale/resolution of the Verilog kernel.

The Sample contents for this file is as follows:

```
include <systemc.h>
class set_time_resolution {
public:
 set_time_resolution()
 {
 try {
 sc_set_time_resolution(10, SC_PS);
 sc_set_default_time_unit(100, SC_PS);
 }
 catch(const sc_exception& x) {
 cerr << "setting time resolution/default time unit
 failed: " <<
 x.what() << endl;
 }
 }
};

static int SetTimeResolution()
{
 new set_time_resolution();
 return 42;
}

static int time_resolution_is_set = SetTimeResolution();
```

---

## Adding a Main Routine for Verilog-On-Top Designs

Normally, a Verilog-on-top design doesn't contain a `sc_main()` function, since all SystemC instantiations are done within the Verilog modules. However, it is possible to add a main routine to perform several initializations for the SystemC side. The basic steps are as follows:

- Create a C++ source file which contains the main function (see example below).

Note:

Do not name this main function as `sc_main`.

- Add the registration function which takes care of the proper calling of the user-defined main routine
- Analyze the file, using `syscan user_main.cpp`. This will add the file to the design database. Note that there are no other options required to analyze this file.

The user defined main routine must look like the following:

```
// File user_main.cpp
int user_main_function(int argc, char **argv)
{
 // you have access to the argc,argv arguments:
 for (int i = 0; i < (argc-1); ++i)
 std::cerr << Arg[" " << i << "] = " << argv[i] << "\n";
 // do other init-stuff here...
 return 0;
}
extern "C" int sc_main_register(int (*)(int, char **));
static int my_sc_main =
sc_main_register(user_main_function);
// end-of user_main.cpp
```

## **SNPS\_REGISTER\_SC\_MAIN**

The macro, `SNPS_REGISTER_SC_MAIN`, is introduced in this release for ease of use. This macro registers the start up function and is defined in the `systemc_user.h`. And you must include this header file to use it.

For example:

```

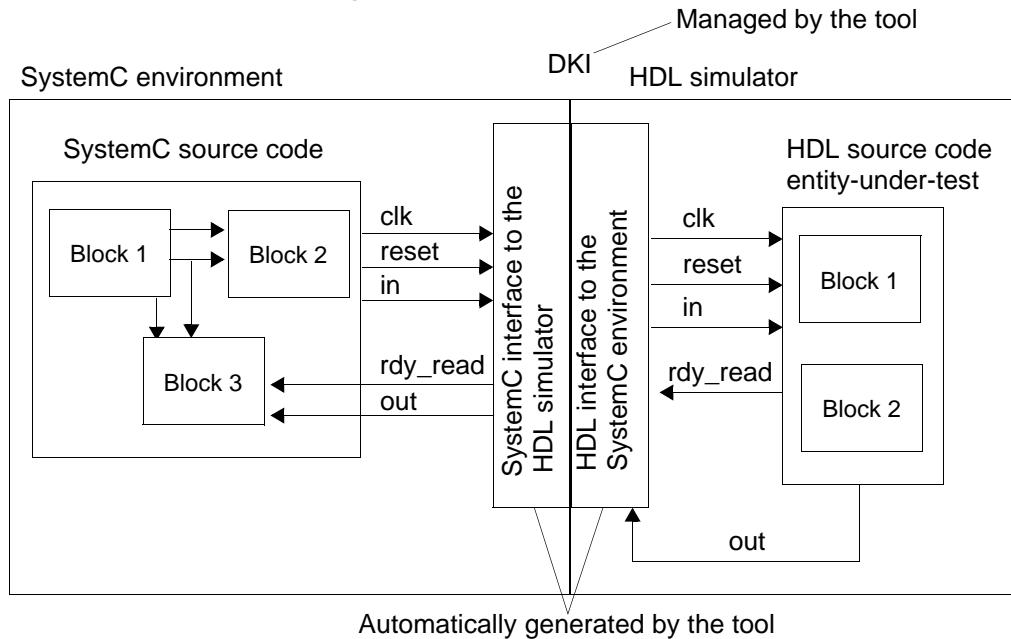
#include "systemc_user.h"
extern "C" int user_main_function(int argc, char **argv)
{
 // you have access to the argc,argv arguments:
 for (int i = 0; i < (argc-1); ++i)
 std::cerr << Arg[" " << i << "] = " << argv[i] << "\n";
 // do other init-stuff here...
 return 0;
}
SNPS_REGISTER_SC_MAIN(user_main_function);

```

## SystemC Designs Containing Verilog Modules

To co-simulate a SystemC design that contains Verilog modules, you need to create header files for those Verilog instances which directly interact with the SystemC design. These header files will be named as `module_name.h` for Verilog modules (see “[Example](#)” on page [26](#)). You can analyze other Verilog files using the `vlogan` executable. The ports of the created SystemC wrapper are connected to signals that are attached to the ports of the corresponding Verilog modules.

**Figure 19-2 VCS DKI Communication of SystemC Design Containing Verilog Modules**



## Usage Model

The usage model to simulate a design having a SystemC testbench with SystemC and Verilog instances involves the following steps:

1. Wrapper Generation
2. Compilation
3. Simulation

### Wrapper Generation

```
% vlogan [options] -sysc -sc_model sc_module_name file1.v
```

For additional information, see “[Generating a SystemC Wrapper for Verilog Modules](#)”.

## Compilation

```
% syscsim Verilog_files other_C++_source_files
[compile_options]
```

## Simulation

```
% simv [runtime_options]
```

---

## Input Files Required

To run co-simulation with a SystemC design containing Verilog modules, you need to provide the following files:

- Verilog source code (.v extensions)
  - Verilog source files necessary for the design.
- SystemC source code including:
  - A SystemC top-level simulation (sc\_main) that instantiates the interface wrappers and other SystemC modules.
  - Any other SystemC source files for the design.
- An optional port mapping file. If you do not provide this file, the interface uses the default port mapping definition. For details of the port mapping file, see “[Using a Port Mapping File](#)” on page 43.
- An optional data type mapping file. If you don’t write a data type mapping file, the interface uses the default file in the VCS installation. For details of the data type mapping files, see “[Using a Data Type Mapping File](#)” on page 45.

## Generating a SystemC Wrapper for Verilog Modules

Use the `vlogan` utility with the `-sc_model` option to generate and build the wrapper and interface files for Verilog modules for co-simulation. This utility creates the `./csrc` directory in the current directory. The `vlogan` utility writes the header and interface files in the `./csrc/sysc/include` directory.

The syntax for the `vlogan` command line is as follows:

```
vlogan [options] -sc_model modulename file.v
```

Here the options are:

`-sc_model modulename file.v`

Specifies the module name and its Verilog source file.

`-cpp path_to_the_compiler`

Specifies the location of the C compiler. If you omit `-cpp path`, your environment will find the following compilers as defaults:

- RH4, RH5, suse10, suse11 : g++
- SunOS : CC (native Sun compiler)

Note:

- See the *VCS Release Notes* for more details on supported compiler versions.
- You can override the default compilers in your environment by supplying a path to the g++ compiler. For example:

```
-cpp /usr/bin/g++
```

`-sc_portmap port_mapping_file`

Specifies a port mapping file. For additional information, see “[Using a Port Mapping File](#)” on page 43.

`-Mdir=directory_path`

Works the same way that the `-Mdir` VCS compile-time option works. If you are using the `-Mdir` option with VCS, you should use the `-Mdir` option with `vlogan` to redirect the `vlogan` output to the same location that VCS uses.

`-V`

Displays code generation and build details. Use this option if you are encountering errors or are interested in the flow that builds the design.

For example, the following command line generates a SystemC wrapper and interface file for a Verilog module display:

```
vlogan -sc_model display display.v
```

---

## Example

In this example, we have SystemC testbench `sc_main`, another SystemC module, stimulus, and a Verilog module display.

```
// SystemC module: stimulus
#include <systemc.h>
#include "stimulus.h"

void stimulus::entry() {

 cycle++;
 // sending some reset values
 if (cycle<25) {
 reset.write(SC_LOGIC_1);
 input_valid.write(SC_LOGIC_0);
 } else {
 reset.write(SC_LOGIC_0);
 input_valid.write(SC_LOGIC_0);
 // sending normal mode values
 if (cycle%60==0) {
 input_valid.write(SC_LOGIC_1);
 sample.write(send_value1.to_int());
 send_value1++;
 };
 }
}

//Verilog module: display
module display (output_data_ready, result);
 input output_data_ready;
 input [31:0] result;
 integer counter;

 ...

endmodule

//SystemC Testbench: sc_main
```

```

#include <systemc.h>
#include "stimulus.h"
#include "fir.h"
#include "display.h" //Header file for Verilog module display

int sc_main(int argc , char *argv[]) {

 sc_clock clock ("CLK", 20, .5, 0.0);
 sc_signal<sc_logic> reset;
 sc_signal<sc_logic> input_valid;
 sc_signal<sc_lv<32> > sample;
 sc_signal<sc_logic> output_data_ready;
 sc_signal<sc_lv<32> > result;

 display display1("display1");
 stimulus stimulus1("stimulus1");

 stimulus1.reset(reset);
 stimulus1.input_valid(input_valid);
 stimulus1.sample(sample);
 stimulus1.clk(clock.signal());
 fir1.reset(reset);
 fir1.input_valid(input_valid);
 fir1.sample(sample);
 fir1.output_data_ready(output_data_ready);
 fir1.result(result);
 fir1.clk(clock.signal());

 display1.output_data_ready(output_data_ready);
 display1.result(result);
 display1.input_valid(input_valid);
 display1.sample(sample);

 sc_start();
 return 0;
}

```

See \$VCS\_HOME/doc/examples/systemc/ for examples.

The usage model for the above example is shown below:

## **Wrapper Generation**

```
% vlogan -sysc -sc_model display display.v
```

For additional information, see “[Generating a SystemC Wrapper for Verilog Modules](#)” on page 24.

## **Compilation**

```
% syscsim -sysc stimulus.cpp
```

## **Simulation**

```
% simv
```

---

## **Compilation Scheme**

When SystemC is at the top of the design hierarchy and you instantiate Verilog code in the SystemC code, the compilation of the simulation is done in the following two steps:

- The first step is to create a temporary simulation executable that contains all SystemC parts, but does not yet contain any HDL parts. VCS then starts this temporary executable to find out which Verilog instances are really needed. All SystemC constructors and `end_of_compilation()` methods are executed; however, simulation does not start.
- VCS creates the final version of the `simv` file containing SystemC, as well as all HDL parts. The design is now fully compiled and ready to simulate.

As a side effect of executing the temporary executable during step 1, you will see that the following message is printed:

```
Error- [SC-VCS-SYSC-ELAB] SystemC elaboration error
```

The design could not be fully elaborated due to an early exit of the SystemC part of the design. The SystemC part must execute the constructors of the design.  
Please find the details in the SystemC chapter of the VCS documentation.

In case your simulation contains statements that should NOT be executed during step 1, guard these statements with a check for environment variable `SYSTEMC_ELAB_ONLY` or, with the following function:

```
extern "C" bool hdl_elaboration_only()
```

Both will be set/yield true only during this extra execution of `simv` during step 1.

For example, guard statements like this:

```
sc_main(int argc, char* argv[])
{
 // instantiate signals, modules, ...
 ModuleA my_top_module(...); // <-- must always be
executed

 // run simulation
 if (!hdl_elaboration_only()) {
 ... open log file for simulation report ...
 }
 sc_start(); // <-- must always be executed
 if (!hdl_elaboration_only()) {
 ... close log file ...
 }

 return 0;
}
```

If you guard statements as mentioned above, make sure that all module constructors and at least one call of `sc_start()` will be executed.

VCS needs to know the entire SystemC module hierarchy during step 1, which in turn means that all SystemC module constructors must be executed.

If your simulation checks the command line arguments `argc + argv`, then you have two choices. Either guard these statements with an IF-statement as shown above.

Alternatively, provide the `simv` command line arguments used during elaboration using the VCS argument `-syscelab`. Example:

For non Unified Use Model (UUM) use model:

```
syscsim main.cpp ... -syscelab A ...
```

or, in UUM:

```
vcs -sysc sc_main ... -syscelab A ...
```

You can specify `-syscelab` multiple times. White space within the arguments is not preserved, instead the arguments are broken up into multiple arguments; multiple arguments can also be enclosed within double quotes, for example with `-syscelab "1 2 3"`.

If your SystemC design topology (the set of SystemC instances) depends on `simv` runtime arguments, then you MUST provide the relevant arguments with `-syscelab`. The SystemC design topology during step 1 and the final execution of `simv` must be identical.

Note that the `-syscelab` option is only supported when SystemC is at the top of the design hierarchy. If Verilog is at the top, then `-syscelab` is neither needed nor supported.

---

### **SNPS\_REGISTER\_SC\_MODULE**

This macro can be used to implement `sc_main()` function in a SystemC on top design.

Until now, you had to write an `sc_main` start up function whenever there was a SystemC-on-top design. Hereafter, you can simply use this macro to implement the `sc_main` function by passing the top level `sc_module` as an argument as shown below. Since this macro is defined in `systemc_user.h`, you must include this header file to use this macro.

For example:

```
#include "systemc_user.h"
SC_MODULE(mytopmodule) {
 ...
}
SNPS_REGISTER_SC_MODULE(mytopmodule);
```

---

## **SystemC Only Designs**

VCS supports simulating and debugging simulations that contain only SystemC models, referred to as a "pure SystemC" simulation.

Pure SystemC simulations contain no Verilog, no SVA, and no NTB modules. The design will have only the SystemC and other C/C++ source files. The usage model to simulate pure SystemC designs is the same as SystemC on top designs, except the wrapper generation phase, which is not required for pure SystemC simulation.

---

## Usage Model

The usage model to simulate a pure SystemC design involves the following steps:

1. Compilation
2. Simulation

### Compilation

```
% syscan <SystemC source files(s) >
% vcs -sysc [compile_options] sc_main
```

### Simulation

```
% simv [runtime_options]
```

### Example 1:

```
% syscan adder.cpp
% syscan foo.cpp bar.cpp xyz.cpp main.cpp
% vcs -sysc sc_main
% ./simv -gui
```

## **Example 2:**

```
% syscan -cpp g++ -cflags -g adder.cpp
% syscan -cpp g++ -cflags -g foo.cpp bar.cpp xyz.cpp
% syscan -cpp g++ -cflags -g main.cpp
% vcs -sysc sc_main \
 -cpp g++ -cflags -g \
 extra_file.o -ldfflags "-L/u/me/lib -labc"
% ./simv -ucli
```

---

## **Restrictions**

The following compilation options are not supported for pure SystemC simulation:

- sverilog: Pure SystemC simulation will not have any SV files.
- ntb\*: Pure SystemC simulation will not have any OV files.
- ova\*: Pure SystemC simulation will not have any OV files.
- cm\*: Coverage related options are not supported.
- comp64: Cross-compilation is not supported. However, pure SystemC simulation is supported in 32-bit and 64-bit mode.
- e: The name of the main routine must always be `sc_main`.
- P: Pure SystemC simulation will not have any HDL files.

---

## **Supported and Unsupported UCLI/DVE and CBug Features**

You can use UCLI commands or the DVE GUI to debug your pure SystemC design. The list of supported features in UCLI and DVE are as follows:

- View SystemC design hierarchy
- VPD tracing of SystemC objects
- Set breakpoints, stepping in C, C++, SystemC sources
- Get values of SystemC (or C/C++ objects)
- stack [-up | -down]
- continue/step/next/finish
- run [time]

The following UCLI and DVE features are not supported for SystemC objects:

- Viewing schematics
- Using force, release commands
- Tracing [active] drivers, and loads
- The UCLI command `next -end` is not supported.
- Commands that apply to HDL objects only

In case of a Control-C (i.e., SIGINT), CBug will always take over and report the current location.

When the simulation stops somewhere in the System C or VCS kernel, between execution of user processes, then a dummy file is reported as the current location. This happens, for example, immediately after the `init` phase. This dummy file contains a description about this situation and instructions how to proceed (i.e., Set BP in SystemC source file, click continue).

---

## Accessing Cross Module Hierarchy

The OSCI function `sc_find_object()` is used to get the handle of the `sc_object` that has the hierarchical name which exactly matches the value of the string argument passed to the function. This works only for pure SystemC.

If there is Verilog and SystemC in the hierarchy, then VCS provides the function `sc_snps::sc_object_handle_by_name()` which is similar to `sc_find_object`. You can use this function to access cross module hierarchy.

Note:

You must include the `systemc_user.h` file because the function `sc_snps::sc_object_handle_by_name()` is defined in this file.

### Example

```
#include "cosim/bf/systemc_user.h"
Void my_module::my_proc() {
 ...
 sc_object *obj =
 sc_snps::sc_object_handle_by_name("my_top.sc_top.sc_add.a_
 s");
 ...
}
```

---

## Controlling TimeScale Resolution

The most convenient way to ensure that Verilog and SystemC use the same time scale/resolution is using the VCS -timescale=1ns/1ps command-line option.

For example:

```
% vcs -sysc top.v -timescale=1ns/1ps
```

This command forces the Verilog kernel to have the same values as the default values from the SystemC kernel. If this is not possible (for example, because you need a higher resolution in a Verilog module), then change the default values of the SystemC kernel as shown in the following section.

---

## Setting Timescale of SystemC Kernel

To control the time resolution of your SystemC module, create a static global object that initializes the timing requirements for the module. This can be a separate file that is included as one of the .cpp files for the design.

Sample contents for this file are:

```
include <systemc.h>
class set_time_resolution {
public:
 set_time_resolution()
 {
 try {
 sc_set_time_resolution(10, SC_PS);
 }
 catch(const sc_exception& x) {
 cerr << "setting time resolution/default time unit
failed: " <<
x.what() << endl;
 }
 }
 static int SetTimeResolution()
 {
 new set_time_resolution();
 return 42;
 }
 static int time_resolution_is_set = SetTimeResolution();
```

## Automatic Adjustment of Time Resolution

If the time resolution of SystemC and HDL differs, VCS can also automatically determine the finer time resolution and set it as the simulator's time scale. To enable this feature, you must use the `-sysc=adjust_timeres` compilation option.

VCS may be unable to adjust the time resolution if you elaborate your HDL with the `-timescale` option and/or use the `sc_set_time_resolution()` function call in your SystemC code. In such cases, VCS reports an error and does not create `simv`.

---

## Considerations for Export DPI Tasks

If you have a SystemC design with Verilog instances, and you want to call export "DPI" tasks from the SystemC side of the design, then you need to do either one of the following three steps:

- “[Use syscan -export\\_DPI \[function-name\]](#)”
- “[Use syscan -export\\_DPI \[Verilog-file\]](#)”
- “[Use a Stubs File](#)”

### **Use syscan -export\_DPI [*function-name*]**

Register the name of all export DPI functions and tasks prior to the final `vcs` or `syscsim` call to compile the design. You need to call `syscan` in the following way:

```
syscan -export_DPI function-name1 [[function-name2] ...]
```

This is necessary for each export DPI task or function that is used by SystemC or C code. Only the name of function must be specified, and formal arguments are neither needed nor allowed. Multiple space-separated function names can be specified in one call of `syscan -export_DPI`. It is allowed to call `syscan -export_DPI` any number of times. A function name can be specified multiple times.

## Example

Assume that you want to instantiate the following SystemVerilog module inside a SystemC module:

```
//myFile.v
module vlog_top;
 export "DPI" task task1;
 import "DPI" context task task2(input int A);
 export "DPI" function function3;

 task task1(int n);
 ...
 endtask
 function int function3(int m);
 ...
 endfunction // int
endmodule
```

You must do the following steps before you can compile the simulation:

```
syscan -export_DPI task1
syscan -export_DPI function3
```

Note that `task2` is not specified because it is an import "DPI" task.

## Use `syscan -export_DPI [Verilog-file]`

This is same as `syscan -export_DPI [function-name]`, however, you can specify the name of a Verilog file instead of the name of an export DPI function. The `syscan` will search for all `export_DPI` declarations in that file.

The syntax is as shown below:

```
syscan -export_DPI [Verilog-file]
```

For example (see `myFile.v` in the above section):

```
% syscan -export_DPI myFile.v
```

This will locate `export_DPI` functions `task1` and `functions3` in the `myFile.v` file.

Note: `syscan` does not apply a complete Verilog or SystemVerilog parser, but instead does a primitive string search in the specified file.

The following restrictions apply:

- The entire `export_DPI` declaration must be written in one line (no line breaks allowed)
- ``include` statements are ignored
- Macros are ignored

VCS will compile the design even if the source files do not comply to the above restrictions. However, `syscan` will be unable to extract some or all of the `export_DPI` declarations. In this case, use `syscan -export_DPI [function-name]`.

## Use a Stubs File

An alternative approach is to use stubs located in a library. For each export DPI function like `my_export_DPI`, create a C stub with no arguments and store it in an archive which is linked by VCS:

```
file my_DPI_stubs.c :
 #include <stdio.h>
 #include <stdlib.h>

 void my_export_DPI() {
 fprintf(stderr,"Error: stub for my_export_DPI is
 used\n");
 exit(1);
 }

 ... more stubs for other export DPI function ...

gcc -c my_DPI_stubs.c
ar r my_DPI_stubs.a my_DPI_stubs.o
...
syscsim ... my_DPI_stubs.a ...
```

It is important to use an archive (file extension `.a`) and not an object file (file extension `.o`).

---

## Using options `-Mlib` and `-Mdir`

You can use VCS options `-Mlib` and `-Mdir` during analysis and elaboration to store analyzed SystemC files in multiple directories. This may be helpful if analyzing (compiling) of SystemC source files takes a long time, and if you want to share analyzed files between different projects.

The use model is as follows:

```
syscan -Mdir=<dir1> model1.cpp:model1
...
syscan -Mdir=<dir2> model2.cpp:model2
...
vcs -sysc -Mlib=<dir1>,<dir2> ...
```

Options `-Mlib` and `-Mdir` are available in all configurations, meaning for SystemC designs containing Verilog modules, and also for Verilog designs containing SystemC modules.

---

## Specifying Runtime Options to the SystemC Simulation

You start a simulation with the `simv` command line. Command line arguments can be passed to just the VCS simulator kernel, or just the `sc_main()` function or both.

By default, all command-line arguments are given to `sc_main()`, as well as the VCS simulator kernel. All arguments following `-systemcrun` will go only to `sc_main()`. All arguments following `-verilogrun` will go only to the VCS simulator kernel. The following arguments are always recognized, and goes only to the VCS simulator kernel:

`-r`, `-restore`, `-pathmap`, `-save`, `-save_nocbk`, `-save_file`,  
`-save_file_skip`, `-gui`, `-ucli`, `-uclimode`, `-ucli2Proc`

For example:

```
simv a b -verilogrun c d -systemcrun e f -ucli g
```

Function `sc_main()` will receive arguments "a b e f g". The VCS simulator kernel will receive arguments "c d -ucli".

---

## Using a Port Mapping File

You can provide an optional port mapping file for the `syscan` command with the `-port` option, and for `vlogan` by using `-sc_portmap`. If you specify a port mapping file, any module port that is not listed in the port mapping file is assigned the default type mapping.

A SystemC port has a corresponding Verilog port in the wrapper for instantiation. The `syscan` utility either uses the default method for determining the type of the HDL port it writes in the wrapper or uses the entry for the port in the port mapping file.

A port mapping file is an ASCII text file. Each line defines a port in the SystemC module, using the format in Example 14-1 and 14-2. A line beginning with a pound sign (#) is a comment.

A port definition line begins with a port name, which must be the same name as that of a port in the HDL module or entity. Specify the number of bits, the HDL port type, and the SystemC port type on the same line, separated by white space. You can specify the port definition lines in any order. You must, however, provide the port definition parameters within each line in this order: port name, bits, HDL type, and SystemC type.

The valid Verilog port types, which are case-insensitive, are as follows:

- `bit` — specifies a scalar (single bit) Verilog port

- `bit_vector` — specifies a vector (multi-bit) unsigned Verilog port (`bit-vector` is a valid alternative)
- `signed` — specifies a Verilog port that is also a reg or a net declared with the `signed` keyword and propagates a signed value.

The following example shows a port mapping file:

*Example 19-1 Port Mapping File*

| # | Port name | Bits | Verilog type            | SystemC type          |
|---|-----------|------|-------------------------|-----------------------|
|   | in1       | 8    | <code>signed</code>     | <code>sc_int</code>   |
|   | in2       | 8    | <code>bit_vector</code> | <code>sc_lv</code>    |
|   | clock     | 1    | <code>bit</code>        | <code>sc_clock</code> |
|   | out1      | 8    | <code>bit_vector</code> | <code>sc_uint</code>  |
|   | out2      | 8    | <code>bit_vector</code> | <code>sc_uint</code>  |

SystemC types are restricted to the `sc_clock`, `sc_bit`, `sc_bv`, `sc_logic`, `sc_lv`, `sc_int`, `sc_uint`, `sc_bigint`, and `sc_bignum` data types.

Native C/C++ types are restricted to the `bool`, `char`, `uchar`, `short`, `ushort`, `int`, `uint`, `long`, and `ulong` data types.

## Automatic Creation of Portmap File

VCS now writes the portmap file automatically thus making the task of mapping the ports easier across the languages. When SystemC is instantiated in HDL or vice-versa, you must write port map file for mapping the data types between the languages. This is a tedious job when we have many ports.

Now, a default portmap file can be created by using the option `-sysc=gen_portmap` and `-sysc=opt_if` while generating the wrapper.

For example:

```
syscan -sysc=gen_portmap -sysc=-opt_if mymod.cpp:mymod
vlogan -sysc=gen_portmap -sysc=-opt_if vmod.v -sc_model vmod
vhdlan -sysc=gen_portmap -sysc=-opt_if hmod.vhdl -sc_model
hmod

mymod.default_map:
ina 8 bitvectorsch_int
clk 1 bit sc_clock
outx 32 bitvectorsch_bv
```

If the port map file already exists, the option `-sysc=gen_portmap` will overwrite it if the file has the write permission. It generates the following message if the file does not have the write permission.

```
Error- [SC-PORTMAP-ERR] Cannot open portmap file
```

---

## Using a Data Type Mapping File

When running a VCS / SystemC simulation, the interface propagates data through the module ports from one language domain to another. This can require the interface to translate data from one data type representation to another. This translation is called mapping, and is controlled by data type mapping files.

The data type mapping mechanism is similar to that used for port mapping, but is more economical and requires less effort to create and maintain. Because the data type mapping is independent of the ports, you can create one or more default mappings for a particular type that will be used for all ports, rather than having to create a port map for every port of each new HDL wrapper model.

Data type mapping files map types, so that ALL ports of that type on ALL instances will now be assigned the specified mapping.

The data type mapping file is named `cosim_defaults.map`. The interface looks for and reads the data mapping file in the following places and in the following order:

1. In `$VCS_HOME/include/cosim`
2. In your `$HOME/.synopsys_ccss` directory
3. In the current directory.

An entry in a later file overrules an entry in an earlier file.

Each entry for a SystemC type has the following:

1. It begins with the keyword `Verilog`.
2. It is followed by the bit width. For vectors, an asterisk (\*) is a wildcard to designate vectors of any bit width not specified elsewhere in the file.
3. The corresponding Verilog “type” using keywords that specify if it is scalar, unsigned vector, or signed port, the same keywords used in the port mapping file.
4. The SystemC or Native C++ type.

[Example 19-2](#) shows an example of a data type mapping file.

### *Example 19-2 Data Type Mapping File*

```
#####
Mappings between SystemC and Verilog datatypes
#####
Verilog * bit_vector sc_bv
Verilog 1 bit bool
Verilog * bit_vector int
Verilog * signed int
Verilog 1 bit sc_logic
Verilog 1 bit sc_bit
Verilog * bit_vector char
Verilog * bit_vector uchar
Verilog * bit_vector short
Verilog * bit_vector ushort
Verilog * bit_vector uint
Verilog * bit_vector long
Verilog * bit_vector ulong
```

---

## Combining SystemC with Verilog Configurations

SystemC can be used in combination with Verilog configurations.  
This is supported since release 2009.06 and only in UUM flow.  
Topologies SystemC-top and Verilog-top are supported.

---

## Verilog-on-top, SystemC

A Verilog-on-top design with SystemC is specified like any other design, where the analysis of the Verilog files, by means of vlogan, must use the libmap option. Added to it is a Verilog source file, containing the configurations. A configuration consists of a config scope. Example:

```
config use_A;
 design top; // name of the Verilog top-entity
 default liblist workA; // library where the top-entity
 // is analyzed
 // different mappings of verilog instances:
 instance top.v_mod.inst1 use workA.v_sub; // verilog-
 subtractor
 instance top.v_mod.inst3 use workA.s_sub; // SystemC-
 subtractor
endconfig

config use_B;
 design top;
 default liblist workA;
 // no overrule for ...inst1
 instance top.v_mod.inst2 use workA.s_sub; // SystemC-
 subtractor
 instance top.v_mod.inst3 use workA.s_sub; // SystemC-
 subtractor
endconfig
```

The name of the Verilog top-entity is obligatory. The default liblist statement defines where this Verilog top-entity is analyzed, by means of the libmap option of vlogan.

The instances are defined by their logical hierarchical name within the design hierarchy.

For setting up a design with Verilog configurations, there must be at least one call to syscan like the one given below:

```
%> syscan s_sub.cpp:s_sub
```

Above command generates an interface model, which has to be instantiated in Verilog.

The libmap option for vlogan requires a correct setting of the `synopsys_sim.setup` file. See the VCS and VCS MX user guides for details.

## Compiling a Verilog/SystemC design

The following example shows how to compile a design containing Verilog and SystemC:

```
%> syscan s_sub.cpp:s_sub -sysc=2.2
%> vlogan v_sub.v -libmap liblist.map -sverilog
%> vlogan v_design.v -libmap liblist.map -sverilog
%> vlogan v_configs.v -libmap liblist.map -sverilog
%> vcs -sverilog -top use_B -sysc=2.2
```

The used configuration for the design is specified with the option `"-top <config-name>"`.

When a different configuration is to be used, or a configuration has changed, it is sufficient to re-analyze the verilog file containing the changed configuration, and redo the elaboration.

---

## SystemC-on-top, Verilog

A SystemC-on-top design with Verilog is specified like any other design, where the analysis of the Verilog files, by means of vlogan, must use the libmap option. Added to it is a Verilog source file, containing the configurations. The following example shows a configuration with a SystemC-on-top topology:

```
config use_SysC_A;
 design sYsTeMcToP; // name of the default SystemC top
 entity
 default liblist workA; // library where the top-entity
 is analyzed
 // different mappings of verilog instances:
 instance sYsTeMcToP.v_mod.inst1 use workA.v_sub; //
 verilog-subtractor
 instance sYsTeMcToP.v_mod.inst2 use workA.v_add; //
 verilog-adder
 instance sYsTeMcToP.\sctop.sc2 .v_mod.inst3 use
 workA.v_add;
endconfig

config use_SysC_B;
 design sYsTeMcToP;
 default liblist workA;
 instance sYsTeMcToP.v_mod.inst2 use workA.v_sub; /
 verilog-subtractor
 instance sYsTeMcToP.\sctop.sc2 .v_mod.inst3 use
 workA.v_add;
endconfig
```

The name of the SystemC top-entity is hard coded as `sYsTeMcToP` and cannot be changed. Note that only Verilog modules can be re-configured; it is not possible to reconfigure a SystemC instance . Also note that it is not possible to re-configure a Verilog-instance to a SystemC-instance.

How to specify the pathname for a Verilog instance depends on the position of the instance within the design hierarchy.

Use a normal path for Verilog modules that are instantiated at the top-level inside the `sc_main()` function and that are not a sub-instance of a SystemC model. Example:

```
"instance sYsTeMcToP.v_mod.inst1"
```

But you must use a partially escaped path name for Verilog instances that are sub-instances of SystemC modules. The path name has to be split into two parts, where the first part contains only SystemC instances, and a second part contain Verilog instances. The first part has to be specified as an extended Verilog identifier.

Example:

```
instance sYsTeMcToP.\sctop.sc2 .v_mod.inst3 use
workA.v_add;
```

The design topology is:

|       |         |
|-------|---------|
| sctop | SystemC |
| sc2   | SystemC |
| v_mod | Verilog |
| inst3 | Verilog |

The first part consists two SystemC instances, 'sctop' and 'sc2'. These instances must be specified as "`\sctop.sc2`".

Note that the space at the end is important and must not be omitted. The second part consist of two Verilog instances, 'v\_mod' and 'inst3' and must not be escaped.

**Note:**

Writing the configuration as given below is not supported:

```
instance sYsTeMcToP.sctop.sc2.v_mod.inst3 use
 workA.v_add;
```

## Compiling a SystemC/Verilog design

```
%> vlogan v_sub.v -libmap liblist.map -sverilog
%> vlogan v_mod.v -libmap liblist.map -sverilog -sc_model
 v_mod -sysc=2.2
%> vlogan v_configs.v -libmap liblist.map -sverilog
%> syscan sc_main.cpp -sysc=2.2
%> vcs -sysc=2.2 -top use_A sc_main -sverilog
```

The used configuration is specified with the `-top <config-name>` option.

**Note:**

The argument `sc_main` specifies that the design topology is SystemC-on-top.

When a different configuration is to be used, or a configuration has changed, it is sufficient to re-analyze the verilog file containing the changed configuration, and redo the elaboration.

---

## Limitations

The following limitation apply:

- A Verilog-on-top design must contain at least one SystemC instance, when no configurations are used. Later on, this SystemC instance can be configured to something else.
- The name of the SystemC-top entity is hard coded to sYsTeMcToP.
- The interfaces of the modules must match. The results are unpredicted otherwise. It is the user's responsibility to keep the consistence here.

---

## Parameters

Parameters are supported between Verilog and SystemC. The parameter values that are specified for a SystemC instance in Verilog are automatically passed to the SystemC domain.

---

### Parameters in Verilog

Supported parameter types in Verilog are signed and unsigned integers and the real data type. For SystemVerilog, the string parameter type is also supported. Parameters are part of a module declaration and can be used like:

```
parameter msb = 7;
parameter e = 7, f = 5;
parameter foo = 8; bar = foo + 42;
parameter av_delay = (e + f) / 2;
parameter signed [3:0] mux_selector = 3;
parameter real pi = 314e-2;
parameter string hi_there = "Verilog String Parameter";
```

---

## Parameters in SystemC

In SystemC, there is no standard definition for parameters. Therefore, a special parameter class is defined for that purpose. The supported types must match the types as being used in (System)Verilog , so the supported datatypes are int, double and std::string. Within SystemC the parameters must be initialized with a default value inside the class constructor. Example:

```
#include "systemc.h"
#include "snps_hdl_param.h"

SC_MODULE(sysc_foo) {
 // declarative part
 hdl_param<int> msb;
 hdl_param<int> e, f;
 hdl_param<double> av_delay;
 hdl_param<std::string> hi_there;

 // initialization part
 SC_CTOR(sysc_foo) : HDL_PARAM(msb, 42), HDL_PARAM(e, 3),
 HDL_PARAM(f, 4), HDL_PARAM(av_delay, "123.456"),
 HDL_PARAM(hi_there, "SystemC String Parameter")
 {
 ...
 }
}
```

---

## Verilog-on-Top, SystemC-down

The instantiation of a parameterized SystemC module inside Verilog is the same as for any other Verilog module:

```
sysc_foo #(11, 2, 3, 12.21, "Verilog-override") foo1(...);
sysc_foo #(.av_delay(44.33), .e(-9)) foo2(...);
sysc_foo foo3(...); // using all default parameter values
```

Within the SystemC constructor, the values of the parameters can be obtained by:

```
// SC_CTOR(sysc_foo) : HDL_PARAM(...)...
{
 int l_msb = msb.get();
 double delay = av_delay.get();
 std::string str = hi_there.get();
}
```

---

## SystemC-on-Top, Verilog

Within SystemC there are two ways to instantiate a foreign module:

- using the default constructor, and using separate setting calls for the parameters, or
- using a fully specified constructor, where each parameter must be assigned a value.

The instantiation can be in any SystemC module and/or in the sc\_main routine:

```
#include "v_add.h" // verilog module
int sc_main(int, char **) {
 v_add m_v1("v1", 3 /* incr value */, 1.01 /* factor */,
 "SystemC Override");
 v_add m_v2("v2");
 m_v2.incr_value(4);
 m_v2.factor(0.99);

 m_v2.hi_there("SystemC Override #2");

 sc_start(-1, SC_NS);
}
```

The hdl\_param class defines the ::operator() to initialize the parameters, and the ::get() function for obtaining the final value of the parameter. Parameters can only be initialized once, and cannot be altered after the value of the parameter is obtained by means of the ::get() function.

---

## Namespace

For SystemC-2.2, name spaces are used to define the SystemC hdl\_param objects:

```
namespace sc_snps {
 template < class T >
 class hdl_param : public sc_object { ... };
} // namespace sc_snps
```

For the declaration of the parameters this namespace must be used:

```
SC_MODULE(sysc_foo) {
 sc_snps::hdl_param<int> i;
};
```

---

## Parameter specification as vcs elaboration arguments

Parameter can be defined using the vcs elaboration command line arguments. This is implemented only for a Verilog-on-top design:

```
* -pvalue+v_top.foo1.msb=33
```

This works only for integer and real parameter types. This doesn't work for string parameters.

```
* -parameters param.lst
```

with param.lst a list of parameter assignments (see the specific vcs part of this guide discussing parameters).

---

## Debug

The SystemC hdl\_param objects are visible as class parameters within a combined hierarchy view (vpd-file). Although parameters are constant and won't change after time == 0, they can be traced.

Access with the UCLI get command is supported. Changing the value with the change or force commands is not supported, since parameters are constant after the construction time.

---

## Limitations

The verilog parameters are not compile constants for SystemC. That has a limitation that these can not be used as template arguments for the construction of templated classes. Example:

```
SC_CTOR(not_possible) : HDL_PARAM(width, 4) {
 sc_int<width> *pint = new sc_int<width>; // NOT SUPPORTED
}
module test(data_in1, data_in2);
 parameter width = 12;
 input [width-1 : 0] data_in1; // NOT SUPPORTED
 input [11 : 0] data_in2;
endmodule
```

---

## Debugging Mixed Simulations Using DVE or UCLI

You can use Discovery Visual Environment (DVE) or the Unified Command-line Interface (UCLI) to debug VCS simulations containing SystemC source code by attaching the C-source debugger to DVE or UCLI.

The following steps outline the general debugging flow. For more information, see *The Discovery Visual Environment User Guide* and the *Unified Command-line Interface User Guide*.

1. Compile your VCS with SystemC modules as you normally would, making sure to compile all SystemC files you want to debug.

For example, with a design with Verilog on top of a SystemC model:

```
% syscan -cpp g++ -cflags "-g" my_module.cpp:my_module
% vcs -cpp g++ -sysc -debug_all top.v
```

Note that you must use `-debug` or `-debug_all` to enable debugging.

2. Start the debugger.

- To start DVE, enter:

```
simv -gui
```

- To start UCLI, enter:

```
simv -ucli
```

3. Attach the C debugger as follows:

- In DVE, select **Simulator > C/C++ Debugging** or enter `cbug` on the console command line.
- In UCLI, enter `cbug` on the command line.

Debugging SystemC source code is enabled and the following message appears:

```
CBug - Copyright Synopsys Inc. 2003-2009.
```

4. Run the simulation.

---

## Improved CBug Debugging Capabilities

The following debugging capabilities have been provided in CBug to ease troubleshooting issues with your SystemC designs.

- [Viewing sc\\_signal of User-defined struct in Waveform Window](#)
- [Driver/Load Support for SystemC Designs in Post Processing](#)

---

### **Viewing sc\_signal of User-defined struct in Waveform Window**

Until now, troubleshooting a user-defined c/c++/SystemC structure was not available in CBug. Hereafter, you can easily dump signals or ports of type user-defined structs and view these signals in the waveform window. This will enable you to debug these user-defined structs by viewing them in the waveform window clearly. This feature enables dumping of signals and ports that are part of the static design hierarchy. However, the local variables inside class methods whose lifetime is valid only for that method call are out of the scope of this feature.

This feature is disabled by default. To enable this feature, perform the following steps:

In UCLI:

```
%ucli> config syscaddstructtypes on
```

In DVE:

Click **Edit -> Preferences**. The Preferences dialog box appears. Select **Testbench/CBug**. Choose **CBug**. CBug options appear on the right hand side of the dialog box. Here, check the box **For signals and ports over struct/union types**.

In shell:

```
%>setenv SYSC_ADD_STRUCT_TYPES 1
```

This feature is not supported on Solaris platform.

---

## **Driver/Load Support for SystemC Designs in Post Processing**

Until now, viewing driver/load on a Verilog signal in a mixed-language design was not possible in the post-processing mode thereby depriving you of a better debug capability. Hereafter, you will be able to view the driver or load on Verilog signals in post-processing mode. This will enable you to understand from where the Verilog signal is being driven so that you can back trace the signal easily in the post-processing mode.

---

## Transaction Level Interface

The transaction level interface (TLI) between SystemVerilog and SystemC supports communication between these languages at the transaction level. At RTL, all communication goes through signals. At transaction level, communication goes through function or task calls.

It is an easy-to-use feature that enables integrating Transaction Level SystemC models into a SystemVerilog environment seamlessly and efficiently. The automated generation of the communication code alleviates the difficulties in implementing a synchronized communication mechanism to fully integrate cycle accurate SystemC models into a SystemVerilog environment.

TLI exploits using the powerful Verification Methodology Manual (VMM methodology) to verify functional or highly accurate SystemC TLMs. TLI improves mixed language simulation performance and speeds-up the development of the verification scenarios.

Furthermore, TLI adds the necessary logic to enable you to debug the transaction traffic using the waveform viewer in DVE.

TLI augments the pin-level interface (DKI) to enable both languages to communicate at different levels of abstraction. Using this interface, you can simulate some part of the design at the transaction-level and the other part at the hardware level, enabling full control over the level of detail required for your simulation runs. This integration also helps you to leverage the powerful features of SystemVerilog for transaction-level verification. Also, you can use the same testbenches for hardware verification. TLI enables you to do the following:

- Call interface methods of SystemC interfaces from SystemVerilog

- Call tasks or functions of SystemVerilog interfaces from SystemC

Methods and tasks can be blocking as well as non-blocking. Blocking in the context of this document means the call may not return immediately, but consumes simulation time before it returns. However, non-blocking calls always return immediately in the same simulation time.

The caller's execution is resumed exactly at the simulation time when the callee returns, so a blocking call consumes the same amount of time in both the language domains – SystemC and SystemVerilog. Non-blocking calls always return immediately.

The tasks or functions must be reachable through an interface of the specific language domain. This means that for SystemVerilog calling SystemC, the TLI can connect to functions that are members of a SystemC interface class. For SystemC calling SystemVerilog, the TLI can call functions or tasks that are part of a SystemVerilog interface.

The usage model of the transaction level interface consists of defining the interface by means of an interface definition file, calling a code generator to create the TLI adapters for each domain, and finally instantiation and binding of the adapters.

---

## Interface Definition File

The interface definition file contains all the necessary information to generate the TLI adapters. It consists of a general section and a section specific to task/function. The order of lines within the general

section is arbitrary, and the first occurrence of a `task` or `function` keyword marks the end of this section. The format of the file is illustrated as follows:

```
interface if_name
direction sv_calls_sc
[verilog_adapter name]
[systemc_adapter name]
[hdl_path XMR-path]

[#include "file1.h"]
[`include "file2.v"]
...

task <method1>
input|output|inout|return vlog_type argument_name_1 return
input|output|inout|vlog_type argument_name_2
.
.
.

function [return type] method2
input|output|inout vlog_type argument_name_1
.
.
.
```

The `interface` entry defines the name of the SystemVerilog "interface". Similarly, the `class` entry defines the name of the SystemVerilog "class". For the direction SystemVerilog calling SystemC, the `if_name` argument must match the name of the SystemC interface class. Specialized template arguments are allowed in this case, for example `my_interface<int>` or `my_interface<32>`. For SystemC calling SystemVerilog, `if_name` must match the SystemVerilog interface name.

The `direction` field specifies the caller and callee language domains, and defaults to `sv_calls_sc`. The SystemC calling SystemVerilog direction is indicated by `sc_calls_sv`.

The `verilog_adapter` and `systemc_adapter` fields are optional and define the names of the generated TLI adapters and the corresponding file names. File extension `.sv` is used for the `verilog_adapter` and file extensions `.h` and `.cpp` for the `systemc_adapter`.

The optional `#include` lines are inserted literally into the generated SystemC header file, and the optional ``include` lines into the generated SystemVerilog file.

The `hdl_path` field is optional and binds the generated Verilog adapter through an XMR to a fixed Verilog module, Verilog interface, or class instance. Using `hdl_path` makes it easier to connect to a specific entity, however, the adapter can be instantiated only once, not multiple times. If you want to have multiple connections, then create multiple adapters which differ only by their name.

A SystemC method may or may not be blocking, meaning it may consume simulation time before it returns or it will return right away. This distinction is important for the generation of the adapter. Use `task` for SystemC methods that are blocking or even potentially blocking. Use `function` for SystemC methods that will not block for sure. Note that `functions` enable faster simulation than `tasks`.

The lines after `task` or `function` define the formal arguments of the interface method. This is done in SystemVerilog syntax. This means that types of the arguments must be valid SystemVerilog types. See “[Supported Data Types of Formal Arguments](#)” on page 72 for more details.

The `return` keyword is only allowed once for each task. It becomes an output argument on the Verilog side to a return value on the SystemC side. This feature is required because blocking functions in SystemC may return values, while Verilog tasks do not have a return value.

The one exception is if the methods of the SystemC interface class use reference parameters. For example, if `my_method(int& par)` is used, then you need to mark this parameter as `inout&` in the interface definition file. Note that the `&` appendix is only allowed for `inout` parameters. For `input` parameters, this special marker is not needed and not supported. Pure `output` parameters that should be passed as reference must be defined as `inout` in the interface definition file.

### **Example interface definition file for the simple\_bus blocking interface:**

```
interface simple_bus_blocking_if
direction sv_calls_sc
verilog_adapter simple_bus_blocking_if_adapter
systemc_adapter simple_bus_blocking_if_adapter
#include "simple_bus_blocking_if.h"

task burst_read
input int unsigned priority_
inout int data[32]
input int unsigned start_address
input int unsigned length
input int unsigned lock
return int unsigned status

task burst_write
input int unsigned priority_
inout int data[32]
input int unsigned start_address
input int unsigned length
input int unsigned lock
return int unsigned status
```

---

## Generation of the TLI Adapters

The following command generates SystemVerilog and SystemC source code for the TLI adapters from the specified interface definition file:

```
syscan -idf interface_definition_file
```

This command generates SystemC and SystemVerilog files that define the TLI adapters for each language domain. All generated files can be compiled just like any other source file for the corresponding domain. The files have to be generated again only when the content of the interface definition file changes.

TLI adapters for the `sv_calls_sc` direction can be generated in two different styles. The SystemC part of the generate adapter is the same for both styles, however, the SystemVerilog part is different.

If you use the `-idf` option along with the `interface` entry in the `.idf` file, then this option creates a SystemVerilog "interface". Similarly, If you use the `-idf` option along with the `class` entry in the `.idf` file , then this option creates a SystemVerilog "class".

A class is generally easier to connect into the SystemVerilog source code and there are situations where a SystemVerilog testbench allows you to instantiate a class but not an interface. However, if a class is generated, then the TLI adapter can create only one connection of this type between the SystemVerilog and SystemC side. Alternatively, if an interface is generated, then multiple connections can be created (which are distinguished by the integer parameter of the interface).

---

## Transaction Debug Output

Since the transaction information traveling back and forth between SystemVerilog and SystemC along with the transaction timing is often crucial information (for example, comparison of ref-model and design for debugging and so on), the SystemC part of the TLI adapters are generated with additional debugging output that can be enabled or disabled. For additional information, see “[Instantiation and Binding](#)” on page 69.

Note:

Transaction debug is an LCA feature. For more information on this feature, refer to *Debugging with Transactions* chapter in VCS LCA Features book

The transaction debug output can either be used as a terminal I/O (stdout) or as a transaction tracing in DVE. In DVE, each TLI adapter has an `sc_signal<string>` member with name `m_task_or_function_name_transactions` that you can display in the waveform viewer of DVE.

Sometimes, the next transaction begins at the same point in time when the previous transaction ends. Prefixes "`->`" and "`<-`" are used such that both transactions could be distinguished. The return values, if any, for the previous transaction are displayed with a leading "`<-`". The input arguments for the new argument are prefixed with "`->`".

If the default scheme how the debug output is formatted does not match the debugging requirements, then do not change the generated code in the TLI adapter. Instead, override the debug methods `m_task_or_function_name_transactions` using a

derived class that defines only these virtual methods. You can copy these methods from the generated adapter code as a starting point and then modify the code according to the debugging requirements.

If the adapter is generated again, then the existing code is overwritten and all manual edits are lost.

Note:

Do not manually modify the code generated by the TLI adapter. Instead, override the debug functions in a derived class.

---

## Instantiation and Binding

TLI adapters must always be instantiated in pairs, where each pair forms a point-to-point connection from one language domain to the other.

If multiple pairs of the same TLI adapter type are needed in the design, you must instantiate the adapter multiple times in each domain. The point-to-point connection must be set up by assigning a matching ID value to the SystemVerilog interface or class, and the SystemC module. The ID value is set for SystemC module and the SystemVerilog class, if generated, as a constructor argument. In case the SystemVerilog Adapter is generated as an interface, the ID is set through a parameter.

The SystemVerilog TLI adapter (either as an interface or a class) can be instantiated and used like any other SystemVerilog interface or class. If you want to call an IMC of a SystemC interface, you need to call the corresponding member function/task of the TLI adapter.

The SystemC part of the TLI adapter is a plain SystemC module that has a port `p` over the specified interface name (`sc_port if_name p`). This module can be instantiated in the systemC design hierarchy, where you can bind the port to the design interface just like any other SystemC module.

As mentioned above, there is an optional constructor argument for the point-to-point ID of type `int` that defaults to zero. There is a second optional constructor argument of type `int` that specifies the format of debug information that the adapter prints when an interface method is called. If the LSB of this argument is set, the TLI adapter prints messages to `stdout`. If the next bit (`LSB+1`) is set, this information is written to an `sc_signal<string>` that you can display in DVE.

For SystemC calling SystemVerilog, the SystemC part of the TLI adapter is an `sc_module` that you can instantiate within the module where you want to call the Verilog tasks or functions. You can execute the cross-boundary task or function calls by calling the corresponding member function of the SystemC TLI adapter instance.

The SystemVerilog portion of the TLI adapter depends on whether the `hdl_path` field and the following options are used:

- The `-idf` option used along with the `interface` entry in the `idf` file.
- The `-idf` option used along with the `class` entry in the `idf` file.

- combination `-idf` used along with the `interface` entry in the `idf` file, no `hdl_path`:

The Verilog adapter has a port over the interface type, as defined in the interface description file. You can instantiate the adapter module in the Verilog design like any other Verilog module, and the port should be bound to the SystemVerilog interface that implements the tasks or functions to be called.

- combination `-idf` used along with the `interface` entry in the `idf` file, with `hdl_path path`:

The Verilog adapter is a Verilog module with no ports. All calls initiated by SystemC are routed through the XMR path to some other Verilog module or interface.

- combination `-idf` used along with the `class` entry in the `idf` file, with `hdl_path path`:

The Verilog adapter is a group of task definitions and other statements that must be included in a program with an ``include "if_name_sc_calls_sv.sv"` statement. Calls initiated by the SystemC side are routed through the XMR path to some class object of the SV testbench.

- combination `-idf` used along with the `class` entry in the `idf` file, no `hdl-path`:

This combination is not supported and displays an error message.

It is important to note that Verilog tasks, in contrast to Verilog functions, must always be called from within a SystemC thread context. This is because tasks can consume time, and in order to

synchronize the simulator kernels, `wait()` is used in the SystemC adapter module. The SystemC kernel throws an error when `wait()` is called from a non-thread context.

---

## Supported Data Types of Formal Arguments

The TLI infrastructure uses the SystemVerilog DPI mechanism to call the functions and transport data, so the basic type mapping rules are inherited from this interface. Refer to the SystemVerilog standard for a detailed description on DPI. In summary, the following mapping rules apply for simple data types:

| SystemVerilog  | SystemC   |
|----------------|-----------|
| input          | byte      |
| inout   output | byte      |
| input          | shortint  |
| inout   output | shortint  |
| input          | int       |
| inout   output | int       |
| input          | longint   |
| inout   output | longint   |
| input          | real      |
| inout   output | real      |
| input          | shortreal |
| inout   output | shortreal |
| input          | chandle   |
| inout   output | chandle   |
| input          | string    |
| inout   output | string    |
| input          | bit       |
| inout   output | bit       |
| input          | logic     |
| inout   output | logic     |

For the integral data types in the above table, the signed and unsigned qualifiers are allowed and mapped to the equivalent C unsigned data type.

All array types listed in the above table are passed as pointers to the specific data types. There are two exceptions to this rule:

- Open arrays, which are only allowed for the SystemVerilog calling SystemC direction, are passed using handles (`void *`). The SystemVerilog standard defines the rules for accessing the data within these open arrays.
- Packed bit arrays with sizes  $\leq 32$  in input direction (for example, `input bit [31:0] myarg`) are passed by value of type `svBitVec32`. Basically, this type is an unsigned `int`, and the individual bits can be accessed by proper masking.

---

## Miscellaneous

The TLI generator uses Perl5 which needs to be installed on the local host machine. Perl5 is picked up in the following order from your installation paths (1=highest priority):

1. `use ${SYSCAN_PERL}, if (defined)`
2. `/usr/local/bin/perl5`
3. `perl5` from local path and print warning

---

## Delta-cycles

VPD dumping of delta-cycles is supported for SystemC elements, but it needs to be enabled as follows:

First, add function call `bf_delta_trace(1)` to the source code.  
Example:

```
#include "cosim/bf/systemc_user.h"
...
int prev_state = bf_delta_trace(1);
```

This function turns on the delta tracing (or, turns off when the argument is 0). This function can be called anywhere, for example in constructors of SystemC classes, and/or in `sc_main`.

Next, make the generated delta-cycles visible in the DVE waveform window as follows:

1. Start the simulator with `-gui` option. This will pop up DVE.
2. Enable CBug Debugger in the DVE, and then select **Simulator -> C/C++ Debugging -> enable**.  
Or, enter CBug in the DVE gui console command line.
3. Select **Simulator -> Capture Delta Cycle Values**. This will turn it on for DVE.
4. Go with the time-marker somewhere, and then Press right-mouse button.
5. select **Expand Time**.

Now the SystemC delta cycles are shown.

---

## Using a Customized SystemC Installation

You can install the OSCI SystemC simulator 2.2.0 and tell VCS to use it for Verilog/SystemC co-simulation. To do so, you need to:

- Obtain OSCI SystemC version from [www.systemc.org](http://www.systemc.org).
- Set the SYSTEMC environment variable to path of the OSCI SystemC installation. For example:

```
setenv SYSTEMC /net/user/download/systemc-2.2.0
```

To create a SystemC 2.2 installation with VCS patches, perform the following series of tasks.

There are several files in the \$VCS\_HOME/etc/systemc-2.2 directories that contain necessary patches. You need to replace the following 4 files from the OSCI installation (\*) with those from \$VCS\_HOME/etc/systemc-2.2:

```
$VCS_HOME/etc/systemc.../
sc_simcontext.cpp
sc_simcontext.h
sc_event.cpp
sc_main_main.cpp
```

(\*): here is the location where you need to replace these files with the those from \$VCS\_HOME

For SC 2.2: *osci\_SC\_installation\_path/src/sysc/kernel*

For example, replace:

```
<your osci SystemC installation>/src/sysc/kernel/
sc_simcontext.cpp
```

with:

```
$VCS_HOME/etc/systemc-2.2/sc_simcontext.cpp
```

Follow the installation instructions provided by OSCI (see file INSTALL which is part the SystemC tar file) and build a SystemC library. Note that you must use `../configure i686-pc-linux-gnu` to build an RH4, RH5, suse10 or suse11 installation; call `../configure` on other platforms.

Set the `SYSTEMC_OVERRIDE` VCS environment variable to the user-defined OSCI SystemC library installation path. For example:

```
setenv SYSTEMC_OVERRIDE /net/user/systemc-2.2.0
```

Header files must exist in the `$SYSTEMC_OVERRIDE/include` directory and the `libsystemc.a` library file must be in the following directories:

- `$SYSTEMC_OVERRIDE/lib-linux/`
- `$SYSTEMC_OVERRIDE/lib-gccsparcos5/`

The `$SYSTEMC_OVERRIDE` environment variable must point to the OSCI SystemC simulator installation. Header files must be located at `$SYSTEMC_OVERRIDE/include` and library files in:

- `$SYSTEMC_OVERRIDE/lib-linux/libsystemc.a`
- `$SYSTEMC_OVERRIDE/lib-gccsparcos5/libsystemc.a`

As of March 19, 2007 (`SYSTEMC_VERSION` 20070314), VcsSystemC 2.2 is binary compatible with OSCI SystemC 2.2.0.

---

## Compatibility with OSCI SystemC

The default, built-in SystemC simulator is binary compatible to the OSCI SystemC 2.2.0 simulator. This means that you can link the object files (\*.o, \*.a, \*.so) compiled with the OSCI SystemC 2.2.0 simulator to a `simv` executable without adding any switch to `vcs` or `syscan`.

---

## Compiling Source Files

If you need to compile the source files that include `systemc.h` in your own environment and not with the `syscan` script, then add compiler flag `-I$VCS_HOME/include/systemc22`.

---

## Using Posix threads or quickthreads

`SC_THREAD` processes can be implemented by `pthreads` (Posix threads) or `quickthreads`. Switching from one `SC_THREAD` to another is significantly slower with `pthreads` than with `quickthreads`. However, `pthreads` have advantages in terms of debugging support with `gdb` or `DVE/CBug` or tools like `Purify` or `Valgrind`.

Whether `pthreads` or `quickthreads` are used depends on the platform and can be influenced by the user in some case(s).

- RHEL32: always `quickthreads`
- Linux 64-bit: `quickthreads` are default, `pthreads` can be selected
- Solaris 32-bit: always `quickthreads`
- Solaris 64-bit: always `pthreads`

The following API allows you to select or check if pthreads are used (if supported on the platform):

```
// wish for either pthreads or quickthreads, return true
// if wish is granted, return false+produce warning if not
// possible.

bool sc_snps::request_to_use_pthreads(bool use_pthreads);

// use pthreads (true) or quickthreads for SC_[C]THREADS

bool sc_snps::use_pthreads();
```

Function `request_to_use_pthreads()` must be called before the simulation starts to run for the first time, for example, before the first call of `sc_start()`. A good position in which to place the statement is at the beginning of the `sc_main()` function.

The function returns true if the request was granted. It returns false if this is not possible and also a warning is printed. Reasons may be the wrong platform (for example, RHEL32), or by calling the function too late.

---

## VCS Extensions to SystemC Library

The following proprietary extensions are available as part of VCS, and not available as part of OSCI SystemC.

- Runtime functions

Include file `systemc_user.h` contains the prototypes of functions that can be called during execution of the simulation. Add this line to your source code to make the header file visible:

```
#include <cosim/bf/systemc_user.h>
```

- `GetFullName()`

Returns the full logical name of the given object or "No Name" on error. The full name can contain hierarchical sub-paths of other domains, like Verilog:

```
namespace sc_snps {
 const char *GetFullName(sc_object *obj);
}
```

- `sc_object::name()` Returns Logical Path Name

Until now, the `sc_object::name()` returned only the physical path (underscore is used when hierarchy crosses the language).

Hereafter, `sc_object::name()` returns the logical path name (dot is used when hierarchy crosses the language) when the following call is made:

```
sc_snps::sysc_configure(sc_snps::VCS_SYSC_LOGIC_NAME, 1);
```

Without the above call, `sc_object::name()` returns the physical path name by default.

The function `sysc_configure()` is defined in `systemc_user.h`. You must include this header file to use this function. This feature works only with SystemC 2.3 which can be enabled using the option `-sysc=2.3`.

If SystemC 2.3 is not used, the following message is generated and the call to `sysc_configure()` is ignored.

[SC-CONF-NO] `sysc_configure` is not supported

**Note:**

The member function `sc_core::sc_object::name()` defined as part of the SystemC language usually does not return the same string as `sc_snps::GetFullName()`. Member `sc_object::name()` does not consider Verilog instances and shows only the path name w.r.t. to the SystemC hierarchy. Alternatively, the `GetFullName()` function considers the entire Verilog/ SystemC instance hierarchy and gives the correct logical name of the SystemC instance inside this hierarchy.

- `GetName()`

Returns the instance name (short name) of the given object or return "No Name" on error:

```
namespace sc_snps {
 const char *GetName(sc_object *obj);
}
```

**Note:**

The corresponding member function `sc_core::sc_object::basename()`, defined as part of the SystemC language, usually does not return the same string as `sc_snps::GetName()`.

- Asynchronous Reset for Clocked Thread Processes

The SystemC standard allows a clocked thread process (`SC_CTHREAD`) to have an optional synchronous reset. This is specified with the `reset_signal_is()` function as follows:

```
SC_CTHREAD(th_1, clk.pos());
reset_signal_is(syncrst, true);
```

In addition, VCS supports an optional asynchronous reset, which is specified with the `async_reset_signal_is()` function. For example:

```
SC_CTHREAD(th_1, clk.pos());
async_reset_signal_is(asyncrst, true);
```

Note:

This feature is a VCS-specific extension. It is not a part of the IEEE 1666 OSCI SystemC standard.

Note the following points about asynchronous resets:

- Both the synchronous and asynchronous resets are optional. A process can have one, both, or none of these resets.
- While you can specify asynchronous resets in any order, ensure that they are within the constructor section (`SCCTOR`).
- An asynchronous reset cannot be specified more than once.
- When the asynchronous reset is specified, the clocked thread process will restart if either of the following conditions are true:
  - the asynchronous reset is active during the clock edge

- the asynchronous reset changes from inactive to active even if there is no clock edge

When the synchronous reset is also specified, the process will also restart if the synchronous reset is active during the clock edge.

If only the synchronous reset is specified, the behavior is as defined in the IEEE 1666 standard.

The syntax of the asynchronous reset function is as follows:

```
async_reset_signal_is (pin, level)
```

Where:

pin

Specifies the signal, which can be either an input port or signal of type `bool`.

level

Defines the level at which the reset becomes active.

This feature has the following limitations:

- Asynchronous reset can be specified only for a `SC_CTHREAD`.
- Asynchronous resets must be specified during elaboration, preferably within the `SC_CTOR` section.

---

## Installing VG GNU Package

VCS supports gcc compiler versions 4.5.2, 4.2.2, and 3.4.6. It supports (besides the SUN "CC" Compiler) Gnu gcc 3.3.2 on Solaris.

Synopsys strongly recommends using the VG GNU package for SystemC.

The FTP instructions to download VG GNU package are available in VCS *Release Notes* under the section *Downloading and Installing VG GNU Package* under *General Platform Support*.

---

## Static and Dynamic Linking

The main difference between static and dynamic linking is the time at which the object files are linked into an application program. In case of static linking, object files are linked during compilation, whereas in the case of dynamic linking, linking is done at runtime.

### Static Linking in VCS

You can compile C/C++/SystemC files into object files and archive them in a common object file (.a's), as shown below:

```
% g++ -O3 -Wall -I. -c ext_inv.cpp -o ext_inv.o
% g++ -O3 -Wall -I. -c ext_buf.cpp -o ext_buf.o
% ar -r extenv.a ext_inv.o ext_buf.o
```

Note:

Add the `-I${VCS_HOME}/include/systemc_version` option to C/C++ compiler to compile SystemC files.

The archive can be statically linked by just passing the archive as any other file on the `vcs` command line.

```
% vcs top.v ./extenv.a
```

Note:

Add the `-sysc` option to the `vcs` command line, if the object file is for SystemC.

## Dynamic Linking in VCS

You can compile C/C++ files into a shared object file or you can have a pre-compiled shared object.

Note:

The pre-compiled shared object should be built on the same compiler as supported by VCS.

The shared object file uses the following naming convention:

`liblibrary_name.so.version`

It begins with the `lib` keyword, followed by any specified name `library_name`, followed by `.so.version`.

The `version` is optional and is user defined. Linker/loader automatically locates and picks the shared object file using `-L` and `-l` options as explained below.

For example, the library name in `libfoo.so` or `libfoo.so.1` is `foo`. The commands to create a shared object file are as shown:

```
% gcc -fPIC -o foo.o -c -I$VCS_HOME/include foo.c
% gcc -shared -o libfoo.so foo.o
```

The shared object file can be dynamically linked by using `-LDFLAGS` with the `-Lpath_to_shared_object` and `-llibrary_name` options on the `vcs` command line.

`-LDFLAGS` options

Specifies the options to the linker/loader.

`-Lpath_to_shared_object`

Specifies the path, where shared objects reside.

`-llibrary_name`

Specifies the library name of the shared object file.

If there are more than one shared object located in different directories, you can specify `-Lpath_to_the_shared_object` multiple times for each directory and `-llibrary_name` multiple times for each shared object file.

```
% vcs top.v -LDFLAGS "-L<path_to_libfoo.so> -lfoo
-L<path_to_libhello.so> -lhello"
```

You can also specify the linker options directly to the `vcs` command line.

```
% vcs top.v -Lpath_to_libfoo.so -lfoo
-Lpath_to_libhello.so -lhello
```

## Dynamic Linking in VCS

Following are the steps for dynamic linking of SystemC files:

- Create a shared object file

```
% gcc -fPIC -o foo.o -c -I$VCS_HOME/include/systemc22
 foo.cpp
% gcc -shared -o libfoo.so foo.o
```

- Analyze your SystemC top file (which is instantiated in HDL design) to create a HDL wrapper.

```
% syscan sc_top.cpp:sc_top -sysc=2.2
```

- The shared object can be dynamically linked by using the `-Lpath_to_shared_object` and `-llibrary_name` options on the `vcs` command line.

```
% vcs -sysc=2.2 top.v -Lpath_to_shared_object file -lfoo
```

## **LD\_LIBRARY\_PATH Environment Variable**

You can set the `LD_LIBRARY_PATH` environment variable to the directory where the shared object file resides.

```
% setenv LD_LIBRARY_PATH
 path_to_shared_objectfile:$LD_LIBRARY_PATH
```

Now, for any change in the C/C++/SystemC files, you simply need to rebuild the shared object file with the commands as mentioned above and execute the `simv`. You do not have to rebuild the `simv`.

## **Limitations**

The following limitations apply to the VCS/SystemC interface.

- No Donuts / Sandwiches

VCS/SystemC does not support having "donuts" or "sandwiches" in SystemC and Verilog modules. Therefore, you cannot have a SystemC instance that is instantiated under an HDL design unit and itself instantiates another HDL design unit. Similarly, a SystemC-HDL-SystemC instance hierarchy is not supported. In other words, following the design hierarchy from a leaf instance towards the root, you can transition from SystemC to HDL or vice-versa only once.

- Number of ports

There is no limitation regarding the number of port for an interface model. It may have none, one, or multiple ports.

- You cannot compile mixed designs (SystemC+HDL) in a directory where the directory path/name contains the symbol ‘:’. For instance, if you have a ‘:’ in your directory path/name, as illustrated below, you might face a compilation error. Depending on the complexity of your flow, you might even face an elaboration error.

```
/remote/vg/work/mixed_design:example/build/
```

## Incremental Compile of SystemC Source Files

SystemC source files are compiled with `syscan`. VCS supports the incremental compile of SystemC source files to reduce the recompilation time. Only the files that have changed (or, the files affected by a change in a header file that they use) are recompiled; all other files are not recompiled. You can choose from among the following different usage models:

- Full build from scratch
- Full incremental build
- Partial build with object files
- Partial build with shared libraries

Incremental compile does not require any change in existing compile scripts. VCS automatically figures out when a `syscan` command needs to trigger compiling a source file with `gcc`.

---

## Full Build from Scratch

When you compile a design for the first time, there are no object files (for SystemC sources) from a previous compilation. A typical command sequence looks like the following example:

```
Analyzing SC source files:
% syscan B1.cpp
% syscan B2.cpp
% syscan A.cpp:A

Analyzing Verilog source files:
% vlogan top.v ...

Elaboration:
% vcs -sysc Top
```

Here, all SC source files are compiled. Each invocation of `syscan` triggers a compilation of the specified SC source files. Object files are stored in `csrc/sysc` or the `mydir/sysc` directory if you use the `-Mdir mydir` option.

This is called a full build from scratch. It serves as a basis for later incremental builds.

---

## Full Incremental Build

If you specify the same commands again (see “[Full Build from Scratch](#)” on page 89), incremental compilation kicks in. It is important not to remove the csrc/sync directory; otherwise, you get another full build.

Each call of `syscan` now checks if the specified files really need to be compiled again. For example, the command:

```
% syscan B1.cpp
```

will compile `B1.cpp` only if either the file `B1.cpp`, or a header file has changed since the last invocation of `syscan`. The dependency check to header files includes any header that is directly or indirectly included by `B1.cpp`.

Note that any compiler option specified with `-cflags` (such as `-Imydir` or `-DMODE=1`) is not considered during the dependency check. If the flags change but the source files remain the same, the files are not recompiled.

Syscan calls can also create a Verilog wrapper. For example, you can use the following command:

```
% syscan A.cpp:A
```

Here, source file `A.cpp` is compiled again if either `A.cpp`, or a header file has changed. This `syscan` call also checks if the signature (the set of interface ports) of the interface has changed. If (and only if) the signature has changed, then the interface file is generated and compiled again. The interface file is only created and compiled again when the signature changes.

Incremental compilation of SystemC files reduces the time spent in `syscan` calls. When the remaining commands:

```
% vlogan top.v ...
% vcs -sysc Top ...
```

are issued again, the Verilog files are analyzed and elaborated again, so these phases of the overall compilation do not benefit directly from the SystemC incremental compilation. However, generation of object code for Verilog files may be skipped by VCS if this feature is enabled.

---

## Partial Build with Object Files

The overall turn-around-time (TAT) to get an updated simulation (`simv`) after a change in a SC source file can be further reduced in some cases. If you are sure that only SC source files have changed, and none of the changes affects the signature of the SC interface file, then invoke a partial build with the following command:

```
% vcs -sysc=incr [-full64]
```

All SC source files that have previously been compiled with `syscan` are checked and automatically compiled again if necessary. Finally, the simulation (`simv`) is linked again.

You cannot specify any other VCS option together with `-sysc=incr`. Only the option `-full64` (aka `-mode64`) can, and must be specified again.

You can call `syscan` before calling `vcs -sysc=incr`. For example:

```
% syscan B1.cpp
% vcs -sysc=incr
```

Using this example, if `B1.cpp`, or a header file has changed, then `B1.cpp` is compiled again by the `syscan` call. The subsequent `vcs -sysc=incr` does not compile `B1.cpp` in this case. That means issuing the `syscan` call neither increase nor decrease the TAT; it just triggers the compilation of `B1.cpp` earlier.

If the signature of an SC interface file has changed, VCS prints an error message and aborts the compilation. You need to do a full incremental build in this case.

This compile flow applies only when the SC source files change. You must use a full incremental build in all other situations; for example:

- a Verilog source file has changed
- the signature of an SC interface file has changed
- SC models instantiate Verilog models, and the set of instances has changed.

---

## Partial Build with Shared Libraries

By default, `syscan` creates object files (for example. `B1.o`) which are part of the final link command to create the simulation (`simv`) during elaboration. For example:

```
g++ -o simv ... B1.o B2.o A.o ...
```

To use shared libraries instead of object files, use this command:

```
% syscan [-Mdir mydir] -shared
```

This command has to be specified without any other options except the optional `-Mdir` argument. It sets a “sticky” flag which applies to the `csrc` (or `mydir`) library. If the flag is present, the final link command uses a shared library. For example:

```
g++ -o simv ... libcsrc_systc.so ...
```

## Updating the Shared Library

The shared library is updated whenever necessary, meaning whenever an SC source file is changed and recompiled. The update is triggered when you invoke the following command:

```
% syscan -shared
```

or during elaboration with the following command:

```
% vcs -sysc Top ...
```

or, with a partial build:

```
% vcs -sysc=incr
```

## Using Different Libraries

Each library specified with `-Mdir` can use either object files or a shared library. For example:

```
% syscan -Mdir=lib1 B1.cpp
% syscan -Mdir=lib1 B2.cpp
% syscan -Mdir=lib1 -shared
% syscan -Mdir=lib2 A.cpp
% vcs -sysc ... -Mlib=lib1,lib2 ...
```

The above example specifies to use a shared library for lib1, but object files for lib2.

## Partial Build Invoked with vcs

You can get a simple use model and short TAT by just calling `vcs -sysc=incr` once the “sticky” flag has been set for one or more libraries.

VCS goes over all SC source files that were previously specified with `syscan`, recompiles them as necessary, updates the shared libraries as necessary, and finally links the simulation.

## Partial Build if Just One Shared Library is Updated

If only the SC source files located in one shared library change, but everything else is not modified, then it is sufficient to update the library. Linking the simulation again is not needed. For example, to specify content of shared library lib1:

```
% syscan -Mdir=lib1 B1.cpp
% syscan -Mdir=lib1 B2.cpp
% syscan -Mdir=lib1 -shared
...
% vcs -sysc -Mlib=lib1 ...
```

Now, you can modify `B1.cpp` and update just the shared library as follows:

```
edit B1.cpp // modify src code
% syscan -Mdir=lib1 -shared // update shared lib
% ./simv // run simulation
```

## **Adding or Deleting SC Source Files in Shared Library**

Whenever a new file is specified with `syscan`, it is compiled and automatically added to the library later on. This means the library remembers the files that were specified with `syscan`.

You cannot directly delete a file from a shared library. Instead, remove the entire `csrc/sysc` directory and do a full build again with the remaining SC source files.

## **Changing From a Shared Library Back to Object Files**

Once you specify `syscan -shared`, this library always remains as a shared library later on. If you want to revert back to using object files, remove the `csrc/sysc/info-comp` file. This removes the “sticky flag.” Existing object files remain valid.

---

## **Suppressing Automatic Dependency Checking**

By default, VCS checks dependencies of all SC source files specified with `syscan` during elaboration. There might be situations when a common header file has changed, but you do not want to recompile all files. You can suppress dependency checking and automatic recompilation using the `-sysc=nodep` option. For example, if you specify:

```
% vcs ... -sysc=nodep ...
```

then the dependency checking for all SC libraries is suppressed. If you specify:

```
% vcs ... -sysc=nodep:lib1,lib3
```

then dependency checking for `lib1` and `lib3` is suppressed, but other libraries are still checked.

---

## Restrictions

On Solaris, gmake (Gnu make) must be installed. Old versions of Sun make cannot be used because they do not understand the Makefiles generated by syscan/vcs.

---

## TLI Direct Access

This section describes the following topics:

- “Accessing SystemC Members from SystemVerilog” on page 97
- “Accessing Struct or Class Members of a SystemC Module from SystemVerilog” on page 113
- “Accessing Verilog Variables from SystemC” on page 124
- “Accessing SystemVerilog Functions and Tasks from SystemC” on page 130
- “Accessing SystemC Members from SystemVerilog Using the `tli_get_<type>` or `tli_set_<type>` Functions” on page 140
- “Generating C++ Struct Definition from SystemVerilog Class Definition” on page 151

---

## **Accessing SystemC Members from SystemVerilog**

This section describes how to directly access SystemC variables from SystemVerilog.

### **TLI Adaptor**

The SystemVerilog Transaction Level Interface (TLI) is created automatically and represents the SystemC instance inside the SV world. It allows the user to directly access public member variables and member functions of a SystemC instance.

The TLI adaptor is created by calling `syscan` with specific arguments. It has a collection of SV functions to access SystemC member variables and call methods. These arguments and functions are described in the following sections.

### **Instantiating the TLI adaptor in SV**

The TLI adaptor, which is an SV interface, is generated automatically, but it needs to be instantiated in the SV design to make it accessible. The SV interface has no ports, but it has one string parameter to specify the hierarchical path of the SystemC instance.

The path refers to the mixed SC or HDL module hierarchy. This path can be absolute, or a relative path name. Consistent with Verilog, a relative path name is resolved relative to the SV module, where the TLI function call occurs.

## Direct Variable Access

The TLI adaptor has a function for each public SystemC member variable, for which access from SV is to be enabled. The function is named `get_<member_variable>`. The function has no arguments, and returns the value of the member variable. The TLI adaptor provides a function `set_<member_variable>()` to write SystemC members from SV with value.

## Calling SystemC Member Function

The public member functions of the SC instance can be called from SV code. The member function is represented by an SV function in the TLI adaptor. Both SV and SC functions have the same signature.

The SC function is represented by an SV task in the TLI adaptor. If the SC member has a return value other than void, then the SV task has an additional output argument at the end into which the return value is written.

The SC function may be “blocking,” meaning it is allowed to call function `wait()` from the SC kernel and consume simulation time.

## Example

Definition of the SystemC instance:

```
#include <systemc.h>
class ABC
{
public:
 int AAA;
 sc_int<10> BBB;
 bool CCC(const char* p1);
 ...
};
```

## Definition of automatically generated TLI adaptor:

```
(* vcs_systemc_1 *)
interface tli_ABC;
 ...
 // DPI definition for SystemC method calls
 task CCC(output bit param_0, input string param_1); ...
 ...
 // DPI definition for SystemC var access
 function int get_AAA(); ...
 function void set_AAA(input int AAA); ...
 ...
 function bit[9:0] get_BBB(); ...
 function void set_BBB(input bit[9:0] BBB); ...
 ...
endinterface
```

## Usage of TLI adaptor in SV code:

```
module top;
 ...
 TLI_ABC #(top.sysc_a.inst0) sc_inst0();
 TLI_ABC #(sysc_b.reader.inst1) sc_inst1();
 ...
 int a;
 initial begin
 ...
 a = sc_inst0.get_AAA();
 a = a + sc_inst1.get_BBB();
 sc_inst0.set_AAA(a+10);
 if (sc_inst0.CCC("final test")) ...
 ...
 end
endmodule
```

## Arguments of Type `char*` used in Blocking Member Functions

Arguments of type `char*`, or `const char*` passed from Verilog into a blocking SystemC method need special attention.

It is not guaranteed that the string remains valid when a blocking statement (a `wait()` statement) is executed. You must therefore make a local copy of the string at the beginning of the method, and then release the string when the method ends. This can be done by using type `std::string`.

### Example

```
void my_blocking_systemC_method(const char* S_from_sv)
{
 std::string S = S_from_sv;
 wait(10, SC_NS);
 ... printf("string=%s", S.c_str()); ...
}
```

## Supported Data Types

### Basic Types

Only a few data types like ANSI integer types, native SystemC bit vector types, `bool`, `sc_logic`, `std::string`, and `char*` that are used within SystemC classes can be accessed.

Data types of SystemC and SV are mapped as follows:

| SystemC               | SV                          |
|-----------------------|-----------------------------|
| -----                 | -----                       |
| <code>bool</code>     | <code>bit</code>            |
| <code>sc_logic</code> | <code>wire (4-state)</code> |
| <code>char</code>     | <code>byte</code>           |

|                     |                        |
|---------------------|------------------------|
| short int           | shortint               |
| int                 | int                    |
| long long           | longint                |
| double              | real                   |
| float               | shortreal              |
| sc_int<n>           | bit [n-1:0]            |
| sc_uint<n>          | bit [n-1:0]            |
| sc_bigint<n>        | bit [n-1:0]            |
| sc_bignum<n>        | bit [n-1:0]            |
| sc_lv<n>            | bit [n-1:0]            |
| std::string         | wire [n-1:0] (4-state) |
| char*               | string                 |
| pointers/references | string (copy-by-value) |
|                     | chandle                |

## SystemC char\* Type

Set method for `char*` type takes optional `bool` argument which controls whether to free the current SystemC `char*` memory or not.

### Example

SV Code

-----

```
function void set_CCC(input string ccc, \
input bit free_mem=0);
```

```
tli_set_CCC(SC_OBJECT_PATH, CD, free_mem);
```

```
endfunction
```

Plumbing Code

-----

```
void tli_set_CCC(const char* id, const char* ccc, \
bool free_mem=false);
{
 SCObject* p = tli_adaptor.find_sc_object(id);
 if (free_mem && p->ccc) free(p->ccc);
 p->ccc = strdup(ccc);
```

```
}
```

The default value for `free_mem` is false. This could mean a potential memory leak. You need to carefully set this value depending on how SC object is constructed.

## SystemC Channel Types

The following templated SystemC classes C can be accessed if the template type is supported:

- `sc_signal_in_if`
- `sc_signal_inout_if`

Classes derived from these classes are also supported. For example:

- `sc_signal`
- `sc_signal_resolved` datatype is `sc_logic`
- `sc_signal_rv` datatype is `sc_lv`
- `sc_in`
- `sc_out`
- `sc_inout`
- `sc_buffer`

Read/write accesses go directly to the underlying channel.

## Example

Definition of SystemC instance:

```

SC_MODULE(ABC)
{
 ...
 sc_signal<int> DDD;
 ...
};

Access in SV code:
int a;
a = sc_inst0.get_DDD();

```

## Arrays

Arrays are supported. Individual elements can be accessed if the type of the element is generally supported. Accessing entire arrays, or sub-arrays (rows, columns) is not supported.

Read or write access takes place with SV function `get` or `set`. Whereby, the index(es) are specified as 2nd, 3rd,... etc. arguments.

## Example

SystemC instance definition:

```

SC_MODULE(ABC) {
 ...
 int BBB[10];
 bool CCC[1024,500];
 ...
};

Usage of TLI adaptor in SV code:
a = sc_inst0.get_BBB(7); // read BBB[7]
b = sc_inst0.get_CCC(700,2); // read CCC[700,2]
sc_inst0.set_CCC(!b,700,2); // write CCC[700,2]

```

## SC\_FIFO

Class `sc_fifo` can be accessed if the template argument type is supported. The access functions permit non-blocking access, and support queries for the number of free or stored elements.

Access to blocking functions `read()` and `write()` is not supported.

## Example

Definition of SystemC instance:

```
SC_MODULE(ABC)
{
 ...
 sc_fifo<int> FFF;
 ...
};
```

Access in SV code:

```
int a, num;
num = sc_inst0.get_FFF_num_available();
num = sc_inst0.get_FFF_num_free();
a= sc_inst0.get_FFF(); //function, will not block
sc_inst0.set_FFF(a); //function, will not block
```

## Non-SystemC Classes

A SystemC module definition is a C++ class derived from `sc_module`. It is often specified with a macro `SC_MODULE`.

All SystemC modules are C++ classes, but all C++ classes are not SystemC modules. The C++ classes that are not SystemC modules are referred to as non-SC-classes.

Accessing members of non-SC-classes is not supported. The top-level class has to be an `sc_module` derived class.

## Sub-classes

A class may have a member which itself is a class. Members of such sub-classes can also be accessed (if they are to be imported, see TLI file below). Members of sub-classes, or sub-sub-classes are accessed by SV functions in the TLI adaptor that reflect the C++ scope name.

### Example

Definition of C++ classes:

```
class C2 {
public:
 int P;
 int Q;
};
struct C1 {
 int M;
 C2 N;
};
SC_MODULE(ABC) {
 ...
 int AAA;
 C1 SSS;
 ...
};
```

Usage in SV code:

```
a = sc_inst0.get_SSS_get_M();
sc_inst0.set_SSS_set_N_set_Q(a+10);
```

Only the sub-classes instantiated as regular members are supported. The sub-classes that are connected to the main class as pointers or arrays are not accessible.

## **Example**

Definition of C++ classes:

```
struct C1 {
 int M;
 C2 N;
};
SC_MODULE(ABC) {
...
C1 SSS;
C1* TTT;
C1 UUU[4];
...
};
```

Members of `SSS` are accessible, but members of `TTT` and `UUU` are not accessible.

## **Name Clashes**

Name clashes can take place in these two types of scenarios:

- var name clashes
- var name clashes with method names

### **var Name Clashes**

Consider the following example:

```
class A { int b; };
class Foo { A a; int a_get_b; }
```

In this case, access methods for `a.b` and `a_get_b` would be `get_a_get_b()`. To handle this scenario, use the following rules:

- Keep the original user methods as is. For example, user method `foo::get_A()` is accessible as `foo.get_A()` in SV.
- In case of name clash, find a new name (based on naming sequence) which does not clash. This is the naming sequence used to find new name: `get_A()` `get_A1()` `get_A2()` ... `get_A()`.

### **var Name Clashes with Method Names**

Consider the following example:

```
class foo
{
 int A;
 int get_A(); //user defined method
};
```

Now, the generated access method `get_A()` for variable `A` clashes with the user-defined method `get_A()`. Note that the name clash in this case is only in the SV domain. The internal plumbing generated names `get_A()` (to access `A`) and `call_get_A()` (to call `get_A()`) are unique.

To handle this case, keep the `get_A()` method (for calling `get_A()`) in the SV domain as is. Change the access method to escaped name

`\:get_A()`.

## Error Handling

### Locating SystemC Instance

The hierarchical path specified as an actual parameter of the TLI adaptor is checked during the startup of the simulation. An error is reported and the simulation aborts when the path cannot be resolved to a SystemC instance.

### Out-of-array Accesses

Reading or writing an array element depends on valid data for the indexes. Invalid indexes may accidentally go over the allocated area and access unrelated memory addresses.

Such an illegal access may trigger a segmentation fault (SEGV) or page zero signal. Currently, there is no protection against such crashes.

Write accesses with invalid indexes may corrupt other memory locations, and do not trigger a signal, so they go unnoticed.

## Compile Flow

The TLI adaptor is generated automatically by calling `syscan` as follows:

```
syscan -tli <tli-file> <cpp-source-file> \
[-o <tli-file>] [-cmp] ...
```

The C++ file is parsed, and most of the necessary data is extracted from there. The TLI file has the function to supplement the information; for example, to define for which classes access functions are to be generated.

The call generates the following files:

```
<tli_file>.sv TLI interface
<tli_file>.cpp helpers for TLI interface
<tli_file>.h helpers for TLI interface
```

The generated files are not automatically compiled or analyzed. This step is under the control of the user.

You can specify C++ compiler directives such as include paths. For example:

```
-cflags -I/some/dir/include
```

## Syntax of TLI File

### Rules for TLI File/Syntax

1. One TLI file for each adaptor/top-level SC\_MODULE class.
2. Directives:
  - adaptor name must match top-level sc\_module class in a cpp file
  - import member [name|glob\_pattern]
  - skip member [name|glob\_pattern]
  - where
    - glob\_pattern includes a special char \*
    - \* matches everything
  - name could be name.[name|glob\_pattern]
3. By default, all plain members of adaptor class are imported.

4. By default, all members of inner class members (bar.\* in example above) are skipped.
5. Precedence rules:
  - order of lines is not important
  - For precedence rules we use the following three types of match-sequences:
    - name (plain name without any \*)
    - name could name.name
    - match\_all (match\_all is single \* at any level)
    - examples are \*, \*.\* , \*.\*.\* , ....
    - select\_pattern (name with a \* but not match\_all)
    - examples are nam\*, \*ame, na\*e, name.\*ame etc.
  - precedence from lowest to highest
    - import member \* (match\_all)
    - skip member \* (match\_all)
    - import member name\* (select\_pattern)
    - skip member name\* (select\_pattern)
    - import member name
    - skip member name
  - rules with higher precedence override rules with lower precedence. For example, skip member \* skips all members even if there is an import member \* directive.

## 6. TLI option syntax

- syscan -tli src\_file
- syscan does not support multiple files with the -tli option.

### Example

```
syscan command

% syscan -tli foo_file.tli foo.cpp

output files

foo_file.[h|cpp|sv]
foo_file.idf (intermediate file)

foo.cpp

class Bar
{
 int a1, a2, b1, b2, c1, c2;
}
class Foo
{
 int aname1, aname2, bname1, bname2, cname1, cname2;
 int x1, x2, y1, y2, z1, z2;
 Bar* bar;
}

foo_file.tli

adaptor sc_data

// (implicit) import *
skip *
```

```

import *name*
skip bname*

import bname1
skip cname2

// (implicit) skip bar.*
import bar.c*
import bar.b1
skip bar.c1
Is the word "member" accidentally missing? E.g.
"skip member *" instead of "skip *" ?

```

Foo.idf

-----

```

adaptor Foo
direction sv_to_sc
verilog_module tli_Foo
systemc_module tli_Foo

var int aname1
var int aname2
var int bname1
var int cname1

var int bar.b1
var int bar.c2

```

## Debug Flow

The TLI implementation uses the existing CBug debug features given below:

- Display in combined HDL or SC design hierarchy: All access functions are visible on the SV side as functions or tasks of the SV interface.

- Underlying DPI functions of the adaptor are visible in the list of DPI, PLI, or DirectC functions.
- Cross-step from calling SV statement into adaptor code, and from there into the user's C function.

---

## **Accessing Struct or Class Members of a SystemC Module from SystemVerilog**

This section describes how to access the user-defined struct or class members in SystemC modules and exchange the generic C++ struct or classes with SystemVerilog, using the TLI byte pack or unpack functionality.

This section contains the following topics:

- “Enhancements to TLI for Providing Access to SystemC/C++ Class Members from SystemVerilog” on page 114
- “Accessing Struct or Class Members of a SystemC Module Object from SystemVerilog” on page 114
- “Accessing Generic C++ Struct or Class” on page 118
- “Extensions of TLI Input File” on page 122
- “Invoking Pack or Unpack Adaptor Code Generation” on page 123
- “Limitations” on page 124

## **Enhancements to TLI for Providing Access to SystemC/C++ Class Members from SystemVerilog**

The TLI adaptor feature restricts the access to a single member of a struct or class. You can specify this member in the TLI file, as `member *.*`. The TLI adaptor does not provide a way to access nested members of a struct or class.

This topic describes the following enhancements made to the TLI adaptor for accessing struct or class members of a SystemC module from SystemVerilog.

- “[Accessing Struct or Class Members of a SystemC Module Object from SystemVerilog](#)”
- “[Accessing Generic C++ Struct or Class](#)”

Access to a member of a SystemC module is only possible if a module is instantiated in the design. An instantiation (object) of the SystemC module can be identified with the hierarchical instance path.

The actual TLI adaptor code makes use of this. You can access SystemC module objects (and their members) using the instance path. In this scenario, only the access to an entire struct or class member is missing.

### **Accessing Struct or Class Members of a SystemC Module Object from SystemVerilog**

You can use the following functions to access an entire struct or class member in a SystemC module object from SystemVerilog:

- `scSetScopeByName()` — Specifies the hierarchical path to an instance or object of a SystemC module

- `get(logic[7:0]ba[])` — Gets the entire structure
- `set(logic[7:0]ba[])` — Sets the entire structure
- `set_<member_name>('Value')` — Sets the Value to the member specified by `<member_name>`
- `get_<member_name>()` — Gets the current value of the `<member_name>`

These functions are extensions to the TLI-2 adaptor code generated for scalar member access. For backward compatibility reasons, the old syntax is still supported.

The following SystemC code example illustrates the usage of above functions:

```
struct simple {
 int A;
 sc_int<8> B;
} simple;
.....
SC_MODULE(S) {
.....
public:
 simple P;
.....
}
```

The content of the member variable `P` of struct type `simple` is supposed to be exchanged with SystemVerilog.

SystemVerilog consists of a corresponding `simple-struct` compliant class. This class does not display the required ``defines` for VMM byte packing, as shown in the following example:

## Example

```
class simple_SV;
 int A;
 bit[7:0] B;
endclass:simple_SV

.....
// declare a variable of SV class simple_SV
simple_SV cl1;
// SV byte pack array
logic[7:0]ba[];

tli_S sc();
sc.scSetScopeByName("top.sc_inst1");
....
// get an entire struct from SC and fill it into class object
//cl1;
sc.P.get(ba);
cl1.byte_unpack(ba);
.....
// fill an entire struct on the SC side with contents of
class object cl1
cl1.byte_pack(ba);
sc.P.set(ba);
.....
// Current individual struct member access
cl1.A = sc.get_P_get_A();
sc.set_P_set_A(cl1.A);

// new additional individual member access, old syntax still
supported
cl1.A = sc.P.get_A();
sc.P.set_A(cl1.A);
.....
```

In the above code, the `tli_S` interface is generated. This interface must be instantiated by referring to a hierarchical path to an instance of `sc_module S` in the SystemVerilog source code. You can change the hierarchical path using the interface function

`scSetScopeByName ()`.

A second interface named `tli_S_P` is generated, and this is instantiated in the `tli_S` interface as the member name (`P`) of the struct within a SystemC module. The interface `tli_S_P` contains the `get(logic[7:0]ba[])` and `set(logic[7:0]ba[])` functions to set and get the entire struct.

You cannot check whether the C++ struct or class is compliant with the SystemVerilog class or not. There is no restriction for you to use only VMM byte pack/unpack when passing the packed byte stream as an argument.

You can write your own SystemVerilog pack/unpack routines, but these routines must be VMM byte pack/unpack compatible. The `set_<member_name>('Value')` and `get_<member_name>` functions are provided for scalar members of the struct. For example, member `A` of a struct or class can be accessed as `set_A(val)` and `get_A()`.

There is no change in the compile steps to generate and compile the generated files compared to the adaptor code generation and byte pack or unpack functionality.

## Generating Adaptor Code

The adaptor code is generated using a `syscan` call and a TLI input file, as shown in the following command:

```
% syscan -tli <input_file> <SC/C++_file>
```

where,

- <input\_file> is the TLI input file
- <SC/C++\_file> is the SystemC/C++ file for which you want to create an adaptor

The adaptor code is the content (the specified directives) of a TLI file, which specifies what is generated. You must use the TLI file with the `syscan -tli` option. If you specify this option with the TLI file, then the byte pack or unpack routines and VMM classes are generated.

There is a change in the TLI input file to inform `syscan` that the code for the functionality, described above, needs to be generated. For more information on the TLI input file extensions, see “[Extensions of TLI Input File](#)” on page 122.

## Accessing Generic C++ Struct or Class

If a struct or class object is not a member of `sc_module`, then you cannot use the instance path approach to find or access the struct or class object.

A new approach is introduced to access generic C++ class objects from SystemVerilog. With C++, the struct or class object is registered with a global unique identifier, and SystemVerilog can access the struct or class object with the same global unique identifier.

If a C++ object is supposed to be deleted, or an access is not necessary from the SystemVerilog side, then the object should be unregistered on the C++ side. You should perform the registration and unregistration in the C++ code.

You can use the following functions to access the generic C++ struct or class from SystemVerilog:

## **C++ Functions TLI\_UNREGISTER\_ID() and TLI\_REGISTER\_ID()**

- `TLI_UNREGISTER_ID(char *)` — Unregisters the structure or class specified by the passed unique identifier. It does not check whether the unique identifier exists or not.
- `TLI_REGISTER_ID(char *, <class_object_pointer>)` — Registers the passed pointer to a struct or class object under the given unique identifier. This function has two arguments, a string holding the global unique identifier and a pointer to the struct or class object.

Note:

VCS generates an error message when:

- A null object pointer to be registered is passed
- The unique identifier is already in use, and is independent of the pointer type (address)

## **SystemVerilog function attach\_by\_id()**

`attach_by_id()` — Stores the unique identifier in the interface instance. There is no check on whether the identifier exists until the first access with the set or get routines.

## **SystemVerilog set or get function**

The `set()` or `get()` functions do not use a caching mechanism. The pointer stored with the unique identifier is checked for each set or get call.

Note:

VCS generates an error message when:

- An identifier is not set in the interface

- An identifier is not registered
- A stored address has the wrong type (not the expected one)

The following SystemC code example illustrates the usage of the functions mentioned above:

```
struct simple {
 int A;
 sc_int<8> B;
} simple;
....
```

The content of a variable of the struct type `simple` is supposed to be exchanged with SystemVerilog.

