Accelera Standard OVL V1.1

Library Reference Manual

Version 1.1 R2

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Suggestions for improvements to the Standard Open Verification Library and/or to this Library Reference Manual are welcome. They should be sent to the Accellera Standard OVL VSVA email reflector: ovl-vsva@list.accellera.org. The OVL VSVA technical committee website address is

http://www.accellera.org/activities/OVL_VSVA

Overview of this standard

This section describes the purpose and organization of this standard, the Accellera Standard V1.1 Open Verification Library (Std. OVL) libraries implemented in IEEE Std. 1364-1995 Verilog and SystemVerilog 3.1a, Accellera's extensions to IEEE Std. 1364-2001 Verilog Hardware Description Language and Library Reference Manual (LRM)

Intent and scope of this document

The intent of this standard is to define Std. OVL accurately. Its primary audience is designers, integrators and verification engineers to check for good/bad behavior, and provides a single and vendor-independent interface for design validation using simulation, semi-formal and formal verification techniques. By using a single well-defined interface, the OVL bridges the gap between the different types of verification, making more advanced verification tools and techniques available for non-expert users.

From time to time, it may become necessary to correct and/or clarify portions of this standard. Such corrections and clarifications may be published in separate documents. Such documents modify this standard at the time of their publication and remain in effect until superseded by subsequent documents or until the standard is officially revised.

ACKNOWLEDGEMENTS

These Accellera Standard OVL Libraries and Library Reference Manual (LRM) were specified and developed by experts from many different fields, including design and verification engineers, Electronic Design Automation companies and members of the OVL VSVA technical committee.

The following contributors were involved in the creation of previous versions of the OVL: Shalom Bresticker, Bryan Bullis, Ben Cohen, Harry Foster, Himanshu Goel, Vijay Gupta, Brent Hayhoe, Richard Ho, Narayanan Krishnamurthy, David Lacey, Jim Lewis, Andrew MacCormack, Erich Marschner, Paul Menchini, Torkil Oelgaard, Joseph Richards, Vinaya Singh, Sean Smith, Andy Tsay and others.

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INTRODUCTION

Welcome to version 1.1 of the Accellera standard Open Verification Library (OVL). The OVL V1.1 is composed of a set of assertion checkers that verify specific properties of a design. These assertion checkers are instantiated in the design establishing a single interface for design validation.

The OVL provides designers, integrators and verification engineers with a single, vendor-independent interface for design validation using simulation, hardware acceleration or emulation, formal verification and semi-/hybrid-/dynamic-formal verification tools. By using a single, well defined, interface, the OVL bridges the gap between different types of verification, making more advanced verification tools and techniques available for non-expert users.

This document provides the reader with a set of data sheets that describe the functionality of each assertion checker in the V1.1 OVL, as well as examples that show how to embed these assertion checkers into a design.

About this Manual

It is assumed the reader is familiar with hardware description languages and conventional simulation environments.

This document targets designers, integrators and verification engineers who intend to use the OVL in their verification flow and to tool developers interested in integrating the OVL in their products.

This document has the following chapters:

- OVL Basics

  Fundamental information about the OVL library, including usage and examples.

- OVL Assertion Data Sheets

  Data sheet for each type of OVL assertion checker.

- OVL Defines

  Information about the define values used in general and for configuring the checkers.

Notational Conventions

The following textual conventions are used in this manual:

emphasis	Italics in plain text are used for two purposes: (1) titles of manual chapters and appendixes, and (2) terminology used inside defining sentences.
variable	Italics in sans-serif text indicate a meta-variable. You must replace the meta-variable with a literal value when you use the associated statement.
literal	Regular sans-serif text indicates literal words used in syntax statements or in output.

Syntax statements appear in sans-serif typeface as shown here. In syntax statements, words in italics are meta-variables. You must replace them with relevant literal values. Words in regular (non-italic) sans-serif type are literals. Type them as they appear. Except for the following meta-characters, regular characters in syntax statements are literals. The following meta-characters have the given syntactical meanings. **You do not type these characters.**

[ ]	Square brackets indicate an optional entry.

Verilog Assertion Syntax Format

All Verilog assertion checkers defined by the Open Verification Library initiative observe the following BNF format, defined in compliance with Verilog Module instantiation of the IEEE Standard 1364-1995 