The register or unregister function declarations are in the following file provided by VCS:

`tli_global_generic_class_info.h`

This file must be included in the C++ code to make use of the register or unregister functions, as shown in the following example:

## Example

```
// user must include file with registration/unregistration
function
// declaration
#include "tli_global_generic_class_info.h"
.....
simple *P;
P = new simple();

// registration of P with global unique id
TLI_REGISTER_ID("my_unique_id1", P);
.....
// unregister P
TLI_UNREGISTER_ID("my_unique_id1");
```

```

.....
On the SV side we have a corresponding and "simple-struct"
compliant class, not showing the required `defines for VMM
byte packing
class simple_SV;
 int A;
 bit[7:0] B;
endclass:simple_SV

.....
class simple_SV;
// SV byte pack array
logic[7:0]ba[];

tli_simple P();
P.attach_by_id("my_unique_id1");
....
// get an entire struct from SC and fill it into class object
cl1;
P.get(ba);
cl1.byte_unpack(ba);

.....
// fill an entire struct on the SC side with contents of
class object cl1
cl1.byte_pack(ba);
P.set(ba);
.....
// individual member access
cl1.A = P.get_A();
P.set_A(cl1.A);
.....

```

The `tli_simple` interface is generated with the generic C++ access functions in SystemVerilog. This is similar to the interface generated for the C++ struct or class member of a SystemC module. The difference is that there is no function named `scSetScopeByName()`, and the `attach_by_id()` function is used. The argument is a string representing a global unique identifier.

Access in SystemVerilog is similar to the struct or class members of a SystemC module. There is no change in the compile steps to generate and compile the generated files compared to the adaptor code generation and byte pack or unpack functionality.

The adaptor code is generated using the `syscan` call and a TLI input file. For more information on adaptor code generation, see [“Generating Adaptor Code” on page 117](#).

## Extensions of TLI Input File

The adaptor code generator must know the structs or classes for which the routines should be generated to exchange data values on the entire struct or class. The following directives are used in the TLI files:

```
class GG_BusModel
import method *
import member *.*
create VMM
create packunpack

class BusModel
import method *
import member *
create directaccess
create adaptor
```

The TLI input file is extended using the following directive:

```
use <struct_type_name> pack:my_pack unpack:my_unpack
/ab/cd/huhu.h
```

You can specify the struct or class members for which pack/unpack adaptor code should be generated, using the above directive. In the case of user-provided code, you must specify the function names of pack and unpack routines and the header file using the function declarations.

The adaptor code is generated using the `create adaptor` directive. The `import member` directive specifies the struct or class members for which the byte pack/unpack adaptor code should be generated.

The `create VMM` and `create packunpack` directives generate VMM classes and byte pack/unpack routines for the structs or classes specified using the `import member` directive. In these cases, the generated pack/unpack routines are used in the adaptor code for pack/unpack of struct or class members.

The C++ byte pack/unpack functions are void functions, and have two arguments. The prototypes are:

- For Pack: `(tli_pack_data&, const <class_type>&)`
- For Unpack: `(tli_pack_data&, <class_type>&)`

## **Invoking Pack or Unpack Adaptor Code Generation**

The pack or unpack adaptor code generation is invoked if:

- The adaptor code generation is enabled in the TLI input file
- A member of type struct or class can be accessed using the `import member` directive
- The `use` and/or `create packunpack` directive is available in the TLI file

## Limitations

The following are the limitations of accessing struct or class members of a SystemC module from SystemVerilog:

- The structs in method calls are not supported
- `sc_fifo` and `tlm_fifo` are not supported
- Nested classes or structs are not supported

---

## Accessing Verilog Variables from SystemC

This section describes how to access the variables of Verilog instances from the SystemC code in the following topics:

- “Usage Model” on page 124
- “Access Functions” on page 125
- “Supported Data Types” on page 126
- “Usage Example” on page 127
- “Type Conversion Mechanism” on page 128

## Usage Model

You can access the variables of Verilog instances from the SystemC code by calling the `tli_get_<type>` (`path`) or `tli_set_<type>` (`val, path`) functions, where `<type>` = `logic|int64|uint64|bv|lv|string`, `path` is the absolute path to the variable in a Verilog instance, and `val` is the value to be set on the variable. The following topic describes the prototypes of these functions.

These functions either get or set the value and return immediately. You can call them either from SystemC methods or from regular C++ functions.

Specify the location of the variable in the code using the absolute path. For example, in `tli_get_int64 ("top.inst0.D")`, `top.inst0` is the absolute path name of a Verilog instance, whereas `D` refers to the variable `D` of that instance.

All `tli_get_<type>` or `tli_set_<type>` APIs are stored in a header file called `systemc_user.h`. You should include this header file in the SystemC file which uses these APIs. Also, you must enable the VPI read/write capabilities during VCS elaboration using either the `-debug` or `-debug_all` option.

## Access Functions

The following are the prototypes of `tli_get_<type>` (`path`) or `tli_set_<type>` (`val, path`) functions:

```
function sc_logic tli_get_logic
 (const char* path);
function void tli_set_logic
 (sc_logic val, const char* path);

function unsigned long long tli_get_uint64
 (const char* path);
function void tli_set_uint64
 (unsigned long long val, const char* path);

function long long tli_get_int64
 (const char* path);
function void tli_set_int64
 (long long val, const char* path);

function sc_bv_base tli_get_bv
 (const char* path);
```

```

function void tli_set_bv
 (const sc_bv_base& val, const char* path);

function sc_lv_base tli_get_lv
 (const char* path);
function void tli_set_lv
 (const sc_lv_base& val, const char* path);

function std::string tli_get_string
 (const char* path);
function void tli_set_string
 (const char* val, const char* path);

```

## Supported Data Types

The `tli_get_<type>` (`path`) or `tli_set_<type>` (`val, path`) functions allow access only to certain member variables of Verilog module instances. These functions internally use VPI calls to get or set a variable. Therefore, any variable which is accessible through VPI can be accessed using these TLI functions.

Following are the data types that can be accessed through these TLI APIs:

- Signed and unsigned versions of all integer types: bit, reg, logic, byte, shortint, longint, and integer
- All net types in Verilog (read only)
- Vectors/memories of the above supported types
- SystemVerilog strings
- Enum types defined as one of the above supported types
- Typedefs to one of the above supported types

- Sub-members of classes, interfaces, structures, or unions can be accessed only if they are of the above supported types
- Parameters (read only)

## Unsupported Data Types

The following data types cannot be accessed with the `tli_get_<type>` (path) or `tli_set_<type>` (val, path) functions:

- Double, float, real, and all other floating point types
- Any type of SystemVerilog array
- SystemVerilog event types

Using any TLI API to access a variable of incompatible type results in an error. For example, accessing a string type using `tli_get_int64` or accessing a bit vector using `tli_get_logic` results in an error.

## Usage Example

The following example shows how you can use the TLI APIs to access SystemVerilog variables:

```
Top.v:
module bot;
 reg [3:0] r = 4'b1100;
endmodule
module top;
 int i1 = 100000;
 bot b1();
endmodule

sc_bot.h:
#include <systemc.h>
```

```

#include <systemc_user.h>
SC_MODULE(sc_bot)
{
 ...
 void Func();
}

sc_bot.cpp
#include "sc_bot.h"
void sc_bot::Func()
{
 sc_bv_base bv = tli_get_bv("top.b1.r");
 tli_set_bv(bv.reverse(), "top.b1.r");
 long long val = tli_get_int64("top.i1");
 tli_set_int64(val+1, "top.i1");
}

```

Follow the regular compile and run steps:

```

% syscan sc_bot.cpp:sc_bot
% vlogan -sv top.v
% vcs -sysc -debug_all top
% ./simv

```

## Type Conversion Mechanism

The type of the variable being accessed must match the type of the TLI access function. You can access:

- All single-bit values using the `tli_get_logic` function.
- All 2-state bit vectors and integer types using the `tli_get_bv` function.
- All 4-state bit vectors using the `tli_get_lv` and corresponding `tli_set*` functions.

If a 4-state value is accessed with a function that accepts only 2-state values (such as `tli_get_bv`), then all `x` and `z` bits are converted to 0. Also, If the source vector (on SystemC side) passed to a set function (such as `tli_set_lv`) is smaller than the destination vector (on Verilog side), then the source vector is padded with 0 bits or sign extended (if it is signed type).

If the source is larger than the destination vector, the upper bits are removed. The `tli_get_bv` and `tli_get_lv` functions preserve bit width; that is, they return a vector whose size is the same as the actual vector on the Verilog side.

*Example 19-3 Accessing 4-state value with a function that accepts only 2-state values*

```
tli_get_bv("top.S2.A")
```

In the above example, if `top.S2.A` refers to a logic vector of size 8, then this function call converts the 4-state value fetched from the Verilog side to 2-state values (by replacing all `x` and `z` with 0), and returns `sc_bv_base<8>`.

If the variable `A` has the binary value `8'b1x1z0x01`, then `tli_get_bv()` converts all `x` and `z` to 0, and returns the value `10100001` in the `sc_bv_base` variable.

*Example 19-4 Padding the upper bits*

```
tli_set_lv(val,"top.S2.A")
```

In the above example, if `val` is a logic vector of size 8 and `top.S2.A` refers to a bit vector of size 20, then this function call first converts all `x` and `z` in `val` to 0, and then pads the upper 12 bits with 0 and assigns it to the referred variable.

If the variable has the binary value 8'11xxzz11, then the `tli_set_lv()` function first converts all x and z to 0, and then adds 12 zeros, so the resulting value is the binary value 20'b000...00011000011 or integer value 12.

#### *Example 19-5 Accessing signed variables*

```
tli_get_bv("top.S2.B")
```

In the above example, `top.S2.B` refers to an 8-bit signed register (`reg signed [7:0] B`). It has the binary value 8'b11111110, which corresponds to hex value 32'hfe or decimal value -2.

The above example returns `sc_bv<8>`, which holds the value 8'b11111110. The assumption here is that you know the signedness of the referred variable when you call `tli_get_bv` and convert the retrieved value appropriately. Instead, you can use `tli_get_int64` to access signed values less than 64-bit.

The `tli_get_logic` and `tli_set_logic` functions operate on single-bit variables only. If you pass a vector value to `tli_set_logic` or try to access a vector value using `tli_get_logic`, then it results in an error. You can access SystemVerilog string type variables using the `tli_get_string` and `tli_set_string` functions only.

---

## **Accessing SystemVerilog Functions and Tasks from SystemC**

This section describes how to directly access SystemVerilog functions and tasks from SystemC code in the following topics:

- “Introduction” on page 131

- “Usage Model” on page 131
- “Function Declaration Hierarchy” on page 132
- “Passing Arguments” on page 134
- “Supported Types” on page 135
- “Usage Example” on page 135
- “Compile Flow” on page 137
- “Usage Guidelines” on page 138
- “Limitations” on page 139

## Introduction

The existing `.idf` file-based mechanism allows you to access variables or function calls on the Verilog side from SystemC class methods. But this mechanism expects you to write an `.idf` file, instantiate the corresponding interfaces in SystemC source files, and access variables or functions using the interface objects.

From this release onwards, you can use the TLI-DirectAccess (TLI-DA) mechanism to directly access SystemVerilog functions and tasks from SystemC code. This mechanism allows you to easily interact across language boundaries.

## Usage Model

Use the following syntax to directly access SystemVerilog functions or tasks from SystemC code:

```
TLI::<Function declaration
hierarchy>::<Function_name>
("⟨design_hierarchy⟩", <comma separate list of
actual arguments>);
```

Following is an example of a TLI function call:

```
TLI::Mid::Add("top.m1", arg1, arg2);
```

You must call a function with the design hierarchy string (xmr) as the first argument, followed by the list of actual arguments.

Note:

The design hierarchy specified in the call should be a string literal (for example, top . m1). You cannot use a variable of type `string` or `char*`.

You must prefix the function call with the function declaration hierarchy. This hierarchy is the scope where a function is declared in the SystemVerilog design. For more information, see the “[Function Declaration Hierarchy](#)” section.

You must include the generated TLI header file `tli_sc_calls_sv.h` in SystemC files which access the TLI function calls.

## Function Declaration Hierarchy

Function declaration hierarchy is the scope where the function is declared in the SystemVerilog design. It consists of a module name which is optionally prefixed by the enclosing library name, and optionally suffixed by the containing class or interface name.

The function declaration hierarchy is used to:

- Locate the function in a SystemVerilog design and extract its prototype. This prototype is required to automatically generate the corresponding DPI wrappers.
- Avoid conflicts with other function calls having the same name, but declared in different scopes.

Use the following syntax to declare function hierarchy:

```
[<lib_name>::]<module_name/program_name/
package_name:: [<class_name>/<interface_name>/
<named_block_name>::]
```

Note:

- If there are any conflicts, then the `module_name` or `package_name` is the only mandatory item.
- Use `library_name` if a module with the same name exists in a different library, and that module also has a function with same name.
- Use `class_name`, `interface_name` or `named_block_name` if a function with the same name is present in two different scopes in the same module.
- You must separate all the above-mentioned strings with a scope resolution operator (`::`).

## Passing Arguments

The type of actual arguments passed to the TLI functions should match the corresponding SystemVerilog type used in the function declaration. Following is the list of compatible types:

*Table 19-1 Compatible Types*

| SystemVerilog Data Type | SystemC Data Type |
|-------------------------|-------------------|
| bit                     | bool              |
| logic                   | sc_logic          |
| reg                     | sc_logic          |
| reg vector              | sc_lv             |
| logic vector            | sc_lv             |
| bit vector              | sc_bv             |
| int                     | int               |
| shortint                | short int         |
| longint                 | long int          |
| byte                    | char              |

**Note:**

- The SystemC compiler generates an error if the sizes of the vectors passed as actual arguments do not match the sizes of the formal parameters.
- Use plain types for input arguments and pointers for output or inout arguments. You must allocate enough space for these pointers. Also, use pointers to collect the return values from these function calls.

- Functions can have reference arguments which are treated as inout types on the SystemC side. The SystemVerilog `ref` semantics are not maintained on the SystemC side. That is, any change to the `ref` variable in the function or task is not immediately visible on the SystemC side.

## Supported Types

The following types are supported:

- You can call functions having arguments of basic data types from SystemC code. Supported argument types include: all integral types, reg, logic, bit, string, and so on.
- Bit vectors of basic types are allowed in the argument list.
- In Verilog-`-top` designs, the design hierarchy should only consist of Verilog instances.
- In SystemC top designs, the design hierarchy should start in SystemC and end in Verilog. Donuts are not allowed.

## Usage Example

```

class C; //In $unit scope
 function int Add(bit [3:0] r1, reg [3:0] r2, output
logic [3:0] r3);
 ...
endfunction
endclass

module Mid;
 class C;
 function int Add(bit [3:0] r1, reg [3:0] r2,
output logic [3:0] r3);
 ...
 endfunction
function int Sub(bit [3:0] r1, reg [3:0] r2, output logic

```

```

[3:0] r3);

...
endfunction
endclass;

C c1 = new;

function int Add(bit [3:0] r1, reg [3:0] r2, ,
output logic [3:0] r3);
...
endfunction

endmodule

package P;
 class C;
 function int Sub(bit [3:0] r1, reg [3:0] r2, output
logic [3:0] r3);
 ...
 endfunction
endclass
endpackage

module top;
 Mid m1();
 C c1 = new;
 P::C c2 = new;
endmodule

File: sc_top.cpp
#include <tli_sc_calls_sv.h>
...
Sc_bv<4> arg1;
Sc_lv<4> arg2;
Sc_lv<4>* arg3 = new sc_lv<4>;
int* I1 = TLI::Mid::Add("top.m1", arg1, arg2, arg3);
int* I2 = TLI::Mid::C::Add("top.m1.c1", arg1, arg2,
arg3);
int* I3 = TLI::Mid::Sub("top.c1", arg1, arg2, arg3);
 int* I4 = TLI::$unit::C::Add("top.c1", arg1, arg2,
arg3);
 int* I5 = TLI::P::Sub("top.c2", arg1, arg2, arg3);

```

In the above example:

- The `int* i = TLI::Mid::Add("top.m1", arg1, arg2, arg3);` function call is equivalent to XMR function call `top.m1.Add(arg1, arg2)`. This function call refers to the function `Add` in module `Mid`.
- The `int* i = TLI::Mid::C::Add("top.m1.c1", arg1, arg2, arg3);` function call is equivalent to XMR function call `top.m1.c1.Add(arg1, arg2)`. This function call refers to the function `Add` in class `C` of module `Mid`. Here, you must mention the class name along with the module name because the module has another function with same name.
- The `int* i = TLI::Mid::Sub("top.m1.c1", arg1, arg2);` function call refers to the function `Sub` in class `C` of module `Mid`. Since the function name is unique in the given module scope, there is no need for you to prefix the function call with the class name. However, you can use the class name to call this function, as follows:

```
res3 = TLI::Mid::C::Sub("top.m1.c1", arg1, arg2);
```

- The `int* i = TLI::$unit::C::Add("top.c1", arg1, arg2);` function call calls the function `Add` in class `C`. This class resides in `$unit` scope, which is outside of all modules.
- The `int* i = TLI::P::Sub("top.c2", arg1, arg2);` function call refers to the function `Sub` in package `P`.

## Compile Flow

Follow these steps to enable direct function access using TLI:

1. Compile Verilog files using vlogan :

```
% vlogan -sverilog top.v ...
```

2. Run syscan using the `-tli_F` option, and then pass all the SystemC files to it (especially the files having TLI function calls). Also, pass all the required include directories using `-cflags`.

```
% syscan -tli_F sc_top.cpp ...
```

Note:

This is an extra step required to automatically generate the TLI adaptor code.

3. Compile all SystemC files:

```
% syscan sc_top.cpp:sc_top ...
```

4. Run VCS elaboration:

```
% vcs -sysc top ...
```

## Usage Guidelines

The following are the guidelines for accessing SystemVerilog functions or tasks from SystemC:

- You must compile all Verilog files before SystemC compilation (with `syscan -tli_F`).
- You must analyze the SystemC source files having TLI function calls with the `syscan -tli_F` command before they are compiled with `syscan`.
- You should specify all files that contain TLI function calls together to the `syscan -tli_F` command. You may observe some slowdown if this command is run on each file separately.

- If there are any changes to the TLI function calls in any of the source files, then you must process the files with the `syscan -tli_F` command before compiling them with `syscan`.
- You must include the `tli_sc_calls_sv.h` file in all source files that access TLI function calls.
- The widths of the formal arguments should match the widths of actual arguments. Also, the types of arguments should be compatible as per SystemC semantics. For example, you cannot pass a `sc_bv` vector to a function that expects a `logic` vector.
- You must specify appropriate declaration hierarchy to handle conflicting function calls.

## Limitations

The following limitations apply when accessing SystemVerilog functions or tasks from SystemC:

- Compound data types (arrays, structures, classes, and so on), enums, and typedefs are not allowed in function arguments.
- Floating point types are not allowed as function arguments.
- Functions declared in nested modules cannot be called from SystemC.
- Donuts (design hierarchies like Verilog-SC-Verilog) are not supported.
- The TLI function call and its first argument should be on the same line. That is, the function name and its first argument should not spread over multiple lines.

---

## **Accessing SystemC Members from SystemVerilog Using the tli\_get\_<type> or tli\_set\_<type> Functions**

This section describes how to access the members of SystemC instances from SystemVerilog code by calling the `tli_get_<type>` or `tli_set_<type>` functions.

This section consists of the following topics:

- “[Using the tli\\_get\\_<type> and tli\\_set\\_<type> Functions](#)” on page 140
- “[Prototypes of tli\\_get\\_<type> and tli\\_set\\_<type> Functions](#)” on page 141
- “[Supported Data Types](#)” on page 142
- “[Member Variables](#)” on page 145
- “[Type Conversion Mechanism](#)” on page 147
- “[Compile Flow](#)” on page 149

### **Using the tli\_get\_<type> and tli\_set\_<type> Functions**

You can access the members of SystemC instances from the SystemVerilog code by calling the

`tli_get_<type> (path [, member_name])` or  
`tli_set_<type> (val, path [, member_name])` functions,  
where:

- `<type> = logic|int64|uint64|string`

- `path` is the absolute path to the member of a SystemC module instance. For example, `top.S2.D` refers to member `D` of SystemC instance `top.S2`. Only absolute path names are supported. Relative paths are not supported.
- `val` is the value to be set on the member variable.
- `member_name` is optional. It is the name of the member variable in a SystemC object. If this argument is not specified, then the first argument is considered as the full path of the variable. For more information on this argument, see the “[Member Variables](#)” topic.

The `tli_get_<type>` and `tli_set_<type>` functions either get or set the value and return immediately.

## Prototypes of `tli_get_<type>` and `tli_set_<type>` Functions

This topic describes the prototypes of the `tli_get_<type>` and `tli_set_<type>` functions.

The following are the prototypes of the

`tli_get_<type>` (`path [, member_name]`) or  
`tli_set_<type>` (`val, path [, member_name]`) functions:

```
function logic tli_get_logic
 (input string path, input string m_name = "");
function void tli_set_logic
 (input logic val, input string path, input string m_name
 = "");
function longint unsigned tli_get_uint64
 (input string path, input string m_name = "");
function void tli_set_uint64
 (input longint unsigned val, input string path, input
 string m_name = "");
```

```

function longint tli_get_int64
 (input string path, input string m_name = "") ;
function void tli_set_int64
 (input longint val, input string path, input string
m_name = "") ;

function logic[63:0] tli_get_logic64
 (input string path, input string m_name = "") ;
function void tli_set_logic64
 (input logic[63:0] val, input string path, input string
m_name = "") ;

function string tli_get_string
 (input string path, input string m_name = "") ;
function void tli_set_string
 (input string val, input string path, input string
m_name="", input bit free_mem=0) ;

```

These functions can access only the:

- Objects of a SystemC module, which are derived from `sc_core::sc_module`.
- Member variables that are public. You cannot access private and protected members.

Note:

You can view all SystemC module instances in the static design hierarchy shown by DVE.

## Supported Data Types

The `tli_get_<type>` (`path [, member_name]`) or `tli_set_<type>` (`val, path [, member_name]`) functions allow access only to certain member variables of SystemC module instances. There are restrictions regarding the data type, accessibility, and compile flow.

The `tli_get_<type>` (path [, member\_name]) or `tli_set_<type>` (val, path [, member\_name]) functions can access the following data types:

- `bool`, `sc_logic`
- All ANSI integer types. For example, `int`, `signed char`, `long int`, `unsigned short int`, and so on
- Native SystemC bit-vectors with a length of no more than 64-bit: `sc_int`, `sc_uint`, `sc_bigint`, `sc_bignum`, `sc_lv`, `sc_bv`
- Signals and ports: `sc_signal<T>`, `sc_signal_rv`, `sc_signal_resolved`, `sc_in<T>`, `sc_inout<T>`, `sc_out<T>`, `sc_inout_rv`, `sc_inout_resolved`
- Strings of type `std::string` or `char*`
- **Sub-members** that have one of the above types

Note:

- The `bool` and `sc_logic` data types are single-bit entities. They can only be accessed using the `tli_get_logic` and `tli_set_logic` functions. `z` and `x` are preserved while accessing the `sc_logic` variable. Using any other `tli_get_<type>` or `tli_set_<type>` function for these types results in an error.
- The `std::string` and `char*` data types can only be accessed through the `tli_get_string` and `tli_set_string` functions. Using any other TLI function results in an error.

- The `tli_set_string` function has a fourth argument `free_mem`, which applies only if the SystemC variable is of type `char*`. If the type is `free_mem=1`, then the TLI does a `free()` of the current string value before assigning the new value. You must ensure that the value is freed.

## Sub-members

The `tli_get_<type>` (`path [, member_name]`) or `tli_set_<type>` (`val, path [, member_name]`) functions can access the members of sub-classes or sub-structs, if these members contain supported type as `int`. This corresponds to an `import member *.*` directive within a TLI file.

**Example:**

```
struct my_struct2 {
 int D;
};

struct my_struct1 {
 int C;
 my_struct2 S2;
};

SC_MODULE(foo) {
 sc_int<40> A;
 my_struct1 S1;
};
```

In the above example, members `A` and `S1.C` of `foo` are accessible, and are of type `int`. Members `S1` and `S1.S2` are not accessible because they refer to entire user-defined structs.

Member `S1.S2.D` is also of type `int`, but is not accessible if the corresponding source file is compiled with the `-tli_D` flag. This flag makes the first-level (`A`) and second-level (`S1.C`) members accessible, but not the third-level (`S1.S2.D`) or any further levels.

Member `S1.S2.D` is accessible if the corresponding source file is compiled with an explicit TLI file which specifies to import this third-level member.

## Unsupported Data Types

The `tli_get_<type>` and `tli_set_<type>` functions cannot access the following data types:

- Base types of native SystemC bit-vectors: `sc_int_base`, `sc_uint_base`, `sc_signed`, `sc_unsigned`, `sc_lv_base`, and `sc_bv_base`.
- Resolved input and output ports: `sc_in_rv`, `sc_out_rv`, `sc_in_resolved`, and `sc_out_resolved`.
- Other SystemC channel types. For example, `sc_fifo`, `sc_buffer`.
- Arrays of fixed or varying size. For example, `int [8]`, `int []`.
- Double, float, and all native SystemC fix-point types. For example, `sc_fix`.

Using any TLI API to access a variable of incompatible type results in an error. For example, accessing string types using `tli_get_int64` or accessing a bit vector using `tli_get_logic` results in an error.

## Member Variables

The `member_name` argument is optional. SystemC instance names have their own name space. They do not clash with other member variables defined in the same class. If sub-members are also

supported, then you might face difficulties in differentiating between member variables. You can overcome these difficulties by using the `member_name` argument.

For example, consider the following code:

```
struct mystruct {
 int B;
};

SC_MODULE(sub) { // instance top.inst.A
 int B;
};

SC_MODULE(foo) { // instance top.inst
 sub inst_A;
 my_struct A;
 SC_CTOR(foo): inst_A("A") {}
};
```

In the above code, member `inst_A` forms sub-instance `top.inst.A`. The constructor (`SC_CTOR`) defines the hierarchical name of C++ member `inst_A` to be `A`.

Member `inst_A` does not clash with member `A` within class `foo`, at least for the C++ compiler. However, it constitutes a clash for the hierarchy, such that the path `top.inst.A.B` can now refer to:

- Member `B` of instance `top.inst.A`
- Member `A.B` of instance `top.inst`

Using any API with the path `top.inst.A.B` creates ambiguity. This ambiguity is resolved by the optional argument `member_name`.

## Example

```
tli_get_int("top.inst.A.B") // ambiguous situation
tli_get_int("top.inst.A", "B") // member "B" of
// instance "top.inst.A"
```

```

tli_set_int(value, "top.inst.A.B")) // member "A.B" of
//instance "top.inst"

tli_set_int(value, "top.inst.A", "B") // member "B" of
//instance "top.inst.A"
tli_get_int("top.inst", "A.B")
tli_set_int(value, "top.inst", "A.B") // member "A.B" of
//instance "top.inst"

```

## Type Conversion Mechanism

The type of the variable being accessed must match the type of the TLI access function. VCS generates an error message if the type of variable being accessed is incompatible with the type of the TLI access function. If the type of variable being accessed is compatible with the type of the TLI access function, then you can do appropriate conversions as follows:

- If a 4-state value logic is accessed with a function that accepts only 2-state values, then all X and Z bits are converted to 0.
- If the source vector passed to a set function is smaller than the destination vector, then the source vector is padded with 0 bits or sign extended (if it is a signed type). If the source is larger than the destination vector, then the upper bits are removed.
- Sign extension is done only when the source is a signed integer type is called; (for example, int, signed char, sc\_int, sc\_bigint) and tli\_get\_int64() or tli\_get\_uint64(). 0 bits are added in all other cases.

*Example 19-6 Accessing 4-state value with a function that accepts only 2-state values*

Consider the following function call:

```
tli_get_int64("top.S2.A")
```

If the above function refers to `sc_lv<8>` (a vector of 8 bits of four values each), it converts the 4-state value to 2-state values (by replacing all `x` and `z` with `0`) and the missing 24 bits are filled with zeros.

If the variable `A` has the binary value `8'bxxzz1100`, then `tli_get_in64()` first converts all `x` and `z` to `0` and then adds 24 zeros, so that the resulting value is the binary value `64'b000...0001100` or integer value 12.

### *Example 19-7 Function returning signed values*

Consider the following function call:

```
tli_get_<type>("top.S2.B")
```

If `top.S2.B` refers to `sc_int<8>` (signed data type with binary value `8'b11111110`, which corresponds to hex value `32'hfe` or decimal value -2), then:

- `tli_get_int64("top.S2.B")` returns integer value -2 or hex value `64'hffff ffff ffff fffe`.
- `tli_get_uint64("top.S2.B")` returns the same hex value `64'hffff ffff ffff fffe`, which corresponds to a very large positive number (18446744073709551490) because `tli_get_uint64()` always returns an unsigned number.
- `tli_get_logic64("top.S2.B")` returns hex value `64'h0000 0000 0000 00fe`.

### *Example 19-8 Setting bit vectors*

If the variable has the binary value 8'b11xxzz11, then tli\_set\_logic64() first converts all x and z to 0, and then adds 12 zeros. Therefore, the resulting value is the binary value 20'b000...00011000011 or integer value 195.

## Compile Flow

Access for tli\_get\_<type> or tli\_set\_<type> must be enabled during compilation of SystemC source files with syscan.

### Using tli\_D Option

Use the -tli\_D option along with syscan, as shown below:

```
% syscan -tli_D <source file>
```

Access is enabled for all SystemC module classes that are present during compilation of the source file. If this option is used for compiling the top-most model of an entire SystemC design tree, then all SystemC modules are supported.

## Example

```
File bottom.h:
SC_MODULE(bottom) {...};

File middle.h:
#include "bottom.h"
SC_MODULE(middle) { bottom inst; };
File top.h:
#include "middle.h"
SC_MODULE(top) { middle inst; }

File top.cpp:
#include "top.h"
...
```

Calling `syscan -tli_D top.cpp` enables `tli_get_<type>` or `tli_set_<type>` access for any instance of SystemC module types top, middle, or bottom.

Using the `-tli_D` option is convenient; however, it may also be expensive in terms of extra compilation time because there is no limit to the number of SystemC modules for which `tli_get_<type>` or `tli_set_<type>` support is built. Therefore, a warning message is generated when the total number of variables from all SystemC modules exceeds 2000.

## Modifying SystemC Code

The information needed for `tli_get_<type>` or `tli_set_<type>` is stored in the `tli_<source_body_file_name>_DirectAccessM.cpp` file, which is automatically generated. It must be included at the end of the `.cpp` file from which it was generated.

### Example

```
File top.cpp:
#include "top.h"
...
...
... at the end of the file add: ...
#include "tli_top_DirectAccessM.cpp"
```

## Modifying SystemVerilog Code

You must analyze and import the TLI package where all `tli_get_<type>` or `tli_set_<type>` functions are defined.

### Example

Analyze the package:

```
% vlogan -sverilog \
$VCS_HOME/etc/systemc/tlm/tli/tli_directaccesspackage.sv
```

Add an `import` statement to your SystemVerilog code, as shown below:

```
File: testbench.sv
...
import tli_direct_access_package::*;
...
int y = tli_get_int64("top.inst.A");
...
```

### TLI Directive (`create directaccess`)

The `-tli_D` option only creates information needed for the `tli_get_<type>` or `tli_set_<type>` functions. For example, it does not create any helper code to call member functions. If this is needed, then you must call `syscan` with an explicit TLI file.

---

## Generating C++ Struct Definition from SystemVerilog Class Definition

This section describes how to generate a C++ struct definition from a SystemVerilog class definition in the following topics:

- “[Use Model for Generating C++ Struct from SystemVerilog Class](#)” on page 152
- “[Data Type Conversion from SystemVerilog to C++](#)” on page 153
- “[Example for Generating C++ Struct from SystemVerilog Class](#)” on page 154
- “[Limitations](#)” on page 155

## Use Model for Generating C++ Struct from SystemVerilog Class

Use the `-tli_gen_struct` option to invoke the C++ struct generation, as shown in the following command:

```
% syscan -tli_gen_struct [-v] <file_name> -class
<class_name> [-o <output_header_file>]
```

where,

- `-v` is the verbose switch. The generated C++ struct is also printed to `stdout`.
- `<file_name>` is the SystemVerilog input file.
- `-class <class_name>` specifies the SystemVerilog class, for which a corresponding C++ struct is generated.
- `-o <output_header_file>` is an optional argument. If specified, the C++ struct is created in this file.

As shown in the above command example, the struct generator requires a SystemVerilog file and the class name, for which the corresponding C++ struct should be created, as inputs. Therefore, a SystemVerilog class is required in the specified SystemVerilog file.

The SystemVerilog file is read for all data members in the class, and the corresponding C++ data types are generated in a struct.

The name of the C++ struct is `tli_struct_<class_name>`. If you do not specify an output file, then the file name is `tli_struct_<class_name>.h`; else it is same as the name specified with the `-o` option.

A comment is printed in the preceding line of each C++ struct data member. This comment contains information about the SystemVerilog input file, line number, and the complete line of the corresponding SystemVerilog class data member.

## **Data Type Conversion from SystemVerilog to C++**

The following table describes the type conversion rules from SystemVerilog to C++.

*Table 19-2 Type Conversion Rules from SystemVerilog to C++*

| SystemVerilog Data Type | C++ Data Type          |
|-------------------------|------------------------|
| bit                     | bool                   |
| bit[]                   | bool*                  |
| bit[size1]              | bool[size1]            |
| logic                   | sc_dt::sc_logic        |
| logic[]                 | sc_dt::sc_logic*       |
| logic[size1]            | sc_dt::sc_logic[size1] |
| byte                    | char                   |
| byte[]                  | char*                  |
| byte[size1]             | char[size1]            |
| byte unsigned           | unsigned char          |
| byte signed             | signed char            |
| string                  | std::string            |
| string[]                | std::string*           |
| string[size1]           | std::string[size1]     |
| shortint                | short int              |
| shortint[]              | short int*             |
| shortint[size1]         | short int[size1]       |
| shortint unsigned       | unsigned short int     |

*Table 19-2 Type Conversion Rules from SystemVerilog to C++*

| SystemVerilog Data Type | C++ Data Type      |
|-------------------------|--------------------|
| shortint signed         | signed short int   |
| int                     | int                |
| int[]                   | int*               |
| int[size1]              | int[size1]         |
| int unsigned            | unsigned int       |
| int signed              | signed int         |
| longint                 | long long          |
| longint[]               | long long*         |
| longint[size1]          | long long[size1]   |
| longint unsigned        | unsigned long long |
| longint signed          | signed long long   |
| bit[nr-1:0]             | sc_dt::sc_bv<nr>   |
| logic[nr-1:0]           | sc_dt::sc_lv<nr>   |
| integer                 | sc_lv<32>          |

## Example for Generating C++ Struct from SystemVerilog Class

The following example shows how a SystemVerilog class `my_payload` in the SystemVerilog file `my_payload.sv`, is converted into a C++ struct:

```
class my_payload;
 byte my_byte[3]; // holds 3 byte values
 shortint myshort; /* some short */
endclass
```

The following call generates a C++ struct named `tli_struct_my_payload` in the `tli_struct_my_payload.h` file:

```
% syscan -tli_gen_struct my_payload.sv -class my_payload
```

The following are the contents of the `tli_struct_my_payload.h` file:

```
#ifndef tli_struct_my_payload_H
#define tli_struct_my_payload_H

#include <string>
#include <systemc.h>

struct tli_struct_my_payload {
 // SV declaration (my_payload.sv, 4): byte my_byte[3];
 char my_byte[3];
 // SV declaration (my_payload.sv, 5): shortint myshort;
 /* some short */
 short int myshort;

};

#endif
```

## Limitations

The following are the limitations of creating a C++ struct from a SystemVerilog class:

- The `syscan -tli_gen_struct` option cannot recognize legal SystemVerilog class definitions. For example, the following types are not supported:
  - User-defined structs
  - Enums
  - Multidimensional arrays

Note:

Data members that could not be converted are created in a comment. By default, the data type is `void`, and appears as shown below:

```
// TODO: void <variable_name>;
```

- The `typedef`, `function`, and `task` constructs cannot be converted to any C++ construct. The `syscan` script ignores these constructs if they are specified in the SystemVerilog class definition.
- Splitting data member definitions over multiple lines is not supported.
- Preprocessor directives are not supported.

---

## Exchanging Data Between SystemVerilog and SystemC Using Byte Pack/Unpack

Transaction-Level Interface (TLI) allows you to exchange user-defined C++ classes or data in struct object between SystemVerilog(SV) and SystemC/C++ using the byte packing and unpacking mechanism. This mechanism allows you to put bits of all the class members into an array of bytes. That is, the values of data types are packed in a byte stream for exchanging the data between SystemVerilog and SystemC/C++. These packed values of data types can be retrieved or unpacked from the byte stream at the other end.

SystemC uses the `tli_pack_data` class object, which contains APIs, to pack and unpack of the data type values.

This chapter contains the following sections:

- “Use Model”
  - “Supported Data Types”
  - “Mapping of SystemC/C++ and SystemVerilog/VMM Data Types”
  - “Usage Examples”
  - “Using Pack and Unpack Functions”
  - “Using Code Generator”
- 

## Use Model

To pack and unpack the data type values using the APIs in SystemC/C++:

1. Include the `tli_packunpack.h` header file.
2. Create a class object `tli_pack_data` which contains the API to provide the pack and unpack functionality.
3. Use the pack operator (`<<`) or the `pack()` function to put data into the byte array. This operator converts data into a byte stream. Similarly, use the unpack operator (`>>`) or `unpack()` function to extract data from the byte array. This operator converts the data of the byte stream into the type coming along with the variable declaration.

Note:

The class `tli_pack_data` provides pack and unpack functionality using:

- The `<<` and `>>` operators for basic data types.

- The `pack()` and `unpack()` functions for 1-dim arrays (fixed size and dynamic) of the supported basic data types.
- 

## Supported Data Types

The following basic integral and SystemC data types are supported:

- `bool`
- `enum`
- Integer Data Types: `char`, `signed char`, `short`, `int`, `long`, `long long`, `sc_int`, `sc_bigint`
- Unsigned Data Types: `unsigned` (`char`, `short`, `int`, `long`, `long long`), `sc_uint`, `sc_biguint`
- String Types: `const char*`, `char*`, `std::string`
- `std::vector`
- `sc_bv`
- `sc_logic`, `sc_lv`
- 1-dim fixed-size arrays of the base types listed above.
- 1-dim dynamic arrays (pointers of) of the base types listed above, except `std::vector`.

## Unsupported Data Types

The following data types are not supported:

- `float`, `double`
- `sc_fixed`, `sc_fix`

- sc\_ufixed, sc\_ufix
  - sc\_bit
  - Struct or Classes: These types cannot be supported by the API. The pack or unpack routines must be written with the knowledge of a single member.
  - Unions
  - Pointer
- 

## **Mapping of SystemC/C++ and SystemVerilog/VMM Data Types**

The following table lists the data types to map from SystemVerilog/VMM to SystemC/C++.

| <b>SystemVerilog Type</b> | <b>SystemC/C++ Type</b>                                 |
|---------------------------|---------------------------------------------------------|
| string                    | std::string, char*                                      |
| string[]                  | std::string*, char**                                    |
| string[size]              | std::string[size], char*[size], std::vector<T>(of size) |
| bit                       | bool                                                    |
| bit[]                     | bool*                                                   |
| bit[size]                 | bool[size], std::vector<T>(of size)                     |
| bit[nr:0]                 | sc_bv<nr+1>                                             |
| bit[nr:0][]               | sc_bv<nr+1>*                                            |
| bit[nr:0][size]           | sc_bv<nr+1>[size], std::vector<sc_bv<nr+1>>(of size)    |
| logic                     | sc_logic                                                |
| logic[]                   | sc_logic*                                               |
| logic[size]               | sc_logic[size], std::vector<sc_logic>[size]             |
| logic[nr:0]               | sc_lv<nr+1>                                             |

| <b>SystemVerilog Type</b> | <b>SystemC/C++ Type</b>                           |
|---------------------------|---------------------------------------------------|
| logic[nr:0][]             | sc_lv<nr+1>*                                      |
| logic[nr:0][size]         | sc_lv<nr+1>[size], std::vector<sc_lv<nr+1>>[size] |
| reg                       | sc_logic                                          |
| reg[]                     | sc_logic*                                         |
| reg[size]                 | sc_logic[size], std::vector<sc_logic>[size]       |
| reg[nr:0]                 | sc_lv<nr+1>                                       |
| reg[nr:0][]               | sc_lv<nr+1>*                                      |
| reg[nr:0][size]           | sc_lv<nr+1>[size], std::vector<sc_lv<nr+1>>[size] |
| byte                      | signed char                                       |
| byte[]                    | signed char*                                      |
| byte[size]                | signed char[size], std::vector<char>(of size)     |
| shortint                  | short                                             |
| shortint[]                | short                                             |
| shortint[size]            | short[size], std::vector<short>(of size)          |
| int                       | int                                               |
| int[]                     | int*                                              |
| int[size]                 | int[size], std::vector<int>(of size)              |
| longint                   | long long                                         |
| longint[]                 | long long                                         |
| longint[size]             | long long[size], std::vector<long long>(of size)  |
| integer                   | sc_lv<32>                                         |
| integer[]                 | sc_lv<32>*                                        |
| integer[size]             | sc_lv<32>[size], std::vector<sc_lv<32>>(of size)  |
| Unsigned Versions         |                                                   |
| byte unsigned             | unsigned char                                     |
| shortint unsigned         | unsigned short                                    |
| int unsigned              | unsigned int                                      |
| long int unsigned         | unsigned long long                                |

| <b>SystemVerilog Type</b> | <b>SystemC/C++ Type</b>                           |
|---------------------------|---------------------------------------------------|
| integer unsigned          | sc_lv<32>                                         |
| Signed Versions           |                                                   |
| bit signed                | bool, sc_bit (deprecated)                         |
| bit signed[nr:0][size]    | sc_bv<nr+1>[size]                                 |
| reg signed                | sc_logic                                          |
| reg signed[nr:0][size]    | sc_lv<nr+1>[size], std::vector<sc_lv<nr+1>>[size] |
| logic signed              | sc_logic                                          |
| logic signed[nr:0][size]  | sc_lv<nr+1>[size], std::vector<sc_lv<nr+1>>[size] |

The following table lists the data types to map from SystemC/C++ to SystemVerilog/VMM:

| <b>SystemC/C++ Type</b> | <b>SystemVerilog Type</b>  |
|-------------------------|----------------------------|
| bool                    | bit                        |
| bool*                   | bit[]                      |
| bool[size]              | bit[size]                  |
| char                    | byte, bit[7:0]             |
| char[size]              | byte[size], bit[7:0][size] |
| char*                   | string                     |
| char**                  | string[]                   |
| char*[size]             | string[size]               |
| std::string             | string                     |
| std::string*            | string[]                   |
| std::string[size]       | string[size]               |
| short                   | shortint                   |
| short*                  | shortint[]                 |
| short[size]             | shortint[size]             |
| int                     | int                        |

| <b>SystemC/C++ Type</b> | <b>SystemVerilog Type</b>            |
|-------------------------|--------------------------------------|
| int*                    | int[]                                |
| int[size]               | int[size]                            |
| long                    | longint                              |
| long*                   | longint[]                            |
| long[size]              | longint[size]                        |
| long long               | longint                              |
| long long*              | longint[]                            |
| long long[size]         | longint[size]                        |
| sc_int<nr>              | bit[nr-1:0]                          |
| sc_int<nr>*             | bit[nr-1:0][]                        |
| sc_int<nr>[size]        | bit[nr-1:0][size]                    |
| sc_bigint<nr>           | bit[nr-1:0]                          |
| sc_bigint<nr>*          | bit[nr-1][]                          |
| sc_bigint<nr>[size]     | bit[nr-1][size]                      |
| sc_bit                  | bit                                  |
| sc_bit*                 | bit[]                                |
| sc_bit[size]            | bit[size]                            |
| sc_logic                | logic, reg                           |
| sc_logic*               | logic[], reg[]                       |
| sc_logic[size]          | logic[size], reg[size]               |
| sc_bv<nr>               | bit[nr-1:0]                          |
| sc_bv<nr>*              | bit[nr-1:0][]                        |
| sc_bv<nr>[size]         | bit[nr-1:0][size]                    |
| sc_lv<nr>               | logic[nr-1:0], reg[nr-1:0]           |
| sc_lv<nr>*              | logic[nr-1:0][], reg[nr-1:0][]       |
| sc_lv<nr>[size]         | logic[nr-1:0][size], reg[nr-1][size] |
| Unsigned Versions       |                                      |
| unsigned char           | byte unsigned, bit[7:0]              |

| <b>SystemC/C++ Type</b> | <b>SystemVerilog Type</b>           |
|-------------------------|-------------------------------------|
| unsigned char*          | byte unsigned[], bit[7:0]           |
| unsigned char[size]     | byte unsigned[size], bit{7:0}[size] |
| unsigned short          | shortint unsigned                   |
| unsigned int            | int unsigned                        |
| unsigned long           | longint unsigned                    |
| unsigned long long      | longint unsigned                    |
| sc_uint<nr>             | bit[nr-1:0]                         |
| sc_biguint<nr>          | bit[nr-1:0]                         |
| Signed Versions         |                                     |
| signed char             | byte, bit signed[7:0]               |
| signed char*            | byte[], bit signed[7:0][]           |
| signed char[size]       | byte[size], bit signed[7:0]size     |

Note:

Byte-packing cannot perform type checking between the byte pack/unpack routines from VMM on one side and the corresponding pack/unpack routines on the SystemC/C++ side.

Once data is packed into bytes and sent across, then only the actual values of data members exist without any information about the structure. The function that unpacks the data must match exactly to the one that packed it. If both do not match, then an invalid object results after unpacking. It is not possible to automatically detect this, no error message is printed.

---

## Usage Examples

This section provides examples to use the pack and unpack operators and functions.

### Using the Pack Operator

You can use the pack operator `<<` to put data into the byte array. You can also use this operator for the data types listed in the above section. The following example illustrates how to use pack operator using an `int`, `std::string`, and a `sc_bv` variable.

*Example 19-9 Packing Using Pack Operator*

```
// variable declaration for variables supposed to be packed
int my_int = 42;
std::string my_str = "This is a string";
sc_bv<9> my_sc_bv = 127;

// Object of class tli_pack_data
tli_pack_data pack_ba;

// The pack can be done for these 3 variables in one
// statement or in multiple pack-stmts.

// First possibility, pack is done in one stmt
pack_ba << my_int << my_string << my_sc_bv;

// Second possibility, pack is done with 3 stmts
pack_ba << my_int;
pack_ba << my_string;
pack_ba << my_sc_bv;
```

## Using Unpack Operator

The unpack operator `>>` is used to unpack the content or value into a variable. The variable into which the information is unpacked should be compatible with the variable which was used to pack. The following example illustrates how to use unpack operator using an `int`, `std::string`, and a `sc_bv` variable.

### *Example 19-10 Unpacking Using the Unpack Operator*

```
int my_int;
std::string my_str;
sc_bv<9> my_sc_bv;
// Object pack_ba has the packed data and the order
// the data is packed
// is the same as in the example above.

// The unpack can be done for these 3 variables in
// one statement or in
// multiple unpack-stmts.

// First possibility, unpack is done in one stmt
pack_ba >> my_int >> my_string >> my_sc_bv;

// Second possibility, unpack is done with 3 stmts
pack_ba >> my_int;
pack_ba >> my_string;
pack_ba >> my_sc_bv;
```

---

## Using Pack and Unpack Functions

The `tli_pack_data` class in the `tli_packunpack.h` file provides:

- Single `pack()` function to be used for 1-dim arrays (fixed and/or dynamic). Following is the syntax:

```
template <class T> tli_pack_data& pack(const T& val,
unsigned int nrOfElems= 0)
```

- Two `unpack()` functions (one for fixed size arrays and one for dynamic arrays (pointers)), as shown below:

```
template <class T> tli_pack_data& unpackArray(T& val,
bool isCharArray=false)
```

```
template <class T> tli_pack_data& unpackDynArray(T& val,
bool isCharArray=false)
```

**Note:**

The `pack()` and `unpack()` functions support only arrays of string types. They do not support `const char*`, `char*`, or `std::string`.

Arrays (fixed or dynamic) are packed using the `pack()` function. In case of a dynamic array, you should provide the number of array elements as second argument to this function.

If the number of array elements to be packed is given in the `pack` routine for a fixed size array, then only the first given number elements of the array are packed.

For unpacking an array with fixed size, you must use the `unpackArray()` function.

You can use the `unpackDynArray()` function for unpacking an array with dynamic size (pointer), if the array is not allocated. This method allocates appropriate memory, even if you have allocated memory before calling the `unpackDynArray()` function.

Use the `unpackArray()` function for unpacking an array with dynamic size, if the array is allocated before calling an unpack routine. The `unpackDynArray()` function always allocates memory. The following example with arrays of type `int` illustrates this scenario:

*Example 19-11 Using Pack and Unpack Functions*

```
// variable decl. and init. used for pack
int my_arr[3] = {2,3,4};
int* my_ptr = new int[3];
my_ptr[0] = 6; my_ptr[1] = 7; my_ptr[2] = 8;

// variable decl. used for unpack
int my_t_arr[3];
int* my_t_ptr_null = 0;
int* my_t_ptr_all = new int[3];

tli_pack_data pack_ba;
 // PACK the different int variables
pack_ba.pack(my_arr);
pack_ba.pack(my_ptr, 3);
pack_ba.pack(my_arr);
pack_ba.pack(my_ptr, 3);

 // UNPACK
 // to unpack into "int[3]" the following method has
 // to be used
pack_ba.unpackArray(my_t_arr);
// to unpack into "the NULL-pointer of int*" the following
 // method has to be used.
pack_ba.unpackDynArray(my_t_ptr_null);
 // to unpack into "allocated int* pointer" the method
 // "unpackArray" should be used
pack_ba.unpackArray(my_t_ptr_all);
 // Calling "unpackDynArray" will allocate new memory,
 // and the address of my_t_ptr_all will not be the same
 // after the call of unpackDynArray.
pack_ba.unpackDynArray(my_t_ptr_all);
```

---

## Using Code Generator

Exchanging user-defined class or struct objects between VMM and SystemC/C++ using byte-packing requires user interaction and coding. You can use the code generator to automatically create SystemVerilog (SV) class definition corresponding to a SystemC/C++ class and functions to pack or unpack the class members.

The code generator automatically creates source code for:

- The SV class definition that correspond to the C++ class definition.
- The C++ `tli_pack` or `tli_unpack` functions for all members of the class.

## Naming Convention

The following naming conventions are used for the following sections of this chapter:

**Table 0-1. Naming Conventions**

| Name               | Description                                                                                                                                                                                                                                                                                                                                          |
|--------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| C side             | Refers to C domain which can be C, C++, or SystemC application.                                                                                                                                                                                                                                                                                      |
| SV side            | Refers to the SystemVerilog, whereby the application is expected to use VMM.                                                                                                                                                                                                                                                                         |
| Class              | Refers to a user-defined C++ class or C struct on the C side. On the SV side, it refers to a SV class.                                                                                                                                                                                                                                               |
| Complex Data types | Complex data types are the types which require additional arguments in the pack/unpack routines. For example, enum, length of a dynamic array. These types are not supported in the provided pack/unpack routines, such as structs and multi dimensional arrays. These data types require manual corrections or modifications in the generated code. |
| Simple Data Types  | Simple data types are the non-pointer built-in data types, such as, std::string, std::vector and fixed-size arrays.                                                                                                                                                                                                                                  |

## Input Files

The code generator requires the following two input files to create source code automatically:

- TLI file
- C source file containing the struct or class

### TLI File

The TLI file defines the name of the class. It provides instructions to generate the corresponding SV/VMM class and the pack or unpack routines. This TLI file is used to create adaptor code. The adaptor

code for the specified module or class is generated using the keyword `adaptor` followed by `class_name`. The syntax is as follows:

```
adaptor <class_name>
```

You can modify or extend the above syntax as follows:

- The class name is specified with the `class` keyword
- The target, for which code is created, is specified with the keyword `create`. Target can be one of the following:
  - `adaptor`
  - `VMM`
  - `packunpack`

The adaptor code generation is invoked with `create adaptor` statement after the `class_name` is specified with `class class_name`. Following is an example for creating adaptor code:

```
class <class_name>
create adaptor
```

The VMM class and the `vmm_data_member` defines are created for the members found in the class specified with the `class` keyword using `create VMM`. The pack and unpack functions for the members of the class specified with the `class` keyword are created

using `create packunpack`. Therefore, VMM class and pack and unpack code generation is invoked if the TLI file contains the following commands:

```
class <class_name>
create VMM
create packunpack
```

Note:

Only the parts of code which are specified with the `create` keyword are generated. For example, for the following TLI file, only the VMM class is created:

```
class <class_name>
create VMM
```

### C source file containing the struct or class

The provided C, C++, or SystemC source file contains the class definition.

## Output Files

### Generated SV class

The SV VMM class declaration together with `vmm_data_member` defines are created in the `tli_vmm_class_name` file. This file contains:

- VMM class member declaration
- VMM `vmm_data_member` defines

This generated file should be included in the SV file which will pack or unpack the class members.

## **Generated C files**

Two files are generated for the C pack or unpack functions: A header file with pack or unpack function definition and another with the function bodies.

- The following are the names of these two functions:

`tli_conv2_pack_class_name`

`tli_conv2_unpack_class_name`

- The following are the signatures of these two functions:

- The first argument is an object of `tli_pack_data`.

- The second argument is the class (with the members to be packed or unpacked).

- The following are the names of the generated files:

`tli_packunpack_class_name.h`

`tli_packunpack_class_name.cpp`

The generated header file should be included in the file in which the conversion (pack/unpack) happens.

## **Supported Data types for Automatic Code Generation**

- `bool, char, signed char, short, int, long, long long, sc_int, sc_big_int`
- `unsigned (char, short, int, long, long long), sc_uint, sc_bignum`
- `std::string, char*`

- sc\_logic
- sc\_bv, sc\_lv
- Array types: std::vector of types listed above and 1-dim fixed-size arrays of types listed above

Note:

- The `const char*` data type is not supported. You cannot unpack a variable of this data type into the same data type.
- Pointer of C scalar types are seen as dynamic arrays, and mapped to SV open array data types. The byte packing on the C side requires the size of the dynamic arrays. The size cannot be automatically detected, so the code generated is put into comment. C data types, which are not based directly on scalar types, are mapped to a `chandle` data type. A `chandle` cannot be packed/unpacked by VMM, so this code is generated in comment.

## Correcting the Generated Files

You must manually modify or correct the generated files for member variables that contain complex data types.

The generated code is put into comments marked with `TODO` (see [“Usage Example for Code Generator”](#)) for all the portions of the code that require manual corrections or modifications. You must manually correct or modify the code of all complex data types.

## Compile Flow

Perform the following steps to compile:

1. Generate the VMM class and the C pack/unpack routines. This step does not compile the C sources. The following syscan command generates the VMM-class declaration (with the `vmm_data_member` defines) and the pack and unpack functions.

```
syscan -tli tli_input_file class_header.h
```

Where, `tli_input_file` specifies the `class_name` (followed by the `class` keyword) and whether the VMM and/or class pack/ unpack functions have to be created (`create` keyword). The file `class_header.h` contains the class definition of the class to be packed or unpacked.

2. Compile the generated pack and unpack functions and the source file containing the class to be packed or unpacked, after manually correcting the generated files (SV and C) which contains complex data types. This is done with the following syscan call:

```
syscan -tlm2 class_source.cpp
tli_packunpack_class_name.cpp
```

3. Generate interface for the class which will pack or unpack the class. Include the include statement of the generated header file `tli_packunpack_class_name.h` in the `test_class.h` file, as shown below:

```
syscan -tlm2 -debug_all
test_class.cpp:test_class_name
```

Other syscan calls for files required for building and running the simulation.

4. Create an executable with the `vcs` command line by passing `.sv` files (`test.sv` and `tli_packunpack.sv`).

```
vcs -sverilog -sysc -debug_all -ntb_opts rvm -timescale=1ns/1ps ${VCS_HOME}/etc/systemc/tlm/tli/tli_packunpack.sv test.sv -o simv1
```

## Usage Example for Code Generator

The test case in this example consists of a Verilog top module called `top`, and a SystemC module `BusModel`. The struct used for byte packing is called `MemAccess`. The file `memaccess.h` contains the user-defined struct `MemAccess`, and the TLI file `memaccess.tli` contains the create statements. The TLI file contains the following commands:

```
class MemAccess
create VMM
create packunpack
```

The `memaccess.h` file contains the following:

```
#ifndef MEMACCESS_H
#define MEMACCESS_H
struct MemAccess {
 unsigned int adr; // address
 bool RW; // true=read, false=write
 unsigned char* data; // data[len] to be read or written
 int len; // number of bytes
};
#endif
```

## Code Generation

The struct contains a dynamic array, `data`. You must manually modify the generated code, if you want to pack this struct member.

Invoke the code generator with the `syscan` command:

```
syscan -tli memaccess.tli memaccess.h
```

The following files are generated:

- **VMM-SV file:** tli\_vmm\_MemAccess.sv
- **C files:** tli\_packunpack\_MemAccess.h,  
tli\_packunpack\_MemAccess.cpp

The following is the generated tli\_vmm\_MemAccess.sv VMM file:

```
// VMM class for C++ class MemAccess
`include "vmm.sv"
class MemAccess extends vmm_data;
 int unsigned adr;
 bit RW;
 // TODO: handled as dynamic array
 // TODO: byte unsigned data[];
 int len;

`vmm_data_member_begin(MemAccess)
`vmm_data_member_scalar(adr, DO_ALL)
`vmm_data_member_scalar(RW, DO_ALL)
//TODO: handled as dynamic array
//TODO: `vmm_data_member_scalar_da(data, DO_ALL)
`vmm_data_member_scalar(len, DO_ALL)
`vmm_data_member_end(MemAccess)
endclass:MemAccess
```

The following is the generated C header file

tli\_packunpack\_MemAccess.h:

```
#ifndef TLI_PACKUNPACK_MemAccess_H
#define TLI_PACKUNPACK_MemAccess_H
#include "tli_packunpack.h"
#include "memaccess.h"

void tli_conv2_pack_MemAccess(tli_pack_data& P, const
MemAccess& MemAccess_obj);
void tli_conv2_unpack_MemAccess(tli_pack_data& P,
```

```

 MemAccess& MemAccess_obj) ;

#endif

```

The following is the generated C source file,  
**tli\_packunpack\_MemAccess.cpp**, with the two function bodies:

```

#include "tli_packunpack.h"
#include "memaccess.h"

// pack/unpack routines for public members of class MemAccess
void tli_conv2_pack_MemAccess(tli_pack_data& P, const
MemAccess& MemAccess_obj)
{
 P << MemAccess_obj.adr;
 P << MemAccess_obj.RW;
 // TODO: handled as dynamic array, length is missing
 // TODO: P.pack(MemAccess_obj.data, data_length());
 P << MemAccess_obj.len;
}
void tli_conv2_unpack_MemAccess(tli_pack_data& P,
MemAccess& MemAccess_obj)
{
 P >> MemAccess_obj.adr;
 P >> MemAccess_obj.RW;
 // TODO: handled as dynamic array, corresponding pack
routine must be fixed before
 // TODO: P.unpackDynArray(MemAccess_obj.data, true);
 P >> MemAccess_obj.len;
}

```

## Manual Modifications

The input struct contains a member with a complex data type, so the generated code must be modified manually. The member data is a dynamic array, therefore the assumption of the code generator is correct.

The generated code for this data member contains to be uncommented in the VMM class declaration and in the C pack and unpack functions. The second argument of the byte pack call of complex data must get the correct variable name containing the size of the data.

After manual corrections, the `tli_vmm_MemAccess.sv` file appears, as shown below:

```
// VMM class for C++ class MemAccess
`include "vmm.sv"
class MemAccess extends vmm_data;
 int unsigned adr;
 bit RW;
 byte unsigned data[];
 int len;

`vmm_data_member_begin(MemAccess)
`vmm_data_member_scalar(adr, DO_ALL)
`vmm_data_member_scalar(RW, DO_ALL)
`vmm_data_member_scalar_da(data, DO_ALL)
`vmm_data_member_scalar(len, DO_ALL)
`vmm_data_member_end(MemAccess)
endclass:MemAccess
```

After manual corrections, the `tli_packunpack_MemAccess.cpp` file appears, as shown below:

```
#include "tli_packunpack.h"
#include "memaccess.h"

// pack/unpack routines for public members of class MemAccess
void tli_conv2_pack_MemAccess(tli_pack_data& P, const
```

```

MemAccess& MemAccess_obj)
{
 P << MemAccess_obj.adr;
 P << MemAccess_obj.RW;
 P.pack(MemAccess_obj.data, MemAccess_obj.len);
 P << MemAccess_obj.len;
}
void tli_conv2_unpack_MemAccess(tli_pack_data& P,
MemAccess& MemAccess_obj)
{
 P >> MemAccess_obj.adr;
 P >> MemAccess_obj.RW;
 P.unpackDynArray(MemAccess_obj.data, true);
 P >> MemAccess_obj.len;
}

```

You must compile the generated and corrected C file `tli_packunpack_MemAccess.cpp`, using the `syscan` command:

```
syscan -tlm2 tli_packunpack_MemAccess.cpp
```

## **SystemC Module Using Byte Packing**

The SystemC module, which is instantiated, requires two byte pack includes, `tli_packunpack.h` and `tli_packunpack_MemAccess.h`.

The following is the BusModel.h header file:

```
#ifndef BUS_MODEL_H
#define BUS_MODEL_H

#include <systemc.h>
#include <tli_packunpack.h>
#include "memaccess.h"
#include "tli_packunpack_MemAccess.h"

SC_MODULE(BusModel)
{
 sc_in<bool> clock;
 SC_CTOR(BusModel)
 : clock("clock")
 {
 m_mem = new unsigned char[m_size];
 for (int n=0; n<m_size; n++)
 m_mem[n] = n % 100;

 SC_THREAD(do_transactions);
 sensitive_pos << clock;
 }

 void do_transactions();
private:
 static const int m_size;
 unsigned char* m_mem;
};

#endif
```

The BusModel method `do_transaction` calls for byte packing the function `tli_conv2_pack_MemAccess( pba, trans)` and for unpacking `tli_conv2_unpack_MemAccess( pba, trans)`,

where pba is a tli\_pack\_data object and trans is a MemAccess instantiation. With the tli\_pack\_data upload and download functions, the byte buffer is loaded or sent from or to SV.

```
#include <BusModel.h>

void BusModel::do_transactions()
{
 tli_pack_data pba;
 MemAccess trans;

 while(1) {
 // get next transaction
 wait();
 wait(5,SC_NS);
 pba.download(0);
 tli_conv2_unpack_MemAccess(pba, trans);

 // execute transaction
 for (int n=0; (n<trans.len) && ((trans.adr+n)<m_size); n++) {
 if (trans.RW) {
 trans.data[n] = m_mem[trans.adr + n];
 } else {
 m_mem[trans.adr + n] = trans.data[n];
 }
 }

 wait(10,SC_NS);
 pba.reset();
 tli_conv2_pack_MemAccess(pba, trans);
 pba.upload(0);
 }
}

const int BusModel::m_size = 1000;
```

With the following syscan command, the interface file is generated and the BusModel source code is compiled.

```
syscan -t lm2 -debug_all BusModel.cpp:BusModel
```

The provided SV package with the `tli_upload` and `tli_download` tasks is analyzed with the following command:

```
vlogan -sverilog ${VCS_HOME}/etc/systemc/tlm/tli/
tli_packunpack.sv
```

### **Verilog Module Using Byte Packing**

The Verilog module `top` is in file `top.v`, and it includes the generated VMM file `tli_vmm_MemAccess.sv`. It imports the `tli_packunpack` package using the `tli_upload` and `tli_download` tasks. The Verilog module `top` instantiates the SystemC module `BusModel`, and data exchange happens with byte packing/unpacking of `MemAccess` class.

```

`include "tli_vmm_MemAccess.sv"
import tli_packunpack::*;

module top;
 reg clock;
 BusModel ref_model(clock);
 MemAccess trans;
 pB bytes;
 chandle ID;
 int n;
 initial clock=0;
 always #50 clock=!clock;
 initial begin
 ID = null;
 trans = new;

 @(posedge clock);
 trans.adr = 98;
 trans.RW = 1'b1;
 trans.len = 5;
 trans.data = new[trans.len];
 trans.byte_pack(bytes);
 tli_upload(bytes, ID);

 #20 ;
 tli_download(bytes, null);
 trans.byte_unpack(bytes);
 for (n=0; n<trans.len; n=n+1)
 $display("trans.data[%3d]=%d", n, trans.data[n]);
 #100 $finish;
 end
endmodule // top

```

The file `top.v` is analyzed using the following command:

```
vlogan -sverilog -ntb_opts rvm top.v
```

## **Building simulation**

The simulation `simv` is then build using the following `vcs` command:

```
vcs -sysc -debug_all top -timescale=1ns/1ps
```

---

## **Using Direct Program Interface Based Communication**

This section describes how to use Direct Programming Interface (DPI) based communication to achieve data transfer speedups between Verilog and SystemC.

Use the `-sysc=dpi_if` option to select the required interface while generating interface code for a SystemC module to be instantiated in Verilog, or for a Verilog module to be instantiated in SystemC.

Note:

You can use the `-sysc=nodpi_if` option, which is the default behavior, to disable the DPI-based interface.

### **Example**

- The following command creates a wrapper for a SystemC module to be instantiated in verilog:

```
% syscan -sysc=2.2 -sysc=dpi_if my_sysc.cpp:my_sysc
```

- The following command creates a wrapper for a Verilog module to be instantiated in SystemC:

```
% vlogan -sysc=2.2 -sysc=dpi_if my_vlog.v -sc_model \
my_vlog
```

You can use both PLI- and DPI-based interfaces within the same simulator. That is, you can use one SystemC model using the DPI-based interface and another SystemC model using the PLI-based interface, within the same simulator.

---

## **Limitations of Using DPI-based Communication Between Verilog and SystemC**

- The DPI-based interface does not work for models containing inout ports. This is detected automatically, and a warning message is generated. The PLI-based interface is used instead.

---

## **Improving VCS-SystemC Compilation Speed Using Precompiled C++ Headers**

This section describes how to use precompiled C++ headers in the VCS-SystemC compile flow to improve compilation speed.

This section contains the following topics:

- “[Introduction to Precompiled Header Files](#)” on page 186
- “[Using Precompiled Header Files](#)” on page 186
- “[Example to Use the Precompiled Header Files](#)” on page 188
- “[Invoking the Creation of Precompiled Header Files](#)” on page 188
- “[Limitations](#)” on page 189

---

## Introduction to Precompiled Header Files

The precompiled header files `systemc.h` and `systemc` must be generated before you use them. The `g++` compiler first searches for a precompiled header file in the specified include paths. If found, the `g++` compiler uses the matching precompiled header file. If not, it parses the specified header file (ASCII version).

A non-match can be caused by the use of different compile options, such as `-m32` and `-m32 -fPIC`, while creating the precompiled header file and the `g++` call.

---

## Using Precompiled Header Files

Use the following `syscan` option to create precompiled header files (`systemc.h` and `systemc`) and compile the given SystemC files with an additional search path to the location of the precompiled header file:

```
% syscan -prec [= <target_directory>] <file1> [<file2> ...]
```

Where,

- `<target_directory>` is the user-specified path. If specified, this path is the first path searched for all includes.
- `<file1>, <file2>` are the SystemC source files.

Note:

The above command creates the precompiled header files `systemc.h` and `systemc`, if they do not exist. Otherwise, it uses the precompiled header files which are already present.

If you mention `target_directory`, then the `g++` call first searches this directory for precompiled header files. This ensures that you get the best performance improvement, and that the precompiled header files are used if they exist.

If you do not specify a directory, then `g++` creates a precompiled header file in each of the following two directories:

```
./csrc/sysc/prec/$hostname/<SC_version>/<GCC_version>/
<VCS_version>/systemc_.h.gch/
```

```
./csrc/sysc/prec/$hostname/<SC_version>/<GCC_version>/
<VCS_version>/systemc_.gch/
```

The file name is based on the compile-time options (for example, `m32_fPIC` for `-m32 -fPIC`).

If `-Mdir` is specified as an argument to `syscan -prec`, then the directory structure appears as follows:

```
<mdir_path>/prec/$hostname/<SC_version>/<GCC_version>/
<VCS_version_id>/systemc_.h.gch/
```

and

```
<mdir_path>/prec/$hostname/<SC_version>/<GCC_version>/
<VCS_version_id>/systemc_.gch/
```

If you specify a directory name with the `-prec` option, then the precompiled header files are generated in the subdirectory `prec/systemc_.h.gch/` and in `prec/systemc_.gch/` of the specified directory. If you use `-Mdir` with `-prec` with a path, then the `-Mdir` option is ignored for the location of the precompiled headers.

The generation of the precompiled header files is done using make files, so that in case of no change, a precompiled header file is not generated again.

---

## **Example to Use the Precompiled Header Files**

The following example shows how to use precompiled header files. This example assumes that the Verilog module `my_top` instantiates a SystemC module called `my_sc_top`.

### **Example**

```
% syscan -prec -t1m2 my_sc_top.cpp:my_sc_top
```

This command creates the precompiled header files:

```
% syscan -prec my_sc_module.cpp
```

These commands use the precompiled header files created by the above command:

```
% vlogan -sverilog my_top.sv
% vcs -sysc my_top
```

---

## **Invoking the Creation of Precompiled Header Files**

If any of the following changes takes place, a precompiled header file must be created with the changes to make use of the precompiled header file in a compile call. The `syscan -prec` call takes care of this, and creates appropriate precompiled header files.

- gcc version is different from the one used for the creation of the precompiled header files `systemc.h` and/or `systemc`

- Compile flags are not the same
- SystemC-related defines passed with `-D` as argument(s) of the `-cflags` option are not the same
- `$VCS_HOME` (version) changes
- SystemC version changes
- Host changes (different system include files)

If the `-prec` option is called with a user-specified path, then a sanity check is done if precompiled header files are already generated at the specified location. If any of the above-mentioned changes takes place, an appropriate message is generated, and the creation and usage of precompiled header files is skipped. This occurs for VCS, gcc, SystemC version, and host name changes.

If the changes are only in compile flags, then the precompiled header files are generated if they do not exist.

## **Limitations**

### **Limitations of GNU Precompiled Header Files**

The following are the limitations of the GNU precompiled header files:

- The option used for creating the precompiled header file and the actual must be the same. If not, the precompiled header file is skipped.
- Only one precompiled header file can be used in one compilation step.
- Any C token before a precompiled header file is skipped.

- **From gcc 4.5.2 version:** You cannot include a precompiled header from inside another header. That means the “systemc.h” include statement should be the on the top of the source file (.cpp), only then the precompiled header files are used. Otherwise precompiled header files are skipped. Older gcc versions were not very stringent of the position of the include directive.
- The g++ used for creating the precompiled header file and the actual g++ must be the same compiler binary.
- Any macro defined before the precompiled header file must be the same when creating and using it.

## **Limitations of syscan -prec**

The following are the limitations of the syscan -prec call:

- gcc supports precompiled header files from version 4.2.2.
- The include statement of a SystemC header file must be on top of a file. Any C/C++ token used before the SystemC header file skips the usage of the precompiled header file and parses the ASCII source file.

Note:

A C/C++ token is any valid C/C++ source code like a typedef or variable declaration. Preprocessor directives (for example, #define, #include) are not C/C++ tokens.

- Two precompiled header files are created, one for systemc.h and one for systemc.
- The size of a precompiled header file is at least 2.5 MB. The size depends on the options passed in a sysc -prec call.

- All syscan calls must use the -prec option to make use of precompiled header files.
- A change in compile flags and/or SystemC related defines in a syscan -prec call results in creation of precompiled header files with these settings.
- If there are SystemC-related defines in front of a SystemC header file, you must create the precompiled SystemC header file with the same defines (names and values) using the -D option (as part of -cflags in a syscan -prec command).

The defines in front of a SystemC header file must match the set of defines used in the precompiled header file creation step. If no matching precompiled file is found, the ASCII version of the SystemC header file is used.

## **Limitations of using -prec with path**

If there are already precompiled header files stored in the path-location, a sanity check is done with respect to changes to hostname, SystemC version, gcc version, and VCS version (time stamp).

If one of these does not match, a warning message is generated, and the creation (and usage) of the precompiled header files is skipped. The result is that the precompiled header files are not used in the compile step. Putting the host name as part of the path prevents skipping (and usage) of precompiled header files in case of any host name changes. All the rest must match.

## **Limitations of Sharing Precompiled Header Files**

- You must call the `-prec` option, along with an absolute path, to share precompiled header files. You should have read (and maybe write) permissions.

If there is a change with respect to name of the host, then VCS, gcc, and SystemC version sharing is not possible. In this case the sanity check creates a warning, and the usage of precompiled header files is skipped.

The most likely thing to change is the name of the host. If the host name is part of the path (like `/some_dir/${hostname}/`), then the precompiled header files can be used. The downside is that the precompiled header files are created in this specific directory with the information used by VCS, SystemC, and gcc version.

- You must call the `syscan` executable with the `-prec` option with the same path. Any change in the compile flags (passed with `-cflags`) invokes the creation of precompiled header files, if they do not exist for the changed combination of compile flags.

---

## **Increasing Stack and Stack Guard Size**

SystemC assigns an individual call stack for each SC thread (`SC_THREAD`, `SC_CTHREAD`, and spawned function or method). Since this stack is limited in size, you need to choose an appropriate stack size.

If an SC thread uses more stack space than available (for example, for large arrays that are local variables or due to an infinite recursion) then memory corruption occurs, or the simulation may crash with an `SEGV` (segmentation violation) error.

The memory allocated for each SC thread is divided into two areas, stack and stack guard (or redzone). Stack guard has no access rights. If an SC thread overruns its stack (for example, due to an endless recursion) then it reaches the stack guard which triggers an SEGV error. The default size of stack and stack guard is 60 KB and 4 KB, respectively.

One way to increase the size is calling the `sc_stack_size()` method, as described in the SystemC LRM. VCS provides an additional way to modify the stack size and stack guard size using runtime options described in the following sections. This allows you to extend the stack size without the need to recompile the simulation.

## Increasing the Stack Size

You can use the following VCS runtime option to increase the stack size of all SC threads:

```
-sysc=stacksize: [0...9] + [K|k|M|m]
```

The `signed_number` passed with this option must be in the range between 64 KB and 10 MB, else VCS generates a warning message. If the size is less than 64 KB, then this option has no effect on the stack size, and the default stack size (60 KB) is used.

If you explicitly specify a size of 10 MB or less using the `sc_stack_size()` method in the SystemC source code, then this option can only increase this limit by using the larger of `sc_stack_size()` and `-sysc=stacksize`.

If you specify more than 10 MB with `sc_stack_size()`, then this option does not override this setting. The decision on which size to use is done individually for each SC thread.

## **Example**

```
simv -sysc=stacksize:1024k
```

This runtime option increases the stack size of all SC\_THREADS, SC\_CTHREADs, and spawned functions to at least 1 MB.

## **Increasing the Stack Guard Size**

You can use the following VCS runtime option to increase the stack guard size of all SC threads:

```
-sysc=stackguardsize: [0 . . . 9] + [K | k | M | m]
```

If the size is less than 4 KB, then this option has no effect on the stack guard size, and the default size of 4 KB is used. If the signed\_number is greater than 1 MB, then the stack guard is increased accordingly, but a warning is generated.

## **Example**

```
simv -sysc=stackguardsize:100k
```

This runtime option increases the stack guard size to 100 KB.

## **Guidelines to Diagnose Stack Overrun**

Following are the recommended guidelines to use the above mentioned runtime options to diagnose a stack overrun:

- If you suspect that the simulation crashes, because one or more SC threads overrun their stacks, then first try to increase the stack to a large value, for example to 100 MB, as shown below:

```
% simv -sysc=stacksize:100M
```

- If the crash goes away, then there is a chance that a stack overrun has occurred before. If so, then leave the stack at its previous size (which is too small), but increase the stack guard size to a large value (for example, 200 MB).

This increases the chance for the simulation to abort with an SEGV on the first time, when a stack overrun occurs. Compile all SystemC source code with debug information, and start the simulation from a debugger such as gdb or from DVE/CBug, as shown below:

```
syscan -cflags -g file1.cpp file2.cpp ...
...
gdb simv
(gdb) run -sysc=stackguardsize:200M
... SEGV occurred in file1.cpp line 123 ...
```

Identify the SC thread that used more memory and increase its stack size by calling `sc_stack_size()` in the constructor. For more information on `sc_stack_size()`, see the SystemC LRM.

## Debugging SystemC Runtime Errors

You can debug SystemC runtime errors effectively during elaboration time and runtime. Besides, VCS also has a mechanism to clearly report runtime crashes caused by certain problems with quick-threads during runtime. The following two sections provide you more details:

- [Debugging SystemC Kernel Errors](#)
- [Diagnosing Quickthread Issues](#)

---

## Debugging SystemC Kernel Errors

VCS now provides an effective mechanism to debug your design issues during elaboration and runtime. Whenever a SystemC Kernel error occurs, error messages were not really helpful to enable you identify which part of your source code was causing the error. Debugging such errors was way too tedious.

Now, VCS provides a new function `cbug_stop_here()` that is called whenever a SystemC kernel error occurs. You can make use of this function to place a breakpoint in this function and see the stack trace to know the source code that is causing the error.

The next section describes how you can troubleshoot your elaboration and runtime issues using the newly introduced function:

- [Troubleshooting Your Elaboration Errors](#)
- [Troubleshooting Your Runtime Errors](#)

## Troubleshooting Your Elaboration Errors

In SystemC on top designs, during elaboration, all SystemC constructors, `end_of_elaboration()` methods and other statements (before `sc_start`) in `sc_main` function are executed. It is possible that something goes wrong in these parts of source code.

Until now, whenever there is a SystemC kernel error during elaboration there was no executable to debug where this error is coming from (in the SystemC source code), hence it was difficult to know which part of SystemC code is causing these elaboration errors.

Hereafter, VCS generates an executable file simv.elab.error. This can be used for debugging the elaboration error with GDB. This way you can know which part of your source code is causing the elaboration error.

## Example

Let us consider a scenario where an SC-top design calls wait() within the sc\_main() function. This is not allowed by the SystemC language and an SC kernel error will occur. This in turn breaks the entire elaboration and results in an error SC-VCS-SYSC-ELAB. This is illustrated in the following example.

```
% vlogan dut.v -sc_model dut
% syscan main.cpp -cflags -g
% vcs -sysc sc_main
...
...
...
Error: (E519) wait() is only allowed in SC_THREADS and
SC_CTHREADS:
 in SC_METHODs use next_trigger() instead
In file: sc_wait.cpp:224

Error-[SC-VCS-SYSC-ELAB] SystemC elaboration error
 The design could not be fully elaborated due to an early
 termination of the SystemC part of the design.
 Please read the hints in file simv.elab.error README or
 review the details in the SystemC chapter of the VCS
 documentation.
%
```

No simv has been generated because the elaboration failed. But you will find an executable file simv.elab.error that can be used for debugging and a test file simv.README is also generated which gives hints on how to debug the failure.

Now, you must debug the design to find the source code line that calls wait(). To debug the issue, you must perform the following steps:

1. Rename simv.elab.error to simv

```
mv simv.elab.error simv
```

2. Set the environment variable SYSTEMC\_ELAB\_ONLY to 1

```
setenv SYSTEMC_ELAB_ONLY 1
```

3. Start simv from gdb (neither UCLI, CBug nor DVE can be used because the simulation is not yet fully elaborated).

```
<VCS_HOME>/<arch>/bin/cbug-gdb-64/bin/gdb --args simv
```

4. Place a breakpoint in function cbug\_stop\_here() and run the simulation

```
(gdb) break cbug_stop_here
(gdb) run
```

```
Starting program: .../simv
[Thread debugging using libthread_db enabled]
```

```
Breakpoint 1, cbug_stop_here (reason=0x829beb0 "Throw:
sc_report is about to be thrown",
 details=0x829c460 "wait() is only allowed in SC_THREADS
and SC_CTHREADS") at bf_cbug_helpers.c:23
23 no++;
```

5. see the stack to see which part of SystemC code caused this elaboration issue.

```
(gdb) backtrace
#0 cbug_stop_here
 (reason=0x829beb0 "Throw: sc_report is about to be
thrown",
 details=0x829c460 "wait() is only allowed in SC_THREADS
and
 SC_CTHREADS")
 at bf_cbug_helpers.c:23
#1 0x081ff4fc in
sc_core::sc_report_handler::default_handler(...)
```

```
#2 0x08200825 in sc_core::sc_report_handler::report(...)
#3 0x081f8f5c in sc_core::wait(...)
#4 0x080e700b in sc_core::wait (v=10,
tu=sc_core::SC_NS,simc=...)
#5 0x080e6bf2 in sc_main (...) at .../main.cpp:60
#6 0x0813ae9a in bf_main ()
#7 0x080e2905 in main ()
```

Notice that the execution stopped inside the function `cbug_stop_here` and the stack trace reveals information useful for debugging. In this example, frame #5 shows the erroneous statement at `main.cpp`, line 60.

## Troubleshooting Your Runtime Errors

Whenever a SystemC kernel error occurs that will terminate the simulation, it is difficult to know which part of the source is causing this issue. Hereafter, you can use `cbug_stop_here()` function to debug such issues.

You must stop the simulation in `cbug_stop_here()` and look at the stack to find out which user source code statement is triggering the error.

In UCLI flow, follow these steps:

- Start `simv` with `-ucli -ucli2Proc`
- Attach CBug
- Enter command '`stop -in cbug_stop_here`'
- Run simulation until the SC kernel error occurs and simulation stops inside function `cbug_stop_here`
- Use the '`stack`' command to find out which user statement caused the error

- Advance the simulation with ‘run’ to get past this error in case there are multiple errors.

For example:

```
% ./simv -ucli -ucli2Proc
ucli% cbug
CBug - Copyright Synopsys Inc 2003-2011
Please wait while CBug is loading symbolic information ...
... done. Thanks for being patient!
ucli% stop -in cbug_stop_here
1
ucli% run

Stop point #1 @ 1000 PS;
CBug% stack
0: cbug_stop_here(
 reason="Throw:sc_reportisabouttobethrown",
 details="SC-MSG-ID") (bf_cbug_helpers.c, line 23)
1: sc_core::sc_report_handler::default_handler(...)
2: sc_core::sc_report_handler::report(...)
3: s_stim::action(this=0x96f2e98) (main.cpp, line 38)
4: $kernel::SystemC::process_activation() (<VCS_HOME>/etc/
cbug/kernel.txt, line 1)
```

Function `cbug_stop_here()` has two arguments. Argument ‘`reason`’ explains why the function is called, usually an error that will terminate the simulation shortly. Argument ‘`details`’ is giving additional information in some cases or may be empty. The callstack provides more information and will reveal in most cases the statement that triggered the error.

In DVE, follow these steps:

- Attach CBug
- Enter command ‘`stop -in cbug_stop_here`’ in the DVE console

- Click the continue button until the SC kernel error occurs and simulation stops inside function `cbug_stop_here()`
- Use the stack pane to locate and debug the user source code that triggered the SC kernel error.
- Click continue to get past this error in case there are multiple errors.

## **Function `cbug_stop_here()`**

Whenever a SystemC kernel error occurs that may terminate the simulation, VCS calls the function `cbug_stop_here()`. The function itself does nothing but is useful for debugging. It helps you to find out from which user source code statement is triggering the error.

Function `cbug_stop_here()` has two arguments. Argument ‘reason’ explain why the function is called, usually an error that will terminate the simulation shortly. Argument ‘details’ is giving additional information in some cases or may be empty.

The function is only available when SystemC is part of the simulation. It can not be used, for example, for a simulation that has just Verilog and DPI but no SystemC.

Function `cbug_stop_here()` will stop in the following situation:

- Argument `reason="P: sc_stop() called"`:

The `sc_stop()` function is called, either from your SC source code or the SC kernel. The simulation will end now. Depending on the SystemC version and settings, it may stop instantly or finish other SystemC and HDL processes also scheduled in the current delta cycle.

- Argument **reason="Stop: SC\_STOP in sc\_report"**:  
An **sc\_report** is being processed and now about to call the **SC\_STOP** action.
- Argument **reason="Interrupt: SC\_INTERRUPT in sc\_report"**:  
An **sc\_report** is being processed and now calls the **SC\_INTERRUPT** action. The simulation may continue or end now, depending on other actions from this **sc\_report**.
- Argument **reason="Abort: SC\_ABORT in sc\_report"**:  
An **sc\_report** is being processed and now calls the **SC\_ABORT** action. The simulation will end instantly.
- Argument **reason="Throw: sc\_report is about to be thrown"**:  
An **sc\_report** is being processed and now throws an **sc\_report** object. The simulation will end soon in most cases, however, it may also continue:

If there is a 'catch' statement in the surrounding user source code, then it may take care of the **sc\_report** and the simulation will continue. But if the exception is not caught in your source code, then the SC or VCS kernel will catch it and terminate the simulation. If so, then `cbug_stop_here()` will be called again with reason 'Error from SC kernel'.

- Argument **reason="Error from SC kernel: sc\_report was not caught and terminates simulation"**:

An `sc_report` was thrown and not caught. The simulation will end now. This is typically the case when `SC_REPORT_ERROR` was called. Look in argument 'details' for the error message.

- Argument `reason="C++ exception was not caught and terminates simulation"`:

Some kind of C++ exception was thrown and not caught in user code. The simulation will end now.

If the function is reached multiple times during a simulation and you want to stop only at a specific call, then you must use a local variable 'no' and a condition breakpoint. The variable is incremented with each call.

There is a case statement inside the function with a case for each reason. You can use it to set a breakpoint to a specific reason.

Note that the exact wording of the string inside 'reason' is subject to change between the releases. The signature (the set of arguments) may also change between or within a release.

## Limitations

Debugging capabilities are very limited when the Virtualizer/Innovator flow (-sysc=snps\_vp) is used. Function `cbug_stop_here()` still exists, but is called only in a few cases. Most SystemC kernel errors do not call `cbug_stop_here()`.

---

## Diagnosing Quickthread Issues

VCS is now equipped with a better mechanism to report VCS runtime crashes caused by certain problems with quickthreads used during VCS runtime. You will get clear feedback as to what went wrong and which thread is causing the crash thereby enabling you to take specific action to circumvent the issue. For more information on this feature, see [Diagnosing Quickthread Issues in SystemC](#).

---

## Using HDL and SystemC Sync Loops

VcsSystemC enables you to simulate both HDL (Verilog, SystemVerilog, VHDL) and SystemC together. A sync loop drives the kernels of both HDL and SystemC parts and ensures that simulation events stay aligned. There are two different sync-loops to select from. They differ in simulation speed, accuracy of the alignment and other aspects.

The two sync loops are:

- The coarse-grained sync loop (`blocksync`).
- The fine-grained sync loop (`deltasync`). This is default.

---

### The Coarse-Grained Sync Loop (`blocksync`)

This sync loop aligns HDL and SystemC at a coarse but efficient level. If there are multiple delta cycles on the SystemC side, then some or all of those SystemC delta cycles are executed consecutively before control is handed back to the HDL side. Similarly, multiple Verilog/VHDL delta cycles may happen before the

next set of SystemC delta cycles will be started. This schema is efficient in terms of simulation time but the interaction between HDL and SystemC is difficult to predict.

This is done by specifying argument `-sysc=blocksync` during elaboration, for example:

```
vcs -sysc ... -sysc=blocksync ...
```

---

## The Fine-Grained Sync Loop (`deltasync`)

If a fine-grained and easy-to-predict alignment between HDL and SystemC is preferred, then use the fine-grained SC/HDL sync loop.

### Run Time

The simulation speed may be affected by using the fine-grained sync loop. The difference depends on the individual design, so there is no simple rule-of-thumb. However, there is a general tendency that simulations will run slower when using the fine-grained sync loop.

### Alignment of Delta Cycles

In the fine-grained SC/HDL sync loop, delta cycles of SystemC and Verilog are aligned. If at a given simulation time there are both SystemC and Verilog events present that span over multiple delta cycles each, then execution of events is aligned as follows:

1. Handle SystemC and Verilog events:
  - If SystemC events are present at current simulation time:  
Execute one SystemC delta cycle;

- If Verilog events present at current simulation time:  
Execute all Verilog events at the current simulation time until there are only NBAs left;
2. Update all SystemC signals, execute all Verilog NBAs, and exchange all value updates between SystemC and Verilog;

The steps repeat until there are no more events at the current time, then proceed to the next simulation time. In short, SystemC delta cycles and Verilog NBAs are strictly aligned.

The order in which the step 1 operations are executed is not specified. However, step 2 happens only after both step 1 operations are done. The order should not matter because value updates are only done after both sides have finished their delta cycle. If there are no SystemC events in a specific delta cycle, then the SystemC event operation in step 1 is skipped. If there are no Verilog events exist then the Verilog event operation in step 1 is skipped.

## **Example Syntax**

```
vlogan verilog_dut.v verilog_top.v

syscan -sysc=22 ./stimulus.cpp:stimulus ./
gen_clk.cpp:gen_clk -cflags "-g"

vcs top -sysc=22 -debug_all -cflags "-g"
simv -ucli -i dump.tcl
```

## **Restrictions**

The fine-grained SC/HDL sync loop has few restrictions:

- SystemC 2.2 or above must be used: an error is printed if another SystemC version is used.
- Pure SystemC mode (=no HDL modules) is not supported. An error is printed when the fine-grained sync loop is used in this situation.
- The time resolution between SystemC and HDL must match. An error is printed and the simulation is aborted during startup of simv when this restriction is violated.
- SystemC inout ports are not supported in combination with the fine-grained sync loop: no error message is printed and the simulation may hang.

## **Restrictions That No Longer Apply**

The VCS slave-mode ("vcs -e ...") was never available with the default coarse sync loop. VCS slave-models are now available when the fine-grained sync loop is used

## **Newsync is Now Default**

The 'newsync' loop has been renamed as 'deltasync' loop and is now default.

As this switch is default, you may see differences in your simulation behavior. The 'oldsync' loop which was default in the previous releases has been introduced as 'blocksync' loop to help you revert to the old flow. To revert to the old flow, use `-sysc=blocksync`.

For more information on the advantages of deltasync loop and the possible backward compatibility issues, refer to the migration helper document.

---

## Controlling Simulation Run From sc\_main

VCS supports multiple calls to `sc_start()` inside `sc_main()`. This allows you to control the simulation from `sc_main()` and enables you to add more functionality in `sc_main()` after a call to `sc_start()`. Sometimes you need to add functionality after a call to `sc_start` when you know that a particular condition for end of simulation is not met.

For SystemC-on-top and pure SystemC designs, you write the entry point function `sc_main()` where the top-level SystemC modules are instantiated. The simulation starts by calling `sc_start()` inside `sc_main()`. When you call the `sc_start()` routine with a time argument, the simulation runs until the specified time and returns to `sc_main()`. This allows you to control the simulation by taking appropriate actions at different simulation times. This functionality is only available in the SystemC `deltasync` flow.

### Note:

In previous releases, VCS started the simulation with a call to `sc_start()` and kept running until the simulation terminated. Therefore, control never came back to the `sc_main()` function. To revert back to the old flow, use `-sysc=nomulti_start`.

This feature removes the following restrictions on coding style inside `sc_main()` that were required for the `save/restore` feature:

- No need to use dynamic allocation for `sc_objects` inside `sc_main()`. However, it is recommended to use dynamic allocation to avoid stack overflow in the `sc_main` thread.
- Multiple `sc_start()` calls are supported and statements located after `sc_start()` are executed.

Note:

The function `sc_main()` is treated as a thread in VCS-SystemC cosimulation.

The `sc_main` thread is run with the default stack size, which is usually 10 MB. At times, the `sc_main` function may create several SystemC objects and hence consume a huge amount of stack space. So, the following three ways are provided to alter the stack size of the `sc_main` thread.

- Use the runtime switch `-sysc=stacksize:1024k` to set the stack size. This is the same switch used to set the stack size for `SC_THREADS`. Since the `sc_main` thread is usually heavier compared to `SC_THREADS`, VCS allocates 16 times to the value specified with this switch.
- Use the environment variable `setenv VCS_SYSC_STACKSIZE 1024k` to set the stack size. This is just an alternative to the above switch. Here also, VCS allocates 16 times to the specified value. The runtime switch takes precedence over this environment setting.
- Use the following API call to set the stack size:

```
sc_snps::sc_set_stack_size_sc_main(const char*
size_string)
```

You can call this API and specify the stack size as a string (for example, `1024k`). Call this routine before the `sc_main()` function gets called. You can do this by placing this function call in a static initializer outside the `sc_main` function. Note that the header file `systemc_user.h` must be included since the namespace `sc_snps` is declared in the header file.

## **Example**

```
static int tmp =
sc_snps::sc_set_stack_size_sc_main("1024K");
```

When you use any or all of the above methods to alter the stack size, the final size is the maximum value of:

- The default size
- Size set using runtime switch or environment variable
- Size set using the API call

Since VCS executes `sc_main` within a thread, you should use dynamic allocation for the `sc_object` created inside `sc_main` and thus minimize the stack utilization.

---

## **Effect on end\_of\_simulation Callbacks**

At the end of simulation, the SystemC kernel provides callbacks to a user-defined function named `end_of_simulation` which can be defined in any `SC_MODULE`. This is possible only if the entire SystemC design is present when the simulation ends. SystemC simulation is terminated in the following cases:

- `sc_stop()` is called
- `$finish` is called on the Verilog side
- `sc_main` function returns

Two of the above conditions can be detected before the design gets cleaned up, but the last condition cannot be detected before the design gets freed up. Once the `sc_main` returns, all `sc_objects` that are statically allocated are deleted. Therefore, the SystemC

kernel cannot issue `end_of_simulation` callbacks on these deleted `sc_objects`. Therefore, you must add an `sc_stop()` call at the end of the `sc_main()` function (before returning from it).

[Example 19-12](#) shows a code snippet with multiple `sc_start` calls.

### *Example 19-12 Multiple sc\_start Calls*

```
int sc_main(...)
{
 ...
 sc_start(t); /* Execute till time t */
 ...
 sc_start(t1); /* Execute till time t1 */
 ...
 sc_stop(); /* Call end_of_simulation routines for
 sc_modules */
 return 0;
}
```

Compile the design as follows:

```
% vcs -sysc -lca -sysc=multi_start ...
```

---

## **UCLI Save Restore Support for SystemC-on-top and Pure-SystemC**

VCS provides the UCLI `save` and `restore` commands to save the state of a simulation and to resume the simulation from a given saved state. In the presence of SystemC, UCLI `save` and `restore` commands work only with Verilog-top and SystemC-down designs. This feature now works for SystemC-on-top and pure SystemC designs as well.

The following sections explain the usage, coding guidelines, and limitations of using the UCLI save and restore commands with SystemC-on-top and pure SystemC designs.

- “[SystemC with UCLI Save and Restore Use Model](#)” on page 212
- “[SystemC with UCLI Save and Restore Coding Guidelines](#)” on page 212
- “[Saving and Restoring Files During Save and Restore](#)” on page 214
- “[Restoring the Saved Files from the Previous Saved Session](#)” on page 215
- “[Limitations of UCLI Save Restore Support](#)” on page 215

---

## **SystemC with UCLI Save and Restore Use Model**

UCLI save and restore commands work only with the SystemC `deltasync` flow for SystemC-on-top and pure SystemC designs.

For more information about the UCLI save and restore commands, see the *Unified Command-line Interface User Guide*.

---

## **SystemC with UCLI Save and Restore Coding Guidelines**

For SystemC-on-top or pure SystemC designs, you must write the entry point function `sc_main()`. This `sc_main()` function is not part of the SystemC kernel, and therefore needs to adhere to the following guidelines to function in the save and restore environment.

- Allocate all SystemC module instances and objects dynamically using the `malloc()` / `new` function. This is necessary because the UCLI `save` and `restore` commands can only save and restore the heap memory.
- Do not call constructors for SystemC modules again when the `sc_main()` function is called during the restore process. You can meet this requirement by guarding the code appropriately with a static variable.

Similarly, functions like `sc_set_time_resolution()` should not be called again during the restore process.

- The `sc_start()` call starts the simulation and continues until simulation terminates. Control never comes back to the `sc_main()` function after `sc_start()` is called. Therefore, do not place any statements after the `sc_start()` call (these statements are never executed).

[Example 19-13](#) shows the supported coding style.

*Example 19-13 Supported SystemC Coding Style for Save and Restore*

```
int sc_main(int argc, char* argv[])
{
 static int isRestore = 0;
 if (isRestore == 0) {
 isRestore = 1;
 sc_core::sc_set_time_resolution(100, SC_PS);
 Stimuli* stim_inst = new Stimuli("stim_inst");
 CPU_BFM* dut = new CPU_BFM("stim_inst");
 }
 sc_start();
 return 0;
}
```

---

## Saving and Restoring Files During Save and Restore

You can save all files that are open in read or write mode at the time of save using the following runtime options. All these files are saved in the directory named:

`<name_of_the_saved_image>.FILES.`

`-save`

Saves all open files in writable mode.

`-save_file <file name> | <directory name>`

Saves all open files in writable mode, and all files that open in read-only mode, depending on the option you specify:

- With `<file name>`, saves the specified open file in read/write mode.
- With `<directory name>`, saves all files in the specified directory open in read/write mode.

`-save_file_skip <file name> | <directory name>`

This allows you to skip saving one or more files depending on the option:

- With `<file name>`, skips saving the specified file that is open in read/write mode.
- With `<directory name>`, skips all files in the specified directory that are open in read/write mode.

---

## Restoring the Saved Files from the Previous Saved Session

At restore time you can remap any old path where files were open at the time of save to the new place where restore searches using the `-pathmap` option. For example:

```
% simv -pathmap <file_with_pathmaps>
```

where,

```
<file_with_pathmaps>:
```

```
<old_directory_path_name>:<new_directory_path_name>
```

---

## Limitations of UCLI Save Restore Support

- `SC_THREADS` must be implemented using quick threads, which are enabled by default. Do not enable POSIX threads using the `SYSC_USE_PTHREADS` environment variable.
- The `save` operation is not allowed when simulation is stopped inside the C domain.
- `Cbug` needs to be disabled before invoking `save` and `restore` commands. You can re-enabled it later, when needed.
- The `save` operation just after the simulation starts is not allowed. Advance the simulation with `run 0` command and then try saving.

---

## Enabling Unified Hierarchy for VCS and SystemC

The following sections explain how to enable the unified hierarchy for VCS and SystemC:

- “[Using Unified Hierarchy Elaboration](#)” on page 216
  - “[Using the –sysc=show\\_sc\\_main Switch](#)” on page 220
- 

### Using Unified Hierarchy Elaboration

You can use the `-sysc=unihier` switch to represent the unified hierarchy for HDL-SystemC for cosimulation. This is useful for designs with SystemC modules on top and Verilog or VHDL instantiated within SystemC. When you use the `-sysc=unihier` switch, the internal structure for how the SystemC-on-top design is implemented changes. The SystemC unified hierarchy flow is not active by default (except for the partition compile with SystemC-on-top flow). Otherwise, you need to be explicitly activated the unified hierarchy flow using:

- `-sysc=unihier`
- or
- `-sysc=show_sc_main`

For example, if you elaborate your SystemC design in the usual way:

```
% vcs ... -sysc ...
```

the SystemC unified hierarchy flow is not active. This is the default.

But if you use the `-sysc=unifier` switch to elaborate your SystemC design:

```
% vcs ... -sysc ... -sysc=unihier ...
```

the SystemC unified hierarchy flow is active.

When you open a SystemC-on-top design with DVE, you see the correct logical design structure: all SystemC, Verilog, and VHDL instances are visible and located in the correct structure. This structure is also properly displayed when you dump the design using UCLI `dump` commands or traverse the design using UCLI `scope` commands (or with the MHPI interface). All these interfaces are aware of SystemC.

However, there are other APIs that expose the underlying implementation and show a different picture of the hierarchy, because they are not aware of SystemC. For example:

- XMR paths within Verilog source code
- `%m` within a Verilog display statement
- DPI access functions
- VPI, and so on

These APIs do not have a concept of SystemC and are therefore unable to deal with the SystemC layer on top in HDL-SC cosimulation.

These APIs expose:

- How the SystemC and Verilog/VHDL parts are internally combined in the HDL-SC cosimulation environment.

- Implementation details that do not reflect the logical structure. For example, if you add the following statement in your design:

```

$display("Inst '%m' of Verilog module VLOG_BOT");

//vlog child vlog_bot
module vlog_bot{.....}

//SystemC child "sc_mod"
SC_MODULE(sc_mod){
 vlog_bot vlog_inst_A;
 SCCTOR(sc_top) : vlog_inst_A("vlog_inst_A") {....}

};

//SystemC top module sc_top
SC_MODULE(sc_top){
 //instantiate vlog_mod and sc_mod here
 vlog_bot vlog_inst_0;
 sc_mod sc_inst_1;
 sc_mod sc_inst_2;
 SCCTOR(sc_top) : vlog_inst_0("vlog_inst_0"),
 sc_inst_1("sc_inst_1"), sc_inst_2("sc_inst_2") {....} };

int sc_main(int argc, char** argv) {
 " sc_top sc_top_o("sc_top);
 sc_start(100,SC_NS)
}

```

Then you get the following:

```
Inst 'sYsTeMcToP.SC_TOP.VLOG_INST_0' of Verilog module
VLOG_BOT
```

```
Inst 'sYsTeMcToP.\SC_TOP.SC_INST_1 .VLOG_INST_A' of
Verilog module VLOG_BOT
```

```
Inst 'sYsTeMcToP.\SC_TOP.SC_INST_2 .VLOG_INST_A' of
Verilog module VLOG_BOT
```

Note:

The `sYsTeMcToP` at the beginning is not part of the logical hierarchy, but exposes an implementation detail. Also, the usage of Verilog escaped identifiers with character \.

Remember that the `%m` exposes implementation details, including details that may change from one VCS release to another or even within a release from one patch to the next.

## **Value Added by Option –sysc=unihier**

If you are using DVE, UCLI, or MHPI to look at the hierarchy, these implementation details are irrelevant because they remain hidden. DVE, UCLI, or MHPI always show the correct logical structure, even if the internals change.

But if you need to use any other API (for example, VPI or the `%m`) the new SystemC unified hierarchy flow (option `-sysc=unihier`) is important because it aligns the internal implementation structures as much as possible with the logical structure. The instance tree is visible to APIs that deal only with Verilog and/or VHDL and it has the correct logical structure. SystemC instances appear as dummy Verilog instances on all locations needed to represent the logical structure.

In the example above, the `$display` statement now prints:

```
Inst 'SC_TOP.SC_INST_1.VLOG_INST_A' of Verilog module
VLOG_BOT
Inst 'SC_TOP.SC_INST_2.VLOG_INST_A' of Verilog module
VLOG_BOT
Inst 'SC_TOP.VLOG_INST_0' of Verilog module VLOG_BOT
```

Note:

Only the SystemC instances are represented as Verilog instances. SystemC ports, signals, processes, and so on are not represented. The Verilog modules representing SystemC instances are therefore mostly empty.

---

## Using the `-sysc=show_sc_main` Switch

All SystemC-on-top designs start with a user-written `sc_main()` function. `sc_main` is a C function and not a SystemC module instance. This function is not part of the reported instance hierarchy. However, there are situations in the SystemC unified hierarchy flow where it is necessary to report `sc_main()` as part of the hierarchy. To do this, you use the `-sysc=show_sc_main` option:

- when the top-level module name is `sc_main()`.
- if a top-level module has at least one port.

In the example above, the `$display` statement now prints:

```
Inst 'sc_main.SC_TOP.SC_INST_1.VLOG_INST_A' of Verilog
module VLOG_BOT
Inst 'sc_main.SC_TOP.SC_INST_2.VLOG_INST_A' of Verilog
module VLOG_BOT
Inst 'sc_main.SC_TOP.VLOG_INST_0' of Verilog module VLOG_BOT
```

The reported hierarchy may change when top-level modules are changed. The `sc_main` may come or go. This could be problematic for automated tests or UCLI scripts because reported path names change. To prevent this problem, add the `-sysc=show_sc_main` option to the elaboration; this ensures that `sc_main` is always used. For example:

```
% vcs ... -sysc=show_sc_main ...
```

Note:

Using the `-sysc=show_sc_main` option implies the SystemC unified hierarchy flow. You don't need to add the `-sysc=unihier` option.

---

## SystemC Unified Hierarchy Flow Limitations

The following limitations apply for the SystemC unified hierarchy flow:

- Generally only available for designs that have SystemC on top of the hierarchy and HDL instantiated below SystemC.
  - Not available for designs that have VHDL or Verilog on top and instantiate SystemC below Verilog/VHDL.
  - Not available for donut designs (Verilog-SystemC-Verilog).
  - Only available with UUM flow (not with non-UUM flow).
- 

## Aligning VMM and SystemC Messages

This section describes how you can align both VMM and SC messages with the same API.

This chapter consists of the following topics:

- [“Introduction” on page 222](#)
- [“Use Model” on page 222](#)
- [“Changing Message Alignment Settings” on page 223](#)

- “[Mapping SystemC to VMM Severities](#)” on page 225
  - “[Filtering Messages](#)” on page 225
  - “[Limitations](#)” on page 228
- 

## Introduction

Both SystemC and VMM contain APIs, which control the functionality of a message (info, warning, and error). Both concepts are similar, but the APIs and underlying implementation is completely independent. For example, if you want to skip all warnings or redirect warnings into a log file, then you must call both the SystemC and VMM APIs. This is tedious.

The scenario explained in the following use model, enables you to decide whether you want to align SystemC messages with VMM or not.

---

## Use Model

To align VMM messages with SystemC:

1. Instantiate the `tli_vmm_sc_msg_align` module in the top module
2. Include the `tli_vmm_sc_msg_align.sv` file before the SV top module.

For Example:

```
`include "tli_vmm_sc_msg_align.sv"
module top;
 tli_vmm_sc_msg_align vmm_msg_align();
 test tb();
 sc_top sysc();
endmodule
```

Only those messages, which are not suppressed from SystemC, are aligned with VMM. If you are registering your own `sc_report_handler`, then the `report_handler` will not be aligned with VMM messaging, and the user-defined report handler takes precedence.

The default setting for VMM message alignment creates a `vmm_log` instance for each SystemC process-id (name for a SystemC process). This process-id is the `instName` of a `vmm_log` instance. You can change this default behavior to use one `vmm_log` instance for all SystemC processes and messages, or you can disable the VMM message alignment.

---

## Changing Message Alignment Settings

This section explains how you can change certain settings, using APIs, for aligning messages.

The following SystemC API disables VMM message alignment, and changes the type of `vmm_log` to be used. VMM message alignment and to change the type of `vmm_log` to be used.

```
// multiple vmm_logs for SystemC-VMM message
sc_snps::align_sc_report_with_VMM(sc_snps::MultipleVMMLogs) ;
// single vmm_log for all SystemC-VMM messages
sc_snps::align_sc_report_with_VMM(sc_snps::SingleVMMLog) ;
// switch off VMM message alignment
sc_snps::align_sc_report_with_VMM(sc_snps::NoVMMLog) ;
```

You can disable VMM message alignment, or switch to the usage of one `vmm_log` for all SystemC processes, only once. There will be no messages generated, and the calls does not have effect on the VMM message behavior.

To use a SystemC API, you must include the `systemc_user.h` file, as shown in the following example. This example shows how to disable the VMM message alignment.

Note:

Disabling of the VMM message alignment takes place before the start of the simulation.

Example:

```
#include "systemc_user.h"
...
sc_main(...)
{
 ...
 sc_snps::align_sc_report_with_VMM(sc_snps::NoVMMLog) ;
 ...
 sc_start(...) ;
 ...
}
```

---

## Mapping SystemC to VMM Severities

The concept of severity applies to both VMM and SystemC. The process of mapping SystemC severities to VMM is:

- `SC_REPORT_INFO` message is converted into a `vmm_note`
- `SC_REPORT_WARNING` is converted into a `vmm_warning`
- `SC_REPORT_ERROR` is converted into a `vmm_error`
- `SC_REPORT_FATAL` is converted into a `vmm_fatal`

The SystemC messages consists of an ID, which is turned into a prefix of the VMM message. For example, if you have the following message definition:

```
SC_DEFINE_MESSAGE(TLM_PKG_FAIL, 801, "failure in package
processing");
```

then the call of the following message definition in SystemC:

```
SC_REPORT_INFO(TLM_PKG_FAIL, "Package got lost");
```

is printed as a VMM message, as shown below:

```
Normal [NOTE] on SystemC(top.sysc.tli1.driver) at 7000:
SC_I_801 [failure in package processing] : Package got lost
In file: /u/me/src/my_systemc_src.cpp:42
```

---

## Filtering Messages

All messages generated with `SC_REPORT_INFO` or similar calls are aligned with VMM. The decision on whether a specific SC message is suppressed or not, is not influenced within the SystemC kernel. If

it is normally (no VMM present) suppressed, then it will also be suppressed when VMM is present. If it is normally processed, then this also occurs in context with VMM.

An SC message triggers a set of actions within the `sc_report_handler`. If VMM message alignment is active, and if `print to stdout` and `print to log` actions are influenced, then other actions (such as stopping the simulator) proceed as usual.

If VMM alignment is active, a message is generated, but not suppressed by the `sc_report_handler`. This message is forwarded to the VMM message handler, which decides what to do with it.

Note:

The filter setting for VMM messages influences the type of SC messages that are printed. For example, if you run `simv` to print only errors, then less severe messages (for example, warnings) are not printed to `stdout`. This applies to both VMM and SC messages.

There are two methods for filtering messages:

- Printing messages into a log file.
- Skipping messages with a specific severity, by influencing the simulator runtime options such as `+vmm_log_default` and `-l`.

Perform the following steps to archive the changes in the settings of SystemC-VMM specific to the `vmm_log` instantiations:

1. Get the actual `vmm_log` instantiation of a SystemC-`instName` (SystemC `process-id(name)`).

- Call the `vmm_log` related methods with the appropriate arguments.

The following SV-task returns the current `vmm_log` used by the SystemC-VMM message alignment as the second argument, depending on the `vmm_log` settings (single or multiple `vmm_logs`).

```
tli_util_get_sysc_vmm_log_by_instName(<string>, <vmm_log>);
```

Where, `<string>` is the process name. If SystemC-VMM alignment is disabled, then the second task argument, `vmm_log`, is 0. The task is declared in the `tli_vmm_sc_msg_align` module. To use this task, the module must be instantiated within the top module. You can then access the task using the following command:

```
<top_module_name>.<instance_name_of_tli_vmm_sc_msg_align>.
tli_util_get_sysc_vmm_log_by_instName(...);
```

For example, if the name of the top SV module is mentioned as `top`, then the `tli_vmm_sc_msg_align` module is instantiated in the top SV module, and the instance name is `vmm_msg_align`, as shown in the following example:

### Example:

```
...
vmm_log log;
string process_name = "top.sysc.vmmconn1.driver";
// call task with XMR path starting with top

top.vmm_msg_align.tli_util_get_sysc_vmm_log_by_instName
(process_name,log);
if (log)
 log.set_verbosity(vmm_log::WARNING_SEV, , ,);
...
```

If multiple vmm\_logs are used (default) and vmm\_log is not created, then a vmm\_log with the instName provided in the string parameter is created. If VMM message alignment is switched-off, then the return value of vmm\_log is 0.

The name of the vmm\_logs used by SystemC message alignment is SystemC. The instance name for single vmm\_log is reporter, and it is process\_id (process name) for multiple vmm\_logs.

SystemC can generate messages to stdout, in a specified SC-log file, to both stdout and SC-log file. If VMM message alignment is active, then the messages are not generated in a specified SC-log file. If the SC-message is not suppressed from SystemC, then the VMM message settings decides what and how to print. As a result, the messages are printed to stdout only, and not in a SC-log file.

Calling the VMM message handler requires a valid (and existing) SV scope. If there is no VMM-scope, then all SystemC messages are generated using the default sc\_report\_handler. If you have registered your own report\_handler, it will be used for messages even if VMM alignment is active.

---

## Limitations

The default setting, using multiple vmm\_logs, can be changed only once, before start of simulation. It can be changed either to use single vmm\_log or to switch-off the SystemC-VMM message alignment.

---

## UVM Message Alignment

SystemC and UVM both have APIs to produce messages (for example, info, warning, error) and an API to control what happens with such messages. Both concepts are similar but the APIs and underlying implementations are totally independent, so you must call both the APIs if you want, for example, to skip all the warnings or redirect warnings into a log file.

With the functionality described below, you can decide whether you want SystemC messages aligned with UVM or not.

---

### Enabling UVM Message Alignment

To enable UVM message alignment, you must either include the provided `tli_uvm_sc_msg_align.sv` file before the SV top module or analyze this file. The path to the SV file is `$VCS_HOME/etc/systemc/tlm/tli/tli_uvm_sc_msg_align.sv`. The module `tli_uvm_sc_msg_align` residing in this file must be instantiated in the top module to enable UVM message alignment (see [Example 19-14](#)).

#### *Example 19-14 UVM Message Align with SV File not Analyzed*

```
`include "tli_uvm_sc_msg_align.sv"
module top;
 tli_uvm_sc_msg_align uvm_msg_align();

 test tb();
 sc_top sysc();
endmodule
```

Using an `ifdef - `endif pair around the `uvm_msg_align` module instantiation, you can control whether you want message alignment enabled or not at compile time (see [Example 19-14](#)).

*Example 19-15 Ifdef for UVM Message Alignment*

```
module top;
`ifndef UVM_MSG_ALIGN
 tli_uvm_sc_msg_align uvm_msg_align();
`endif
 test tb();
 sc_top sysc();
endmodule
compile it with "vlogan -sverilog -ntb_opts uvm
+define+UVM_MSG_ALIGN top.sv ...
```

Only those messages are aligned with UVM, which are not suppressed from SystemC. If you are registering your own `sc_report_handler`, this report handler does not align with UVM messaging. The user-defined report handler takes precedence.

The default setting for UVM message alignment is that for each SystemC process-id a UVM report object is created with the process-id as the `instName` of a UVM report instance. You can change this default behavior to use one UVM report instance for all SystemC processes or you can disable the UVM message alignment.

The following API (see [Example 19-16](#), [Example 19-17](#), and [Example 19-18](#)) is provided for SystemC to disable UVM message alignment or change the kind of UVM report object to be used.

*Example 19-16 Multiple UVM Report Objects for SystemC-UVM Message*

```
sc_snps::align_sc_report_with_UVM(sc_snps::MultipleUVMLogs);
```

*Example 19-17 Single UVM Report Object for all SystemC-UVM Messages*

```
sc_snps::align_sc_report_with_UVM(sc_snps::SingleUVMLog) ;
```

*Example 19-18 Switch off UVM Message Alignment*

```
sc_snps::align_sc_report_with_UVM(sc_snps::NoUVMLog) ;
```

Disabling UVM message alignment or switching to one UVM report object for all SystemC processes can only be done once. Disabling UVM message alignment can only be done before simulation starts. In this case no messages are generated. The calls have no effect on the UVM message behavior.

To use the API in SystemC, include the `systemc_user.h` file at compile time. [Example 19-19](#) shows how to disable UVM message alignment. Note that disabling happens before simulation starts.

*Example 19-19 Disabling UVM Message Alignment*

```
#include "systemc_user.h"
...
sc_main(....)
{
 ...
 sc_snps::align_sc_report_with_UVM(sc_snps::NoUVMLog) ;
 ...
 sc_start(....) ;
 ...
}
```

UVM and SystemC messages both have severities, and the mapping of SystemC severities to UVM is as you might expect:

- `SC_REPORT_INFO` maps to UVM info message
- `SC_REPORT_WARNING` maps to UVM warning message
- `SC_REPORT_ERROR` maps to a UVM error message

- `SC_REPORT_FATAL` maps to a UVM fatal message.

The SystemC messages have an ID. For UVM, this ID is prefixed with SC.

Here are some examples of converted messages. Assume the following SystemC message definition (as define):

```
SC_DEFINE_MESSAGE(TLM_PKG_FAIL, 801, "failure in
package processing");
```

The following call:

```
SC_REPORT_INFO(TLM_PKG_FAIL, "Package got lost");
```

if SystemC, is printed as a UVM message.

In the case of single UVM report object:

```
UVM_INFO my_sc_file.cpp(18) @ 50000: SystemC(reporter)
SC-801] failure in package processing : Package got lost
```

In SystemC process: `top.sysc.do_transactions`

In the case of multiple UVM message objects:

```
UVM_INFO my_sc_file.cpp(18) @ 50000:
SystemC(top.sysc.do_transactions) [SC-801] failure in
package processing : Package got lost
```

The following SystemC report handler call with an SC message without an ID in a file called `my_sc_file.cpp`:

```
SC_REPORT_INFO("failure in package processing", "Package got
lost");
```

results in:

```
UVM_INFO my_sc_file.cpp(31) @ 50000:
SystemC(top.sysc.do_transactions) [SC-NAN] failure in
package processing : Package got lost
```

An SC message triggers a set of actions within the `sc_report_handler`. If a UVM message alignment is active “print to stdout” and “print to log” action is influenced. Other actions (such as stopping the simulator) proceed as usual.

If UVM message alignment is active, a message is emitted and not suppressed by the `sc_report_handler`. Then it is forwarded to the UVM message handler, which decides what to do with it.

Note that setting the filter for UVM messages also influences which SC messages are printed. For example, if you tell `simv` to filter `uvm_note`, then only more severe messages like warnings, errors, and fatal are printed to `stdout`. This applies to UVM and SC messages.

There are two ways to filter messages. You can print them into a log file and skip messages with a specific severity for SC-messages using the `+UVM_VERBOSITY=` and `-l` simulator runtime options.

---

## Accessing UVM Report Object of SystemC Instance

You can get the actual UVM report object of a SystemC instance (SystemC process-id(name)) and call the UVM report object related methods. Below is the SV task used to get the UVM report object of a SystemC instance.

```
uvm_report_object log =
tli_util_uvm_sc_get_log_by_instName(<string>);
```

where,

*<string>* is the process name.

If SystemC-UVM alignment is disabled, the returned UVM report object is 0. The function is declared in the package `tli_uvm_sc_msg_align_pkg`. To use this function, you must include or analyze the provided `tli_uvm_sc_msg_align.sv` file beforehand. You can access the task explicitly as follows:

```
uvm_report_object log =
tli_uvm_sc_msg_align_pkg::tli_util_uvm_sc_get_log_by_instN
ame(<string>);
```

or by previously importing the package function, as follows:

```
import
tli_uvm_sc_msg_align_pkg::tli_util_uvm_sc_get_log_by_instN
ame;

uvm_report_object log =
tli_util_uvm_sc_get_log_by_instName(<string>);
```

For example, assuming that the top SV module is named `top`, the module `tli_uvm_sc_msg_align` is instantiated in the top SV module, and the instance name is `uvm_msg_align`, you can access the UVM report object of the SystemC instance as shown in [Example 19-20](#).

#### *Example 19-20 Accessing UVM Report Object in SystemC Instance*

```
...
uvm_report_object log;
string process_name = "top.sysc.uvmconn1.driver";
// call task with package-XMR
log =
tli_uvm_msg_align_pkg::tli_util_uvm_sysc_get_log_by_instNa
me(process_name);
if (log)
 // switch off warnings
 log.set_report_severity_action(UVM_WARNING,
```

```
 UVM_NO_ACTION) ;
 ...
```

Note the following naming conventions:

- The name used by SystemC message alignment in a UVM report object is always “SystemC”.
- The instance name in case of a single UVM report object is always “reporter”.

The instance name in case of multiple UVM report objects is the SystemC/nop> process id (process name).

VCS TLI Adapters (SystemVerilog - SystemC TLM 2.0) enables transaction-level communication between SystemVerilog (SV) and SystemC (SC). VCS provides a built-in TLI adapter to connect the SV to SystemC OSCI TLM 2.0 interface.

The TLI adapter consists of SV and SystemC adapters. These adapters communicate with each other using Direct Programming Interface (DPI). The SV adapter consists of the following packages:

- [User Package](#)
- [Global Package](#)

The SV interface of TLI adapter is generic and user-extensible. The present SV implementation of TLI adapter connects the following SV interfaces:

- VMM Channel Interface
- VMM TLM Interface

Apart from the above two interfaces, you can connect any other SV interface with minimum changes in the TLI adapter.

Note:

TLI adapters provided by VCS are only for `vmm_tlm_generic_payload` data objects. If the data objects are of different data type, you must modify the User Package in TLI adapters.

---

## Introducing TLI Adapters

This section describes the overview of TLI Adapters and packages associated with these adapters. This section includes the following topics:

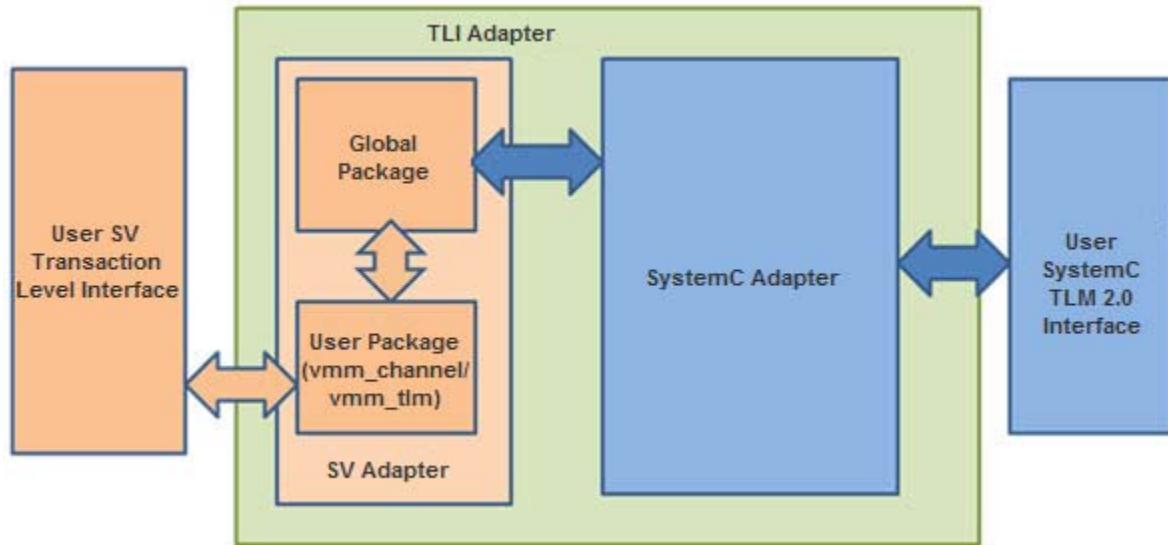
- “[TLI Adapter Overview](#)”
- “[SystemC Adapters](#)”
- “[Global Package](#)”
- “[User Package](#)”

### TLI Adapter Overview

[Figure 19-3](#) shows the block diagram of TLI Adapters.

The User SV Transaction Level Interface communicates the transaction information to the User Package. The User Package and Global Package communicate the data with each other using API. The SystemC Adapter gets the transaction information from the Global Package through DPI calls and process the information to SystemC module.

Figure 19-3 Block Diagram of TLI Adapters



Similarly, SystemC Adapter communicates information from SystemC module to the Global Package. The User Package gets information from the Global Package and process the information to User SV Transaction Level Interface.

## SystemC Adapters

The SystemC adapter implements OSCI TLM 2.0 LT/AT initiator or target to connect to the SystemC world.

## Global Package

The Global Package is the SV package, where the User Package and TLI SystemC adapters exchange data through the API's provided by this package. The TLI SystemC adapters transfer the

data in either direction across the Global Package using the DPI tasks or functions. The User Package transfers the data across the Global Package using its API's, as described below.

The Global Package provides following tasks and functions:

### **Global Package APIs**

```
task put_data (tlmpkt) // SV Producer
```

// tlmpkt is the generic payload type defined by TLI

This task performs the following:

- Transmits data to the global package
- Generates a data event to indicate global package that the data is transmitted
- Waits for the received event from the global package, to make sure data is received by the SystemC world.

```
function put_data_func (tlmpkt) //SV Producer
```

This function transmits data to global package and generates data event. This function can be called from the user package in case of non-blocking communication.

```
task get_resp (tlmpkt) // SV Producer
```

This task waits for the `put` response event from the global package to make sure response is received by the global package, and then reads the data response from the global package.

```
task get_data (tlmpkt) // SV Consumer
```

This task waits for the data event and reads data from the global package.

```
task put_resp (tlmpkt) // SV Consumer
```

This task calls the `send_rsp_to_fifo(chandle sc_obj)` dpi imported function to put the response into the SystemC adapter.

Except the `put_data_func` function, which returns immediately, all other tasks are blocking tasks.

In addition to the above API functions, the global package also provides the `register_unique_id(string)` function to register the unique id. The user package should call this function in the implementation of the bind function.

Note:

The TLI adaptor can be used with other SV interfaces (other than `vmm_channel/vmm_tlm`) by modifying the user package. You must not modify the global package implementation while using any SV interface including `vmm_channel` or `vmm_tlm`.

The `vmm_tlm` package also supports the AT phase communication between SC and SV. This package uses the phase enum `vmm_tlm::phase_e` and sync enum `vmm_tlm::sync_e` of `vmm_tlm` (similar to the OSCI TLM2 standard). However, you can also use your own phasing by modifying your user package accordingly.

## User Package

The VCS TLI adaptor provides the following packages for the VMM channel interface and VMM TLM interface respectively:

- vmm\_channel\_binds
- vmm\_tlm\_binds

The VCS TLI adaptor supports only the `vmm_tlm_generic_payload` data objects. For different interface (other than VMM channel or VMM TLM) and data type (other than `vmm_tlm_generic_payload`), you must modify the user package by implementing conversion functions.

## **User Package for VMM Channel Interface**

This package imports Global Package and consists of the following:

- Bind Function
- Conversion Functions
- Processes

### **Bind Function**

```
tli_channel_bind (SV channel object, unique id,
 direction)
```

This function registers its unique id using the `register_unique_id(id)` function provided by the global package to register its ID with DPI. The direction argument in the bind function is an enum which indicates the direction SV-SC or SC-SV for both blocking and non-blocking communication. It invokes separate processes based on the direction.

### **Conversion Functions**

The following conversion functions are implemented to convert `vmm_tlm_generic_payload` to `tlmpkt` (generic payload type of TLI) and vice versa.

```
conv_userdata_to_tlmpkt (user data, tlmpkt)
```

If tlmpkt is not allocated before, this function allocates a new object of tlmpkt and converts user data to tlmpkt.

```
conv_tlmpkt_to_userdata(tlmpkt, user data)
```

If user data is not allocated before, this function allocates a new object of vmm generic payload and converts tlmpkt to vmm generic payload.

## Processes

Depending on the direction, one of the following processes will be forked off from the bind function:

- channel\_get\_b\_process()
- channel\_get\_nb\_process()
- channel\_put\_b\_process()
- channel\_put\_nb\_process()

For more information on the above processes, see “[VMM Channel Interface Details](#)”.

## User Package for VMM TLM Interface

This package imports the Global Package, and consists of the following:

- Bind function
- Conversion Functions
- Processes

- [Target Class](#)

## Bind function

```
tli_tlm_bind (SV port/export object, port type,
unique id)
```

The SV port/export object is bind to export/port of type specified by you. This function registers its unique id using `register_unique_id(id)` provided by the global package to register its ID with DPI. The `port type` in the bind function is an enum define in VMM TLM `intf_e`, which indicates the type of port/export to be connected to. It invokes separate processes based on this enum value. For more information, see *VMM TLM User Guide*.

## Conversion Functions

See "[Conversion Functions](#)".

## Processes

Depending on the port type, one of the following processes will be forked off from the bind function:

- `call_transport_process ()`
- `call_nb_transport_fw_process ()`
- `call_write_process ()`

For more information on the above processes, see "[“VMM Channel Interface Details”](#)".

## Target Class

This class provides the implementation of all VMM TLM functions or tasks.

- `b_transport()`
- `nb_transport_fw()`
- `nb_transport_bw()`
- `write()`

For more information on the above processes, see “[VMM Channel Interface Details](#)”.

---

## Use Model

This section describes how to use TLI adapters to connect SV to SystemC OSCI TLM2.0 interface. You can have the following SV interfaces with data type as `vmm_tlm_generic_payload`.

- “[VMM Channel Interface \(`vmm\_tlm\_generic\_payload`\)](#)”
- “[VMM TLM Interface \(`vmm\_tlm\_generic\_payload`\)](#)”

## VMM Channel Interface (`vmm_tlm_generic_payload`)

Perform the following steps, if SV has VMM channel interface (`vmm_tlm_generic_payload`).

Perform the following steps for SV:

1. Include `tli_sv_bindings.sv`, where SV adaptor packages (User Package and Global Package) are available.

```
`include tli_sv_bindings.sv
```

2. Import the `vmm_channel_binds` package into the SV program block.

```
import vmm_channel_binds::*;


```

3. Call the bind function, which is defined in `vmm_channel_binds` package, in `vmm_group` connect phase (`connect_ph`).

```
tli_channel_bind(vmm_tlm_generic_payload_channe
l obj, string unique_id, direction_e dir);

//direction_e is the enum inside the channel
package
```

**Example:**

```
tli_channel_bind(chan_obj,"initiator0",SV_SC_B)
;
```

**Note:**

For SC Producer–SV Consumer flow, you should invoke the same bind function with `SC_SV_B/SC_SV_NB` `direction_e` enum value.

Perform the following steps for SC:

1. In the SC top, include the `tli_sc_bindings.h` file.

```
#include tli_sc_bindings.h
```

2. Call the bind function defined in the `tli_sc_bindings.h` file.

```
tli_tlm_bind_target(tlm::tlm_target_socket<>
socket, init_type_e type, std::string unique_id,
bool debug_en, bool is_sv_phase)

// init_type_e type is the enum inside the header
file
```

```
// is_sv_phase must be true, if SV phasing communication is
// required, otherwise TLI adapter takes care of phasing on SC side
// when set to false.
```

For example, if SC has target socket:

```
tli_tlm_bind_target(tgt_socket, LT,
"initiator0", false, false);
```

Call the following bind function, if SC has the initiator socket:

```
tli_tlm_bind_initiator(tlm::tlm_initiator_socket<
> socket, init_type_e type, std::string unique_id,
bool debug_en, bool is_sv_phase)
```

//init\_type\_e type is the enum inside header file

```
// is_sv_phase must be true, if SV phasing communication is
// required, otherwise TLI adapter takes care of phasing on SC side
// when set to false.
```

Example:

```
tli_tlm_bind_initiator(init_socket, LT,
"initiator1", false, false);
```

Call the following bind function, if SC has analysis port:

```
tli_tlm_bind_analysis_parent
(tlm::tlm_analysis_port<> socket, std::string
unique_id, bool debug_en)
```

Example:

```
tli_tlm_bind_analysis_parent(anal_port,"parent1",
false);
```

Call the following bind function, if SC is analysis subscriber:

```
tli_tlm_bind_analysis_subscriber
(tlm::tlm_analysis_if<> socket, std::string
unique_id, bool debug_en)
```

Example:

```
tli_tlm_bind_analysis_subscriber(subs_inst,
"subscriber1", false);
```

Note:

Unique id in all the bind functions should be same as given in the corresponding SV bind function.

## **VMM TLM Interface (vmm\_tlm\_generic\_payload)**

Perform the following steps, if SV has VMM TLM Interface (vmm\_tlm\_generic\_payload).

Perform the following steps for SV:

1. Include `tli_sv_bindings.sv`, where SV adaptor packages (User Package and Global Package) are available.

```
`include tli_sv_bindings.sv
```

2. Import the `vmm_tlm_binds` package into the SV program block.

```
import vmm_tlm_binds::*;


```

3. Call the bind function, which is defined in `vmm_tlm_binds` package, in `vmm_group` connect phase (`connect_ph`).

```
tli_tlm_bind(vmm_tlm_base user_port,
vmm_tlm::intf_e, string unique_id);
```

```
//vmm_tlm::intf_e is the enum defined in VMM TLM
```

Example:

```
tli_tlm_bind(userport_obj,
vmm_tlm::TLM_BLOCKING_PORT, "initiator0");
```

Note:

For SC Producer–SV Consumer flow, you should invoke the same bind function with SC\_SV\_B/SC\_SV\_NB direction\_e enum value.

Perform the following steps for SC:

1. In the SC top, include the `tli_sc_bindings.h` file.

```
#include tli_sc_bindings.h
```

2. Call the bind function defined in the `tli_sc_bindings.h` file.

```
tli_tlm_bind_target(tlm::tlm_target_socket<>
socket, init_type_e type, std::string unique_id,
bool debug_en, bool is_sv_phase)
```

```
// init_type_e type is the enum inside the header
file
```

```
// is_sv_phase must be true, if SV phasing communication is
required, otherwise TLI adapter takes care of phasing on SC side
when set to false.
```

For example, if SC has target socket:

```
tli_tlm_bind_target(tgt_socket, LT,
"initiator0", false, false);
```

Call the following bind function, if SC has the initiator socket:

```
tli_tlm_bind_initiator(tlm::tlm_initiator_socket<
> socket, init_type_e type, std::string unique_id,
bool debug_en, bool is_sv_phase)

// init_type_e type is the enum inside header file

// is_sv_phase must be true, if SV phasing communication is
required, otherwise TLI adapter takes care of phasing on SC side
when set to false.
```

Example:

```
tli_tlm_bind_initiator(init_socket, LT,
"initiator1", false, false);
```

Call the following bind function, if SC has analysis port:

```
tli_tlm_bind_analysis_parent
(tlm::tlm_analysis_port<> socket, std::string
unique_id, bool debug_en)
```

Example:

```
tli_tlm_bind_analysis_parent(anal_port,"parent1",
false);
```

Call the following bind function, if SC is analysis subscriber:

```
tli_tlm_bind_analysis_subscriber
(tlm::tlm_analysis_if<> socket, std::string
unique_id, bool debug_en)
```

Example:

```
tli_tlm_bind_analysis_subscriber(subs_inst,
"subscriber1", false);
```

Note:

Unique id in all the bind functions should be same as given in the corresponding SV bind function.

## **VMM Channel/TLM Interface (Other data type)**

If you have the data type other than `vmm_tlm_generic_payload`, you must rewrite the conversion functions in user package. The function should convert the user data type to `tlmpkt` of TLI.

## **SV Interface Other Than vmm\_channel/vmm\_tlm**

Follow the below instructions to create a new package, if you have interface other than VMM channel or VMM TLM.

- Package should implement a bind function like `tli_tlm_bind` and `tli_channel_bind`, which binds the user interface to package interface.
- In the bind function, call the `register_unique_id(string id)` function to register its id with DPI. This is a global function defined by global package.
- Call `tli_imc.put_data()` to send data to SC, and call `tli_imc.get_resp()` to get the response from SC. These functions are provided by the global package. See section global package (SC Consumer).
- Call `tli_imc.get_data()` to get the data from SC, and call `tli_imc.put_resp()` to update the response to SC (SC Producer).

- Even when the SV interface is unidirectional, you must call `tli_imc.put_resp()` after calling `tli_imc.get_data()`. Since SC is bidirectional, you can call `tli_imc.put_resp()` with same object received from SC.
- If the interface does not have any virtual functions, then calling the above API's can happen in a process forked off from the bind functions (like in channel interface).
- Implement the conversion functions to convert user data type to `t1mpkt` (data type for TLI) and `t1mpkt` to user data type.
- All the API functions take the type `t1mpkt`. Therefore, you must convert the data before calling an API.

**Note:**

You must call API functions using the `tli_imc` object. This is the object of the class `tli_interconnect` in the global package, where all these API's are defined.

## VMM Channel Interface Details

This package imports the Global Package, and consists of the following:

- [Bind Function](#)
- [Conversion Functions](#)
- [Processes](#)

### Bind Function

See "[VMM Channel Interface](#)"

## Conversion Functions

See “[VMM Channel Interface](#)”

## Processes

Depending on the direction, one of the following processes will be forked off from the bind function:

`channel_get_b_process()`

This process is forked off when the direction is from SV blocking to SC blocking.

- This process reads the data from the SV channel using `channel.peek(obj)`.
- Converts the data into `tlmPkt` using a conversion function.
- Calls the `put_data(tlmPkt obj)` API provided by the global package.
- Calls the `get_resp(tlmPkt obj)` API provided by the global package.
- Again converts back the `tlmPkt` to user data object using conversion function.
- Indicates the `userData::ENDED`
- Deletes the object from the SV channel using `channel.get(obj)`.

`channel_get_nb_process()`

This process is forked off when the direction is from SV non-blocking to SC non-blocking.

- This process reads the data from the SV channel using `channel.peek(obj)`.
- Converts the data into `t1mpkt` using a conversion function.
- Calls the `put_data(t1mpkt obj)` API provided by the global package.
- Deletes the object from the SV channel using `channel.get()`.
- Forks off a task to call the `get_resp(t1mpkt)` API and to indicate `data::ENDED`.

`channel_put_b_process()`

This process is forked off when the direction is from SV blocking to SC blocking.

- Calls the `get_data(t1mpkt obj)` API provided by the global package.
- Converts the data into user data using conversion function.
- Puts the data into SV channel using `channel.put(obj)`.
- Calls the `put_resp(t1mpkt)` API provided by the global package. Since this is blocking, `channel.put()` is blocked till the SV updates the transaction with a response.

`channel_put_nb_process()`

This process is forked off when the direction is from SV non-blocking to SC non-blocking.

- Calls the `get_data(t1mpkt)` API provided by the global package.
- Converts the data into user data using conversion function.

- Puts the data into SV channel using `channel.put()`.
- Forks off a task to wait for `data::ENDED`, to convert the data into `t1mpkt`, and finally, to call the `put_resp(t1mpkt)` API provided by the global package.

For more information on the API's used above, see “[Global Package](#)”.

## VMM TLM Interface Details

This package imports the Global Package, and consists of the following:

- Bind Function
- Conversion Functions
- Processes
- Target Class
- Non-blocking Extended Class

### **Bind Function**

See “[VMM TLM interface](#)”

### **Conversion Functions**

See “[VMM TLM interface](#)”

### **Processes**

Depending on the port type, one of the following processes will be forked off from the bind function.

```
call_transport_process()
```

This process is forked off when SV has blocking export. It must call `b_transport()` of VMM TLM.

- Call the `get_data(tlmpkt)` API provided by the global package.
- Convert `data(tlmpkt)` to user data using a conversion function.
- Call `port.b_transport(data)`.
- Convert back the user data to `tlmpkt` using the conversion function.
- Call the `put_resp(tlmpkt)` API provided by the global package.

```
call_nb_transport_fw_process()
```

This process is forked off when SV has non-blocking forward export. It is required to call `nb_transport_fw()` of VMM TLM.

- Call the `get_data(tlmpkt)` API provided by the global package.
- Convert `data(tlmpkt)` into user data using a conversion function.
- Call `port.nb_transport_fw(data)`
- There is no backward path here. However, since SC requires it, call the API `put_resp()` with the same object.

```
call_write_process()
```

This process is forked off when SV has analysis export. It is required to call `write()` of VMM TLM.

- Call the `get_data(tlmpkt)` API provided by the global package.
- Convert `data(tlmpkt)` into user data using a conversion function.
- Call `port.write(data)`

## Target Class

This class provides the implementation of all VMM TLM functions or tasks.

`b_transport()`

This implementation is required when SV has blocking port.

- Convert user data to `tlmpkt` using a conversion function.
- Call the `put_data(tlmpkt)` API provided by the global package.
- Call the `get_resp(tlmpkt)` API provided by the global package.
- Convert back the `tlmpkt` object to user data object of `b_transport()`.

`nb_transport_fw()`

This implementation is required when SV has a non-blocking port.

- Convert user data to `tlmpkt` using a conversion function.
- Call the `put_data_func(tlmpkt)` API provided by the global package. Since `put_data` API is a blocking task, `put_data_func` is used here.
- Return `TLM::ACCEPTED`.

```
nb_transport_bw()
```

This implementation is required when SV has non-blocking export.

- Get the `tlmpkt` object from user data obj.
- Call the `put_resp(tlmpkt)` API.
- Return `TLM::COMPLETED`

```
write()
```

This implementation is required when SV has analysis port.

- Convert the user data to `tlmpkt` using a conversion function.
- Call the `put_data_func(tlmpkt)` API provided by the global package. Since this is a function, the `put_data` API task cannot be called.

## Non-blocking Extended Class

This class is extended from a base class provided by global package, to support AT phasing function call mechanism.

```
nb_transport_fw_call()
```

This implementation is required when SV has vmm tlm interface with non-blocking target ports and SC is the initiator.

- Convert `tlmpkt` to user data
- Call `nb_transport_fw()` of SV
- Convert user data back to `tlmpkt`

```
nb_transport_bw_call()
```

This implementation is required when SV has vmm tlm interface with non-blocking initiator ports and SC is the target.

- Convert `t1mpkt` to user data
  - Call `nb_transport_bw()` of SV
  - Convert user data back to `t1mpkt`
- 

## Examples

This section explains different combinations with the help of the examples given below. These examples are located at `$VCS_HOME/doc/examples`.

- “SV Producer Channel Connected to SC OSCI TLM2.0 LT Consumer”
- “SV Producer Channel Connected to SC OSCI TLM2.0 AT Consumer”
- “SV Producer VMM\_TLM (Blocking Interface) Connected to SC OSCI TLM2.0 LT Consumer”
- “SV Producer VMM\_TLM (Non-Blocking Interface) Connected to SC OSCI TLM2.0 AT Consumer”
- “SC Producer OSCI TLM2.0 LT Connected to SV Channel Consumer”
- “SC Producer OSCI TLM2.0 AT Initiator Connected to SV Channel Consumer”
- “SC Producer OSCI TLM2.0 LT Connected to SV VMM-TLM (Blocking Interface) Consumer”

- “SC Producer OSCI TLM2.0 AT Initiator Connected to SV VMM-TLM (Non-Blocking Interface) Consumer”
- “SV Producer VMM-TLM (Analysis Port) Connected to SC OSCI TLM2.0 Subscriber”
- “SC Producer OSCI TLM2.0 Analysis Parent Connected to SV VMM-TLM Analysis Subscriber”

## **Example-1**

### **SV Producer Channel Connected to SC OSCI TLM2.0 LT Consumer**

In this example, SV channel acts as a producer and SC OSCI TLM2.0 LT acts as a consumer. SV channel is connected to TLI adaptor using the `tli_channel_bind` function (see “[Use Model](#)”), similarly SC LT target is connected to TLI adaptor using `tli_tlm_bind_target` function. This example shows these connections:

### Example 19-21 producer.sv

```
'include "tli_sv_bindings.sv"
...
program test();
'include "vmm.sv"
import vmm_channel_binds::*
class sv_initiator extends vmm_xactor;
 vmm_tlm_generic_payload_channel out_channel;
 function new(string name,string instance, integer stream_id = -1, vmm_group parent,
 vmm_tlm_generic_payload_channel out);
 ...
 endfunction
```

Include "tli\_sv\_bindings.sv" where  
vmm\_channel\_binds and vmm\_tlm\_binds

Import the "vmm\_channel\_binds" package where  
adapter for "vmm\_channel" interface is available

Channel which acts  
as a producer

### Example 19-22 producer.sv

```
task run_ph();
...
forever begin
 vmm_tlm_generic_payload trans;
 trans = new();
 ...
 out_channel.put(trans);
 ...
end
endtask: run_ph
endclass //SV Initiator

class env extends vmm_group;
 sv_initiator sv_initiator0;
 ...
 vmm_tlm_generic_payload_channel out0 = new("name", "channel0");
 ...
function void connect_ph();
 tli_channel_bind(out0,"initiator0", SV_2_SC_B);
 ...
endfunction : connect_ph
...
endclass: env
vmm_timeline t1;
initial begin
 ...
 t1.run_phase();
end
endprogram: test
```

Send the transaction using "out\_channel"

Connect the channel to TLI adapter using the "tli\_channel\_bind" function

Make sure that you pass same unique id to both producer and consumer bind functions

### Example 19-23 consumer.h

```
class consumer : public sc_module
{
public:
 tlm_utils::simple_target_socket<consumer> target_socket;
 SC_CTOR(consumer) : target_socket("target_socket")
 {
 target_socket.register_b_transport(this, &consumer::b_transport);
 }
 void b_transport(tlm::tlm_generic_payload &gp, sc_core::sc_time &delay);
};
```

SC OSCI TLM2.0 target socket acts as consumer

Register the blocking transport function

### Example 19-24 sc\_top.h

```
.....
#include "tli_sc_bindings.h"

class sc_top : public sc_module
{
public:
 consumer consumer_inst0;
 ...
 SC_CTOR(sc_top) : consumer_inst0("consumer_inst0")
 {
 ...
 tli_tlm_bind_target(consumer_inst0.target_socket,LT,"initiator0");
 ...
 }
};
```

Include "tli\_sc\_bindings.h" where adaptor bind functions are implemented

Bind SC target socket "target\_socket" using the "tli\_tlm\_bind\_target" function

Make sure that you pass same unique id to both producer and consumer bind functions

## **Example-2**

### **SV Producer Channel Connected to SC OSCI TLM2.0 AT Consumer**

In this example, SV channel acts as a producer and SC OSCI TLM2.0 AT acts as a consumer. SV channel is connected to TLI adaptor using the `tli_channel_bind` function (see "[Use Model](#)"), similarly SC AT target is connected to TLI adaptor using the `tli_tlm_bind_target` function. This example shows these connections:

### Example 19-25 producer.sv

```
'include "tli_sv_bindings.sv"
program test();
import vmm_channel_binds::*;

class sv_initiator extends vmm_xactor;
 vmm_tlm_generic_payload_channel out_channel;
 function new(string name,string instance, integer stream_id = -1, vmm_group parent,
 vmm_tlm_generic_payload_channel out);
 ...
 endfunction

 task run_ph();
 ...
 forever begin
 vmm_tlm_generic_payload trans;
 trans = new();
 ...
 out_channel.put(trans);
 ...
 end
 endtask: run_ph
endclass //SV Initiator

class env extends vmm_group;
 sv_initiator sv_initiator0;
 vmm_tlm_generic_payload_channel out0 = new("name", "channel0");
 ...
 function void connect_ph();
 ...
 tli_channel_bind(out0,"initiator0", SV_2_SC_NB);
 ...
 endfunction: connect_ph
 ...
endclass: env
endprogram: test
```

Import the "vmm\_channel\_binds" package where adapter for vmm channel interface is available

Channel which acts as a producer

Send the transaction using "out\_channel"

Connect the channel to TLI adapter using the "tli\_channel\_bind" function

This argument tells the adapter that channel should bind to SC Non-Blocking interface

Make sure that you pass same unique id to the both producer and consumer bind functions

### Example 19-26 consumer.h

```
class consumer : public sc_module
 ,virtual public tlm::tlm_fw_transport_if<>
{
public:
 tlm::tlm_target_socket<> m_socket;
 consumer(sc_core::sc_module_name nm);

 tlm::tlm_sync_enum nb_transport_fw(tlm::tlm_generic_payload &gp,
 tlm::tlm_phase &ph,
 sc_core::sc_time &delay);
};
```

SC OSCI TLM2.0 target socket acts as consumer

### Example 19-27 sc\_top.h

```
.....
#include "tli_sc_bindings.h"

class sc_top : public sc_module
{
public:
 consumer m_target0;
 ...
 sc_top(sc_core::sc_module_name name):
 sc_core::sc_module(name)
 ,m_target0("sc_target0")
 {
 tli_tlm_bind_target(m_target0.m_socket,AT,"initiator0",true);
 }
};
```

Include "tli\_sc\_bindings.h" where adaptor bind functions are implemented

Bind SC target socket "m\_socket" using "tli\_tlm\_bind\_target" function

Make sure that you pass same unique id to the both producer and consumer bind functions

## **Example-3**

### **SV Producer VMM\_TLM (Blocking Interface) Connected to SC OSCI TLM2.0 LT Consumer**

In this example, SV VMM\_TLM acts as a producer and SC OSCI TLM2.0 LT acts as a consumer. SV VMM\_TLM is connected to TLI adaptor using the `tli_tlm_bind` function (see “[Use Model](#)”), similarly SC LT target is connected to TLI adaptor using the `tli_tlm_bind_target` function. This example shows these connections. For SystemC code snippets, refer [Example 19-21](#) and [Example 19-22](#).

### Example 19-28 producer.sv

```
'include "tli_sv_bindings.sv"
program test();
import vmm_tlm_binds::*;

class sv_initiator extends vmm_xactor;
 vmm_tlm_b_transport_port#(initiator, vmm_tlm_generic_payload) socket;
 ...
 task run_ph();
 ...
 forever begin
 vmm_tlm_generic_payload trans;
 trans = new();
 ...
 socket.b_transport(trans, delay);
 ...
 end
 endtask: run_ph
endclass //SV Initiator

class env extends vmm_group;
 sv_initiator initiator0;

 ...
 function void connect_ph();
 ...
 tli_tlm_bind(initiator0.socket,vmm_tlm::TLM_BLOCKING_EXPORT,"port0");
 ...
 endfunction : connect_ph
 ...
endclass: env
endprogram: test
```

Import the "vmm\_tlm\_binds" package where adapter for vmm\_tlm interface is available

VMM\_TLM port, which acts as a producer

Send the transaction using the "socket"

Connect the VMM\_TLM to TLI adapter using "tli\_tlm\_bind" function

Make sure that you pass same unique id to the both producer and consumer bind functions

## **Example-4**

### **SV Producer VMM\_TLM (Non-Blocking Interface) Connected to SC OSCI TLM2.0 AT Consumer**

In this example, SV VMM\_TLM acts as a producer and SC OSCI TLM2.0 AT acts as a consumer. SV VMM\_TLM is connected to TLI adaptor using the `tli_tlm_bind` function (see “[Use Model](#)”), similarly SC AT consumer is connected to TLI adaptor using the `tli_tlm_bind_target` function. This example shows these connections. For SystemC code snippets, refer [Example 19-26](#) and [Example 19-27](#).

### Example 19-29 producer.sv

```
'include "tli_sv_bindings.sv"
program test();
import vmm_tlm_binds::*;

class sv_initiator extends vmm_xactor;
 vmm_tlm_nb_transport_port#(initiator, vmm_tlm_generic_payload) socket;
 vmm_tlm::phase_e ph = vmm_tlm::BEGIN_REQ;
 ...
task run_ph();
 ...
 forever begin
 vmm_tlm_generic_payload trans;
 trans = new();
 ...
 socket.nb_transport_fw(trans,ph,delay);
 ...
 end
endtask: run_ph
endclass //SV Initiator

class env extends vmm_group;
 sv_initiator initiator0;
 ...
 function void connect_ph();
 ...
 ...
 tli_tlm_bind(initiator0.socket,vmm_tlm::TLM_NONBLOCKING_EXPORT,"port0");
 ...
endfunction: connect_ph
...
endclass: env
endprogram: test
```

Import the "vmm\_tlm\_binds" package where adapter for vmm\_tlm interface is available

VMM\_TLM port, which acts as a producer

Send the transaction using the "socket"

Connect the VMM\_TLM to TLI adapter using "tli\_tlm\_bind" function

Make sure that you pass same unique id to the both producer and consumer bind functions

## **Example-5**

### **SC Producer OSCI TLM2.0 LT Connected to SV Channel Consumer**

In this example, SC OSCI TLM2.0 LT acts as a producer and SV channel acts as a consumer. SV channel is connected to TLI adaptor using the `tli_channel_bind` function (see “[Use Model](#)”), similarly SC LT producer is connected to TLI adaptor using the `tli_tlm_bind_initiator` function. This example shows these connections.

### Example 19-30 producer.h

```
class producer : public sc_module
{
public:
 tlm_utils::simple_initiator_socket<producer> in_socket;
 SC_CTOR(producer) : in_socket("in_socket")
 {
 SC_THREAD(send_proc);
 }
 void send_proc();
 ...
};

void producer::send_proc()
{
 ...
 in_socket->b_transport(*trans, delay);
 ...
}
```

SC OSCI TLM2.0 initiator socket acts as producer

Send transaction using initiator socket "in\_socket"

### Example 19-31 sc\_top.h

```
#include "tli_sc_bindings.h"
class sc_top : public sc_module
{
public:
 producer producer_inst0;
 SC_CTOR(sc_top) : producer_inst0("producer_inst0")
 {
 tli_tlm_bind_initiator(producer_inst0.in_socket,LT,"target0");
 ...
 }
};
```

Add the "tli\_sc\_bindings.h" file where SC bind functions are implemented

Make sure that you pass same unique id to both producer and consumer bind functions

Bind SC initiator socket "in\_socket" using the "tli\_tlm\_bind\_initiator" function

### Example 19-32 consumer.sv

```
'include "tli_sv_bindings.sv"
program test();
import vmm_channel_binds::*;
class sv_target extends vmm_xactor;
 vmm_tlm_generic_payload_channel in_channel;
 ...
task run_ph();
 forever begin
 vmm_tlm_generic_payload trans;
 in_channel.peek(trans);
 ...
 in_channel.get(trans);
 end
endtask: run_ph
endclass: sv_target

class env extends vmm_group;
 sv_target sv_target0;
 vmm_tlm_generic_payload_channel in1 = new("name", "channel1");
 ...
 virtual function void connect_ph();
 ...
 ...
 tl_channel_bind(in1,"target0", SC_2_SV_B);
 ...
 endfunction:connect_ph
 ...
endclass: env
...
endprogram: test
```

Import the "vmm\_channel\_binds" package where adapter for vmm\_channel interface is available

Channel which acts as a Consumer

Read the transaction using the "in\_channel"

Connect the channel to TLI adapter using the "tl\_channel\_bind" function

This argument tells the adapter that SV is consumer and blocking

Make sure that you pass same unique id to the both producer and consumer bind functions

## **Example-6**

### **SC Producer OSCI TLM2.0 AT Initiator Connected to SV Channel Consumer**

In this example, SC OSCI TLM2.0 AT acts as a producer and SV channel acts as a consumer. SV channel is connected to TLI adaptor using the `tli_channel_bind` function (see “[Use Model](#)”), similarly SC AT producer is connected to TLI adaptor using the `tli_tlm_bind_initiator` function. This example shows these connections.

### Example 19-33 producer.h

```
class producer : public sc_module, virtual public tlm::tlm_bw_transport_if<>
{
public:
 tlm::tlm_initiator_socket<> init_socket;
 producer(sc_core::sc_module_name name);
 void initiator_thread(void);
 tlm::tlm_sync_enum nb_transport_bw(tlm::generic_payload& tr, tlm::tlm_phase& phase,
 sc_core::sc_time& time);
 ...
};

void producer::initiator_thread() {
 tlm::tlm_sync_enum return_val;
 ...
 return_val = init_socket->nb_transport_fw(*trans,phase,delay);
 ...
}
```

SC OSCI TLM2.0  
initiator socket acts  
as producer

Send the transaction  
using initiator socket  
"init\_socket"

### Example 19-34 sc\_top.h

```
#include "tli_sc_bindings.h"
class sc_top : public sc_module
{
public:
 producer producer_inst0;
 SC_CTOR(sc_top) : producer_inst0("producer_inst0")
 {
 tli_tlm_bind_initiator(producer_inst0.init_socket,AT,"target0");
 ...
 }
};
```

Add the "tli\_sc\_bindings.h" file  
where SC bind functions are  
implemented

Make sure that you pass same  
unique id to both producer and  
consumer bind functions

Bind SC initiator socket  
"init\_socket" using the  
"tli\_tlm\_bind\_initiator" function

### Example 19-35 consumer.sv

```
 `include "tli_sv_bindings.sv"
 program test();
 import vmm_channel_binds::*;
 class sv_target extends vmm_xactor;
 vmm_tlm_generic_payload_channel in_channel;
 ...
 task run_ph();
 forever begin
 vmm_tlm_generic_payload trans;
 in_channel.peek(trans);
 ...
 in_channel.get(trans);
 end
 endtask: run_ph
 endclass: sv_target

 class env extends vmm_group;
 sv_target sv_target0;
 vmm_tlm_generic_payload_channel in1 = new("name", "channel1");
 ...
 function void connect_ph();
 ...
 ...
 tli_channel_bind(in1,"target0", SC_2_SV_NB);
 ...
 endfunction : connect_ph
 ...
 endclass: env
 ...
 endprogram: test
```

Import the "vmm\_channel\_binds" package where adapter for vmm\_channel interface is available

Channel which acts as a Consumer

Read the transaction using "in\_channel"

Connect the channel to TLI adapter using the "tli\_channel\_bind" function

This argument tells the adapter that SV is consumer and non-blocking.

Make sure that you pass same unique id to both producer and consumer bind functions

## **Example-7**

### **SC Producer OSCI TLM2.0 LT Connected to SV VMM-TLM (Blocking Interface) Consumer**

In this example, SC OSCI TLM2.0 LT acts as a producer and SV VMM TLM acts as a consumer. SV VMM TLM is connected to TLI adaptor using the `tli_tlm_bind` function (see “[Use Model](#)”), similarly SC LT producer is connected to TLI adaptor using the `tli_tlm_bind_initiator` function. This example shows these connections. For SystemC code snippets, refer [Example 19-30](#) and [Example 19-31](#).

### Example 19-36 consumer.sv

```
'include "tli_sv_bindings.sv"
program test();
import vmm_tlm_binds::*;

class target extends vmm_xactor;
 vmm_tlm_b_transport_export#(target, vmm_tlm_generic_payload) socket;
 ...
 virtual task b_transport(int id = -1, vmm_tlm_generic_payload trans, ref int delay);
 ...
 trans.m_response_status = 1;
 trans.notify.indicate(vmm_data::ENDED);
 endtask: b_transport
endclass: target

class env extends vmm_group;
 target target0;
 ...
 function void connect_ph();
 ...
 ...
 tli_tlm_bind(target0.socket,vmm_tlm::TLM_BLOCKING_PORT,"export0");
 endfunction : connect_ph
 ...
endclass: env
...
endprogram: test
```

Import the "vmm\_tlm\_binds" package where adapter for vmm\_tlm interface is available

TLM port which acts as a consumer

Read the transaction using the "b\_transport implementation"

Connect the VMM TLM to TLI adapter using "tli\_tlm\_bind" function

Make sure that you pass same unique id to the both producer and consumer bind functions

## **Example-8**

### **SC Producer OSCI TLM2.0 AT Initiator Connected to SV VMM-TLM (Non-Blocking Interface) Consumer**

In this example, SC OSCI TLM2.0 AT acts as a producer and SV VMM TLM acts as a consumer. SV VMM TLM is connected to TLI adaptor using the `tli_tlm_bind` function (see “[Use Model](#)”), similarly SC LT producer is connected to TLI adaptor using the `tli_tlm_bind_initiator` function. This example shows these connections. For SystemC code snippets, refer [Example 19-33](#) and [Example 19-34](#).

### Example 19-37 consumer.sv

```
 `include "tli_sv_bindings.sv"
program test();
import vmm_tlm_binds::*;

class target extends vmm_xactor;
 vmm_tlm_nb_transport_export#(target, vmm_tlm_generic_payload,tli_phase_e) socket;
 ...
 virtual function vmm_tlm::sync_e nb_transport_fw(int id = -1, vmm_tlm_generic_payload trans, ref tli_phase_e phase, ref int delay);
 vmm_tlm_generic_payload tr = trans;
 ...
 send_bw_call();
 return vmm_tlm::TLM_ACCEPTED;
 endfunction: nb_transport_fw

 task automatic send_bw_call();
 ...
 socket.nb_transport_bw(data, ph, delay);
 endtask
endclass: target

class env extends vmm_group;
 target target0;
 ...
 function void connect_ph();
 ...
 ...
 tl_i_tlm_bind(target0.socket,vmm_tlm::TLM_NONBLOCKING_PORT,"export0");
 ...
 endfunction: connect_ph
 ...
endclass: env
...
```

Import the "vmm\_tlm\_binds" package where adapter for vmm\_tlm interface is available

TLM export which acts as a Consumer

Read the transaction using the "nb\_transport\_fw" implementation

Connect the VMM TLM to TLI adapter using "tl\_i\_tlm\_bind" function

Make sure that you pass same unique id to the both producer and consumer bind functions

## **Example-9**

### **SV Producer VMM-TLM (Analysis Port) Connected to SC OSCI TLM2.0 Subscriber**

In this example, SV VMM-TLM analysis port acts as a producer and SC OSCI TLM2.0 analysis subscriber acts as a consumer. SV VMM TLM is connected to TLI adaptor using the `tli_tlm_bind` function (see “[Use Model](#)”), similarly SC analysis subscriber is connected to TLI adaptor using the `tli_tlm_bind_analysis_subscriber` function. This example shows these connections.

### Example 19-38 producer.sv

```
'include "tli_sv_bindings.sv"
program test();
import vmm_tlm_binds::*;

class sv_initiator extends vmm_xactor;
 vmm_tlm_analysis_port#(initiator, vmm_tlm_generic_payload) socket;
 ...
 task run_ph();
 ...
 forever begin
 vmm_tlm_generic_payload trans;
 trans = new();
 ...
 socket.write(trans);
 ...
 end
 endtask: run_ph
endclass //SV Initiator

class env extends vmm_group;
 sv_initiator initiator0;
 ...
 function void connect_ph();
 ...
 ...
 tli_tlm_bind(initiator0.socket,vmm_tlm::TLM_ANALYSIS_EXPORT,"port0");
 ...
 endfunction : connect_ph
 ...
endclass: env
endprogram: test
```

Import the "vmm\_tlm\_binds" package where adapter for vmm\_tlm interface is available

VMM\_TLM port, which acts as a producer

Send the transaction using the "socket"

Connect the VMM\_TLM to TLI adapter using "tli\_tlm\_bind" function

Make sure that you pass same unique id to the both producer and consumer bind functions

### Example 19-39 consumer.h

```
class consumer : public sc_module
 ,virtual public tlm::tlm_analysis_if<tlm::tlm_generic_payload>
{
public:
 consumer(sc_core::sc_module_name nm);
 void write(const tlm::tlm_generic_payload &gp);
};
```

Implement write method

### Example 19-40 sc\_top.h

```
.....
#include "tli_sc_bindings.h"
class sc_top : public sc_module
{
public:
 consumer m_target0;
 ...
 sc_top(sc_core::sc_module_name name):
 sc_core::sc_module(name)
 ,m_target0("sc_target0")
 {
 tli_tlm_bind_analysis_subscriber(m_target0,"port0");
 }
};
```

Include "tli\_sc\_bindings.h" where adaptor bind functions are implemented

Bind SC target socket "m\_socket" using the "tli\_tlm\_bind\_analysis\_subscriber" function

Make sure that you pass same unique id to both producer and consumer bind functions

## **Example-10**

### **SC Producer OSCI TLM2.0 Analysis Parent Connected to SV VMM-TLM Analysis Subscriber**

In this example, SC OSCI TLM2.0 analysis parent acts as a producer and SV VMM-TLM analysis subscriber acts as a consumer. SV VMM TLM is connected to TLI adaptor using the `tli_tlm_bind` function (see “[Use Model](#)”), similarly SC analysis parent is connected to TLI adaptor using the `tli_tlm_bind_analysis_parent` function. This example shows these connections.

### Example 19-41 producer.h

```
SC_MODULE(parent)
{
public:
 tlm::tlm_analysis_port<tlm::tlm_generic_payload> ap;
 SC_CTOR(parent):ap("ap")
 {
 SC_THREAD(send_proc);
 }
 ...
};

void parent::send_proc() {
 ...
 ...
 ap.write(trans);
 ...
}
```

SC OSCI TLM2.0 analysis port acts as a producer

Send transaction using the "init\_socket" initiator socket

### Example 19-42 sc\_top.h

```
#include "tli_sc_bindings.h"
class sc_top : public sc_module
{
public:
 parent sc_parent;
 SC_CTOR(sc_top) : sc_parent("sc_parent")
 {
 tli_tlm_bind_analysis_parent(sc_parent.ap,"subscriber0",true);
 ...
 }
};
```

Add "tli\_sc\_bindings.h" file where SC bind functions are implemented

Bind SC analysis parent "ap" using the "tli\_tlm\_bind\_analysis\_parent" function

Make sure that you pass same unique id to both producer and consumer bind functions

### Example 19-43 consumer.sv

```
'include "tli_sv_bindings.sv"
program test();
import vmm_tlm_binds::*;

class target extends vmm_xactor;
 vmm_tlm_analysis_export#(target, vmm_tlm_generic_payload) socket;
 ...
 virtual function write(int id = -1, vmm_tlm_generic_payload trans);
 vmm_tlm_generic_payload tr = trans;
 ...
 endfunction
endfunction: nb_transport_fw

endclass: target

class env extends vmm_group;
 target target0;
 ...
 function void connect_ph();
 ...
 ...
 tli_tlm_bind(target0.socket,vmm_tlm::TLM_ANALYSIS_PORT,"subscriber0");
 ...
 endfunction
endfunction : connect_ph

endclass: env

endprogram: test
```

Import the "vmm\_tlm\_binds" package where adapter for vmm\_tlm interface is available

TLM export which acts as a Consumer

Read the transaction using the "write" implementation"

Connect the VMM TLM to TLI adapter using the "tli\_tlm\_bind" function

Make sure that you pass same unique id to both producer and consumer bind functions

---

## Using VCS UVM TLI Adapters

VCS UVM TLI adapters (UVM SV TLM interface – SC TLM2.0 interface) enable transaction-level communication between UVM SV and SC models. VCS provides a built-in UVM TLI adapter to connect UVM SV TLM models to SC TLM2.0 models.

The UVM TLI adapter consists of a UVM SV adapter which communicates with existing SystemC adapters. These adapters communicate with each other using the DPI. The UVM TLI adapter consists of the `uvm_tlm2_sv_bind_pkg` package. This package contains a parameterized UVM wrapper class (`uvm_tlm2_sv_bind`). This class is parameterized with payload type and TLM phase type. So the UVM TLI adapters provided by VCS are supported for any user-defined payload and phase.

---

## Using the UVM TLI Adapters

This section explains how to use the UVM TLI adapters to connect SV models with the UVM TLM interface and SC models with the TLM2.0 interface. You can have any type of payload (like `uvm_tlm2_generic_payload` payload) extended from `uvm_transaction` or `uvm_sequence_item`.

Note:

You must define the SC flag `-DUSER_PAYLOAD` SC flag for payloads other than `tlm_generic_payload`.

### UVM TLM Interface

When SV has a UVM TLM interface, follow these steps:

## Steps for SV

1. Include the `uvm_tlm2_sv_bind.svh` file where the UVM SV adapter is defined.

```
`include "uvm_tlm2_sv_bind.svh"
```

2. Import `uvm_tlm2_sv_bind_pkg`.

```
import uvm_tlm2_sv_bind_pkg::*;
```

3. Call the connect functions in the connect\_phase of `uvm_env`.

```
uvm_tlm2_sv_bind#(payload_type)::connect(user_socket,
uvm_tlm_typ_e(Eg:UVM_TLM_B_TARGET),unique_id);
```

Here, the second argument indicates the type of socket to which the user socket is connected:

- When SV is a blocking initiator, the second argument is `UVM_TLM_B_TARGET`.
- When SV is a non-blocking initiator, the second argument is `UVM_TLM_NB_TARGET`.
- When SV is a blocking target, the second argument is `UVM_TLM_B_INITIATOR`.
- When SV is a non-blocking target, the second argument is `UVM_TLM_NB_INITIATOR`.

## Steps for SC

1. Include the file `uvm_tlm2_sc_bind.h`.

```
#include "uvm_tlm2_sc_bind.h"
```

2. Call the bind functions in the SystemC top constructor:

```
// SC Target
```

```

uvm_tlm2_bind_sc_target(target socket, UVM_TLM_B,
(UVM_TLM_NB, if non blocking) unique_id, dbg_prints);

// SC Initiator

uvm_tlm2_bind_sc_initiator(initiator socket, UVM_TLM_B,
(UVM_TLM_NB, if non blocking) unique_id, dbg_prints);

```

3. Set up the SC pack/unpack functions for user-defined payloads. For user-defined payloads, SC has to provide pack/unpack functions for the following two functions and should compile and link these functions.

```

void tli_conv2_pack_tlmgp(tli_pack_data& P, T &gp)
// T user payload

void tli_conv2_unpack_tlmgp(tli_pack_data& P, T &gp)

```

The implementation of these functions is provided by VCS TLI adapters for the generic payload. For other payload types, you must provide these functions.

Use the UVM-SC Byte pack/unpack feature for packing/unpacking the user fields in the above functions. For more information, see the UVM-SC Byte pack/unpack document.

## **UVM Analysis Interface**

When SV has a UVM analysis interface, follow these steps:

### **Steps for SV**

1. Include the `uvm_tlm2_sv_bind.svh` file where the UVM SV adapter is defined:

```
`include "uvm_tlm2_sv_bind.svh"
```

2. Import `uvm_tlm2_sv_bind_pkg`:

```
import uvm_tlm2_sv_bind_pkg::*;


```

3. Call the connect functions in the connect\_phase of uvm\_env:

```
typedef payload_type T; typedef phase_type P; typedef
uvm_tlm_if_base#(T,T) IF;
uvm_tlm2_sv_bind#(T,P,IF)::connect(user analysis port,
uvm_tlm_typ_e(Eg:UVM_TLM_ANALYSIS_EXPORT), unique_id);
```

Here, the second argument indicates the type of socket to which the user socket is connected:

- When SV is an analysis parent, the second argument is UVM\_TLM\_ANALYSIS\_EXPORT.
- When SV is an analysis subscriber, second argument is UVM\_TLM\_ANALYSIS\_PORT.

### Steps for SC

1. Include the `uvm_tlm2_sc_bind.h` file:

```
#include "uvm_tlm2_sc_bind.h"
```

2. Call the bind functions in the SystemC-top constructor:

```
// SC subscriber
```

```
tli_tlm_bind_analysis_subscriber(user port, unique_id,
is_debug_prints, // enables debug messages
is_uvm) // Set to 1 if SV has UVM interface
```

```
// SC parent
```

```
tli_tlm_bind_analysis_parent(user port, unique_id,
is_debug_prints, // enables debug messages
is_uvm) // Set to 1 if SV has UVM interface
```

## Handling Multiple Subscribers

When SV/SC has  $n$  subscribers, the parent should call the bind functions  $n$  number of times. With each call, the first argument (parent's analysis port) remains the same; only the unique id of each bind call should match with the unique names of the subscribers.

---

## UVM TLM Communication Examples

This section explains UVM TLM blocking and non-blocking communication with the help of the following examples, which you can find in \$VCS\_HOME/doc/examples:

- “[uvm\\_tlm\\_blocking Example](#)” on page 291
- “[uvm\\_tlm\\_nonblocking Example](#)” on page 293
- “[uvm\\_tlm\\_analysis Example](#)” on page 295

### **uvm\_tlm\_blocking Example**

In this example, there is one SV blocking initiator connected to one SC LT target and one SC LT initiator connected to one SV blocking target. The example files are shown in [Example 19-44](#), [Example 19-45](#), and [Example 19-46](#).

- SV UVM TLM blocking initiator <-> SC TLM2.0 LT target
- SV UVM TLM blocking target <-> SC TLM2.0 LT initiator

#### *Example 19-44 top.v File*

```
// Include "uvm_tlm2_sv_bind.svh" where the UVM TLI adapter
// is defined.
`include "uvm_tlm2_sv_bind.svh"
...
```

```

module top;
 import uvm_pkg::*;
 // Import the "uvm_tlm2_sv_bind_pkg" package where adapter
 // for vmm_channel interface is available.
 import uvm_tlm2_sv_bind_pkg::*;
 ...
endmodule

```

*Example 19-45 tb\_env.sv File*

```

class tb_env extends uvm_env;
`uvm_component_utils(tb_env);
initiator initiator0; // SV UVM TLM initiator instance
target target0; // SV UVM TLM target instance

function new(..);
endfunction

function build_phase(..)
// build initiator
// build target
endfunction

function void connect_phase(uvm_phase phase);
// Connect function to connect SV initiator to SC target.
uvm_tlm2_sv_bind#(payload)::connect(initiator0.socket,
UVM_TLM_B_TARGET, "port0");
//Connect function to connect SV target to SC initiator.
uvm_tlm2_sv_bind#(payload)::connect(target0.socket,
UVM_TLM_B_INITIATOR, "port1");
endfunction
endclass

```

*Example 19-46 sc\_top.h File*

```

#include "initiator.h"
#include "target.h"
// Include this file which defines the bind functions.
#include "uvm_tlm2_sc_bind.h"

class sc_top : public sc_module {

```

```

public:

 initiator init1;
 target trgt0;
 SC_CTOR(sc_top) : trgt0("trgt0"), init1("init1")
 {

 // Bind function to connect SV initiator to SC target and
 // SV target to SC initiator respectively.
 uvm_tlm2_bind_sc_target(trgt0.target_socket, UVM_TLM_B, "
port0");
 uvm_tlm2_bind_sc_initiator(init1.initiator_socket,
UVM_TLM_B, " port1");
 }
};

```

## **uvm\_tlm\_nonblocking Example**

In this example there is one SV non-blocking initiator connected to one SC AT target and one SC AT initiator connected to one SV non-blocking target. The example files are shown in [Example 19-47](#), [Example 19-48](#), and [Example 19-49](#).

- SV UVM TLM non-blocking initiator <->SC TLM2.0 AT target
- SV UVM TLM non-blocking target <-> SC TLM2.0 AT initiator

### *Example 19-47 top.v File*

```

//Include "uvm_tlm2_sv_bind.svh" where the UVM TLI adapter
//is defined.
`include "uvm_tlm2_sv_bind.svh"
...
module top;
import uvm_pkg::*;
//Import the "uvm_tlm2_sv_bind_pkg" package where adapter
//for vmm_channel interface is available.
import uvm_tlm2_sv_bind_pkg::*;

endmodule

```

### *Example 19-48 tb\_ebv.sv File*

```
class tb_env extends uvm_env;
`uvm_component_utils(tb_env);
initiator initiator0; // SV UVM TLM initiator instance
target target0; // SV UVM TLM target instance

function new(..);
endfunction

function build_phase(..)
// build initiator
// build target
endfunction

function void connect_phase(uvm_phase phase);

// Connect function to connect SV initiator to SC target.
uvm_tlm2_sv_bind#(payload)::connect(initiator0.socket,
UVM_TLM_NB_TARGET, "port0");

// Connect function to connect SV target to SC initiator.
uvm_tlm2_sv_bind#(payload)::connect(target0.socket,
UVM_TLM_NB_INITIATOR, "port1");

endfunction
endclass
```

### *Example 19-49 sc\_top.h File*

```
#include "initiator.h"
#include "target.h"
//Include this file which defines the bind functions.
#include "uvm_tlm2_sc_bind.h"

class sc_top : public sc_module {
public:

 initiator init1;
 target trgt0;
 SC_CTOR(sc_top) : trgt0("trgt0"), init1("init1")
```

```

{
 // Bind function to connect SV initiator to SC target and
 // SV target to SC initiator respectively.
 uvm_tlm2_bind_sc_target(trgt0.target_socket, UVM_TLM_NB, "port0");
 uvm_tlm2_bind_sc_initiator(init1.initiator_socket,
 UVM_TLM_NB, "port1");
}
;

```

## **uvm\_tlm\_analysis Example**

In this example, there is one SV analysis parent connected to two SC analysis subscribers and one SC analysis parent connected to two SV analysis subscribers:

- SV UVM TLM analysis parent <-> Two SC TLM2.0 analysis subscribers (2)
- Two SV UVM TLM analysis subscribers (2) <-> SC TLM2.0 AT analysis parent

### *Example 19-50 top.v File*

```

// Include "uvm_tlm2_sv_bind.svh" where the UVM TLI adapter
// is defined.
`include "uvm_tlm2_sv_bind.svh"
...
module top;
import uvm_pkg::*;
// Import the "uvm_tlm2_sv_bind_pkg" package where adapter
// for vmm_channel interface is available.
import uvm_tlm2_sv_bind_pkg::*;
...
endmodule

```

### *Example 19-51 tb\_ebv.sv File*

```
class tb_env extends uvm_env;
```

```

`uvm_component_utils(tb_env);
initiator initiator0; // SV UVM analysis parent
target target0; // SV UVM analysis subscriber1
target target1; // SV UVM analysis subscriber2

typedef uvm_tlm_generic_payload T;
typedef uvm_tlm_phase_e P;
typedef uvm_tlm_if_base#(T,T) IF;
function new(..);
endfunction

function build_phase(..)
 // build initiator
 // build target
endfunction

function void connect_phase(uvm_phase phase);
// Connect function to connect SV parent to two SC
//subscribers.

uvm_tlm2_sv_bind#(T, P, IF)::connect(initiator0.an_port,
UVM_TLM_ANALYSIS_EXPORT, "port0");

uvm_tlm2_sv_bind#(T, P, IF)::connect(initiator0.an_port,
UVM_TLM_ANALYSIS_EXPORT, "port1");

uvm_tlm2_sv_bind#(T, P, IF)::connect(target0.socket,
UVM_TLM_ANALYSIS_PORT, "ex_port0");

// Connect function to connect two SV targets to SC initiator.
uvm_tlm2_sv_bind#(T, P, IF)::connect(target1.socket,
UVM_TLM_ANALYSIS_PORT, "ex_port1");

endfunction
endclass

```

### *Example 19-52 sc\_top.h File*

```

#include "initiator.h"
#include "target.h"
//Include this file which defines the bind functions.
#include "uvm_tlm2_sc_bind.h"

```

```

class sc_top : public sc_module {
public:

 consumer m_target0;
 consumer m_target1;
 parent m_parent;
 SC_CTOR(sc_top) : m_target0("trgt0"), m_target1("trgt1"),
 m_parent("parent");

 {

 // Bind functions to connect SV parent to SC subscribers and
 // SV subscribers to SC analysis parents respectively.

 tli_tlm_bind_analysis_subscriber(m_target0, "port0",
 false, true);

 tli_tlm_bind_analysis_subscriber(m_target1, "port1",
 false, true);

 tli_tlm_bind_analysis_parent(m_parent, "ex_port0", false,
 true);

 tli_tlm_bind_analysis_parent(m_parent, "ex_port1", false,
 true);

 }
};


```

## Modeling SystemC Designs with SCV

You can easily model your designs containing SystemC and SCV (SystemC Verification Standard), hereafter, using VCS. The following is a list of features covered in this section:

### 3. SCV library in VCS

#### 4. msglog extensions for transaction recording with SCV in VCS

---

## SCV Library in VCS

The SCV library is now shipped along with the VCS image. SCV library is supported for SystemC-2.2 and SystemC-2.3 for all the compilers. SCV library is not binary compatible with OSCI-SystemC, but belongs to the SystemC version shipped with VCS.

### Use model

Use the option `-sysc=scv` on `syscan` while compiling the source code containing SCV. This option adds the required include directories within the VCS image during analysis. Also, use the option `-sysc=scv` on VCS command which selects the correct library to be linked.

For example:

```
syscan -sysc=scv myscv.cpp
syscan -sysc=scv mymod.cpp:mymod
vlogan vtop.v
vcs -sysc -sysc=scv vtop
```

Note: SCV library is only supported on RHEL32 and RHEL64 platforms, and not on any solaris platform. If you attempt to use on Solaris OS, the tool flags an error message.

---

## **msglog Extensions for Transaction Recording with SCV in VCS**

VCS provides a capability to record SCV transactions using `msglog`. SCV provides callbacks, which are implemented to record the user transactions during the below calls:

- `begin_transaction()`
- `end_transaction()`
- `record_attribute()`

You can view the SCV transactions in DVE waveform window using this feature. The callback functions provided by SCV, which are executed when the above methods are called are implemented in VCS. This way you don't need to write any custom code to record the SCV transactions in `MSGLOG` apart from registering the callback functions implemented in VCS.

## **Use Model**

You must register the callback functions implemented in VCS. Since these callback functions are declared in `vcs_scv_callback.h`, you must include this file before registering these functions. The source file has to be compiled with the option `-sysc=scv` as these are a part of the SCV library.

For example:

```

#include "vcs_scv_callback.h"
scv_tr_handle::callback_h tr_handle1, tr_handle2;
//registering the call back function for recording the begin and end
attributes

tr_handle1 =
scv_tr_handle::register_class_cb(&vcs_scv_callback);
//registering the call back function for recording the special attributes

tr_handle2 =
scv_tr_handle::register_record_attribute_cb(&vcs_scv_callback_record_attribute);
syscan -sysc=scv main.cpp

```

By default, all the transactions are recorded in the same stream, assuming that the second transaction starts only after finishing the first transaction and so on. If there are overlapping transactions in your SCV testbench (second transaction starting even before first transaction has finished), then compile your source code along with the define `-DSNPS_MSGLOG_OVERLAP=1` on syscan. This way transactions are recorded in multiple streams.

## **Viewing SystemC sc\_report\_handler Messages from Log File**

Until now, you could only see HDL/HVL messages in a log file but not the messages from SystemC. Hereafter, `simv -l logfile` will capture all the messages sent to `sc_report_handler()` in the log file. The log file will now have all the HDL/HVL messages along with the `sc_report_handler` messages.



# 20

## C Language Interface

It is common to mix C and C++ with both Verilog and VHDL. There are many different mechanisms and what you do will depend on your objective as well as the performance and restrictions of each mechanism. VCS supports the following ways to use C and C++ with your design:

- “[Using PLI](#)”
- “[Using VPI Routines](#)”
- “[Using DirectC](#)”
- Using SystemC - See the [Using SystemC](#) chapter.
- Using SystemVerilog DPI routines - See the SystemVerilog LRM.

Note:

PLI1.0 refers to TF and ACC routines, and PLI2.0 refers to VPI.

---

## Using PLI

PLI is the programming language interface (PLI) between C/C++ functions and VCS. It helps to link applications containing C/C++ functions with VCS, so that they execute concurrently. The C/C++ functions in the application use the PLI to read and write delay and simulation values in the VCS executable, and VCS can call these functions during simulation.

VCS supports PLI 1.0 and PLI 2.0 routines for the PLI. Therefore, you can use VPI, ACC or TF routines to write the PLI application. See [Appendix , "PLI Access Routines"](#).

This chapter covers the following topics:

- ["Writing a PLI Application"](#)
- ["Functions in a PLI Application"](#)
- ["Header Files for PLI Applications"](#)
- ["PLI Table File"](#)
- ["Enabling ACC Capabilities"](#)

---

## Writing a PLI Application

When writing a PLI application, you need to do the following:

1. Write the C/C++ functions of the application calling the VPI, ACC or TF routines to access data inside VCS.

2. Associate user-defined system tasks and system functions with the C/C++ functions in your application. VCS will call these functions when it compiles or executes these system tasks or system functions in the Verilog source code. In VCS, associate the user-defined system tasks and system functions with the C/C++ functions in your application using a PLI table file (see “[PLI Table File](#)” on page 6). In this file, you can also limit the scope and operations of the ACC routines for faster performance.
3. Enter the user-defined system tasks and functions in the Verilog source code.
4. Compile and simulate your design, specifying the table file and including the C/C++ source files (or compiled object files or libraries) so that the application is linked with VCS in the `simv` executable. If you include object files, use the `-cc` and `-ld` options to specify the compiler and linker that generated them. Linker errors occur if you include a C/C++ function in the PLI table file, but omit the source code for this function at compile-time.

To use the debugging features, perform the following:

1. Write a PLI table file, limiting the scope and operations of the ACC routines used by the debugging features.
2. Compile and simulate your design, specifying the table file.

These procedures are not mutually exclusive. It is, for example, quite possible that you have a PLI application that you write and use during the debugging phase of your design. If so, you can write a PLI table file that both:

- Associates user-defined system tasks or system functions with the functions in your application and limits the scope and operations called by your functions for faster performance.

- Limits scope and operations of the functions called by the debugging features in VCS.
- 

## Functions in a PLI Application

When you write a PLI application, you typically write a number of functions. The following are PLI functions that VCS expects with a user-defined system task or system function:

- The function that VCS calls when it executes the user-defined system task. Other functions are not necessary but this call function must be present. It is not unusual for there to be more than one call function. You'll need a separate user-defined system task for each call function. If the function returns a value then you must write a user-defined system function for it instead of a user-defined system task.
- The function that VCS calls during compilation to check if the user-defined system task has the correct syntax. You can omit this check function.
- The function that VCS calls for miscellaneous reasons such as the execution of \$stop, \$finish, or other reasons such as a value change. When VCS calls this function, it passes a reason argument to it that explains why VCS is calling it. You can omit this miscellaneous function.

These are the functions you tell VCS about in the PLI table file; apart from these PLI applications can have several more functions that are called by other functions.

Note:

You do not specify a function to determine the return value size of a user-defined system function; instead you specify the size directly in the PLI table file.

---

## Header Files for PLI Applications

For PLI applications, you need to include one or more of the following header files:

`vpi_user.h`

For PLI Applications whose functions call IEEE Standard VPI routines as documented in the *IEEE Verilog Language Reference Manual*.

`acc_user.h`

For PLI Applications whose functions call IEEE Standard ACC routines as documented in the *IEEE Verilog Language Reference Manual*.

`vcsuser.h`

For PLI applications whose functions call IEEE Standard TF routines as documented in the *IEEE Verilog Language Reference Manual*.

`vcs_acc_user.h`

For PLI applications whose functions call the special ACC routines implemented exclusively for VCS.

These header files are located in the  
`$VCS_HOME/your_platform/lib` directory.

---

## PLI Table File

The PLI table file (also referred to as the `pli.tab` file) is used to:

- Associate user-defined system tasks and system functions with functions in a PLI application. This enables VCS to call these functions when it compiles or executes the system task or function.
- Limit the scope and operation of the PLI 1.0 or PLI 2.0 functions called by the debugging features. See “[Specifying Access Capabilities for PLI Functions](#)” on page 10 and “[Specifying Access Capabilities for VCS Debugging Features](#)” on page 15.

## Syntax

The following is the syntax of the PLI table file:

```
$name PLI_specifications [access_capabilities]
```

Here:

`$name`

Specify the name of the user-defined system task or function.

`PLI_specifications`

Specify one or more specifications such as the name of the C function (mandatory), size of the return value (mandatory only for user-defined system functions), and so on. For a complete list of PLI specifications, see “[PLI Specifications](#)” on page 7.

`access_capabilities`

Specify the access capabilities of the functions defined in the PLI application. Use this to control the PLI 1.0 or PLI 2.0 functions' ability to access the design hierarchy. See "["Access Capabilities" on page 9](#)" for more information.

Synopsys recommends you enable this feature while using PLIs to improve the runtime performance.

## PLI Specifications

The PLI specifications are as follows:

`call=`*function*

Specifies the name of the function defined in the PLI application. This is mandatory.

`check=`*function*

Specifies the name of the check function.

`misc=`*function*

Specifies the name of the misc function.

`data=`*integer*

Specifies the value passed as the first argument to the call, check, and misc functions. The default value is 0.

Use this argument if you want more than one user-defined system task or function to use the same call, check, or misc function. In such a case, specify a different integer for each user-defined system task or function that uses the same call, check, or misc function.

`size=`*number*

Specifies the size of the returned value in bits. While this is mandatory for user-defined system functions, you can ignore or specify 0 for user-defined system tasks. For user-defined system functions, specify a decimal value for the number of bits. For example, `size=64`. If the user-defined system function returns a real value, specify `r`. For example, `size=r`

`args=number`

Specifies the number of arguments passed to the user-defined system task or function.

`minargs=number`

Specifies the minimum number of arguments.

`maxargs=number`

Specifies the maximum number of arguments.

`nocelldefinepli`

Disables the dumping of value change and simulation time data of modules defined under the `'celldefine` compiler directive into a VPD file created by the `$vcddpluson` system task. This capability is only used for batch simulation.

`persistent`

Checks if the specified function is defined in the PLI application, even if the corresponding system task or function is not used in the Verilog file. If the function is not found or defined in the PLI application, VCS exits with an undefined reference error message.

Note that if you use the `-debug`, `-debug_all`, or `-debug_pp` options during compilation, VCS performs these checks on every function mapped in the tab file.

To ignore this check, which is enabled by the above debug options or the `persistent` specification, set the `PERSISTENT_FLAG` environment variable to 1.

### **Example 1**

```
$val_proc call=val_proc check=check_proc misc=misc_proc
```

In this line, VCS calls the function named `val_proc` when it executes the associated user-defined system task named `$val_proc`. It calls the `check_proc` function at compile-time to see if the user-defined system task has the correct syntax, and calls the `misc_proc` function in special circumstances like interrupts.

### **Example 2**

```
$set_true size=16 call=set_true
```

In this line, there is an associated user-defined system function that returns a 15-bit return value. VCS calls the function named `set_true` when it executes this system function.

Note:

Do not enter blank spaces inside a PLI specification. The following copy of the last example of PLI specifications does not work:

```
$set_true size = 16 call = set_true
```

## **Access Capabilities**

You can specify access capabilities in a PLI table file for the following reasons:

- PLI functions associated with your user-defined system task or system function. To do this, specify the access capabilities on a line in a PLI table file after the name of the user-defined system task or system function and its PLI specifications. See “[Specifying Access Capabilities for PLI Functions](#)” on page 10 for more details.
- For the debugging features VCS can use. To do this, specify access capabilities alone on a line in a PLI table file, without an associated user-defined system task or system function. See “[Specifying Access Capabilities for VCS Debugging Features](#)” on page 15 for more details.

In many ways, specifying access capabilities for your PLI functions, and specifying them for VCS debugging features, is the same. However, the capabilities that you enable, and the parts of the design to which you can apply them are different.

## **Specifying Access Capabilities for PLI Functions**

The format for specifying access capabilities is as follows:

`acc= | += | -= | :=capabilities:module_names [+] | %CELL | %TASK | *`

Here:

`acc`

Keyword that begins a line for specifying access capabilities.

`= | += | -= | :=`

Operators for adding, removing, or changing access capabilities.

The operators in this syntax are as follows:

`=`

A shorthand for `+=`.

**+ =**

Specifies adding the access capabilities that follow to the parts of the design that follow, as specified by module name, %CELL, %TASK, or \* wildcard character.

**- =**

Specifies removing the access capabilities that follow from the parts of the design that follow, as specified by module name, %CELL, %TASK, or \* wildcard character.

**: =**

Specifies changing the access capabilities of the parts of the design that follow, as specified by module name, %CELL, %TASK, or \* wildcard character, to only those in the list of capabilities on this specification. A specification with this operator can change the capabilities specified in a previous specification.

## capabilities

Comma-separated list of access capabilities. The capabilities that you can specify for the functions in your PLI specifications are as follows:

**r or read**

Reads the values of nets and registers in your design.

**rw or read\_write**

Both reads from and writes to the values of registers or variables (but not nets) in your design.

**wn**

Enables writing values to nets.

`cbk` or `callback`

To be called when named objects (nets registers, ports) change value.

`cbka` or `callback_all`

To be called when named and unnamed objects (such as primitive terminals) change value.

`frc` or `force`

Forces values on nets and registers.

`prx` or `pulserx_backannotation`

Sets pulse error and pulse rejection percentages for module path delays.

`s` or `static_info`

Enables access to static information, such as instance or signal names and connectivity information. Signal values are not static information.

`tchk` or `timing_check_backannotation`

Back-annotates timing check delay values.

`gate` or `gate_backannotation`

Back-annotates delay values on gates.

`mp` or `module_path_backannotation`

Back-annotates module path delays.

`mip` or `module_input_port_backannotation`

Back-annotates delays on module input ports.

`mipb` or `module_input_port_bit_backannotation`

Back-annotates delays on individual bits of module input ports.

`module_names`

Comma-separated list of module identifiers (or names).

Specifying modules enables, disables, or changes (depending on the operator) the ability of the PLI function to use the access capability in all instances of the specified module.

+

Specifies adding, removing, or changing the access capabilities for not only the instances of the specified modules but also the instances hierarchically under the instances of the specified modules.

`%CELL`

Enables, disables, or changes (depending on the operator) the ability of the PLI function to use the access capability in all instances of module definitions compiled under the `'celldefine` compiler directive and all module definitions in Verilog library directories and library files (as specified with the `-y` and `-v` analysis options).

`%TASK`

Enables, disables, or changes (depending on the operator) the ability of the PLI function to use the access capability in all instances of module definitions that contain the user-defined system task or system function associated with the PLI function.

\*

Enables, disables, or changes (depending on the operator) the ability of the PLI function to use the access capability throughout the entire design. Using wildcard characters could seriously impede the performance of VCS.

**Note:**

There are no blank spaces when specifying access capabilities.

The following examples are the PLI specification examples from the previous section with access capabilities added to them. The examples wrap to more than one line, but when you edit your PLI table file, be sure there are no line breaks in these lines.

**Example 1**

```
$val_proc call=val_proc check=check_proc misc=misc_proc
acc+= rw,tchk:top,bot acc-=tchk:top
```

This example adds the access capabilities for reading and writing to nets and registers, and for back-annotating timing check delays, to these PLI functions, and enables them to do these things in all instances of modules `top` and `bot`. It then removes the access capability for back-annotating timing check delay values from these PLI functions in all instances of module `top`.

**Example 2**

```
$value_passer size=0 args=2 call=value_passer persistent
acc+=rw:%TASK acc-=rw:%CELL
```

This example adds the access capability to read from and write to the values of nets and registers to these PLI functions. It enables them to do these things in all instances of modules declared in module definitions that contain the `$value_passer` user-defined system

task. The example then removes the access capability to read from and write to the values of nets and registers, from these PLI functions, in module definitions compiled under the `celldefine compiler directive and all module definitions in Verilog library directories and library files.

### **Example 3**

```
$set_true size=16 call=set_true acc+=rw:*
```

This example adds the access capability to read from and write to the values of nets and registers to the PLI functions. It enables them to do this throughout the entire design.

### **Specifying Access Capabilities for VCS Debugging Features**

The format for specifying these capabilities for VCS debugging features is as follows:

```
acc= | += | -= | :=capabilities:module_names [+] | %CELL | *
```

Here:

acc

Keyword that begins a line for specifying access capabilities.

= | += | -= | :=

Operators for adding, removing, or changing access capabilities.

*capabilities*

Comma separated list of access capabilities.

*module\_names*

Comma-separated list of module identifiers. The specified access capabilities will be added, removed, or changed for all instances of these modules.

+

Specifies adding, removing, or changing the access capabilities for not only the instances of the specified modules but also the instances hierarchically under the instances of the specified modules.

%CELL

Specifies all modules compiled under the `celldefine compiler directive and all modules in Verilog library directories and library files (as specified with the -y and -v options.)

\*

Specifies all modules in the design. Using a wildcard character is no more efficient than using the -debug option with vcs.

The access capabilities and the interactive commands they enable are as follows:

| ACC Capability | What it enables your PLI functions to do                                                                                                                                                                                                                                                                                                                                                                                                     |
|----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| r or read      | For specifying “reads” in your design, it enables commands for performing the following: <ul style="list-style-type: none"><li>• Creating an alias for another UCLI command (alias)</li><li>• Displaying UCLI help</li><li>• Specifying the radix of displayed simulation values (ofORMAT)</li><li>• Displaying simulation values</li><li>• Descending and ascending the module hierarchy</li><li>• Depositing values on registers</li></ul> |

| <b>ACC Capability</b>                      | <b>What it enables your PLI functions to do</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|--------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                            | <ul style="list-style-type: none"> <li>• Displaying the set breakpoints on signals</li> <li>• Displaying the port names of the current location, and the current module instance or scope, in the module hierarchy</li> <li>• Displaying the names of instances in the current module instance or scope</li> <li>• Displaying the nets and registers in the current scope</li> <li>• Moving up the module hierarchy</li> <li>• Deleting an alias for another UCLI command</li> <li>• Ending the simulation</li> </ul>                                                                                                                                                 |
| <code>rw</code> or <code>read_write</code> | For specifying “reads and writes” in your design but <code>r</code> enables everything that <code>rw</code> does. A longer way to specify this capability is with the <code>read_write</code> keyword.                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| <code>cbk</code> or <code>callback</code>  | <p>Commands for performing the following:</p> <ul style="list-style-type: none"> <li>• Setting a repeating breakpoint. In other words always halting simulation, when a specified signal changes value</li> <li>• Setting a one shot breakpoint. In other words halting simulation the next time the signal changes value but not the subsequent times it changes value</li> <li>• Removing a breakpoint from a signal</li> <li>• Showing the line number or number in the source code of the statement or statements that causes the current value of a net</li> <li>• A longer way to specify this capability is with the <code>callback</code> keyword.</li> </ul> |
| <code>frc</code> or <code>force</code>     | <p>Commands for performing the following:</p> <ul style="list-style-type: none"> <li>• Forcing a net or a register to a specified value so that this value cannot be changed by subsequent simulation events in the design</li> <li>• Releasing a net or register from its forced value</li> </ul> <p>A longer way to specify this capability is with the <code>force</code> keyword.</p>                                                                                                                                                                                                                                                                             |

## **Example 1**

The following specification enables many interactive commands including those for displaying the values of signals in specified modules and depositing values to the signals that are registers:

```
acc+=r:top,mid,bot
```

Notice that there are no blank spaces in this specification. Blank spaces cause a syntax error.

## **Example 2**

The following specifications enable most interactive commands for most of the modules in a design. They then change the ACC capabilities preventing breakpoint and force commands in instances of modules in Verilog libraries and modules designated as cells with the `'celldefine` compiler directive.

```
acc+=rw,cbk,frc:top+ acc:=rw:%CELL
```

In this example, the first specification enables the interactive commands that are enabled by the `rw`, `cbk`, and `frc` capabilities for module `top`, which, in this example, is the top-level module of the design, and all module instances under it. The second specification limits the interactive commands for the specified modules to only those enabled by the `rw` (same as `r`) capability.

## **Using the PLI Table File**

You specify the PLI table file with the `-P` compile-time option, followed by the name of the PLI table file (by convention, the PLI table file has a `.tab` extension). For example:

```
-P pli.tab
```

When you enter this option on the `vcs` command line, you can also enter C source files, compiled `.o` object files, or `.a` libraries on the `vcs` command line, to specify the PLI application that you want to link with VCS. For example:

```
vcs -P pli.tab pli.c my_design.v
```

One advantage to entering `.o` object files and `.a` libraries is that you do not have to recompile the PLI application every time you compile your design.

---

## Enabling ACC Capabilities

As well as specifying ACC capabilities in only specific parts of your design (as described in “[PLI Table File](#)” on page 6), VCS allows you to enable ACC capabilities throughout your design. It also enables you to specify selected write capabilities using a configuration file. Since enabling ACC capabilities has an adverse effect on performance, VCS also allows you to enable only the ACC capabilities you need.

### Globally

You can enter the `+acc+level_number` compile-time option to globally enable ACC capabilities throughout your design.

Note:

Using the `+acc+level_number` option significantly impedes the simulation performance of your design. Synopsys recommends that you use a PLI table file to enable ACC capabilities for only the parts of your design where you need them. For more details on doing this, see “[PLI Table File](#)” on page 6.

The `level_number` in this option specifies additional ACC capabilities as follows:

`+acc+1` or `+acc`

Enables all capabilities except value change callbacks and delay annotation.

`+acc+2`

Above, plus value change callbacks.

`+acc+3`

Above, plus module path delay annotation.

`+acc+4`

Above, plus gate delay annotation.

## Using the Configuration File

Specify the configuration file with the `+optconfigfile` compile-time option. For example:

`+optconfigfile+filename`

The VCS configuration file enables you to enter statements that specify:

- Using the optimizations of Radiant Technology on part of a design
- Enabling PLI ACC write capabilities for all memories in the design, disabling them for the entire design, or enabling them for part or parts of the design hierarchy
- Four state simulation for part of a design

The entries in the configuration file override the ACC write-enabling entries in the PLI table file.

The syntax of each type of statement in the configuration file to enable ACC write capabilities is as follows:

`set writeOnMem;`

or

`set noAccWrite;`

or

`module {list_of_module_identifiers} {accWrite};`

or

`instance {list_of_module_instance_hierarchical_names} {accWrite};`

or

`tree [(depth)] {list_of_module_identifiers} {accWrite};`

or

`signal {list_of_signal_hierarchical_names} {accWrite};`

Here:

`set`

Keyword preceding a property that applies to the entire design.

`writeOnMem`

Enables ACC write to memories (any single or multi-dimensional array of the `reg` data type) throughout the entire design.

`noAccWrite`

Disables ACC write capabilities throughout the entire design.

`accWrite`

Enables ACC write capabilities.

`module`

Keyword specifying that the `accWrite` attribute in this statement applies to all instances of the modules in the list, specified by module identifier.

`list_of_module_identifiers`

Comma-separated list of module identifiers (also called module names).

`instance`

Keyword specifying that the `accWrite` attribute in this statement applies to all instances in the list.

`list_of_module_instance_hierarchical_names`

Comma-separated list of module instance hierarchical names.

Note:

Follow the Verilog syntax for signal names and hierarchical names of module instances.

tree

Keyword specifying that the `accWrite` attribute in this statement applies to all instances of the modules in the list, specified by module identifier, and also applies to all module instances hierarchically under these module instances.

depth

An integer that specifies how far down the module hierarchy from the specified modules you want to apply the `accWrite` attribute. You can specify a negative value. A negative value specifies descending to the leaf level and counting up levels of the hierarchy to apply these attributes. This specification is optional. Enclose this specification in parentheses: ()

signal

Keyword specifying that the `accWrite` attribute in this statement applies to all signals in the list.

`list_of_signal_hierarchical_names`

Comma-separated list of signal hierarchical names.

## Selected ACC Capabilities

There are compile-time and runtime options that enable VCS and PLI applications to use only the ACC capabilities they need and no more. The procedure to use these options is as follows:

1. Use the `+vcs+learn+pli` runtime option to tell VCS to keep track of, or learn, the ACC capabilities that are used by different modules in your design. VCS uses this information to create a secondary PLI table file, named `pli_learn.tab`. You can use this table file to recompile your design so that subsequent simulations use only the ACC capabilities that are needed.
2. Tell VCS to apply what it has learned in the next compilation of your design, and specify the secondary PLI table file, with the `+applylearn+filename` compile-time option (if you omit `+filename` from the `+applylearn` compile-time option, VCS uses the `pli_learn.tab` secondary PLI table file).
3. Simulate again with a `simv` executable in which only the ACC capabilities you need are enabled.

### **Learning What Access Capabilities are Used**

You include the `+vcs+learn+pli` runtime option to tell VCS to learn the access capabilities that were used by the modules in your design and write them into a secondary PLI table file named, `pli_learn.tab`.

This file is considered a secondary PLI table file because it does not replace the first PLI table file that you used (if you used one). This file does, however, modify whatever access capabilities are specified in a first PLI table file, or other means of specifying access capabilities, so that you enable only the capabilities you need in subsequent simulations.

You should look at the contents of the `pli_learn.tab` file that VCS writes to see what access capabilities were actually used during simulation. The following is an example of this file:

```
////////////// SYNOPSYS INC /////////////
// PLI LEARN FILE
```

```
// AUTOMATICALLY GENERATED BY VCS (TM) LEARN MODE
///////////////////////////////
acc=r:testfixture
 //SIGNAL STIM_SRLS:r
acc=rw:SDFFR
 //SIGNAL S1:rw
```

The following line in this file specifies that during simulation, the read capability was needed for signals in the module named testfixture.

```
acc=r:testfixture
 //SIGNAL STIM_SRLS:r
```

The comment lets you know that the only signal for which this capability was needed was the signal named, STIM\_SRLS. This line is in the form of a comment because the syntax of the PLI table file does not permit specifying access capabilities on a signal-by-signal basis.

The following line in this file specifies that during simulation, the read and write capabilities were needed for signals in the module named, SDFFR, specifically for the signal named S1.

```
acc=rw:SDFFR
 //SIGNAL S1:rw
```

## **Signs of a Potentially Significant Performance Gain**

You might see one of following comments in the pli\_learn.tab file:

```
// !VCS_LEARNED: NO_ACCESS_PERFORMED
```

This indicates that none of the enabled access capabilities were used during the simulation.

```
// !VCS_LEARNED: NO_DYNAMIC_ACCESS_PERFORMED
```

This indicates that only static information was accessed through access capabilities and there was no value change information during simulation.

These comments indicate that there is a potentially significant performance gain when you apply the access capabilities in the `pli_learn.tab` file.

### **Compiling to Enable Only the Access Capabilities You Need**

After you have run the simulation to learn what access capabilities were actually used by your design, you can then recompile the design with the information you have learned, so the resulting `simv` executable uses only the access capabilities you require.

When you recompile your design, include the `+applylearn` compile-time option.

If, for some reason, you renamed the `pli_learn.tab` file that VCS writes when you include the `+vcs+learn+pli` runtime option, specify the new filename in the compile-time option by appending it to the option with the following syntax:

```
+applylearn+filename
```

When you recompile your design with the `+applylearn` compile-time option, it is important that you also re-enter all the compile-time options that you used for the previous compilation. For example, if in a previous compilation, you specified a PLI table file with the `-P` compile-time option, specify this PLI table file again, using the `-P` option, along with the `+applylearn` option.

Note:

If you change your design after VCS writes the `pli_learn.tab` file, and you want to make sure that you are using only the access capabilities you need, you will need to have VCS write another one, by including the `+vcs+learn+pli` runtime option and then compiling your design again with the `+applylearn` option.

## Limitations

VCS is not able to maintain a history of all access capabilities. However, the capabilities it does maintain, and specify in the `pli_learned.tab` file, are as follows:

- `r` - read
- `rw` - read and write
- `cbk` - callbacks
- `cbka` - callback all including unnamed objects
- `frc` - forcing values on signals

The `+applylearn` compile-time option does not work if you also use either the `+multisource_int_delays` or `+transport_int_delays` compile-time option, because interconnect delays need global access capabilities.

If you enter the `+applylearn` compile-time option more than once on the `vcs` command line, VCS ignores all instances, except for the first occurrence.

---

## PLI Access to Ports of Celldefine and Library Modules

VCS provides a compile-time option `+nocelldefinepli` that blocks debug access to celldefine and library modules. This option deletes (Programming Language Interface) PLI capabilities from the modules that are cell-defined or library modules.

However, you can access the ports inside such modules even in the presence of `+nocelldefinepli` optimization with an additional option `+ports`.

`+nocelldefinepli+1+ports`

Removes the PLI caps from `celldefine modules and allows PLI access to port nodes and parameters.

`+nocelldefinepli+2+ports`

Removes the PLI caps from library and ‘celldefine modules and allows PLI access to port nodes and parameters.

### Example

Following is a sample Verilog code in which the dut is a cell define module.

#### **test.sv**

```
`celldefine
module ram (Addr, Data, CS, WE, OE);

parameter AddrSize = 4;
parameter WordSize = 1;

input [AddrSize-1:0] Addr;
inout [WordSize-1:0] Data;
```

```

input CS, WE, OE;

reg [WordSize-1:0] Mem [0:1<<AddrSize] ;

assign Data = (!CS && !OE) ? Mem[Addr] : {WordSize{1'b0}};

always @(CS or WE)
 if (!CS && !WE)
 Mem[Addr] = Data;

endmodule
`endcelldefine

module ramTop;
reg [7:0] addr;
wire [7:0] data;
reg cs, we, oe;
reg [7:0] data_temp;

ram #(8,8) dut (addr, data, cs, we, oe);

assign data = (!cs && !we) ? data_temp : data;

initial begin
 $vcndlpluson;
 $vcndlplusmemon;
 repeat (10) begin
 #10;
 { cs, we, oe} = {$urandom%2, $urandom%2, $urandom%2};
 addr = {$urandom%2, $urandom%2, $urandom%2, $urandom%2,
$urandom%2, $urandom%2, $urandom%2, $urandom%2};
 data_temp = {$urandom%2, $urandom%2, $urandom%2,
$urandom%2, $urandom%2, $urandom%2, $urandom%2,
$urandom%2};
 end
end
endmodule

```

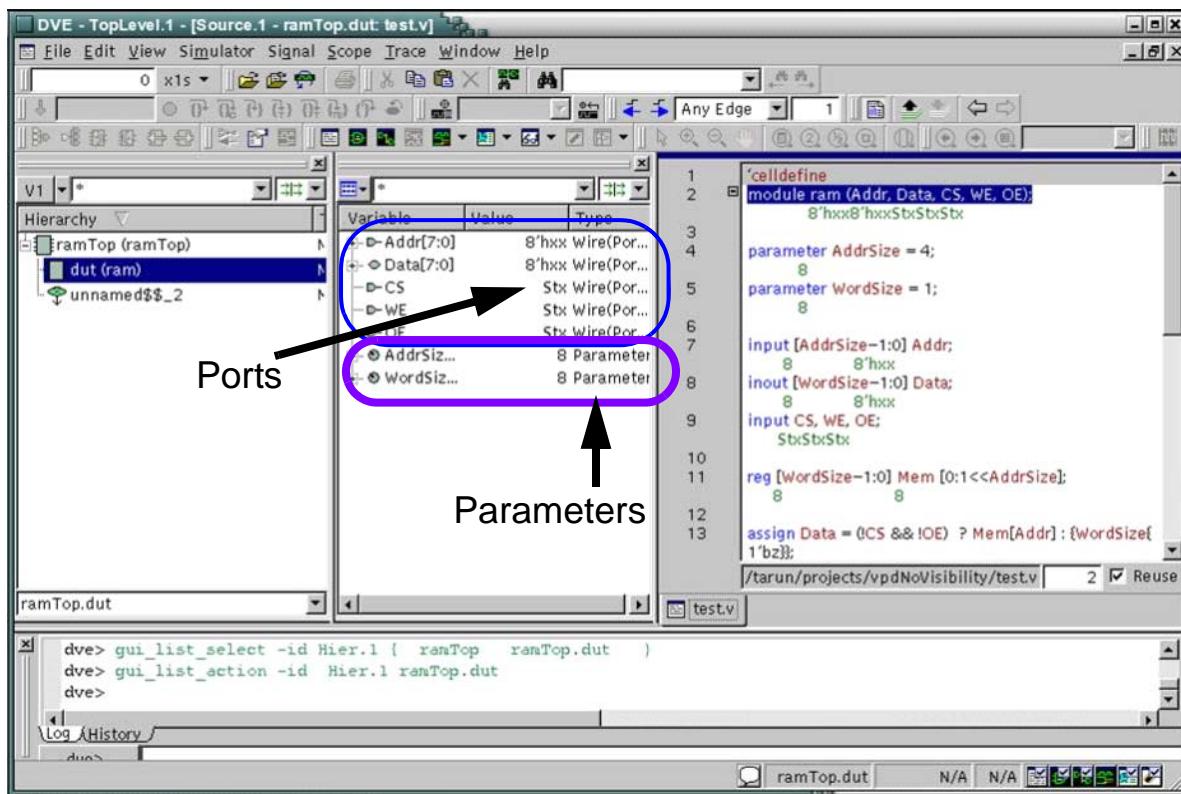
To compile this example code, use the following commands:

```
vcs test.sv -debug_all -sverilog +nocelldefinepli+2+ports
```

```
simv -gui &
```

## Visualization in DVE

In the following illustration, you can see that “Mem” which is an internal signal for the “ram” module is not shown in the Data pane anymore. However other signals, which are ports or parameters, are visible.



## Limitations

- Only Direct Kernel Interface (DKI) applications can access the ports, PLI applications cannot access.

---

## Using VPI Routines

To enable VPI capabilities in VCS, use the compilation option `+vpi`. as shown in the following example:

```
% vcs +vpi top -P test.tab test.c
```

The header file for the VPI routines is `$VCS_HOME/include/vpi_user.h`.

You can register your user-defined system tasks/function-related callbacks using the `vpi_register_systf` VPI routine, see “[Support for the vpi\\_register\\_systf Routine](#)” on page 32.

You can also use a PLI `.tab` file to associate your user-defined system tasks with your VPI routines, see “[PLI Table File for VPI Routines](#)” on page 35.

---

## Support for VPI Callbacks for Reasons `cbForce` and `cbRelease`

The `vpi_register_cb()` callback mechanism can be registered for callbacks to occur for simulation events, such as value changes on an expression or terminal, or the execution of a behavioral statement. When the `cb_data_p->reason` field is set to one of the following, the callback occurs as described below:

- `cbForce`/`cbRelease` — After a force or release has occurred
- `cbAssign`/`cbDeassign` — After a procedural assign or deassign statement has been executed

VPI callbacks reasons cbForce and cbRelease are now supported with the following limitations:

- The force and release commands generates a callback only if cb\_data\_p > obj is a valid handle. If it is set to NULL, it doesn't generate a callback.
- For cbForce, cbRelease, cbAssign, and cbDeassign callbacks, the handle that you supplied while registering the callback is returned and not the corresponding statement handle [NULL handles are not allowed].

For more information about the VPI callbacks, see the section *Simulation-event-related callbacks in the Verilog IEEE LRM 1364-2001*.

---

## Support for the vpi\_register\_systf Routine

VCS supports the vpi\_register\_systf VPI access routine. To use this routine, you need to make an entry in the vpi\_user.c file. You can copy this file from \$VCS\_HOME/etc/vpi.

The following is an example::

```
/*=====
Copyright (c) 2003 Synopsys Inc
=====*/
/* Fill your start up routines in this array, Last entry
should be
zero, use -use_vpiobj to pick up this file */
extern void register_me();
void (*vlog_startup_routines[])(() = {
 register_me, ←
 0 /* Last Entry */ ↘ entry here
};
```

In this example:

- The routine named `register_me` is externally declared.
- It is also included in the array named `vlog_startup_routines`.
- The last entry in the array is zero.

You specify this file with the `-use_vpiobj` compilation option. For example:

```
% vcs top.v -use_vpiobj vpi_user.c +vpi
```

You can also write a PLI table file for VPI routines. See “[PLI Table File for VPI Routines](#)”.

---

## Integrating a VPI Application With VCS

If you create one or more shared libraries for a VPI application, the application should not contain the `vlog_startup_routines` array.

Instead, enter the `-load` compile-time option to specify the registration routine. The syntax is as follows:

```
-load shared_library:registration_routine
```

You do not have to specify the path name of the shared library, if that path is part of your `LD_LIBRARY_PATH` environment variable.

The following are some examples of using this option:

- `-load lib1.so:my_register`

The `my_register()` routine is in `lib1.so`. The location of `lib1.so` is in the `LD_LIBRARY_PATH` environment variable.

- `-load lib1.so:my_register,new_register`

The registration routines `my_register()` and `new_register()` are in `lib1.so`. The location of `lib1.so` is in the `LD_LIBRARY_PATH` environment variable.

- `-load lib1.so:my_register -load lib2.so:new_register`

The registration routine `my_register()` is in `lib1.so` and the second registration routine `new_register()` is in `lib2.so`. The path to both of these libraries are in the `LD_LIBRARY_PATH` environment variable. You can enter more than one `-load` option to specify multiple shared libraries and their registration routines.

- `-load lib1.so:my_register`

The registration routine `my_register()` is in `lib1.so`. The location of `lib1.so` is in the `LD_LIBRARY_PATH` environment variable.

- `-load /usr/lib/mylib.so:my_register`

The registration routine `my_register()` is in `lib1.so`, which is in `/usr/lib/mylib.so`, and not in the `LD_LIBRARY_PATH` environment variable.

---

## PLI Table File for VPI Routines

The PLI table file for VPI routines works the same way, and with the same syntax as a PLI table file for user-defined system tasks that execute C functions. The following is an example of such a PLI table file:

```
$set_mipd_delays call=PLIbook_SetMipd_calltf
check=PLIbook_SetMipd_completetf
acc=mip,mp,gate,tchk,rw:test+
```

Note that this entry includes acc= even though the C functions in the PLI specification call VPI routines instead of PLI 1.0 routines. The syntax has not changed; you use the same syntax for enabling PLI 1.0 and PLI 2.0 routines.

This PLI table file is used for an example file named `set_mipd_delays_vpi.c`, which is available with *The Verilog PLI Handbook* by Stuart Sutherland, Kluwer Academic Publishers, Boston, Dordrecht, and London.

---

## Virtual Interface Debug Support

You can debug the Virtual Interface object. A Virtual Interface is a reference object that can either be initially assigned at its declaration or not assigned.

You can debug the Virtual Interface object when it is initially assigned or not assigned within a module or a class.

To debug the Virtual Interface objects, the VPI properties defined in the SystemVerilog LRM, such as `vpiVirtual`, `vpiActual`, and `vpiInterfaceDecl`, are supported. For more information about these properties, see the IEEE SystemVerilog LRM.

## Example

The following example show the VPI routines usage for Virtual Interface Debug:

`virtual_interface.sv`

```
interface ifc (input logic clk);
 event reset;
 int ifci;
 modport tracker (input clk);
endinterface: ifc

package p;

class C;
 virtual ifc.tracker busmpIF; VI declared in Class scope
 virtual ifc busIF;
 int i;

 function new (virtual ifc inf);
 busIF = inf;
 endfunction // new

 function test(virtual ifc inf);
 busIF = inf;
 $display("hello");
 endfunction: test
endclass: C
endpackage: p
```

```

module mod(input logic clk);
 import p::*;

 ifc trkIF(.clk(clk));

 virtual ifc modbusIF = trkIF;
 virtual ifc.tracker modportIF2;

 C c;

 initial begin
`ifdef DUMP
 $vcdpluson;
`endif
 c = new(trkIF);
 c.test(modbusIF);
 modbusIF.ifci <= 10;
#1
 $getVar;
 $display("end the first round\n");
#1
 modbusIF.ifci <= 11;
 $getVar;
 $display("end the second round.");
 end
endmodule: mod
pli.c

#include <stdio.h>
#include <stdlib.h>
#include "vcs_vpi_user.h"
#include "sv_vpi_user.h"

void traverse(){
 vpiHandle Han, iterHan, scanHan, cls, obj, intfHan,
Href, Hactual;

 vpi_configure(vpiDisplayWarnings,"true");

 intfHan = vpi_handle_by_name("mod.vbusIF",NULL);
 vpi_printf("\tVAR `%s'\n", vpi_get_str(vpiName,intfHan));
}

```

VI declared in Module  
scope

```

 vpi_printf("\t--- DefName `%s'\n\t--- FullName:%s\n\t-
-- vpiType:%s\n",
 vpi_get_str(vpiDefName,intfHan) ,
vpi_get_str(vpiFullName,intfHan) ,
 vpi_get_str(vpiType,intfHan));
 if(vpi_get(vpiVirtual, intfHan)){
 vpi_printf("\t%s is Virtual
Interface\n",vpi_get_str(vpiName,intfHan));
 }
 Hactual = vpi_handle(vpiActual, intfHan);
 if (Hactual)
 {
 vpi_printf("\n\tActual `%s'\n",
vpi_get_str(vpiName,Hactual));
 vpi_printf("\t--- DefName `%s'\n\t--- FullName:%s\n\t-
-- vpiType:%s\n",
 vpi_get_str(vpiDefName,Hactual),
vpi_get_str(vpiFullName,Hactual),
 vpi_get_str(vpiType,Hactual));
 if(vpi_get(vpiVirtual, Hactual)){
 vpi_printf("\tActual Handle is Virtual Interface\n");
 }
 }
}
pli.tab
```

\$getVar call=traverse acc+=r:\* acc+=cbk:\*

To compile this example code, use the following commands:

```
vcs -P pli.tab pli.c virtual_interface.sv -debug_all
-sverilog

simv -gui &
```

To view how the virtual interface objects appear in DVE, see the DVE User Guide.

## Limitations

- Virtual Interface passed as a method port is not shown in DVE.
- Virtual Interface as an array is not supported.
- Virtual Interface debugging is not supported in UCLI.
- `$vcdplustblog` and `$vcdplusmsglog` do not dump Virtual Interface.

---

## Unimplemented VPI Routines

VCS has not implemented everything specified for VPI routines in the *IEEE Verilog Language Reference Manual*, because some routines would be rarely used and some of the data access operations of other routines would be rarely used. The unimplemented routines are as follows:

- `vpi_get_data`
- `vpi_put_data`
- `vpi_sim_control`

Object data model diagrams in the *IEEE Verilog Language Reference Manual* specify that some VPI routines should be able to access data that is rarely needed. These routines, and the data they cannot access, are as follows:

`vpi_get_value`

- Cannot retrieve the value of `var` select objects (diagram 26.6.8 Variables) and `func` call objects (diagram 26.6.18 Task, function declaration).

- Cannot retrieve the value of VPI operators (expressions) unless they are arguments to system tasks or system functions.
- Cannot retrieve the value of UDP table entries (`vpiVectorVal` not implemented).

#### `vpi_put_value`

Cannot set the value of `var` select objects (diagram 26.6.8 Variables) and primitive objects (diagram 26.6.13 Primitive, `prim` term).

#### `vpi_get_delays`

Cannot retrieve the values of continuous assign objects (diagram 26.6.24 Continuous assignment) or procedurally assigned objects.

#### `vpi_put_delays`

Cannot put values on continuous assign objects (diagram 26.6.24 Continuous assignment) or procedurally assigned objects.

#### `vpi_register_cb`

Cannot register the following types of callbacks that are defined for this routine:

|                                |                       |                         |
|--------------------------------|-----------------------|-------------------------|
| <code>cbEndOfSimulation</code> | <code>cbError</code>  | <code>cbPliError</code> |
| <code>cbTchkViolation</code>   | <code>cbSignal</code> |                         |

Also, the `cbValueChange` callback is not supported for the following objects:

- A memory or a memory word (index or element)
- `VarArray` or `VarSelect`

---

## Diagnostics for VPIPLI Applications

As per LRM, VPIremain silent when an error occurs. The application checks for error status to report an error. If error detection mechanisms are not in place, the C code of the application must be modified and recompiled. In addition, you may need to recompile the HDL code, if required.

However, you can use the following new runtime diagnostic option to make the PLI application to report errors without code modification:

- `-diag vpi`

For more information, see “[Diagnostics for VPI/VHPI PLI Applications](#)” .

---

## Using DirectC

DirectC is an extended interface between Verilog and C/C++. It is an alternative to the PLI that, unlike the PLI, enables you to do the following:

- More efficiently pass values between Verilog module instances and C/C++ functions by calling the functions directly, along with actual parameters, in your Verilog code.
- Pass more types of data between Verilog and C/C++. With the PLI, you can only pass Verilog information to and from a C/C++ application. With DirectC you do not have this limitation.

With DirectC, for example, you can model a simulation environment for your design in C/C++ in which you can pass pointers from the environment to your design and store them in Verilog signals, and at a later simulation time, pass these pointers to the simulation environment.

Similarly, you can use DirectC to develop applications to run with VCS to which you can pass pointers to the location of simulation values for your design.

DirectC is an alternative to, but not a replacement for, the PLI. You can do things with the PLI that you cannot do with DirectC. For example, there are PLI TF and ACC routines to implement a callback to start a C/C++ function when a Verilog signal changes value. You cannot do this with DirectC.

You can use Direct C/C++ function calls for existing and proven C code as well as C/C++ code that you write in the future. You can also use them without much rewriting of, or additions to, your Verilog code. You call them the same way you call (or enable) a Verilog function or Verilog task.

This section describes the DirectC interface in the following sections:

- “[Using Direct C/C++ Function Calls](#)”
- “[Using Direct Access](#)”
- “[Using Abstract Access](#)”
- “[Enabling C/C++ Functions](#)”
- “[Extended BNF for External Function Declarations](#)”

---

## Using Direct C/C++ Function Calls

To enable a direct call of a C/C++ function during simulation, perform the following:

1. Declare the function in your Verilog code.
2. Call the function in your Verilog code.
3. Compile your design and C/C++ code using compile-time options for DirectC.

However, there are complications to this otherwise straightforward procedure.

DirectC allows the invocation of C++ functions that are declared in C++ using the `extern "C"` linkage directive. The `extern "C"` directive is necessary to protect the name of the C++ function from being mangled by the C++ compiler. Plain C functions do not undergo mangling, and therefore, do not need any special directive.

The declaration of these functions involves specifying a direction for the parameters of the C function, because, in the Verilog environment, they become analogous to Verilog tasks as well as functions. Verilog tasks are similar to void C functions in that they do not return a value. However, Verilog tasks do have input, output, and inout arguments, whereas C function parameters do not have explicitly declared directions. See “[Declaring the C/C++ Function](#)” .

There are two access modes for C/C++ function calls. These modes do not make much difference in your Verilog code; they only pertain to the development of the C/C++ function. They are as follows:

- The slightly more efficient direct access mode - this mode has rules for how values of different types and sizes are passed to and from Verilog and C/C++. This mode is explained in detail in the section, “[Using Direct Access](#)” .
- The slightly less efficient, but with better error handling abstract access mode - in this implementation, VCS creates a descriptor for each actual parameter of the C function. You access these descriptors using a specially defined pointer called a handle. All formal arguments are handles. DirectC comes with a library of accessory functions for using these handles. This mode is explained in detail in the section, “[Using Abstract Access](#)” .

The abstract access library of accessory functions contains operations for reading and writing values and for querying about argument types, sizes, etc. An alternative library, with perhaps different levels of security or efficiency, can be developed and used in abstract access without changing your Verilog or C/C++ code.

If you have an existing C/C++ function that you want to use in a Verilog design, you consider using direct access and see if you really need to edit your C/C++ function or write a wrapper so that you can use direct access inside the wrapper. There is a small performance gain by using direct access compared to abstract access.

If you are about to write a C/C++ function to use in a Verilog design, first decide how you wish to use it in your Verilog code and write the external declaration for it, then decide which access mode you want. You can change the mode later with perhaps a small change in your Verilog code.

Using abstract access is “safer” because the library of accessory functions for abstract access has error messages to help you to debug the interface between C/C++ and Verilog. With direct access, errors simply result in segmentation faults, memory corruption, etc.

Abstract access can be generalized more easily for your C/C++ function. For example, with open arrays you can call the function with 8-bit arguments at one point in your Verilog design and call it again some place else with 32-bit arguments. The accessory functions can manage the differences in size. With abstract access you can have the size of a parameter returned to you. With direct access you must know the size.

## How C/C++ Functions Work in a Verilog Environment

Like Verilog functions, and unlike Verilog tasks, no simulation time elapses during the execution of a C/C++ function.

C/C++ functions work in two-state and four-state simulation, and in some cases, work better in two-state simulation. Short vector values, 32-bits or less, are passed by value instead of by reference. Using two-state simulation makes a difference in how you declare a C/C++ function in your Verilog code.

The parameters of C/C++ functions, are analogous to the arguments of Verilog tasks. They can be input, output, or inout just like the arguments of Verilog tasks. You don't specify them as such in your C code, but you do when you declare them in your Verilog code. Accordingly your Verilog code can pass values to parameters declared to be input or inout, but not output, in the function declaration in your Verilog code, and your C function can only pass values from parameters declared to be inout or output, but not input, in the function declaration in your Verilog code.

If a C/C++ function returns a value to a Verilog register (the C/C++ function is in an expression that is assigned to the register) the return value of the C/C++ function is restricted to the following:

- The value of a scalar `reg` or `bit`

Note:

In two-state simulation, a `reg` has a new name, `bit`.

- The value of the C type `int`
- A pointer
- A short, 32 bits or less, vector `bit`
- The value of a Verilog `real` which is represented by the C type `double`

So C/C++ functions cannot return the value of a four-state vector `reg`, long (longer than 32 bits) vector `bit`, or Verilog `integer`, `realtime`, or `time` data type. You can pass these type of values out of the C/C++ function using a parameter that you declare to be inout or output in the declaration of the function in your Verilog code.

## Declaring the C/C++ Function

A partial EBNF specification for external function declaration is as follows:

```
source_text ::= description +

description ::= module | user_defined_primitive | extern_declaration

extern_declaration ::= extern access_mode ? attribute ? return_type function_id
 (extern_func_args ?) ;

access_mode ::= ("A" | "C")

attribute ::= pure

return_type ::= void | reg | bit | DirectC_primitive_type
 | small_bit_vector

small_bit_vector ::= bit [(constant_expression : constant_expression)]

extern_func_args ::= extern_func_arg (, extern_func_arg) *
```

```

extern_func_arg ::= arg_direction ? arg_type arg_id ?
arg_direction ::= input | output | inout

arg_type ::= bit_or_reg_type | array_type | DirectC_primitive_type

bit_or_reg_type ::= (bit | reg) optional_vector_range ?

optional_vector_range ::= [(constant_expression : constant_expression) ?]

array_type ::= bit_or_reg_type array [(constant_expression :
constant_expression) ?]

DirectC_primitive_type ::= int | real | pointer | string

```

Here:

*extern*

Keyword that begins the declaration of the C/C++ function declaration.

*access\_mode*

Specifies the mode of access in the declaration. Enter C for direct access, or A for abstract access. Using this entry enables some functions to use direct access and others to use abstract access.

*attribute*

An optional attribute for the function. The `pure` attribute enables some optimizations. Enter this attribute if the function has no side effects and is dependent only on the values of its input parameters.

*return\_type*

The valid return types are `int`, `bit`, `reg`, `string`, `pointer`, and `void`. See [Table 20-1](#) for a description of what these types specify.

*small\_bit\_vector*

Specifies a bit-width of a returned vector `bit`. A C/C++ function cannot return a four-state vector `reg`, but it can return a vector `bit` if its bit-width is 32 bits or less.

`function_id`

The name of the C/C++ function.

`direction`

One of the following keywords: `input`, `output`, `inout`. In a C/C++ function, these keywords specify the same thing that they specify in a Verilog task; see [Table 20-2](#).

`arg_type`

The valid argument types are `real`, `reg`, `bit`, `int`, `pointer`, `string`.

`[bit_width]`

Specifies the bit-width of a vector `reg` or `bit` that is an argument to the C/C++ function. You can leave the bit-width open by entering `[]`.

`array`

Specifies that the argument is a Verilog memory.

`[index_range]`

Specifies a range of elements (words, addresses) in the memory. You can leave the range open by entering `[]`.

`arg_id`

The Verilog register argument to the C/C++ function that becomes the actual parameter to the function.

Note:

Argument direction (i.e., input, output, inout) applies to all arguments that follow it until the next direction occurs; the default direction is input.

*Table 20-1 C/C++ Function Return Types*

| <b>Return Type</b> | <b>Specifies</b>                                                                                                         |
|--------------------|--------------------------------------------------------------------------------------------------------------------------|
| int                | The C/C++ function returns a value for type int.                                                                         |
| bit                | The C/C++ function returns the value of a bit, which is a Verilog reg in two state simulation, if it is 32 bits or less. |
| reg                | The C/C++ function returns the value of a Verilog scalar reg.                                                            |
| string             | The C/C++ function returns a pointer to a character string.                                                              |
| pointer            | The C/C++ function returns a pointer.                                                                                    |
| void               | The C/C++ function does not return a value.                                                                              |

*Table 20-2 C/C++ Function Argument Directions*

| <b>keyword</b> | <b>Specifies</b>                                                                                                                                            |
|----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------|
| input          | The C/C++ function can only read the value or address of the argument. If you specify an input argument first, you can omit the <code>input</code> keyword. |
| output         | The C/C++ function can only write the value or address of the argument.                                                                                     |
| inout          | The C/C++ function can both read and write the value or address of the argument.                                                                            |

*Table 20-3 C/C++ Function Argument Types*

| keyword | Specifies                                                                                         |
|---------|---------------------------------------------------------------------------------------------------|
| real    | The C/C++ function reads or writes the address of a Verilog real data type.                       |
| reg     | The C/C++ function reads or writes the value or address of a Verilog reg.                         |
| bit     | The C/C++ function reads or writes the value or address of a Verilog reg in two state simulation. |
| int     | The C/C++ function reads or writes the address of a C/C++ int data type.                          |
| pointer | The C/C++ function reads or writes the address that a pointer is pointing to.                     |
| string  | The C/C++ function reads from or writes to the address of a string.                               |

### **Example 1**

```
extern "A" reg return_reg (input reg r1);
```

This example declares a C/C++ function named `return_reg`. This function returns the value of a scalar reg. When we call this function, the value of a scalar reg named `r1` is passed to the function. This function uses abstract access.

### **Example 2**

```
extern "C" bit [7:0] return_vector_bit (bit [7:0] r3);
```

This example declares a C/C++ function named `return_vector_bit`. This function returns an 8-bit vector bit (a reg in two state simulation). When we call this function, the value of an 8-bit vector bit (a reg in two state simulation) named `r3` is passed to the function. This function uses direct access.

The keyword `input` is omitted. This keyword can be omitted if the first argument specified is an input argument.

### **Example 3**

```
extern string return_string();
```

This example declares a C/C++ function named `return_string`. This function returns a character string and takes no arguments.

### **Example 4**

```
extern void receive_string(input string r5);
```

This example declares a C/C++ function named `receive_string`. It is a void function. At some time earlier in the simulation, another C/C++ function passed the address of a character string to reg `r5`. When we call this function, it reads the address in reg `r5`.

### **Example 5**

```
extern pointer return_pointer();
```

This example declares a C/C++ function named `return_pointer`. When we call this function, it returns a pointer.

### **Example 6**

```
extern void receive_pointer (input pointer r6);
```

This example declares a C/C++ function named `receive_pointer`. When we call this function the address in reg `r6` is passed to the function.

### **Example 7**

```
extern void memory_reorg (input bit [32:0] array [7:0] mem2,
output bit [32:0] array [7:0] mem1);
```

This example declares a C/C++ function named `memory_reorg`. When we call this function, the values in memory `mem2` are passed to the function. After the function executes, new values are passed to memory `mem1`.

### **Example 8**

```
extern void incr (inout bit [] r7);
```

This example declares a C/C++ function named `incr`. When we call this function, the value in bit `r7` is passed to the function. When it finishes executing, it passes a new value to bit `r7`. We did not specify a bit width for vector bit `r7`. This allows us to use various sizes in the parameter declaration in the C/C++ function header.

### **Example 9**

```
extern void passbig (input bit [63:0] r8,
 output bit [63:0] r9);
```

This example declares a C/C++ function named `passbig`. When we call this function, the value in bit `r8` is passed by reference to the function because it is more than 32 bits; see “[Using Direct Access on page 61](#)”. When it finishes executing, a new value is passed by reference to bit `r9`.

## **Calling the C/C++ Function**

After declaring the C/C++ function, you can call it in your Verilog code. You call a void C/C++ function in the same manner as you call a Verilog task-enabling statement, that is, by entering the function name and its arguments, either on a separate line in an `always` or `initial` block, or in the procedural statements in a Verilog task or function declaration. Unlike Verilog tasks, you can call a C/C++ function in a Verilog function.

You call a non-void (returns a value) C/C++ function in the same manner as you call a Verilog function call, that is, by entering its name and arguments, either in an expression on the RHS of a procedural assignment statement in an `always` or `initial` block, or in a Verilog task or function declaration.

## Examples

```
r2=return_reg(r1);
```

The value of scalar reg `r1` is passed to C/C++ function `return_reg`. It returns a value to reg `r2`.

```
r4=return_vector_bit(r3);
```

The value of vector bit `r3` is passed to C/C++ function `return_vector_bit`. It returns a value to vector bit `r4`.

```
r5=return_string();
```

The address of a character string is passed to reg `r5`.

```
receive_string(r5);
```

The address of a character string in reg `r5` is passed to C/C++ function `receive_string`.

```
r6=return_pointer();
```

The address pointed to in a pointer in C/C++ function `return_pointer` is passed to reg `r6`.

```
get_pointer(r6);
```

The address in reg `r6` is passed to C/C++ function `get_pointer`.

```
memory_reorg(mem1,mem2);
```

In this example, all the values in memory `mem2` are passed to C/C++ function `memory_reorg`, and when it finishes executing, it passes new values to memory `mem1`.

```
incr(r7);
```

In this example, the value of bit `r7` is passed to C/C++ function `incr`, and when it finishes executing, it passes a new value to bit `r7`.

## Storing Vector Values in Machine Memory

Users of direct access need to know how vector values are stored in memory. This information is also helpful for users of abstract access.

Verilog four-state simulation values (1, 0, x, and z) are represented in machine memory with data and control bits. The control bit differentiates between the 1 and x and the 0 and z values, as shown in the following table:

| Simulation Value | Data Bit | Control Bit |
|------------------|----------|-------------|
| 1                | 1        | 0           |
| x                | 1        | 1           |
| 0                | 0        | 0           |
| z                | 0        | 1           |

When a routine returns Verilog data to a C/C++ function, how that data is stored depends on whether it is from a two-state or four-state value, and whether it is from a scalar, a vector, or from an element in a Verilog memory.

For a four-state vector (denoted by the keyword reg), the Verilog data is stored in type `vec32`, which for abstract access is defined as follows:

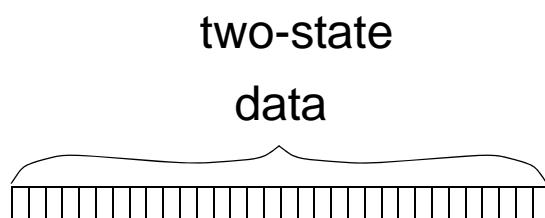
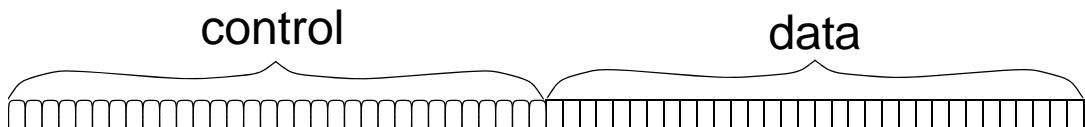
```
typedef unsigned int U;
typedef struct { U c; U d; } vec32;
```

So, type `vec32*` has two members of type `U`; member `c` is for control bits and member `d` is for data bits.

For a two-state vector bit, the Verilog data is stored in type `U*`.

Vector values are stored in arrays of chunks of 32 bits. For four-state vectors there are chunks of 32 bits for data values and 32 bits for control values. For two-state vectors, there are chunks of 32 bits for data values.

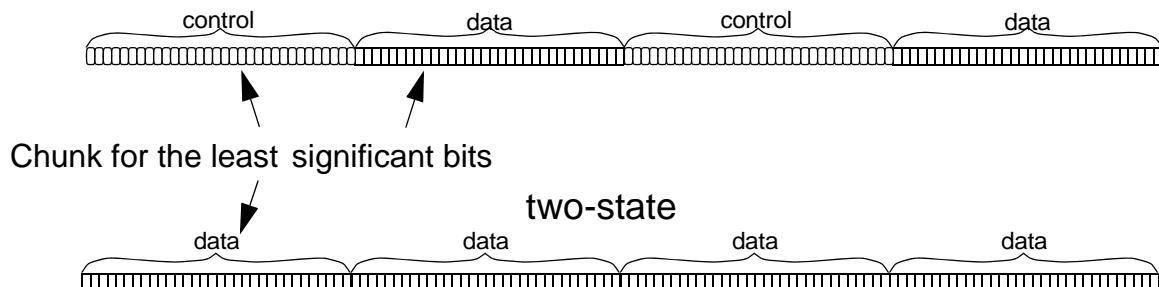
*Figure 20-1 Storing Vector Values*  
**four-state**



Long vectors, more than 32 bits, have their value stored in more than one group of 32 bits and can be accessed by chunk. Short vectors, 32 bits or less, are stored in a single chunk.

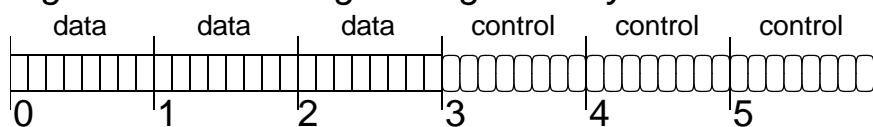
For long vectors, the chunk for the least significant bits come first, followed by the chunks for the more significant bits.

*Figure 20-2 Storing Vector Values of More than 32 Bits  
four-state*



In an element in a Verilog memory, for each eight bits in the element, there is a data byte and a control byte with an additional set of bytes for remainder bit. So, if a memory had 9 bits, it would need two data bytes and two control bytes. If it had 17 bits, it would need three data bytes and three control bytes. All the data bytes precede the control bytes. Two-state memories have both data and control bytes, but the bits in the control bytes always have a zero value.

*Figure 20-3 Storing Verilog Memory Elements in Machine Memory*



## Converting Strings

There are no \*true\* strings in Verilog, and a string literal, like "some\_text," is just a notation for vectors of bits, based on the same principle as binary, octal, decimal, and hexadecimal numbers. So there is a need for a conversion between the two representations of "strings": the C-style representation (which actually is a pointer to the sequence of bytes terminated with null byte) and the Verilog vector encoding a string.

DirectC comes with the `vc_ConvertToString()` routine that you can use to convert a Verilog string to a C string. Its syntax is as follows:

```
void vc_ConvertToString(vec32 *, int, char *)
```

There are scenarios in which a string is created on the Verilog side and is passed to C code, and therefore, has to be converted from Verilog representation to C representation. Consider the following example:

```
extern void WriteReport(string result_code, /* other stuff */);
```

Example of a valid call:

```
WriteReport("Passes",);
```

Example of incorrect code:

```
reg [100*8:1] message;
.
.
.message = "Failed";
.
.
.WriteReport(message,);
```

This call causes a core dump because the function expects a pointer and gets some random bits instead.

It may happen that a string, or different strings, are assigned to a signal in Verilog code and their values are passed to C. For example:

```
task DoStuff(..., result_code); ... output reg [100*8:1]
```

```

result_code;
begin
.
.
.
if (...) result_code = "Bus error";
.
.
.
if (...) result_code = "Erroneous address";
.
.
.
else result_code = "Completed");
end
endtask

reg [100*8:1] message;

.....
DoStuff(..., message);

```

You cannot directly call the function as follows:

```
WriteReport(message, ...)
```

There are two solutions:

Solution 1: Write a C wrapper function, pass "message" to this function and perform the conversion of vector-to-C string in C, calling vc\_ConvertToString.

Solution 2: Perform the conversion on the Verilog side. This requires some additional effort, as the memory space for a C string has to be allocated as follows:

```
extern "C" string malloc(int);
extern "C" void vc_ConvertToString(reg [], int, string);
```

```

// this function comes from DirectC library

reg [31:0] sptr;
.

.

.

// allocate memory for a C-string
sptr = malloc(8*100+1);
//100 is the width of 'message', +1 is for NULL terminator
// perform conversion
vc_ConvertToString(message, 800, sptr);
WriteReport(sptr, ...);

```

## Avoiding a Naming Problem

In a module definition, do not call an external C/C++ function with the same name as the module definition. The following is an example of the type of source code you should avoid:

```

extern void receive_string (input string r5);
.

.

.

module receive_string;
.

.

.

always @ r5
begin
.

.

.

receive_string(r5);
.

.

.

end
endmodule

```

## Using Pass by Reference

You can use pass by reference with DirectC. The following source files: `main.v` and `pythag.c`, illustrate using pass by reference.

### **main.v**

```
extern void pythag(inout real);
module main;
real p;
initial begin
 p = 7.89;
 pythag(p);
 $finish;
end
endmodule
```

### **pythag.c**

```
#include <stdio.h>
void pythag(double *p)
{
 printf ("Passed real value from verilog p=%f \n", *p);
}
```

You can try out this example with the following command-line:

```
vcs +vc main.v pythag.c -R -l somv.log
```

At runtime, VCS displays the following:

```
Passed real value from verilog p=7.890000
```

---

## Using Direct Access

Direct access was implemented for C/C++ routines whose formal parameters are of the following types:

|       |        |         |         |        |
|-------|--------|---------|---------|--------|
| int   | int*   | double* | void*   | void** |
| char* | char** | scalar  | scalar* |        |
| U*    | vec32  | UB*     |         |        |

Some of these type identifiers are standard C/C++ types; those that are not, were defined with the following `typedef` statements:

```
typedef unsigned int U;
typedef unsigned char UB;
typedef unsigned char scalar;
typedef struct {U c; U d;} vec32;
```

The type identifier you use depends on the corresponding argument direction, type, and bit-width that you specified in the declaration of the function in your Verilog code. The following rules apply:

- Direct access passes all output and inout arguments by reference, so their corresponding formal parameters in the C/C++ function must be pointers.
- Direct access passes a Verilog bit by value only if it is 32 bits or less. If it is larger than 32 bits, direct access passes the bit by reference so the corresponding formal parameters in the C/C++ function must be pointers if they are larger than 32 bits.
- Direct access passes a scalar reg by value. It passes a vector reg direct access by reference, so the corresponding formal parameter in the C/C++ function for a vector reg must be a pointer.

- An open bit-width for a reg makes it possible for you to pass a vector reg, so the corresponding formal parameter for a reg argument, specified with an open bit-width, must be a pointer. Similarly, an open bit-width for a bit makes it possible for you to pass a bit larger than 32 bits, so the corresponding formal parameter for a bit argument specified with an open bit width must be a pointer.
- Direct access passes by value the following types of input arguments: int, string, and pointer.
- Direct access passes input arguments of type real by reference.

The following tables show the mapping between the data types you use in the C/C++ function and the arguments you specify in the function declaration in your Verilog code.

*Table 20-4 For Input Arguments*

| argument type                                         | C/C++ formal parameter data type | Passed by |
|-------------------------------------------------------|----------------------------------|-----------|
| int                                                   | int                              | value     |
| real                                                  | double*                          | reference |
| pointer                                               | void*                            | value     |
| string                                                | char*                            | value     |
| bit                                                   | scalar                           | value     |
| reg                                                   | scalar                           | value     |
| bit [] - 1-32 bit wide vector                         | U                                | value     |
| bit [] - open vector, any vector wider than 32 bits   | U*                               | reference |
| reg [] - 1-32 bit wide vector                         | vec32*                           | reference |
| array [] - open vector, any vector wider than 32 bits | UB*                              | reference |

*Table 20-5 For Output and Inout Arguments*

| argument type                                                  | C/C++ formal parameter data type | Passed by |
|----------------------------------------------------------------|----------------------------------|-----------|
| int                                                            | int*                             | reference |
| real                                                           | double*                          | reference |
| pointer                                                        | void**                           | reference |
| string                                                         | char**                           | reference |
| bit                                                            | scalar*                          | reference |
| reg                                                            | scalar*                          | reference |
| bit [] - any vector, including open vector                     | U*                               | reference |
| reg [] - any vector, including open vector                     | vec32*                           | reference |
| array [] - any array, 2 state or 4 state, including open array | UB*                              | reference |

In direct access, the return value of the function is always passed by value. The data type of the returned value is the same as the input argument.

### **Example 1**

Consider the following C/C++ function declared in the Verilog source code:

```
extern reg return_reg (input reg r1);
```

In this example, the function named `return_reg` returns the value of a scalar reg. The value of a scalar reg is passed to it. The header of the C/C++ function is as follows:

```
extern "C" scalar return_reg(scalar reti);
scalar return_reg(scalar reti);
```

If `return_reg()` is a C++ function, it must be protected from name mangling, as follows:

```
extern "C" scalar return_reg(scalar reti);
```

Note:

The `extern "C"` directive has been omitted in subsequent examples, for brevity.

A scalar reg is passed by value to the function so the parameter is not a pointer. The parameter's type is scalar.

## Example 2

Consider the following C/C++ function declared in the Verilog source code:

```
extern "C" bit [7:0] return_vector_bit (bit [7:0] r3);
```

In this example, the function named `return_vector_bit` returns the value of a vector bit. The "`C`" entry specifies direct access.

Typically, a declaration includes this when some other functions use abstract access. The value of an 8-bit vector bit is passed to it. The header of the C/C++ function is as follows:

```
U return_vector_bit(U returner);
```

A vector bit is passed by value to the function because the vector bit is less than 33 bits so the parameter is not a pointer. The parameter's type is U.

### **Example 3**

Consider the following C/C++ function declared in the Verilog source code:

```
extern void receive_pointer (input pointer r6);
```

In this example, the function named `receive_pointer` does not return a value. The argument passed to it is declared to be a pointer. The header of the C/C++ function is as follows:

```
void receive_pointer(*pointer_receiver);
```

A pointer is passed by value to the function so the parameter is a pointer of type `void`, a generic pointer. In this example, we don't need to know the type of data that it points to.

### **Example 4**

Consider the following C/C++ function declared in the Verilog source code:

```
extern void memory_rewriter (input bit [1:0] array [1:0]
 mem2, output bit [1:0] array [1:0] mem1);
```

In this example, the function named `memory_rewriter` has two arguments, one declared as an input, the other as an output. Both arguments are bit memories. The header of the C/C++ function is as follows:

```
void memory_rewriter(UB *out[2], *in[2]);
```

Memories are always passed by reference to a C/C++ function so the parameter named `in` is a pointer of type UB with the size that matched the memory range. The parameter named `out` is also a pointer, because its corresponding argument is declared to be output. Its type is also UB because it outputs to a Verilog memory.

### **Example 5**

Consider the following C/C++ function declared in the Verilog source code:

```
extern void incr (inout bit [] r7);
```

In this example, the function named `incr`, that does not return a value, has an argument declared as `inout`. No bit-width is specified, but the `[]` entry for the argument specifies that it is not a scalar bit. The header of the C/C++ function is as follows:

```
void incr (U *p);
```

Open bit-width parameters are always passed to by reference. A parameter whose corresponding argument is declared to be `inout` is passed to and from by reference. So there are two reasons for parameter `p` to be a pointer. It is a pointer to type `U` because its corresponding argument is a vector bit.

### **Example 6**

Consider the following C/C++ function declared in the Verilog source code:

```
extern void passbig1 (input bit [63:0] r8,
 output bit [63:0] r9);
```

In this example, the function named `passbig1`, that does not return a value, has input and output arguments declared as `bit` and larger than 32 bits. The header of the C/C++ function is as follows:

```
void passbig (U *in, U *out)
```

In this example, the parameters `in` and `out` are pointers to type `U`. They are pointers because their corresponding arguments are larger than 32 bits and type `U` because their corresponding arguments are type `bit`.

### **Example 7**

Consider the following C/C++ function declared in the Verilog source code:

```
extern void passbig2 (input reg [63:0] r10,
 output reg [63:0] r11);
```

In this example, the function named `passbig2`, that does not return a value, has input and output arguments declared as non-scalar `reg`. The header of the C/C++ function is as follows:

```
void passbig2(vec32 *in, vec32 *out)
```

In this example, the parameters `in` and `out` are pointers to type `vec32`. They are pointers because their corresponding arguments are non-scalar type `reg`.

### **Example 8**

Consider the following C/C++ function declared in the Verilog source code:

```
extern void reality (input real real1, output real real2);
```

In this example, the function named `reality`, that does not return a value, has `input` and `output` arguments of declared type `real`. The header of the C/C++ function is as follows:

```
void reality (double *in, double *out)
```

In this example, the parameters `in` and `out` are pointers to type `double` because their corresponding arguments are type `real`.

## Using the `vc_hdrs.h` File

When you compile your design for DirectC (by including the `+vc` compile-time option), VCS writes a file in the current directory named `vc_hdrs.h`. In this file, there are `extern` declarations for all the C/C++ functions that you declared in your Verilog code. For example, if you compile the Verilog code that contains all the C/C++ declarations in the examples in this section, the `vc_hdrs.h` file contains the following `extern` declarations:

```
extern void memory_rewriter(UB* mem2, /*OUT*/UB* mem1);
extern U return_vector_bit(U r3);
extern void receive_pointer(void* r6);
extern void incr(/*INOUT*/U* r7);
extern void* return_pointer();
extern scalar return_reg(scalar r1);
extern void reality(double* real1, /*OUT*/double* real2);
extern void receive_string(char* r5);
extern void passbig2(vec32* r8, /*OUT*/vec32* r9);
extern char* return_string();
extern void passbig1(U* r8, /*OUT*/U* r9);
```

These declarations contain the `/*OUT*/` comment in the parameter specification if its corresponding argument in your Verilog code is of type `output` in the declaration of the function.

These declarations contain the `/*INOUT*/` comment in the parameter specification if its corresponding argument in your Verilog code is of type `inout` in the declaration of the function.

You can copy from these `extern` declarations to the function headers in your C code. If you do, you will always use the right type of parameter in your function header and you do not have to learn the rules for direct access. Let VCS do this for you.

## Access Routines for Multi-Dimensional Arrays

DirectC requires that Verilog multi-dimensional arrays be linearized (turned into arrays of the same size, but with only one dimension). VCS provides routines for obtaining information about Verilog multi-dimensional arrays when using direct access. This section describes these routines.

### **UB \*vc\_arrayElemRef(UB\*, U, ...)**

The `UB*` parameter points to an array, either a single dimensional array or a multi-dimensional array, and the `U` parameters specify indices in the multi-dimensional array. This routine returns a pointer to an element of the array or `NULL` if the indices are outside the range of the array or there is a null pointer.

```
U dgetelem(UB *mem_ptr, int i, int j) {
 int indx;
 U k;
 /* remaining indices are constant */
 UB *p = vc_arrayElemRef(mem_ptr,i,j,0,1);
 k = *p;
 return(k);
}
```

There are specialized versions of this routine for one-, two-, and three-dimensional arrays:

```
UB *vc_array1ElemRef(UB*, U)
UB *vc_array2ElemRef(UB*, U, U)
UB *vc_array3ElemRef(UB*, U, U, U)
```

### **U vc\_getSize(UB\*,U)**

This routine is similar to the `vc_mdaSize()` routine used in abstract access. It returns the following:

- If the U type parameter has a value of 0, it returns the number of indices in an array.
- If the U type parameter has a value greater than 0, it returns the number of values in the index specified by the parameter. There is an error condition if this parameter is out of the range of indices.

If the UB pointer is null, this routine returns 0.

---

## **Using Abstract Access**

In abstract access, VCS creates a descriptor for each argument in a function call. The corresponding formal parameters in the function uses a specially defined pointer to these descriptors called `vc_handle`. In abstract access, you use these “handles” to pass data and values by reference to and from these descriptors.

The idea behind abstract access is that you do not have to worry about the type you use for parameters, because you always use a special pointer type called `vc_handle`.

In abstract access, VCS creates a descriptor for every argument that you enter in the function call in your Verilog code. The `vc_handle` is a pointer to the descriptor for the argument. It is defined as follows:

```
typedef struct VeriC_Descriptor *vc_handle;
```

## Using `vc_handle`

In the function header, the `vc_handle` for a Verilog reg, bit, or memory is based on the order that you declare the `vc_handle` and the order that you entered its corresponding reg, bit, or memory in the function call in your Verilog code. For example, you could have declared the function and called it in your Verilog code as follows:

```
extern "A" void my_function(input bit [31:0] r1,
 input bit [32:0] r2);

module dev1;
reg [31:0] bit1;
reg [32:0] bit2;
initial
begin
.
. .
. .
my_function(bit1,bit2);
. .
. .
end
endmodule
```

Declare the function

Enter first bit1 then bit2 as arguments in the function call

This is using abstract access so VCS created descriptors for `bit1` and `bit2`. These descriptors contain information about their value, but also other information such as whether they are scalar or vector, and whether they are simulating in two- or four-state simulation.

The corresponding header for the C/C++ function is as follows:

```
:
my_function(vc_handle h1, vc_handle h2)
{
:
 up1=vc_2stVectorRef(h1);
 up2=vc_2stVectorRef(h2);
:
}
```

Diagram annotations:

- A callout box points to the parameters `h1` and `h2` with the text: "h1 is the vc\_handle for bit1  
h2 is the vc\_handle for bit2".
- A callout box points to the assignment statements `up1=vc_2stVectorRef(h1);` and `up2=vc_2stVectorRef(h2);` with the text: "A routine that accesses the data structures for bit1 and bit2 using their vc\_handles".

After declaring the `vc_handles`, you can use them to pass data to and from these descriptors.

## Using Access Routines

Abstract access comes with a set of access routines that enable your C/C++ function to pass values to and from the descriptors for the Verilog reg, bit, and memory arguments in the function call.

These access routines use the `vc_handle` to pass values by reference, but the `vc_handle` is not the only type of parameter for many of these routines. These routines also have the following types of parameters:

- Scalar — an unsigned char
- Integers — uninterpreted 32 bits with no implied semantics
- Other types of pointers — primitive types “string” and “pointer”
- Real numbers

The access routines were named to help you to remember their function. Routine names beginning with `vc_get` are for retrieving data from the descriptor for the Verilog parameter. Routine names beginning with `vc_put` are for passing new values to these descriptors.

These routines can convert Verilog representation of simulation values and strings to string representation in C/C++. Strings can also be created in a C/C++ function and passed to Verilog, but you should keep in mind that they can be overwritten in Verilog. Therefore, you should copy them to local buffers if you want them to persist.

The following are the access routines, their parameters, and return values, and examples of how they are used. There is a summary of the access routines at the end of this chapter; see “[Summary of Access Routines](#)” .

### **int vc\_isScalar(vc\_handle)**

Returns a 1 value if the `vc_handle` is for a one-bit reg or bit; returns a 0 value for a vector reg or bit or any memory including memories with scalar elements. For example:

```
extern "A" void scalarfinder(input reg r1,
 input reg [1:0] r2,
 input reg [1:0] array [1:0] r3,
 input reg array [1:0] r4);

module top;
reg r1;
reg [1:0] r2;
reg [1:0] r3 [1:0];
reg r4 [1:0];
initial
scalarfinder(r1,r2,r3,r4);
endmodule
```

In this example, we declare a routine named scalarfinder and input a scalar reg, a vector reg and two memories (one with scalar elements).

The declaration contains the "A" specification for abstract access. You typically include it in the declaration when other functions will use direct access, that is, you have a mix of functions with direct and abstract access.

```
#include <stdio.h>
#include "DirectC.h"

scalarfinder(vc_handle h1, vc_handle h2, vc_handle h3,
vc_handle h4)
{
 int i1 = vc_isScalar(h1),
 i2 = vc_isScalar(h2),
 i3 = vc_isScalar(h3),
 i4 = vc_isScalar(h4);
 printf("\ni1=%d i2=%d i3=%d i4=%d\n\n",i1,i2,i3,i4);
}
```

Parameters h1, h2, h3, and h4 are vc\_handles to regs r1 and r2 and memories r3 and r4, respectively. The function prints the following:

```
i1=1 i2=0 i3=0 i4=0
```

### **int vc\_isVector(vc\_handle)**

This routine returns a 1 value if the vc\_handle is to a vector reg or bit. It returns a 0 value for a vector bit or reg or any memory. For example, using the Verilog code from the previous example, and the following C/C++ function:

```
scalarfinder(vc_handle h1, vc_handle h2, vc_handle h3,
vc_handle h4)
{
```

```

int i1 = vc_isVector(h1),
 i2 = vc_isVector(h2),
 i3 = vc_isVector(h3),
 i4 = vc_isVector(h4);
printf("\ni1=%d i2=%d i3=%d i4=%d\n\n",i1,i2,i3,i4);
}

```

The function prints the following:

```
i1=0 i2=1 i3=0 i4=0
```

### **int vc\_isMemory(vc\_handle)**

This routine returns a 1 value if the vc\_handle is to a memory. It returns a 0 value for a bit or reg that is not a memory. For example, using the Verilog code from the previous example and the following C/C++ function:

```

#include <stdio.h>
#include "DirectC.h"

scalarfinder(vc_handle h1, vc_handle h2, vc_handle h3,
vc_handle h4)
{
int i1 = vc_isMemory(h1),
 i2 = vc_isMemory(h2),
 i3 = vc_isMemory(h3),
 i4 = vc_isMemory(h4);
printf("\ni1=%d i2=%d i3=%d i4=%d\n\n",i1,i2,i3,i4);
}

```

The function prints the following:

```
i1=0 i2=0 i3=1 i4=1
```

### **int vc\_is4state(vc\_handle)**

This routine returns a 1 value if the vc\_handle is to a reg or memory that simulates with four states. It returns a 0 value for a bit or a memory that simulates with two states. For example, the following Verilog code uses metacomments to specify four- and two-state simulation:

```
extern void statefinder (input reg r1,
 input reg [1:0] r2,
 input reg [1:0] array [1:0] r3,
 input reg array [1:0] r4,
 input bit r5,
 input bit [1:0] r6,
 input bit [1:0] array [1:0] r7,
 input bit array [1:0] r8);

module top;
reg /*4value*/ r1;
reg /*4value*/ [1:0] r2;
reg /*4value*/ [1:0] r3 [1:0];
reg /*4value*/ r4 [1:0];
reg /*2value*/ r5;
reg /*2value*/ [1:0] r6;
reg /*2value*/ [1:0] r7 [1:0];
reg /*2value*/ r8 [1:0];
initial
statefinder(r1,r2,r3,r4,r5,r6,r7,r8);
endmodule
```

The C/C++ function that calls the vc\_is4state routine is as follows:

```
#include <stdio.h>
#include "DirectC.h"

statefinder(vc_handle h1, vc_handle h2, vc_handle h3,
 vc_handle h4,vc_handle h5, vc_handle h6,
 vc_handle h7, vc_handle h8)
{
printf("\nThe vc_handles to 4state are:");
```

```

printf("\nh1=%d h2=%d h3=%d h4=%d\n\n",
 vc_is4state(h1),vc_is4state(h2),
 vc_is4state(h3),vc_is4state(h4));
printf("\nThe vc_handles to 4state are:");
printf("\nh5=%d h6=%d h7=%d h8=%d\n\n",
 vc_is4state(h5),vc_is4state(h6),
 vc_is4state(h7),vc_is4state(h8));
}

```

The function prints the following:

```

The vc_handles to 4state are:
h1=1 h2=1 h3=1 h4=1

```

```

The vc_handles to 2state are:
h5=0 h6=0 h7=0 h8=0

```

### **int vc\_is2state(vc\_handle)**

This routine does the opposite of the `vc_is4state` routine. For example, using the Verilog code from the previous example and the following C/C++ function:

```

#include <stdio.h>
#include "DirectC.h"

statefinder(vc_handle h1, vc_handle h2, vc_handle h3,
 vc_handle h4, vc_handle h5, vc_handle h6,
 vc_handle h7, vc_handle h8)
{
 printf("\nThe vc_handles to 4state are:");
 printf("\nh1=%d h2=%d h3=%d h4=%d\n\n",
 vc_is2state(h1),vc_is2state(h2),
 vc_is2state(h3),vc_is2state(h4));
 printf("\nThe vc_handles to 2state are:");
 printf("\nh5=%d h6=%d h7=%d h8=%d\n\n",
 vc_is2state(h5),vc_is2state(h6),
 vc_is2state(h7),vc_is2state(h8));
}

```

The function prints the following:

```
The vc_handles to 4state are:
h1=0 h2=0 h3=0 h4=0
```

```
The vc_handles to 2state are:
h5=1 h6=1 h7=1 h8=1
```

### **int vc\_is4stVector(vc\_handle)**

This routine returns a 1 value if the vc\_handle is to a vector reg. It returns a 0 value if the vc\_handle is to a scalar reg, scalar or vector bit, or memory. For example, using the Verilog code from the previous example, and the following C/C++ function:

```
#include <stdio.h>
#include "DirectC.h"

statefinder(vc_handle h1, vc_handle h2,
 vc_handle h3, vc_handle h4,
 vc_handle h5, vc_handle h6,
 vc_handle h7, vc_handle h8)
{
printf("\nThe vc_handle to a 4state Vector is:");
printf("\nh2=%d \n\n",vc_is4stVector(h2));
printf("\nThe vc_handles to 4state scalars or
memories and 2state are:");
printf("\nh1=%d h3=%d h4=%d h5=%d h6=%d h7=%d h8=%d\n\n",
 vc_is4stVector(h1), vc_is4stVector(h3),
 vc_is4stVector(h4), vc_is4stVector(h5),
 vc_is4stVector(h6), vc_is4stVector(h7),
 vc_is4stVector(h8));
}
```

The function prints the following:

```
The vc_handle to a 4state Vector is:
h2=1
```

```
The vc_handles to 4state scalars or
 memories and 2state are:
h1=0 h3=0 h4=0 h5=0 h6=0 h7=0 h8=0
```

### **int vc\_is2stVector(vc\_handle)**

This routine returns a 1 value if the vc\_handle is to a vector bit. It returns a 0 value if the vc\_handle is to a scalar bit, scalar or vector reg, or to a memory. For example, using the Verilog code from the previous example and the following C/C++ function:

```
#include <stdio.h>
#include "DirectC.h"

statefinder(vc_handle h1, vc_handle h2,
 vc_handle h3, vc_handle h4,
 vc_handle h5, vc_handle h6,
 vc_handle h7, vc_handle h8)
{
 printf("\nThe vc_handle to a 2state Vector is:");
 printf("\nh6=%d \n\n", vc_is2stVector(h6));
 printf("\nThe vc_handles to 2state scalars or
 memories and 4state are:");
 printf("\nh1=%d h2=%d h3=%d h4=%d h5=%d h7=%d h8=%d\n\n",
 vc_is2stVector(h1), vc_is2stVector(h2),
 vc_is2stVector(h3), vc_is2stVector(h4),
 vc_is2stVector(h5), vc_is2stVector(h7),
 vc_is2stVector(h8));
}
```

The function prints the following:

```
The vc_handle to a 2state Vector is:
h6=1
```

```
The vc_handles to 2state scalars or
 memories and 4state are:
h1=0 h2=0 h3=0 h4=0 h5=0 h7=0 h8=0
```

### **int vc\_width(vc\_handle)**

Returns the width of a vc\_handle. For example:

```
void memcheck_int(vc_handle h)
{
 int i;

 int mem_size = vc_arraySize(h);

 /* determine minimal needed width, assuming signed int */
 for (i=0; (1 << i) < (mem_size-1); i++) ;

 if (vc_width(h) < (i+1)) {
 printf("Register too narrow to be assigned %d\n",
 (mem_size-1));
 return;
 }

 for(i=0;i<8;i++) {
 vc_putMemoryInteger(h,i,i*4);
 printf("memput : %d\n",i*4);
 }
 for(i=0;i<8;i++) {
 printf("memget:: %d \n",vc_getMemoryInteger(h,i));
 }
}
```

### **int vc\_arraySize(vc\_handle)**

Returns the number of elements in a memory or multi-dimensional array. The previous example also shows a usage of vc\_arraySize().

### **scalar vc\_getScalar(vc\_handle)**

Returns the value of a scalar reg or bit. For example:

```
void rotate_scalars(vc_handle h1, vc_handle h2, vc_handle
```

```

h3)
{
 scalar a;

 a = vc_getScalar(h1);
 vc_putScalar(h1, vc_getScalar(h2));
 vc_putScalar(h2, vc_getScalar(h3));
 vc_putScalar(h3, a);
 return;
}

```

### **void vc\_putScalar(vc\_handle, scalar)**

Passes the value of a scalar reg or bit to a `vc_handle` by reference. The previous example also shows a usage of `vc_putScalar()`.

### **char vc\_toChar(vc\_handle)**

Returns the 0, 1, x, or z character. For example:

```

void print_scalar(vc_handle h) {
 printf("%c", vc_toChar(h));
 return;
}

```

### **int vc\_toInteger(vc\_handle)**

Returns an int value for a `vc_handle` to a scalar bit or a vector bit of 32 bits or less. For a vector reg or a vector bit with more than 32 bits this routine returns a 0 value and displays the following warning message:

```
DirectC interface warning: 0 returned for 4-state value
(vc_toInteger)
```

The following is an example of Verilog code that calls a C/C++ function that uses this routine:

```

extern void rout1 (input bit onebit, input bit [7:0] mobits);

module top;
reg /*2value*/ onebit;
reg /*2value*/ [7:0] mobits;
initial
begin
rout1(onebit,mobits);
onebit=1;
mobits=128;
rout1(onebit,mobits);
end
endmodule

```

Notice that the function declaration specifies that the parameters are of type bit. It includes metacomments for two-state simulation in the declaration of reg onebit and mobits. There are two calls to the function rout1, before and after values are assigned in this Verilog code.

The following C/C++ function uses this routine:

```

#include <stdio.h>
#include "DirectC.h"

void rout1 (vc_handle onebit, vc_handle mobits)
{
printf("\n\nonebit is %d mobits is %d\n\n",
 vc_toInteger(onebit), vc_toInteger(mobits));
}

```

This function prints the following:

```
onebit is 0 mobits is 0
```

```
onebit is 1 mobits is 128
```

### **char \*vc\_toString(vc\_handle)**

Returns a string that contains the 1, 0, x, and z characters. For example:

```
extern void vector_printer (input reg [7:0] r1);

module test;
reg [7:0] r1,r2;

initial
begin
#5 r1 = 8'bzx01zx01;
#5 vector_printer(r1);
#5 $finish;
end
endmodule

void vector_printer (vc_handle h)
{
vec32 b,*c;
c=vc_4stVectorRef(h) ;
b=*c;
printf("\n b is %x[control] %x[data]\n\n",b.c,b.d) ;
printf("\n b is %s \n\n",vc_toString(h)) ;
}
```

In this example, a vector reg is assigned a value that contains x and z values, as well as, 1 and 0 values. In the abstract access C/C++ function, there are two ways of displaying the value of the reg:

- Recognize that type `vec32` is defined as follows in the `DirectC.h` file:

```
typedef struct {U c; U d;} vec32;
```

In machine memory, there are control, as well as, data bits for Verilog data to differentiate X from 1 and Z from 0 data, so there are c (control) and d (data) data variables in the structure and you must specify which variable when you access the `vec32` type.

- Use the `vc_toString` routine to display the value of the reg that contains X and Z values.

This example displays:

```
b is cc[control 55[data]
```

```
b is zx01zx01
```

### **char \*vc\_toStringF(vc\_handle, char)**

Returns a string that contains the 1, 0, x, and z characters and allows you to specify the format or radix for the display. The `char` parameter can be '`b`', '`o`', '`d`', or '`x`'.

So, if we modify the C/C++ function in the previous example, it is as follows:

```
void vector_printer (vc_handle h)
{
vec32 b,*c;
c=vc_4stVectorRef(h) ;
b=*c;
printf("\n b is %s \n\n",vc_toStringF(h,'b'));
printf("\n b is %s \n\n",vc_toStringF(h,'o'));
printf("\n b is %s \n\n",vc_toStringF(h,'d'));
printf("\n b is %s \n\n",vc_toStringF(h,'x'));
}
```

This example now displays:

```
b is zx01zx01
```

b is XZX

b is X

b is XX

### **void vc\_putReal(vc\_handle, double)**

Passes by reference a real (double) value to a vc\_handle. For example:

```
void get_PI(vc_handle h)
{
 vc_putReal(h, 3.14159265);
}
```

### **double vc\_getReal(vc\_handle)**

Returns a real (double) value from a vc\_handle. For example:

```
void print_real(vc_handle h)
{
 printf("[print_real] %f\n", vc_getReal(h));
}
```

### **void vc\_putValue(vc\_handle, char \*)**

This function passes, by reference, through the vc\_handle, a value represented as a string containing the 0, 1, x, and z characters. For example:

```
extern void check_vc_putvalue(output reg [] r1);

module tester;
reg [31:0] r1;
```

```

initial
begin
check_vc_putvalue(r1);
$display("r1=%0b",r1);
$finish;
end
endmodule

```

In this example, the C/C++ function is declared in the Verilog code specifying that the function passes a value to a four-state reg (and, therefore, can hold X and Z values).

```

#include <stdio.h>
#include "DirectC.h"

void check_vc_putvalue(vc_handle h)
{
 vc_putValue(h, "10xz");
}

```

The `vc_putValue` routine passes the string "10xz" to the reg `r1` through the `vc_handle`. The Verilog code displays:

```
r1=10xz
```

### **void vc\_putValueF(vc\_handle, char \*, char )**

This function passes by reference, through the `vc_handle`, a value for which you specify a radix with the third parameter. The valid radices are 'b', 'o', 'd', and 'x'. For example the following Verilog code declares a function named `assigner` that uses this routine:

```

extern void assigner (output reg [31:0] r1,
 output reg [31:0] r2,
 output reg [31:0] r3,
 output reg [31:0] r4);

module test;

```

```

reg [31:0] r1,r2,r3,r4;
initial
begin
assigner(r1,r2,r3,r4);
$display("r1=%0b in binary r1=%0d in decimal\n",r1,r1);
$display("r2=%0o in octal r2 =%0d in decimal\n",r2,r2);
$display("r3=%0d in decimal r3=%0b in binary\n",r3,r3);
$display("r4=%0h in hex r4= %0d in decimal\n\n",r4,r4);
$finish;
end
endmodule

```

The following is the C/C++ function:

```

#include <stdio.h>
#include "DirectC.h"

void assigner (vc_handle h1, vc_handle h2, vc_handle h3,
vc_handle h4)
{
vc_putValueF(h1, "10",'b');
vc_putValueF(h2, "11",'o');
vc_putValueF(h3, "10",'d');
vc_putValueF(h4, "aff",'x');
}

```

The Verilog code displays the following:

```

r1=10 in binary r1=2 in decimal

r2=11 in octal r2 =9 in decimal

r3=10 in decimal r3=1010 in binary

r4=aff in hex r4= 2815 in decimal

```

```
void vc_putPointer(vc_handle, void*)
void *vc_getPointer(vc_handle)
```

These functions pass a generic type of pointer or string to a `vc_handle` by reference. Do not use these functions for passing Verilog data (the values of Verilog signals). Use them for passing C/C++ data instead. `vc_putPointer` passes this data by reference to Verilog and `vc_getPointer` receives this data in a pass by reference from Verilog. You can also use these functions for passing Verilog strings.

For example:

```
extern void passback(output string, input string);
extern void printer(input pointer);

module top;
reg [31:0] r2;
initial
begin
passback(r2, "abc");
printer(r2);
end
endmodule
```

This Verilog code passes the string "abc" to the `passback` C/C++ function by reference, and that function passes it by reference to reg `r2`. The Verilog code then passes it by reference to the C/C++ function `printer` from reg `r2`.

```
passback(vc_handle h1, vc_handle h2)
{
vc_putPointer(h1, vc_getPointer(h2));
}

printer(vc_handle h)
{
printf("Procedure printer prints the string value %s\n\n",

```

```
 vc_getPointer (h)) ;
}
```

The function named `printer` prints the following:

```
Procedure printer prints the string value abc
```

### **void vc\_StringToVector(char \*, vc\_handle)**

Converts a C string (a pointer to a sequence of ASCII characters terminated with a null character) into a Verilog string (a vector with 8-bit groups representing characters). For example:

```
extern "C" stringFullPath(string filename);
// find full path to the file
// C string obtained from C domain

extern "A" void s2v(string, output reg[]);
// string-to-vector
// wrapper for vc_StringToVector().

`define FILE_NAME_SIZE 512

module Test;
 reg [`FILE_NAME_SIZE*8:1] file_name;
 // this file_name will be passed to the Verilog code that
 // expects
 // a Verilog-like string
 .
 .
 .
 initial begin
 s2vFullPath("myStimulusFile"), file_name); // C-string to
 // Verilog-string
 // bits of 'file_name' represent now 'Verilog string'
 end
 .
 .
 .
endmodule
```

The C code is as follows:

```
void s2v(vc_handle hs, vc_handle hv) {
 vc_StringToVector((char *)vc_getPointer(hs), hv);
}
```

### **void vc\_VectorToString(vc\_handle, char \*)**

Converts a vector value to a string value.

### **int vc\_getInteger(vc\_handle)**

Same as vc\_toInteger.

### **void vc\_putInteger(vc\_handle, int)**

Passes an int value by reference through a vc\_handle to a scalar reg or bit or a vector bit that is 32 bits or less. For example:

```
void putter (vc_handle h1, vc_handle h2, vc_handle h3,
vc_handle h4)
{
int a,b,c,d;
a=1;
b=2;
c=3;
d=9999999;

vc_putInteger(h1,a);
vc_putInteger(h2,b);
vc_putInteger(h3,c);
vc_putInteger(h4,d);
}
```

### **vec32 \*vc\_4stVectorRef(vc\_handle)**

Returns a vec32 pointer to a four-state vector. Returns NULL if the specified vc\_handle is not to a four-state vector reg. For example:

```

typedef struct vector_descriptor {
 int width; /* number of bits */
 int is4stte; /* TRUE/FALSE */
} VD;

void WriteVector(vc_handle file_handle, vc_handle a_vector)
{
 FILE *fp;
 int n, size;
 vec32 *v;
 VD vd;
 fp = vc_getPointer(file_handle);

 /* write vector's size and type */
 vd.is4state = vc_is4stVector(a_vector);
 vd.width = vc_width(a_vector);
 size = (vd.width + 31) >> 5; /* number of 32-bit chunks */
 /* printf("writing: %dbits, is 4 state: %d, #chunks:
 %d\n", vd.width, vd.is4state, size); */
 n = fwrite(&vd, sizeof(vd), 1, fp);
 if (n != 1) {
 printf("Error: write failed.\n");
 }

 /* write the vector into a file; vc_*stVectorRef
 is a pointer to the actual Verilog vector */
 if (vc_is4stVector(a_vector)) {
 n = fwrite(vc_4stVectorRef(a_vector), sizeof(vec32),
 size, fp);
 } else {
 n = fwrite(vc_2stVectorRef(a_vector), sizeof(U),
 size, fp);
 }
 if (n != size) {
 printf("Error: write failed for vector.\n");
 }
}

```

**U \*vc\_2stVectorRef(vc\_handle)**

Returns a U pointer to a bit vector that is larger than 32 bits. If you specify a short bit vector (32 bits or fewer) this routine returns a NULL value. For example:

In this example, the Verilog code declares a 32-bit vector bit, `r1`, and a 33-bit vector bit, `r2`. The values of both are passed to the C/C++ function `big_2state`.

When we pass the short bit vector `r1` to `vc_2stVectorRef`, it returns a null value because it has fewer than 33 bits. This is not the case when we pass bit vector `r2` because it has more than 32 bits. Notice that from right to left, the first 32 bits of `r2` have a value of 2 and the MSB 33rd bit has a value of 1. This is significant in how the C/C++ stores this data.

```
#include <stdio.h>
#include "DirectC.h"

big_2state(vc_handle h1, vc_handle h2)
{
 U u1,*up1,u2,*up2;
 int i;
```

```

int size;

up1=vc_2stVectorRef(h1);
up2=vc_2stVectorRef(h2);
if (up1){ /* check for the null value returned to up1 */
 u1=*up1; } else{
 u1=0;
 printf("\nShort 2 state vector passed to up1\n");
}
if (up2){ /* check for the null value returned to up2 */
 size = vc_width (h2); /* to find out the number of bits */
 /* in h2 */
 printf("\n width of h2 is %d\n",size);
 size = (size + 31) >> 5; /* to get number of 32-bit chunks */
 printf("\n the number of chunks needed for h2 is %d\n\n",
 size);
 printf("loading into u2");
 for(i = size - 1; i >= 0; i--){
 u2=up2[i]; /* load a chunk of the vector */
 printf(" %x",up2[i]);}
 printf("\n");}
else{
 u2=0;
 printf("\nShort 2 state vector passed to up2\n");}
}

```

In this example, the short bit vector is passed to the `vc_2stVectorRef` routine, so it returns a null value to pointer `up1`. Then the long bit vector is passed to the `vc_2stVectorRef` routine, so it returns a pointer to the Verilog data for vector bit `r2` to pointer `up2`.

It checks for the null value in `up1`. If it doesn't have a null value, whatever it points to is passed to `u1`. If it does have a null value, the function prints a message about the short bit vector. In this example, you can expect it to print this message.

Still later in the function, it checks for the null value in `up2` and the size of the long bit vector that is passed to the second parameter. Then, because Verilog values are stored in 32-bit chunks in C/C++, the function finds out how many chunks are needed to store the long bit vector. It then loads one chunk at a time into `u2` and prints the chunk starting with the most significant bits. This function displays the following:

```
Short 2 state vector passed to up1
width of h2 is 33
the number of chunks needed for h2 is 2
loading into u2 1 2
```

```
void vc_get4stVector(vc_handle, vec32 *)
void vc_put4stVector(vc_handle, vec32 *)
```

Passes a four-state vector by reference to a `vc_handle` to and from an array in C/C++ function. `vc_get4stVector` receives the vector from Verilog and passes it to the array and `vc_put4stVector` passes the array to Verilog.

These routines work only if there are enough elements in the array for all the bits in the vector. The array must have an element for every 32 bit in the vector plus an additional element for any remaining bits. For example:

```
extern void copier (input reg [67:0] r1,
 output reg [67:0] r2);

module top;

reg [67:0] r1,r2;

initial
```

```
begin
 r1 [67:65] = 3'b111;
 r1 [64:33] = 32'bzz;
 r1 [32:0] = 32'b00;
 copier(r1,r2);
 $display("r1=%0b\n",r1);
 $display("r2=%0b\n",r2);

end
endmodule
```

In this example, there are two 68-bit regs. Values are assigned to all the bits of one reg and both of these regs are parameters to the C/C++ function named `copier`.

```
copier(vc_handle h1, vc_handle h2)
{
vec32 holder[3];
vc_get4stVector(h1,holder);
vc_put4stVector(h2,holder);
}
```

This function declares a `vec32` array of three elements named `holder`. It uses three elements because its parameters are 68-bit regs so we need an element for every 32 bits and one more for the remaining four bits.

The Verilog code displays the following:

```
void vc_get2stVector(vc_handle, U *)
void vc_put2stVector(vc_handle, U *)
```

Passes a two-state vector by reference to a vc\_handle to and from an array in C/C++ function. `vc_get2stVector` receives the vector from Verilog and passes it to the array and `vc_put2stVector` passes the array to Verilog.

These routines, just like the `vc_get4stVector` and `vc_put4stVector` routines, work only if there are enough elements in the array for all the bits in the vector. The array must have an element for every 32 bit in the vector plus an additional element for any remaining bits.

The only differences between these routines and the `vc_get4stVector` and `vc_put4stVector` routines are the type of data they pass, two- or four-state simulation values, and the type you declare for the array in the C/C++ function.

### **UB \*vc\_MemoryRef(vc\_handle)**

Returns a pointer of type UB that points to a memory in Verilog. For example:

```
extern void mem_doer (input reg [1:0] array [3:0]
 memory1, output reg [1:0] array
 [31:0] memory2) ;

module top;
reg [1:0] memory1 [3:0];
reg [1:0] memory2 [31:0];
initial
begin
memory1 [3] = 2'b11;
memory1 [2] = 2'b10;
memory1 [1] = 2'b01;
memory1 [0] = 2'b00;
mem_doer(memory1,memory2) ;
```

```

$display("memory2[31]=%0d" , memory2[31]) ;
end
endmodule

```

In this example, we declare two memories, one with 4 addresses, `memory1`, the other with 32 addresses, `memory2`. We assign values to the addresses of `memory1`, and then pass both memories to the C/C++ function `mem_doer`.

```

#include <stdio.h>
#include "DirectC.h"

void mem_doer(vc_handle h1, vc_handle h2)
{
 UB *p1, *p2;
 int i;

 p1 = vc_MemoryRef(h1);
 p2 = vc_MemoryRef(h2);

 for (i = 0; i < 8; i++) {
 memcpy(p2,p1,8);
 p2 += 8;
 }
}

```

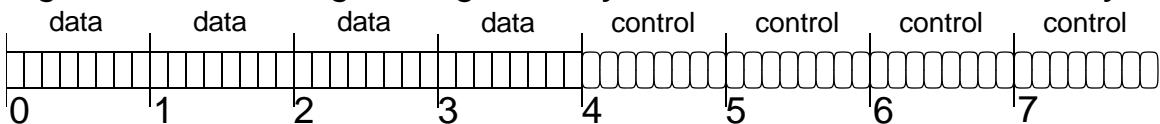
The purpose of the C/C++ function `mem_doer` is to copy the four elements in Verilog memory `memory1` into the 32 elements of `memory2`.

The `vc_MemoryRef` routines return pointers to the Verilog memories and the machine memory locations they point to are also pointed to by pointers `p1` and `p2`. Pointer `p1` points to the location of Verilog memory `memory1`, and `p2` points to the location of Verilog memory `memory2`.

The function uses a for loop to copy the data from Verilog memory `memory1` to Verilog memory `memory2`. It uses the standard `memcpy` function to copy a total of 64 bytes by copying eight bytes eight times.

This example copies a total of 64 bytes because each element of `memory2` is only two bits wide, but for every eight bits in an element in machine memory there are two bytes, one for data and another for control. The bits in the control byte specify whether the data bit with a value of 0 is actually 0 or Z, or whether the data bit with a value of 1 is actually 1 or X.

*Figure 20-4 Storing Verilog Memory Elements in Machine Memory*



In an element in a Verilog memory, for each eight bits in the element there is a data byte and a control byte with an additional set of bytes for a remainder bit. So, if a memory had 9 bits it would need two data bytes and two control bytes. If it had 17 bits it would need three data bytes and three control bytes. All the data bytes precede the control bytes.

Therefore, `memory1` needs 8 bytes of machine memory (four for data and four for control) and `memory2` needs 64 bytes of machine memory (32 for data and 32 for control). Therefore, the C/C++ function needs to copy 64 bytes.

The Verilog code displays the following:

```
memory2 [31] =3
```

## **UB \*vc\_MemoryElemRef(vc\_handle, U indx)**

Returns a pointer to an element (word, address or index) of a Verilog memory. You specify the `vc_handle` of the memory and the element. For example:

```
extern void mem_elem_doir(inout reg [25:1] array [3:0]
memory1);

module top;
reg [25:1] memory1 [3:0];
initial
begin
memory1 [0] = 25'b00000000xxxxxxxx11111111;
$display("memory1 [0] = %0b\n", memory1[0]);
mem_add_doir(memory1);
$display("\nmemory1 [3] = %0b", memory1[3]);
end
endmodule
```

In this example, there is a Verilog memory with four addresses, each element has 25 bits. This means that the Verilog memory needs eight bytes of machine memory because there is a data byte and a control byte for every eight bits in an element, with an additional data and control byte for any remainder bits.

In this example, in element 0 the 25 bits are assigned, from right to left, eight 1 bits, eight unknown x bits, eight 0 bits, and one high impedance z bit.

```
#include <stdio.h>
#include "DirectC.h"

void mem_elem_doir(vc_handle h)
{
 U indx;
 UB *p1, *p2, t [8];
```

```

 indx = 0;
 p1 = vc_MemoryElemRef(h, indx);
 indx = 3;
 p2 = vc_MemoryElemRef(h, indx);
 memcpy(p2,p1,8);

 memcpy(t,p2,8);
 printf(" %d from t[0], %d from t[1]\n",
 (int)t[0], (int) t[1]);
 printf(" %d from t[2], %d from t[3]\n",
 (int)t[2], (int) t[3]);
 printf(" %d from t[4], %d from t[5]\n",
 (int)t[4], (int)t[5]);
 printf(" %d from t[6], %d from t[7]\n",
 (int)t[6], (int)t[7]);

}

```

C/C++ function `mem_elem_doir` uses the `vc_MemoryElemRef` routine to return pointers to addresses 0 and 3 in Verilog `memory1` and pass them to UB pointers `p1` and `p2`. The standard `memcpy` routine then copies the eight bytes for address 0 to address 3.

The remainder of the function is additional code to show you data and control bytes. The eight bytes pointed to by `p2` are copied to array `t` and then the elements of the array are printed.

The combined Verilog and C/C++ code displays the following:

```

memory1 [0] = z0000000xxxxxxxxx11111111

255 from t[0], 255 from t[1]
0 from t[2], 0 from t[3]
0 from t[4], 255 from t[5]
0 from t[6], 1 from t[7]

memory1 [3] = z0000000xxxxxxxxx11111111

```

As you can see, function `mem_elem_door` passes the contents of the Verilog memory `memory1` element 0 to element 3.

In array `t`, the elements contain the following:

- [0] The data bits for the eight 1 values assigned to the element.
- [1] The data bits for the eight X values assigned to the element
- [2] The data bits for the eight 0 values assigned to the element
- [3] The data bit for the Z value assigned to the element
- [4] The control bits for the eight 1 values assigned to the element
- [5] The control bits for the eight X values assigned to the element
- [6] The control bits for the eight 0 values assigned to the element
- [7] The control bit for the Z value assigned to the element

### **scalar vc\_getMemoryScalar(vc\_handle, U indx)**

Returns the value of a one-bit memory element. For example:

```
extern void bitflipper (inout reg array [127:0] mem1);

module test;
reg mem1 [127:0];
initial
begin
mem1 [0] = 1;
$display("mem1[0]=%0d",mem1[0]);
bitflipper(mem1);
$display("mem1[0]=%0d",mem1[0]);
$finish;
end
endmodule
```

In this example of Verilog code, we declare a memory with 128 one-bit elements, assign a value to element 0, and display its value before and after we call a C/C++ function named `bitflipper`.

```
#include <stdio.h>
```

```

#include "DirectC.h"

void bitflipper(vc_handle h)
{
 scalar holder=vc_getMemoryScalar(h, 0);
 holder = ! holder;
 vc_putMemoryScalar(h, 0, holder);
}

```

In this example, we declare a variable of type scalar, named `holder`, to hold the value of the one-bit Verilog memory element. The routine `vc_getMemoryScalar` returns the value of the element to the variable. The value of `holder` is inverted and then the variable is included as a parameter in the `vc_putMemoryScalar` routine to pass the value to that element in the Verilog memory.

The Verilog code displays the following:

```

mem[0]=1
mem[0]=0

```

### **void vc\_putMemoryScalar(vc\_handle, U indx, scalar)**

Passes a value of type scalar to a Verilog memory element. You specify the memory by `vc_handle` and the element by the `indx` parameter. This routine is used in the previous example.

### **int vc\_getMemoryInteger(vc\_handle, U indx)**

Returns the integer equivalent of the data bits in a memory element whose bit-width is 32 bits or less. For example:

```

extern void mem_elem_halver (inout reg [] array [] memX);

module test;
reg [31:0] mem1 [127:0];

```

```

reg [7:0] mem2 [1:0];
initial
begin
mem1 [0] = 999;
mem2 [0] = 8'b1111xxxx;
$display("mem1[0]=%0d",mem1[0]);
$display("mem2[0]=%0d",mem2[0]);
mem_elem_halver(mem1);
mem_elem_halver(mem2);
$display("mem1[0]=%0d",mem1[0]);
$display("mem2[0]=%0d",mem2[0]);
$finish;
end
endmodule

```

In this example, when the C/C++ function is declared on our Verilog code it does not specify a bit-width or element range for the inout argument to the `mem_elem_halver` C/C++ function, because in the Verilog code we call the C/C++ function twice, with a different memory each time and these memories have different bit widths and different element ranges.

Notice that we assign a value that included X values to the 0 element in memory `mem2`.

```

#include <stdio.h>
#include "DirectC.h"

void mem_elem_halver(vc_handle h)
{
int i = vc_getMemoryInteger(h, 0);
i = i/2;
vc_putMemoryInteger(h, 0, i);
}

```

This C/C++ function inputs the value of an element and then outputs half that value. The `vc_getMemoryInteger` routine returns the integer equivalent of the element you specify by `vc_handle` and

index number, to an int variable `i`. The function halves the value in `i`. Then the `vc_putMemoryInteger` routine passes the new value by value to the specified memory element.

The Verilog code displays the following before the C/C++ function is called twice with the different memories as the arguments:

```
mem1 [0] =999
mem2 [0]=X
```

Element `mem2 [0]` has an X value because half of its binary value is x and the value is displayed with the %d format specification and, in this example, a partially unknown value is just an unknown value. After the second call of the function, the Verilog code displays:

```
mem1 [1] =499
mem2 [0]=127
```

This occurs because before calling the function, `mem1 [0]` had a value of 999, and after the call it has a value of 499 which is as close as it can get to half the value with integer values.

Before calling the function, `mem2 [0]` had a value of 8'b1111xxxx, but the data bits for the element would all be 1s (11111111). It's the control bits that specify 1 from x and this routine only deals with the data bits. So, the `vc_getMemoryInteger` routine returned an integer value of 255 (the integer equivalent of the binary 11111111) to the C/C++ function, which is why the function outputs the integer value 127 to `mem2 [0]`.

### **void vc\_putMemoryInteger(vc\_handle, U indx, int)**

Passes an integer value to a memory element that is 32 bits or fewer. You specify the memory by `vc_handle` and the element by the `indx` argument. This routine is used in the previous example.

### **void vc\_get4stMemoryVector(vc\_handle, U indx, vec32 \*)**

Copies the value in an Verilog memory element to an element in an array. This routine copies both the data and control bytes. It copies them into an array of type `vec32` which is defined as follows:

```
typedef struct { U c; U d; } vec32;
```

Therefore, type `vec32` has two members, `c` and `d`, for control and data information. This routine always copies to the 0 element of the array. For example:

```
extern void mem_elem_copier (inout reg [] array [] memX);

module test;
reg [127:0] mem1 [127:0];
reg [7:0] mem2 [64:0];
initial
begin
mem1 [0] = 999;
mem2 [0] = 8'b0000000z;
$display("mem1[0]=%0d",mem1[0]);
$display("mem2[0]=%0d",mem2[0]);
mem_elem_copier(mem1);
mem_elem_copier(mem2);
$display("mem1[32]=%0d",mem1[32]);
$display("mem2[32]=%0d",mem2[32]);
$finish;
end
endmodule
```

In the Verilog code, a C/C++ function is declared that is called twice. Notice the value assigned to `mem2 [0]`. The C/C++ function copies the values to another element in the memory.

```
#include <stdio.h>
#include "DirectC.h"

void mem_elem_copier(vc_handle h)
```

```

{
vec32 holder[1];
vc_get4stMemoryVector(h,0,holder);
vc_put4stMemoryVector(h,32,holder);
printf(" holder[0].d is %d holder[0].c is %d\n\n",
 holder[0].d,holder[0].c);
}

```

This C/C++ function declares an array of type `vec32`. We must declare an array for this type, but as shown here, we specify that it have only one element. The `vc_get4stMemoryVector` routine copies the data from the Verilog memory element (in this example, specified as the 0 element) to the 0 element of the `vec32` array. It always copies to the 0 element. The `vc_put4stMemoryVector` routine copies the data from the `vec32` array to the Verilog memory element (in this case, element 32).

The call to `printf` is to show you how the Verilog data is stored in element 0 of the `vec32` array.

The Verilog and C/C++ code display the following:

```

mem1 [0]=999
mem2 [0]=Z
holder[0].d is 999 holder[0].c is 0

holder[0].d is 768 holder[0].c is 1

mem1 [32]=999
mem2 [32]=Z

```

As you can see, the function does copy the Verilog data from one element to another in both memories. When the function is copying the 999 value, the `c` (control) member has a value of 0; when it is copying the 8'b0000000z value, the `c` (control) member has a value of 1 because one of the control bits is 1, the rest are 0.

**void vc\_put4stMemoryVector(vc\_handle, U indx, vec32 \*)**

Copies Verilog data from a `vec32` array to a Verilog memory element. This routine is used in the previous example.

**void vc\_get2stMemoryVector(vc\_handle, U indx, U \*)**

Copies the data bytes, but not the control bytes, from a Verilog memory element to an array in your C/C++ function. For example, if you use the Verilog code from the previous example, but simulate in two-state and use the following C/C++ code:

```
#include <stdio.h>
#include "DirectC.h"

void mem_elem_copier(vc_handle h)
{
 U holder[1];
 vc_get2stMemoryVector(h, 0, holder);
 vc_put2stMemoryVector(h, 32, holder);

}
```

The only difference here is that we declare the array to be of type `U` instead and we do not copy the control bytes, because there are none in two-state simulation.

**void vc\_put2stMemoryVector(vc\_handle, U indx, U \*)**

Copies Verilog data from a `U` array to a Verilog memory element. This routine is used in the previous example.

### **void vc\_putMemoryValue(vc\_handle, U idx, char \*)**

This routine works like the vc\_putValue routine except that is for passing values to a memory element instead of to a reg or bit. You enter an argument to specify the element (index) to which you want the routine to pass the value. For example:

```
#include <stdio.h>
#include "DirectC.h"

void check_vc_putvalue(vc_handle h)
{
 vc_putMemoryValue(h, 0, "10xz");
}
```

### **void vc\_putMemoryValueF(vc\_handle, U idx, char, char \*)**

This routine works like the vc\_putValueF routine except that it is for passing values to a memory element instead of to a reg or bit. You enter an argument to specify the element (index) to which you want the routine to pass the value. For example:

```
#include <stdio.h>
#include "DirectC.h"

void assigner (vc_handle h1, vc_handle h2, vc_handle h3,
vc_handle h4)
{
 vc_putMemoryValueF(h1, 0, "10", 'b');
 vc_putMemoryValueF(h2, 0, "11", 'o');
 vc_putMemoryValueF(h3, 0, "10", 'd');
 vc_putMemoryValueF(h4, 0, "aff", 'x');
```

### **char \*vc\_MemoryString(vc\_handle, U indx)**

This routine works like the vc\_toString routine except that it used is for passing values to/from memory elements instead of to a reg or bit. You enter an argument to specify the element (index) whose value you want the routine to pass. For example:

```
extern void memcheck_vec(inout reg[] array[]) ;

module top;
reg [0:7] mem[0:7];
integer i;

initial
begin
 for(i=0;i<8;i=i+1) begin
 mem[i] = 8'b00000111;
 $display("Verilog code says \\"mem [%0d] = %0b\\\"", i,mem[i]);
 end

 memcheck_vec(mem);
end

endmodule
```

The C/C++ function that calls vc\_MemoryString is as follows:

```
#include <stdio.h>
#include "DirectC.h"

void memcheck_vec(vc_handle h)
{
 int i;

 for(i= 0; i<8;i++) {
 printf("C/C++ code says \"mem [%d] is %s
\"\\n",i,vc_MemoryString(h,i));
 }
}
```

```
 }
}
```

The Verilog and C/C++ code display the following:

```
Verilog code says "mem [0] = 111"
Verilog code says "mem [1] = 111"
Verilog code says "mem [2] = 111"
Verilog code says "mem [3] = 111"
Verilog code says "mem [4] = 111"
Verilog code says "mem [5] = 111"
Verilog code says "mem [6] = 111"
Verilog code says "mem [7] = 111"
C/C++ code says "mem [0] is 00000111 "
C/C++ code says "mem [1] is 00000111 "
C/C++ code says "mem [2] is 00000111 "
C/C++ code says "mem [3] is 00000111 "
C/C++ code says "mem [4] is 00000111 "
C/C++ code says "mem [5] is 00000111 "
C/C++ code says "mem [6] is 00000111 "
C/C++ code says "mem [7] is 00000111 "
```

### **char \*vc\_MemoryStringF(vc\_handle, U indx, char)**

This routine works like the `vc_MemoryString` function except that you specify a radix with the third parameter. The valid radices are '`b`', '`o`', '`d`', and '`x`'. For example:

```
extern void memcheck_vec(inout reg[] array[]);

module top;
reg [0:7] mem[0:7];

initial begin
mem[0] = 8'b00000111;
$display("Verilog code says \\"mem[0]=%0b radix b\\\"",mem[0]);
$display("Verilog code says \\"mem[0]=%0o radix o\\\"",mem[0]);
$display("Verilog code says \\"mem[0]=%0d radix d\\\"",mem[0]);
$display("Verilog code says \\"mem[0]=%0h radix h\\\"",mem[0]);
memcheck_vec(mem);
```

```
end

endmodule
```

The C/C++ function that calls `vc_MemoryStringF` is as follows:

```
#include <stdio.h>
#include "DirectC.h"

void memcheck_vec(vc_handle h)
{

printf("C/C++ code says \"mem [0] is %s radix b\"\n",
 vc_MemoryStringF(h, 0, 'b'));
printf("C/C++ code says \"mem [0] is %s radix o\"\n",
 vc_MemoryStringF(h, 0, 'o'));
printf("C/C++ code says \"mem [0] is %s radix d\"\n",
 vc_MemoryStringF(h, 0, 'd'));
printf("C/C++ code says \"mem [0] is %s radix x\"\n",
 vc_MemoryStringF(h, 0, 'x'));
}
```

The Verilog and C/C++ code display the following:

```
Verilog code says "mem [0]=111 radix b"
Verilog code says "mem [0]=7 radix o"
Verilog code says "mem [0]=7 radix d"
Verilog code says "mem [0]=7 radix h"
C/C++ code says "mem [0] is 00000111 radix b"
C/C++ code says "mem [0] is 007 radix o"
C/C++ code says "mem [0] is 7 radix d"
C/C++ code says "mem [0] is 07 radix x"
```

### **void vc\_FillWithScalar(vc\_handle, scalar)**

This routine fills all the bits or a reg, bit, or memory with all 1, 0, x, or z values (you can choose only one of these four values).

You specify the value with the scalar argument, which can be a variable of the scalar type. The scalar type is defined in the DirectC.h file as:

```
typedef unsigned char scalar;
```

You can also specify the value with integer arguments as follows:

|   |                    |
|---|--------------------|
| 0 | Specifies 0 values |
| 1 | Specifies 1 values |
| 2 | Specifies z values |
| 3 | Specifies x values |

If you declare a scalar type variable, enter it as the argument, and assign only the 0, 1, 2, or 3 integer values to it, they specify filling the Verilog reg, bit, or memory with the 0, 1, z, or x values.

You can use the following definitions from the DirectC.h file to specify these values:

```
#define scalar_0 0
#define scalar_1 1
#define scalar_z 2
#define scalar_x 3
```

The following Verilog and C/C++ code shows you how to use this routine to fill a reg and a memory using the following values:

```
extern void filler (inout reg [7:0] r1,
 inout reg [7:0] array [1:0] r2,
 inout reg [7:0] array [1:0] r3);
module top;
reg [7:0] r1;
reg [7:0] r2 [1:0];
reg [7:0] r3 [1:0];
initial
```

```

begin
$display("r1 is %0b",r1);
$display("r2[0] is %0b",r2[0]);
$display("r2[1] is %0b",r2[1]);
$display("r3[0] is %0b",r3[0]);
$display("r3[1] is %0b",r3[1]);
filler(r1,r2,r3);
$display("r1 is %0b",r1);
$display("r2[0] is %0b",r2[0]);
$display("r2[1] is %0b",r2[1]);
$display("r3[0] is %0b",r3[0]);
$display("r3[1] is %0b",r3[1]);
end
endmodule

```

The C/C++ code for the function is as follows:

```

#include <stdio.h>
#include "DirectC.h"

filler(vc_handle h1, vc_handle h2, vc_handle h3)
{
 scalar s = 1;
 vc_FillWithScalar(h1,s);
 vc_FillWithScalar(h2,0);
 vc_FillWithScalar(h3,scalar_z);
}

```

The Verilog code displays the following:

```

r1 is xxxxxxxx
r2[0] is xxxxxxxx
r2[1] is xxxxxxxx
r3[0] is xxxxxxxx
r3[1] is xxxxxxxx
r1 is 11111111
r2[0] is 0
r2[1] is 0
r3[0] is zzzzzzzz
r3[1] is zzzzzzzz

```

### **char \*vc\_argInfo(vc\_handle)**

Returns a string containing the information about the argument in the function call in your Verilog source code. For example, if you have the following Verilog source code:

```
extern void show(reg [] array []);
module tester;
reg [31:0] mem [7:0];
reg [31:0] mem2 [16:1];
reg [64:1] mem3 [32:1];
initial begin
 show(mem);
 show(mem2);
 show(mem3);
end
endmodule
```

Verilog memories `mem`, `mem2`, and `mem3` are all arguments to the function named `show`. If that function is defined as follows:

```
#include <stdio.h>
#include "DirectC.h"

void show(vc_handle h)
{
 printf("%s\n", vc_argInfo(h)); /* notice \n after the
string */
}
```

This routine prints the following:

```
input reg[0:31] array[0:7]
input reg[0:31] array[0:15]
input reg[0:63] array[0:31]
```

### **int vc\_Index(vc\_handle, U, ...)**

Internally, a multi-dimensional array is always stored as a one-dimensional array and this makes a difference in how it can be accessed. In order to avoid duplicating many of the previous access routines for multi-dimensional arrays, the access process is split into two steps. The first step, which this routine performs, is to translate the multiple indices into a single index of a linearized array. The second step is for another access routine to perform an access operation on the linearized array.

This routine returns the index of a linearized array or returns -1 if the U-type parameter is not an index of a multi-dimensional array or the vc\_handle parameter is not a handle to a multi-dimensional array of the reg data type.

```
/* get the sum of all elements from a 2-dimensional slice
 of a 4-dimensional array */
int getSlice(vc_handle vh_array, vc_handle vh_idx1,
vc_handle vh_idx2) {

 int sum = 0;
 int i1, i2, i3, i4, idx;

 i1 = vc_getInteger(vh_idx1);
 i2 = vc_getInteger(vh_idx2);
 /* loop over all possible indices for that slice */
 for (i3 = 0; i3 < vc_mdaSize(vh_array, 3); i3++) {

 for (i4 = 0; i4 < vc_mdaSize(vh_array, 4); i4++) {

 idx = vc_Index(vh_array, i1, i2, i3, i4);
 sum += vc_getMemoryInteger(vh_array, idx);
 }
 }
 return sum;
}
```

There are specialized, more efficient versions for two- and three-dimensional arrays. They are as follows:

```
int vc_Index2(vc_handle, U, U)
```

Specialized version of `vc_Index()` where the two U parameters are the indices in a two-dimensional array.

```
int vc_Index3(vc_handle, U, U, U)
```

Specialized version of `vc_Index()` where the two U parameters are the indices in a three-dimensional array.

### **U vc\_mdaSize(vc\_handle, U)**

Returns the following:

- If the U-type parameter has a value of 0, it returns the number of indices in the multi-dimensional array.
- If the U-type parameter has a value greater than 0, it returns the number of values in the index specified by the parameter. There is an error condition if this parameter is out of the range of indices.
- If the `vc_handle` parameter is not an array, it returns 0.

## **Summary of Access Routines**

[Table 20-6](#) summarizes all the access routines described in the previous section.

**Table 20-6 Summary of Access Routines**

| <b>Access Routine</b>                             | <b>Description</b>                                                                                                                                                                |
|---------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <code>int vc_isScalar(vc_handle)</code>           | Returns a 1 value if the vc_handle is for a one-bit reg or bit. It returns a 0 value for a vector reg or bit or any memory including memories with scalar elements.               |
| <code>int vc_isVector(vc_handle)</code>           | This routine returns a 1 value if the vc_handle is to a vector reg or bit. It returns a 0 value for a vector bit or reg or any memory.                                            |
| <code>int vc_isMemory(vc_handle)</code>           | This routine returns a 1 value if the vc_handle is to a memory. It returns a 0 value for a bit or reg that is not a memory.                                                       |
| <code>int vc_is4state(vc_handle)</code>           | This routine returns a 1 value if the vc_handle is to a reg or memory that simulates with four states. It returns a 0 value for a bit or a memory that simulates with two states. |
| <code>int vc_is2state(vc_handle)</code>           | This routine does the opposite of the vc_is4state routine.                                                                                                                        |
| <code>int vc_is4stVector(vc_handle)</code>        | This routine returns a 1 value if the vc_handle is to a vector reg. It returns a 0 value if the vc_handle is to a scalar reg, scalar or vector bit, or to a memory.               |
| <code>int vc_is2stVector(vc_handle)</code>        | This routine returns a 1 value if the vc_handle is to a vector bit. It returns a 0 value if the vc_handle is to a scalar bit, scalar or vector reg, or to a memory.               |
| <code>int vc_width(vc_handle)</code>              | Returns the width of a vc_handle.                                                                                                                                                 |
| <code>int vc_arraySize(vc_handle)</code>          | Returns the number of elements in a memory.                                                                                                                                       |
| <code>scalar vc_getScalar(vc_handle)</code>       | Returns the value of a scalar reg or bit.                                                                                                                                         |
| <code>void vc_putScalar(vc_handle, scalar)</code> | Passes the value of a scalar reg or bit to a vc_handle by reference.                                                                                                              |
| <code>char vc_toChar(vc_handle)</code>            | Returns the 0, 1, x, or z character.                                                                                                                                              |
| <code>int vc_toInteger(vc_handle)</code>          | Returns an int value for a vc_handle to a scalar bit or a vector bit of 32 bits or less.                                                                                          |
| <code>char *vc_toString(vc_handle)</code>         | Returns a string that contains the 1, 0, x, and z characters.                                                                                                                     |

| Access Routine                                                                  | Description                                                                                                                                                                                                                                                                                                                                                                                                |
|---------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| char<br>*vc_toStringF(vc_handle,<br>char)                                       | Returns a string that contains the 1, 0, x, and z characters and allows you to specify the format or radix for the display. The char parameter can be 'b', 'o', 'd', or 'x'.                                                                                                                                                                                                                               |
| void<br>vc_putReal(vc_handle,<br>double)                                        | Passes by reference a real (double) value to a vc_handle.                                                                                                                                                                                                                                                                                                                                                  |
| double<br>vc_getReal(vc_handle)                                                 | Returns a real (double) value from a vc_handle.                                                                                                                                                                                                                                                                                                                                                            |
| void<br>vc_putValue(vc_handle,<br>char *)                                       | This function passes, by reference through the vc_handle, a value represented as a string containing the 0, 1, x, and z characters.                                                                                                                                                                                                                                                                        |
| void<br>vc_putValueF(vc_handle,<br>char, char *)                                | This function passes by reference through the vc_handle a value for which you specify a radix with the third parameter. The valid radices are 'b', 'o', 'd', and 'x'.                                                                                                                                                                                                                                      |
| void<br>vc_putPointer(vc_handle,<br>void*)<br>void<br>*vc_getPointer(vc_handle) | These functions pass, by reference to a vc_handle, a generic type of pointer or string. Do not use these functions for passing Verilog data (the values of Verilog signals). Use it for passing C/C++ data. vc_putPointer passes this data by reference to Verilog and vc_getPointer receives this data in a pass by reference from Verilog. You can also use these functions for passing Verilog strings. |
| void<br>vc_StringToVector(char *,<br>vc_handle)                                 | Converts a C string (a pointer to a sequence of ASCII characters terminated with a null character) into a Verilog string (a vector with 8-bit groups representing characters).                                                                                                                                                                                                                             |
| void<br>vc_VectorToString(vc_handle,<br>char *)                                 | Converts a vector value to a string value.                                                                                                                                                                                                                                                                                                                                                                 |
| int<br>vc_getInteger(vc_handle)                                                 | Same as vc_tolinteger.                                                                                                                                                                                                                                                                                                                                                                                     |
| void<br>vc_putInteger(vc_handle,<br>int)                                        | Passes an int value by reference through a vc_handle to a scalar reg or bit or a vector bit that is 32 bits or less.                                                                                                                                                                                                                                                                                       |

| Access Routine                                                                                   | Description                                                                                                                                                                                                                 |
|--------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| vec32<br>*vc_4stVectorRef(vc_handle)<br>)                                                        | Returns a vec32 pointer to a four state vector.<br>Returns NULL if the specified vc_handle is not to a four-state vector reg.                                                                                               |
| U<br>*vc_2stVectorRef(vc_handle)<br>)                                                            | This routine returns a U pointer to a bit vector that is larger than 32 bits. If you specify a short bit vector (32 bits or fewer), this routine returns a NULL value.                                                      |
| void<br>vc_get4stVector(vc_handle,<br>vec32 *)<br>void<br>vc_put4stVector(vc_handle,<br>vec32 *) | Passes a four-state vector by reference to a vc_handle to and from an array in C/C++ function.<br>vc_get4stVector receives the vector from Verilog and passes it to the array. vc_put4stVector passes the array to Verilog. |
| void<br>vc_get2stVector(vc_handle,<br>U *)<br>void<br>vc_put2stVector(vc_handle,<br>U *)         | Passes a two state vector by reference to a vc_handle to and from an array in C/C++ function.<br>vc_get2stVector receives the vector from Verilog and passes it to the array. vc_put4stVector passes the array to Verilog.  |
| UB<br>*vc_MemoryRef(vc_handle)                                                                   | Returns a pointer of type UB that points to a memory in Verilog.                                                                                                                                                            |
| UB<br>*vc_MemoryElemRef(vc_handle, U indx)                                                       | Returns a pointer to an element (word, address or index) of a Verilog memory. You specify the vc_handle of the memory and the element.                                                                                      |
| scalar<br>vc_getMemoryScalar(vc_handle, U indx)                                                  | Returns the value of a one-bit memory element.                                                                                                                                                                              |
| void<br>vc_putMemoryScalar(vc_handle, U indx, scalar)                                            | Passes a value, of type scalar, to a Verilog memory element. You specify the memory by vc_handle and the element by the indx parameter.                                                                                     |
| int<br>vc_getMemoryInteger(vc_handle, U indx)                                                    | Returns the integer equivalent of the data bits in a memory element whose bit-width is 32 bits or less.                                                                                                                     |
| void<br>vc_putMemoryInteger(vc_handle, U indx, int)                                              | Passes an integer value to a memory element that is 32 bits or fewer. You specify the memory by vc_handle and the element by the indx parameter.                                                                            |

| Access Routine                                              | Description                                                                                                                                                                                                                            |
|-------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| void<br>vc_get4stMemoryVector(vc_handle, U indx, vec32 *)   | Copies the value in an Verilog memory element to an element in an array. This routine copies both the data and control bytes. It copies them into an array of type vec32.                                                              |
| void<br>vc_put4stMemoryVector(vc_handle, U indx, vec32 *)   | Copies Verilog data from a vec32 array to a Verilog memory element.                                                                                                                                                                    |
| void<br>vc_get2stMemoryVector(vc_handle, U indx, U *)       | Copies the data bytes, but not the control bytes, from a Verilog memory element to an array in your C/C++ function.                                                                                                                    |
| void<br>vc_put2stMemoryVector(vc_handle, U indx, U *)       | Copies Verilog data from a U array to a Verilog memory element.                                                                                                                                                                        |
| void<br>vc_putMemoryValue(vc_handle, U indx, char *)        | This routine works like the vc_putValue routine except that it is for passing values to a memory element instead of to a reg or bit. You enter an parameter to specify the element (index) you want the routine to pass the value to.  |
| void<br>vc_putMemoryValueF(vc_handle, U indx, char, char *) | This routine works like the vc_putValueF routine except that it is for passing values to a memory element instead of to a reg or bit. You enter an parameter to specify the element (index) you want the routine to pass the value to. |
| char<br>*vc_MemoryString(vc_handle, U indx)                 | This routine works like the vc_toString routine except that it is for passing values from memory element instead of to a reg or bit. You enter an parameter to specify the element (index) you want the routine to pass the value of.  |
| char<br>*vc_MemoryStringF(vc_handle, U indx, char)          | This routine works like the vc_MemoryString function except that you specify a radix with the third parameter. The valid radices are 'b', 'o', 'd', and 'x'.                                                                           |
| void<br>vc_FillWithScalar(vc_handle, scalar)                | This routine fills all the bits of a reg, bit, or memory with all 1, 0, x, or z values (you can choose only one of these four values).                                                                                                 |

| Access Routine                                 | Description                                                                                                                                                                                                                                                                                                                                                                                  |
|------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <code>char *vc_argInfo(vc_handle)</code>       | Returns a string containing the information about the parameter in the function call in your Verilog source code.                                                                                                                                                                                                                                                                            |
| <code>int vc_Index(vc_handle, U, ...)</code>   | Returns the index of a linearized array, or returns -1 if the U-type parameter is not an index of a multi-dimensional array, or the vc_handle parameter is not a handle to a multi-dimensional array of the reg data type.                                                                                                                                                                   |
| <code>int vc_Index2(vc_handle, U, U)</code>    | Specialized version of vc_Index() where the two U parameters are the indices in a two-dimensional array.                                                                                                                                                                                                                                                                                     |
| <code>int vc_Index3(vc_handle, U, U, U)</code> | Specialized version of vc_Index() where the two U parameters are the indexes in a three-dimensional array.                                                                                                                                                                                                                                                                                   |
| <code>U vc_mdaSize(vc_handle, U)</code>        | If the U type parameter has a value of 0, it returns the number of indices in multi-dimensional array. If the U type parameter has a value greater than 0, it returns the number of values in the index specified by the parameter. There is an error condition if this parameter is out of the range of indices. If the vc_handle parameter is not a multi-dimensional array, it returns 0. |

---

## Enabling C/C++ Functions

The `+vc` compile-time option is required for enabling the direct call of C/C++ functions in your Verilog code. When you use this option you can enter the C/C++ source files on the `vcs` command line. These source files must have a `.c` extension.

There are suffixes that you can append to the `+vc` option to enable additional features. You can append all of them to the `+vc` option in any order. For example:

```
+vc+abstract+allhdrs+list
```

These suffixes specify the following:

+abstract

Specifies that you are using abstract access through vc\_handles to the data structures for the Verilog arguments.

When you include this suffix, all functions use abstract access except those with "C" in their declaration; these exceptions use direct access.

If you omit this suffix, all functions use direct access except those with the "A" in their declaration; these exceptions use abstract access.

+allhdrs

Writes the vc\_hdtrs.h file that contains external function declarations that you can use in your Verilog code.

+list

Displays on the screen all the functions that you called in your Verilog source code. In this display, void functions are called procedures. The following is an example of this display:

---

The following external functions have been actually called:

```
procedure receive_string
procedure passbig2
function return_string
procedure passbig1
procedure memory_rewriter
function return_vector_bit
procedure receive_pointer
procedure incr
function return_pointer
```

```
function return_reg
```

---

```
[DirectC interface]
```

---

## Mixing Direct And Abstract Access

If you want some C/C++ functions to use direct access and others to use abstract access, you can do so by using a combination of "A" or "C" entries for abstract or direct access in the declaration of the function and the use of the `+abstract` suffix. The following table shows the result of these combinations:

|                               | <b>no +abstract suffix</b> | <b>include the +abstract suffix</b> |
|-------------------------------|----------------------------|-------------------------------------|
| extern<br>(no mode specified) | direct access              | abstract access                     |
| extern "A"                    | abstract access            | abstract access                     |
| extern "C"                    | direct access              | direct access                       |

## Specifying the DirectC.h File

The C/C++ functions need the `DirectC.h` file in order to use abstract access. This file is located in `$VCS_HOME/include` (and there is a symbolic link to it at `$VCS_HOME/platform/lib/DirectC.h`). You need to tell VCS where to look for it. You can accomplish this in the following three ways:

- Copy the `$VCS_HOME/include/DirectC.h` file to your current directory. VCS will always look for this file in your current directory.
- Establish a link in the current directory to the `$VCS_HOME/include/DirectC.h` file.
- Include the `-CC` option as follows:

```
-CC "-I$VCS_HOME/include"
```

---

## Extended BNF for External Function Declarations

A partial EBNF specification for external function declaration is as follows:

```
source_text ::= description +
description ::= module | user_defined_primitive |
extern_function_declaration
extern_function_declaration ::= extern access_mode
extern_func_type extern_function_name (
list_of_extern_func_args ?) ;
access_mode ::= ("A" | "C") ?
```

Note:

If access mode is not specified, then the command-line option +abstract rules; default mode is "C".]

```
extern_func_type ::= void | reg | bit |
DirectC_primitive_type | bit_vector_type
bit_vector_type ::= bit [constant_expression :
constant_expression]
list_of_extern_func_args ::= extern_func_arg
(, extern_func_arg) *
extern_func_arg ::= arg_direction ? arg_type
optional_arg_name ?
```

Note:

Argument direction (i.e., input, output, inout) applies to all arguments that follow it until the next direction occurs; the default direction is input.

```
arg_direction ::= input | output | inout
arg_type ::= bit_or_reg_type | array_type |
DirectC_primitive_type
bit_or_reg_type ::= (bit | reg) optional_vector_range ?
optional_vector_range ::= [(constant_expression :
constant_expression) ?]
array_type ::= bit_or_reg_type array [(constant_expression :
constant_expression) ?]
DirectC_primitive_type ::= int | real | pointer | string
```

In this specification, `extern_function_name` and `optional_arg_name` are user-defined identifiers.

# 21

## SAIF Support

---

The Synopsys Power Compiler enables you to perform power analysis and power optimization for your designs by entering the `power` command at the `vcs` prompt. This command outputs Switching Activity Interchange Format (SAIF) files for your design.

SAIF files support signals and ports for monitoring as well as constructs such as generates, enumerated types, records, array of arrays, and integers.

This chapter covers the following topics:

- [Using SAIF Files](#)
- [SAIF System Tasks](#)
- [The Flows to Generate a Backward SAIF File](#)
- [“SAIF Support for Two-Dimensional Memories in v2k Designs”](#)

- “UCLI SAIF Dumping”
  - Criteria for Choosing Signals for SAIF Dumping
- 

## Using SAIF Files

VCS has native SAIF support so you no longer need to specify any compile-time options to use SAIF files. If you want to switch to the old flow of dumping SAIF files with the PLI, you can continue to give the option `-P $VPOWER_TAB $VPOWER_LIB` to VCS, and the flow will not use the native support.

Note the following when using VCS native support for SAIF files:

- VCS does not need any additional switches.
  - VCS does not need a Power Compiler specific tab file (and the corresponding library)
  - VCS does not need any additional settings.
  - Functionality is built into VCS.
- 

## SAIF System Tasks

This section describes SAIF system tasks that you can use at the command line prompt.

`$set_toggle_region`

Specifies a module instance (or scope) for which VCS records switching activity in the generated SAIF file. Syntax:

`$set_toggle_region(instance[, instance] );`

`$toggle_start`

Instructs VCS to start monitoring switching activity.

Syntax:

```
$toggle_start();
```

`$toggle_stop`

Instructs VCS to stop monitoring switching activity.

Syntax

```
$toggle_stop();
```

`$toggle_reset`

Sets the toggle counter to 0 for all the nets in the current toggle region.

Syntax:

```
$toggle_reset();
```

`$toggle_report`

Reports switching activity to an output file.

Syntax:

```
$toggle_report("outputFile", synthesisTimeUnit,
Scope);
```

This task has a slight change in native SAIF implementation compared to PLI-based implementation. VCS considers only the arguments specified here for processing. Other arguments have no meaning.

VCS does not report signals in modules defined under the 'celldefine compiler directive.

```
$read_lib_saif
```

Allows you to read in a state dependent and path dependent (SDPD) library forward SAIF file. It registers the state and path dependent information on the scope. It also monitors the internal nets of the design.

Syntax:

```
$read_lib_saif("inputFile");
```

```
$set_gate_level_monitoring
```

Allows you to turn on/off the monitoring of nets in the design if \$read\_lib\_saif is present in the design.

Syntax:

```
$set_gate_level_monitoring("on" | "off" | "rtl_on");
```

"rtl\_on"

All reg type of objects are monitored for toggles. Net type of objects are monitored only if it is a cell highconn. This is the default monitoring policy.

"off"

net type of objects are not monitored.

"on"

reg type of objects are monitored only if it is a cell highconn.

For more details on these task calls, refer to the *Power Compiler User Guide*.

Note:

The \$read\_mpm\_saif, \$toggle\_set, and \$toggle\_count tasks in the PLI-based vpower.tab file are obsolete and no longer supported.

---

## The Flows to Generate a Backward SAIF File

You can generate the following kinds of backward (or output) SAIF files:

- an SDPD backward SAIF file — using a library forward (or input) SAIF file
- a non-SDPD backward SAIF file — without using a library forward (or input) SAIF file.

---

### Generating an SDPD Backward SAIF File

To generate an SDPD backward SAIF file, include the SAIF system tasks in the module definition containing the

`$read_lib_saif("inputFile")` system task.

For example:

```
initial begin
 $read_lib_saif("inputFile");
 $set_toggle_region(Scope);
 // initialization of Verilog signals
 M
 $toggle_start;
 // testbench
 M
 $toggle_stop;
 $toggle_report("outputFile", timeUnit,Scope);
end
```

The `$set_toggle_region(Scope)` system task's scope argument must be one level higher in the design hierarchy than the scope of the module in the library forward SAIF file, for which you intend VCS MX to generate the backward SAIF file.

For example, if VCS monitors instance `top.u_dut.u_saif_module`, the argument to the `$set_toggle_region` system task is `top.u_dut`, as follows:

```
$set_toggle_region(top.u_dut);
```

Enclose the modules listed in the library forward SAIF file, those from which you intend VCS to monitor and generate the backward SAIF file, between '`celldefine`' and '`endcelldefine`' compiler directives.

---

## Generating a Non-SPDP Backward SAIF File

If you are not including a library forward (or input) SAIF file, include the `$set_gate_level_monitoring("on")` system task with the other SAIF system tasks.

For example:

```
initial begin
 $set_gate_level_monitoring("on");
 $set_toggle_region(Scope);
 // initialization of Verilog signals, and then:
 $toggle_start;
 // testbench
 M
 $toggle_stop;
 $toggle_report("outputFile", timeUnit,Scope);
end
```

---

## **SAIF Support for Two-Dimensional Memories in v2k Designs**

SAIF supports monitoring of two-dimensional memories in v2k designs.

You must pass the `mda` keyword to the `$set_gate_level_monitoring` system task to monitor two-dimensional memories in v2k designs.

Note:

You must pass the `+memcbk` compile-time option at vcs command-line, to dump two-dimensional wire or register.

If you want to dump through the UCLI command, you must pass the `mda` string to the `power -gate_level` command, as shown in the below section.

---

## **UCLI SAIF Dumping**

The following is the use model for UCLI SAIF dumping:

```
% simv -ucli
ucli% power -gate_level on mda
ucli% power <scope>
ucli% power -enable
ucli% run 100
ucli% power -disable
ucli% power -report <saif_filename> <timeUnit> <modulename>
ucli% quit
```

---

## Criteria for Choosing Signals for SAIF Dumping

VCS supports only scalar wire and reg, as well as vector wire and reg, for monitoring. It does not consider wire/reg declared within functions, tasks and named blocks for dumping. Also, it does not support bit selects and part selects as arguments to `$set_toggle_region` or `$toggle_report`. In addition, it monitors cell highconns based on the policy.

# 23

## Encrypting Source Files

---

You can use VCS to encrypt your HDL source files in such a way that they can be used only with VCS. This chapter describes how to use VCS to encrypt the source files for this purpose.

VCS uses the 128-bit Advanced Encryption Standard (AES) to encrypt the Verilog and VHDL files. The 128-bit key is generated internally by VCS. This 128-bit encryption methodology is exclusive to VCS, and can be decrypted only by VCS.

You can choose to encrypt only certain parts of your source files or entire files using either of the following methods:

- “[Using Compiler Directives or Pragmas](#)” on page 2
- “[Using Automatic Protection Options](#)” on page 5

---

## Using Compiler Directives or Pragmas

You can use VCS to encrypt selected parts of your source files. In order to achieve this, complete the following steps:

1. Enclose the Verilog code that you want to encrypt between the `'protect128` and the `'endprotect128` compiler directives.  
Enclose the VHDL code that you want to encrypt between the `--protect128` and `--endprotect128` pragmas.
2. Analyze the files with the `-protect128` option. For example:

```
% vlogan -protect128 foo.v
% vcs -protect128 foo.v
```

When you analyze the design with the `-protect128` option, VCS creates new files with the `.vp` or `.vhdp` extension for each Verilog or VHDL file specified at the command line. For example, VCS creates `foo.vp` and `foo.vhdp` when you execute the commands listed above.

In the `.vp` files, VCS replaces the `'protect128` and `'endprotect128` compiler directives with the `'protected128` and `'endprotected128` compiler directives, and encrypts the code in between these directives. In the `.vhdp` files, VCS replaces the `--protect128` and `--endprotect128` pragmas with the `--protected128` and `-endprotected128` pragmas, and encrypts everything in between.

**Note:**

By default, the encrypted .vp or .vhdp files are saved in the same directory as the source files. You can change this location by using the -putprotect128 analysis option. For example, the following command saves the foo.vp encrypted file in the ./out directory:

```
% vlogan -putprotect128 ./out -protect128 foo.v
```

**Note:**

- If you specify the protect and protect128 analysis options on the same vcs command line, VCS ignores the protect128 option and uses the protect option. It also reports a warning message.
- The Protect128 and genip options are mutually exclusive, you cannot specify both of these options on the same vcs command line.

---

## Example

The following Verilog file illustrates the use of `protect128 and `endprotect128 to mark the code that needs to be encrypted:

```
module top(inp, outp);
 input [7:0] inp;
 output [7:0] outp;
 reg [7:0] count;
 assign outp = count;
 always
 begin:counter
 `protect128 //begin protected region
 reg [7:0] int;
 count = 0;
 int = inp;
 while (int)
 begin
 if (int [0]) count = count + 1;
```

```

 int = int >> 1;
 end
`endprotect128 //end protected region
end
endmodule

```

The contents of the .vp file that is generated using the -protect128 analysis option is shown below:

```

module top(inp, outp) ;
 input [7:0] inp;
 output [7:0] outp;
 reg [7:0] count;
 assign outp = count;
 always
 begin:counter
`protected128
P$<-:U="&
Y0_+\[?7SYR'AYPDX_H5!KR%>.,^%':>9A_+^UF,6X]=F0S&\-5<;IQ
P:F]/8/)U-%R2 MKD.FB#6?UC"0>XE?R>]^
3)4@K<.5;* [DX>, +7P@1!S%QA\MME
P>E#R7!*4#IQNK
LU):.T[LT=4Y6DP5VWKXN^)F[@L34;C>,=1D'8!9ILX<,AE[6H
P^<P2#1%RY0X??,5)! ,84>FHD @RVX1K=E9UK5,[7Q$^;
U\,<JLM#>2@OZ! "!"7
P&ZV60$$CTNE)N+A%]UN19] (H;D,L#V&?&=X) (U!CGVRF3],F!+IC2/
KRLG:(- (60
P'>K\BRT_2/_/(5^%FBS#-
*O$IB[R.;V"1SMJBB:"P4#J="EH".5^?!MYZ#>84>:Q.
`endprotected128
//end protected region
end
endmodule

```

---

## Using Automatic Protection Options

You can encrypt an entire Verilog or VHDL file using the

- autoprotect128, -auto2protect128, or
- auto3protect128 analysis options.

Note:

All these options take precedence over the -protect128 option.  
The -auto3protect128 option takes precedence over  
-auto2protect128 and -autoprotect128 options,  
-auto2protect128 takes precedence over  
-autoprotect128, and -autoprotect128 takes precedence  
over -protect128.

### -autoprotect128

For Verilog files, VCS encrypts the module port list (or UDP terminal list) along with the body of the module (or UDP).

For VHDL files, VCS encrypts the ports, generics, and bodies of entity declarations, and all of the contents of architecture bodies, package declarations, package bodies, and configuration declarations.

### -auto2protect128

For Verilog files, VCS encrypts only the body of the module or UDP. It does not encrypt port lists or UDP terminal lists. This option produces a syntactically correct Verilog module or UDP header statement.

For VHDL files, VCS encrypts everything other than the ports in the entity declarations. Though the generated file is syntactically correct file, it may not be semantically correct as the VHDL port declarations can refer to generics in the encrypted portion.

-auto3protect128

This option is similar to the `-auto2protect128` option except for the following differences.

For Verilog files, VCS does not encrypt parameters preceding the ports declaration in a Verilog module.

For VHDL files, VCS does not encrypt the generic clause of entity declarations.

# 23

## Integrating VCS with Vera

---

Vera® is a comprehensive testbench automation solution for module, block and full system verification. The Vera testbench automation system is based on the OpenVera™ language. This is an intuitive, high-level, object-oriented programming language developed specifically to meet the unique requirements of functional verification.

You can use Vera with VCS to simulate your testbench and design. This chapter describes the required environment settings and usage model to integrate Vera with VCS.

---

## Setting Up Vera and VCS

To use Vera, you must set the Vera environment as shown below:

```
% setenv VERA_HOME Vera_Installation
% setenv PATH $VERA_HOME/bin:$PATH
% setenv LM_LICENSE_FILE license_path:$LM_LICENSE_FILE
or
% setenv SNPSLMD_LICENSE_FILE license_path:$SNPSLMD_LICENSE_FILE
```

Note:

If you set the SNPSLMD\_LICENSE\_FILE environment variable, then VCS ignores the LM\_LICENSE\_FILE environment variable.

Set the VCS environment as shown below:

```
% setenv VCS_HOME VCS_Installation
% setenv PATH $VCS_HOME/bin:$PATH
% setenv LM_LICENSE_FILE license_path:$LM_LICENSE_FILE
or
% setenv SNPSLMD_LICENSE_FILE license_path:$SNPSLMD_LICENSE_FILE
```

Note:

If you set the SNPSLMD\_LICENSE\_FILE environment variable, then VCS ignores the LM\_LICENSE\_FILE environment variable.

For more information on VCS installation, see “[Setting Up the Simulator](#)” .

---

## Using Vera with VCS

The usage model to use Vera with VCS includes the following steps:

- Compile your OpenVera code using Vera

This will generate a `.vro` file and a `filename_vshell.v` file.  
The `filename_vshell.v` is a Verilog file.

The following table lists the Vera option to generate a shell file based on your design topology:

**Table 0-1.**

| Option             | Description                                                                                                               |
|--------------------|---------------------------------------------------------------------------------------------------------------------------|
| <code>-vlog</code> | Generates a Verilog shell file, <code>filename_vshell.v</code> . Use this option if your design is a Verilog-only design. |

- Compile your design and the `filename_vshell.v` file using the `-vera` option. This option is required to use Vera with VCS.
- Simulate the design by specifying the `.vro` file created in the first step using the `+vera_load` runtime option. You can also specify this `.vro` file in the `vera.ini` file in your working directory as shown in the following example:

```
vera_load = tb_top.vro
```

See the *Vera User Guide* for more information.

---

## Usage Model

Use the following usage model to compile OpenVera code using Vera:

```
% vera -cmp [Vera_options] OpenVera_files
```

See the *Vera User Guide* for a list of Vera compilation options.

### Compilation

```
% vcs [compile_options] -vera verilog_filelist
filename_vshell.v
```

### Simulation

```
% simv [simv_options] +vera_load=file.vro
```

# 25

## Integrating VCS with HSIM

---

HSIM-VCS DKI is a new mixed-signal simulation implementation using the Synopsys HSIM and VCS simulators. Unlike the VPI/PLI implementation of mixed-signal simulation previously used by HSIM with VPI/PLI standard compliant digital simulators, HSIM-VCS DKI uses a Direct Kernel Interface to exchange information between the HSIM analog simulator and the VCS digital simulator. This approach is similar to the NanoSim-VCS mixed-signal simulation flow and provides more flexibility and better performance over VPI/PLI-based mixed-signal simulation.

HSIM-VCS DKI mixed-signal simulation supports:

- The use of both Verilog top-level netlists and SPICE top-level netlists.
- Donut partitioning, which is the arbitrary instantiation of Spice subcircuits and Verilog modules under either Spice or Verilog throughout the design hierarchy.
- The use of either instance-based or cell-based partitioning.

---

## Environment Setup

A working installation of VCS and a matching version of HSIM are required to run DKI mixed-signal simulation. The compatibility table for versions of HSIM and VCS that work together is available at: <https://solvnet.synopsys.com/retrieve/020828.html>.

The following environment variables must be set:

```
% setenv LM_LICENSE_FILE Location_of_License_File
or
% setenv SNPSLMD_LICENSE_FILE license_file_path
% setenv VCS_HOME VCS_install_directory
% setenv HSIM_HOME HSIM_install_directory
% set path = ($VCS_HOME/bin $HSIM_HOME/bin $path)
% setenv HSIM_64 1
```

Unset the variable `HSIM_64` if you are using in 32-bit mode.

Note:

If you set the `SNPSLMD_LICENSE_FILE` environment variable, then VCS ignores the `LM_LICENSE_FILE` environment variable.

---

## Usage Model

### To Compile

The syntax to start the compile process is:

```
% vcs -ad=init_file Verilog_source_files [other_VCS_options]
```

This links the `libvcsdkihsim.so` file and generates an executable called `simv`. A directory called `simv.daidir` is created that contains all of the generated files for VCS and HSIM to run.

`-ad=init_file`

Enables mixed-signal simulation. In the absence of the *init\_file*, VCS looks for the default initialization file `vcsAD.init`.

## To Run Simulation

The syntax to run the mixed-signal simulation is:

```
% simv [runtime_options]
```

This dynamically loads the `libvcsdkihsim.so` file and runs the simulation.

For more information about VCS-HSIM mixed-signal simulation, see the HSIM documentation.

# 26

## Integrating VCS with NanoSim

---

VCS-NanoSim (VCS-NS) allows a mixed-signal simulation solution, which enables simulating a design that is partly modeled in both analog and digital.

It is recommended that before starting a mixed-signal simulation, both SPICE subcircuits and Verilog modules should be error-free (individually tested).

This chapter briefly describes the environment setup and usage model of VCS-NanoSim mixed-signal simulations. For more information, see the `co_sim.pdf` file in the NanoSim documentation (`/NanoSim_installation/doc/ns/manuals/co_sim.pdf`).

VCS-NanoSim mixed-signal simulation supports:

- The use of both Verilog top-level netlists and SPICE top-level netlists.
- Donut partitioning, which is the arbitrary instantiation of Spice subcircuits and Verilog modules under either Spice or Verilog throughout the design hierarchy.

- The use of either instance-based or cell-based partitioning.
- 

## Environment Setup

A working installation of VCS and a matching version of NanoSim are required to run mixed-signal simulation. The compatibility table for versions of VCS and NanoSim that work together can be found at: <https://solvnet.synopsys.com/retrieve/020828.html>.

The following environment variables must be set:

### Licenses

```
setenv LM_LICENSE_FILE license_file_path
```

or

```
setenv SNPSLMD_LICENSE_FILE license_file_path
```

Note:

If you set the SNPSLMD\_LICENSE\_FILE environment variable, then VCS ignores the LM\_LICENSE\_FILE environment variable.

### For NanoSim

```
source NanoSim_install_directory/CSHRC_platform
```

### For VCS

```
setenv VCS_HOME vcs_install_directory
set path = ($VCS_HOME/bin $path)
```

---

# Usage Model

## To Compile

The syntax to start the compile process is:

```
% vcs -ad=init_file verilog_source_files [other_vcs_options]
-ad=init_file
```

Enables mixed-signal simulation. In the absence of the *init\_file*, VCS looks for the default initialization file, `vcsAD.init`.

## To Run Simulation

The syntax to run the mixed-signal simulation is:

```
% simv [runtime_options]
```

# 27

## Integrating VCS with Specman

---

The VCS ESI Adapter integrates VCS with the Specman Elite. This chapter describes how to prepare a stand-alone Verilog design for use with the ESI interface. See the *Specman Elite User Guide* for further information.

The VCS ESI adapter is implemented as a Verilog PLI application, and is called `specman.v`. This file is generated using the `specman` command, as explained later in the chapter.

This chapter includes the following topics:

- “Type Support”
- “Usage Flow”
- “Using specrun and specview”
- “Adding Specman Objects To DVE”

- “Version Checker for Specman”
- 

## Type Support

The VCS ESI adapter supports the following Verilog Types:

- nets
- wires
- registers
- integers
- array of registers (verilog memory)

Other Verilog support:

- Verilog macros
- Verilog tasks
- Verilog functions
- Verilog events
- in/out/inout ports

---

## Usage Flow

This section explains how to integrate Specman with VCS.

---

### Setting Up The Environment

To set up the environment to run Specman with VCS:

- Set your `VCS_HOME` and `VRST_HOME` environment variables:

```
% setenv VCS_HOME [vcs_installation_path]
% set path = ($VCS_HOME/bin $path)
% setenv VRST_HOME [specman installation]
```

- Source your `env.csh` file for Specman:

```
% source ${VRST_HOME}/env.csh
```

For 64-bit simulation, source your `env.csh` file as shown below:

```
% source ${VRST_HOME}/env.csh -64bit
```

---

### Specman e Code Accessing Verilog

Create the Verilog stub file `specman.v` and compile all Verilog files including `specman.v` as shown below:

```
% specman -c "load [top_e_file]; write stubs -verilog;"
```

Compile the design as given in the following table:

| <b>Elaboration Mode</b> |                      | <b>Commands</b>                                                                                                                               | <b>Generated Executable</b> |
|-------------------------|----------------------|-----------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------|
| Compile                 | Execution with -o    | "% sn_compile.sh -sim vcs \<br>-sim_flags "[compile-<br>time_options] \<br>-debug top_cfg/entity/module" -o <exe_name><br><top_e_file>.e<br>" | vcs_<exe_name>              |
|                         | Execution without -o | "% sn_compile.sh -sim vcs \<br>-sim_flags "[compile-<br>time_options] \<br>-debug top_cfg/entity/module" <top_e_file>.e<br>"                  | vcs_<top_e_file>            |
| Loaded                  | Execution with -o    | "% sn_compile.sh -sim vcs \<br>-sim_flags "[compile-<br>time_options] \<br>-debug top_cfg/entity/module" -o <exe_name><br>"                   | <exe_name>                  |
|                         | Execution without -o | "% sn_compile.sh -sim vcs \<br>-sim_flags "[compile-<br>time_options] \<br>-debug top_cfg/entity/module"<br>"                                 | vcs_specman                 |

Simulate the design as given below:

- In Compiled mode:

```
% vcs_simv -ucli [simv_options]
ucli> sn "test"
ucli> run
```

```
ucli> quit
```

Note:

Notice the use of the `-o` option with this script in compile mode to change the name of the executable generated to `vcs_simv` from the default name given by the script which is `vcs_<top_e_file>`.

- In Loaded mode:

```
% simv -ucli [simv_options]
ucli% sn "load <top_e_file>; test"
ucli% run
ucli% quit
```

Note:

Notice the use of the `-o` option with this script in loaded mode to change the name of the executable generated to `simv` from the default name given by the script which is `vcs_specman`.

---

## Using specrun and specview

VCS allows you to use the following Specman utilities to simulate your design:

- `specrun`
- `specview`

`specrun` invokes Specman in batch mode, while `specview` invokes the Specman GUI. The usage model is shown below:

## Using `specrun`

- In Compiled mode:

```
% specrun -p "test -seed=1;" simv [simv_options]
```

- In Loaded mode:

```
% specrun -p "load [top_e_file]; test -seed=1;" \
simv [simv_options]
```

## Using `specview`

Set the environment variable `SPECMAN_OUTPUT_TO_TTY` as shown below:

```
% setenv SPECMAN_OUTPUT_TO_TTY 1
```

- In Compiled mode:

```
% specview -p "test -seed=1;" -sio simv -gui
```

- In Loaded mode:

```
% specview -p "load [top_e_file]; test -seed=1;" \
-sio simv -gui
```

You can also specify VCS runtime options with `specview` or `specrun` as shown in the following examples:

### *Example 27-1 To Invoke DVE Using `specview`*

The following command invokes the Specman GUI, as well as, DVE.

```
% specview -p "test -seed=1;" -sio simv -gui
```

Similarly, you can also use `-ucli` with `specview` to invoke simulation in UCLI mode.

*Example 27-2 To Invoke UCLI Using specrun*

The following command invokes the simulation in UCLI mode:

```
% specrun -p "test -seed=1;" simv -ucli -i include.cmd
```

Similarly, you can also use **-gui** with **specrun** to invoke DVE.

---

## Adding Specman Objects To DVE

Following are the steps involved to add e-objects to the DVE wave window:

- Compile the design. See “[Usage Flow](#)” .
- Create the `wave.ecom` file containing the list of e-objects to be added. For example:

```
wave exp sys.U_TbDut.My_Trans
wave event *.clk
```

- Simulate the design as shown below:

- In Compiled mode:

```
% simv -gui -do run.do
```

Here, the `run.do` contains:

```
sn set wave -mode=manual dve
sn config wave -event_data=all_data
sn test
sn @wave
run 8 us
```

- In Loaded mode:

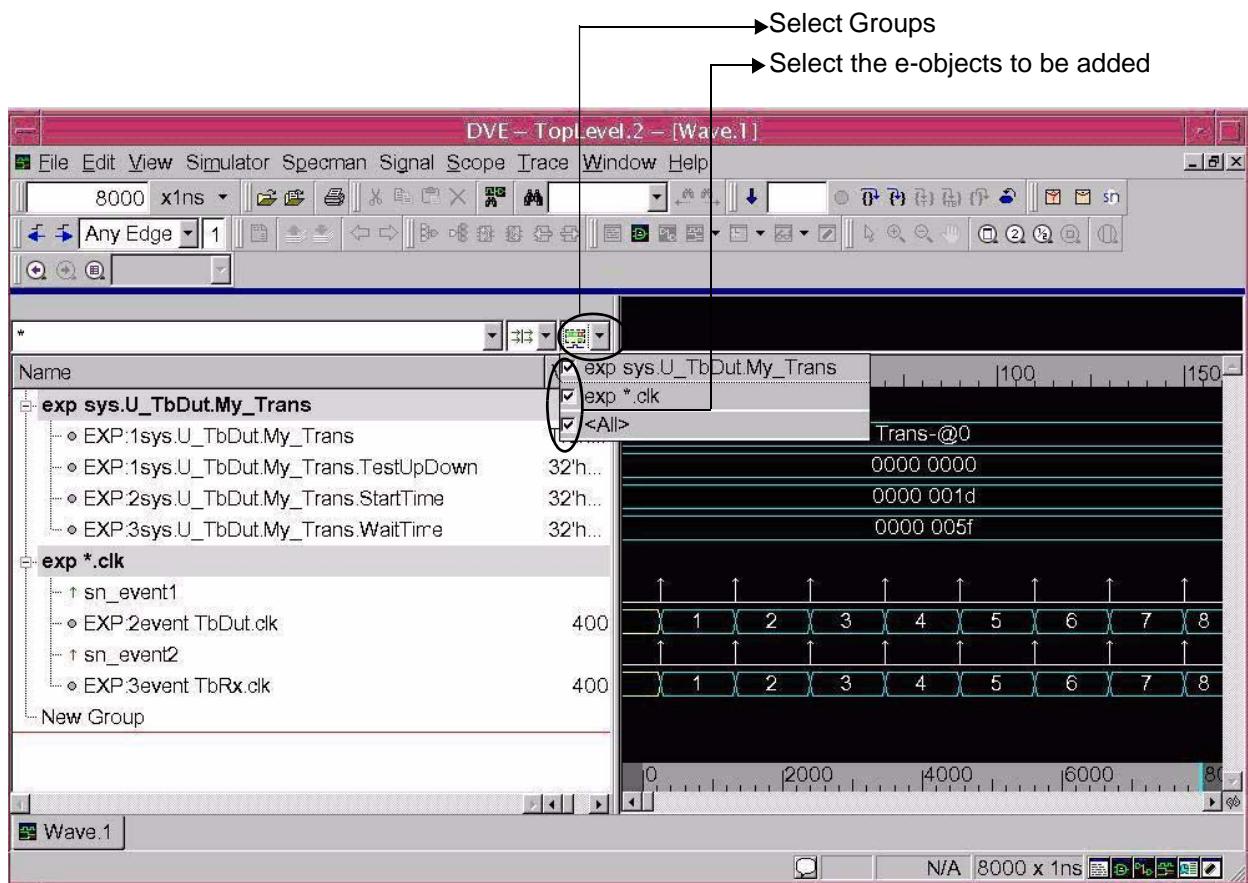
```
% simv -gui -do run.do
```

Here, the `run.do` contains:

```
sn set wave -mode=manual dve
sn config wave -event_data=all_data
sn load top_e_file.e
sn test
sn @wave
run 8 us
```

The `simv -gui -do run.do` command starts DVE, executes the UCLI commands specified in `run.do` and creates the `sn_wave_sys.tcl` session file.

- Now, load `sn_wave_sys.tcl` using **File > Load Session** and the dumped e-objects will be added to the Wave window automatically.
- Go to the Wave window and click on the groups icon to the side of the filter pane and select the e-objects to be added. See the figure shown below:



---

## **Version Checker for Specman**

This section describes how to check the compatibility version of Specman with VCS. If non-compatible version of Specman is used, then VCS generates a warning message at compile-time.

---

### **Use Model**

#### **Through Command-line Options**

```
% vcs +warn=V2V_CHECK_SPECMAN
```

To convert warning to error:

```
% vcs +vcs+error=V2V_CHECK_SPECMAN
```

Enabling at Runtime:

```
%simv +warn=V2V_CHECK_SPECMAN
```

You can use the `+warn=noV2V_CHECK_SPECMAN` option to turn off the warning message. In this option, `no` specifies disabling warning messages .

# 28

## Integrating VCS with Denali

---

Denali, a third-party Memory Modeler - Advanced Verification (MMAV) product, can be integrated with VCS through a set of APIs. Denali provides a complete solution for memory modeling and system verification. It automatically monitors all the timing and protocol requirements specified by the memory vendor.

---

### Setting Up Denali Environment for VCS

To use Denali along with VCS, set your Denali environment as shown below:

```
% setenv DENALI [installation_path_of_DENALI]
% setenv LM_LICENSE_FILE [Denali_license] :$LM_LICENSE_FILE
```

---

## Integrating Denali with VCS

The generic functionality of various memory architectures are captured in a set of highly-optimized 'C' models. The vendor-specific features and the timing for any particular memory device are defined within the specification of memory architecture (SOMA) file. Once the Denali model objects are linked into the simulation environment, modeling any type of memory is as simple as referencing the appropriate SOMA file for that particular memory device.

To access a particular SOMA file, include the following declaration in the source code:

```
parameter memory_spec = soma_file_path;
parameter init_file = "";
```

Note:

`memory_spec` and `init_file` are keywords.

---

## Usage Model

This section describes the following:

- Usage Model for Verilog Memory Models
- Execute Denali Commands at UCLI Prompt

---

### Usage Model for Verilog Memory Models

Verilog memory models can be integrated with VCS using PLIs. To use Verilog memory models, you need to specify the `pli.tab` file and `denverlib.o` during compilation.

The usage model is shown below:

## Compilation

```
% vcs -debug [vcs_options] verilog_filelist \
-P $DENALI/verilog/pli.tab $DENALI/verilog/denverlib.o
```

Note:

To compile the design in 64-bit mode, you must use the  
-lpthread option.

## Simulation

```
% simv [simv_options]
```

---

## Execute Denali Commands at UCLI Prompt

VCS allows you to execute Denali commands at the UCLI prompt.  
For example:

```
% simv -ucli
ucli% mmload :top:I_dut:I_denali_model data_file
```

The above UCLI command loads the Denali memory in the instance I\_denali\_model with the data specified in the data\_file.

For more information on invoking UCLI, see “[Using UCLI](#)” .

# 29

## Integrating VCS with Debussy

---

In this release, VCS supports Novas 2010.07 version under the `-fsdb` option.

This chapter contains the following section:

- “[Using the Current Version of VCS with Novas 2010.07 Version](#)”  
on page 1

---

### Using the Current Version of VCS with Novas 2010.07 Version

This section describes the required environmental settings and the usage model to dump an fsdb file:

- “[Setting Up Debussy](#)”

- “Usage Model to Dump fsdb File”
  - “Examples”
- 

## Setting Up Debussy

To dump an `fsdb` file, you need to set the following environment variables:

```
% setenv DEBUSSY_HOME Debussy安装目录
% setenv DEBUSSY_LIB ${DEBUSSY_HOME}/share/PLI/VCS/LINUX
% setenv LD_LIBRARY_PATH ${DEBUSSY_HOME}/share/PLI/lib/
LINUX:$DEBUSSY_LIB
% setenv LM_LICENSE_FILE [Debussy_license] :$LM_LICENSE_FILE
```

---

## Usage Model to Dump fsdb File

This section describes the usage model to dump an `fsdb` file using Verilog system tasks, or UCLI.

- Using Verilog System Tasks

You can use the Verilog system tasks `$fsdbDumpfile()` and `$fsdbDumpvars()` in your Verilog design to dump an `fsdb` file (see “[Using Verilog System Tasks](#)”).

- UCLI

At UCLI prompt, you can use the UCLI commands `fsdbDumpfile` and `fsdbDumpvars` to dump an `fsdb` file.

Irrespective of whether you are using system tasks or UCLI commands, you must use the `-fsdb` compile-time option to enable `fsdb` dumping, as shown below:

## Using Verilog System Tasks

### Compilation

This can be done in following two ways:

- `% vcs -fsdb [compile_options] verilog_filelist`
- For `-P` tab flow, replace `vcsd.tab` with `novas.tab`, where `novas.tab` is available in:

```
<NOVAS_INST_DIR>/share/PLI/VCS/${PLATFORM}/
novas.tab
```

The following is the use model change:

```
% vcs -debug_pp -P $DEBUSSY_LIB/novas.tab
$DEBUSSY_LIB/pli.a [compile_options]
verilog_filelist
```

### Simulation

```
% simv [run_options]
```

## Using UCLI

### Compilation

This can be done in following two ways:

- `% vcs -fsdb [compile_options] verilog_filelist`
- For `-P` tab flow, include `-load libnovas.so:FSDBDumpCmd` in the compilation step.

The following is the use model change:

```
% vcs -debug_pp -P $DEBUSSY_LIB/novas.tab
$DEBUSSY_LIB/pli.a -load libnovas.so:FSDBDumpCmd
```

## Simulation

```
% simv [run_options] -ucli
ucli> fsdbDumpfile your_fsdb_dumpfile
ucli> fsdbDumpvars level module/entity
```

Note:

The default fsdb file name is novas.fsdb.

---

## Examples

### Example 29-1 Using Verilog System Tasks

This example demonstrates the use of Verilog system tasks, \$fsdbDumpfile and \$fsdbDumpvars.

```
`timescale 1ns\1ns
module test;
initial
begin
 $fsdbDumpfile("test.fsdb");
 $fsdbDumpvars(0,test);
end

...
endmodule
```

Now the usage model to compile and simulate the above design is as shown below:

## Compilation

```
% vcs -fsdb test.v
```

## **Simulation**

```
% simv
```

The above set of commands dumps all the instances in `test` into the `test.fsdb` file.

### *Example 29-2 Using UCLI*

This example demonstrates the use of UCLI commands `fsdbDumpfile` and `fsdbDumpvars` at the UCLI prompt to dump an fsdb file:

Consider the following Verilog file:

```
'timescale 1ns/1ns
module test();
 ...
endmodule
```

The usage model to compile the design to use UCLI commands is as shown below:

## **Compilation**

```
% vcs -fsdb -debug_pp test.v
```

## **Simulation**

```
% simv -ucli
ucli> fsdbDumpfile test.fsdb
ucli> fsdbDumpvars 0 test
ucli> run
ucli> quit
```

The above command dumps the whole design `test` into the `test.fsdb` file.

# 30

## Integrating VCS with XA

---

XA-VCS allows a mixed-signal simulation solution, which enables simulating a design that is partly modeled in both analog and digital.

It is recommended that before starting a mixed-signal simulation, both SPICE subcircuits and Verilog modules should be error-free (individually tested).

This chapter briefly describes the environment setup and usage model of XA-VCS mixed-signal simulations. For more information, please refer Discovery AMS: Mixed-Signal Simulation User Guide in the XA documentation.

XA-VCS mixed-signal simulation supports:

- The use of both Verilog top-level netlists and SPICE top-level netlists.
- Donut partitioning, which is the arbitrary instantiation of SPICE subcircuits and Verilog modules under either SPICE or Verilog throughout the design hierarchy.
- The use of either instance-based or cell-based partitioning.

---

# Environment Setup

A working installation of VCS and a matching version of XA are required to run mixed-signal simulation. The compatibility table for versions of VCS and XA that work together can be found at:  
<https://solvnet.synopsys.com/retrieve/020828.html>.

The following environment variables must be set:

## Licenses

```
% setenv LM_LICENSE_FILE license_file_path
```

or

```
% setenv SNPSLMD_LICENSE_FILE license_file_path
```

## Note:

If you set the SNPSLMD\_LICENSE\_FILE environment variable, then VCS ignores the LM\_LICENSE\_FILE environment variable.

## For XA

```
source XA_install_directory/CSHRC_platform
```

## For VCS

```
setenv VCS_HOME vcs_install_directory
set path = ($VCS_HOME/bin $path)
```

---

# Usage Model

## To Compile

The syntax to start the compile process is:

```
% vcs -ad=init_file verilog_source_files
[other_vcs_options]
```

-ad=*init\_file*

Enables mixed-signal simulation. In the absence of the *init\_file*, VCS looks for the default initialization file, `vcsAD.init`.

## To Run Simulation

The syntax to run the mixed-signal simulation is:

```
% simv [runtime_options]
```

# 30

## Integrating VCS with MVSIM Native Mode

This chapter provides brief description on the MVSIM tool and how VCS works with MVSIM native mode.

---

### **Introduction to MVSIM**

MVSIM is a multivoltage simulation tool that enables voltage-level aware simulation and verification of power-managed designs. The tool enables you to simulate the impact of voltage variation on digital logic.

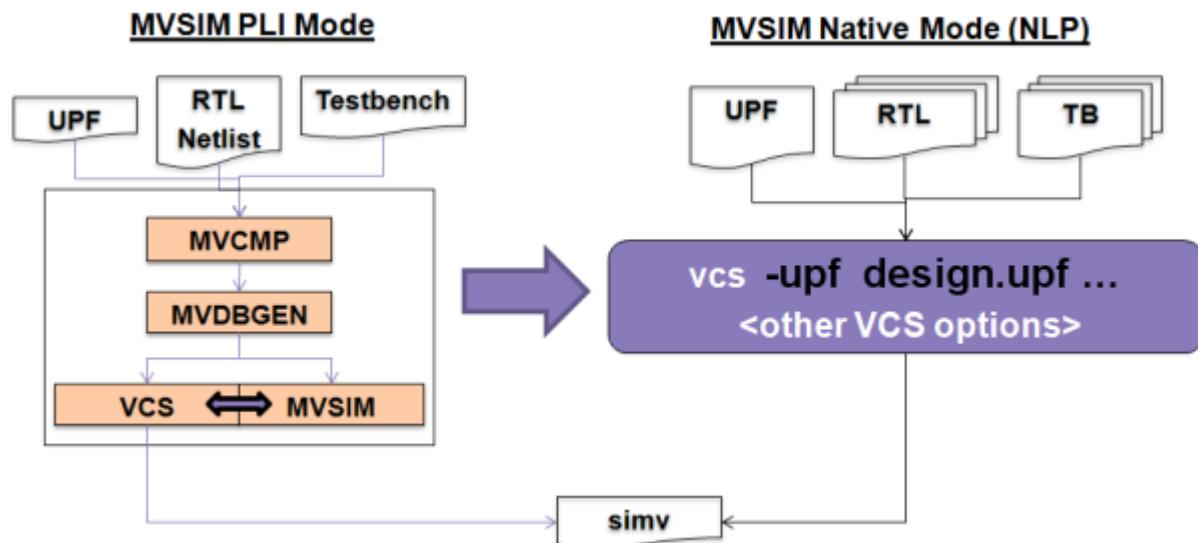
You can use MVSIM for both RTL and Netlist simulations. MVSIM uses IEEE-1801 (also known as UPF) as the format to capture power-intent of a design.

## MVSIM Native Mode in VCS

Native mode of MVSIM enables you to specify the UPF based power-intent of your design directly to VCS and generate a simulation model, which contains all power-objects directly instrumented in it.

MVSIM-Native mode eliminates MVCMP or MVDBGEN based compilation (as done in MVSIM-PLI mode), EV or EVHD compilation, and the intermediate apdb database, giving significant improvement in performance and ease-of-use over MVSIM-PLI mode. MVSIM-Native requires the MVSIM license, as does the MVSIM-PLI mode.

The following figure illustrates the architecture of MVSIM PLI and Native modes:



---

## References

For more details about getting the license for MVSIM and installing it, refer to the *Multi-Voltage Low Power Verification Tools Suite Installation Guide*.

For more details about MVSIM Native mode in VCS, refer to the *MVSIM Native Mode User Guide*.

# A

## VCS Environment Variables

---

This appendix covers the following topics:

- “[Simulation Environment Variables](#)”
- “[Optional Environment Variables](#)”

---

### Simulation Environment Variables

To run VCS, you need to set the following basic environment variables:

`$VCS_HOME`

When you or someone at your site installed VCS, the installation created a directory that we call the `vcs_install_dir` directory. Set the `$VCS_HOME` environment variable to the path of the `vcs_install_dir` directory. For example:

```
setenv VCS_HOME /u/net/eda_tools/vcs2005.06
```

## PATH

On UNIX, set this environment variable to \$VCS\_HOME/bin. Add the following directories to your PATH environment variable:

```
set path=($VCS_HOME/bin\
 $VCS_HOME/'$VCS_HOME/bin/vcs -platform'/bin\
 $path)
```

Also, make sure the path environment variable is set to a bin directory containing a make or gmake program.

## LM\_LICENSE\_FILE or SNPSLMD\_LICENSE\_FILE

The definition can either be an absolute path name to a license file or to a port on the license server. Separate the arguments in this definition with colons. For example:

```
setenv LM_LICENSE_FILE 7182@serveroh:/u/net/server/
eda_tools/license.dat
```

or

```
setenv SNPSLMD_LICENSE_FILE 7182@serveroh:/u/net/
server/eda_tools/license.dat
```

Note:

- You can use SNPSLMD\_LICENSE\_FILE environment variable to set licenses explicitly for Synopsys tools.
- If you set the SNPSLMD\_LICENSE\_FILE environment variable, then VCS ignores the LM\_LICENSE\_FILE environment variable.
-

---

## Optional Environment Variables

VCS also includes the following environment variables that you can set in certain circumstances.

### DISPLAY\_VCS\_HOME

Enables the display, at compile time, of the path to the directory specified in the VCS\_HOME environment variable. Specify a value other than 0 to enable the display. For example:

```
setenv DISPLAY_VCS_HOME 1
```

### PERSISTENT\_FLAG

When set to 1, VCS disables the checks enabled by the persistent specification in the tab file. It also disables similar checks that are enabled by the -debug, -debug\_all, or -debug\_pp options. See the section “[PLI Table File](#)” on page 6.

### SYSTEMC\_OVERRIDE

Specifies the location of the SystemC simulator used with the VCS/SystemC co-simulation interface. See [Using SystemC](#).

### TMPDIR

Specifies the directory used by VCS and the C compiler to store temporary files during compilation.

### **VCS\_CC**

Indicates the C compiler to be used. To use the gcc compiler specify the following:

```
setenv VCS_CC gcc
```

### **VCS\_COM**

Specifies the path to the VCS compiler executable named vcs1, not the compile script. If you receive a patch for VCS, you might need to set this environment variable to specify the patch. This variable is used for solving problems that require patches from VCS and should not be set by default.

### **VCS\_LIC\_EXPIRE\_WARNING**

By default, VCS displays a warning message 30 days before a license expires. You can specify that this warning message begin fewer days before the license expires with this environment variable, for example:

```
VCS_LIC_EXPIRE_WARNING 5
```

To disable the warning, enter the 0 value:

```
VCS_LIC_EXPIRE_WARNING 0
```

### **VCS\_LOG**

Specifies the runtime log file name and location.

### **VCS\_NO\_RT\_STACK\_TRACE**

Tells VCS not to return a stack trace when there is a fatal error and instead dump a core file for debugging purposes.

### **VCS\_SWIFT\_NOTES**

Enables the `printf` PCL command. PCL is the Processor Control Language that works with SWIFT microprocessor models. To enable it, set the value of this environment variable to 1.

#### VCS\_DIAGTOOL

Generates valgrind data for `vcs1`, if you set this environment variable as shown below:

```
% setenv VCS_DIAGTOOL "valgrind --tool=memcheck"
```

Once you set this environment variable, any subsequent invocation of `vcs1` generates valgrind data.

# C

## Compile-time Options

---

The `vcs` command performs compilation of your design and creates a simulation executable. Compiled event code is generated and used by default. The generated simulation executable, `simv`, can then be used to run multiple simulations.

This section describes the `vcs` command and related options.

Syntax:

```
vcs source_files [source_or_object_files] [options]
```

Here:

*source\_files*

The Verilog or OVA source files for your design separated by spaces.

## `source_or_object_files`

Optional C files ( .c), object files ( .o), or archived libraries ( .a). These are DirectC or PLI applications that you want VCS to link into the binary executable file along with the object files from your Verilog source files. When including object files include the -cc and -ld options to specify the compiler and linker that generated them.

## `options`

Compile-time options that control how VCS compiles your design.

This appendix lists the following:

- “Options for Accessing Verilog Libraries”
- “Options for Incremental Compilation”
- “Options for Help and Documentation”
- “Options for SystemVerilog Assertions”
- “Options to Enable Compilation of OVA Case Pragmas”
- “Options for Native Testbench”
- “Options for Different Versions of Verilog”
- “Options for Initializing Memories and Registers with Random Values”
- “Options for Using Radiant Technology”
- “Options for 64-bit Compilation”
- “Options for Starting Simulation Right After Compilation”
- “Options for Specifying Delays and SDF Files”

- “Options for Compiling an SDF File”
- “Options for Specify Blocks and Timing Checks”
- “Options for Pulse Filtering”
- “Options for Negative Timing Checks”
- “Options for Profiling Your Design”
- “Options to Specify Source Files and Compile-time Options in a File”
- “Options for Compiling Runtime Options into the Executable”
- “Options for PLI Applications”
- “Options to Enable the VCS DirectC Interface”
- “Options for Flushing Certain Output Text File Buffers”
- “Options for Simulating SWIFT VMC Models and SmartModels”
- “Options for Controlling Messages”
- “Options for Cell Definition”
- “Options for Licensing”
- “Options for Controlling the Linker”
- “Options for Controlling the C Compiler”
- “Options for Source Protection”
- “Options for Mixed Analog/Digital Simulation”
- “Options for Changing Parameter Values”
- “Checking for X and Z Values in Conditional Expressions”

- “Options for Detecting Race Conditions”
  - “Options to Specify the Time Scale”
  - "Options for Overriding Parameters"
  - “General Options”
- 

## Options for Accessing Verilog Libraries

`-v filename`

Specifies a Verilog library file. VCS looks in this file for definitions of the module and UDP instances that VCS found in your source code, but for which it did not find the corresponding module or UDP definitions in your source code.

`-y directory`

Specifies a Verilog library directory. VCS looks in the source files in this directory for definitions of the module and UDP instances that VCS found in your source code, but for which it did not find the corresponding module or UDP definitions in your source code. VCS looks in this directory for a file with the same name as the module or UDP identifier in the instance (not the instance name). If it finds this file, VCS looks in the file for the module or UDP definition to resolve the instance.

Note:

If you have multiple modules with the same name in different libraries, VCS chooses the module defined in the library that is specified with the first occurrence of the `-y` option.

For example:

If `rev1/cell.v`, `rev2/cell.v` and `rev3/cell.v` all exist and define the module `cell()`, and you issue the following command:

```
% vcs -y rev1 -y rev2 -y rev3 +libext+.v top.v
```

VCS picks `cell.v` from `rev1`.

However, if the `top.v` file has a ``uselib` compiler directive as shown below, then ``uselib` takes priority:

```
//top.v
`uselib directory = /proj/libraries/rev3
//rest of top module code
//end top.v
```

In this case, VCS will use `rev3/cell.v` when you issue the following command:

```
% vcs -y rev1 -y rev2 +libext+.v top.v
```

Include the `+libext` compile-time option to specify the file name extension of the files you want VCS to look for in these directories.

`+libext+extension+`

Specifies that VCS searches only for files with the specified file name extensions in a library directory. You can specify more than one extension, separating the extensions with the plus (+) character. For example, `+libext+.v+.V+` specifies searching for files with either the `.v` or `.V` extension in a library. The order in which you add file name extensions to this option does not specify an order in which VCS searches files in the library with these file name extensions.

`+liborder`

Specifies searching for module definitions for unresolved module instances through the remainder of the library where VCS finds the instance, then searching the next and then the next library on the vcs command line before searching in the first library on the command line.

#### +librescan

Specifies always searching libraries for module definitions for unresolved module instances beginning with the first library on the vcs command line.

#### +libverbose

Tells VCS to display a message when it finds a module definition in a source file in a Verilog library directory that resolves a module instantiation statement that VCS read in your source files, a library file, or in another file in a library directory. The message is as follows:

Resolving module "*module\_identifier*"

By default, VCS does not display this message when it finds a module definition in a Verilog library file that resolves a module instantiation statement.

---

## Options for Incremental Compilation

#### -Mdirectory=*directory*

Specifies the incremental compile directory. The default name for this directory is `csrc`, and its default location is your current directory. You can substitute the shorter `-Mdir` for `-Mdirectory`.

`-Mlib=dir`

This option provides VCS with a central place to look for the descriptor information before it compiles a module and a central place to get the object files when it links together the executable. This option allows you to use the parts of a design that have been already tested and debugged by other members of your team without recompiling the modules for these parts of the design.

You can specify more than one place for VCS to look for descriptor information and object files by providing multiple arguments with this option.

### **Example:**

```
vcs design.v -Mlib=/design/dir1 -Mlib=/design/
dir2
```

Or, you can specify more than one directory with this option, using a colon (:) as a delimiter between them, as shown below:

```
vcs design.v -Mlib=/design/dir1:/design/dir2
```

`-noIncrComp`

Disables incremental compilation.

`-parallel_compile_off`

Turns off parallel compilation and uses serial compilation.

---

## **Options for Help and Documentation**

`-h or -help`

Lists descriptions of the most commonly used VCS compile and runtime options.

`-doc`

Displays the VCS documentation in your system's default web browser.

---

## Options for SystemVerilog

`-sverilog`

Enables SystemVerilog constructs specified in the IEEE Standard of SystemVerilog, IEEE Std 1800-2009.

SystemVerilog Native Testbench (SV-NTB) is not supported on `-comp64`. For more information on the `-comp64` option, see [“Options for 64-bit Compilation”](#).

`-sv_package_export`

Enables the alternative implementation of how iVCS exports SystemVerilog packages. This implementation is less optimistic and is more rigidly compliant with the SystemVerilog IEEE Std 1800-2009 standard.

In this implementation, declarations imported into a package are not visible by way of subsequent imports of that package. Package export declarations allow a package to specify those imported declarations to be made visible in subsequent imports.

---

## Options for SystemVerilog Assertions

`-ignore keyword_argument`

Suppresses warning messages depending on which keyword argument is specified. The keyword arguments are as follows:

`unique_checks`

Suppresses warning messages about `unique if` and `unique case` statements.

`priority_checks`

Suppresses warning messages about `priority if` and `priority case` statements.

`all`

Suppresses warning messages about `unique if`, `unique case`, `priority if` and `priority case` statements.

You can tell VCS to report errors for both `unique` and `priority` violations with the `+vcs+error` compile-time option as shown below:

`+vcs+error=UNIQUE`

VCS reports `unique` violations as error conditions.

`+vcs+error=PRIORITY`

VCS reports `priority` violations as error conditions.

`+vcs+error=UNIQUE, PRIORITY`

VCS reports `unique` and `priority` violations as error conditions.

`-assert keyword_argument`

The keyword arguments are as follows:

`enable_diag`

Enables further control of results reporting with runtime options. The runtime assert options are enabled only if you compile the design with this option.

`func hier`

Enables enhanced reporting for assertions in functions.

`hier=file_name`

You can use the `-assert hier=file_name` compile-time option to specify the configuration file for enabling and disabling SystemVerilog assertions. You can either enable or disable:

- Assertions in a module or in a hierarchy.
- An individual assertion.

Note:

The types of entries that you can specify in the file are as follows:

`-assert <assertion_name> or <assertion_hierarchical_name>`

If `assertion_name` is provided, VCS disables the assertions based on wildcard matching of the name in the full design. If `assertion_hierarchical_name` is provided, VCS disables the assertions based on wildcard matching of the name in the particular hierarchy given.

## Examples

`-assert my_assert`

Disables all assertions with name `my_assert` in the full design.

```
-assert A*
```

Disables all assertions whose name starts with `A` in the full design.

```
-assert *
```

Disables all assertions in the full design.

```
-assert top.INST2.A
```

Disables all assertions whose names start with `A` in the hierarchy `top.INST2`. If assertions whose name starts with `A` exists in inner scopes under `top.INST2`, they are not disabled. This command has affect on assertions only in scope `top.INST2`.

```
+tree <module_instance_name> or
 <assertion_hierarchical_name>
```

If `module_instance_name` is provided, VCS enables assertions in the specified module instance and all module instances hierarchically under that instance. If `assertion_hierarchical_name` is provided, VCS enables the specified SystemVerilog assertion. Wildcard characters can also be used for specifying the hierarchy.

## Examples

```
+tree top.inst1
```

Enables the assertions in module instance `top.inst1` and all the assertions in the module instances under this instance.

```
+tree top.inst1.a1
```

Enables the SystemVerilog assertion with the hierarchical name `top.inst1.a1`.

```
+tree top.INST*.A1
```

Enables assertion `A1` from all the instances whose names start with `INST` under module `top`.

```
-tree <module_instance_name> or
<assertion_hierarchical_name>
```

If `module_instance_name` is provided, VCS disables the assertions in the specified module instance and all module instances hierarchically under that instance. If `assertion_hierarchical_name` is provided, VCS disables the specified SystemVerilog assertion. Wildcard characters can also be used for specifying the hierarchy.

## Examples

```
-tree top.inst1
```

Disables the assertions in module instance `top.inst1` and all the assertions in the module instances under this instance.

```
-tree top.inst1.a1
```

Disables SystemVerilog assertion with the hierarchical name `top.inst1.a1`.

```
-tree top.INST*.A1
```

Disables assertion A1 from all the instances whose names start with INST under module top.

```
+module module_identifier
```

VCS enables all the assertions in all instances of the specified module, for example:

```
+module dev
```

VCS enables the assertions in all instances of module dev.

```
-module module_identifier
```

VCS disables all the assertions in all instances of the specified module, for example:

```
-module dev
```

VCS disables the assertions in all instances of module dev.

The specifications are applied serially as they appear in file file\_name. The result of applying the specifications in this file is that a group of assertions get excluded. The remaining assertions are available for further exclusion by other means, such as the \$assertoff system task in the source code. However, the following should be noted:

- The first specification denotes the default exclusion for interpreting the file. If the first specification is a minus(-), then all assertions are included before applying the first and the following specifications. Conversely, if the first specification is a plus(+), then all assertions are excluded prior to applying the first and the following specifications.
- Unlike -/+module and -/+tree specifications, any assertion excluded by applying –assert specification cannot be included by the later specifications in the file.

#### `enable_hier`

Enables the use of the runtime option `-assert hier=file.txt`, which allows turning assertions on or off.

#### `filter_past`

For assertions that are defined with the \$past system task, ignore these assertions when the past history buffer is empty. For instance, at the very beginning of the simulation, the past history buffer is empty. Therefore, the first sampling point and subsequent sampling points should be ignored until the past buffer has been filled with respect to the sampling point.

#### `disable`

Disables all SystemVerilog assertions in the design.

#### `disable_cover`

When you include the `-cm assert` compile-time and runtime option, VCS includes information about cover statements in the assertion coverage reports. This keyword prevents cover statements from appearing in these reports.

#### `disable_assert`

Disables only the assert and assume directives without affecting the cover directives. It complements the existing control options which allows you to disable only cover directives or all of the assertions such as assert/assume/cover.

#### `disable_file=filename`

Disables the SystemVerilog assertions specified in the file. This file should contain the hierarchical path to your SVA, as shown in the following example:

```
% vcs -assert disable_file=dsbl.txt top
% cat dsbl.txt
top.U.SVA1
top.U.COV1
```

In this example, `dsbl.txt` is disabling the assertions SVA1 and COV1.

#### `disable_rep_opt`

Specifying a delay or a repetition value greater than 5000 in the assertion expression will affect both compile-time and runtime performance. Therefore, VCS optimizes expression and issues a warning message as shown below:

```
Warning-[LDRF] Large delay or repetition found.
VCS will optimize compile time. However it may affect runtime.
Use '-assert disable_rep_opt' to disable this optimization.
"design.v", 156: (b_ce_idle [* 1:50000])
```

Use `-assert disable_rep_opt` to switch off the optimization and disable this message.

#### `dumpoff`

Disables the dumping of SVA information in the VPD file during simulation.

`vpiSeqBeginTime`

Enables you to see the simulation time that a SystemVerilog assertion sequence starts when using Debussy.

`vpiSeqFail`

Enables you to see the simulation time that a SystemVerilog assertion sequence doesn't match when using Debussy.

---

## Options to Enable Compilation of OVA Case Pragmas

`-ova_enable_case`

Enables the compilation of OVA case pragmas only, when used without `-xova` or `-ova_inline`. All inlined OVA assertion pragmas are ignored.

---

## Options for Native Testbench

`-ntb`

Enables the use of the OpenVera testbench language constructs described in the *OpenVera Language Reference Manual: Native Testbench*.

OpenVera Native Testbench (OV-NTB) is not supported on `-comp64`. For more information on the `-comp64` option, see [“Options for 64-bit Compilation”](#).

`-ntb_define macro`

Specifies any OpenVera macro name on the command line. You can specify multiple macro names using the plus (+) character.

The macro can also be defined to be a fixed number. For example, in the following:

```
program test
{
 integer x;
 x =12345;
printf ("DEBUG==> my value = %d and x = %d\n", MYVALUE,
x);
}
```

When you compile and run:

```
% vcs -ntb -ntb_define MYVALUE=10000 myprog.vr -R
```

This outputs are:

```
DEBUG==> my value = 10000 and x = 12345
```

```
-ntb_fileext .ext
```

Specifies an OpenVera file name extension. You can specify multiple file name extensions using the plus (+) character.

```
-ntb_incdir directory_path
```

Specifies the include directory path for OpenVera files. You can specify multiple include directories using the plus (+) character.

```
-ntb_cmp
```

Compiles and generates the testbench shell (`file.vshell`) and shared object files.

```
-ntb_noshell
```

Tells VCS not to generate the shell file. Use this option when you recompile a testbench.

`-ntb_opts keyword_argument`

The keyword arguments are as follows:

`ansi`

Preprocesses the OpenVera files in the ANSI mode. The default preprocessing mode is the Kernighan and Ritchie mode of the C language.

`check`

Does a bounds check on dynamic type arrays (dynamic, associative, queues) and issues an error at runtime.

`check=dynamic`

Same as `check`. Does a bounds check on dynamic type arrays (dynamic, associative, queues) and issues an error at runtime.

`check=fixed`

Does a bounds check only on fixed size arrays and issues an error at runtime.

`check=all`

Does a bounds check on both fixed size and dynamic type arrays and issues an errors at runtime.

`dep_check`

Enables dependency analysis and incremental compilation. Detects files with circular dependencies and issues an error message when VCS cannot determine which file to compile first.

#### `no_file_by_file_pp`

By default, VCS does file-by-file preprocessing on each input file, feeding the concatenated result to the parser. This argument disables this behavior.

#### `print_deps`

Tells VCS to display the dependencies for the source files on the screen. Enter this argument with the `dep_check` argument.

#### `rvm`

Use `rvm` when RVM or VMM is used in the testbench. For more information, refer to the “[Using VMM with SV](#)” section.

#### `sv_fmt`

The default padding used in displayed or printed strings is right padding. The `sv_fmt` option specifies left padding. For example, when `-ntb_opts sv_fmt` is used, the result of

```
$display("%10s", "my_string");
```

is to put 10 spaces to the left of `my_string`.

To specify right padding when `-ntb_opts sv_fmt` is used, put a dash before the number of spaces. For example, the result of

```
$display("%-10s", "my_string");
```

is to put 10 spaces to the right of `my_string`.

`tb_timescale=value`

Specifies an overriding timescale for the testbench, whenever the required testbench timescale is different from that of the design. It must be used in conjunction with the `-timescale` option that specifies the timescale for the design.

If the required testbench timescale is different from the design or DUT timescale, then both the testbench timescale and the DUT timescale must be passed during VCS compilation.

**Example:**

The following command specifies a required testbench timescale of 10ns/10ps and a design timescale of 1ns/1ps:

```
%> vcs -ntb_opts tb_timescale=1ns/1ps
-timescale=10/10ns file.sv
```

`tokens`

Preprocesses the OpenVera files to generate two files, `tokens.vr` and `tokens.vrp`. The `tokens.vr` contains the preprocessed result of the non-encrypted OpenVera files, while the `tokens.vrp` contains the preprocessed result of the encrypted OpenVera files. If there is no encrypted OpenVera file, VCS sends all the OpenVera preprocessed results to the `tokens.vr` file.

`use_sigprop`

Enables the signal property access functions. For example, `vera_get_ifc_name()`.

`vera_portname`

Specifies the following:

- The Vera shell module name is named `vera_shell`.
- The interface ports are named `ifc_signal`.
- Bind signals are named, for example, as: `\if_signal [3 : 0]`.

`-ntb_shell_only`

Generates only a `.vshell` file. Use this option when compiling a testbench separately from the design file.

`-ntb_sfname filename`

Specifies the file name of the testbench shell.

`-ntb_sname module_name`

Specifies the name and directory where VCS writes the testbench shell module.

`-ntb_spath`

Specifies the directory where VCS writes the testbench shell and shared object files. The default is the compilation directory.

`-ntb_vipext .ext`

Specifies an OpenVera encrypted-mode file extension to mark files for processing in OpenVera encrypted IP mode. Unlike the `-ntb_filext` option, the default encrypted-mode extensions `.vrp` and `.vrhp` are not overridden and will always be in effect. You can pass multiple file extensions at the same time using the plus (+) character.

`-ntb_vl`

Specifies the compilation of all Verilog files, including the design, the testbench shell file, and the top-level Verilog module.

---

## Options for Different Versions of Verilog

`-v95`

Specifies not recognizing Verilog 2001 keywords.

`+systemverilogext+ext`

Specifies a file name extension for SystemVerilog source files. If you use a different file name extension for the SystemVerilog part of your source code and you use this option, the `-sverilog` option has to be omitted.

Note:

If you specify this option in a command to run a design, then this option behaves as the `-sverilog` option, which does the semantic check on the entire design with SystemVerilog LRM syntax.

`+verilog2001ext+ext`

Specifies a file name extension for Verilog 2001 source files.

`+verilog1995ext+ext`

Specifies a file name extension for Verilog 1995 files. Using this option allows you to write Verilog 1995 code that would be invalid in Verilog 2001 or SystemVerilog code, such as using Verilog 2001 or SystemVerilog keywords, like `localparam` and `logic`, as names.

Note:

Do not enter all three of these options on the same command line.

-extinclude

If a source file for one version of Verilog contains the `include compiler directive, VCS by default compiles the included file for the same version of Verilog, even if the included file has a different filename extension. If you want VCS to compile the included file with the version specified by its extension, enter this compile-time option. The following code examples show using this option.

If source file a.v contains the following:

```
`include "b.sv"
module a();
reg ar;
endmodule
```

and if source file b.sv contains the following:

```
module b();
logic ar;
endmodule
```

VCS compiles b.sv for SystemVerilog with the following command line:

```
vcs a.v +systemverilogext+.sv -extinclude
```

---

## Options for Initializing Memories and Registers with Random Values

+vcs+initreg+random

Initializes all state variables (`reg` data type), registers defined in sequential UDPs, and memories including MDAs (`reg` data type) in the design, to random logic 0 or 1, at time zero.

Note:

- This option works only for the Verilog portion of your design.
- This option does not initialize registers (variables) and memories other than the `reg` data type.

To prevent race conditions, avoid the following when you use this option:

- Assigning initial values to a `reg` in their declaration, when the value you assign is not the same as the value specified with the `+vcs+initreg+random` option.
- Initializing state variables to state "x".
- Inconsistent states in the design due to the randomization.

---

## Options for Using Radiant Technology

`+rad`

Performs Radiant Technology optimizations on your design.

`+optconfigfile+filename`

Specifies a configuration file that lists the parts of your design you want to optimize (or not optimize) and the level of optimization for these parts. You can also use the configuration file to specify ACC write capabilities. See “[Compiling With Radiant Technology](#)” .

---

## Options for 64-bit Compilation

`-full64`

Enables compilation and simulation in 64-bit mode.

You can also enable VCS in 64-bit mode using the following environment variable per your platform and OS:

For Linux RH 3.0/4.0 64-bit:

```
setenv VCS_TARGET_ARCH amd64
```

For Suse Linux Enterprise Server 9 64-bit:

```
setenv VCS_TARGET_ARCH suse64
```

For Solaris 64-bit:

```
setenv VCS_TARGET_ARCH sparc64
```

`-comp64`

Enables 64-bit compilation that generates a 32-bit `simv` executable.

Note:

The following are the limitations of `-comp64` option:

- OpenVera Native Testbench (OV-NTB) and SystemVerilog Native Testbench (SV-NTB) are not supported.
- Cross-compilation is not supported in pure SystemC simulation.

- Interactive debugging with CBug is not supported on -comp64 flow of VCS.
- 

## Options for Starting Simulation Right After Compilation

-R

Runs the executable file immediately after VCS links it together.

---

## Options for Specifying Delays and SDF Files

-sdf min|typ|max:*instance\_name*:*file.sdf*

Enables sdf annotation. Minimum, typical or maximum values specified in *file.sdf* will be annotated on the instance, *instance\_name*.

+allmtm

Specifies compiling separate files for minimum, typical, and maximum delays when there are min:typ:max delay triplets in SDF files. If you use this option, you can use the +mindelays, +typdelays, or +maxdelays options at runtime to specify which compiled SDF file VCS uses. Do not use this option with the +maxdelays, +mindelays, or +typdelays compile-time options.

+charge\_decay

Enables charge decay in trireg nets. Charge decay will not work if you connect the trireg to a transistor (bidirectional pass) switch such as tran, rtran, tranif1, or rtranif0.

+delay\_mode\_path

Uses only the delay specifications in module path delays in specify blocks. Overrides all the delay specifications on all gates, switches, and continuous assignments to zero.

`+delay_mode_zero`

Overrides all the delay specifications in module path delays in specify blocks to zero delays. Overrides all the delay specifications on all gates, switches, and continuous assignments to zero.

`+delay_mode_unit`

Overrides all the delay specifications in module path delays in specify blocks to zero delays. Overrides all the delay specifications on all gates, switches, and continuous assignments to the shortest time precision argument of all the `'timescale` compiler directives in the source code. The default time unit and time precision argument of the `'timescale` compiler directive is `1s`.

`+delay_mode_distributed`

Overrides all the delay specifications in module path delays in specify blocks to zero delays. Uses only the delay specifications on all gates, switches, and continuous assignments.

`+maxdelays`

Specifies using the maximum timing delays in `min:typ:max` delay triplets when compiling the SDF file. The `mtm_spec` argument to the `$sdf_annotate` system task overrides this option.

`+mindelays`

Specifies using the minimum timing delays in min:typ:max delay triplets when compiling the SDF file. The *mtm\_spec* argument to the \$sdf\_annotation system task overrides this option.

**+typdelays**

Specifies using the typical timing delays in min:typ:max delay triplets when compiling the SDF file. The *mtm\_spec* argument to the \$sdf\_annotation system task overrides this option.

**+multisource\_int\_delays**

Enables the multisource INTERCONNECT feature, including transport delays with full pulse control.

**+nbaopt**

Removes all intra-assignment delays in all the nonblocking assignment statements in the design. Many users enter a #1 intra-assignment delay in nonblocking procedural assignment statements to make debugging in the Wave window easier. For example:

```
reg1 <= #1 reg2;
```

These delays impede the simulation performance of the design, so after debugging, you can remove these delays with this option.

**Note:**

The **+nbaopt** option removes all intra-assignment delays in all the nonblocking assignment statements in the design, not just the #1 delays.

**+sdf\_nocheck\_celltype**

For a module instance to which an SDF file back-annotates delay data, disables comparing the module identifier in the source code with the `CELLTYPE` entry in the SDF file.

`+transport_int_delays`

Enables transport delays for delays on nets with a delay back-annotated from an `INTERCONNECT` entry in an SDF file. The default is inertial delays.

`+transport_path_delays`

Enables transport delays for module path delays.

`-sdfretain`

Enables timing annotation as specified by a `RETAIN` entry on `IOPATH` delays. By default, VCS ignores `RETAIN` entries with the following warning message:

```
Warning- [SDFCOM_RCI] RETAIN clause ignored
SDF_filename, line_number
module: module_name, "instance: hierarchical_name"
 SDF Warning: RETAIN clause ignored, but IOPATH
 annotated,
 Please use -sdfretain switch to consider RETAIN
```

The syntax for `RETAIN` entries are as follows:

```
(IOPATH port_spec port_instance (RETAIN
delval_list)* delval_list)
```

For example:

```
(IOPATH RCLK DOUT[0] (RETAIN (40)) (100.1)
(100.2))
```

`-sdfretain=warning`

If the RETAIN entry values are larger than the delay values, VCS displays the following warning message at runtime:

```
Warning- [SDFRT_IRV] RETAIN value ignored
RETAIN value is ignored as it is greater than IOPATH
delay
```

If you want to see a warning message at compile-time, enter this option along with the `-sdfretain` option. The following is an example of this warning message:

```
Warning- [SDFCOM_RLTPD] RETAIN value larger than IOPATH
delay
SDF_filename, line_number
module: module_name, "instance: hierarchical_name"
SDF Warning: RETAIN value (value) is larger than IOPATH
delay, RETAIN will be ignored at runtime
```

`+iopath+edge+sub-option`

This option is used when edge sensitivity is used in IOPATH SDF file entries. The different sub-options used with `+iopath+edge+option` and their descriptions are as follows:

`+iopath+edge+strict`

This option is used for LRM compliance. When edge sensitivity is specified for the input port in the SDF file and corresponding arc is not found in Verilog model, VCS by default does not give the warning message, you should use the switch `+iopath+edge+strict` to display the warning message. After the warning message is displayed, the data from SDF will not be back-annotated to the Verilog model.

`+iopath+edge+match`

This option can be used to make the annotation work by ignoring the edge in SDF.

+iopath+edge+max

This option is used for annotating higher delays.

+iopath+edge+min

This option is used for annotating smaller delays.

---

## Options for Compiling an SDF File

+csdf+precompile

Precompiles your SDF file into a format that VCS can parse when it compiles your Verilog code. See “[Precompiling an SDF File](#)” .

---

## Options for Specify Blocks and Timing Checks

+pathpulse

Enables the search for PATHPULSE\$ specparam in specify blocks.

+nospecify

Suppresses module path delays and timing checks in specify blocks. This option can significantly improve simulation performance.

+notimingcheck

Tells VCS to ignore timing check system tasks when it compiles your design. This option can moderately improve simulation performance. The extent of this improvement depends on the number of timing checks that VCS ignores. You can also use this option at runtime to disable these timing checks after VCS has compiled them into the executable. However, the executable simulates faster if you include this option at compile-time so that the timing checks are not in the executable. If you need the delayed versions of the signals in negative timing checks but want faster performance, include this option at runtime. The delayed versions are not available if you use this option at compile-time.

Note:

- VCS recognizes `+notimingchecks` to be the same as `+notimingcheck` when you enter it on the vcs or simv command line.
- The `+notimingcheck` option has higher precedence than any tcheck command in UCLI.

`+no_notifier`

Disables toggling of the notifier register that you specify in some timing check system tasks. This option does not disable the display of warning messages when VCS finds a timing violation that you specified in a timing check.

`+no_tchk_msg`

Disables display of timing violations, but does not disable the toggling of notifier registers in timing checks. This is also a runtime option.

---

## Options for Pulse Filtering

`+pulse_e/number`

Displays an error message and propagates an X value for any path pulse whose width is less than or equal to the percentage of the module path delay specified by the *number* argument, but is still greater than the percentage of the module path delay specified by the *number* argument to the `+pulse_r/number` option.

`+pulse_r/number`

Rejects any pulse whose width is less than *number* percent of the module path delay. The *number* argument is in the range of 0 to 100.

`+pulse_int_r`

Same as the existing `+pulse_r` option, except it applies only to INTERCONNECT delays.

`+pulse_int_e`

Same as the existing `+pulse_e` option, except it applies only to INTERCONNECT delays.

`+pulse_on_event`

Specifies that when VCS encounters a pulse shorter than the module path delay, VCS waits until the module path delay elapses and then drives an X value on the module output port and displays an error message. It drives that X value for a simulation time equal to the length of the short pulse or until another simulation event drives a value on the output port.

`+pulse_on_detect`

Specifies that when VCS encounters a pulse shorter than the module path delay, VCS immediately drives an X value on the module output port, and displays an error message. It does not wait until the module path delay elapses. It drives that X value until the short pulse propagates through the module or until another simulation event drives a value on the output port.

---

## Options for Negative Timing Checks

-negdelay

Enables the use of negative values in IOPATH and INTERCONNECT entries in SDF files.

To consider a negative INTERCONNECT delay, one of the following should be true:

- Sum of INTERCONNECT and PORT delays should be greater than zero
- Sum of INTERCONNECT and IOPATH delays should be greater than zero
- Sum of INTERCONNECT and DEVICE delays should be greater than zero

Otherwise, the negative INTERCONNECT delay will be ignored, and a warning message is generated for the same.

Similarly, to consider a negative IOPATH delay, the sum of IOPATH and DEVICE delays should be greater than zero. Otherwise, the negative IOPATH delay will be ignored, and a warning message is generated for the same.

## Limitations

This option is not supported in the following scenarios:

- Precompiled SDF
- RETAIN on negative IOPATH
- INCREMENT delay

+neg\_tchk

Enables negative values in timing checks.

+old\_ntc

Prevents the other timing checks from using delayed versions of the signals in the \$setuphold and \$recrm timing checks.

+NTC2

In \$setuphold and \$recrm timing checks, specifies checking the timestamp and timecheck conditions when the original data and reference signals change value instead of when their delayed versions change value.

+overlap

Enables accurate simulation of multiple non-overlapping violation windows for the same signals specified with negative delay values back-annotated from an SDF file to timing checks.

---

## Options for Profiling Your Design

+prof

Specifies that VCS writes the vcs .prof file during simulation. This file tells you which module definitions, module instances, and Verilog constructs in your design use the most CPU time.

Note:

The current profiler and the `+prof` compile-time option will be replaced by the unified profiler and the `-simprofile` compile-time option in the next release of VCS. The unified profiler is now an LCA feature, see [The Unified Simulation Profiler](#).

---

## Options to Specify Source Files and Compile-time Options in a File

`-f filename`

Specify a file that contains a list of source files and compile-time options, including C source files and object files.

The following are the features of `-f` option:

- You can use Verilog comment characters such as `//` and `/* */` to comment out entries in the file.
- You can use this option inside the `file` to point to another file.
- You can specify all compile-time options that begin with a plus (+) character.

There is a limitation you can only specify the following compile-time options that begin with a minus (-) character:

|                 |                       |                       |
|-----------------|-----------------------|-----------------------|
| <code>-f</code> | <code>-gen_asm</code> | <code>-gen_obj</code> |
| <code>-y</code> | <code>-l</code>       | <code>-u</code>       |
|                 |                       | <code>-v</code>       |

`-file filename`

Specify a file that contains a list of source files and VCS compile-time options, including C source files and object files.

You can use this option to overcome the limitation of the `-f` compile-time option.

### **Limitations of `-f` and `-file` options**

- These options do not support the `-full64` and `-comp64` options in the file. You must enter these options on the `vcs` command-line.
- You cannot specify escape characters in the file.
- You cannot use meta characters in the file, except \* and \$.

---

## **Options for Compiling Runtime Options into the Executable**

`+pluarg_save`

Some runtime options must be preceded by the `+plusarg_save` option for VCS to compile them into the executable.

`+plusarg_ignore`

Tells VCS not to compile the following runtime options into the `simv` executable. This option is used to counter the `+plusarg_save` option on a previous line.

---

## **Options for PLI Applications**

`+acc+level_number`

Enables PLI ACC capabilities for the entire design. The level number can be any number between 1 and 4:

`+acc` or `+acc+1`

Enables all capabilities except breakpoints and delay annotation.

+acc+2

Above, plus breakpoints.

+acc+3

Above, plus module path delay annotation.

+acc+4

Above, plus gate delay annotation.

+applylearn+*filename*

Recompiles your design to enable only the ACC capabilities that you needed for the debugging operations you did during a previous simulation of the design.

-e *new\_name\_for\_main*

Specifies the name of your `main()` routine. You write your own `main()` routine when you are writing a C++ application or when your application does some processing before starting the simv executable.

Note:

Do not use the `-e` option with the VCS/SystemC Cosimulation Interface.

-slave

Specifies VCS should build a shared executable library instead of simv executable. This option enables the slave mode operation of VCS .

Note:

- In this case, your C program hosts the `main()` routine. Hence, you must rename vcs `main()` routine using the `-e` option.
- Some of the VCS features like UCLI, DVE, `$save`, and `$restart` are not supported in slave mode. For more information on features that are supported with VCS slave mode, contact `vcs_support@synopsys.com`.

`-P pli.tab`

Compiles a user-defined PLI definition table file.

`+vpi`

Enables the use of VPI PLI access routines.

`+vpi+1`

Allows you to reduce the runtime memory by reducing the information storage for VPI interface at runtime. This option limits the behavioral information at compile-time, but preserves the structural information.

This option allows you to:

- Browse the design hierarchy and read the values of variables. This facilitates debugging.
- Write over or force values on variables using `vpi_put_value()`. This allows a foreign language testbench to drive a stimulus to a Verilog design.

- Register VPI callbacks. This facilitates the waveform dumping features. However, certain advance debugging features (such as Line stepping, Driver/Loads information, and so on) will not be available.

### **Limitations:**

- You cannot use this option to browse, enable, or disable SV and RT assertions.

#### **Note:**

The `+vpi+1+assertion` option allows you to browse, enable, and disable SV and RT assertions to the base features of `+vpi+1`.

- If you use `+vpi+1` with any debug option (`-debug_all`, `-debug_pp`, or `-debug`), and try to use UCLI commands, then some of the commands may fail. No diagnostics or error messages will be generated to suggest that those commands are failing due to existence of `+vpi+1` option.

#### **`+vpi+1+assertion`**

Allows you to browse, enable, and disable SV and RT assertions to the base features of `+vpi+1`.

#### **`-load shared_library:registration_routine`**

Specifies the registration routine in a shared library for a VPI application.

#### **`-use_vpiobj`**

Specifies the `vpi_user.c` file that enables you to use the `vpi_register_systf` VPI access routine.

---

## Options to Enable the VCS DirectC Interface

+vc+ [abstract+allhdrs+list]

The `+vc` option enables extern declarations of C/C++ functions and calling these functions in your source code. See the *VCS DirectC Interface User Guide*. The optional suffixes to this option are as follows:

`+abstract`

Enables abstract access through `vc_handles`.

`+allhdrs`

Writes the `vc_hdrs.h` file that contains external function declarations that you can use in your Verilog code.

`+list`

Displays all the C/C++ functions that you called in your Verilog source code.

---

## Options for Flushing Certain Output Text File Buffers

When VCS creates a log, VCD, or text file specified with the `$fopen` system function, VCS writes the data for the file in a buffer and periodically dumps the data from the buffer to the file on disk. The frequency of these dumps varies depending on many factors including the amount of data that VCS has to write to the buffer as simulation or compilation progresses. If you need to see or use the latest information in these files more frequently than the rate at which VCS normally flushes this data, these options tell VCS to flush the data more often during compilation or simulation.

`+vcs+flush+log`

Increases the frequency of flushing both the compilation and simulation log file buffers.

`+vcs+flush+dump`

Increases the frequency of flushing all VCD file buffers.

`+vcs+flush+fopen`

Increases the frequency of flushing all the buffers for the files opened by the `$fopen` system function.

`+vcs+flush+all`

Shortcut option for entering all three of the `+vcs+flush+log`, `+vcs+flush+dump` and `+vcs+flush+fopen` options.

These options do not increase the frequency of dumping other text files, including the VCDE files specified by the `$dumports` system task or the simulation history file for LSI certification specified by the `$lsi_dumports` system task.

These options can also be entered at runtime. Entering them at compile-time modifies the simv executable so that it runs as if these options were always entered at runtime.

---

## Options for Simulating SWIFT VMC Models and SmartModels

`-lmc-swift`

Includes the LMC SWIFT interface.

`-lmc-swift-template`

Generates a Verilog template for a SWIFT Model.

---

## Options for Controlling Messages

`+libverbose`

Tells VCS to display a message when it finds a module definition in a source file in a Verilog library directory that resolves a module instantiation statement that VCS read in your source files, a library file, or in another file in a library directory. The message is:

`Resolving module "module_identifier"`

VCS does not display this message when it finds a module definition in a Verilog library file that resolves a module instantiation statement.

`+lint=[no] ID|none|all`

Enables messages that tell you when your Verilog code contains something that is bad style, but is often used in designs.

`-no_error ID+ID`

Changes the error messages with the UPIMI and IOPCWM IDs to warning messages with the `-no_error` compile-time option. You include one or both IDs as arguments, for example:

`-noerror UPIMI+IOPCWM`

This option does not work with the ID for any other error message.

`-notice`

Enables verbose diagnostic messages.

-q

Quiet mode; suppresses messages such as those about the C compiler VCS is using, the source files VCS is parsing, the top-level modules, or the specified timescale.

-V

Verbose mode; compiles verbosely. The compiler driver program prints the commands it executes as it runs the C compiler, assembler, and linker. If you include the -R option with the -V option, the -V option is also passed to runtime executable, just as if you had entered `simv -V`.

-Vt

Verbose mode; provides CPU time information. Like -V, but also prints the amount of time used by each command. Use of the -Vt option can cause the simulation to slow down.

+warn= [no] ID | none | all

Uses warning message IDs to enable or disable display of warning messages. In the following warning message:

```
Warning- [TFIPC] Too few instance port connections
```

The text string TFIPC is the message ID. The syntax of this option is as follows:

+warn= [no] ID | none | all, ...

Where:

- |    |                                                                                                                     |
|----|---------------------------------------------------------------------------------------------------------------------|
| no | Specifies disabling warning messages with the ID that follows. There is no space between the keyword no and the ID. |
|----|---------------------------------------------------------------------------------------------------------------------|

- |      |                                                                                                                                     |
|------|-------------------------------------------------------------------------------------------------------------------------------------|
| none | Specifies disabling all warning messages. IDs that follow, in a comma-separated list, specify exceptions.                           |
| all  | Specifies enabling all warning messages, IDs that follow preceded by the keyword no, in a comma separated list, specify exceptions. |

The following are examples that show how to use this option:

|                      |                                                                     |
|----------------------|---------------------------------------------------------------------|
| +warn=noIPDW         | Enables all warning messages except the warning with the IPDW ID.   |
| +warn=none,TFIPC     | Disables all warning messages except the warning with the TFIPC ID. |
| +warn=noIPDW,noTFIPC | Disables the warning messages with the IPDW and TFIPC IDs.          |
| +warn=all            | Enables all warning messages. This is the default.                  |

## Options for Cell Definition

+nolibcell

Does not define as a cell modules defined in libraries unless they are under the `celldefine compiler directive.

+nocelldefinepli+0

Enables recording in VPD files, the transition times and values of nets and registers in all modules defined under the `celldefine compiler directive or defined in a library that you specify with the -v or -y options. This option also enables full PLI access to these modules.

+nocelldefinepli+1

Disables recording in VPD files, the transition times and values of nets and registers in all modules defined under the `celldefine compiler directive. This option also disables full PLI access to these modules. Modules in a library file or directory are not affected by this option unless they are defined under the `celldefine compiler directive.

+nocelldefinepli+2

In VPD files, disables recording the transition times and values of nets and registers in all modules defined under the `celldefine compiler directive or defined in a library that you specify with the -v or -y options, whether the modules in these libraries are defined under the `celldefine compiler directive or not. This option also disables PLI access to these modules.

Disabling recording of transition times and values of the nets and registers in library cells can significantly increase simulation performance.

Note:

Disabling recording transitions in library cells is intended for batch simulation only and not for interactive debugging with DVE. Any attempt in DVE to access a part of your design for which VPD has been disabled may have unexpected results.

+nocelldefinepli+1+ports

Removes the PLI capabilities from `celldefine modules but allows PLI access to port nodes and parameters.

+nocelldefinepli+2+ports

Removes the PLI capabilities from library and `celldefine modules and allows PLI access to port nodes and parameters.

---

## Options for Licensing

`+vcs+lic+vcsi`

Checks out three VCSI licenses to run VCS.

`+vcsi+lic+vcs`

Checks out a VCS license to run VCSI when all VCSI licenses are in use.

`+vcs+lic+wait`

Tells VCS to wait for a network license if none is available.

`+vcsi+lic+wait`

Tells VCSI to wait for a network license if none is available.

`-licwait timeout`

Enables license queuing, where *timeout* is the time in minutes that VCS waits for a license before finally exiting.

`-licqueue`

Tells VCS to wait for a network license if none is available.

`-ID`

Returns useful information about a number of things: the version of VCS that you have set the VCS\_HOME environment variable to, the name of your work station, your workstation's platform, the host ID of your workstation (used in licensing), the version of the VCS compiler (same as VCS) and the VCS build date.

---

## Options for Controlling the Linker

`-ld linker`

Specifies an alternate front-end linker. Only applicable in incremental compile mode, which is the default.

`-LDFLAGS options`

Passes flag options to the linker. Only applicable in incremental compile mode, which is the default.

`-C`

Tells VCS to compile the source files, generate the intermediate C, assembly, or object files, and compile or assemble the C or assembly code, but not to link them. Use this option if you want to link by hand.

`-lname`

Links the *name* library to the resulting executable. Usage is the letter `l` followed by a name (no space between `l` and *name*). For example: `-lm` (instructs VCS to include the math library).

`-Marchive=number_of_module_definitions`

By default, VCS compiles module definitions into individual object files and sends all the object files in a command line to the linker. Some platforms use a fixed-length buffer for the command line, and if VCS sends too long a list of object files, this buffer overflows and the link fails. A solution to this problem is to have the linker create temporary object files containing more than one module definition so there are fewer object files on the linker command line. With this option, you enable creating these temporary object files and specify how many module definitions are in these files.

Using this option briefly doubles the amount of disk space used by the linker because the object files containing more than one module definition are copies of the object files for each module definition. After the linker creates the `simv` executable, it deletes the temporary object files.

`-picarchive`

VCS can fail during linking due to the following two reasons:

- Huge size of object files: VCS compiles the units of your design into object files, then calls the linker to combine them together. Sometimes the size of a design is large enough that the size of text section of these object files exceeds the limit allowed by the linker. If so, the linker fails and generates the following error:

```
relocation truncated to fit:....
```

- Large number of object files: By default, VCS compiles module or entity definitions into individual object files and sends this list of object files in a single command line to the linker. Some platforms use a fixed-length buffer for the command line. If VCS sends a long list of object files, this buffer overflows and the link fails, generating errors such as:

```
make: execvp: gcc: Argument list too long
```

```
make: execvp: g++: Argument list too long
```

You can use the `-picarchive` option to deal with the above linker errors. The `-picarchive` option does the following:

- 1 . Enables Position Independent Code (PIC) object file generation along with linking the shared object version of VCS libraries.

2 . Archives generated PIC code into multiple shared objects inside simv.daidir or simv.db.dir directory.

3 . Links the Shared objects at runtime to the final executable, instead of linking all the objects statically into final executable in a single step at compile-time.

---

## Options for Controlling the C Compiler

`-cc compiler`

Specifies an alternate C compiler.

`-CC options`

Passes options to the C compiler or assembler.

`-CFLAGS options`

Passes options to C compiler. Multiple `-CFLAGS` are allowed.

Allows passing of C compiler optimization levels. For example, if your C code, test.c, calls a library file in your VCS installation under `$VCS_HOME/include`, use any of the following `CFLAGS` option arguments:

```
%vcs top.v test.c -CFLAGS "-I$VCS_HOME/include"
```

or

```
%setenv CWD `pwd`
```

```
%vcs top.v test.c -CFLAGS "-I$CWD/include"
```

or

```
%vcs top.v test.c -CFLAGS "-I../include"
```

**Note:**

The reason to enter ".../include" is because VCS creates a default `csrc` directory where it runs gcc commands. The `csrc` directory is under your current working directory.

Therefore, you need to specify the relative path of the `include` directory to the `csrc` directory for gcc C compiler. Further, you cannot edit files in the `csrc` because VCS automatically creates this directory.

`-cpp`

Specifies the C++ compiler.

**Note:**

If you are entering a C++ file or an object file compiled from a C++ file on the `vcs` command line, you must tell VCS to use the standard C++ library for linking. To do this, enter the `-lstdc++` linker flag with the `-LDFLAGS` elaboration option.

For example:

```
vcs top.v source.cpp -P my.tab \
 -cpp /net/local/bin/c++ -LDFLAGS -lstdc++
```

`-j number_of_processes`

Specifies the number of processes that VCS forks for parallel compilation. There is no space between the "j" character and the number. You can use this option in any compilation mode: directly generating object files from the parallel compilation of your Verilog source files (`-gen_obj`, default on the Solaris and RHEL32 platforms), generating intermediate assembly files (`-gen_asm`) and then their parallel assembly, or generating intermediate C files (`-gen_c`) and their parallel compilation.

**-C**

Stops after generating the C code intermediate files.

**-O0**

Suppresses optimization for faster compilation (but slower simulation). Suppresses optimization for how VCS both writes intermediate C code files and compiles these files. This option is the uppercase letter "O" followed by a zero with no space between them.

**-Onumber**

Specifies an optimization level for how VCS both writes and compiles intermediate C code files. The number can be in the 0-4 range; 2 is the default, 0 and 1 decrease optimization, 3 and 4 increase optimization. This option is the uppercase letter "O" followed by 0, 1, 2, 3 or 4 with no space between them. See above, for additional information regarding the -O0 variant.

**-override-cflags**

Tells VCS not to pass its default options to the C compiler. By default, VCS has a number of C compiler options that it passes to the C compiler. The options it passes depends on the platform, whether it is a 64-bit compilation and other factors. VCS passes these options and then passes the options you specify with the -CFLAGS compile-time option.

---

## Options for Source Protection

**+autoprotect [file\_suffix]**

Creates a protected source file; all modules are encrypted.

+auto2protect [*file\_suffix*]

Creates a protected source file that does not encrypt the port connection list in the module header; all modules are encrypted.

+auto3protect [*file\_suffix*]

Creates a protected source file that does not encrypt the port connection list in the module header or any parameter declarations that precede the first port declaration; all modules are encrypted.

+deleteprotected

Allows overwriting of existing files when doing source protection.

+pli\_unprotected

Enables PLI and UCLI access to the modules in the protected source file being created (PLI and UCLI access is normally disabled for protected modules).

+protect [*file\_suffix*]

Creates a protected source file, only encrypting `protect/`endprotect regions.

+object\_protect <sourcefile>

Debugs the partially encrypted source code.

```
vcs +protect +object_protect <sourcefile.v>
```

+putprotect+target\_dir

Specifies the target directory for protected files.

+sdfprotect [*file\_suffix*]

Creates a protected SDF file.

`-Xmangle=number`

Produces a mangled version of input, changing variable names to words from list. Useful to get an entire Verilog design into a single file. Output is saved in the `tokens.v` file. You can substitute `-Xman` for `-Xmangle`.

The argument `number` can be 1, 4, 12, or 28:

`-Xman=1`

Randomly changes names and identifiers, and removes comments, to provide more secure code.

`-Xman=4`

Preserves variable names, but removes comments.

`-Xman=12`

Does the same thing as `-Xman=4`, but also enters, in comments, the original source file name and the line number of each module header.

`-Xman=28`

Does the same thing as `-Xman=12`, but also writes at the bottom of the file comprehensive statistics about the contents of the original source file.

`-Xnomangle=.first | module_identifier, ...`

Specifies module definitions whose module and port identifiers VCS does not change. You use this option with the `-Xman` option. The `.first` argument specifies the module by location (first in file) rather than by identifier. You can substitute `-Xnoman` for `-Xnomangle`.

---

## Options for Mixed Analog/Digital Simulation

`+ad=partition_filename`

Specifies the partition file that you use in mixed Analog/Digital simulation to specify the part of the design simulated by the analog simulator, the analog simulator you want to use, and the resistance mapping information that maps analog drive resistance ranges to Verilog strengths.

`-ams_discipline discipline_name`

Specifies the default discrete discipline in VerilogAMS.

`-ams_iereport`

If information on auto-inserted connect modules (AICMs) is available, displays this information on the screen and in the log file.

`+bidir+1`

Tells VCS to finish compilation when it finds a bidirectional registered mixed-signal net.

`+print+bidir+warn`

Tells VCS to display a list of bidirectional, registered, mixed signal nets.

---

## Options for Changing Parameter Values

`-pvalue+parameter_hierarchical_name=value`

Changes the specified parameter to the specified value.

`-parameters filename`

Changes parameters specified in the file to values specified in the file. The syntax for a line in the file is as follows:

`assign value path_to_parameter`

The path to the parameter is similar to a hierarchical name, except that you use the forward slash character (/) instead of a period as the delimiter.

---

## Checking for X and Z Values in Conditional Expressions

`-xzcheck [nofalseneg]`

Checks all the conditional expressions in the design and displays a warning message every time VCS evaluates a conditional expression to have an X or Z value.

`nofalseneg`

Suppress the warning message when the value of a conditional expression transitions to an X or Z value and then to 0 or 1 in the same simulation time step.

---

## Options for Detecting Race Conditions

`-race`

Specifies that VCS generate a report of all the race conditions in the design and write this report in the `race.out` file during simulation. For more information, see “[The Dynamic Race Detection Tool](#)” .

Note:

The `-race` compile-time option supports dynamic race detection for both pure Verilog and SystemVerilog data types.

`-racecd`

Specifies that during simulation, VCS generate a report of the race conditions in the design between the `'race` and `'endrace` compiler directives and write this report in the `race.out` file. For more information, see “[The Dynamic Race Detection Tool](#)” .

Note:

The `-racecd` compile-time option supports dynamic race detection for both pure Verilog and SystemVerilog data types.

`+race=all`

Analyzes the source code during compilation to look for coding styles that cause race conditions. For more information, see “[The Static Race Detection Tool](#)” .

Note:

The `+race=all` option supports only pure Verilog constructs.

---

## Options to Specify the Time Scale

`-timescale=time_unit/time_precision`

Occasionally, some source files contain the `timescale compiler directive and others do not. In this case, if you specify the source files that do not contain the `timescale compiler directive on the command line before you specify the ones that do, this is an error condition and VCS halts compilation, by default. This option enables you to specify the timescale for the source files that do not contain this compiler directive and precede the source files that do. Do not include spaces when specifying the arguments to this option.

`-unit_timescale [= <default_timescale>]`

The `-unit_timescale` option enables you to specify the default time unit for the compilation-unit scope. You must not include spaces when specifying arguments to this option.

The IEEE Standard 1800-2005 LRM, topic 19.10, page 340 explains the time unit declaration, as follows:

*"The time unit of the compilation-unit scope can only be set by a time unit declaration, not a `timescale directive. If it is not specified, then the default time unit shall be used."*

Since the `-timescale` option does not affect the compilation-unit scope, you must use the `-unit_timescale` option to specify the default time unit for the compilation-unit scope.

The `default_timecale` value should be in the same format as the ``timescale` directive. If the default timescale is not specified, then `1s/1s` is taken as the default timescale of the compilation-unit.

`-override_timescale=time_unit/time_precision`

Overrides the time unit and precision unit for all the `timescale compiler directives in the source code, and, similar to the -timescale option, provides a timescale for all module definitions that precede the first `timescale compiler directive. Do not include spaces when specifying the arguments to this option.

---

## Options for Overriding Parameters

-gfile

You can use the -gfile compile-time option, to override parameter values through a file.

You need to specify the file name, which contains the list of all parameters that should be overridden, with the -gfile option.

The syntax for -gfile option is as follows:

```
vcs top_level_module -gfile
parameters_or_generics_file other_options
```

The syntax for the *parameters\_or\_generics\_file* is as follows:

*assign val path*

Each option In the above syntax is described below:

*val*: The value that overrides the Specified parameter.

*path*: Specifies the absolute hierarchical path to the parameter value which is to be overridden.

Note:

The `-gfile` supports only VHDL syntax for hierarchical path representation.

All escaped identifiers in the Verilog path must be converted into VHDL extended identifiers. If the escaped identifier contains '\' characters, they must be escaped with another '\' character.

For example, consider the following Verilog hierarchical path for the parameter 'P1'.

```
top.dut.\inst1_\cpu .inst2.P1
```

The corresponding `generics_file` entry is as follows:

```
assign 'hfffffffff /top/dut/\inst1_\\cpu\\/
inst2/P1
```

All 'for-generate' and 'instance-array' parentheses must be round parentheses, and the path delimiter must be '/'. All instance paths must start with '/'.

### **Example:**

You can override the parameter and generic values using the `-gfile` option as follows:

```
vcs test.v -gfile overrides.txt
```

where, `overrides.txt` contains the following entries:

```
assign 'hfffffffff /top/dut/\inst1_\\cpu\\/
inst2/P1
```

```
assign "DUMMY" /top/dut/\inst1_\\cpu\inst2/
P2

assign 10.34 /top/dut/\inst1_\\cpu\inst2/P3
```

### **Supported Data Types:**

The following data types are supported in `-gfile` option:

- Integer
- Real
- String

The `-gfile` option ignores other data types with a suitable warning message.

`-pvalue`

You can use the `-pvalue` compile-time option for changing the parameter values from the vcs command line.

You specify a parameter with the `-pvalue` option. It has the following syntax:

```
vcs -pvalue+hierarchical_name_of_parameter=
value
```

### **Example:**

```
vcs source.v -pvalue+test.d1.param1=33
```

### **Note:**

The `-pvalue` option does not work with a localparam or a specparam.

---

## General Options

### Specifying Directories for ‘include Searches

+incdir+*directory*+

Specifies the directory or directories in which VCS searches for include files used in the `include compiler directive. More than one directory may be specified, separated by the plus (+) character.

### Enable the VCS/SystemC Cosimulation Interface

-sysc

Enables SystemC cosimulation engine.

-sysc=adjust\_timeres

Determines the finer time resolution of SystemC and HDL in case of a mismatch, and sets it as the simulator’s timescale. VCS may be unable to adjust the time resolution if you elaborate your HDL with the -timescale option or use the `sc_set_time_resolution()` function call in your SystemC code. In such cases, VCS reports an error and does not create simv.

Note:

You must use this option along with the -sysc option.

## **TetraMAX**

+tetramax

Enables simulation of TetraMAX's testbench in zero delay mode.

## **Suppressing Port Coersion to inout**

+noportcoerce

Prevents VCS MX from coercing ports to inout ports, which is the default condition. This option is the equivalent of the `noportcoerce` compiler directive.

## **Allow Inout Port Connection Width Mismatches**

+noerrorIOPCWM

Changes the error condition, when a signal is wider or narrower than the inout port to which it is connected, to a warning condition, thus allowing VCS to create the simv executable after displaying the warning message.

## **Allow Zero or Negative Multiconcat Multiplier**

-noerror ZONMCM

Changes the following errors to a warning condition, thus allowing VCS to create the simv executable after displaying the warning message:

Error- [ZMMCM] Zero multiconcat multiplier cannot be used in this context  
A replication with a zero replication constant is considered to have a size of zero and is ignored. Such a replication shall appear only within a concatenation in which at least one of the operands of the concatenation has a positive size.  
target : {0 {1'bx}}

```
Error- [NMCM] Negative multiconcat multiplier
target : {(-1) {1'bx}}
"my_test.v", 6
```

VCS errors out if you use "0" or a negative number as a multiconcat multiplier. You can change that error to a warning message using this option.

## Specifying a VCD File

+vcs+dumpvars

A substitute for entering the `$dumpvars` system task, without arguments, in your Verilog code.

## Enabling Dumping

+vcs+vcdpluson

A compile-time substitute for `$vcdpluson` option. The `+vcs+vcdpluson` switch enables dumping for the entire design. You would however need to use a debug switch (example `-debug_pp`) to dump the data.

## Memories and Multi-Dimensional Arrays (MDAs)

+memcbk

Enables callbacks for memories and multi-dimensional arrays (MDAs). Use this option if your design has memories or MDAs and you are doing any of the following:

- Writing a VCD or VPD file during simulation. For VCD files, at runtime, you must also enter the `+vcs+dumparrays` runtime option. For VPD files, you must also enter the `$vcdplusmemon` system task. VCD and VPD files are used for post-processing with DVE.
- Using the VCS/SystemC Interface.
- Writing an FSDB file for Debussy.
- Using any debugging interface application - VCSD/PLI (acc/vpi) that needs to use value change callbacks on memories or MDAs. APIs like `acc_add_callback`, `vcsd_add_callback` and `vpi_register_cb` need this option if these APIs are used on memories or MDAs.

Note:

The `+memcbk` option is enabled by default when any one of the following debug options is used at compile-time:

`-debug -debug_pp -debug_all`

## Specifying a Log File

`-l filename`

Specifies a file where VCS records compilation messages. If you also enter the `-R` option, VCS records messages from both compilation and simulation in the same file.

`-a logfilename`

Captures simulation output and appends the log information in the existing log file. If the log file doesn't exist, then this option would create a log file.

## **Changing Source File Identifiers to Upper Case**

-u

Changes all the characters in identifiers to uppercase. It does not change identifiers in quoted strings such as the first argument to the \$monitor system task. You do not see this change in the DVE Source window, but you do see it in all the other DVE windows.

## **Defining a Text Macro**

+define+macro=value+

Defines a text macro in your source code to a value or character string. You can test for this definition in your Verilog source code using the `ifdef compiler directive. If there are blank spaces in the character string, then you must enclose it in quotation marks. For example:

```
vcs design.v +define+USELIB="dir=dir1 dir=dir2"
```

The macro is used in a `uselib compiler directive:

```
'uselib 'USELIB libext+.v
```

## **Specifying the Name of the Executable File**

-o name

Specifies the name of the executable file. In UNIX, the default is simv.

## **Returning The Platform Directory Name**

-platform

Returns the name of the *platform* directory in your VCS installation directory. For example, when you install VCS on a Solaris version 5.4 workstation, VCS creates a directory named, sun\_sparc\_solaris\_5.4, in the directory where you install VCS. In this directory are subdirectories for licensing, executable libraries, utilities, and other important files and executables. You need to set your path to these subdirectories. You can do so by using this option:

```
set path=($VCS_HOME/bin\
$VCS_HOME/'$VCS_HOME/bin/vcs -platform'/bin\$path)
```

## **Enable Loop Detect**

+vcs+loopreport+*number*

Displays a runtime warning message, terminates the simulation, and generates a report when a zero delay loop is detected. By default, VCS checks if a simulation event loops for more than 2,000,000 times during the same simulation time. You can change this default value by specifying any *number* along with this option.

+vcs+loopdetect+*number*

Displays a runtime error message and terminates the simulation when a zero delay loop is detected. By default, VCS checks if a simulation event loops for more than 2,000,000 times during the same simulation time. You can change this default value by specifying any *number* along with this option.

## **Changing the Time Slot of Sequential UDP Output Evaluation**

+udpsched

By default, VCS evaluates the output terminals of sequential UDP (user-defined primitive) in the Active time slot of a simulation time. This can cause a race condition. This switch prevents these race conditions by changing the evaluation to the NBA time slot.

The default behavior is required by the SystemVerilog LRM, IEEE Std 1800-2009, section 4.9.6 “Port connections” which specifies “Changes from primitive evaluations are scheduled as active update events in the connected nets.”

## Gate-Level Performance

`-hsopt=gates`

Improves runtime performance on gate-level designs (both functional and timing simulations with SDF). You may see some compile-time degradation when you use this switch.

Note:

You cannot use this option on a design, if there are PLI writes to sequential UDPs.

## Option to Omit Compilation of Code Between Pragmas

`-skip_translate_body`

Tells VCS to omit compilation of Verilog or SystemVerilog code between the following:

```
the //synopsys translate_off or
/* synopsys translate_off */ pragma
```

and

```
the //synopsys translate_on or
/* synopsys translate_on */ pragma
```

The following code example shows what this option can do:

```
module test;
initial begin
$display("\n before translate_off");
//synopsys translate_off
$display("\n after translate_off before translate_on");
//synopsys translate_on
$display("\n after translate_on before translate_off");
//synopsys translate_off
$display("\n 2nd after translate_off before translate_on");
//synopsys translate_on
$display("\n after translate_on\n");
end
endmodule
```

Without the `-skip_translate_body` option, VCS displays the following:

```
before translate_off

after translate_off before translate_on

after translate_on before translate_off

2nd after translate_off before translate_on

after translate_on
```

VCS compiles and executes all the `$display` system tasks.

With the `-skip_translate_body` option, VCS displays the following:

```
before translate_off
```

```
after translate_on before translate_off
```

```
after translate_on
```

VCS does not compile and execute the \$display system tasks between the //synopsys translate\_off and //synopsys translate\_on pragmas.

# D

## Simulation Options

---

This appendix describes the options and syntax associated with the `simv` executable. These runtime options are typically entered on the `simv` command line but some of them can be compiled into the `simv` executable at compile-time.

This appendix describes the following runtime options:

- “[Options for Simulating Native Testbenches](#)”
- “[Options for SystemVerilog Assertions](#)”
- “[Options to Control Termination of Simulation](#)”
- “[Options for Enabling and Disabling Specify Blocks](#)”
- “[Options for Specifying When Simulation Stops](#)”
- “[Options for Recording Output](#)”
- “[Options for Controlling Messages](#)”

- “Options for VPD Files”
  - “Options for VCD Files”
  - “Options for Specifying Delays”
  - “Options for Flushing Certain Output Text File Buffers”
  - “Options for Licensing”
  - “Option to Specify User-Defined Runtime Options in a File”
  - “Option for Initializing Integer Data Type Variables at Runtime”
  - “General Options”
- 

## Options for Simulating Native Testbenches

`-cg_coverage_control`

Enables/disables the coverage data collection for all the coverage groups in your NTB-OV or SystemVerilog testbench.

Note:

The system task `$cg_coverage_control` has precedence over this option.

Syntax: `-cg_coverage_control=value`

The valid values for `-cg_coverage_control` are 0 and 1. A value of 0 disables coverage collection and a value of 1 enables coverage collection.

Note:

You can also use this runtime option with the `coverage_control()` system task. The `coverage_control()` system task enables/disables data collection for one or more coverage groups at the program level. The runtime option takes precedence over the system task. For more information on this system task, refer to the *OpenVera Language Reference Manual: Native Testbench*.

`+ntb_cache_dir`

Specifies the directory location of the cache that VCS maintains as an internal disk cache for randomization.

`+ntb_delete_disk_cache=value`

Specifies whether VCS deletes the disk cache for randomization before simulation. The valid values are:

0 - do not delete (the default condition)

1 - delete the disk cache

`+ntb_disable_cnst_null_object_warning [=value]`

VCS produces the following warning when a null object handle is encountered in an object being randomized. Allowed values are 0 and 1.

0 - Do not disable null object warning (this is the default)

1 - Disable null object warning

Here is an example of the null object warning:

```
Warning- [CNST-PPRW] Constraint randomize NULL
object warning test.sv, <line number>. Null
object found during randomization. Please make
sure all random variables/arrays/function calls
being randomized are allocated fully and
properly.
```

The null handle may be intentional or the result of an oversight. If you want to randomize objects which contain null handles, you can use this switch to disable the runtime warning.

```
+ntb_enable_checker_trace=0|1
```

In-line constraint checker using `randomize(null)` returns 1 if all constraints are satisfied and 0 otherwise. This option controls whether the constraint checker trace is enabled or not. The valid arguments are as follows:

0 - do not display the constraint checker trace (default)

1 - displays the constraint checker trace

If `+ntb_enable_solver_trace` is specified without an argument, the default value is 1. If it is not specified, the default value is 0.

```
+ntb_enable_checker_trace_on_failure [=value]
```

Enables a mode that prints trace information only when the `randomize` returns 0. Allowed values are 0, 1, and 2.

- |   |                                       |
|---|---------------------------------------|
| 0 | Disables tracing                      |
| 1 | Enables tracing                       |
| 2 | Enables more verbose message in trace |

- 3        In addition to the message in trace with option 2, the checker reports all the earlier solved constraints, which could have lead to the current failing constraint.

If `ntb_enable_checker_trace_on_failure` is specified without an argument, the default value is 1. If the `ntb_enable_checker_trace_on_failure` is not specified, the default value is 2.

`+ntb_enable_solver_trace_on_failure [=0|1|2|3]`

Displays trace information when the VCS constraint solver fails to compute a solution. The valid argument values are as follows:

- 0        Disables displaying trace information  
1        Enables displaying trace information  
2        Enables more verbose trace information  
3        In addition to the more verbose trace information specified with 2, the solver reports all the earlier solved constraints, which could have lead to the current failing constraint.

`+ntb_exit_on_error [=value]`

Causes VCS to exit when the value is less than 0. The value can be:

0 - continue

1 - exit on first error (default value)

N - exit on nth error

When the value is 0, the simulation finishes regardless of the number of errors.

`+ntb_load=path_name_to_libtb.so`

Specifies loading the testbench shared object file, *libtb.so*.

`+ntb_random_seed=value`

Sets the seed value to be used by the top-level random number generator at the start of simulation. The `srandom(seed)` system function call overrides this setting. The value can be any integer.

`+ntb_random_seed_automatic`

Picks a unique value to supply as the first seed used by a testbench. The value is determined by combining the time of day, host name and process id. This ensures that no two simulations have the same starting seed.

The `+ntb_random_seed_automatic` seed appears in both the simulation log and the coverage report. When you enter both `+ntb_random_seed_automatic` and `+ntb_random_seed` VCS MX displays a warning message and uses the `+ntb_random_seed` value.

`+ntb_random_reseed`

Enables the re-seeding of the value the top-level random number generator uses after a save and restore of the simulation.

You enter this option with the `+ntb_random_seed_automatic` or `+ntb_random_seed=value` options. The seed value after the restore is the same as the one specified or generated by these other options.

if you omit these other options VCS ignores the +ntb\_random\_reseed option and displays the following informational message:

```
Info- [RNG-SEED-MISSING] New seed was not specified for reseeding.
```

```
Please use runtime option +ntb_random_seed= or +ntb_random_automatic to specify new seed.
```

The `srandom(seed)` system function overrides this re-seeding.

`+ntb_solver_array_size_warn=value`

Specifies the array size warning limit (default is 10000) for constrained array sizes.

`+ntb_solver_debug=keyword_argument`

Tells VCS to give you more information so you can debug the constraints for the `randomize()` calls in batch mode. The keyword arguments are as follows:

`extract`

Tells VCS to extract a standalone test case in SystemVerilog for the specified `randomize()` call(s). To use this keyword argument also enter the `+ntb_solver_debug_filter` runtime option.

`profile`

Enables constraint profiling in VCS. You can view the constraint profile report in `simv.cst/html/profile.xml` using a web browser (`simv` is the default name of the VCS `simv` executable).

This keyword argument also writes a file with a listing of the top randomize calls in `simv.cst/serial2trace.txt` (`simv` is the default name of the VCS `simv` executable).

`serial`

Displays the randomize serial number at the end of each `randomize()` completion.

`trace`

Displays the solver trace to show how VCS solved the constraints for the random variables in specified `randomize()` call(s). To use this argument also enter the `+ntb_solver_debug_filter` runtime option.

`trace_all`

Displays the solver trace for all `randomize()` calls.

`+ntb_solver_debug=trace_all` is the equivalent of entering the following options and arguments together:

`+ntb_solver_debug=trace`  
`+ntb_solver_debug_filter=all`

You can enter multiple the keyword arguments using a plus (+) as a delimiter, for example:

```
vcs source.sv +ntb_solver_debug=serial+extract+profile \
+ntb_solver_debug_filter=12
```

You cannot enter multiple `+ntb_solver_debug` options.

`+ntb_solver_debug_dir=pathname`

Directs VCS to place profiles and extracted testcases in the specified directory. The default directory name is `simv.cst`, after the `simv` executable with the `.cst` extension.

```
+ntb_solver_debug_filter=
 serial_num [.partition_num] | file[:filename] |
all
```

Specifies a list of `randomize()` calls that VCS displays debug information about. You can specify this list in the following ways:

- a comma separated list, for example:

```
+ntb_solver_debug_filter=1.5,4,20
```

This example specifies: the 5th partition of 1st call, and all partitions of the 4th and 20th call.

- in a file. The default filename is:

```
simv.cst/serial2trace.txt.
```

You just need to enter the keyword argument `file` if the file is the default file name and location.

- the keyword `all` as in:

```
+ntb_solver_debug_filter=all
```

Specifying `all` means you want debug information about all `randomize()` calls.

Note:

The `all` argument can result in a large amount of solver trace information or extracted test cases.

```
+ntb_solver_mode=value
```

Allows you to choose between one of two constraint solver modes. When set to 1, the solver spends more preprocessing time in analyzing the constraints during the first call to randomize() on each class. Therefore, subsequent calls to randomize() on that class are very fast. When set to 2, the solver does minimal preprocessing, and analyzes the constraint in each call to randomize(). The default is 2.

`+ntb_stop_on_constraint_solver_error=0 | 1`

Specifies whether VCS continues or exits after a constraint solver failure due to constraint inconsistency.

- |   |                                                                   |
|---|-------------------------------------------------------------------|
| 0 | VCS continues to run after a constraint solver failure (default). |
| 1 | VCS exits on the first constraint solver error                    |

---

## Options for SystemVerilog Assertions

`-assert keyword_argument`

Note:

The `-assert keyword_argument` runtime options are enabled only when the `-assert enable_diag` switch is given at compile-time.

The keyword arguments are as follows:

`dumpoff`

Disables the dumping of SVA information in the VPD file during simulation.

`finish_maxfail=N`

Terminates the simulation if the number of failures for any assertion reaches  $N$ . You must supply  $N$ , otherwise no limit is set.

`global_finish_maxfail=N`

Stops the simulation when the total number of failures, from all SystemVerilog assertions, reaches  $N$ .

`maxcover=N`

Disables the collection of coverage information for cover statements after the cover statements are covered  $N$  number of times.  $N$  must be a positive integer; it cannot be 0.

`maxfail=N`

Limits the number of failures for each assertion to  $N$ . When the limit is reached, VCS disables the assertion. You must supply  $N$ , otherwise no limit is set.

`maxsuccess=N`

Limits the total number of reported successes to  $N$ . You must supply  $N$ , otherwise no limit is set. VCS continues to monitor assertions even after the limit is reached.

`nocovdb`

Tells VCS not to write the `program_name.db` database file for assertion coverage.

`nopostproc`

Disables the display of the SystemVerilog `assert` and `cover` statement summary at the end of simulation.

This begins with the assert and cover statements that started but did not finish, in the following format:

```
"source_filename.v", line_number:
assert_or_cover_statement_hierarchical_name:
started at simulation_time not finished
```

If the assert or cover statement doesn't start, this summary also reports this in the following format::

```
***** Following assertions did not fire at all
during simulation. *****
"source_filename.v", line_number:
assert_or_cover_statement_hierarchical_name:
No attempt started
```

This is followed by a cover statement summary in the following format:

```
"source_filename.v", line_number:
cover_statement_hierarchical_name, number
attempts, number match
```

no\_fatal\_action

Excludes failures on SVA assertions with fail action blocks for computation of failure count in the -assert [global\_] finish\_maxfail=N runtime option.

no\_default\_msg [=SVA|OVA|PSL]

Disables the display of default failure messages for SVA assertions that contain a fail action block, and OVA and PSL assertions that contain user messages.

`quiet`

Disables the display of messages when assertions fail.

`quiet1`

Disables the display of messages when assertions fail, but enables the display of summary information at the end of simulation. For example:

Summary: 2 assertions, 2 with attempts, 2 with failures

`report [=path/filename]`

- Generates a report file in addition to printing results on your screen. By default, the report file name and location is `./assert.report`, but you can change it by entering the `path/filename` argument. The report file name can start with a number or letter.
- Generates a report of all assertions that are disabled using any one of the following mechanisms:
  - System tasks `$assertOn/off/kill`
  - `assert hier` at compile/runtime

The report is categorized based on:

- Disabled assertions on a module level (compile-time)
- Assertions disabled through the `-assert hier` option
- Disabled assertions at End-of-Simulation

Note:

- If the file name is specified by the user, it is dumped as <user\_file>.disablelog.
- If the file name is not specified by the user, it is dumped as assert.report.disablelog

The following special characters are acceptable in the file name: %, ^, and @. Using the following unacceptable special characters: #, &, \*, [], \$, (), or ! has the following consequences:

- A file name containing # or & results in a file name truncation to the character before the # or &.
- A file name containing \* or [] results in a No match message.
- A file name containing \$ results in an Undefined variable message.
- A file name containing () results in a Badly placed ()'s message.
- A file name containing ! results in an Event not found message.

success

Enables reporting of successful matches, and successes on cover and assert statements respectively, in addition to failures. The default is to report only failures.

vacuous

Enables reporting of vacuous successes on assert statements in addition to the failures. By default, VCS reports only failures.

`verbose`

Adds more information to the end of the report specified by the `report` keyword argument, and a summary with the number of assertions present, attempted, and failed.

`hier=file_name`

Specifies a file to enable and disable SystemVerilog assertions when you simulate your design. This feature enables you to control which assertions are active and VCS records in the coverage database, without having to recompile your design.

The types of entries you can make in the file are as follows:

`-assert <assertion_name> or <assertion_hierarchical_name>`

If `assertion_name` is provided, VCS disables the assertions based on wildcard matching of the name in the full design. If `assertion_hierarchical_name` is provided, VCS disables the assertions based on wildcard matching of the name in the particular hierarchy given.

## Examples

`-assert my_assert`

Disables all assertions with name `my_assert` in the full design.

`-assert A*`

Disables all assertions whose name starts with `A` in the full design.

`-assert *`

Disables all assertions in the full design.

```
-assert top.INST2.A
```

Disables all assertions whose names start with A in the hierarchy `top.INST2`. If assertions whose name starts with A exists in inner scopes under `top.INST2`, they are not disabled. This command has affect on assertions only in scope `top.INST2`.

```
+tree <module_instance_name> or
 <assertion_hierarchical_name>
```

If `module_instance_name` is provided, VCS enables assertions in the specified module instance and all module instances hierarchically under that instance. If `assertion_hierarchical_name` is provided, VCS enables the specified SystemVerilog assertion. Wildcard characters can also be used for specifying the hierarchy.

## Examples

```
+tree top.inst1
```

Enables the assertions in module instance `top.inst1` and all the assertions in the module instances under this instance.

```
+tree top.inst1.a1
```

Enables SystemVerilog assertion with the hierarchical name `top.inst1.a1`.

```
+tree top.INST*.A1
```

Enables assertion A1 from all the instances whose names start with INST under module top.

```
-tree <module_instance_name> or
 <assertion_hierarchical_name>
```

If *module\_instance\_name* is provided, VCS disables the assertions in the specified module instance and all module instances hierarchically under that instance. If *assertion\_hierarchical\_name* is provided, VCS disables the specified SystemVerilog assertion. Wildcard characters can also be used for specifying the hierarchy.

## Examples

```
-tree top.inst1
```

Disables the assertions in module instance top.inst1 and all the assertions in the module instances under this instance.

```
-tree top.inst1.a1
```

Disables the SystemVerilog assertion with the hierarchical name top.inst1.a1.

```
-tree top.INST*.A1
```

Disables assertion A1 from all the instances whose names start with INST under module top.

```
+module module_identifier
```

VCS enables all the assertions in all instances of the specified module.

For example, `+module dev`. VCS enables the assertions in all instances of module dev.

`-module module_identifier`

VCS disables all the assertions in all instances of the specified module.

For example, `-module dev`. VCS disables the assertions in all instances of module dev.

`-assert assertion_block_identifier`

VCS disables the assertion with the specified block identifier. You can use wildcard characters in specifying the block identifier to specify more than one assertion.

You can enter more than one keyword using the plus (+) separator. For example:

`-assert maxfail=10+maxsuccess=20+success+filter.`

`-cm assert`

Specifies monitoring for SystemVerilog assertions coverage. When enabled, the option `-cm assert` does the following:

- Generates the number of attempts, pass, fail, and incomplete data.
- Generates vacuous and non-vacuous coverage.
- Irrespective of type of assert statement, reports coverage.
- Covers immediate and deferred assertions.
- Does not cover Expect statement.
- Affects SVA and OVA as well.

---

## Options to Control Termination of Simulation

`-ova_enable_case_maxfail`

Includes OVA case violations in computation of global failure count for the `-assert global_finish_maxfail=N` option.

---

## Options for Enabling and Disabling Specify Blocks

`+no_notifier`

Suppresses the toggling of notifier registers that are optional arguments of system timing checks. The reporting of timing check violations is not affected. This is also a compile-time option.

`+no_tchk_msg`

Disables the display of timing violations, but does not disable the toggling of notifier registers in timing checks. This is also a compile-time option.

`+notimingcheck`

Disables timing check system tasks in your design. Using this option at runtime can improve the simulation performance of your design, depending on the number of timing checks that this option disables.

You can also use this option at compile time. Using this option at compile time tells VCS to ignore timing checks when it compiles your design so that the timing checks are not compiled into the executable. This results in a faster simulating executable than one that includes timing checks, which are disabled by this option at runtime.

If you need the delayed versions of the signals in negative timing checks, but want faster performance, include this option at runtime.

Note:

The `+notimingcheck` option has higher precedence than any `tcheck` command in UCLI.

---

## Options for Specifying When Simulation Stops

`+vcs+stop+time`

Stop simulation at the `time` value specified. The `time` value must be less than  $2^{32}$  or 4,294,967,296.

`+vcs+finish+time`

Ends simulation at the `time` value specified. The `time` value must be also less than  $2^{32}$ .

For both of these options, there is a special procedure (See [“Specifying a Long Time Before Stopping The Simulation”](#) ) for specifying time values larger than  $2^{32}$ .

---

## Options for Recording Output

`-l filename`

Specifies writing all messages from simulation to the specified file as well as displaying these messages on the standard output.

---

## Options for Controlling Messages

-q

Quiet mode; suppresses display of VCS header and summary information. Suppresses the proprietary message at the beginning of simulation and suppresses the VCS Simulation Report at the end (time, CPU time, data structure size, and date).

-V

Verbose mode; displays VCS version and extended summary information. Displays VCS compile and runtime version numbers, and copyright information, at the start of simulation.

+no\_pulse\_msg

Suppresses pulse error messages, but not the generation of StE values at module path outputs when a pulse error condition occurs.

You can enter this runtime option on the `vcs` command line. You cannot enter this option in the file you use with the `-f` compile-time option.

+sdfverbose

By default, VCS displays no more than ten warning and ten error messages about back-annotating delay information from SDF files. This option enables the display of all back-annotation warning and error messages.

This default limitation on back-annotation messages applies only to messages displayed on the screen and written in the simulation log file. If you specify an SDF log file in the `$sdf_annotation` system task, this log file receives all messages.

`+vcs+nostdout`

Disables all text output from VCS including messages and text from `$monitor` and `$display` and other system tasks. VCS still writes this output to the log file if you include the `-l` option.

---

## Options for VPD Files

`-vpd_bufsize+number_of_megabytes`

To gain efficiency, VPD uses an internal buffer to store value changes before saving them on disk. This option modifies the size of that internal buffer. The minimum size allowed is what is required to share two value changes per signal. The default size is the size required to store 15 value changes for each signal, but not less than 2 megabytes.

Note:

VCS automatically increases the buffer size as needed to comply with this limit.

`+vpdfile+file_name`

Specifies the name of the output VPD file (default is `vcdplus.vpd`). You must include the full file name with the `.vpd` extension.

`+vpdfilesize+number_of_megabytes`

Creates a VPD file that has a moving window in time while never exceeding the file size specified by `number_of_megabytes`. When the VPD file size limit is reached, VPD continues saving simulation history by overwriting older history.

File size is a direct result of circuit size, circuit activity, and the data being saved. Test cases show that VPD file sizes will likely run from a few megabytes to a few hundred megabytes. Many users can share the same VPD history file, which may be a reason for saving all time value changes when you do simulation. You can save one history file for a design and overwrite it on each subsequent run.

#### `+vpdfswitchsize+number_in_MB`

Specifies a size for the vpd file. When the vpd file reaches this size, VCS closes this file and opens a new one with the same hierarchy as the previous vpd file. There is a number suffix added to all new vpd file names to differentiate them. For example:

`simv +vpdfile+test.vpd +vpdfswitchsize+10.`

The first vpd file is named `test.vpd`. When its size reaches 10MB, VCS starts a new file `test_01.vpd`, the third vpd file is `test_02.vpd`, and so on.

#### `+vpdignore`

Tells VCS to ignore any `$vcplusxx` system tasks and license checking. By default, VCS checks out a VPD PLI license if there is a `$vcplusxx` system task in the Verilog source. In some cases, this statement is never executed and VPD PLI license checkout should be suppressed. The `+vpdignore` option performs the license suppression.

#### `+vpdports`

Causes VPD to store port information, which is then used by the Hierarchy Browser to show whether a signal is a port, and if so, its direction. This option to some extent affects simulation initialization time and memory usage for larger designs.

#### `+vpdportsonly`

Dumps only the port type information.

+vpdnoports

Dumps only the signal not the ports (input/output).

+vpddrivers

Stores data for changes on drivers of resolved nets.

+vpdupdate

Enables VPD file locking.

+vpdnocompress

Disables the default compression of data as it is written to the VPD file.

+vpdnostrengths

Disables the default storage of strength information on value changes to the VPD file. Use of this option may lead to slight improvements in VCS performance.

---

## Options for VCD Files

-vcd *file\_name*

Sets the name of the \$dumpvars output file to *filename*. The default file name is verilog.dump. A \$dumpfile system task in the Verilog source code overrides this option.

+vcs+dumpoff+*t*+*ht*

Turns off value change dumping (\$dumpvars) at time *t*. *ht* is the high 32 bits of a time value greater than 32 bits.

`+vcs+dumpon+t+ht`

Suppresses the `$dumpvars` system task until time *t*. *ht* is the high 32 bits of a time value greater than 32 bits.

`+vcs+dumparrays`

Enables recording memory and multi-dimensional array values in the VCD file. You must also have used the `+memcbk` compile-time option.

`+vcs+flush+dump`

Increases the frequency of dumping all VCD files.

---

## Options for Specifying Delays

`+maxdelays`

Specifies using the maximum delays in min:typ:max delay triplets in module path delays and timing checks, if you compiled your design with the `+allmtm` compile-time option. Also specifies using the maximum timing delays in min:typ:max delay triplets in an uncompiled SDF file.

If you compiled the SDF file with the `+allmtm` compile-time option, the `+maxdelays` option specifies using the compiled SDF file with the maximum delays.

Another use for this runtime option is to specify timing for SWIFT VMC and SmartModels when you also include the `+override_model_delays` runtime option.

`+mindelays`

Specifies using the minimum delays in min:typ:max delay triplets in module path delays and timing checks, if you compiled your design with the `+allmtm` compile-time option. Also specifies using the minimum timing delays in min:typ:max delay triplets in an uncompiled SDF file.

If you compiled the SDF file with the `+allmtm` compile-time option, the `+mindelays` option specifies using the compiled SDF file with the minimum delays.

Another use for this runtime option is to specify timing for SWIFT VMC and SmartModels when you also include the `+override_model_delays` runtime option.

#### `+typdelays`

Specifies using the typical delays in min:typ:max delay triplets in module path delays and timing checks, if you compiled your design with the `+allmtm` compile-time option. Also specifies using the typical timing delays in min:typ:max delay triplets in an uncompiled SDF file.

If you compiled the SDF file with the `+allmtm` compile-time option, the `+typdelays` option specifies using the compiled SDF file with the typical delays.

This is a default option. By default, VCS uses the typical delay in min:typ:max delay triplets in your source code and in uncompiled SDF files unless you specify otherwise with the `mtm_spec` argument to the `$sdf_annotation` system task. Also, by default, VCS uses the compiled SDF file with typical values.

Another use for this runtime option is to specify timing for SWIFT VMC and SmartModels when you also include the `+override_model_delays` runtime option.

---

## Options for Flushing Certain Output Text File Buffers

When VCS creates a log file, VCD file, or a text file specified with the `$fopen` system function. VCS writes the data for the file in a buffer and periodically dumps the data from the buffer to the file on disk. The frequency of these dumps varies depending on many factors including the amount of data that VCS has to write to the buffer as simulation or compilation progresses. If you need to see or use the latest information in these files more frequently than the rate at which VCS normally dumps this data, these options tell VCS to dump the data more frequently. The amount of frequency also depends on many factors, but the increased frequency will always be significant.

`+vcs+flush+log`

Increases the frequency of dumping both the compilation and simulation log files.

`+vcs+flush+dump`

Increases the frequency of dumping all VCD files.

`+vcs+flush+fopen`

Increases the frequency of dumping all files opened by the `$fopen` system function.

`+vcs+flush+all`

Increases the frequency of dumping all log files, VCD files, and all files opened by the `$fopen` system function.

These options do not increase the frequency of dumping other text files including the VCDE files specified by the `$dumpports` system task or the simulation history file for LSI certification specified by the `$lsi_dumpports` system task.

You can also enter these options at compile time. There is no performance gain to entering them at compile time.

---

## **Options for Licensing**

`+vcs+lic+vcsi`

Checks out three VCSI licenses to run VCS.

`+vcsi+lic+vcs`

Checks out a VCS license to run VCSI when all VCSI licenses are in use.

`+vcs+lic+wait`

Waits for a network license if none is available when the job starts.

`-licwait timeout`

Enables license queuing, where *timeout* is the time in minutes that VCS waits for a license before finally exiting.

`-licqueue`

Tells VCS to wait for a network license if none is available.

---

## **Option to Specify User-Defined Runtime Options in a File**

`-f filename`

You can use the `-f` runtime option to specify user-defined plusargs in a file. The user-defined plusargs are the plus arguments on the `simv` command line defined using `$test$plusargs` or `$value$plusargs` system tasks in RTL code as per *IEEE Standard 1364-2001 17.10 Commandline input*. All other VCS runtime options should be specified on the `simv` command line.

## Option for Initializing Integer Data Type Variables at Runtime

`+vcs+initreg+0 | 1 | random | seed`

Initializes all state variables (`reg` data type) and memories (`reg` data type) in the design, to random logic 0 or 1, at time zero. It gives you the flexibility to override the initialization of random values requested at compile-time.

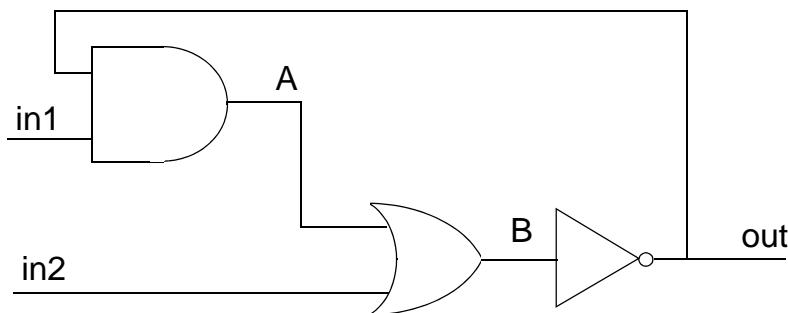
The following table describes all combinations of this option:

| Syntax                           | Description                                                                                                                                                                                                                                    |
|----------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <code>+vcs+initreg+0</code>      | Initializes all state variables ( <code>reg</code> data type) and memories ( <code>reg</code> data type) in the design, to random logic 0.                                                                                                     |
| <code>+vcs+initreg+1</code>      | Initializes all state variables ( <code>reg</code> data type) and memories ( <code>reg</code> data type) in the design, to random logic 1.                                                                                                     |
| <code>+vcs+initreg+random</code> | Initializes all state variables ( <code>reg</code> data type) and memories ( <code>reg</code> data type) in the design, to random logic 0 or 1 (with default seed).                                                                            |
| <code>+vcs+initreg+100</code>    | Initializes all state variables ( <code>reg</code> data type) and memories ( <code>reg</code> data type) in the design, to random logic 0 or 1, with user-defined seed 100.<br><br>Note: seed cannot be 1 or 0 and 1 or 0 has special meaning. |

Note:

- This option works only if the `+vcs+initreg+random` option is used at compile-time.
- This option works only for the Verilog portion of the design.
- This option does not initialize registers (variables) and memories other than the `reg` data type.
- This option may expose an infinite simulation loop at time zero in combinational logic with a feedback loop, as shown in [Figure D-1](#).

*Figure D-1 Combinational Logic With a Feedback Loop*



In the above example, `in1`, `in2`, `A` and `B` (`reg` data type) have initial values of `x` by default. Assigning logic 0 or 1 to `in1` or `in2` does not alter the value of `A`, `B` and `out`. The feedback loop is stabilized and the simulation advances. Some combinations of initial values assigned to these `reg` data types trigger a continuous re-evaluation of the combinational logic which results in an infinite simulation loop.

To prevent race conditions, avoid the following when you use this option:

- Assigning initial values to a `reg` in their declaration, when the value you assign is not the same as the value specified with the `+vcs+initreg+0|1|random|<seed>` option.
- Initializing state variables to state "X".
- Inconsistent states in the design due to the randomization.

## Use Model

For information on use model of this option, see “[Use Model](#)” section documented under “[Initializing Verilog Memories and Registers](#)”.

---

## General Options

### Viewing the Compile-Time Options

`-E program`

Starts the *program* that displays the compile-time options that were on the `vcs` command line when you created the `simv` (or `simv.exe`) executable file.

For example: `simv -E echo`

You cannot use any other runtime options with the `-E` option.

## **Recording Where ACC Capabilities are Used**

`+vcs+learn+pli`

ACC capabilities enable debugging operations, but they have a performance cost so you only want to enable them where you need them. This option keeps track of where in your design you use them for debugging operations so that you can recompile your design, and in the next simulation, enable them only where you need them. When you use this option VCS writes the `pli_learn.tab` secondary PLI table file. You input this file with the `+applylearn` compile-time option when you recompile your design.

## **Suppressing the \$stop System Task**

`+vcs+ignorestop`

Tells VCS to ignore the `$stop` system tasks in your source code.

## **Enabling User-defined Plusarg Options**

`+plus-options`

User-defined runtime options to perform some operation when the option is on the `simv` command line. The `$test$plusargs` system task can check for such options.

## **Enabling Overriding the Timing of a SWIFT SmartModel**

`+override_model_delays`

Instead of using the DelayRange parameter definition in the template file, this option enables the +mindelays, +typdelays, and +maxdelays runtime options to specify the timing used by SWIFT SmartModels.

## **Specifying acc\_handle\_simulated\_net PLI Routine**

+vcs+mipd+noalias

For the acc\_handle\_simulated\_net PLI routine, aliasing of a loconn net and a hiconn net across the port connection is disabled if MIPD delay annotation happens for the port. If you specify ACC capability: mip or mipb in the pli.tab file, such aliasing is disabled only when actual MIPD annotation happens.

If during a simulation run, acc\_handle\_simulated\_net is called before MIPD annotation happens, VCS issues a warning message. When this happens you can use this option to disable such aliasing for all ports whenever mip, mipb capabilities have been specified. This option works for reading an ASCII SDF file during simulation and not for compiled SDF files.

# E

## Compiler Directives and System Tasks

---

This appendix describes:

- “[Compiler Directives](#)”
- “[System Tasks and Functions](#)”

---

### Compiler Directives

Compiler directives are commands in the source code that specify how VCS compiles the source code that follows them, both in the source files that contain these compiler directives and in the remaining source files that VCS subsequently compiles.

Compiler directives are not effective down the design hierarchy. A compiler directive written above a module definition affects how VCS compiles that module definition, but does not necessarily affect how

VCS compiles module definitions instantiated in that module definition. If VCS has already compiled these lower-level module definitions, it does not recompile them. If VCS has not yet compiled these module definitions, the compiler directive does affect how VCS compiles them.

Note:

Compile-time options override compiler directives.

---

## Compiler Directives for Cell Definition

`celldefine

Specifies that the modules under this compiler directive be tagged as “cell” for delay annotation. See IEEE Std 1364-2001 page 350.

Syntax: `celldefine

`endcelldefine

Disables `celldefine. See IEEE Std 1364-2001 page 350.

Syntax: `endcelldefine

---

## Compiler Directives for Setting Defaults

`default\_nettype

Sets default net type for implicit nets. See IEEE Std 1364-2001 page 350.

Syntax: `default\_nettype wire | tri | tri0 | wand  
| triand | tri1 | wor | trior | trireg | none

``resetall`

Resets all compiler directives. See IEEE 1364-2001 page 357.

Syntax: ``resetall`

---

## Compiler Directives for Macros

``define`

Defines a text macro. See IEEE Std 1364-2001 page 351. Syntax:

``define text_macro_name macro_text`

``else`

Used with ``ifdef`. Specifies an alternative group of source code lines that VCS compiles if the text macro specified with an ``ifdef` compiler directive is not defined. See IEEE Std 1364-2001 page 353. Syntax: ``else second_group_of_lines`

``elseif`

Used with ``ifdef`. Specifies an alternative group of source code lines that VCS compiles if the text macro specified with an `'ifdef` compiler directive is not defined, but the text macro specified with this compiler directive is defined. See IEEE Std 1364-2001 page 353. Syntax: ``elseif text_macro_name second_group_of_lines`

``endif`

Used with ``ifdef`. Specifies the end of a group of lines specified by the ``ifdef` or ``else` compiler directives. See IEEE Std 1364-2001 page 353. Syntax: ``endif`

```
`ifdef
```

Specifies compiling the source lines that follow if the specified text macro is defined by either the `define compiler directive or the +define compile-time option. See IEEE Std 1364-2001 page 353. Syntax: `ifdef *text\_macro\_name group\_of\_lines*

The exception is the character string “VCS”, which is a predefined text macro in VCS. Therefore, in the following source code, VCS compiles and executes the first block of code and ignores the second block even when you do not include `define VCS or +define+VCS:

```
`ifdef VCS
 begin
 // Block of code for VCS
 .
 .
 .
 end
`else
 begin
 // Alternative block of code
 .
 .
 .
 end
`endif
```

When you encrypt source code, VCS inserts `ifdef VCS before all encrypted parts of the code.

```
`ifndef
```

Specifies compiling the source code that follows if the specified text macro is not defined. See IEEE Std 1364-2001 page 353. Syntax: `ifndef *text\_macro\_name group\_of\_lines*

``undef`

Undefines a macro definition. See IEEE Std 1364-2001 page 351.

Syntax: ``undef text_macro_name`

---

## Compiler Directives for Delays

``delay_mode_path`

Ignores the delay specifications on all gates and switches in all those modules under this compiler directive that contain specify blocks. Uses only the module path delays and the delay specifications on continuous assignments. Syntax:

``delay_mode_path`

``delay_mode_distributed`

Ignores the module path delays specified in specify blocks in modules under this compiler directive and uses only the delay specifications on all gates, switches, and continuous assignments. Syntax: ``delay_mode_distributed`

``delay_mode_unit`

Ignores the module path delays. Changes all the delay specifications on all gates, switches, and continuous assignments to the shortest time precision argument of all the `'timescale` compiler directives in the source code. The default time unit and time precision argument of the `'timescale` compiler directive is 1 ns. Syntax: ``delay_mode_unit`

``delay_mode_zero`

Changes all the delay specifications on all gates, switches, and continuous assignments to zero and changes all module path delays to zero. Syntax: ``delay_mode_zero`

---

## **Compiler Directives for Backannotating SDF Delay Values**

``vcs_mipdexpand`

This compiler directive enables the runtime back-annotation of individual bits of a port declared in an ASCII text SDF file. This is done by entering the compiler directive over the port declarations for these ports. Similarly, entering this compiler directive over port declarations enables a PLI application to pass delay values to individual bits of a port.

As an alternative to using this compiler directive, you can use the `+vcs+mipdexpand` compile-time option, or you can enter the `mipb ACC` capability. For example:

```
$sdf_annotation call=sdf_annotation_call
acc+=rw,mipb:top_level_mod+
```

When you compile the SDF file, which Synopsys recommends, you do not need to use this compiler directive to back-annotate the delay values for individual bits of a port.

``vcs_mipdnoexpand`

Turns off the enabling of back-annotating delay values on individual bits of a port as specified by a previous ``vcs_mipdexpand` compiler directive.

---

## **Compiler Directives for Source Protection**

``endprotect`

Defines the end of code to be protected. Syntax: ``endprotect`

``endprotected`

Defines the end of protected code. Syntax: ``endprotected`

``protect`

Defines the start of code to be protected. Syntax: ``protect`

``protected`

Defines the start of protected code. Syntax: ``protected`

## Debugging Partially Encrypted Source Code

The partial encrypted code is a code that has some of its part enclosed with the `'protect` and `'endprotect` macros. VCS allows you to debug the objects that are not enclosed within `'protect` and `'endprotect` while restricting access to the variables that are within `'protected` and `'endprotected` macros.

Note:

When you enclose a part of code using `'protect` and `'endprotect`, VCS converts it into `'protected` and `'endprotected` when you pass `+protect`.

To debug the partially encrypted source code, use the `+object_protect` option as follows:

```
vcs +protect +object_protect <sourcefile.v>
```

You can enable partial debug capability by adding the `+object_protect` option to the VCS encryption command line, so that partial encryption is applied and the encrypted file is also enabled with debug capability (`-debug_all`) for the unencrypted objects.

---

## **Compiler Directives for Controlling Port Coercion**

``noportcoerce`

Does not coerce ports to inout. Syntax: ``noportcoerce`

``portcoerce`

Coerces ports as appropriate (default). Syntax: ``portcoerce`

---

## **General Compiler Directives**

### **Compiler Directive for Including a Source File**

``include`

Includes (also compiles as part of the design) the specified source file. See IEEE Std 1364-1995 pages 224-225. Syntax:

``include "filename"`

Note:

If the included file is a different version of Verilog from the source file that contains the `'include` compiler directive, and you want VCS to compile the included file for the version specified by its filename extension, enter the `-ext include` compile-time option, see "[Options for Different Versions of Verilog](#)"

### **Compiler Directive for Setting the Time Scale**

``timescale`

Sets the timescale. See IEEE Std 1364-2001 page 357. Syntax:

``timescale time_unit / time_precision`

In VCS, the default time unit is 1 s (a full second) and the default time precision is also 1 s.

## Compiler Directive for Specifying a Library

```
`uselib file | directory
```

Searches the specified library for unresolved modules. You can specify either a library file or a library directory. Syntax: `uselib file = *filename*

or

```
`uselib dir = directory_name libext+.ext |
libext=.ext
```

Enter path names if the library file or directory is not in the current directory. For example:

```
`uselib file = /sys/project/speclib.lib
```

If specifying a library directory, include the *libext+.ext* keyword and append to it the extensions of the source files in the library directory, similar to the *+libext+.ext* compile-time option, for example:

```
`uselib dir = /net/designlibs/project.lib
libext+.v
```

To specify more than one search library, enter additional *dir* or *file* keywords, for example:

```
`uselib dir = /net/designlibs/library1.lib dir=/
net/designlibs/library2.lib libext+.v
```

Here, the `libext+.ext` keyword applies to both libraries.

## **Compiler Directive for File Names and Line Numbers**

``line line_number "filename" level`

Maintains the file name and line number. See IEEE Std 1364-2001 page 358.

---

## **Unimplemented Compiler Directives**

The following compiler directives are IEEE Std 1364-1995 compiler directives that are not yet implemented in VCS.

``unconnected_drive`

``nounconnected_drive`

---

## **System Tasks and Functions**

This section describes the system tasks and functions that are supported by VCS and then lists the system tasks that it does not support.

System tasks are described in the IEEE Std 1364-2001 or see the VCS SystemVerilog LRM for more information.

---

### **System Tasks for SystemVerilog Assertions Severity**

`$fatal`

Generates a runtime fatal assertion error.

`$error`

Generates a runtime assertion error.

`$warning`

Generates a runtime warning message.

`$info`

Generates an information message.

---

### **System Tasks for SystemVerilog Assertions Control**

`$assertoff`

Tells VCS to stop monitoring any of the specified assertions that start at a subsequent simulation time.

`$assertkill`

Tells VCS to stop monitoring any of the specified assertions that start at a subsequent simulation time, and stop the execution of any of these assertions that are now occurring.

`$asserton`

Tells VCS to resume the monitoring of assertions that it stopped monitoring due to a previous `$assertoff` or `$assertkill` system task.

These system tasks provide file name and line number from where these system tasks are called which would otherwise be difficult to track in the absence of this information.

Note:

The runtime option `-assert old_ctrl_msg` reverts the messaging to the old style for backward compatibility.

---

## System Tasks for SystemVerilog Assertions

`$onehot`

Returns true if only one bit in the expression is true.

`$onehot0`

Returns true if, at the most, one bit of the expression is true (also returns true if none of the bits are true).

`$isunknown`

Returns true if one of the bits in the expression has an X value.

---

## System Tasks for VCD Files

VCD files are ASCII files that contain a record of a net or register's transition times and values. There are a number of third-party products that read VCD files to show you simulation results. VCS has the following system tasks for specifying the names and contents of these files. They require the \$dumpvars system task.

`$dumpall`

Creates a checkpoint in the VCD file. When VCS executes this system task, VCS records the current values of all specified nets and registers into the VCD file, whether there is a value change at this time or not.

`$dumpoff`

Stops recording value change information in the VCD file.

`$dumpon`

Starts recording value change information in the VCD file.

`$dumpfile`

Specifies the name of the VCD file you want VCS to record.

Syntax: `$dumpfile("filename") ;`

`$dumpflush`

Empties the VCD file buffer and writes all this data to the VCD file.

`$dumplimit`

Limits the size of a VCD file.

`$dumpvars`

Specifies the nets and variables whose transition times and values you want VCS to record in the VCD file.

Syntax: `$dumpvars (level_number, module_instance | net_or_var) ;`

You can specify individual nets or variables, or specify all the nets and variables, in an instance.

The `$dumpvars` system task enables the other VCD system tasks like `$dumpon` and `$dumpfile`.

#### `$dumpchange`

Tells VCS to stop recording transition times and values in the current dump file and to start recording in the specified new file.

Syntax: `$dumpchange ("filename") ;`

Code example: `$dumpchange ("vcd16a.dmp") ;`

#### `$fflush`

VCS stores VCD data in the operating system's dump file buffer and as simulation progresses, reads from this buffer to write to the VCD file on disk. If you need the latest information written to the VCD file at a specific time, use the `$fflush` system task.

Syntax: `$fflush("filename") ;`

Code example: `$fflush("vcdfile1.vcd") ;`

#### `$fflushall`

If you are writing more than one VCD file and need VCS to write the latest information to all these files at a particular time, use the `$fflushall` system task. Syntax: `$fflushall ;`

```
$gr_waves
```

Produces a VCD file with the name `grw.dump`. In this system task, you can specify a display label for a net or register whose transition times and values VCS records in the VCD file. Syntax:  
`$gr_waves(["label"], net_or_reg, ...);`

Code example: `$gr_waves("wire w1",w1, "reg r1",r1);`

---

## System Tasks for LSI Certification VCD and EVCD Files

```
$lsi_dumpports
```

For LSI certification of your design, this system task specifies recording a simulation history file that contains the transition times and values of the ports in a module instance. This simulation history file for LSI certification contains more information than the VCD file specified by the `$dumpvars` system task. The information in this file includes strength levels and whether the test fixture module (test bench) or the Device Under Test (the specified module instance or DUT) is driving a signal's value.

Syntax:

```
$lsi_dumpports(module_instance,"filename");
```

Code example:

```
$lsi_dumpports(top.middle1,"dumpports.dmp");
```

If you would rather have the `$lsi_dumpports` system task generate an extended VCD (EVCD) file instead, include the `+dumpports+ieee` runtime option.

```
$dumpports
```

Creates an EVCD file as specified in IEEE Std. 1364-2001 pages 339-340. You can, for example, input a EVCD file into TetraMAX for fault simulation. EVCD files are similar to the simulation history files generated by the `$lsi_dumpports` system task for LSI certification, but there are differences in the internal statements in the file. Further, the EVCD format is a proposed IEEE standard format, whereas the format of the LSI certification file is specified by LSI.

In the past, the `$dumpports` and `$lsi_dumpports` system tasks both generated simulation history files for LSI certification and had identical syntax except for the name of the system task.

Syntax of the `$dumpports` system task is now:

```
$dumpports (module_instance, [module_instance,]
"filename") ;
```

You can specify more than one module instance.

Code example: `$dumpports (top.middle1, top.middle2,  
"dumpports.evcd") ;`

If your source code contains a `$dumpports` system task, and you want it to generate simulation history files for LSI certification, include the `+dumpports+lsi` runtime option.

`$dumpportsoff`

Suspends writing to files specified in `$lsi_dumpports` or `$dumpports` system tasks. You can specify a file to which VCS suspends writing or specify no particular file, in which case VCS suspends writing to all files specified by `$lsi_dumpports` or `$dumpports` system tasks. See IEEE Std 1364-2001 page 340-341. Syntax: `$dumpportsoff ("filename") ;`

`$dumpportson`

Resumes writing to the file after writing was suspended by a `$dumpportsoff` system task. You can specify the file to which you want VCS to resume writing or specify no particular file, in which case VCS resumes writing to all files to which writing was halted by any `$dumpportsoff` or `$dumpports` system tasks. See IEEE Std 1364-2001 page 340-341. Syntax:

`$dumpportson ("filename") ;`

`$dumpportsall`

By default, VCS writes to files only when a signal changes value. The `$dumpportsall` system task records the values of the ports in the module instances, which are specified by the `$lsi_dumpports` or `$dumpports` system task, whether there is a value change on these ports or not. You can specify the file to which you want VCS to record the port values for the corresponding module instance or specify no particular file, in which case VCS writes port values in all files opened by the `$lsi_dumpports` or `$dumpports` system task. See IEEE Std 1364-2001 page 341. Syntax:

`$dumpportsall ("filename") ;`

`$dumpportsflush`

VCS stores simulation data in a buffer during simulation from which it writes data to the file. If you want VCS to write all simulation data from the buffer to the file or files at a particular time, execute this `$dumpportsflush` system task. You can specify the file to which you want VCS to write from the buffer or specify no particular file, in which case VCS writes all data from the buffer to all files opened by the `$lsi_dumpports` or `$dumpports` system task. See IEEE Std 1364-2001 page 342. Syntax: `$dumpportsflush ("filename") ;`

`$dumpportslimit`

Specifies the maximum file size of the file specified by the `$lsi_dumpports` or `$dumpports` system task. You specify the file size in bytes. When the file reaches this limit, VCS no longer writes to the file. You can specify the file whose size you want to limit or specify no particular file, in which case your specified size limit applies to all files opened by the `$lsi_dumpports` or `$dumpports` system task. See IEEE Std 1364-2001 page 341-342.

Syntax: `$dumpportslimit(filesize, "filename") ;`

---

## System Tasks for VPD Files

VPD files are files that store the transition times and values for nets and registers but they differ from VCD files in the following ways:

- You can use the DVE to view the simulation results that VCS recorded in a VPD file. You cannot actually load a VCD file directly into DVE; when you load a VCD file, DVE translates the file to VPD and loads the VPD file.
- They are binary format and therefore take less disk space and load much faster.
- They can also record the order of statement execution so that you can use the Source Window in DVE to step through the execution of your code if you specify recording this information.

VPD files are commonly used in post-processing, where VCS writes the VPD file during batch simulation, and then you review the simulation results using DVE.

There are system tasks that specify the information that VCS writes in the VPD file.

Note:

To use the system tasks for VPD files, you must compile your source code with the `-debug_pp` option.

`$vcdplusautoflushoff`

Turns off the automatic “flushing” of simulation results to the VPD file whenever there is an interrupt, such as when VCS executes the `$stop` system task. Syntax: `$vcdplusautoflushoff ;`

`$vcdplusautoflushon`

Tells VCS to “flush” or write all the simulation results in memory to the VPD file whenever there is an interrupt, such as when VCS executes a `$stop` system task or when you halt VCS using the UCLI stop command, or the Stop button on the DVE Interactive window. Syntax: `$vcdplusautoflushon ;`

`$vcdplusclose`

Tells VCS to mark the current VPD file as completed, and close the file. Syntax: `$vcdplusclose ;`

`$vcdplusdeltacycleon`

The `$vcdplusdeltacycleon` task enables reporting of delta cycle information from the Verilog source code. It must be followed by the appropriate `$vcdpluson`/`$vcdplusoff` tasks.

Glitch detection is automatically turned on when VCS executes \$vcdplusdeltacycleon unless you have previously used \$vcdplusglitchon/off. Once you use \$vcdplusglitchon/off, DVE allows you explicit control of glitch detection.

### Syntax

```
$vcdplusdeltacycleon;
```

#### Note:

Delta cycle collection can start only at the beginning of a time sample. The \$vcdplusdeltacycleon task must precede the \$vcdplusevent command to ensure that delta cycle collection will start at the beginning of the time sample.

```
$vcdplusevent
```

The \$vcdplusevent task allows you to record a unique event for a signal at the current simulation time unit.

### Syntax

```
$vcdplusevent (net_or_reg, "event_name",
 "<E|W|I><S|T|D>");
```

A symbol is displayed in DVE on the signal's waveform and in the Logic Browser. The event\_name argument appears in the status bar when you click on the symbol.

E | W | I — Specifies severity.

- E for error, displays a red symbol.
- W for warning, displays a yellow symbol.
- I for information, displays a green symbol.

`S | T | D` — Specifies the symbol shape.

- `S` for square.
- `T` for triangle.
- `D` for diamond.

Do not enter space between the arguments `E | W | I` and `S | T | D`. Do not include angle brackets `< >`. There is a limit of 244 unique events.

`$vcdplusdumpportsoff`

Tells VCS to suspend writing to VPD file the transition times and values of the module instance specified by

`$vcdplusdumpportson` system task. You can use `$vcdplusdumpportsoff` system task with arguments, but it is not required. Syntax:

`$vcdplusdumpportsoff (level_number,  
module_instance);`

`$vcdplusdumpportson`

Records transition times and values of ports in a module instance. A level value of 0 tells VCS to dump all levels below the specified instance. If you do not specify a level, the default level is 1. If you use the system task without arguments, VCS dumps all the ports from the entire design to the VPD file. Syntax:

`$vcdplusdumpportson (level_number,  
module_instance);`

Use `$vcdplusdumpportson` and `$vcdplusdumpportsoff` system tasks to create a VPD file with port drive information for bidirectional ports if you want to use `dumpports` and `dumpvcdports` options in `vpd2vcd` filtering.

Note:

This system task records additional drive information for inout ports of type wire. It does not dump ports with unpacked dimensions. Furthermore, it is unable to determine if a wire is being forced.

`$vcdplusfile`

Specifies the next VPD file that DVE opens during simulation, after it executes the `$vcdplusclose` system task and when it executes the next `$vcdpluson` system task. Syntax:

`$vcdplusfile("filename");`

`$vcdplusglitchon`

Turns on checking for zero delay glitches and other cases of multiple transitions for a signal at the same simulation time.

Syntax: `$vcdplusglitchon;`

`$vcdplusflush`

Tells VCS to “flush” or write all the simulation results in memory to the VPD file at the time VCS executes this system task. Use `$vcdplusautoflushon` to enable automatic flushing of simulation results to the file when simulation stops. Syntax:  
`$vcdplusflush;`

`$vcdplusmemon`

Records value changes and times for memories and multi-dimensional arrays. Syntax: `system_task( Mda [, dim1Lsb [, dim1Rsb [, dim2Lsb [, dim2Rsb [, ... dimNLsb [, dimNRsb]]]]] ) ;`

`Mda`

This argument specifies the name of the multi-dimensional array (MDA) to be recorded. It must not be a part select. If no other arguments are given, then all elements of the MDA are recorded to the VPD file.

#### dim1Lsb

This is an optional argument that specifies the name of the variable that contains the left bound of the first dimension. If no other arguments are given, then all elements under this single index of this dimension are recorded.

#### dim1Rsb

This is an optional argument that specifies the name of variable that contains the right bound of the first dimension.

#### Note:

The `dim1Lsb` and `dim1Rsb` arguments specify the range of the first dimension to be recorded. If no other arguments are given, then all elements under this range of addresses within the first dimension are recorded.

#### dim2Lsb

This is an optional argument with the same functionality as `dim1Lsb`, but refers to the second dimension.

#### dim2Rsb

This is an optional argument with the same functionality as `dim1Rsb`, but refers to the second dimension.

#### dimNlLsb

This is an optional argument that specifies the left bound of the  $N$ th dimension.

`dimNRsb`

This is an optional argument that specifies the right bound of the  $N$ th dimension.

Note that MDA system tasks can take 0 or more arguments, with the following caveats:

- No arguments: The whole design will be traversed and all memories and MDAs will be recorded. Note that this process may cause significant memory usage and simulator drag.
- One argument: If the object is a scope instance, all memories/MDAs contained in that scope instance and its children will be recorded. If the object is a memory/MDA, that object will be recorded.

`$vcdplusmemoff`

Stops recording value changes and times for memories and multi-dimensional arrays. Syntax is the same as the `$vcdplusmenon` system task.

`$vcdplusmemorydump`

Records (dumps) a snapshot of the values in a memory or multi-dimensional array into the VPD file. Syntax is the same as the `$vcdplusmenon` system task.

`$vcdplusoff`

Stops recording, in the VPD file, the transition times and values for the nets and registers in the specified module instance or individual nets or registers. Syntax:

```
$vcdplusoff [(level_number, module_instance |
net_or_reg)] ;
```

Where:

*level\_number*

Specifies the number of hierarchy scope levels for which to stop recording signal value changes (a zero value records all scope instances to the end of the hierarchy; default is all).

*module\_instance*

Specifies the name of the scope for which to stop recording signal value changes (default is all).

*net\_or\_reg*

Specifies the name of the signal for which to stop recording signal value changes (default is all).

`$vcdpluson`

Starts recording, in the VPD file, the transition times and values for the nets and registers in the specified module instance or individual nets or registers. Syntax:

`$vcdpluson [ (level_number, module_instance |  
net_or_variable) ] ;`

where:

*level\_number*

Specifies the number of hierarchy scope levels for which to record signal value changes (a zero value records all scope instances to the end of the hierarchy; default is all).

*module\_instance*

Specifies the name of the scope for which to record signal value changes (default is all).

`net_or_variable`

Specifies the name of the signal for which to record signal value changes (default is all).

`$vcdplustraceoff`

Stops recording, in the VPD file, the order of statement execution in the specified module instance. Syntax:

`$vcdplustraceoff (module_instance) ;`

`$vcdplustraceon`

Starts recording, in the VPD file, the order of statement execution in the specified module instance and the module instances hierarchically under it. Syntax:

`$vcdplustraceon [ (module_instance) ] ;`

---

## System Tasks for SystemVerilog Assertions

### Important:

Enter these system tasks in an initial block. Do not enter them in an always block.

`$assert_monitor`

Analogous to the standard `$monitor` system task; it continually monitors specified assertions and displays what is happening with them (you can only have it display on the next clock of the assertion). The syntax is as follows:

`$assert_monitor([0|1,] assertion_identifier...);`

Where:

0

Specifies reporting on the assertion if it is active (VCS checks for its properties) and if not, reporting on the assertion or assertions, whenever they start.

1

Specifies reporting on the assertion or assertions only once, the next time they start.

If you specify neither 0 or 1, the default is 0.

*assertion\_identifier...*

A comma separated list of assertions. If one of these assertions is not declared in the module definition containing this system task, specify it by its hierarchical name.

`$assert_monitor_off`

Disables the display from the `$assert_monitor` system task.

`$assert_monitor_on`

Re-enables the display from the `$assert_monitor` system task.

---

## System Tasks for Executing Operating System Commands

`$system`

Executes operating system commands. Syntax:

`$system("command") ;`

Code example: `$system("mv -f savefile savefile.1") ;`

`$systemf`

Executes operating system commands and accepts multiple formatted string arguments. Syntax: `$systemf ("command %s . . .", "string", . . .);`

Code example: `int = $systemf ("cp %s %s", "file1", "file2");`

The operating system copies the file named `file1` to a file named `file2`.

---

## System Tasks for Log Files

`$log`

If a filename argument is included, this system task stops writing to the `vcs.log` file or the log file specified with the `-l` runtime option and starts writing to the specified file. If the file name argument is omitted, this system task tells VCS to resume writing to the log file after writing to the file was suspended by the `$nolog` system task. Syntax: `$log [ ("filename")];`

Code example: `$log ("reset.log");`

`$nolog`

Disables writing to the `vcs.log` file or the log file specified by either the `-l` runtime option or the `$log` system task. Syntax: `$nolog;`

---

## System Tasks for Data Type Conversions

`$bitstoreal [b]`

Converts a bit pattern to a real number. See IEEE std 1364-2001 page 310.

`$itor[i]`

Converts integers to real numbers. See IEEE std 1364-2001 page 310.

`$realtobits`

Passes bit patterns across module ports, converting a real number to a 64-bit representation. See IEEE std 1364-2001 page 310.

`$rtoi`

Converts real numbers to integers. See IEEE std 1364-2001 page 310.

---

## System Tasks for Displaying Information

`$display [b|h|0] ;`

Display arguments. See IEEE std 1364-2001 pages 278-285.

`$monitor [b|h|0]`

Display data when arguments change value. See IEEE Std 1364-2001 page 286.

`$monitoroff`

Disables the `$monitor` system task. See IEEE std 1364-2001 page 286.

`$monitoron`

Re-enables the \$monitor system task after it was disabled with the \$monitoroff system task. See IEEE std 1364-2001 page 286.

\$strobe [b|h|0] ;

Displays simulation data at a selected time. See IEEE 1364-2001 page 285.

\$write [b|h|0]

Displays text. See IEEE std 1364-2001 pages 278-285.

---

## System Tasks for File I/O

\$fclose

Closes a file. See IEEE std 1364-2001 pages 286-288.

\$fdisplay [b|h|0]

Writes to a file. See IEEE std 1364-2001 pages 288-289.

\$ferror

Returns additional information about an error condition in file I/O operations. See IEEE Std 1364-2001 pages 294-295.

\$fflush

Writes buffered data to files. See IEEE Std 1364-2001 page 294.

\$fgetc

Reads a character from a file. See IEEE Std 1364-2001 page 290.

\$fgets

Reads a string from a file. See IEEE Std 1364-2001 page 290.

`$fmonitor [b|h|0]`

Writes to a file when an argument changes value. See IEEE std 1364-2001 pages 287-288.

`$fopen`

Opens files. See IEEE std 1364-2001 pages 286-288.

`$fread`

Reads binary data from a file. See IEEE Std 1364-2001 page 293.

`$fscanf`

Reads characters in a file. See IEEE Std 1364-2001 pages 290-293.

`$fseek`

Sets the position of the next read or write operation in a file. See IEEE Std 1364-2001 page 294.

`$fstrobe [b|h|0]`

Writes arguments to a file. See IEEE std 1364-2001 pages 288-289.

`$ftell`

Returns the offset of a file. See IEEE Std 1364-2001 page 294.

`$fwrite [b|h|0]`

Writes to a file. See IEEE Std 1364-2001 pages 88-289.

`$rewind`

Sets the next read or write operation to the beginning of a file.  
See IEEE Std 1364-2001 page 294.

`$sformat`

Assigns a string value to a specified signal. See IEEE Std  
1364-2001 pages 289-290.

`$sscanf`

Reads characters from an input stream. See IEEE Std 1364-2001  
pages 290-293.

`$swrite`

Assigns a string value to a specified signal, similar to the  
`$sformat` system function. See IEEE Std 1364-2001 pages  
289-290.

`$ungetc`

Returns a character to the input stream. See IEEE Std 1364-2001  
page 290.

---

## System Tasks for Loading Memories

`$readmemb`

Loads binary values in a file into memories. See IEEE std 1364-  
2001 pages 295-296.

`$readmemh`

Loads hexadecimal values in a file into memories. See IEEE std  
1364-2001 pages 295-296.

`$sreadmemb`

Loads specified binary string values into memories. See IEEE std 11364-2001 page 744.

`$sreadmemh`

Loads specified string hexadecimal values into memories. See IEEE std 1364-2001 page 744.

`$writememb`

Writes binary data in a memory to a file. Syntax: `$writememb ("filename", memory [, start_address] [, end_address]);`

Code example: `$writememb ("testfile.txt", mem, 0, 255);`

`$writememh`

Writes hexadecimal data in a memory to a file. Syntax:

`$writememh ("filename", memory [, start_address] [, end_address]);`

---

## System Tasks for Time Scale

`$printtimescale`

Displays the time unit and time precision from the last '`timescale`' compiler directive that VCS has read before it reads the module definition containing this system task. See IEEE std 1364-2001 pages 297-298.

`$timeformat`

Specifies how the `%t` format specification reports time information. See IEEE std 1364-2001 pages 298-301.

---

## System Tasks for Simulation Control

`$stop`

Halts simulation. See IEEE std 1364-2001 pages 301-302.

`$finish`

Ends simulation. See IEEE std 1364-2001 page 301.

---

## System Tasks for Timing Checks

`$disable_warnings`

Disables the display of timing violations but does not disable the toggling of notifier registers. Syntax:

`$disable_warnings [(module_instance, ...)] ;`

An alternative syntax is:

`$disable_warnings ("timing" [, module_instance, ...]) ;`

If you specify a module instance, this system task disables timing violations for the specified instance and all instances hierarchically under this instance. If you omit module instances, this system task disables timing violations throughout the design.

Code example: `$disable_warnings (seqdev1) ;`

`$enable_warnings`

Re-enables the display of timing violations after the execution of the `$disable_warnings` system task. This system task does not enable timing violations during simulation when you used the `+no_tchk_msg` compile-time option to disable them. Syntax:

`$enable_warnings [(module_instance, ...)] ;`

An alternative syntax is:

```
$enable_warnings("timing" [,module_instance, . . .]);
```

If you specify a module instance, this system task enables timing violations for the specified instance and all instances hierarchically under this instance. If you omit module instances, this system task enables timing violations throughout the design.

---

## Timing Checks for Clock and Control Signals

`$hold`

Reports a timing violation when a data event happens too soon after a reference event. See IEEE Std 1364-2001 pages 241-242.

`$nochange`

Reports a timing violation if the data event occurs during the specified level of the control signal (the reference event). See IEEE Std 1364-2001 pages 256-257.

`$period`

Reports a timing violation when an edge triggered event happens too soon after the previous matching edge triggered an event on a signal. See IEEE Std 1364-2001 pages 255-256.

`$recovery`

Reports a timing violation when a data event happens too soon after a reference event. Unlike the `$setup` timing check, the reference event must include the `posedge` or `negedge` keyword. Typically the `$recovery` timing check has a control signal, such as `clear`, as the reference event, and the clock signal as the data event. See IEEE 1364-2001 pages 245-246.

`$recrem`

Reports a timing violation if a data event occurs less than a specified time limit before or after a reference event. This timing check is identical to the `$setuphold` timing check except that typically the reference event is on a control signal and the data event is on a clock signal. You can specify negative values for the recovery and removal limits. The syntax is as follows:

```
$recrem(reference_event, data_event,
recovery_limit, removal_limit, notifier,
timestamp_cond, timecheck_cond, delay_reference,
delay_data);
```

See IEEE Std 1364-2001 pages 246-248.

`$removal`

Reports a timing violation if the reference event, typically an asynchronous control signal, happens too soon after the data event, the clock signal. See IEEE Std 1364-2001 pages 244-245.

`$setup`

Reports a timing violation when the data event happens before and too close to the reference event. See IEEE Std 1364-2001 page 241. This timing check also has an extended syntax like the `$recrem` timing check. This extended syntax is not described in IEEE Std 1364-2001.

`$setuphold`

Combines the \$setup and \$hold system tasks. See IEEE Std 1364-1995 page 189 for the official description. There is also an extended syntax that is in IEEE Std 1364-2001 pages 242-244.

This extended syntax is as follows:

```
$setuphold(reference_event, data_event,
setup_limit, hold_limit, notifier,
timestamp_cond, timecheck_cond, delay_reference,
delay_data);
```

\$skew

Reports a timing violation when a reference event happens too long after a data event. See IEEE std 1364-2001 pages 249-250.

\$width

Reports a timing violation when a pulse is narrower than the specified limit. See IEEE std 1364-2001 pages 254-255. VCS ignores the threshold argument.

---

## System Tasks for PLA Modeling

\$async\$and\$array to \$sync\$nor\$plane

See IEEE Std 1364-2001 page 302.

---

## System Tasks for Stochastic Analysis

\$q\_add

Places an entry on a queue in stochastic analysis. See IEEE Std 1364-2001 page 307.

`$q_exam`

Provides statistical information about activity at the queue. See IEEE Std 1364-2001 page 307.

`$q_full`

Returns 0 if the queue is not full, returns a 1 if the queue is full. See IEEE Std 1364-2001 page 307.

`$q_initialize`

Creates a new queue. See IEEE Std 1364-2001 page 306-307.

`$q_remove`

Receives an entry from a queue. See IEEE Std 1364-2001 page 307.

---

## **System Tasks for Simulation Time**

`$realtime`

Returns a real number time. See IEEE Std 1364-2001 pages 309-310.

`$stime`

Returns an unsigned integer that is a 32-bit time. See IEEE Std 1364-2001 page 309.

`$time`

Returns an integer that is a 64-bit time. See IEEE Std 1364-2001 pages 308-309.

---

## System Tasks for Probabilistic Distribution

`$dist_exponential`

Returns random numbers where the distribution function is exponential. See IEEE std 1364-2001 page 312.

`$dist_normal`

Returns random numbers with a specified mean and standard deviation. See IEEE Std 1364-2001 page 312.

`$dist_poisson`

Returns random numbers with a specified mean. See IEEE Std 1364-2001 page 312.

`$dist_uniform`

Returns random numbers uniformly distributed between parameters. See IEEE Std 1364-2001 page 312.

`$random`

Provides a random number. See IEEE Std 1364-2001 page 312. Using this system function in certain kinds of statements might cause simulation failure.

`$get_initial_random_seed`

Returns the integer number used as the seed for a simulation run, if the seed was set by `+ntb_random_seed=value` or by `+ntb_random_seed_automatic`, or returns the default random seed value if the seed was not set using one of those two options.

---

## System Tasks for Resetting VCS

`$reset`

Resets the simulation time to 0. See IEEE Std 1364-2001 pages 741-742.

`$reset_count`

Keeps track of the number of times VCS executes the `$reset` system task in a simulation session. See IEEE std 1364-2001 pages 741-742.

`$reset_value`

System function that you can use to pass a value from, before or after VCS executes the `$reset` system task, that is, you can enter a `reset_value` integer argument to the `$reset` system task, and after VCS resets the simulation, the `$reset_value` system function returns this integer argument. See IEEE std 1364-2001 pages 741-742.

---

## General System Tasks and Functions

### Checks for a Plusarg

`$test$plusargs`

Checks for the existence of a given plusarg on the runtime executable command line. Syntax:

`$test$plusargs ("plusarg_without_the_+");`

## SDF Files

`$sdf_annotate`

Tells VCS to back-annotate delay values from an SDF file to your Verilog design.

## Counting the Drivers on a Net

`$countdrivers`

Counts the number of drivers on a net. See IEEE std 1364-2001 page 738-739.

## Depositing Values

`$deposit`

Deposits a value on a net or variable. This deposited value overrides the value from any other driver of the net or variable. The value propagates to all loads of the net or variable. A subsequent simulation event can override the deposited value. You cannot use this system task to deposit values to bit-selects or part-selects.

Syntax: `$deposit (net_or_variable, value);`

The deposited value can be the value of another net or variable. You can deposit the value of a bit-select or part-select.

## Fast Processing Stimulus Patterns

`$getpattern`

Provides for fast processing of stimulus patterns. See IEEE std 1364-2001 page 739.

## Saving and Restarting The Simulation State

`$save`

Saves the current simulation state in a file. See IEEE std 1364-2001 pages 742-743.

`$restart`

Restores the simulation to the state that you saved in the check file with the `$save` system task. See IEEE std 1364-2001 pages 742-743.

## Checking for X and Z Values in Conditional Expressions

`$xzcheckon`

Displays a warning message every time VCS evaluates a conditional expression to have an X or Z value.

Syntax: `$xzcheckon(level_number, hierarchical_name)`

*level\_number* (Optional)

Specifies the number of hierarchy scope levels from the specified module instance to check for X and Z values. If the number is 0 or not specified, implies to check all scope instances to the end of the hierarchy.

*hierarchical\_name* (Optional)

Hierarchical name of the module instance, that is, the top-level instance of the subhierarchy for which you want to enable checking.

`$xzcheckoff`

Suppress the warning message every time VCS evaluates a conditional expression to have an X or Z value.

Syntax:

`$xzcheckoff(level_number,hierarchical_name)`

*level\_number* (Optional)

Specifies the number of hierarchy scope levels from the specified module instance, for which X and Z value check is disabled. If the number is 0 or not specified, implies to disable the check on all scope instances to the end of the hierarchy.

*hierarchical\_name* (Optional)

Hierarchical name of the module instance, that is, the top-level instance of the subhierarchy for which you want to disable checking.

## Calculating Bus Widths

`$clog2`

Use this system function to calculate bus widths from, for example, parameters. The following illustrates its use:

```
integer result;
result = $clog2(n);
```

Note:

If the argument has x or z values then that bit will be considered as 1 or 0 respectively by VCS. The argument could be a vector with a few bits having x or z values.

For more information on this system function, see section named “*Integer math functions*” in the *IEEE Std-1800-2009 SystemVerilog LRM*.

## Displaying the Method Stack

```
$stack();
```

Displays method stack information, the various lines in your code that trigger the execution of an entry of this system task. These executable lines are called the method stack. This system task is for easier debugging and back tracing. If you have multiple entries of this system task you see multiple stacks.

You can enter this system task in modules and SystemVerilog programs, classes, packages, and interfaces; in user defined tasks and functions, and in initial, always, and final blocks (Synopsys recommends naming begin-end blocks in these initial, always, and final blocks).

The following code example illustrates an entry of this system task in a file named `test.sv`:

```
program test;

 class C;
 static function f3();
 $stack(); // line 5
 endfunction
 endclass

 function f1();
 f2(); // line 10
 endfunction

 function f2();
 C::f3(); // line 14
 endfunction

 task t();
 f1(); // line 18
 endtask
```

```

task t1();
 t(); // line 22
endtask

initial begin :B0
 t1(); // line 26
end

endprogram

module top;
 test p();
endmodule

```

At runtime VCS displays the following method stack information:

```

#0 in \C::f3 at test.sv:5
#1 in f2 at test.sv:14
#2 in f1 at test.sv:10
#3 in t at test.sv:18
#4 in t1 at test.sv:22
#5 in B0 at test.sv:26
#6 in top.p

```

In this method stack:

#0 is always the line containing the \$stack system task. In this example it is in class C, user defined function named f3, at line number 5 is test.sv.

#1 is a call of function f3 in user defined function f2 at line number 14. VCSexecuting f2 causes VCSto execute f3.

#2 is a call of function f2 in user defined function f1 at line number 10. VCSexecuting f1 causes VCSto execute f2.

#3 is a call of function f1 in user defined task t at line number 18. VCSexecuting t causes VCSto execute f1.

#4 is a task enabling statement for task t in user defined task t1 at line number 22. VCSexecuting t1 causes VCSto execute t.

#5 is a task enabling statement for t1 in the begin-end block named B0. VCSexecuting B0 causes VCSto execute t1.

#6 is the instance of program test. VCSdoes not include the line number because this instantiation is in the top level module.

---

## **IEEE Standard System Tasks Not Yet Implemented**

The following Verilog system tasks are included in the IEEE Std 1364-2001 standards, but are not yet implemented in VCS:

- \$dist\_chi\_square
- \$dist\_erlang
- \$dist\_t

# E

## PLI Access Routines

---

VCS includes a number of access routines. This appendix describes these access routines in the following sections:

- “Access Routines for Reading and Writing to Memories”
- “Access Routines for Multidimensional Arrays”
- “Access Routines for Probabilistic Distribution”
- “Access Routines for Returning a Pointer to a Parameter Value”
- “Access Routines for Extended VCD Files”
- “Access Routines for Line Callbacks”
- “Access Routines for Source Protection”
- “Access Routine for Signal in a Generate Block”
- “VCS API Routines”

---

## Access Routines for Reading and Writing to Memories

VCS includes a number of access routines for reading and writing to a memory.

These access routines are as follows:

`acc_setmem_int`

Writes an integer value to specific bits in a Verilog memory word. See “[“acc\\_setmem\\_int” on page 4](#) for details.

`acc_getmem_int`

Reads an integer value from specific bits in a Verilog memory word. See “[“acc\\_getmem\\_int” on page 5](#) for details.

`acc_clearmem_int`

Clears a memory, that is, writes zeros to all bits. See “[“acc\\_clearmem\\_int” on page 6](#) for details.

`acc_setmem_hexstr`

Writes a hexadecimal string value to specific bits in a Verilog memory word. See “[“acc\\_setmem\\_hexstr” on page 11](#) for details.

`acc_getmem_hexstr`

Reads a hexadecimal string value from specific bits in a Verilog memory word. See “[“acc\\_getmem\\_hexstr” on page 15](#) for details.

`acc_setmem_bitstr`

Writes a string of binary bits (including x and z) to a Verilog memory word. See “[“acc\\_setmem\\_bitstr” on page 16](#) for details.

`acc_getmem_bitstr`

Reads a bit string from specific bits in a Verilog memory word.  
See “[“acc\\_getmem\\_bitstr” on page 17](#) for details.

`acc_handle_mem_by_fullname`

Returns the handle used by `acc_readmem`. See  
“[“acc\\_handle\\_mem\\_by\\_fullname” on page 18](#) for details.

`acc_readmem`

Reads a data file and writes the contents to a memory. See  
“[“acc\\_readmem” on page 18](#) for details.

`acc_getmem_range`

Returns the upper and lower limits of a memory. See  
“[“acc\\_getmem\\_range” on page 21](#) for details.

`acc_getmem_size`

Returns the number of elements (or words or addresses) in a  
memory. See “[“acc\\_getmem\\_size” on page 22](#) for details.

`acc_getmem_word_int`

Returns the integer of a memory element. See  
“[“acc\\_getmem\\_word\\_int” on page 23](#) for details.

`acc_getmem_word_range`

Returns the least significant bit of a memory element and the  
length of the element. See “[“acc\\_getmem\\_word\\_range” on page 24](#) for details.

---

## **acc\_setmem\_int**

You use the `acc_setmem_int` access routine to write an integer value to specific bits in a Verilog memory word.

**Table 0-1.**

| acc_setmem_int    |                                                                                                                                                                                                                                                                                                                                                                                                                        |             |                                                                                                |
|-------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|------------------------------------------------------------------------------------------------|
| Synopsis:         | Writes an integer value to specific bits in a memory word.                                                                                                                                                                                                                                                                                                                                                             |             |                                                                                                |
| Syntax:           | <code>acc_setmem_int (memhand, value, row, start, length)</code>                                                                                                                                                                                                                                                                                                                                                       |             |                                                                                                |
| Returns:          | Type                                                                                                                                                                                                                                                                                                                                                                                                                   | Description |                                                                                                |
| Arguments:        | void                                                                                                                                                                                                                                                                                                                                                                                                                   |             |                                                                                                |
|                   | Type                                                                                                                                                                                                                                                                                                                                                                                                                   | Name        | Description                                                                                    |
| Arguments:        | handle                                                                                                                                                                                                                                                                                                                                                                                                                 | memhand     | Handle to memory                                                                               |
|                   | int                                                                                                                                                                                                                                                                                                                                                                                                                    | value       | The integer value written in binary format to the bits in the word.                            |
|                   | int                                                                                                                                                                                                                                                                                                                                                                                                                    | row         | The memory array index.                                                                        |
|                   | int                                                                                                                                                                                                                                                                                                                                                                                                                    | start       | Bit number of the leftmost bit in the memory word where this routine starts writing the value. |
|                   | int                                                                                                                                                                                                                                                                                                                                                                                                                    | length      | Starting with the start bit, specifies the total number of bits this routine writes to.        |
| Related routines: | <code>acc_getmem_int</code><br><code>acc_setmem_hexstr</code><br><code>acc_getmem_hexstr</code><br><code>acc_setmem_bitstr</code><br><code>acc_getmem_bitstr</code><br><code>acc_clearmem_int</code><br><code>acc_handle_mem_by_fullname</code><br><code>acc_readmem</code><br><code>acc_getmem_range</code><br><code>acc_getmem_size</code><br><code>acc_getmem_word_int</code><br><code>acc_getmem_word_range</code> |             |                                                                                                |

---

## **acc\_getmem\_int**

You use the `acc_getmem_int` access routine to return an integer value for certain bits in a Verilog memory word.

**Table 0-1.**

| acc_getmem_int    |                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                      |
|-------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------|
| Synopsis:         | Returns an integer value for specific bits in a memory word.                                                                                                                                                                                                                                                                                                                                                           |                                                                                                      |
| Syntax:           | <code>acc_getmem_int (memhand, row, start, length)</code>                                                                                                                                                                                                                                                                                                                                                              |                                                                                                      |
|                   | Type                                                                                                                                                                                                                                                                                                                                                                                                                   | Description                                                                                          |
| Returns:          | int                                                                                                                                                                                                                                                                                                                                                                                                                    | Integer value of the bits in the memory word.                                                        |
| Arguments:        | Type                                                                                                                                                                                                                                                                                                                                                                                                                   | Name Description                                                                                     |
|                   | handle                                                                                                                                                                                                                                                                                                                                                                                                                 | memhand Handle to memory                                                                             |
|                   | int                                                                                                                                                                                                                                                                                                                                                                                                                    | row The memory array index                                                                           |
|                   | int                                                                                                                                                                                                                                                                                                                                                                                                                    | start Bit number of the leftmost bit in the memory word where this routine starts reading the value. |
|                   | int                                                                                                                                                                                                                                                                                                                                                                                                                    | length Specifies the total number of bits this routine reads starting with the start bit.            |
| Related routines: | <code>acc_setmem_int</code><br><code>acc_setmem_hexstr</code><br><code>acc_getmem_hexstr</code><br><code>acc_setmem_bitstr</code><br><code>acc_getmem_bitstr</code><br><code>acc_clearmem_int</code><br><code>acc_handle_mem_by_fullname</code><br><code>acc_readmem</code><br><code>acc_getmem_range</code><br><code>acc_getmem_size</code><br><code>acc_getmem_word_int</code><br><code>acc_getmem_word_range</code> |                                                                                                      |

---

## **acc\_clearmem\_int**

You use the `acc_clearmem_int` access routine to write zeros to all bits in a memory.

**Table 0-1.**

| acc_clearmem_int  |                                                                                                                                                                                                                                                                                                                                                                                                                      |                      |                  |
|-------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------|------------------|
| Synopsis:         | Clears a memory word.                                                                                                                                                                                                                                                                                                                                                                                                |                      |                  |
| Syntax:           | <code>acc_clearmem_int (memhand)</code>                                                                                                                                                                                                                                                                                                                                                                              |                      |                  |
| Returns:          | Type                                                                                                                                                                                                                                                                                                                                                                                                                 | Description          |                  |
|                   | <code>void</code>                                                                                                                                                                                                                                                                                                                                                                                                    |                      |                  |
| Arguments:        | Type                                                                                                                                                                                                                                                                                                                                                                                                                 | Name                 | Description      |
|                   | <code>handle</code>                                                                                                                                                                                                                                                                                                                                                                                                  | <code>memhand</code> | Handle to memory |
| Related routines: | <code>acc_setmem_int</code><br><code>acc_getmem_int</code><br><code>acc_setmem_hexstr</code><br><code>acc_getmem_hexstr</code><br><code>acc_setmem_bitstr</code><br><code>acc_getmem_bitstr</code><br><code>acc_handle_mem_by_fullname</code><br><code>acc_readmem</code><br><code>acc_getmem_range</code><br><code>acc_getmem_size</code><br><code>acc_getmem_word_int</code><br><code>acc_getmem_word_range</code> |                      |                  |

## **Examples**

The following code examples illustrate how to use `acc_getmem_int`, `acc_setmem_int`, and `acc_clearmem_int`:

- [Example E-1](#) shows C code that includes a number of functions to be associated with user-defined system tasks.

- [Example E-2](#) shows the PLI table for associating these functions with these system tasks.
- [Example E-3](#) shows the Verilog source code containing these system tasks.

*Example E-1 C Source Code for Functions Calling acc\_getmem\_int, acc\_setmem\_int, and acc\_clearmem\_int*

```
#include <stdio.h>
#include "acc_user.h"
#include "vcs_acc_user.h"

void error_handle(char *msg)
{
 printf("%s", msg);
 fflush(stdout);
 exit(1);
}

void set_mem()
{
 handle memhand = NULL;
 int value = -1;
 int row = -1;
 int start_bit = -1;
 int len = -1;

 memhand = acc_handle_tfarg(1);
 if(!memhand) error_handle("NULL MEM HANDLE\n");
 value = acc_fetch_tfarg_int(2);
 row = acc_fetch_tfarg_int(3);
 start_bit = acc_fetch_tfarg_int(4);
 len = acc_fetch_tfarg_int(5);

 acc_setmem_int(memhand, value, row, start_bit, len);
}

void get_mem()
{
 handle memhand = NULL;
```

```

int row = -1;
int start_bit = -1;
int len = -1;
int value = -1;

memhand = acc_handle_tfarg(1);
if(!memhand) error_handle("NULL MEM HANDLE\n");
row = acc_fetch_tfarg_int(2);
start_bit = acc_fetch_tfarg_int(3);
len = acc_fetch_tfarg_int(4);
value = acc_getmem_int(memhand, row, start_bit, len);
printf("getmem: value of word %d is : %d\n",row,value);
fflush(stdout);
}

void clear_mem()
{
 handle memhand = NULL;

 memhand = acc_handle_tfarg(1);
 if(!memhand) error_handle("NULL MEM HANDLE\n");

 acc_clearmem_int(memhand);
}

```

The function with the `set_mem` identifier calls the IEEE standard `acc_fetch_tfarg_int` routine to get the handles for arguments to the user-defined system task that you associate with this function in the PLI table file. It then assigns the handles to local variables and calls `acc_setmem_int` to write to the specified memory in the specified word, start bit, for the specified length.

Similarly, the function with the `get_mem` identifier calls the `acc_fetch_tfarg_int` routine to get the handles for arguments to a user-defined system task and assign them to local variables. It then calls `acc_gtetmem_int` to read from the specified memory in

the specified word, starting with the specified start bit for the specified length. It then displays the word index of the memory and its value.

The function with the `clear_mem` identifier likewise calls the `acc_fetch_tfarg_int` routine to get a handle and then calls `acc_clear_mem_int` with that handle.

#### *Example E-2 PLI Table File*

```
$set_mem call=set_mem acc+=rw:*
$get_mem call=get_mem acc+=r:*
$clear_mem call=clear_mem acc+=rw:*
```

Here the `$set_mem` user-defined system task is associated with the `set_mem` function in the C code, as are the `$get_mem` and `$clear_mem` with their corresponding `get_mem` and `clear_mem` function identifiers.

#### *Example E-3 Verilog Source Code Using These System Tasks*

```
module top;
// read and print out data of memory
parameter start = 0;
parameter finish = 9 ;
parameter bstart =1 ;
parameter bfinish =8 ;
parameter size = finish - start + 1;
reg [bfinish:bstart] mymem[start:finish];
integer i;
integer len;
integer value;

initial
begin
// $set_mem(mem_name, value, row, start_bit, len)
$clear_mem(mymem);

// set values
```

```

#1 $set_mem(mymem, 8, 2, 1, 5);
#1 $set_mem(mymem, 32, 3, 1, 6);
#1 $set_mem(mymem, 144, 4, 1, 8);
#1 $set_mem(mymem,29,5,1,8);

// print values through acc_getmem_int
#1 len = bfinish - bstart + 1;
$display();
$display("Begin Memory Values");
for (i=start;i<=finish;i=i+1)
begin
 $get_mem(mymem,i,bstart,len);
end
$display("End Memory Values");
$display();

// display values
#1 $display();
$display("Begin Memory Display");
for (i=start;i<=finish;i=i+1)
begin
 $display("mymem word %d is %b",i,mymem[i]);
end
$display("End Memory Display");
$display();
end
endmodule

```

In this Verilog code, in the initial block, the following events occur:

1. The `$clear_mem` system task clears the memory.
2. Then the `$set_mem` system task deposits values in specified words, and in specified bits in the memory named `mymem`.
3. In a `for` loop, the `$get_mem` system task reads values from the memory and displays those values.

---

## **acc\_setmem\_hexstr**

You use the `acc_setmem_hexstr` access routine for writing the corresponding binary representation of a hexadecimal string to a Verilog memory.

**Table 0-1.**

| acc_setmem_hexstr |                                                                                                                                                                                                                                                                                                                                                                                                                     |             |                                                                                                 |
|-------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|-------------------------------------------------------------------------------------------------|
| Synopsis:         | Writes a hexadecimal string to a word in a Verilog memory.                                                                                                                                                                                                                                                                                                                                                          |             |                                                                                                 |
| Syntax:           | <code>acc_setmem_hexstr (memhand, hexStrValue, row, start)</code>                                                                                                                                                                                                                                                                                                                                                   |             |                                                                                                 |
| Returns:          | Type                                                                                                                                                                                                                                                                                                                                                                                                                | Description |                                                                                                 |
|                   | void                                                                                                                                                                                                                                                                                                                                                                                                                |             |                                                                                                 |
| Arguments:        | Type                                                                                                                                                                                                                                                                                                                                                                                                                | Name        | Description                                                                                     |
|                   | handle                                                                                                                                                                                                                                                                                                                                                                                                              | memhand     | Handle to memory                                                                                |
|                   | char *                                                                                                                                                                                                                                                                                                                                                                                                              | hexStrValue | Hexadecimal string                                                                              |
|                   | int                                                                                                                                                                                                                                                                                                                                                                                                                 | row         | The memory array index                                                                          |
|                   | int                                                                                                                                                                                                                                                                                                                                                                                                                 | start       | Bit number of the leftmost bit in the memory word where this routine starts writing the string. |
| Related routines: | <code>acc_setmem_int</code><br><code>acc_getmem_int</code><br><code>acc_getmem_hexstr</code><br><code>acc_setmem_bitstr</code><br><code>acc_getmem_bitstr</code><br><code>acc_clearmem_int</code><br><code>acc_handle_mem_by_fullname</code><br><code>acc_readmem</code><br><code>acc_getmem_range</code><br><code>acc_getmem_size</code><br><code>acc_getmem_word_int</code><br><code>acc_getmem_word_range</code> |             |                                                                                                 |

This routine takes a value argument which is a hexadecimal string of any size and puts its corresponding binary representation into the memory word indexed by `row`, starting at the bit number `start`.

## Examples

The following code examples illustrates the use of `acc_setmem_hexstr`:

- [Example E-4](#) shows the C source code for an application that calls `acc_setmem_hexstr`.
- [Example E-5](#) shows the contents of a data file read by the application.
- [Example E-6](#) shows the PLI table file that associates the user-defined system task in the Verilog code with the application.
- [Example E-7](#) shows the Verilog source that calls the application.

*Example E-4 C Source Code For an Application Calling  
acc\_setmem\_hexstr*

```
#include <stdio.h>
#include "acc_user.h"
#include "vcsuser.h"
#define NAME_SIZE 256
#define len 100
pli()
{
 FILE *infile;
 char memory_name[NAME_SIZE] ;
 char value[len];
 handle memory_handle;
 int row,start;

 infile = fopen("initfile","r");
 while (fscanf(infile,"%s %s %d %d ",
 memory_name,value,&row,&start) != EOF)
 {
 printf ("The mem= %s \n value= %s \n row= %d \n start= %d \n ",
 memory_name,value,row,start);
 memory_handle=acc_handle_object(memory_name);
 acc_setmem_hexstr(memory_handle,value,row,start);
```

```
 }
}
```

[Example E-4](#) shows the source code for a PLI application that:

1. Reads a data file named `initfile` to find the memory identifiers of the memories it writes to, the hexadecimal string to be converted to its bit representation when written to the memory, the index of the memory where it writes this value, and the starting bit for writing the binary value.
2. Displays where in the memory it is writing these values
3. Calls the access routine to write the values in the `initfile`.

*Example E-5 The Data File Read by the Application*

```
testbench.U2.cmd_array 5 0 0
testbench.U2.cmd_array a5 1 4
testbench.U2.cmd_array a5a5 2 8
testbench.U1.slave_addr a073741824 0 4
testbench.U1.slave_addr 16f0612735 1 8
testbench.U1.slave_addr 2b52a90e15 2 12
```

Each line lists a Verilog memory, followed by a hex string, a memory index, and a start bit.

*Example E-6 PLI Table File*

```
$pli call=pli acc=rw:*
```

Here the `$pli` system task is associated with the function with the `pli` identifier in the C source code.

*Example E-7 Verilog Source Calling the PLI Application*

```
module testbench;
 monitor U1 ();
 master U2 ();
 initial begin
```

```

$monitor($stime,,,
 "sladd[0]=%h sladd[1]=%h sladd[2]=%h load=%h
 cmd[0]=%h cmd[1]=%h cmd[2]=%h",
 testbench.U1.slave_addr[0],
 testbench.U1.slave_addr[1],
 testbench.U1.slave_addr[2],
 testbench.U1.load,
 testbench.U2.cmd_array[0],
 testbench.U2.cmd_array[1],
 testbench.U2.cmd_array[2]);
#10;
$plic();
end
endmodule

module master;
 reg[31:0] cmd_array [0:2];
 integer i;
initial begin //setup some default values
 for (i=0; i<3; i=i+1)
 cmd_array[i] = 32'h0000_0000;
end
endmodule

module monitor;
 reg load;
 reg[63:0] slave_addr [0:2];
 integer i;
initial begin //setup some default values
 for (i=0; i<3; i=i+1)
 slave_addr[i] = 64'h0000_0000_0000_0000;
 load = 1'b0;
end
endmodule

```

In Example E-7 module testbench calls the application using the \$pli user-defined system task for the application. The display string in the \$monitor system task is on two lines to enhance readability.

---

## **acc\_getmem\_hexstr**

You use the `acc_getmem_hexstr` access routine to get a hexadecimal string from a Verilog memory.

**Table 0-1.**

| acc_getmem_hexstr |                                                                                                                                                                                                                                                                                                                                                                                                                     |             |                                                                                                 |
|-------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|-------------------------------------------------------------------------------------------------|
| Synopsis:         | Returns a hexadecimal string from a Verilog memory.                                                                                                                                                                                                                                                                                                                                                                 |             |                                                                                                 |
| Syntax:           | <code>acc_getmem_hexstr (memhand, hexStrValue, row, start, len)</code>                                                                                                                                                                                                                                                                                                                                              |             |                                                                                                 |
| Returns:          | Type                                                                                                                                                                                                                                                                                                                                                                                                                | Description |                                                                                                 |
|                   | void                                                                                                                                                                                                                                                                                                                                                                                                                |             |                                                                                                 |
| Arguments:        | Type                                                                                                                                                                                                                                                                                                                                                                                                                | Name        | Description                                                                                     |
|                   | handle                                                                                                                                                                                                                                                                                                                                                                                                              | memhand     | Handle to memory                                                                                |
|                   | char *                                                                                                                                                                                                                                                                                                                                                                                                              | hexStrValue | Pointer to a character array into which the string is written                                   |
|                   | int                                                                                                                                                                                                                                                                                                                                                                                                                 | row         | The memory array index                                                                          |
|                   | int                                                                                                                                                                                                                                                                                                                                                                                                                 | start       | Bit number of the leftmost bit in the memory word where this routine starts reading the string. |
|                   | int                                                                                                                                                                                                                                                                                                                                                                                                                 | length      | Specifies the total number of bits this routine reads starting with the start bit.              |
| Related routines: | <code>acc_setmem_int</code><br><code>acc_getmem_int</code><br><code>acc_setmem_hexstr</code><br><code>acc_setmem_bitstr</code><br><code>acc_getmem_bitstr</code><br><code>acc_clearmem_int</code><br><code>acc_handle_mem_by_fullname</code><br><code>acc_readmem</code><br><code>acc_getmem_range</code><br><code>acc_getmem_size</code><br><code>acc_getmem_word_int</code><br><code>acc_getmem_word_range</code> |             |                                                                                                 |

---

## **acc\_setmem\_bitstr**

You use the `acc_setmem_bitstr` access routine for writing a string of binary bits (including x and z) to a Verilog memory.

**Table 0-1.**

| acc_setmem_bitstr |                                                                                                                                                                                                                                                                                                                                                                                                                     |             |                                                                                                 |
|-------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|-------------------------------------------------------------------------------------------------|
| Synopsis:         | Writes a string of binary bits to a word in a Verilog memory.                                                                                                                                                                                                                                                                                                                                                       |             |                                                                                                 |
| Syntax:           | <code>acc_setmem_bitstr (memhand, bitStrValue, row, start)</code>                                                                                                                                                                                                                                                                                                                                                   |             |                                                                                                 |
| Returns:          | Type                                                                                                                                                                                                                                                                                                                                                                                                                | Description |                                                                                                 |
| Arguments:        | void                                                                                                                                                                                                                                                                                                                                                                                                                |             |                                                                                                 |
|                   | Type                                                                                                                                                                                                                                                                                                                                                                                                                | Name        | Description                                                                                     |
| Related routines: | handle                                                                                                                                                                                                                                                                                                                                                                                                              | memhand     | Handle to memory                                                                                |
|                   | char *                                                                                                                                                                                                                                                                                                                                                                                                              | bitStrValue | Bit string                                                                                      |
|                   | int                                                                                                                                                                                                                                                                                                                                                                                                                 | row         | The memory array index                                                                          |
|                   | int                                                                                                                                                                                                                                                                                                                                                                                                                 | start       | Bit number of the leftmost bit in the memory word where this routine starts writing the string. |
| Related routines: | <code>acc_setmem_int</code><br><code>acc_getmem_int</code><br><code>acc_setmem_hexstr</code><br><code>acc_getmem_hexstr</code><br><code>acc_getmem_bitstr</code><br><code>acc_clearmem_int</code><br><code>acc_handle_mem_by_fullname</code><br><code>acc_readmem</code><br><code>acc_getmem_range</code><br><code>acc_getmem_size</code><br><code>acc_getmem_word_int</code><br><code>acc_getmem_word_range</code> |             |                                                                                                 |

This routine takes a value argument that is a bit string of any size, which can include the x and z values, and puts its corresponding binary representation into the memory word indexed by `row`, starting at the bit number `start`.

---

## **acc\_getmem\_bitstr**

You use the `acc_getmem_bitstr` access routine to get a bit string, including x and z values, from a Verilog memory.

**Table 0-1.**

| acc_getmem_bitstr |                                                                                                                                                                                                                                                                                                                                                                                                                     |             |                                                                                                 |
|-------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|-------------------------------------------------------------------------------------------------|
| Synopsis:         | Returns a hexadecimal string from a Verilog memory.                                                                                                                                                                                                                                                                                                                                                                 |             |                                                                                                 |
| Syntax:           | <code>acc_getmem_bitstr (memhand,bitStrValue,row,start,len)</code>                                                                                                                                                                                                                                                                                                                                                  |             |                                                                                                 |
| Returns:          | Type                                                                                                                                                                                                                                                                                                                                                                                                                | Description |                                                                                                 |
|                   | void                                                                                                                                                                                                                                                                                                                                                                                                                |             |                                                                                                 |
| Arguments:        | Type                                                                                                                                                                                                                                                                                                                                                                                                                | Name        | Description                                                                                     |
|                   | handle                                                                                                                                                                                                                                                                                                                                                                                                              | memhand     | Handle to memory                                                                                |
|                   | char *                                                                                                                                                                                                                                                                                                                                                                                                              | hexStrValue | Pointer to a character array into which the string is written                                   |
|                   | int                                                                                                                                                                                                                                                                                                                                                                                                                 | row         | The memory array index                                                                          |
|                   | int                                                                                                                                                                                                                                                                                                                                                                                                                 | start       | Bit number of the leftmost bit in the memory word where this routine starts reading the string. |
|                   | int                                                                                                                                                                                                                                                                                                                                                                                                                 | length      | Specifies the total number of bits this routine reads starting with the start bit.              |
| Related routines: | <code>acc_setmem_int</code><br><code>acc_getmem_int</code><br><code>acc_setmem_hexstr</code><br><code>acc_getmem_hexstr</code><br><code>acc_setmem_bitstr</code><br><code>acc_clearmem_int</code><br><code>acc_handle_mem_by_fullname</code><br><code>acc_readmem</code><br><code>acc_getmem_range</code><br><code>acc_getmem_size</code><br><code>acc_getmem_word_int</code><br><code>acc_getmem_word_range</code> |             |                                                                                                 |

---

## **acc\_handle\_mem\_by\_fullname**

Returns a handle to a memory that can only be used as a parameter to acc\_readmem.

**Table 0-1.**

| acc_handle_mem_by_fullname |                                                                |                        |
|----------------------------|----------------------------------------------------------------|------------------------|
| Synopsis:                  | Returns a handle to be used as a parameter to acc_readmem only |                        |
| Syntax:                    | acc_handle_mem_by_fullname (fullMemInstName)                   |                        |
|                            | Type                                                           | Description            |
| Returns:                   | handle                                                         | Handle to the instance |
|                            | Type                                                           | Name                   |
| Arguments:                 | char*                                                          | fullMemInstName        |
| Related routines:          | Hierarchical name for a memory                                 |                        |
|                            | acc_setmem_int                                                 |                        |
|                            | acc_getmem_int                                                 |                        |
|                            | acc_setmem_hexstr                                              |                        |
|                            | acc_getmem_hexstr                                              |                        |
|                            | acc_setmem_bitstr                                              |                        |
|                            | acc_getmem_bitstr                                              |                        |
|                            | acc_handle_mem_by_fullname                                     |                        |
|                            | acc_readmem                                                    |                        |
|                            | acc_getmem_range                                               |                        |

---

## **acc\_readmem**

You use the acc\_readmem access routine to read a data file into a memory. It is similar to the \$readmemb or \$readmemh system tasks.

The `memhandle` argument must be the handle returned by `acc_handle_mem_by_fullname`.

**Table 0-1.**

| acc_readmem       |                                                                                                                                                                                                                                                                                                                                                                                                                      |                        |                                                                                             |
|-------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|---------------------------------------------------------------------------------------------|
| Synopsis:         | Reads a data file into a memory                                                                                                                                                                                                                                                                                                                                                                                      |                        |                                                                                             |
| Syntax:           | <code>acc_readmem (memhandle, data_file, format)</code>                                                                                                                                                                                                                                                                                                                                                              |                        |                                                                                             |
|                   | Type                                                                                                                                                                                                                                                                                                                                                                                                                 | Description            |                                                                                             |
| Returns:          | <code>void</code>                                                                                                                                                                                                                                                                                                                                                                                                    |                        |                                                                                             |
|                   | Type                                                                                                                                                                                                                                                                                                                                                                                                                 | Name                   | Description                                                                                 |
| Arguments:        | <code>handle</code>                                                                                                                                                                                                                                                                                                                                                                                                  | <code>memhandle</code> | Handle returned by <code>acc_handle_mem_fullname</code>                                     |
|                   | <code>const char*</code>                                                                                                                                                                                                                                                                                                                                                                                             | <code>data_file</code> | Data file this routine reads                                                                |
|                   | <code>int</code>                                                                                                                                                                                                                                                                                                                                                                                                     | <code>format</code>    | Specify a character that is promoted to int. 'h' for hexadecimal data, 'b' for binary data. |
| Related routines: | <code>acc_setmem_int</code><br><code>acc_getmem_int</code><br><code>acc_setmem_hexstr</code><br><code>acc_getmem_hexstr</code><br><code>acc_setmem_bitstr</code><br><code>acc_getmem_bitstr</code><br><code>acc_handle_mem_by_fullname</code><br><code>acc_readmem</code><br><code>acc_getmem_range</code><br><code>acc_getmem_size</code><br><code>acc_getmem_word_int</code><br><code>acc_getmem_word_range</code> |                        |                                                                                             |

## Examples

The following code examples illustrate the use of `acc_readmem` and `acc_handle_mem_by_fullname`.

*Example E-8 C Source Code Calling Tacc\_readmem and acc\_handle\_mem\_by\_fullname*

```
#include "acc_user.h"
#include "vcs_acc_user.h"
#include "vcsuser.h"

int test_acc_readmem(void)
{
 const char *memName = tf_getcstringp(1);
 const char *memFile = tf_getcstringp(2);
 handle mem = acc_handle_mem_by_fullname(memName);

 if (mem) {
 io_printf("test_acc_readmem: %s handle found\n",
memName);
 acc_readmem(mem, memFile, 'h');
 }
 else {
 io_printf("test_acc_readmem: %s handle NOT found\n",
memName);
 }
}
```

*Example E-9 The PLI Table File*

```
$test_acc_readmem call=test_acc_readmem
```

*Example E-10 The Verilog Source Code*

```
module top;
reg [7:0] CORE[7:0];
initial $acc_readmem(CORE, "CORE");
initial $test_acc_readmem("top.CORE", "test_mem_file");
endmodule
```

---

## **acc\_getmem\_range**

You use the acc\_getmem\_range access routine to access the upper and lower limits of a memory.

**Table 0-1.**

| acc_getmem_range  |                                                                                                                                                                                                                                      |                              |      |             |      |  |
|-------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------|------|-------------|------|--|
| Synopsis:         | Returns the upper and lower limits of a memory                                                                                                                                                                                       |                              |      |             |      |  |
| Syntax:           | acc_getmem_range (memhandle, p_left_index,p_right_index)                                                                                                                                                                             |                              |      |             |      |  |
| Returns:          | <table><thead><tr><th>Type</th><th>Description</th></tr></thead><tbody><tr><td>void</td><td></td></tr></tbody></table>                                                                                                               |                              | Type | Description | void |  |
| Type              | Description                                                                                                                                                                                                                          |                              |      |             |      |  |
| void              |                                                                                                                                                                                                                                      |                              |      |             |      |  |
| Arguments:        | Type                                                                                                                                                                                                                                 | Name Description             |      |             |      |  |
|                   | handle                                                                                                                                                                                                                               | memhandle Handle to a memory |      |             |      |  |
|                   | int*                                                                                                                                                                                                                                 | p_left_index Pointer to int  |      |             |      |  |
|                   | int                                                                                                                                                                                                                                  | p_right_index Pointer to int |      |             |      |  |
| Related routines: | acc_setmem_int<br>acc_getmem_int<br>acc_setmem_hexstr<br>acc_getmem_hexstr<br>acc_setmem_bitstr<br>acc_getmem_bitstr<br>acc_handle_mem_by_fullname<br>acc_readmem<br>acc_getmem_size<br>acc_getmem_word_int<br>acc_getmem_word_range |                              |      |             |      |  |

---

## **acc\_getmem\_size**

You use the `acc_getmem_size` access routine to access the number of elements in a memory.

**Table 0-1.**

| acc_getmem_size   |                                            |                                    |
|-------------------|--------------------------------------------|------------------------------------|
| Synopsis:         | Returns the number of elements in a memory |                                    |
| Syntax:           | <code>acc_getmem_size (memhandle)</code>   |                                    |
|                   | Type                                       | Description                        |
| Returns:          | int                                        | The number of elements in a memory |
|                   | Type                                       | Name                               |
| Arguments:        | handle                                     | memhandle                          |
| Related routines: | Handle to a memory                         |                                    |
|                   | acc_setmem_int                             |                                    |
|                   | acc_getmem_int                             |                                    |
|                   | acc_setmem_hexstr                          |                                    |
|                   | acc_getmem_hexstr                          |                                    |
|                   | acc_setmem_bitstr                          |                                    |
|                   | acc_getmem_bitstr                          |                                    |
|                   | acc_handle_mem_by_fullname                 |                                    |
|                   | acc_readmem                                |                                    |
|                   | acc_getmem_range                           |                                    |

---

## **acc\_getmem\_word\_int**

You use the `acc_getmem_word_int` access routine to access the integer value of an element (or word, address, or row).

**Table 0-1.**

| acc_getmem_word_int                                                                                                                                                                                                               |                                                   |                            |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------|----------------------------|
| Synopsis:                                                                                                                                                                                                                         | Returns the integer value of an element           |                            |
| Syntax:                                                                                                                                                                                                                           | <code>acc_getmem_word_int (memhandle, row)</code> |                            |
|                                                                                                                                                                                                                                   | Type                                              | Description                |
| Returns:                                                                                                                                                                                                                          | int                                               | The integer value of a row |
|                                                                                                                                                                                                                                   | Type                                              | Name                       |
| Arguments:                                                                                                                                                                                                                        | handle                                            | memhandle                  |
|                                                                                                                                                                                                                                   | int                                               | row                        |
| Related routines:                                                                                                                                                                                                                 | Handle to a memory                                |                            |
|                                                                                                                                                                                                                                   | The element (word address, or row) in the memory  |                            |
| acc_setmem_int<br>acc_getmem_int<br>acc_setmem_hexstr<br>acc_getmem_hexstr<br>acc_setmem_bitstr<br>acc_getmem_bitstr<br>acc_handle_mem_by_fullname<br>acc_readmem<br>acc_getmem_range<br>acc_getmem_size<br>acc_getmem_word_range |                                                   |                            |

---

## **acc\_getmem\_word\_range**

You use the acc\_getmem\_word\_range access routine to access the least significant bit of an element (or word, address, or row) and the length of the element.

**Table 0-1.**

| acc_getmem_word_range |                                                                                                                                                                                                                                 |                                          |      |             |      |  |
|-----------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------|------|-------------|------|--|
| Synopsis:             | Returns the least significant bit of an element and the length of the element                                                                                                                                                   |                                          |      |             |      |  |
| Syntax:               | acc_getmem_word_range (memhandle, lsb, len)                                                                                                                                                                                     |                                          |      |             |      |  |
| Returns:              | <table><thead><tr><th>Type</th><th>Description</th></tr></thead><tbody><tr><td>void</td><td></td></tr></tbody></table>                                                                                                          |                                          | Type | Description | void |  |
| Type                  | Description                                                                                                                                                                                                                     |                                          |      |             |      |  |
| void                  |                                                                                                                                                                                                                                 |                                          |      |             |      |  |
| Arguments:            | Type                                                                                                                                                                                                                            | Name Description                         |      |             |      |  |
|                       | handle                                                                                                                                                                                                                          | memhandle Handle to a memory             |      |             |      |  |
|                       | int*                                                                                                                                                                                                                            | lsb Pointer to the least significant bit |      |             |      |  |
|                       | int*                                                                                                                                                                                                                            | len Pointer to the length of the element |      |             |      |  |
| Related routines:     | acc_setmem_int<br>acc_getmem_int<br>acc_setmem_hexstr<br>acc_getmem_hexstr<br>acc_setmem_bitstr<br>acc_getmem_bitstr<br>acc_handle_mem_by_fullname<br>acc_readmem<br>acc_getmem_range<br>acc_getmem_size<br>acc_getmem_word_int |                                          |      |             |      |  |

---

## **Access Routines for Multidimensional Arrays**

The type for multi-dimensional arrays is defined in the vcs\_acc\_user.h file. Its name is accMda.

We also have the following tf and access routines for accessing data in a multi-dimensional array:

`tf_mdanodeinfo` and `tf_imdanodeinfo`

Returns access parameter node information from a multi-dimensional array. See “[tf\\_mdanodeinfo and tf\\_imdanodeinfo](#)” on [page 26](#) for details.

`acc_get_mda_range`

Returns all the ranges of the multi-dimensional array. See “[acc\\_get\\_mda\\_range](#)” on [page 27](#) for details.

`acc_get_mda_word_range`

Returns the range of an element in a multi-dimensional array. See “[acc\\_get\\_mda\\_word\\_range\(\)](#)” on [page 29](#) for details.

`acc_getmda_bitstr`

Reads a bit string, including X and Z values, from an element in a multi-dimensional array. See “[acc\\_getmda\\_bitstr\(\)](#)” on [page 30](#) for details.

`acc_setmda_bitstr`

Writes a bit string, including X and Z values, from an element in a multi-dimensional array. See “[acc\\_setmda\\_bitstr\(\)](#)” on [page 31](#) for details.

---

## **tf\_mdanodeinfo and tf\_imdanodeinfo**

You use these routines to access parameter node information from a multi-dimensional array.

**Table 0-1.**

| tf_mdanodeinfo(), tf_imdanodeinfo()                                  |                                                                                                                                           |                                                                                                    |
|----------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------|
| Synopsis:                                                            | Returns access parameter node information from a multi-dimensional array.                                                                 |                                                                                                    |
| Syntax:                                                              | <code>tf_mdanodeinfo(npParam, mdanodeinfo_p)</code><br><code>tf_imdanodeinfo(npParam, mdanodeinfo_p, instance_p)</code>                   |                                                                                                    |
| >Returns:                                                            | Type                                                                                                                                      | Description                                                                                        |
| Returns:<br>mdanodeinfo_p *                                          |                                                                                                                                           |                                                                                                    |
| The value of the second argument if successful; 0 if an error occurs |                                                                                                                                           |                                                                                                    |
| Arguments:                                                           |                                                                                                                                           |                                                                                                    |
| Arguments:                                                           | int                                                                                                                                       | nparam<br>Index number of the multi-dimensional array parameter                                    |
|                                                                      | struct t_tfmdanodeinfo *                                                                                                                  | mdanodeinfo_p<br>Pointer to a variable declared as the <code>t_tfmdanodeinfo</code> structure type |
|                                                                      | char *                                                                                                                                    | instance_p<br>Pointer to a specific instance of a multi-dimensional array                          |
| Related routines:                                                    | <code>acc_get_mda_range</code><br><code>acc_get_mda_word_range</code><br><code>acc_getmda_bitstr</code><br><code>acc_setmda_bitstr</code> |                                                                                                    |

Structure `t_tfmdanodeinfo` is defined in the `vcsuser.h` file as follows:

```
typedef struct t_tfmdanodeinfo
{
 short node_type;
 short node_fulltype;
 char *memoryval_p;
 char *node_symbol;
 int node_ngroups;
```

```

int node_vec_size;
int node_sign;
int node_ms_index;
int node_ls_index;
int node_mem_size;
int *node_lhs_element;
int *node_rhs_element;
int node_dimension;
int *node_handle;
int node_vec_type;
} s_tfmdanodeinfo, *p_tfmdanodeinfo;

```

---

## **acc\_get\_mda\_range**

The `acc_get_mda_range` routine returns the ranges of a multi-dimensional array.

**Table 0-1.**

| <b>acc_get_mda_range()</b> |                                                                                |                        |                                                    |
|----------------------------|--------------------------------------------------------------------------------|------------------------|----------------------------------------------------|
| Synopsis:                  | Gets all the ranges of the multi-dimensional array.                            |                        |                                                    |
| Syntax:                    | <code>acc_get_mda_range(mdaHandle, size, msb, lsb, dim, plndx, prindex)</code> |                        |                                                    |
|                            | Type                                                                           | Description            |                                                    |
| Returns:                   | <code>void</code>                                                              |                        |                                                    |
|                            | Type                                                                           | Name                   | Description                                        |
| Arguments:                 | <code>handle</code>                                                            | <code>mdaHandle</code> | Handle to the multi-dimensional array              |
|                            | <code>int *</code>                                                             | <code>size</code>      | Pointer to the size of the multi-dimensional array |
|                            | <code>int *</code>                                                             | <code>msb</code>       | Pointer to the most significant bit of a range     |

**Table 0-1.**

|                   |                                                                                                        |       |                                                                    |
|-------------------|--------------------------------------------------------------------------------------------------------|-------|--------------------------------------------------------------------|
|                   | int *                                                                                                  | lsb   | Pointer to the least significant bit of a range                    |
|                   | int *                                                                                                  | dim   | Pointer to the number of dimensions in the multi-dimensional array |
|                   | int *                                                                                                  | plndx | Pointer to the left index of a range                               |
|                   | int *                                                                                                  | prndx | Pointer to the right index of a range                              |
| Related routines: | tf_mdanodeinfo and tf_imdanodeinfo<br>acc_get_mda_word_range<br>acc_getmda_bitstr<br>acc_setmda_bitstr |       |                                                                    |

If you have a multi-dimensional array such as the following:

```
reg [7:0] my_mem[255:0][255:0][31:0];
```

And you call a routine, such as the following:

```
handle hN = acc_handle_by_name(my_mem);
acc_get_mda_range(hN, &size, &msb, &lsb, &dim, &plndx,
&prndx);
```

It yields the following result:

```
size = 8;
msb = 7, lsb = 0;
dim = 4;
plndx[] = {255, 255, 31}
prndx[] = {0, 0, 0}
```

---

## **acc\_get\_mda\_word\_range()**

The `acc_get_mda_word_range` routine returns the range of an element in a multi-dimensional array.

**Table 0-1.**

| acc_get_mda_word_range() |                                                                                                                                                                    |                        |                                                 |
|--------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|-------------------------------------------------|
| Synopsis:                | Gets the range of an element in a multi-dimensional array.                                                                                                         |                        |                                                 |
| Syntax:                  | <code>acc_get_mda_range(mdaHandle, msb, lsb)</code>                                                                                                                |                        |                                                 |
|                          | Type                                                                                                                                                               | Description            |                                                 |
| Returns:                 | <code>void</code>                                                                                                                                                  |                        |                                                 |
|                          | Type                                                                                                                                                               | Name                   | Description                                     |
| Arguments:               | <code>handle</code>                                                                                                                                                | <code>mdaHandle</code> | Handle to the multi-dimensional array           |
|                          | <code>int *</code>                                                                                                                                                 | <code>msb</code>       | Pointer to the most significant bit of a range  |
|                          | <code>int *</code>                                                                                                                                                 | <code>lsb</code>       | Pointer to the least significant bit of a range |
| Related routines:        | <code>tf_mdanodeinfo</code> and <code>tf_imdanodeinfo</code><br><code>acc_get_mda_range</code><br><code>acc_getmda_bitstr</code><br><code>acc_setmda_bitstr</code> |                        |                                                 |

If you have a multi-dimensional array such as the following:

```
reg [7:0] my_mem[255:0][255:0][31:0];
```

And you call a routine, such as the following:

```
handle hN = acc_handle_by_name(my_mem);
acc_get_mda_word_range(hN, &left, &right);
```

It yields the following result:

```

left = 7;
right = 0;

```

---

## **acc\_getmda\_bitstr()**

You use the `acc_getmda_bitstr` access routine to read a bit string, including x and z values, from a multi-dimensional array.

**Table 0-1.**

| acc_getmda_bitstr() |                                                                                                                                                                         |             |                                                         |
|---------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|---------------------------------------------------------|
| Synopsis:           | Gets a bit string from a multi-dimensional array.                                                                                                                       |             |                                                         |
| Syntax:             | <code>acc_getmda_bitstr(mdaHandle, bitStr, dim, start, len)</code>                                                                                                      |             |                                                         |
| Type                |                                                                                                                                                                         | Description |                                                         |
| Returns:            | void                                                                                                                                                                    |             |                                                         |
| Arguments:          | Type                                                                                                                                                                    | Name        | Description                                             |
|                     | handle                                                                                                                                                                  | mdaHandle   | Handle to the multi-dimensional array                   |
|                     | char *                                                                                                                                                                  | bitStr      | Pointer to the bit string                               |
|                     | int *                                                                                                                                                                   | dim         | Pointer to the dimension in the multi-dimensional array |
|                     | int *                                                                                                                                                                   | start       | Pointer to the start element in the dimension           |
| Related routines:   | int *                                                                                                                                                                   | len         | Pointer to the length of the string                     |
|                     | <code>tf_mdanodeinfo</code> and <code>tf_imdanodeinfo</code><br><code>acc_get_mda_range</code><br><code>acc_get_mda_word_range</code><br><code>acc_setmda_bitstr</code> |             |                                                         |

If you have a multi-dimensional array such as the following:

```
reg [7:0] my_mem[255:0][255:0][31:0];
```

And you call a routine, such as the following:

```

dim[]={5, 5, 10};
handle hN = acc_handle_by_name(my_mem);
acc_getmda_bitstr(hN, &bitStr, dim, 3, 3);

```

It yields the following string from my\_mem[5][5][10][3:5].

### **acc\_setmda\_bitstr()**

You use the `acc_setmda_bitstr` access routine to write a bit string, including x and z values, into a multi-dimensional array.

**Table 0-1.**

| acc_setmda_bitstr() |                                                                                                                                                                               |             |                                                         |
|---------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|---------------------------------------------------------|
| Synopsis:           | Sets a bit string in a multi-dimensional array.                                                                                                                               |             |                                                         |
| Syntax:             | <code>acc_setmda_bitstr(mdaHandle, bitStr, dim, start, len)</code>                                                                                                            |             |                                                         |
|                     | Type                                                                                                                                                                          | Description |                                                         |
| Returns:            | void                                                                                                                                                                          |             |                                                         |
| Arguments:          | Type                                                                                                                                                                          | Name        | Description                                             |
|                     | handle                                                                                                                                                                        | mdaHandle   | Handle to the multi-dimensional array                   |
|                     | char *                                                                                                                                                                        | bitStr      | Pointer to the bit string                               |
|                     | int *                                                                                                                                                                         | dim         | Pointer to the dimension in the multi-dimensional array |
|                     | int *                                                                                                                                                                         | start       | Pointer to the start element in the dimension           |
|                     | int *                                                                                                                                                                         | len         | Pointer to the length of the string                     |
| Related routines:   | <a href="#">tf_mdanodeinfo</a> and <a href="#">tf_imdanodeinfo</a><br><code>acc_get_mda_range</code><br><code>acc_get_mda_word_range</code><br><code>acc_getmda_bitstr</code> |             |                                                         |

If you have a multi-dimensional array such as the following:

```
reg [7:0] my_mem[255:0][255:0][31:0];
```

And you call a routine, such as the following:

```
dim[]={5, 5, 10};
bitstr="111";
handle hN = acc_handle_by_name(my_mem);
acc_setmda_bitstr(hN, &bitStr, dim, 3, 3);
```

It writes 111 in my\_mem[5] [5] [10] [3:5].

---

## Access Routines for Probabilistic Distribution

VCS includes the following API routines that duplicate the behavior of the Verilog system functions for probabilistic distribution:

`vcs_random`

Returns a random number and takes no argument. See “[“vcs\\_random” on page 33](#) for details.

`vcs_random_const_seed`

Returns a random number and takes an integer argument. See “[“vcs\\_random\\_const\\_seed” on page 34](#) for details.

`vcs_random_seed`

Returns a random number and takes a pointer to integer argument. See “[“vcs\\_random\\_seed” on page 34](#) for details.

`vcs_dist_uniform`

Returns random numbers uniformly distributed between parameters. See “[“vcs\\_dist\\_uniform” on page 35](#) for details.

`vcs_dist_normal`

Returns random numbers with a specified mean and standard deviation. See “[“vcs\\_dist\\_normal” on page 35](#) for details.

`vcs_dist_exponential`

Returns random numbers where the distribution function is exponential. See “[“vcs\\_dist\\_exponential” on page 36](#) for details.

`vcs_dist_poisson`

Returns random numbers with a specified mean. See “[“vcs\\_random” on page 33](#) for details.

These routines are declared in the `vcs_acc_user.h` file in the `$VCS_HOME/lib` directory.

---

## **vcs\_random**

You use this routine to obtain a random number.

**Table 0-1.**

| vcs_random()      |                                                                                                                                                                                               |               |
|-------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|
| Synopsis:         | Returns a random number.                                                                                                                                                                      |               |
| Syntax:           | <code>vcs_random()</code>                                                                                                                                                                     |               |
|                   | Type                                                                                                                                                                                          | Description   |
| Returns:          | <code>int</code>                                                                                                                                                                              | Random number |
|                   | Type                                                                                                                                                                                          | Name          |
| Arguments:        | <code>None</code>                                                                                                                                                                             |               |
| Related routines: | <code>vcs_random_const_seed</code> <code>vcs_random_seed</code> <code>vcs_dist_uniform</code><br><code>vcs_dist_normal</code> <code>vcs_dist_exponential</code> <code>vcs_dist_poisson</code> |               |

---

## **vcs\_random\_const\_seed**

You use this routine to return a random number and you supply an integer constant argument as the seed for the random number.

**Table 0-1.**

| vcs_random_const_seed |                                                                                                      |               |                      |
|-----------------------|------------------------------------------------------------------------------------------------------|---------------|----------------------|
| Synopsis:             | Returns a random number.                                                                             |               |                      |
| Syntax:               | vcs_random_const_seed(integer)                                                                       |               |                      |
|                       | Type                                                                                                 | Description   |                      |
| Returns:              | int                                                                                                  | Random number |                      |
|                       | Type                                                                                                 | Name          | Description          |
| Arguments:            | int                                                                                                  | integer       | An integer constant. |
| Related routines:     | vcs_random vcs_random_seed vcs_dist_uniform vcs_dist_normal<br>vcs_dist_exponential vcs_dist_poisson |               |                      |

---

## **vcs\_random\_seed**

You use this routine to return a random number and you supply a pointer argument.

**Table 0-1.**

| vcs_random_seed() |                                                                                                            |               |                         |
|-------------------|------------------------------------------------------------------------------------------------------------|---------------|-------------------------|
| Synopsis:         | Returns a random number.                                                                                   |               |                         |
| Syntax:           | vcs_random_seed(seed)                                                                                      |               |                         |
|                   | Type                                                                                                       | Description   |                         |
| Returns:          | int                                                                                                        | Random number |                         |
|                   | Type                                                                                                       | Name          | Description             |
| Arguments:        | int *                                                                                                      | seed          | Pointer to an int type. |
| Related routines: | vcs_random vcs_random_const_seed vcs_dist_uniform vcs_dist_normal<br>vcs_dist_exponential vcs_dist_poisson |               |                         |

---

## **vcs\_dist\_uniform**

You use this routine to return a random number uniformly distributed between parameters.

**Table 0-1.**

| vcs_dist_uniform  |                                                                                                           |               |                                            |
|-------------------|-----------------------------------------------------------------------------------------------------------|---------------|--------------------------------------------|
| Synopsis:         | Returns random numbers uniformly distributed between parameters.                                          |               |                                            |
| Syntax:           | vcs_dist_uniform(seed, start, end)                                                                        |               |                                            |
|                   | Type                                                                                                      | Description   |                                            |
| Returns:          | int                                                                                                       | Random number |                                            |
|                   | Type                                                                                                      | Name          | Description                                |
| Arguments:        | int *                                                                                                     | seed          | Pointer to a seed integer value.           |
|                   | int                                                                                                       | start         | Starting parameter for distribution range. |
|                   | int                                                                                                       | end           | Ending parameter for distribution range.   |
| Related routines: | vcs_random vcs_random_const_seed vcs_random_seed vcs_dist_normal<br>vcs_dist_exponential vcs_dist_poisson |               |                                            |

---

## **vcs\_dist\_normal**

You use this routine to return a random number with a specified mean and standard deviation.

**Table 0-1.**

| vcs_dist_normal |                                                                      |               |
|-----------------|----------------------------------------------------------------------|---------------|
| Synopsis:       | Returns random numbers with a specified mean and standard deviation. |               |
| Syntax:         | vcs_dist_normal(seed, mean, standard_deviation)                      |               |
|                 | Type                                                                 | Description   |
| Returns:        | int                                                                  | Random number |

**Table 0-1.**

|                   | Type                                                                                                       | Name               | Description                                                                          |
|-------------------|------------------------------------------------------------------------------------------------------------|--------------------|--------------------------------------------------------------------------------------|
| Arguments:        | int *                                                                                                      | seed               | Pointer to a seed integer value.                                                     |
|                   | int                                                                                                        | mean               | An integer that is the average value of the possible returned random numbers.        |
|                   | int                                                                                                        | standard_deviation | An integer that is the standard deviation from the mean for the normal distribution. |
| Related routines: | vcs_random vcs_random_const_seed vcs_random_seed vcs_dist_uniform<br>vcs_dist_exponential vcs_dist_poisson |                    |                                                                                      |

## **vcs\_dist\_exponential**

You use this routine to return a random number where the distribution function is exponential.

**Table 0-1.**

| vcs_dist_exponential |                                                                                                       |               |                                                                               |
|----------------------|-------------------------------------------------------------------------------------------------------|---------------|-------------------------------------------------------------------------------|
| Synopsis:            | Returns random numbers where the distribution function is exponential.                                |               |                                                                               |
| Syntax:              | vcs_dist_exponential(seed, mean)                                                                      |               |                                                                               |
| Returns:             | Type                                                                                                  | Description   |                                                                               |
| Arguments:           | int                                                                                                   | Random number |                                                                               |
|                      | Type                                                                                                  | Name          | Description                                                                   |
|                      | int *                                                                                                 | seed          | Pointer to a seed integer value.                                              |
| Related routines:    | int                                                                                                   | mean          | An integer that is the average value of the possible returned random numbers. |
|                      | vcs_random vcs_random_const_seed vcs_random_seed vcs_dist_uniform<br>vcs_dist_normal vcs_dist_poisson |               |                                                                               |
|                      |                                                                                                       |               |                                                                               |

---

## vcs\_dist\_poisson

You use this routine to return a random number with a specified mean.

**Table 0-1.**

| vcs_dist_poisson  |                                                                                                           |               |                                                                               |
|-------------------|-----------------------------------------------------------------------------------------------------------|---------------|-------------------------------------------------------------------------------|
| Synopsis:         | Returns random numbers with a specified mean.                                                             |               |                                                                               |
| Syntax:           | vcs_dist_poisson(seed, mean)                                                                              |               |                                                                               |
| >Returns:         | Type                                                                                                      | Description   |                                                                               |
|                   | int                                                                                                       | Random number |                                                                               |
| Arguments:        | Type                                                                                                      | Name          | Description                                                                   |
|                   | int *                                                                                                     | seed          | Pointer to a seed integer value.                                              |
|                   | int                                                                                                       | mean          | An integer that is the average value of the possible returned random numbers. |
| Related routines: | vcs_random vcs_random_const_seed vcs_random_seed vcs_dist_uniform<br>vcs_dist_normal vcs_dist_exponential |               |                                                                               |

---

## Access Routines for Returning a Pointer to a Parameter Value

The 1364 Verilog standard states that for access routine `acc_fetch_paramval`, you can cast the return value to a character pointer using the C language cast operators `(char*) (int)`. For example:

```
str_ptr=(char*)(int)acc_fetch_paramval(...);
```

In 64-bit simulation, you should use `long` instead of `int`:

```
str_ptr=(char*)(long)acc_fetch_paramval(...);
```

For your convenience, VCS provides the `acc_fetch_paramval_str` routine to directly return a string pointer.

---

### **acc\_fetch\_paramval\_str**

Returns the value of a string parameter directly as `char*`.

**Table 0-1.**

| acc_fetch_paramval_str |                                                                          |                           |                                            |
|------------------------|--------------------------------------------------------------------------|---------------------------|--------------------------------------------|
| Synopsis:              | Returns the value of a string parameter directly as <code>char*</code> . |                           |                                            |
| Syntax:                | <code>acc_fetch_paramval_str(param_handle)</code>                        |                           |                                            |
|                        | Type                                                                     | Description               |                                            |
| Returns:               | <code>char*</code>                                                       | string pointer            |                                            |
|                        | Type                                                                     | Name                      | Description                                |
| Arguments:             | <code>handle</code>                                                      | <code>param_handle</code> | Handle to a module parameter or specparam. |
| Related routines:      | <code>acc_fetch_paramval</code>                                          |                           |                                            |

---

## **Access Routines for Extended VCD Files**

VCS provides the following routines to monitor the port activity of a device:

`acc_lsi_dumpports_all`

Adds a checkpoint to the file. See “[“acc\\_lsi\\_dumpports\\_all” on page 40](#) for details.

`acc_lsi_dumpports_call`

Monitors instance ports. See “[acc\\_lsi\\_dumpports\\_call](#)” on page 41 for details.

`acc_lsi_dumpports_close`

Closes specified VCDE files. See “[acc\\_lsi\\_dumpports\\_close](#)” on page 43 for details.

`acc_lsi_dumpports_flush`

Flushes cached data to the VCDE file on disk. See “[acc\\_lsi\\_dumpports\\_flush](#)” on page 44 for details.

`acc_lsi_dumpports_limit`

Sets the maximum VCDE file size. See “[acc\\_lsi\\_dumpports\\_limit](#)” on page 45 for details.

`acc_lsi_dumpports_misc`

Processes miscellaneous events. See “[acc\\_lsi\\_dumpports\\_misc](#)” on page 46 for details.

`acc_lsi_dumpports_off`

Suspends VCDE file dumping. See “[acc\\_lsi\\_dumpports\\_off](#)” on page 47 for details.

`acc_lsi_dumpports_on`

Resumes VCDE file dumping. See “[acc\\_lsi\\_dumpports\\_on](#)” on page 48 for details.

`acc_lsi_dumpports_setformat`

Specifies the format of the VCDE file. See “[acc\\_lsi\\_dumpports\\_setformat](#)” on page 50 for details.

`acc_lsi_dumpports_vhdl_enable`

Enables or disables the inclusion of VHDL drivers in the determination of driver values. See “[“acc\\_lsi\\_dumpports\\_vhdl\\_enable” on page 51](#) for details.

---

## **acc\_lsi\_dumpports\_all**

### **Syntax**

```
int acc_lsi_dumpports_all(char *filename)
```

### **Synopsis**

Adds a checkpoint to the file.

This is a PLI interface to the `$dumpportsall` system task. If the `filename` argument is NULL, this routine adds a checkpoint to all open VCDE files.

### **Returns**

The number of VCDE files that matched.

#### *Example E-11 Example of acc\_lsi\_dumpports\_all*

```
#include "acc_user.h"
#include "vcs_acc_user.h"

handle instance = acc_handle_by_name("test_bench.device",
0);
char *outfile = "device.evcd";

/* use IEEE format for this file */
acc_lsi_dumpports_setformat(USE_DUMPPORTS_FORMAT_IEEE);
if (acc_lsi_dumpports_call(instance, outfile)) {
/* rut-roh, error ... */
}
acc_lsi_dumpports_limit(100000, outfile);
...
```

```

if (time == yada_yada)
 acc_lsi_dumpports_off(outfile);
 ...

if (time == yada_yada_yada) {
 /* add checkpoint (no need to enable dumping) */
 acc_lsi_dumpports_all(outfile);
 acc_lsi_dumpports_flush(outfile);
}
 ...

if (resume_dumping_now)
 acc_lsi_dumpports_on(outfile);
 ...

```

## **Caution**

This routine may affect files opened by the \$dumpports and \$lsi\_dumpports system tasks.

---

## **acc\_lsi\_dumpports\_call**

### **Syntax**

```
int acc_lsi_dumpports_call(handle instance, char *filename)
```

### **Synopsis**

Monitors instance ports.

This is a PLI interface to the \$lsi\_dumpports task. The default file format is the original LSI format, but you can select the IEEE format by calling the routine `acc_lsi_dumpports_setformat()` prior to calling this routine. Your tab file will need the following acc permissions:

```
acc=cbka, cbk, cbkv: [<instance_name> | *] .
```

## Returns

Zero on success, non-zero otherwise. VCS displays error messages through `tf_error()`. A common error is specifying a file name also being used by a `$dumpports` or `$lsi_dumpports` system task.

### *Example E-12 Example of acc\_lsi\_dumpports\_all*

```
#include "acc_user.h"
#include "vcs_acc_user.h"

handle instance = acc_handle_by_name("test_bench.device",
0);
char *outfile = "device.evcd";

acc_lsi_dumpports_setformat(USE_DUMPPORTS_FORMAT_IEEE);

if (acc_lsi_dumpports_call(instance, outfile)) {
 /* error */
}
```

## Caution

Multiple calls to this routine are allowed, but the output file name must be unique for each call.

For proper dumpports operation, your task's miscellaneous function must call `acc_lsi_dumpports_misc()` with every call it gets. This ensures that the dumpports routines sees all of the simulation events needed for proper update and closure of the dumpports (extended VCD) files. For example, your miscellaneous routine would do the following:

```
my_task_misc(int data, int reason)
{
 acc_lsi_dumpports_misc(data, reason);
 ...
}
```

---

## **acc\_lsi\_dumpports\_close**

### **Syntax**

```
int acc_lsi_dumpports_call(handle instance, char *filename)
```

### **Synopsis**

Closes specified VCDE files.

This routine reads the list of files opened by a call to the system tasks \$dumpports and \$lsi\_dumpports or the routine acc\_lsi\_dumpports\_call() and closes all that match either the specified instance handle or the filename argument.

One or both arguments can be used. If the instance handle is non-null, this routine closes all files opened for that instance.

### **Returns**

The number of files closed.

#### *Example E-13 Example of acc\_lsi\_dumpports\_close*

```
#include "acc_user.h"
#include "vcs_acc_user.h"

handle instance = acc_handle_by_name("test_bench.device",
0);
char *outfile1 = "device.evcd1";
char *outfile2 = "device.evcd2";

acc_lsi_dumpports_setformat(USE_DUMPPORTS_FORMAT_LSI);

acc_lsi_dumpports_call(instance, outfile1);
acc_lsi_dumpports_call(instance, outfile2);
...
acc_lsi_dumpports_close(NULL, outfile1);
...
acc_lsi_dumpports_close(NULL, outfile2);
```

## **Caution**

A call to this function can also close files opened by the \$lsi\_dumpports or \$dumpports system tasks.

---

## **acc\_lsi\_dumpports\_flush**

### **Syntax**

```
int acc_lsi_dumpports_flush(char *filename)
```

### **Synopsis**

Flushes cached data to the VCDE file on disk.

This is a PLI interface to the \$dumpportsflush system task. If the filename is NULL all open files are flushed.

### **Returns**

The number of files matched.

#### *Example E-14 Example of acc\_lsi\_dumpports\_flush*

```
#include "acc_user.h"
#include "vcs_acc_user.h"

handle instance = acc_handle_by_name("test_bench.device",
0);
char *outfile = "device.evcd";

/* use IEEE format for this file */
acc_lsi_dumpports_setformat(USE_DUMPPORTS_FORMAT_IEEE);
if (acc_lsi_dumpports_call(instance, outfile)) {
 /* rut-roh */
}
acc_lsi_dumpports_limit(100000, outfile);
...
```

```

if (time == yada_yada)
 acc_lsi_dumpports_off(outfile);
...
if (time == yada_yada_yada) {
 /* add checkpoint (no need to enable dumping) */
 acc_lsi_dumpports_all(outfile);
 acc_lsi_dumpports_flush(outfile);
}
...
if (resume_dumping_now)
 acc_lsi_dumpports_on(outfile);
...

```

---

## **acc\_lsi\_dumpports\_limit**

### **Syntax**

```
int acc_lsi_dumpports_limit(unsigned long filesize, char *filename)
```

### **Synopsis**

Sets the maximum VCDE file size.

This is a PLI interface to the \$dumpportslimit task. If the filename is NULL, the file size is applied to all files.

### **Returns**

The number of files matched.

#### *Example E-15 Example of acc\_lsi\_dumpports\_limit*

```
#include "acc_user.h"
#include "vcs_acc_user.h"

handle instance = acc_handle_by_name("test_bench.device",
0);
char *outfile = "device.evcd";
```

```

/* use IEEE format for this file */
acc_lsi_dumpports_setformat(USE_DUMPPORTS_FORMAT_IEEE);
if (acc_lsi_dumpports_call(instance, outfile)) {
 /* rut-roh */
}
acc_lsi_dumpports_limit(100000, outfile);
...

if (time == yada_yada)
 acc_lsi_dumpports_off(outfile);
...

if (time == yada_yada_yada) {
 /* add checkpoint (no need to enable dumping) */
 acc_lsi_dumpports_all(outfile);
 acc_lsi_dumpports_flush(outfile);
}
...

if (resume_dumping_now)
 acc_lsi_dumpports_on(outfile);
...

```

## **Caution**

This routine may affect files opened by the \$dumpports and \$lsi\_dumpports system tasks.

## **acc\_lsi\_dumpports\_misc**

### **Syntax**

```
void acc_lsi_dumpports_misc(int data, int reason)
```

### **Synopsis**

Processes miscellaneous events.

This is a companion routine for `acc_lsi_dumpports_call()`.

For proper dumpports operation, your task's miscellaneous function must call this routine for each call it gets.

### Returns

No return value.

#### *Example E-16 Example of acc\_lsi\_dumpports\_misc*

```
#include "acc_user.h"
#include "vcs_acc_user.h"

void my_task_misc(int data, int reason)
{
 acc_lsi_dumpports_misc(data, reason);
 ...
}
```

---

## **acc\_lsi\_dumpports\_off**

### Syntax

```
int acc_lsi_dumpports_off(char *filename)
```

### Synopsis

Suspends VCDE file dumping.

This is a PLI interface to the \$dumpportsoff system task. If the file name is NULL, dumping is suspended on all open files.

### Returns

The number of files that matched.

#### *Example E-17 of acc\_lsi\_dumpports\_off Example*

```
#include "acc_user.h"
#include "vcs_acc_user.h"
```

```

handle instance = acc_handle_by_name("test_bench.device",
0);
char *outfile = "device.evcd";

/* use IEEE format for this file */
acc_lsi_dumpports_setformat(USE_DUMPPORTS_FORMAT_IEEE);
if (acc_lsi_dumpports_call(instance, outfile)) {
 /* rut-roh */
}
acc_lsi_dumpports_limit(100000, outfile);
...

if (time == yada_yada)
 acc_lsi_dumpports_off(outfile);
...

if (time == yada_yada_yada) {
 /* add checkpoint (no need to enable dumping) */
 acc_lsi_dumpports_all(outfile);
 acc_lsi_dumpports_flush(outfile);
}
...

if (resume_dumping_now)
 acc_lsi_dumpports_on(outfile);
...

```

## **Caution**

This routine may suspend dumping on files opened by the \$dumpports and \$lsi\_dumpports system tasks.

## **acc\_lsi\_dumpports\_on**

### **Syntax**

```
int acc_lsi_dumpports_on(char *filename)
```

## Synopsis

Resumes VCDE file dumping.

This is a PLI interface to the \$dumpportson system task. If the filename is NULL, dumping is resumed on all open files.

## Returns

The number of files that matched.

### *Example E-18 Example of acc\_lsi\_dumpports\_on*

```
#include "acc_user.h"
#include "vcs_acc_user.h"

handle instance = acc_handle_by_name("test_bench.device",
0);
char *outfile = "device.evcd";

/* use IEEE format for this file */
acc_lsi_dumpports_setformat(USE_DUMPPORTS_FORMAT_IEEE);
if (acc_lsi_dumpports_call(instance, outfile)) {
 /* rut-roh */
}
acc_lsi_dumpports_limit(100000, outfile);
...

if (time == yada_yada)
 acc_lsi_dumpports_off(outfile);
...

if (time == yada_yada_yada) {
 /* add checkpoint (no need to enable dumping) */
 acc_lsi_dumpports_all(outfile);
 acc_lsi_dumpports_flush(outfile);
}
...

if (resume_dumping_now)
 acc_lsi_dumpports_on(outfile);
```

...

## **Caution**

This routine may resume dumping on files opened by the \$dumpports and \$lsi\_dumpports system tasks.

---

## **acc\_lsi\_dumpports\_setformat**

### **Syntax**

```
int acc_lsi_dumpports_setformat(lsi_dumpports_format_type
format)
```

Where the valid `lsi_dumpports_format_types` are as follows:

`USE_DUMPPORTS_FORMAT_IEEE`

`USE_DUMPPORTS_FORMAT_LSI`

### **Synopsis**

Specifies the format of the VCDE file.

Use this routine to specify which output format (IEEE or the original LSI) should be used. This routine must be called before `acc_lsi_dumpports_call()`.

### **Returns**

Zero if success, non-zero if error. Errors are reported through `tf_error()`.

#### *Example E-19 Example of acc\_lsi\_dumpports\_setformat*

```
#include "acc_user.h"
#include "vcs_acc_user.h"
```

```

handle instance = acc_handle_by_name("test_bench.device",
0);
char *outfile1 = "device.evcd1";
char *outfile2 = "device.evcd2";

/* use IEEE format for this file */
acc_lsi_dumpports_setformat(USE_DUMPPORTS_FORMAT_IEEE);
if (acc_lsi_dumpports_call(instance, outfile1)) {
 /* error */
}

/* use LSI format for this file */
acc_lsi_dumpports_setformat(USE_DUMPPORTS_FORMAT_LSI);
if (acc_lsi_dumpports_call(instance, outfile2)) {
 /* error */
}
...

```

## **Caution**

The runtime plusargs `+dumpports+ieee` and `+dumpports+lsi` have priority over this routine.

The format of files created by calls to the `$dumpports` and `$lsi_dumpports` tasks are not affected by this routine.

## **acc\_lsi\_dumpports\_vhdl\_enable**

### **Syntax**

```
void acc_lsi_dumpports_vhdl_enable(int enable)
```

The valid enable integer parameters are as follows:

1 enables VHDL drivers

0 disables VHDL drivers

## Synopsis

Use this routine to enable or disable the inclusion of VHDL drivers in the determination of driver values.

## Returns

No return value.

### *Example E-20 Example of acc\_lsi\_dumpports\_vhdl\_enable*

```
#include "acc_user.h"
#include "vcs_acc_user.h"

handle instance = acc_handle_by_name("test_bench.device",
0);
char *outfile1 = "device.evcd1";
char *outfile2 = "device.evcd2";

/* Include VHDL drivers in this report */
acc_lsi_dumpports_vhdl_enable(1);
acc_lsi_dumpports_call(instance, outfile1);

/* Exclude VHDL drivers from this report */
acc_lsi_dumpports_vhdl_enable(0);
acc_lsi_dumpports_call(instance, outfile1);

...
```

## Caution

This routine has precedence over the +dumpports+vhdl+enable and +dumpports+vhdl+disable runtime options.

---

## Access Routines for Line Callbacks

VCS includes a number of access routines to monitor code execution. These access routines are as follows:

`acc_mod_lcb_add`

Registers a line callback routine with a module so that VCS calls the routine whenever VCS executes the specified module. See “[“acc\\_mod\\_lcb\\_add” on page 53](#) for details.

`acc_mod_lcb_del`

Unregisters a line callback routine previously registered with the `acc_mod_lcb_add()` routine. See “[“acc\\_mod\\_lcb\\_del” on page 55](#) for details.

`acc_mod_lcb_enabled`

Tests to see if line callbacks is enabled. See “[“acc\\_mod\\_lcb\\_enabled” on page 57](#) for details.

`acc_mod_lcb_fetch`

Returns an array of breakable lines. See “[“acc\\_mod\\_lcb\\_fetch” on page 57](#) for details.

`acc_mod_lcb_fetch2`

Returns an array of breakable lines. See “[“acc\\_mod\\_lcb\\_fetch2” on page 59](#) for details.

`acc_mod_sfi_fetch`

Returns the source file composition for a module. See “[“acc\\_mod\\_sfi\\_fetch” on page 61](#) for details.

---

## **acc\_mod\_lcb\_add**

### **Syntax**

```
void acc_mod_lcb_add(handle handleModule,
 void (*consumer)(), char *user_data)
```

## Synopsis

Registers a line callback routine with a module so that VCS calls the routine whenever VCS executes the specified module.

The prototype for the callback routine is:

```
void consumer(char *filename, int lineno, char *user_data,
 int tag)
```

The tag field is a unique identifier that you use to distinguish between multiple 'include' files.

Protected modules cannot be registered for callback. This routine will just ignore the request.

## Returns

No return value.

### *Example E-21 Example of acc\_mod\_lcb\_add*

```
#include <stdio.h>
#include "acc_user.h"
#include "vcs_acc_user.h"

/* VCS callback rtn */
void line_call_back(filename, lineno, userdata, tag)
char *filename;
int lineno;
char *userdata;
int tag;
{
 handle handle_mod = (handle)userdata;

 io_printf("Tag %2d, file %s, line %2d, module %s\n",
 tag, filename, lineno,
 acc_fetch_fullname(handle_mod));
}
```

```

/* register all modules for line callback (recursive) */
void register_lcb (parent_mod)
handle parent_mod;
{
 handle child = NULL;

 if (! acc_object_of_type(parent_mod, accModule)) return;

 io_printf("Registering %s\n",
 acc_fetch_fullname (parent_mod));

 acc_mod_lcb_add (parent_mod, line_call_back, parent_mod);

 while ((child = acc_next_child (parent_mod, child))) {
 register_lcb (child);
 }
}

```

---

## **acc\_mod\_lcb\_del**

### **Syntax**

```
void acc_mod_lcb_del(handle handleModule,
 void (*consumer)(), char *user_data)
```

### **Synopsis**

Unregisters a line callback routine previously registered with the acc\_mod\_lcb\_add() routine.

### **Returns**

No return value.

#### *Example E-22 Example of acc\_mod\_lcb\_del*

```
#include <stdio.h>
#include "acc_user.h"
#include "vcs_acc_user.h"
```

```

/* VCS 4.x callback rtn */
void line_call_back(filename, lineno, userdata, tag)
char *filename;
int lineno;
char *userdata;
int tag;
{
 handle handle_mod = (handle)userdata;

 io_printf("Tag %2d, file %s, line %2d, module %s\n",
 tag, filename, lineno,
 acc_fetch_fullname(handle_mod));
}

/* unregister all line callbacks (recursive) */
void unregister_lcb (parent_mod)
handle parent_mod;
{
 handle child = NULL;

 if (! acc_object_of_type(parent_mod, accModule)) return;

 io_printf("Unregistering %s\n",
 acc_fetch_fullname (parent_mod));

 acc_mod_lcb_del (parent_mod, line_call_back, parent_mod);

 while ((child = acc_next_child (parent_mod, child))) {
 register_lcb (child);
 }
}

```

## **Caution**

The module handle, consumer routine, and user data arguments must match those supplied to the `acc_mod_lcb_add()` routine for a successful delete.

For example, using the result of a call such as `acc_fetch_name()` as the user data will fail, because that routine returns a different pointer each time it is called.

---

## **acc\_mod\_lcb\_enabled**

### **Syntax**

```
int acc_mod_lcb_enabled()
```

### **Synopsis**

Test to see if line callbacks is enabled.

By default, the extra code required to support line callbacks is not added to a simulation executable. You can use this routine to determine if line callbacks have been enabled.

### **Returns**

Non-zero if line callbacks are enabled; 0 if not enabled.

#### *Example E-23 Example of acc\_mod\_lcb\_enabled*

```
if (! acc_mod_lcb_enable) {
 tf_warning("Line callbacks not enabled. Please recompile
with -line.");
}
else {
 acc_mod_lcb_add (...);
 ...
}
```

---

## **acc\_mod\_lcb\_fetch**

### **Syntax**

```
p_location acc_mod_lcb_fetch(handle handleModule)
```

## Synopsis

Returns an array of breakable lines.

This routine returns all the lines in a module that you can set breakpoints on.

## Returns

The return value is an array of line number, file name pairs. Termination of the array is indicated by a NULL file name field. The calling routine is responsible for freeing the returned array.

```
typedef struct t_location {
 int line_no;
 char *filename;
} s_location, *p_location;
```

Returns NULL if the module has no breakable lines or is source protected.

### *Example E-24 Example of acc\_mod\_lcb\_fetch*

```
#include <stdio.h>
#include "acc_user.h"
#include "vcs_acc_user.h"

void ShowLines(handleModule)
handle handleModule;
{
 p_location plocation;

 if ((plocation = acc_mod_lcb_fetch(handleModule)) != NULL)
 {
 int i;

 io_printf("%s:\n", acc_fetch_fullname(handleModule));

 for (i = 0; plocation[i].filename; i++) {
```

```

 io_printf("%s:%d]\n",
 plocation[i].filename,
 plocation[i].line_no);
 }
 acc_free(plocation);
}
}

```

---

## **acc\_mod\_lcb\_fetch2**

### **Syntax**

`p_location2 acc_mod_lcb_fetch2(handle handleModule)`

### **Synopsis**

Returns an array of breakable lines.

This routine returns all the lines in a module that you can set breakpoints on.

The tag field is a unique identifier used to distinguish `include files. For example, in the following Verilog module, the breakable lines in the first `include of the file sequential.code have a different tag than the breakable lines in the second `include. (The tag numbers will match the vcs\_srcfile\_info\_t->SourceFileTag field. See the `acc_mod_sfi_fetch()` routine for details.)

```

module x;
initial begin
 `include sequential.code
 `include sequential.code
end
endmodule

```

## Returns

The return value is an array of location structures. Termination of the array is indicated by a NULL filename field. The calling routine is responsible for freeing the returned array.

```
typedef struct t_location2 {
 int line_no;
 char *filename;
 int tag;
} s_location2, *p_location2;
```

Returns NULL if the module has no breakable lines or is source protected.

### *Example E-25 Example of acc\_mod\_lcb\_fetch2*

```
#include <stdio.h>
#include "acc_user.h"
#include "vcs_acc_user.h"

void ShowLines2(handleModule)
handle handleModule;
{
 p_location2 plocation;

 if ((plocation = acc_mod_lcb_fetch2(handleModule)) != NULL) {
 int i;

 io_printf("%s:\n", acc_fetch_fullname(handleModule));

 for (i = 0; plocation[i].filename; i++) {
 io_printf(" file %s, line %d, tag %d\n",
 plocation[i].filename,
 plocation[i].line_no,
 plocation[i].tag);
 }
 acc_free(plocation);
 }
}
```

---

## **acc\_mod\_sfi\_fetch**

### **Syntax**

```
vcs_srcfile_info_p acc_mod_sfi_fetch(handle handleModule)
```

### **Synopsis**

Returns the source file composition for a module. This composition is a file name with line numbers, or, if a module definition is in more than one file, it is an array of vcs\_srcfile\_info\_s struct entries specifying all the file names and line numbers for the module definition.

### **Returns**

The returned array is terminated by a NULL SourceFileName field. The calling routine is responsible for freeing the returned array.

```
typedef struct vcs_srcfile_info_t {
 char *SourceFileName;
 int SourceFileTag;
 int StartLineNum;
 int EndLineNum;
} vcs_srcfile_info_s, *vcs_srcfile_info_p;
```

Returns NULL if the module is source protected.

#### *Example E-26 Example of acc\_mod\_sfi\_fetch*

```
#include <stdio.h>
#include "acc_user.h"
#include "vcs_acc_user.h"

void print_info (mod)
handle mod;
{
 vcs_srcfile_info_p infoa;
```

```

 io_printf("Source Info for Module %s:\n",
 acc_fetch_fullname(mod)) ;

 if ((infoa = acc_mod_sfi_fetch(mod)) != NULL) {
 int i;
 for (i = 0; infoa[i].SourceFileName != NULL; i++) {
 io_printf(" Tag %2d, StartLine %2d, ",
 infoa[i].SourceFileTag,
 infoa[i].StartLineNum);
 io_printf("EndLine %2d, SrcFile %s\n",
 infoa[i].EndLineNum,
 infoa[i].SourceFileName);
 }
 acc_free(infoa);
 }
}

```

## Access Routines for Source Protection

The `enclib.o` file provides a set of access routines that you can use to create applications which directly produce encrypted Verilog source code. Encrypted code can only be decoded by the VCS compiler. There is no user-accessible decode routine.

Note that both Verilog and SDF code can be protected. VCS knows how to automatically decrypt both.

VCS provides the following routines to monitor the port activity of a device:

`vcsspClose`

This routine frees the memory allocated by `vcsspInitialize()`. See “[vcsSpClose](#)” on page 66 for details.

`vcsspEncodeOff`

This routine inserts a trailer section containing the 'endprotected' compiler directive into the output file. It also toggles the encryption flag to false so that subsequent calls to `vcsspWriteString()` and `vcsspWriteChar()` will NOT cause their data to be encrypted. See "["vcsSpEncodeOff" on page 67](#)" for details.

#### `vcsspEncodeOn`

This routine inserts a trailer section containing the 'protected' compiler directive into the output file. It also toggles the encryption flag to false so that subsequent calls to `vcsspWriteString()` and `vcsspWriteChar()` will have their data encrypted. See "["vcsSpEncodeOn" on page 68](#)" for details.

#### `vcsspEncoding`

This routine gets the current state of encoding. See "["vcsSpEncoding" on page 70](#)" for details.

#### `vcsspGetFilePtr`

This routine just returns the value previously passed to the `vcsspSetFilePtr()` routine. See "["vcsSpGetFilePtr" on page 71](#)" for details.

#### `vcsspInitialize`

Allocates a source protect object. See "["vcsSpInitialize" on page 72](#)" for details.

#### `vcsspOvaDecodeLine`

Decrypts one line. See "["vcsSpOvaDecodeLine" on page 73](#)" for details.

#### `vcsspOvaDisable`

Switches to regular encryption. See “[vcsSpOvaDisable](#)” on page [74](#) for details.

#### `vcsSpOvaEnable`

Enables the OpenVera assertions (OVA) encryption algorithm. Tells VCS’s encrypter to use the OVA IP algorithm. See “[vcsSpOvaEnable](#)” on page [75](#) for details.

#### `vcsSpSetDisplayMsgFlag`

Sets the DisplayMsg flag. See “[vcsSpSetDisplayMsgFlag](#)” on page [77](#) for details.

#### `vcsSpSetFilePtr`

Specifies the output file stream. See “[vcsSpSetFilePtr](#)” on page [77](#) for details.

#### `vcsSpSetLibLicenseCode`

Sets the OEM license code. See “[vcsSpSetLibLicenseCode](#)” on page [78](#) for details.

#### `vcsSpSetPliProtectionFlag`

Sets the PLI protection flag. See “[vcsSpSetPliProtectionFlag](#)” on page [79](#) for details.

#### `vcsSpWriteChar`

Writes one character to the protected file. See “[vcsSpWriteChar](#)” on page [80](#) for details.

#### `vcsSpWriteString`

Writes a character string to the protected file. See “[vcsSpWriteString](#)” on page [81](#) for details.

**Example E-27** outlines the basic use of the source protection routines.

*Example E-27 Using the Source Protection Routines*

```
#include <stdio.h>
#include "enclib.h"
void demo_routine()
{
 char *filename = "protected.vp";
 int write_error = 0;
 vcssSpStateID esp;
 FILE *fp;

 /* Initialization */

 if ((fp = fopen(filename, "w")) == NULL) {
 printf("Error: opening file %s\n", filename);
 exit(1);
 }

 if ((esp = vcssSpInitialize()) == NULL) {
 printf("Error: Initializing src protection
routines.\n");
 printf(" Out Of Memory.\n");
 fclose(fp);
 exit(1);
 }

 vcssSpSetFilePtr(esp, fp); /* tell rtns where to write */

 /* Write output */

 write_error += vcssSpWriteString(esp,
 "This text will *not* be encrypted.\n");

 write_error += vcssSpEncodeOn(esp);
 write_error += vcssSpWriteString(esp,
 "This text *will* be encrypted.");
 write_error += vcssSpWriteChar(esp, '\n');

 write_error += vcssSpEncodeOff(esp);
```

```

 write_error += vcsspWriteString(esp,
 "This text will *not* be encrypted.\n");

 /* Clean up */

 write_error += fclose(fp);
 vcsspClose(esp);

 if (write_error) {
 printf("Error while writing to '%s'\n", filename);
 }
}

```

## **Caution**

If you are encrypting SDF or Verilog code that contains include directives, you must switch off encryption (`vcsspEncodeOff`), output the include directive and then switch encryption back on. This ensures that when the parser begins reading the included file, it is in a known (non-decode) state.

If the file being included has proprietary data it can be encrypted separately. (Don't forget to change the '`include`' compiler directive to point to the new encrypted name.)

## **vcsspClose**

### **Syntax**

```
void vcsspClose(vcsspStateID esp)
```

### **Synopsis**

This routine frees the memory allocated by `vcsspInitialize()`. Call it when source encryption is finished on the specified stream.

## Returns

No return value.

### *Example E-28 Example of vcsSpClose*

```
vcsspStateID esp = vcsspInitialize();
...
vcsspClose(esp);
```

---

## **vcsspEncodeOff**

### Syntax

```
int vcsspEncodeOff(vcsspStateID esp)
```

### Synopsis

This function performs two operations:

1. It inserts a trailer section that contains some closing information used by the decryption algorithm into the output file. It also inserts the `endprotected` compiler directive in the trailer section.
2. It toggles the encryption flag to false so that subsequent calls to `vcsspWriteString()` and `vcsspWriteChar()` will NOT cause their data to be encrypted.

### Returns

Non-zero if there was an error writing to the output file, 0 if successful.

### *Example E-29 Example of vcsspEncodeOff*

```
vcsspStateID esp = vcsspInitialize();
FILE *fp = fopen("protected.file", "w");
int write_error = 0; *
if (fp == NULL) exit(1);
```

```

vcsspSetFilePtr(esp, fp);

if (vcsspWriteString(esp, "This text will *not* be encrypted.

++write_error;

if (vcsspEncodeOn(esp)) ++write_error;
if (vcsspWriteString(esp, "This text *will* be encrypted.

++write_error;

if (vcsspEncodeOff(esp)) ++write_error;
if (vcsspWriteString(esp, "This text will *not* be encrypted.

++write_error;

fclose(fp);
vcsspClose(esp);

```

## **Caution**

You must call vcsspInitialize() and vcsspSetFilePtr() before calling this routine.

---

## **vcsspEncodeOn**

### **Syntax**

```
int vcsspEncodeOn(vcsspStateID esp)
```

### **Synopsis**

This function performs two operations:

1. It inserts a header section which contains the 'protected' compiler directive into the output file. It also inserts some initial header information used by the decryption algorithm.

2. It toggles the encryption flag to true so that subsequent calls to `vcsSpWriteString()` and `vcsSpWriteChar()` will have their data encrypted.

## Returns

Non-zero if there was an error writing to the output file, 0 if successful.

### *Example E-30 Example of vcsSpEncodeOn*

```
vcsSpStateID esp = vcsSpInitialize();
FILE *fp = fopen("protected.file", "w");
int write_error = 0;

if (fp == NULL) exit(1);

vcsSpSetFilePtr(esp, fp);

if (vcsSpWriteString(esp, "This text will *not* be
encrypted.\n"))
 ++write_error;

if (vcsSpEncodeOn(esp)) ++write_error;
if (vcsSpWriteString(esp, "This text *will* be
encrypted.\n"))
 ++write_error;

if (vcsSpEncodeOff(esp)) ++write_error;
if (vcsSpWriteString(esp, "This text will *not* be
encrypted.\n"))
 ++write_error;
fclose(fp);
vcsSpClose(esp);
```

## Caution

You must call `vcsSpInitialize()` and `vcsSpSetFilePtr()` before calling this routine.

---

## vcsSpEncoding

### Syntax

```
int vcsSpEncoding(vcsSpStateID esp)
```

### Synopsis

Calling `vcsSpEncodeOn()` and `vcsSpEncodeOff()` turns encoding on and off. Use this function to get the current state of encoding.

### Returns

1 for on, 0 for off.

#### *Example E-31 Example of vcsSpEncoding*

```
vcsSpStateID esp = vcsSpInitialize();
FILE *fp = fopen("protected.file", "w");

if (fp == NULL) { printf("ERROR: file ..."); exit(1); }

vcsSpSetFilePtr(esp, fp);
...

if (! vcsSpEncoding(esp))
 vcsSpEncodeOn(esp)
...

if (vcsSpEncoding(esp))
 vcsSpEncodeOff(esp);

fclose(fp);
vcsSpClose(esp);
```

---

## vcsspGetFilePtr

### Syntax

```
FILE *vcsspGetFilePtr(vcsspStateID esp)
```

### Synopsis

This routine just returns the value previously passed to the vcsspSetFilePtr() routine.

### Returns

File pointer or NULL if not set.

#### *Example E-32 Example of vcsspGetFilePtr*

```
vcsspStateID esp = vcsspInitialize();
FILE *fp = fopen("protected.file", "w");
if (fp != NULL)
 vcsspSetFilePtr(esp, fp);
else
 /* doh! */

...
if ((gfp = vcsspGetFilePtr(esp)) != NULL) {
 /* Add comment before starting encryption */
 fprintf(gfp, "\n// TechStuff Version 2.2\n");
 vcsspEncodeOn(esp);
}
```

### Caution

Don't use non-vcssp\* routines (like fprintf) in conjunction with vcssp\* routines, while encoding is enabled.

---

## vcsSpInitialize

### Syntax

```
vcsspStateID vcsSpInitialize(void)
```

### Synopsis

This routine allocates a source protect object.

Returns a handle to a malloc'd object which must be passed to all the other source protection routines.

This object stores the state of the encryption in progress. When the encryption is complete, this object should be passed to `vcsspClose()` to free the allocated memory.

If you need to write to multiple streams at the same time (perhaps you're creating include or SDF files in parallel with model files), you can make multiple calls to this routine and assign a different file pointer to each handle returned.

Each call mallocs less than 100 bytes of memory.

### Returns

The `vcsspStateID` pointer or NULL if memory could not be malloc'd.

#### *Example E-33 Example of vcsspStateID*

```
vcsspStateID esp = vcsSpInitialize();
if (esp == NULL) {
 fprintf(stderr, "out of memory\n");
 ...
}
```

## **Caution**

This routine must be called before any other source protection routine.

A NULL return value means the call to `malloc()` failed. Your program should test for this.

---

## **vcsSpOvaDecodeLine**

### **Syntax**

```
vcsspstateid vcsspovaline(vcsspstateid esp, char *line)
```

### **Synopsis**

This routine decrypts one line.

Use this routine to decrypt one line of protected IP code such as OVA code. Pass in a null `vcsspstateid` handle with the first line of code and a non-null handle with subsequent lines.

### **Returns**

Returns NULL when the last line has been decrypted.

#### *Example E-34 Example of vcsSpOvaDecodeLine*

```
#include "enclib.h"

if (strcmp(linebuf, "'protected_ip synopsys\n") == 0) {
 /* start IP decryption */
 vcsspstateid esp = NULL;
 while (fgets(linebuf, sizeof(linebuf), infile)) {
 /* linebuf contains encrypted source */
 esp = vcsspovaline(esp, linebuf);
 if (linebuf[0]) {
 /* linebuf contains decrypted source */
```

```

 ...
 }
 if (!esp) break; /* done */
}
/* next line should be 'endprotected_ip' */
fgets(linebuf, sizeof(linebuf), infile);
if (strcmp(linebuf, "'endprotected_ip\n") != 0) {
 printf("warning - expected 'endprotected_ip\n");
}
}

```

---

## vcsSpOvaDisable

### Syntax

```
void vcsSpOvaDisable(vcsSpStateID esp)
```

### Synopsis

This routine switches to regular encryption. It tells VCS's encrypter to use the standard algorithm. This is the default mode.

### Returns

No return value.

#### *Example E-35 Example of vcsSpOvaDisable*

```
#include "enclib.h"
#include "encint.h"

int write_error = 0;
vcsSpStateID esp;

if ((esp = vcsSpInitialize()) == NULL) printf("Out Of Memory");

vcsSpSetFilePtr(esp, fp); /* previously opened FILE* pointer */

/* Configure for OVA IP encryption */
vcsSpOvaEnable(esp, "synopsys");
```

```

if (vcsspWriteString(esp, "This text will NOT be
encrypted.\n"))
 ++write_error;

if (vcsspEncodeOn(esp)) ++write_error;

if (vcsspWriteString(esp, "This text WILL be encrypted.\n"))
 ++write_error;

if (vcsspEncodeOff(esp)) ++write_error;

if (vcsspWriteString(esp, "This text will NOT be
encrypted.\n"))
 ++write_error;
/* Switch back to regular encryption */
vcsspOvaDisable(esp);

if (vcsspEncodeOn(esp)) ++write_error;

if (vcsspWriteString(esp, "This text WILL be encrypted.\n"))
 ++write_error;

if (vcsspEncodeOff(esp)) ++write_error;

vcsspClose(esp);

```

---

## **vcsspOvaEnable**

### **Syntax**

```
void vcsspOvaEnable(vcsspStateID esp, char *vendor_id)
```

### **Synopsis**

Enables the OpenVera assertions (OVA) encryption algorithm. Tells VCS's encrypter to use the OVA IP algorithm.

### **Returns**

No return value.

*Example E-36 Example of vcsSpOvaEnable*

```
#include "enclib.h"
#include "encint.h"

int write_error = 0;
vcsSpStateID esp;

if ((esp = vcsSpInitialize()) printf("Out Of Memory");

vcsSpSetFilePtr(esp, fp); /* previously opened FILE* pointer */
 */

/* Configure for OVA IP encryption */
vcsSpOvaEnable(esp, "synopsys");

if (vcsSpWriteString(esp, "This text will NOT be
encrypted.\n"))
 ++write_error;

if (vcsSpEncodeOn(esp)) ++write_error;

if (vcsSpWriteString(esp, "This text WILL be encrypted.\n"))
 ++write_error;

if (vcsSpEncodeOff(esp)) ++write_error;

if (vcsSpWriteString(esp, "This text will NOT be
encrypted.\n"))
 ++write_error;
/* Switch back to regular encryption */
vcsSpOvaDisable(esp);

if (vcsSpEncodeOn(esp)) ++write_error;

if (vcsSpWriteString(esp, "This text WILL be encrypted.\n"))
 ++write_error;

if (vcsSpEncodeOff(esp)) ++write_error;

vcsSpClose(esp);
```

---

## **vcsSpSetDisplayMsgFlag**

### **Syntax**

```
void vcsSpSetDisplayMsgFlag(vcsSpStateID esp, int enable)
```

### **Synopsis**

This routine sets the DisplayMsg flag. By default, the VCS compiler does not display decrypted source code in its error or warning messages. Use this routine to enable this display.

### **Returns**

No return value.

#### *Example E-37 Example of vcsSpSetDisplayMsgFlag*

```
vcsSpStateID esp = vcsSpInitialize();
vcsSpSetDisplayMsgFlag(esp, 0);
```

---

## **vcsSpSetFilePtr**

### **Syntax**

```
void vcsSpSetFilePtr(vcsSpStateID esp, FILE *fp)
```

### **Synopsis**

This routine specifies the output file stream. Before using the `vcsSpWriteChar()` or `vcsSpWriteString()` routines, you must specify the output file stream.

### **Returns**

No return value.

#### *Example E-38 Example of vcsSpSetFilePtr*

```
vcsSpStateID esp = vcsSpInitialize();
```

```

FILE *fp = fopen("protected.file", "w");
if (fp != NULL)
 vcsspSetFilePtr(esp, fp);
else
 /* abort */

```

---

## **vcsspSetLibLicenseCode**

### **Syntax**

```
void vcsspSetLibLicenseCode(vcsspStateID esp, unsigned int code)
```

### **Synopsis**

This routine sets the OEM library license code that will be added to each protected region started by `vcsspEncodeOn()`.

This code can be used to protect library models from unauthorized use.

When the VCS parser decrypts the protected region, it verifies that the end user has the specified license. If the license does not exist or has expired, VCS exits.

### **Returns**

No return value.

#### *Example E-39 Example of vcsspSetLibLicenseCode*

```

unsigned int lic_code = MY_LICENSE_CODE;
vcsspStateID esp = vcsspInitialize();
...
/* The following text will be encrypted and licensed */
vcsspSetLibLicenseCode(esp, code); /* set license code */
vcsspEncodeOn(esp); /* start protected region */
vcsspWriteString(esp, "this text will be encrypted and"

```

```

licensed");
vcsSpEncodeOff(esp); /* end protected region */

/* The following text will be encrypted but unlicensed */
vcsSpSetLibLicenseCode(esp, 0); /* clear license code */
vcsSpEncodeOn(esp); /* start protected region */
vcsSpWriteString(esp, "this text encrypted but not
licensed");
vcsSpEncodeOff(esp); /* end protected region */

```

## **Caution**

The rules for mixing licensed and unlicensed code is determined by your OEM licensing agreement with Synopsys.

The code segment in [Example E-39](#) shows how to enable and disable the addition of the license code to the protected regions. Normally you would call this routine once, that is, after calling `vcsSpInitialize()` and before the first call to `vcsSpEncodeOn()`.

## **vcsSpSetPliProtectionFlag**

### **Syntax**

```
void vcsSpSetPliProtectionFlag(vcsSpStateID esp, int
enable)
```

### **Synopsis**

This routine sets the PLI protection flag. You can use it to disable the normal PLI protection that is placed on encrypted modules. The output files will still be encrypted, but CLI and PLI users will not be prevented from accessing data in the modules.

This routine only affects encrypted Verilog files. Encrypted SDF files, for example, are not affected.

## Returns

No return value.

### *Example E-40 Example of vcsSpSetPliProtectionFlag*

```
vcsSpStateID esp = vcsSpInitialize();
vcsSpSetPliProtectionFlag(esp, 0); /* disable PLI protection
*/
```

## Caution

Turning off PLI protection will allow users of your modules to access object names, values, etc. In essence, the source code for your module could be substantially reconstructed using the CLI commands and ACC routines.

---

## vcsSpWriteChar

### Syntax

```
void vcsSpSetPliProtectionFlag(vcsSpStateID esp, int
enable)
```

### Synopsis

This routine writes one character to the protected file.

If encoding is enabled (see “[vcsSpEncodeOn](#)” on page 68) the specified character is encrypted as it is written to the output file.

If encoding is disabled (see “[vcsSpEncodeOff](#)” on page 67) the specified character is written as-is to the output file (no encryption.)

## Returns

Non-zero if the file pointer has not been set (see “[vcsSpSetFilePtr](#)” on page 77) or if there was an error writing to the output file (out-of-disk-space, etc.)

Returns 0 if the write was successful.

*Example E-41 Example of vcsSpWriteChar*

```
vcsspStateID esp = vcsspInitialize();
FILE *fp = fopen("protected.file", "w");
int write_error = 0;

if (fp == NULL) exit(1);

vcsspSetFilePtr(esp, fp);

if (vcsspWriteChar(esp, 'a')) /* This char will *not* be
encrypted.*/
 ++write_error;

if (vcsspEncodeOn(esp))
 ++write_error;

if (vcsspWriteChar(esp, 'b')) /* This char *will* be
encrypted. */
 ++write_error;
if (vcsspEncodeOff(esp))
 ++write_error;

fclose(fp);
vcsspClose(esp);
```

**Caution**

`vcsspInitialize()` and `vcsspSetFilePtr()` must be called prior to calling this routine.

---

## **vcsspWriteString**

### **Syntax**

```
int vcsspWriteString(vcsspStateID esp, char *s)
```

## Synopsis

This routine writes a character string to the protected file.

If encoding is enabled (see “[vcsSpEncodeOn](#)” on page 68) the specified string is encrypted as it is written to the output file.

If encoding is disabled (see “[vcsSpEncodeOff](#)” on page 67) the specified string will be written as-is to the output file (no encryption.)

## Returns

Non-zero if the file pointer has not been set (see “[vcsSpSetFilePtr](#)” on page 77) or if there was an error writing to the output file (out-of-disk-space, etc.)

Returns 0 if the write was successful.

### *Example E-42 Example of vcsSpWriteString*

```
vcsSpStateID esp = vcsSpInitialize();
FILE *fp = fopen("protected.file", "w");
int write_error = 0;

if (fp == NULL) exit(1);

vcsSpSetFilePtr(esp, fp);

if (vcsSpWriteString(esp, "This text will *not* be
encrypted.\n"))
 ++write_error;

if (vcsSpEncodeOn(esp)) ++write_error;
if (vcsSpWriteString(esp, "This text *will* be
encrypted.\n"))
 ++write_error;

if (vcsSpEncodeOff(esp)) ++write_error;
if (vcsSpWriteString(esp, "This text will *not* be
encrypted.\n"))
```

```
++write_error;

fclose(fp);
vcsSpClose(esp);
```

### **Caution**

vcsSpInitialize() and vcsSpSetFilePtr() must be called prior to calling this routine.

---

## **Access Routine for Signal in a Generate Block**

There is only one access routine for signals in generate blocks.

---

### **acc\_object\_of\_type**

#### **Syntax**

```
bool acc_object_of_type(accGenerated, sigHandle)
```

#### **Synopsis**

This routine returns true if the signal is in a generate block.

#### **Returns**

1 - if the signal is in a generate block.

0 - if the signal is not in a generate block.

---

## **VCS API Routines**

Typically VCS controls the PLI application. If you write your application so that it controls VCS, you need these API routines.

---

## **Vcsinit()**

When VCS is run in slave mode, you can call this function to elaborate the design and to initialize various data structures, scheduling queues, etc. that VCS uses. After this routine executes, all the initial time 0 events, such as the execution of initial blocks, are scheduled.

Call the `vmc_main(int argc, char *argv)` routine to pass runtime flags to VCS before you call `VcsInit()`.

---

## **VcsSimUntil()**

This routine tells VCS to schedule a stop event at the specified simulation time and execute all scheduled simulation events until it executes the stop event. The syntax for this routine is as follows:

```
VcsSimUntil (unsigned int* t)
```

Argument `t` is for specifying the simulation time. It needs two words. The first [0] is for simulation times from 0 to  $2^{32} - 1$ , the second is for simulation times that follow.

If any events are scheduled to occur after time `t`, their execution must wait for another call to `VcsSimUntil`.

If `t` is less than the current simulation time, VCS returns control to the calling routine.

# Index

---

runtime information message generating  
D-11

## Symbols

B-68, C-8  
-a filename B-65  
-ams\_discipline B-55  
-ams\_iereport B-55  
-assert B-9  
-C B-52  
-c B-48  
-CC B-50  
-cc B-50  
-CFLAGS B-50  
-cm assert B-14  
-comp64 B-16, B-25  
-cpp B-51  
-debug B-65  
-debug\_all B-65  
-debug\_pp B-65  
-doc 2-3, B-8  
-e name\_for\_main B-38  
-E program runtime option C-31  
-extinclude B-23, D-8  
-f filename B-36  
-full64 B-25  
-gui 2-6, 5-7  
-h 2-3, B-7  
-help 2-3, B-7  
-ID 2-3, B-47  
-jnumber\_of CPUs B-51  
-I C-22  
-l filename 2-7, B-65, C-20  
-ld linker B-48  
-LDFLAGS B-48  
-lmcs-swift B-42  
-lmcs-swift-template B-42  
-lname B-48  
-load 21-33, B-40  
-Mdir B-6  
-Mdirectory B-6  
-Mlib=dir B-7  
-negdelay B-34  
-nolncComp B-7  
-ntb B-16  
-ntb\_cmp B-17  
-ntb\_define B-16  
-ntb\_filext B-17  
-ntb\_incdir B-17  
-ntb\_opts B-18  
-ntb\_sfname B-21  
-ntb\_vipext B-21  
-ntb\_vl B-21  
-o name B-66

-O number B-52  
 -O0 B-52  
 -ova\_enable\_case B-16  
 -override\_timescale B-58  
 -P pli.tab B-39  
 -parameters 2-6, 4-6, B-56  
 -platform B-66  
 -PP D-19  
 -pvalue 2-6, 4-6, B-56  
 -q 2-7, B-44, C-21  
 -R 2-6, B-26, B-65  
 -sysc B-62  
 -u B-65  
 -ucli 5-6  
 -V 2-7, B-44, C-21  
 -v 2-3, B-4  
 -vcf filename C-24  
 -Vt B-44  
 -Xman B-54  
 -Xmangle B-54  
 -Xnoman B-55  
 -Xnomangle B-54  
 -Xova B-16  
 -y 2-4, B-4  
 assert hier=file.txt B-14  
 'celldefine B-45, B-46, D-2, D-3  
 'default\_nettpe D-2  
 'define D-3  
 'delay\_mode\_distributed D-5  
 'delay\_mode\_path D-5  
 'delay\_mode\_unit D-5  
 'delay\_mode\_zero D-5  
 'else D-3  
 'elseif D-3  
 'endcelldefine D-2  
 'endif D-3  
 'endprotect D-6  
 'endprotected D-7  
 'endrace B-57  
 'ifdef D-4  
 'ifndef D-4  
 'include B-23, D-8  
     specifying the search directories B-62  
     with a different verion of Verilog B-23  
 'line D-10  
 'noportcoerce 3-29, D-8  
 'nunconnected\_drive D-10  
 'portcoerce D-8  
 'protect B-53, D-7  
 'protected D-7  
 'race B-57  
 'resetall D-3  
 'timescale B-59, D-8  
 'unconnected\_drive D-10  
 'undef D-5  
 'uselib D-9  
 'vcs\_mipdexpand D-6  
 "A" specifier of abstract access 21-47  
 "C" specifier of direct access 21-47  
 \*\*NC 3-15  
 /\*synopsys translate\_off\*/ pragma B-68  
 /\*synopsys translate\_on\*/ pragma B-68  
 //synopsys translate\_off pragma B-68  
 //synopsys translate\_on pragma B-68  
 %CELL 21-13, 21-16  
 %TASK 21-13  
 +abstract 21-122  
 +acc+2 B-38  
 +acc+3 B-38  
 +acc+4 B-38  
 +acc+level\_number 21-20, B-37  
 +ad B-55  
 +allhdrs 21-122  
 +allmtm B-26, C-25, C-26  
 +applylearn 21-24–21-30, C-32  
 +applylearn+filename B-38  
 +auto2protect B-53  
 +auto3protect B-53  
 +autoprotect B-52  
 +charge\_decay B-26  
 +define+macro=value 2-7, B-66  
 +delay\_mode\_distributed 10-37, B-27

+delay\_mode\_path 10-36, B-26  
+delay\_mode\_unit 10-37, B-27  
+delay\_mode\_zero 10-37, B-27  
+deleteprotected B-53  
+evalorder 4-19  
+inmdir 2-5, B-62  
+iopath+edge B-30  
+libext 2-5, B-5  
+libborder 2-5, B-5  
+librescan B-6  
+libverbose B-6, B-43  
+lint B-43  
+list 21-122  
+maxdelays B-26, B-27, C-25, C-33  
+memcbk B-64  
+mindelays B-26, B-27, C-25, C-33  
+module module\_identifier C-17  
+multisource\_int\_delays 10-22, B-28  
+nbaopt B-28  
+neg\_tchk 10-58, 10-65, B-35  
+no\_notifier 10-58, B-32, C-19  
+no\_pulse\_msg C-21  
+no\_tchk\_msg 10-58, B-32, C-19  
+nocelldefinepli+0 B-45  
+nocelldefinepli+1 B-45  
+nocelldefinepli+2 B-46  
+noerrorIOPCWM B-63  
+nolibcell B-45  
+nospecify 10-59, B-31  
+notimingcheck 10-59, B-31, C-19  
+ntb\_cache\_dir C-3  
+ntb\_delete\_disk\_cache C-3  
+ntb\_disable\_cnst\_null\_object\_warning C-3  
+ntb\_enable\_checker\_trace C-4  
+ntb\_enable\_checker\_trace\_on\_failure C-4  
+ntb\_enable\_solver\_trace\_on\_failure C-5  
+ntb\_enable\_solver\_trace\_on\_failure=value C-5  
+ntb\_exit\_on\_error C-5  
+ntb\_load C-6  
+ntb\_random\_seed C-6  
+ntb\_random\_seed\_automatic C-6  
+ntb\_solver\_array\_size\_warn C-7  
+ntb\_solver\_debug 15-7, C-7  
    extract 15-13, 15-16  
    profile 15-12, 15-16  
    serial 15-15  
    trace 15-9, 15-11, 15-16  
+ntb\_solver\_debug\_dir C-8  
+ntb\_solver\_debug\_filter 15-9, 15-11, 15-13, C-9  
+ntb\_solver\_mode C-9  
+ntb\_solver\_mode=value C-9  
+NTC2 10-64, B-35  
+object\_protect D-7  
+old\_ntc B-35  
+optconfigfile 9-6, B-24  
+overlap 10-68, B-35  
+override\_model\_delays C-25, C-26, C-32  
+pathpulse B-31  
+pli\_unprotected B-53  
+plusarg\_ignore B-37  
+plusarg\_save B-37  
+plus-options C-32  
+prof B-35  
+protect file\_suffix B-53  
+pulse\_e/number 10-23, 10-25, 10-27, 10-32, 10-33, B-33  
+pulse\_int\_e 10-22, 10-23, 10-25, 10-27, B-33  
+pulse\_int\_r 10-22, 10-23, 10-25, 10-27, B-33  
+pulse\_on\_detect 10-33, B-33  
+pulse\_on\_event 10-32, B-33  
+pulse\_r/number 10-23, 10-25, 10-27, 10-32, 10-33, B-33  
+putprotect+target\_dir B-53  
+race=all 3-20, 3-21, B-57  
+rad 9-6, B-24  
+sdf\_nocheck\_celltype B-28  
+sdfprotect file\_suffix B-53  
+sdfverbose C-21  
+systemverilogext B-22  
+tetramax B-63

+timopt [10-39](#)  
 +transport\_int\_delays [10-22](#), [10-25](#), [10-27](#),  
[B-28](#)  
 +transport\_path\_delays [10-22](#), [10-25](#), [10-27](#),  
[B-29](#)  
 +typdelays [B-26](#), [B-28](#), [C-26](#), [C-33](#)  
 +udpsched [3-5](#), [B-67](#)  
 +UVM\_VERBOSITY= [20-233](#)  
 +vc [21-121](#), [B-41](#)  
 +vcs+dumpoff+t+ht [C-24](#)  
 +vcs+dumpon+t+ht [C-25](#)  
 +vcs+finish [5-27](#), [C-20](#)  
 +vcs+flush+all [B-42](#), [C-27](#)  
 +vcs+flush+dump [B-42](#), [C-25](#), [C-27](#)  
 +vcs+flush+fopen [B-42](#), [C-27](#)  
 +vcs+flush+log [B-42](#), [C-27](#)  
 +vcs+ignorestop [C-32](#)  
 +vcs+initreg+0|1|random| [C-29](#)  
 +vcs+initreg+random [B-23](#), [C-30](#)  
 +vcs+learn+pli [21-24](#)–[21-27](#), [C-32](#)  
 +vcs+lic+vcsi [B-47](#), [C-28](#)  
 +vcs+lic+wait [C-28](#)  
 +vcs+loopdetect+number [B-67](#)  
 +vcs+loopreport+number [B-67](#)  
 +vcs+mipd+noalias [C-33](#)  
 +vcs+mipdexpan [D-6](#)  
 +vcs+nostdout [C-22](#)  
 +vcs+stop [5-26](#), [C-20](#)  
 +vcs+vcpluson [B-64](#)  
 +vcsi+lic+vcs [B-47](#), [C-28](#)  
 +vcsi+lic+wait [B-47](#)  
 +verilog1995ext [B-22](#)  
 +verilog2001ext [B-22](#)  
 +vpddrivers [C-24](#)  
 +vpdfile [5-7](#)  
 +vpdfileswitchsize [5-7](#)  
 +vpdfileswitchsize+number\_in\_MB [C-23](#)  
 +vpdnoports [C-24](#)  
 +vpdportsonly [C-23](#)  
 +vpdupdate [C-24](#)  
 +vpi [B-39](#)  
 +vpi+1 [B-39](#)  
 +vpi+1+assertion [B-40](#)  
 +warn [3-49](#), [B-44](#)  
 \$assert\_category\_start [18-23](#), [18-26](#)  
 \$assert\_category\_stop [18-22](#)  
 \$assert\_monitor [18-9](#), [D-26](#)  
 \$assert\_monitor\_off [18-9](#), [D-27](#)  
 \$assert\_monitor\_on [18-9](#), [D-27](#)  
 \$assert\_set\_category [18-15](#), [18-22](#)  
 \$assert\_set\_severity [18-14](#)  
 \$assert\_severity\_stop [18-22](#)  
 \$assertkill [D-12](#)  
 \$assertoff [D-11](#)  
 \$asserton [D-12](#)  
 \$async\$and\$array [D-37](#)  
 \$bitstoreal [D-28](#)  
 \$countdrivers [D-41](#)  
 \$deposit [D-41](#)  
 \$disable\_warnings [D-34](#)  
 \$display [D-29](#)  
 \$dist\_exponential [D-39](#)  
 \$dist\_normal [D-39](#)  
 \$dist\_poisson [D-39](#)  
 \$dist\_uniform [D-39](#)  
 \$dumpall [D-13](#)  
 \$dumpfile [D-13](#)  
 \$dumpflush [D-13](#)  
 \$dumplimit [D-13](#)  
 \$dumpoff [D-13](#)  
 \$dumpon [D-13](#)  
 \$dumpsports [8-20](#), [D-15](#)  
 \$dumpsports system task [C-27](#)  
 \$dumpsportsall [D-17](#)  
 \$dumpsportsflush [D-17](#)  
 \$dumpsportslimit [D-18](#)  
 \$dumpsportsoff [D-16](#)  
 \$dumpsportson [D-17](#)  
 \$dumpvars [D-13](#)  
 \$enable\_warnings [D-34](#)  
 \$error [D-11](#)  
 \$fatal [18-34](#), [D-11](#)

**\$fclose** D-30  
**\$fdisplay** D-30  
**\$ferror** D-30  
**\$fflush** D-14, D-30  
**\$fflushall** D-14  
**\$fgetc** D-30  
**\$fgets** D-30  
**\$finish** D-34  
**\$fmonitor** D-31  
**\$fopen** B-41, D-31  
    increasing the frequency of flushing B-42  
**\$fopen** system function C-27  
    increasing the frequency of \$fopen file, log  
        file, and VCD file dumping C-27  
    increasing the frequency of dumping to files  
        opened by \$fopen C-27  
**\$fread** D-31  
**\$fscanf** D-31  
**\$fseek** D-31  
**\$fstobe** D-31  
**\$ftell** D-31  
**\$fwrite** D-31  
**\$get\_initial\_random\_seed** D-39  
**\$getpattern** D-41  
**\$gr\_waves** D-14  
**\$hold** D-35  
**\$info** D-11  
**\$isunknown** D-12  
**\$itor** D-29  
**\$log** D-28  
**\$lsl\_dumpports** 3-49–3-54, 8-19, D-15  
**\$lsl\_dumpports** system task C-27  
**\$monitor** D-29  
**\$monitoroff** D-29  
**\$monitoron** D-29  
**\$nolog** D-28  
**\$onehot0** D-12  
**\$past**  
    ignoring B-14  
**\$period** D-35  
**\$printtimescale** D-33  
  
**\$q\_add** D-37  
**\$q\_exam** D-38  
**\$q\_full** D-38  
**\$q\_initialize** D-38  
**\$q\_remove** D-38  
**\$random** 3-47, D-39  
**\$read\_lib\_saif** 22-5  
**\$readmemb** D-32  
**\$readmemh** D-32  
**\$realtime** D-38  
**\$realtobits** D-29  
**\$recovery** D-35  
**\$recrrem** D-36  
    checking timestamp and timecheck  
        conditions B-35  
    disabling delayed versions of signals in other  
        timing checks B-35  
**\$removal** D-36  
**\$reset** D-40  
**\$reset\_count** D-40  
**\$reset\_value** D-40  
**\$restart** D-42  
**\$rtoi** D-29  
**\$save** D-42  
**\$sdf\_annotate** D-41  
**\$set\_toggle\_region** 22-5  
**\$setup** D-36  
**\$setuphold** D-36  
    checking timestamp and timecheck  
        conditions B-35  
    disabling delayed versions of signals in other  
        timing checks B-35  
**\$skew** D-37  
**\$sreadmemb** D-33  
**\$sreadmemh** D-33  
**\$stime** D-38  
**\$stop** D-34  
    ignoring C-32  
**\$strobe** D-30  
**\$sync\$nor\$plane** D-37  
**\$system** D-27  
**\$systemf** D-28

**\$test\$plusargs** C-32, D-40  
**\$time** D-38  
**\$timeformat** D-33  
**\$ungetc** D-32  
**\$uniq\_prior\_checkoff** system task 13-73  
**\$uniq\_prior\_checkon** system task 13-73  
**\$value\$plusargs** 5-8  
**\$vcplusplusautoflushoff** D-19  
**\$vcplusplusautoflushon** D-19  
**\$vcplusplusclose** D-19  
**\$vcplusplusdeltacycleoff** 8-18  
**\$vcplusplusdeltacycleon** 8-18, D-19  
**\$vcplusplusdumpportsoff** D-21  
**\$vcplusplusdumpports on** D-21  
**\$vcplusplusevent** D-20  
**\$vcplusplusfile** D-22  
**\$vcplusplusflush** D-22  
**\$vcplusplusglitchon** D-22  
**\$vcplusplusmemoff** 8-8, D-24  
**\$vcplusplusmemon** 8-8, D-22  
**\$vcplusplusmemorydump** 8-8, D-24  
**\$vcplusplusoff** D-24  
**\$vcpluspluson** D-25  
**\$vcplusplustraceoff** D-26  
**\$vcplusplusxx** system tasks  
  ignoring C-23  
**\$warning** D-11  
**\$width** D-37  
**\$write** D-30  
**\$writememb** D-33  
**\$writememh** D-33

"A" specifier of abstract access 21-47  
 +abstract 21-122  
 abstract access for C/C++ functions  
  access routines for 21-72–21-116  
  enabling with a compile-time option 21-122  
  using 21-70–21-116  
 +acc+level\_number 21-20, B-37  
 ACC capabilities 21-26, B-37  
  applying in the design only where they are  
  needed C-32  
 cbk 21-12, 21-17  
 cbka 21-12  
  enabling debugging B-38  
 frc 21-12, 21-17  
 gate 21-12  
 mip 21-12, C-33  
 mipb 21-13  
 mipd C-33  
 mp 21-12  
 prx 21-12  
 r 21-11, 21-16  
  recording where in the design they are  
  needed C-32  
 rw 21-11, 21-17  
 s 21-12  
  specifying 21-9–21-18  
 tchk 21-12  
 acc\_handle\_simulated\_net C-33  
  access routines for abstract access of C/C++  
  functions 21-72–21-116  
  accessing signed variablesa 20-130  
  Active time slot  
  changing UDP output evaluation to the NBA  
  time slot 3-5, B-67  
 +ad B-55  
 adaptor code  
  generating 20-117  
 AICMs  
  information messages B-55  
 +allhdrs 21-122  
 +allmtm B-26, C-25, C-26  
 alt\_retain 10-5  
 -ams\_discipline B-55  
 -ams\_iereport B-55

## Numerics

64-bit  
  compilation and 32-bit simulation B-25  
  compilation and simulation B-25

## A

-a filename B-65

ansi argument to -ntb\_opts [B-18](#)  
 ANSI mode  
   in OpenVera files [B-18](#)  
 aop  
   advice  
     before/after/around [14-16](#)  
   dominates [14-7](#)  
   extends directive [14-3](#)  
   placement element  
     after [14-11](#)  
     around [14-11](#)  
**C-32**  
`+applylearn` [21-24–21-30](#)  
`arb.v` [12-5](#)  
`args` PLI Specification [21-8](#)  
 array  
   output and inout argument type [21-63](#)  
 array index [15-26](#)  
 array members [15-31](#)  
 assembler  
   passing options to [B-50](#)  
`-assert` [B-9, C-10](#)  
`-assert assertion_block_identifier` [C-18](#)  
`-assert funchier` [18-29, 18-30](#)  
`-assert hier=file.txt` [B-14](#)  
`-assert no_default_msg` [18-32](#)  
`-assert no_default_msg` [18-32](#)  
`-assert no_fatal_action` [18-33](#)  
`-assert quiet` [18-32](#)  
`-assert report` [18-32](#)  
`$assert_monitor` [18-9, D-26](#)  
`$assert_monitor_off` [18-9, D-27](#)  
`$assert_monitor_on` [18-9, D-27](#)  
 assertion failure messages  
   controlling [18-31](#)  
 assertion warning messages  
   suppressing [B-8](#)  
 Assertions  
   SystemVerilog  
     enabling or disabling a module or a  
       hierarchy [B-10](#)  
 assertions  
 fatal error generating [D-11](#)  
 OpenVera [B-16](#)  
   blind signals [B-21](#)  
   bounds check in dynamic and fixed-size  
     arrays [B-18](#)  
   bounds check in dynamic arrays [B-18](#)  
   bounds check in fixed-size arrays [B-18](#)  
   circular dependency check [B-18](#)  
     display on screen [B-19](#)  
   disabling default failure messages [C-12](#)  
   encrypted IP mode  
     filename extension [B-21](#)  
   encryption  
     tokens file [B-20](#)  
   file name extension [B-17](#)  
   file-by-file preprocessing  
     disabling [B-19](#)  
   include directory path [B-17](#)  
   including case violations in the global  
     failure count [C-19](#)  
   interface ports named ifc\_signal [B-21](#)  
   left padding in strings [B-19](#)  
   RVM enabling [B-19](#)  
   shell module name vera\_shell  
     specifying [B-21](#)  
   signal property access functions  
     enabling [B-20](#)  
   teshbench shell  
     compiling [B-21](#)  
     filename specifying [B-21](#)  
     generating only [B-21](#)  
     not generating [B-17](#)  
   teshbench shell and shared object files  
     generating [B-17](#)  
     specifying the directory [B-21](#)  
   timescale [B-20](#)  
   VMM enabling [B-19](#)  
 Openvera  
   ANSI mode [B-18](#)  
 PSL  
   disabling default failure messages [C-12](#)  
 resume monitoring [D-12](#)  
 returning true if one bit is true [D-12](#)  
 returning true if one bit is X [D-12](#)  
 returning true if only one bit is true or no bits  
   are true [D-12](#)

runtime error generating [D-11](#)  
 runtime information message generating [D-11](#)  
 runtime warning generating [D-11](#)  
**SystemVerilog**  
 cover statements  
     disabling [B-14](#)  
 disabling  
     from a file [B-15](#)  
 disabling [B-14](#)  
 disabling assertion failure messages [C-13](#)  
     but enabling summary information [C-13](#)  
 disabling default failure messages [C-12](#)  
 disabling from a file  
     specifying assertion block [C-18](#)  
     specifying module definitions [C-18](#)  
 disabling information in a VPD file [B-15](#)  
 dumping SVA in VPD file  
     disabling [C-10](#)  
 enabling and disabling from a file [C-15](#)  
 enabling assertion match (success)  
     messages [C-14](#)  
 enabling from a file  
     specifying module definitions [C-17](#)  
 enabling runtime options [B-10](#)  
 enabling the -assert hier=file.txt runtime  
     option for turning assertions off [B-14](#)  
 enabling vacuous success messages [C-14](#)  
 enhsnce reporting for assertions in  
     functions [B-10](#)  
 excluding assertion failures with fail action  
     blocks [C-12](#)  
 failure simulation time in Debussy [B-16](#)  
 generationg a report file [C-13](#)  
     adding more information [C-15](#)  
 ignoring \$past [B-14](#)  
 maximum number of cover statement  
     specifying the total number of cover  
         statements in the assertion coverage  
         information [C-11](#)  
 monitoring for assertion coverage [C-18](#)  
 no match simulation time in Debussy [B-16](#)  
 not displaying the assert or cover  
     statement summary [C-11](#)  
 not writing the program\_name.db database  
     file [C-11](#)  
     specifying configuration file [B-10](#)  
     specifying the maximum number of failures  
         for each assertion [C-11](#)  
     specifying the maximum number of  
         successes for each assertion [C-11](#)  
     specifying the number of failures for an  
         assertion [C-10](#)  
     specifying the rotal number of assertion  
         failures [C-11](#)  
     starting simulation time in Debussy [B-16](#)  
     turning off monitoring [D-11, D-12](#)  
**\$assertkill** [D-12](#)  
**\$assertoff** [D-11](#)  
**\$asserton** [D-12](#)  
**assert.report** file [C-13](#)  
     adding more information [C-15](#)  
**\$async\$and\$array** [D-37](#)  
**attach\_by\_id()** [20-119](#)  
**+auto2protect** [B-53](#)  
**+auto3protect** [B-53](#)  
 auto-inserted connect modules (AICMs)  
     displaying information about [B-55](#)  
**+autoprotect** [B-52](#)

## B

Backward SAIF File [22-5](#)  
 bidirectional registered mixed-signal net  
     dispalying a list of [B-55](#)  
     finishing compilation at [B-55](#)  
 bit  
     C/C++ function argument type [21-50](#)  
     C/C++ function return type [21-49](#)  
     input argument type [21-62](#)  
     output and inout argument type [21-63](#)  
     reg data type in two-state simulation [21-46](#)  
**\$bitstoreal** [D-28](#)  
 bounds check  
     in OpenVera dynamic and fixed-size arrays  
         [B-18](#)  
     in OpenVera dynamic arrays [B-18](#)  
     in OpenVera fixed-sise arrays [B-18](#)  
 buffer

emptying into VCD files [D-13](#)

## C

-C [B-52](#)

C [15-37](#)

-c [12-5](#), [B-48](#)

C code generating

halt before compiling the generated C code  
[B-52](#)

passing options to the compiler [B-50](#)

specifying another compiler [B-50](#)

specifying the optimization level [B-52](#)

suppressing optimization for faster compilation [B-52](#)

C compiler

not passing default options [B-52](#)

optimization levels [B-50](#)

passing options to [B-50](#)

specifying [B-50](#)

C compiler, environment variable specifying the [A-4](#)

"C" specifier of direct access [21-47](#)

C/C++ functions

argument direction [21-48](#), [21-49](#)

argument type [21-48](#), [21-50](#)

calling [21-52–21-54](#)

declaring [21-46–21-52](#)

extern declaration [21-47](#)

in a Verilog environment [21-45–21-46](#)

return range [21-48](#)

return type [21-47](#), [21-49](#)

using abstract access [21-70–21-116](#)

    access routines for [21-72–21-116](#)

using direct access [21-61–21-70](#)

    examples [21-63–21-68](#)

C++

generating struct [20-151](#)

precompiled headers [20-185](#)

C++ compiler

specifying [B-51](#)

call PLI specification [21-7](#)

callbacks for memories and multi-dimensional arrays

enabling [B-64](#)

calling C/C++ functions in your Verilog code  
[21-52–21-54](#)

case pragmas

enabling [B-16](#)

cbk ACC capability [21-12](#), [21-17](#)

cbka ACC capability [21-12](#)

CBug [20-215](#)

-CC [B-50](#)

-cc [B-50](#)

cell

for delay annotation

disabling [D-2](#)

specifying [D-2](#)

cell modules

excluding from compilation [B-45](#)

'celldefine [B-45](#), [B-46](#), [D-2](#), [D-3](#)

CELLTYPE entries in SDF files

disabling [B-28](#)

-CFLAGS [B-50](#)

-cg\_coverage\_control [C-2](#)

char\*

direct access for C/C++ functions

formal parameter type [21-61](#)

char\*\*

direct access for C/C++ functions

formal parameter type [21-61](#)

charge decay

enabling [B-26](#)

+charge\_decay [B-26](#)

check argument to -ntb\_opts [B-18](#)

check PLI specification [21-7](#)

check=all [B-18](#)

check=fixed [B-18](#)

checkpoint

in VCD files

recording current values [D-13](#)

start recording current values [D-13](#)

stop recording current values [D-13](#)

circular dependency check check

in OpenVera [B-18](#)

display on screen [B-19](#)

class [15-29](#)

classes

- inheritance between [15-31](#)
- clock signals [10-38–10-43](#)
- cm [11-3](#), [C-18](#)
- cm assert [B-14](#)
- comp64 [B-16](#), [B-25](#)
- compilation order [15-32](#)
- compiler directives [D-1–D-10](#)
  - resetting [D-3](#)
- compile-time options [B-1–??](#)
  - displaying at runtime [C-31](#)
  - specifying in a file [B-36](#)
- compiling
  - incremental compilation
  - triggering [??–9-3](#)
  - omitting compilation between pragmas [B-68](#)
  - OpenVera testbench shell [B-21](#)
  - verbose messages [2-7](#), [B-44](#)
  - with ‘include and -extinclude [B-23](#)
- compression
  - disasbling for VPD files [C-24](#)
- conditional expressions
  - warning when evaluate to X or Z [B-56](#)
  - filtering out false negatives [B-56](#)
- configuration file
  - for Radiant technology [B-24](#)
- constraint solver
  - array size warning [C-7](#)
  - OpenVera
    - trace information [C-5](#)
- constraints
  - conflicts [15-26](#)
  - constraint profiling [15-12](#), [15-16](#)
  - debugging [C-7](#), [C-9](#)
  - partitions [15-4](#)
  - test case extraction [15-13](#), [15-16](#)
- copyright information
  - displaying [C-21](#)
- \$countdrivers [D-41](#)
- coverage groups
  - OpenVera
    - enabling [C-2](#)
- cpp [B-51](#)

## D

data PLI specification [21-7](#)

Data Type Mapping File

- VCS/SystemC cosimulation interface [20-45](#)

-debug [B-65](#)

-debug\_all [B-65](#)

debug\_all, option [5-7](#)

-debug\_pp [5-6](#), [B-65](#)

debug\_pp, option [5-6](#)

debug, option [5-7](#)

Debussy [B-64](#)

- assertions
  - failure simulation time [B-16](#)
  - no match simulation time [B-16](#)
  - stating simulation time [B-16](#)

declaring C/C++ functions in your Verilog code [21-46–21-52](#)

default discrete discipline

- in VerilogAMS [B-55](#)

default net data type

- specifying [D-2](#)

'default\_nettpe [D-2](#)

'define [D-3](#)

+define+macro=value [2-7](#), [B-66](#)

delay mode distributed behavior [B-27](#)

delay mode path behavior [B-26](#)

delay mode unit behavior [B-27](#)

delay mode zero behavior [B-27](#)

delay values

- back annotating to your design [D-41](#)

'delay\_mode\_distributed [D-5](#)

+delay\_mode\_distributed [10-37](#), [B-27](#)

'delay\_mode\_path [D-5](#)

+delay\_mode\_path [10-36](#), [B-26](#)

'delay\_mode\_unit [D-5](#)

+delay\_mode\_unit [10-37](#), [B-27](#)

'delay\_mode\_zero [D-5](#)

+delay\_mode\_zero [10-37](#), [B-27](#)

delays [C-25](#), [C-26](#)

- changing all delays to zero [D-5](#)
- changing all to 0 [B-27](#)

ignoring all delays except gate, switch, and continuous assignment delays [D-5](#)  
 ignoring all delays except module path delays [D-5](#)  
 ignoring all module path delays and using for all other delay specifications the shortest time precision argument [D-5](#)  
 ignoring module path delays and changing gate, switch, and continuous assignment delays to time precision [B-27](#)  
 ignoring module path delays and using gate, switch, and continuous assignment delays [B-27](#)  
 module path delays  
     X value [B-33](#)  
         with error message [B-33](#)  
 on gates and switches  
     ignoring [B-26](#)  
 specifies using max of min|typ|max delays [B-27](#)  
 specifies using min of min|typ|max delays [B-27](#)  
 specifies using typ of min|typ|max delays [B-28](#)  
     transport delays [B-28, B-29](#)  
`+deleteprotected` [B-53](#)  
 delta cycle information [D-19](#)  
 Denali [28-1](#)  
`dep_check` argument to `-ntb_opts` [B-18](#)  
`$deposit` [D-41](#)  
 Design Description [12-6](#)  
 diagnostic messages [B-43](#)  
 direct access for C/C++ functions  
     examples [21-63–21-68](#)  
     formal parameters  
         types [21-61](#)  
     rules for parameter types [21-61–21-63](#)  
     using [21-61–21-121](#)  
 DirectC  
     abstract access  
         specifying [B-41](#)  
     enabling [B-41](#)  
     listing the C/C++ functions [B-41](#)  
     using pass by reference [21-60](#)  
     vc\_hdrs.h file [B-41](#)  
 direction of a C/C++ function argument [21-49](#)  
 directory for constraint solver profiles and testcases [C-8](#)  
`disable` [B-14](#)  
`disable soft` [15-34](#)  
`disable_cover` [B-14](#)  
`disable_file=filename` [B-15](#)  
`$disable_warnings` [D-34](#)  
`$display` [D-29](#)  
`DISPLAY_VCS_HOME` [A-3](#)  
`$dist_exponential` [D-39](#)  
`$dist_normal` [D-39](#)  
`$dist_poisson` [D-39](#)  
`$dist_uniform` [D-39](#)  
 DKI communication [20-6](#)  
`-doc` [2-3, B-8](#)  
 documentation [B-8](#)  
 dominates [15-33](#)  
`double*`  
     direct access for C/C++ functions  
         formal parameter type [21-61](#)  
`DPI` [15-36, 20-184, 20-287](#)  
`$dumpall` [D-13](#)  
`$dumpfile` [D-13](#)  
`$dumpflush` [D-13](#)  
`$dumplimit` [D-13](#)  
`$dumpoff` [D-13](#)  
`dumpoff` [B-15, C-10](#)  
`$dumpon` [D-13](#)  
`$dumpports` [8-20, D-15](#)  
`$dumpportsall` [D-17](#)  
`$dumpportsflush` [D-17](#)  
`$dumpportslimit` [D-18](#)  
`$dumpportsoff` [D-16](#)  
`$dumpportson` [D-17](#)  
`$dumpvars` [D-13](#)  
 dynamic race detection [B-57](#)  

## E

`-e name_for_main` [B-38](#)

-E program C-31  
 echo C-31  
 edge sensitivity  
   in SDF file IOPATH entries B-30  
 'else D-3  
 'elseif D-3  
 enable\_diag B-10  
 enable\_hier B-14  
 \$enable\_warnings D-34  
 enabling C-2  
   only where used in the last simulation 21-26  
 encryption  
   all modules B-52  
     but not the module header B-53  
     but not the module header and parameter  
       declarations B-53  
 enabling overwriting of existing files B-53  
 enabling PLI and UCLI access B-53  
 OpenVera  
   tokens file B-20  
 SDF files B-53  
   specifying the directory for encrypted files  
     B-53  
   specifying with 'protect 'endprotect B-53  
 'endcelldefine D-2  
 'endif D-3  
 ending simulation at a specified time C-20  
 'endprotect D-6  
 'endprotected D-7  
 Environment variables 1-6–1-7, A-1–A-5  
 \$error D-11  
 error messages  
   changing to warning B-43  
 +evalorder 4-19  
 EVCD files D-15  
   flushing the buffer D-17  
   recording all port values D-17  
   resume recording D-17  
   specifying the file size D-18  
   suspending D-16  
 executable  
   specifying the name of B-66  
 exporting SystemVerilog packages 13-82, B-8  
   extended summary information  
     displaying C-21  
   extends 15-32  
   extends directive  
     advice 14-4  
     introduction 14-4  
   extern declaration 21-47  
   extern declarations 21-68  
   -extinclude B-23, D-8

**F**

-f filename B-36  
 fail action blocks C-12  
 \$fatal D-11  
 fatal assertion error generating D-11  
 \$fclose D-30  
 \$fdisplay D-30  
 \$ferror D-30  
 \$fflush D-14, D-30  
 \$fflushall D-14  
 \$fgetc D-30  
 \$fgets D-30  
 -file 2-6, B-36  
 file  
   for runtime options C-28  
 file name extension in Verilog library  
 directories  
   specifying B-5  
 files  
   grw.dump file D-14  
   tokens.v B-54  
   VCD files  
     specifying the filename D-13  
 filter\_past B-14  
 \$finish D-34  
 finish\_maxfail=N C-10  
 \$fmonitor D-31  
 \$fopen B-41, D-31  
   increasing the frequency of flushing B-42  
 foreach loops 15-41  
 four state Verilog data

stored in vec32 21-55  
-fPIC 20-186  
frc ACC capability 21-12, 21-17  
\$fread D-31  
\$fscanf D-31  
FSDB files B-64  
\$fseek D-31  
\$fstobe D-31  
\$ftell D-31  
-full64 B-25  
function calls  
    context 15-38  
    DPI 15-36  
    non-pure 15-37  
    pure 15-37  
\$fwrite D-31

## G

g++ 20-186  
gate ACC capability 21-12  
gate-level  
    improving runtime performance B-68  
gd\_pulsewarn 10-7  
generating adaptor code 20-117  
generics  
    overriding with the -gfile elaboration option  
        B-59  
\$get\_initial\_random\_seed D-39  
\$getpattern D-41  
-gfile B-59  
global\_finish\_maxfail=N C-11  
globalDirective 18-26  
gmake A-2  
GNU 20-189  
\$gr\_waves D-14  
grw.dump file D-14  
-gui 2-6, 5-7

## H

-h 2-3, B-7

hard constraint 15-27  
header and summary  
    suppressing C-21  
header files  
    pre-compiled 20-186  
-help 2-3, B-7  
help with compile-time options, runtime  
options, and environment variables B-7  
hier=file\_name C-15  
\$hold D-35  
-hsopt=gates B-68

## I

-ID 2-3, B-47  
ifc\_signal  
    OpenVera interface ports named B-21  
'ifdef D-4  
'ifndef D-4  
-ignore B-8  
+incdir 2-5, B-62  
'include D-8  
    specifying the search directories B-62  
including one source file in another D-8  
increasing the stack guard size 20-194  
increasing the stack size 20-193  
incremental compilation B-6–B-7  
    central place for descriptor information and  
        object files B-7  
    disabling B-7  
incremental compile directory  
    specifying B-6  
\$info D-11  
information messages  
    about finding module definitions in a library  
        B-43  
    lint B-43  
-ignore B-8  
initializing integer data type variables C-29  
initializing state variables B-23  
inout  
    C/C++ function argument direction 21-49

input  
  C/C++ function argument direction [21-49](#)

int  
  C/C++ function argument type [21-50](#)  
  C/C++ function return type [21-49](#)  
  direct access for C/C++ functions  
    formal parameter type [21-61](#)  
  input argument type [21-62](#)  
  output and inout argument type [21-63](#)

int\*

  direct access for C/C++ functions  
    formal parameter type [21-61](#)

integer data type variables  
  initializing [C-29](#)

INTERCONNECT delays  
  rejecting [B-33](#)  
  SDF files [B-28](#)  
    changing to transport delays [B-28](#)  
    negative values enabling [B-34](#)

interface [12-7](#)

  self() [13-78](#)

Interface Description [12-14](#)

internal disk cache for randomization  
  delete before simulation [C-3](#)  
  location [C-3](#)

intra-assigment delays  
  removing [B-28](#)

IOPATH delays  
  SDF files  
    negative values enabling [B-34](#)

+iopath+edge [B-30](#)

\$isunknown [D-12](#)

\$itor [D-29](#)

## J

-jnumber\_of CPUs [B-51](#)

## K

keywords  
  after [14-11](#)

around [14-11](#)  
before [14-11](#)  
extends [14-3](#)  
virtuals [14-31](#)

## L

-I [C-22](#)

-l filename [2-7, B-65, C-20](#)

-ld linker [B-48](#)

-LDFLAGS options [B-48](#)

+libext [2-5, B-5](#)

-libmap [4-12](#)

+liborder [2-5, B-5](#)

+librescan [B-6](#)

+libverbose [B-6, B-43](#)

licenses  
  enabling license queuing [C-28](#)  
  running VCS with three VCSI licenses [C-28](#)  
  running VCSI with a VCS license [C-28](#)  
  waiting for a license [C-28](#)  
  waiting for a network license [C-28](#)

licensing  
  using VCS licenses for VCSI [B-47](#)  
  using VCSI licenses for VCS [B-47](#)  
  wait for a license [B-47](#)  
    specifying the wait time [B-47](#)  
  wait for a network license [B-47](#)  
  wait for a VCSI license [B-47](#)

-licqueue [B-47](#)

-licwait timeout [B-47](#)

'line [D-10](#)

linker  
  linking a library to the executable [B-48](#)  
  linking by hand [B-48](#)  
  passing flags to [B-48](#)  
  specifying [B-48](#)  
  temporary object files [B-48](#)

linking  
  linking a specified library to the executable  
    [B-48](#)  
  linking by hand [B-48](#)  
  passing options to the linker [B-48](#)

specifying another linker [B-48](#)  
`+lint` [B-43](#)  
 lint messages [B-43](#)  
`+list` [21-122](#)  
 LMC SWIFT interface  
     including [B-42](#)  
`-lmc-swift` [B-42](#)  
`-lmc-swift-template` [B-42](#)  
`-lname` [B-48](#)  
`-load` [21-33](#), [B-40](#)  
`$log` [D-28](#)  
 log file  
     appending to [B-65](#)  
     simulation  
         specifying [C-20](#)  
 log file buffers  
     increasing the frequency of flushing [B-42](#)  
 log file, environment variable specifying the  
[A-4](#)  
 log files  
     increasing the frequency of log file dumping  
[C-27](#)  
     increasing the frequency of log file, VCD file,  
         and `$fopen` file dumping [C-27](#)  
     specifying compilation log file [2-7](#), [B-65](#)  
     specifying with a system task [D-28](#)  
 loops  
     specifying the maximum number of loops for  
         a simulation event [B-67](#)  
     specifying the maximum number of loops for  
         a simulation event warning [B-67](#)  
 LSI certification [D-15](#)  
     EVCD files [D-15](#)  
     flushing the buffer [D-17](#)  
     including strength levels in the VCD file [D-15](#)  
     recording all port values [D-17](#)  
     resume recording [D-17](#)  
     specifying the file size [D-18](#)  
     suspects recording [D-16](#)  
`$lsi_dumpports` [3-49](#)–[3-54](#), [8-19](#), [D-15](#)

**M**  
`-m32` [20-186](#)  
 macros  
     text macro defining [B-66](#)  
     text macros  
         defining [D-3](#)  
         else defining [D-3](#)  
         else if end [D-3](#)  
         elseif defining [D-3](#)  
         if defining [D-4](#)  
         if not defined [D-4](#)  
         undefining [D-5](#)  
`main()` routine  
     specifying for PLI [B-38](#)  
 maintaining filename and line number [D-10](#)  
 make [A-2](#)  
 mangled file source protection [B-54](#)  
     except module and port identifiers [B-54](#)  
`-Marchive` [B-6](#), [B-48](#)  
 maxargs PLI specification [21-8](#)  
`maxcover=N` [C-11](#)  
[C-33](#)  
`+maxdelays` [B-26](#), [B-27](#), [C-25](#)  
`maxfail=N` [C-11](#)  
`maxsuccess=N` [C-11](#)  
 MDAs [15-43](#)  
`-Mdir` [20-187](#), [B-6](#)  
`-Mdirectory` [B-6](#)  
 member variables [20-145](#)  
`+memcbk` [B-64](#)  
 memories  
     sparse memory models [3-40](#)  
 Memory Modeler - Advanced Verification  
     (MMAV) [28-1](#)  
 memory size limits [3-39](#)  
 messages  
     about finding module definitions in a library  
[B-43](#)  
     changing error to warning [B-43](#)  
`lint` [B-43](#)  
     quiet mode [B-44](#)  
     verbose diagnostic [B-43](#)

verbose mode [B-44](#)  
     including CPU time information [B-44](#)  
 warning  
     disabling [B-44](#)  
**MHPI** [20-217](#)  
**minargs** PLI specification [21-8](#)  
[C-33](#)  
**+mindelays** [B-26, B-27, C-25](#)  
**mip ACC capability** [21-12](#)  
**mipp ACC capability** [21-13, D-6](#)  
**MIPDs** [C-33](#)  
     disabling connection upon MIPD delay  
         annotation [C-33](#)  
**misc PLI specification** [21-7](#)  
**mixed analog/digital simulation**  
     specifying [B-55](#)  
**mixed signal simulation**  
     specifying [B-55](#)  
**-Mlib=dir** [B-7](#)  
**module description , Verilog** [12-15](#)  
**-module module\_identifier** [C-18](#)  
**module path delays**  
     changing to transport delays [B-29](#)  
     disabling [B-31](#)  
     disabling for an instance [10-38](#)  
     suppressing  
         in specific module instances [10-38](#)  
         X value [B-33](#)  
         X value with error message [B-33](#)  
**\$monitor** [D-29](#)  
**\$monitoroff** [D-29](#)  
**\$monitoron** [D-29](#)  
**mp ACC capability** [21-12](#)  
**multiple packed dimensions** [15-42](#)  
**+multisource\_int\_delays** [10-22, B-28](#)

**N**

**NBA time slot**  
     changing UDP outputs to the NBA time slot  
         [3-5, B-67](#)  
**+nbaopt** [B-28](#)

**\*\*NC** [3-15](#)  
**+neg\_tchk** [10-58, 10-65, B-35](#)  
**negative multiconcat multiplier**  
     allowing [B-63](#)  
**negative timing checks** [B-34](#)  
**-negdelay** [B-34](#)  
**nets**  
     specifung defult data type [D-2](#)  
**no\_default\_msg** [C-12](#)  
**-no\_error ID+ID** [B-43](#)  
**no\_fatal\_action** [C-12](#)  
**no\_file\_by\_file\_pp** argument to **-ntb\_opts** [B-19](#)  
**+no\_identifier** [C-19](#)  
**+no\_notifier** [10-58, B-32](#)  
**+no\_pulse\_msg** [C-21](#)  
**+no\_tchk\_msg** [10-58, B-32, C-19](#)  
**+nocelldefinepli+1** [B-45](#)  
**nocelldefinepli** PLI specification [21-8](#)  
**+nocelldefinepli+0** [B-45](#)  
**+nocelldefinepli+2** [B-46](#)  
**nocovdb** [C-11](#)  
**-noerror UPIMI+IOPCWM** [B-43](#)  
**-xzcheck** [B-56](#)  
**-nolncrComp** [B-7](#)  
**+nolibcell** [B-45](#)  
**\$nolog** [D-28](#)  
**nonblocking assignments**  
     removing intra-assignment delays [B-28](#)  
**'noportcoerce** [3-29, D-8](#)  
**nopostproc** [C-11](#)  
**+nospecify** [10-59, B-31](#)  
**-notice** [2-7, B-43](#)  
**notifier register**  
     in timincheck system tasks  
         disabling [B-32](#)  
**notifier registers, suppressing the toggling of**  
[C-19](#)  
**+notimingcheck** [10-59, B-31, C-19](#)  
**'ounconnected\_drive** [D-10](#)  
**-ntb** [B-16](#)  
**+ntb\_cache\_dir** [C-3](#)

- ntb\_cmp [B-17](#)
- ntb\_define [B-16](#)
- +ntb\_delete\_disk\_cache [C-3](#)
- +ntb\_enable\_solver\_trace\_on\_failure [C-5](#)
- +ntb\_exit\_on\_error [C-5](#)
- ntb\_filext [B-17](#)
- ntb\_incdir [B-17](#)
- +ntb\_load [C-6](#)
- ntb\_noshell [B-17](#)
- ntb\_opts [B-18](#)
  - print\_deps [B-19](#)
  - rvm [B-19](#)
  - sv\_fmt [B-19](#)
- ntb\_opts no\_file\_by\_file\_pp [12-28](#)
- +ntb\_random\_seed [C-6](#)
- +ntb\_random\_seed\_automatic [C-6](#)
- ntb\_sfname [B-21](#)
- ntb\_shell\_only [B-21](#)
- ntb\_sname [B-21](#)
- +ntb\_solver\_array\_size\_warn [C-7](#)
- +ntb\_solver\_debug [15-7, C-7](#)
  - extract [15-13, 15-16](#)
  - profile [15-16](#)
  - serial [15-15](#)
  - trace [15-9, 15-16](#)
- +ntb\_solver\_debug\_dir [C-8](#)
- +ntb\_solver\_debug\_filter [15-9, 15-11, 15-13, C-9](#)
- +ntb\_solver\_mode [C-9](#)
- ntb\_spath [B-21](#)
- ntb\_vipext [12-28, B-21](#)
- ntb\_vl [B-21](#)
- +NTC2 [10-64, B-35](#)
  
- O**
- o name [B-66](#)
- O number [B-52](#)
- O0 [B-52](#)
- object files
  - enabling position independent code [B-49](#)
  - specifying temporary [B-48](#)
  
- P**
- P pli.tab [21-18, B-39](#)
- packed constraints [15-41](#)

packed dimensions 15-42  
 padding 20-129  
 parallel compilation B-7, B-51  
     disabling B-7  
     specifying the number of forks B-51  
 -parallel\_compile\_off B-7  
 -parameters 2-6, 4-6, B-56  
 parameters  
     overriding B-56, B-61  
     overriding with the -gfile elaboration option B-59  
 partitions  
     in constraints 15-4  
 pass by reference in DirectC 21-60  
 –pathmap 20-215  
 +pathpulse B-31  
 PATHPULSE\$ specparam, enabling B-31  
 performance  
     improving for gate-level designs B-68  
 \$period D-35  
 -picarchive B-49  
 placement element  
     after 14-11  
     around 14-11  
 -platform B-66  
 platform directory in the VCS installation  
     returning B-66  
 PLI  
     ACC capabilities B-37  
         enabling debugging B-38  
         allowing access to ports and parameters B-46  
     disabling capabilities for 'celldesign and library modules B-46  
     disabling capabilities for 'celldesign modules B-46  
     enabling in encrypted files B-53  
     slave mode B-38  
     specifying the name of your main() routine B-38  
 PLI specifications  
     args 21-8  
     call 21-7  
     check 21-7  
     data 21-7  
     maxargs 21-8  
     minargs 21-8  
     misc 21-7  
     nocelldefinepli 21-8  
     size 21-7  
 PLI table file 21-6–21-19, C-32  
     specifying B-39  
 pli\_learn.tab C-32  
 +pli\_unprotected B-53  
 pli.tab file 21-6–21-19, C-33  
     specifying B-39  
 +plusarg\_ignore B-37  
 +plusarg\_save B-37  
 plusargs, checking for on the simv command line D-40  
 +plus-options C-32  
 pointer  
     C/C++ function argument type 21-50  
     C/C++ function return type 21-49  
     input argument type 21-62  
     output and inout argument type 21-63  
 port coercion 3-28  
     disabling D-8  
     enabling D-8  
 Port Mapping File  
     VCS/SystemC cosimulation interface 20-43  
 ‘portcoerce’ D-8  
 position independent code  
     enabling B-49  
 POSIX 20-215  
 -PP D-19  
 -prec 20-192  
 pre-compiled header files 20-186  
 print\_deps argument to -ntb\_opts B-19  
 \$printtimescale D-33  
 priority keyword 13-66  
 procedure\_prototype  
     example 14-28, 14-29  
 +prof B-35  
 profiling B-35  
 program\_name.db database file

not writing C-11  
 proprietary message  
     suppressing C-21  
 'protect B-53, D-7  
 +protect file\_suffix B-53  
 'protected D-7  
 prx ACC capability 21-12  
 PSL 18-31  
 pulse error messages  
     suppressing C-21  
 +pulse\_e/number 10-23, 10-25, 10-27, 10-32,  
   10-33, B-33  
 +pulse\_int\_e 10-22, 10-23, 10-25, 10-27, B-33  
 +pulse\_int\_r 10-22, 10-23, 10-25, 10-27, B-33  
 +pulse\_on\_detect 10-33, B-33  
 +pulse\_on\_event 10-32, B-33  
 +pulse\_r/number 10-23, 10-25, 10-27, 10-32,  
   10-33, B-33  
 pulses  
     filtering out narrow pulses B-33  
     and flag as error B-33  
     on INTERCONNECT delays  
         INTERCONNECT delays  
             filtering out  
             SDF files  
                 INTERCONNECT  
                     delays  
                 filtering out  
                 B-33  
     rejecting narrow pulses B-33  
     on SDF INTERCONNECT delays B-33  
 X value B-33  
 +putprotect+target\_dir B-53  
 -pvalue 2-6, 4-6, B-56, B-61

**R**  
 \$q\_remove D-38  
 quiet mode - suppressing  
     header and summary information C-21  
 proprietary message C-21  
 simulation report at the end of simulation  
     C-21

**R**  
 -R 2-6, B-26, B-65  
 r ACC capability 21-11, 21-16  
 -race B-56  
 race conditions  
     avoiding 3-2-3-7  
     continuous assignment evaluations 3-5  
     generating a report of B-56, B-57  
     in counting events 3-6  
     in flip-flops 3-4  
     limiting the exposure of 4-19  
     setting a value twice at the same time 3-3  
     time zero 3-7  
     using and setting a value at the same time  
         3-2  
 +race=all 3-20, 3-21, B-57  
 -racecd B-57  
 race.out file B-57  
 +rad 9-6, B-24  
 Radiant technology  
     configuration file B-24  
     enabling B-24  
 rand members 15-29  
 rand\_mode() method 13-37  
 \$random 3-47, D-39  
 random  
     initializing 0 or 1 C-29  
 random number generator  
     re-seeding C-6  
 random values  
     setting the seed C-6  
         after restore C-6  
 randomize() method 13-37  
 randomize() serial number 15-15  
 randomize()solver trace 15-7

**Q**  
 -q 2-7, B-44, C-21  
 \$q\_add D-37  
 \$q\_exam D-38  
 \$q\_full D-38  
 \$q\_initialize D-38

randomized objects in a structure [15-46](#)  
**\$readmemb** [D-32](#)  
**\$readmemh** [D-32](#)  
**real**  
 C/C++ function argument type [21-50](#)  
 input argument type [21-62](#)  
 output and inout argument type [21-63](#)  
**\$realtime** [D-38](#)  
**\$realtobits** [D-29](#)  
**\$recovery** [D-35](#)  
**\$recrrem** [D-36](#)  
 checking timestamp and timecheck  
 conditions [B-35](#)  
 disabling delayed versions of signals in other  
 timing checks [B-35](#)  
**reg**  
 C/C++ function argument type [21-50](#)  
 C/C++ function return type [21-49](#)  
 input argument type [21-62](#)  
 output and inout argument type [21-63](#)  
**\$reset** [D-40](#)  
**\$reset\_count** [D-40](#)  
**\$reset\_value** [D-40](#)  
**'resetall** [D-3](#)  
**resetting**  
 keeping track of the number of resets [D-40](#)  
 passing a value from before to after a reset  
[D-40](#)  
 resetting VCS to simulation time 0 [D-40](#)  
 Resolving message upon instance resolution  
[B-6](#)  
 resolving module instances [D-9](#)  
**\$restart** [D-42](#)  
 RETAIN entries  
 SDF files  
 enabling [B-29](#)  
 return range of a C/C++ function [21-48](#)  
 return type of a C/C++ function [21-47, 21-49](#)  
 RTL Verilog example [12-7](#)  
**\$rtoi** [D-29](#)  
 runtime assertion error generating [D-11](#)  
 runtime assertion warning generating [D-11](#)  
 runtime options  
 compiling into the executable [B-37](#)  
 prevent compiling into the executable [B-37](#)  
 specifying in as file [C-28](#)  
**RVM** [B-19](#)  
**rvm** [B-19](#)  
 rw ACC capability [21-11, 21-17](#)

## S

**s** ACC capability [21-12](#)  
**\$save** [D-42](#)  
**SC\_CTHREAD** [20-192, 20-194](#)  
**sc\_main** [20-208](#)  
**sc\_objects** [20-208](#)  
**sc\_report\_handler** [20-233](#)  
**sc\_stack\_size** [20-193, 20-195](#)  
**sc\_start** [20-208](#)  
**SC\_THREAD** [20-192, 20-194](#)  
**SC\_THREADS** [20-215](#)  
**scalar**  
 direct access for C/C++ functions  
 formal parameter type [21-61](#)  
**scalar\***  
 direct access for C/C++ functions  
 formal parameter type [21-61](#)  
 scope randomize method [13-36](#)  
**SDF** [10-5](#)  
 optimistic mode [10-5](#)  
**SDF backannotating**  
 enabling more than 10 warning and error  
 messages [C-21](#)  
**SDF delay back-annotation**  
 disabling back-annotation to individual bits of  
 an input port [D-6](#)  
 to individual bits of an input port [D-6](#)  
**SDF files**  
 compiling separate files for min|typ|max  
 delays [B-26](#)  
 disabling CELLTYPE entries [B-28](#)  
 enabling accurate simulatiuon of multiple  
 non-overlapping violation windows [B-35](#)  
 encryption [B-53](#)  
 INTERCONNECT delays [B-28](#)

changing to transport delays [B-28](#)  
 negative values enabling [B-34](#)  
 rejecting [B-33](#)  
**INTERCONNECT** entries  
 negative values enabling [B-34](#)  
**IOPATH** delays  
 negative values enabling [B-34](#)  
**IOPATH** entries  
 edge sensitivity [B-30](#)  
 negative values enabling [B-34](#)  
**min|typ|max** delays  
 specified in a file [B-26](#)  
**RETAIN** entries  
 enabling [B-29](#)  
**-sdf min|typ|max**  
 instance\_name  
 file.sdf [B-26](#)  
**\$sdf\_annotation** [D-41](#)  
**+sdf\_nocheck\_celltype** [B-28](#)  
**+sdfprotect file\_suffix** [B-53](#)  
**-sdfretain** [10-5](#), [B-29](#)  
**-sdfretain=warning** [B-29](#)  
**SDFRT\_IRV**  
 wanring [B-29](#)  
**+sdfverbose** [C-21](#)  
 search order of Verilog library directories [B-5](#)  
 rescan [B-6](#)  
 segmentation violation [20-192](#)  
**SEGV** [20-192](#)  
 sequential devices  
 inferring [3-31](#)–[3-35](#), [10-38](#)–[10-43](#)  
 sequential UDPs  
 changing output evaluation to the NBA tile  
 slot [3-5](#), [B-67](#)  
 serial2trace.txt file [15-12](#)  
**\$setup** [D-36](#)  
**\$setuphold** [D-36](#)  
 checking timestamp and timecheck  
 conditions [B-35](#)  
 disabling delayed versions of signals in other  
 timing checks [B-35](#)  
 shared object file  
 OpenVera [C-6](#)  
 signal port mismatch  
 changing from an error to a warning condition  
[B-63](#)  
 signal property access funtions  
 OpenVera  
 enabling [B-20](#)  
 signed variables  
 accessing [20-130](#)  
 simulation  
 immediately after compilation [B-26](#)  
 simulation report at the end of simulation  
 suppressing [C-21](#)  
 simulation state  
 saving [D-42](#)  
 simv executable  
 specifying a deifferent name [B-66](#)  
 single class [15-28](#)  
 single packed dimension [15-42](#)  
 size PLI specification [21-7](#)  
**\$skew** [D-37](#)  
**-skip\_translate\_body** [B-68](#)  
**-slave** [B-38](#)  
 slave mode in PLI [B-38](#)  
 Smart Order [26-1](#)  
 soft constraint [15-27](#)  
 soft constraints [15-26](#), [15-34](#)  
 disabling [15-26](#)  
 prioritization [15-28](#)  
 soft keyword [15-27](#)  
 solver trace reporting  
 for the specified randomize() calls [15-16](#)  
**SOMA** [28-2](#)  
 souce protection  
 enabling overwriting of existing files [B-53](#)  
 enabling PLI and UCLI access [B-53](#)  
 encrypting all modules [B-52](#)  
 but not the module headers [B-53](#)  
 but not the module headers and parameter  
 declarations [B-53](#)  
 specifying the directory for protected files  
[B-53](#)  
 specifying with ‘protect ‘endprotect [B-53](#)  
 source file

specifying in a file [B-36](#)  
 source protection  
     mangling [B-54](#)  
         except module and port identifiers [B-54](#)  
     SDF files [B-53](#)  
     specifying the end of the code to be  
         protected [D-6](#)  
     specifying the end of the protected code [D-7](#)  
     specifying the start of the code to be  
         protected [D-7](#)  
     specifying the start of the protected code [D-7](#)  
 sparse memory models [3-40](#)  
 specify blocks  
     disabling for an instance [10-38](#)  
     suppressing [B-31](#)  
         in specific module instances [10-38](#)  
 specifying [B-40](#)  
 srand(seed) system function [C-6, C-7](#)  
 \$sreadmemb [D-33](#)  
 \$sreadmemh [D-33](#)  
 stack guard  
     increasing size [20-194](#)  
 stack overrun  
     diagnosing [20-194](#)  
 stack size  
     increasing [20-193](#)  
 state variables [15-25](#)  
     initializing [B-23](#)  
 Static Race Detection Tool [B-57](#)  
 std  
     randomize() method [13-36](#)  
 \$stimen [D-38](#)  
     [C-32](#)  
 \$stop [D-34](#)  
 stopping simulation at a specified time [C-20](#)  
 strength information  
     disabling in VPD files [C-24](#)  
 string  
     C/C++ function argument type [21-50](#)  
     C/C++ function return type [21-49](#)  
     input argument type [21-62](#)  
     output and inout argument type [21-63](#)  
     \$strobe [D-30](#)  
     sub-members [20-144](#)  
     SV and RT assertions  
         browse, enable, and disable [B-40](#)  
         sv\_fmt argument to -ntb\_opts [B-19](#)  
         -sv\_package\_export [13-82, B-8](#)  
     SVA [18-31](#)  
     -sverilog [B-8](#)  
 SWIFT SmartModels [C-33](#)  
     generating a template [B-42](#)  
     replaying DelayRange parameter definition  
         with +mindelay, +typdelay, or +maxdelay  
         [C-32](#)  
     \$sync\$nor\$plane [D-37](#)  
     /\*synopsys translate\_off\*/ pragma [B-68](#)  
     //synopsys translate\_off pragma [B-68](#)  
     /\*synopsys translate\_on\*/ pragma [B-68](#)  
     //synopsys translate\_on pragma [B-68](#)  
     -sysc [B-62](#)  
     SYSC\_USE\_PTHREADS [20-215](#)  
     -sysc=dpi\_if [20-184](#)  
     -sysc=nodpi\_if [20-184](#)  
     -sysc=nomulti\_start [20-208](#)  
     -sysc=show\_sc\_main [20-220](#)  
     -sysc=stacksize [20-193](#)  
         1024k [20-209](#)  
     -sysc=unihier [20-216](#)  
     syscan [20-184](#)  
         -prec [20-186](#)  
     syscan -prec  
         limitations [20-190](#)  
     syscan utility [20-9–20-12](#)  
 \$system [D-27](#)  
 system tasks [D-11–D-46, ??–D-46](#)  
     disabling text output from [C-22](#)  
     IEEE standard system tasks not  
         implemented [D-46](#)  
 SystemC [20-184](#)  
     accessing Verilog variables [20-124](#)  
     cosimulating with Verilog [1-2, 20-1](#)  
 SystemC cosimulation [B-64](#)  
     enabling [B-62](#)

time resolution B-62  
 systemc\_user.h 20-231  
 systemc.h 20-186  
 \$systemf D-28  
 SystemVerilog 15-26  
     enabling B-8  
     exporting packages 13-82, B-8  
     randomized objects in a structure 15-46  
     specifying the filename extension B-22  
 SystemVerilog assertions 18-1–??  
 SystemVerilog LRM 15-36  
 +systemverilogext B-22

**T**

-t 12-5  
 target\_directory 20-186  
 tb\_timescale argument to -ntb\_opts B-20  
 tchk ACC capability 21-12  
 temporary object files B-48  
 \$test\$plusargs D-40  
 testbench  
     OpenVera  
         enabling B-16  
         macro on command line B-16  
         timescale B-20  
 testbench template 12-7  
 +tetramax B-63  
 TetraMAX testbench simulation in zero delay mode B-63  
 text macros  
     defining B-66, D-3  
     else defining D-3  
     else if end D-3  
     elseif defining D-3  
     if defining D-4  
     if not defined D-4  
     undefining D-5  
 text output display from system tasks  
     disabling C-22  
 \$time D-38  
 time precision  
     as delay specification D-5

time scale  
     for the compilation-unit scope B-58  
     overriding the 'timescale compiler directive from the vcs command line B-58  
     specifying on the vcs command line B-57  
 time scale for time units and time precision D-8  
 \$timeformat D-33  
 -timescale B-57  
 'timescale D-8  
 timescale  
     OpenVera testbench B-20  
 timing check system tasks  
     checking timestamp and timecheck conditions B-35  
     disabling B-31  
         in specific module instances 10-38  
         disabling delayed versions of signals B-35  
         disabling display of timing violations B-32  
         disabling toggling the notifier register B-32  
         negative values enabling B-35  
     timing check system tasks, disabling B-31  
 timing checks  
     disabling C-19  
     disabling for an instance 10-38  
     suppressing the toggling of notifier registers C-19  
 timing violations  
     disabling B-32  
     disabling the display of C-19  
 timing checks  
     disabling the display of timing violations C-19  
 Timopt  
     the timing optimizer 10-38–10-43  
 +timopt 10-39  
 TLI  
     function call 20-132  
 TLI adapters 20-287  
 –tli\_D 20-151  
 tli\_D 20-149  
 tli\_gen\_struct 20-152  
 tli\_get\_ 20-124, 20-141  
 tli\_get bv 20-129  
 tli\_get\_int64 20-145

tli\_get\_logic 20-145  
tli\_get\_lv 20-129  
TLI\_REGISTER\_ID(char \*, ) 20-119  
tli\_set\_ 20-124, 20-141  
tli\_simple 20-121  
TLI\_UNREGISTER\_ID(char \*) 20-119  
TLI-2  
    adaptor code 20-115  
-tlif 20-138  
TMPDIR A-3  
tokens argument to -ntb\_opts B-20  
tokens.v file 18-17, B-54  
top-level Verilog Module 12-7  
transport delays B-28, B-29  
+transport\_int\_delays 10-22, 10-25, 10-27, B-28  
+transport\_path\_delays 10-22, 10-25, 10-27, B-29  
C-33  
+typdelays B-26, B-28, C-26  
type conversion mechanism 20-147

changing output evaluation to the NBA time slot 3-5, B-67  
+udpsched 3-5, B-67  
unaccelerated  
    definitions and declarations 3-30–3-31  
    structural instance declarations 3-30  
'unconnected\_drive D-10  
'undef D-5  
\$ungetc D-32  
uniq\_prior\_final compiler switch 13-66  
unique keyword 13-66  
uniquifying identifier codes in VCD files 8-25  
-unit\_timescale B-58  
uppercase  
    changing Verilog identifiers to B-65  
use\_sigprop B-20  
use\_sigprop argument to -ntb\_opts B-20  
-use\_vpiobj 21-33, B-40  
'uselib D-9  
user guides, reference manuals, quick references, tutorials in HTML format B-8  
user-defined plusarg enabling C-32  
user-defined seed C-29  
utility, vcsplit 8-48  
UVM 20-229

## U

U  
    direct access for C/C++ functions  
        formal parameter type 21-61  
-u B-65  
U\*  
    direct access for C/C++ functions  
        formal parameter type 21-61  
UB\*  
    direct access for C/C++ functions  
        formal parameter type 21-61  
UCLI 20-215  
    dump 20-217  
    enabling in encrypted files B-53  
    save and restore 20-211  
    scope 20-217  
-ucli 5-6  
UDPs  
    sequential UDPs

    changing output evaluation to the NBA time slot 3-5, B-67  
+udpsched 3-5, B-67  
unaccelerated  
    definitions and declarations 3-30–3-31  
    structural instance declarations 3-30  
'unconnected\_drive D-10  
'undef D-5  
\$ungetc D-32  
uniq\_prior\_final compiler switch 13-66  
unique keyword 13-66  
uniquifying identifier codes in VCD files 8-25  
-unit\_timescale B-58  
uppercase  
    changing Verilog identifiers to B-65  
use\_sigprop B-20  
use\_sigprop argument to -ntb\_opts B-20  
-use\_vpiobj 21-33, B-40  
'uselib D-9  
user guides, reference manuals, quick references, tutorials in HTML format B-8  
user-defined plusarg enabling C-32  
user-defined seed C-29  
utility, vcsplit 8-48  
UVM 20-229

## V

-V 2-7, B-44, C-21  
-v 2-3, B-4, B-45  
vacuous success message enabling C-14  
\$value\$plusargs 5-8  
+vc 21-121, B-41  
vc\_2stVectorRef() 21-92  
vc\_4stVectorRef() 21-90  
vc\_argInfo() 21-114  
vc\_arraySize() 21-80  
vc\_FillWithScalar() 21-111  
vc\_get2stMemoryVector() 21-107  
vc\_get2stVector() 21-96  
vc\_get4stMemoryVector() 21-105

**vc\_get4stVector()** 21-94  
**vc\_getInteger()** 21-90  
**vc\_getMemoryInteger()** 21-102  
**vc\_getMemoryScalar()** 21-101  
**vc\_getPointer()** 21-88  
**vc\_getReal()** 21-85  
**vc\_getScalar()** 21-80  
**vc\_handle**  
  definition 21-70  
  using 21-71–21-72  
**vc\_hdrs.h file** 21-68–21-69  
  in DirectC B-41  
**vc\_Index()** 21-115  
**vc\_Index2()** 21-116  
**vc\_Index3()** 21-116  
**vc\_is2state()** 21-77  
**vc\_is2stVector()** 21-79  
**vc\_is4state()** 21-76  
**vc\_is4stVector()** 21-78  
**vc\_isMemory()** 21-75  
**vc\_isScalar()** 21-73  
**vc\_isVector()** 21-74, 21-117  
**vc\_mdaSize()** 21-116  
**vc\_MemoryElemRef()** 21-99  
**vc\_MemoryRef()** 21-96  
**vc\_MemoryString()** 21-109  
**vc\_MemoryStringF()** 21-110  
**vc\_put2stMemoryVector()** 21-107  
**vc\_put2stVector()** 21-96  
**vc\_put4stMemoryVector()** 21-107  
**vc\_put4stVector()** 21-94  
**vc\_putInteger()** 21-90  
**vc\_putMemoryInteger()** 21-104  
**vc\_putMemoryScalar()** 21-102  
**vc\_putMemoryValue()** 21-108  
**vc\_putMemoryValueF()** 21-108  
**vc\_putPointer()** 21-88  
**vc\_putReal()** 21-85  
**vc\_putScalar()** 21-81  
**vc\_putValue()** 21-85  
**vc\_putValueF()** 21-86

**vc\_StringToVector()** 21-89  
**vc\_toChar()** 21-81  
**vc\_toInteger()** 21-81  
**vc\_toString()** 21-83  
**vc\_toStringF()** 21-84  
**vc\_VectorToString()** 21-90  
**vc\_width()** 21-80  
**vcat utility** 8-35  
**VCD file**  
  specifying on the vcs command line B-64  
**-vcd filename** C-24  
**VCD files**  
  checkpoint  
    recording current values D-13  
    start recording current values D-13  
    stop recording current values D-13  
  emptying or flushing the buffer D-13  
  enabling VCD dumping for memories and  
    multi-dimensional arrays C-25  
  flushing the latest data to all open VCD files  
    D-14  
  flushing the latest data to the VCD file D-14  
  for LSI certification D-15  
  grw.dump file D-14  
    including strength levels D-15  
  increasing the frequency of flushing B-42  
  increasing the frequency of VCD file dumping  
    C-25, C-27  
  LSI certification  
    flushing the buffer D-17  
    recording all port values D-17  
    resume recording D-17  
    specifying the file size D-18  
    suspending D-16  
  recording in another VCD file D-14  
  specifying the time to turn on VCD dumping  
    C-25  
  specifying a limit to the VCD file size D-13  
  specifying the filename D-13  
  specifying the name of the VCD file C-24  
  specifying the nets and variables recorded in  
    the file D-13  
  specifying the time to turn off VCD dumping  
    C-24

**VCD+** [8-2](#)  
 Advantages [8-2](#)  
 System Tasks  
   \$vcplusdeltacycleoff [8-18](#)  
   \$vcplusdeltacycleon [8-18](#)  
   \$vcplusmemoff [8-8](#)  
   \$vcplusmemon [8-8](#)  
   \$vcplusmemorydump [8-8](#)  
**vcdiff** utility [8-27](#)  
   syntax [6-25](#), [8-27](#)  
**\$vcplusautoflushoff** [D-19](#)  
**\$vcplusautoflushon** [D-19](#)  
**\$vcplusclose** [D-19](#)  
**\$vcplusdeltacycleon** [D-19](#)  
**\$vcplusdumpportoff** [D-21](#)  
**\$vcplusdumpportson** [D-21](#)  
**\$vcplusevent** [D-20](#)  
**\$vcplusfile** [D-22](#)  
**\$vcplusflush** [D-22](#)  
**\$vcplusglitchon** [D-22](#)  
**\$vcplusmemoff** [D-24](#)  
**\$vcplusmemon** [D-22](#)  
**\$vcplusmemorydump** [D-24](#)  
**\$vcplusoff** [D-24](#)  
**\$vcpluson** [D-25](#)  
**\$vcplustraceoff** [D-26](#)  
**vcpost** utility [8-24](#)  
   syntax [8-26](#)  
**VCS** [4-11](#)  
   predefined text macro [D-4](#)  
**VCS MX V2K Configurations and Libmaps**  
[4-11](#)  
**VCS\_CC** [A-4](#)  
**VCS\_COM** [A-4](#)  
**VCS\_HOME** [B-47](#)  
**VCS\_LIC\_EXPIRE\_WARNING** [A-4](#)  
**VCS\_LOG** [A-4](#)  
‘vcs\_mipdexpand’ [D-6](#)  
**VCS\_NO\_RT\_STACK\_TRACE** [A-4](#)  
**VCS\_SWIFT\_NOTES** [A-4](#), [A-5](#)  
**VCS\_SYSC\_STACKSIZE** [20-209](#)  
+**vcs+dumpoff+t+ht** [C-24](#)  
+**vcs+dumpon+t+ht** [C-25](#)  
+**vcs+finish** [5-27](#), [C-20](#)  
+**vcs+flush+all** [C-27](#)  
+**vcs+flush+dump** [C-25](#), [C-27](#)  
+**vcs+flush+fopen** [C-27](#)  
+**vcs+flush+log** [C-27](#)  
+**vcs+ignorestop** [C-32](#)  
+**vcs+initreg+random**  
   [C-30](#)  
+**vcs+learn+pli** [21-24](#)–[21-27](#), [C-32](#)  
+**vcs+lic+vcsi** [C-28](#)  
+**vcs+lic+wait** [C-28](#)  
+**vcs+mipd+noalias** [C-33](#)  
+**vcs+mipdexpand** [D-6](#)  
+**vcs+nostdout** [C-22](#)  
+**vcs+stop** [5-26](#), [C-20](#)  
+**vcsi+lic+vcs** [C-28](#)  
+**vcsi+lic+wait** [B-47](#)  
**vcsplit** utility [8-48](#)  
**vec32**  
   storing four state Verilog data [21-55](#)  
**vec32\***  
   direct access for C/C++ functions  
   formal parameter type [21-61](#)  
**vera\_portname** argument to -ntb\_opts [B-20](#)  
**vera\_shell**  
   Vera shell module name [B-21](#)  
**verbose mode** - displaying  
   compile-time and runtime numbers [C-21](#)  
   copyright information [C-21](#)  
   version and extended summary information  
   [C-21](#)  
**Verilog**  
   different versions  
     filename extension [B-22](#)  
   different versions‘include’  
     filename extension [B-23](#)  
**Verilog 1995**  
   specifying the filename extension [B-22](#)  
**Verilog 2001**  
   specifying the filename extension [B-22](#)  
**Verilog identifiers**

changing to uppercase [B-65](#)  
 Verilog library  
     resolving module instances [D-9](#)  
 Verilog library directories  
     displaying a message upon instance resolution [B-6](#)  
     file name extensions  
         specifying [B-5](#)  
     specifying [B-4](#)  
     specifying the search order [B-5](#)  
         rescan [B-6](#)  
 Verilog library files  
     specifying [B-4](#)  
 Verilog model, example [12-7](#)  
 Verilog module [12-7](#)  
 Verilog module description [12-15](#)  
 Verilog parameters  
     overriding [B-56](#), [B-61](#)  
     overriding with the -gfile elaboration option [B-59](#)  
 +verilog1995ext [B-22](#)  
 +verilog2001ext [B-22](#)  
 VerilogAMS  
     default discrete discipline [B-55](#)  
 version number  
     returning [B-47](#)  
 VHDL generics  
     overriding with the -gfile elaboration option [B-59](#)  
 violation windows  
     using multiple non-overlapping [10-68–10-73](#)  
 virtual interface  
     self instance [13-78](#)  
 vlogan [20-184](#)  
 vlogan utility [20-24–20-25](#)  
 VMM [B-19](#)  
 void  
     C/C++ function return type [21-49](#)  
 void\*  
     direct access for C/C++ functions  
         formal parameter type [21-61](#)  
 void\*\*  
     direct access for C/C++ functions

formal parameter type [21-61](#)  
 VPD file  
     specifying on the vcs command line [B-64](#)  
 VPD files [D-18](#)  
     buffer for  
         specifying the size of [C-22](#)  
     disable recording values for memories and MDAs [D-24](#)  
     disabling file compression [C-24](#)  
     disabling recording in transition times an values defined under 'celldefine [B-45](#)  
     disabling recording in transition times an values defined under 'celldefine or in a library [B-46](#)  
     disabling recording strength information [C-24](#)  
     enable or resume recording [D-21](#)  
     enabling recording in transition times an values defined under 'celldefine [B-45](#)  
     enabling VPD file locking [C-24](#)  
     ignoring \$vcplusxx system tasks [C-23](#)  
     marking as completed and closing [D-19](#)  
     record a unique event for a signal [D-20](#)  
     recording changes on the drivers of resolved nets [C-24](#)  
     recording delta cycle information [D-19](#)  
     recording only ports and their direction [C-23](#)  
     recording ports and their direction [C-23](#)  
     recording signals but not ports [C-24](#)  
     recording values for memories and MDAs [D-22](#)  
     records a snapshot of memories and MDAs [D-24](#)  
     specifying the name [C-22](#)  
     specifying the next VPD file [D-22](#)  
     specifying the size of [C-22](#)  
     start recording [D-25](#)  
     stop recording [D-24](#)  
     suspend recording [D-21](#)  
     switching to record another VPD file [C-23](#)  
     turn off recording of the order of statement execution [D-26](#)  
     turn on recording of the order of statement execution [D-26](#)  
     turning off automatic flushing [D-19](#)  
     turning on automatic flushing [D-19](#)

turning on zero delay glitches [D-22](#)  
 write simulation results to the VPD file [D-22](#)  
**+vpdfile** [5-7](#)  
**+vpdfileswitchsize** [5-7](#)  
**VPI** [15-39](#)  
     specifying the registration routine in a shared  
         library [B-40](#)  
     SV and RT assertions  
         browse, enable, and disable [B-40](#)  
     vpi\_user.c file  
         specifying [B-40](#)  
**+vpi** [B-39](#)  
**VPI PLI access routines**  
     enabling [B-39](#)  
**vpi\_user.c file** [B-40](#)  
**vpiSeqBeginTime** [B-16](#)  
**vpiSeqFail** [B-16](#)  
**-Vt** [B-44](#)

**\$write** [D-30](#)  
**\$writememb** [D-33](#)  
**\$writememh** [D-33](#)

**X**  
**-xlm** [10-5](#)  
**-xlm alt\_retain** [10-5](#)  
**-xlm gd\_pulseprop** [10-6](#)  
**-xlm gd\_pulsegarn** [10-7](#)  
**-xlm uniq\_prior\_final** compile switch [13-66](#)  
**-Xman** [B-54](#)  
**-Xmangle** [B-54](#)  
**XMR** [15-24](#)  
**-Xnoman** [B-55](#)  
**-Xnomangle** [B-54](#)  
**-Xova** [18-36](#)  
**-Xova** [B-16](#)

**Y**  
**-y** [2-4, B-4, B-45](#)

**Z**  
 zero multiconcat multiplier  
     allowing [B-63](#)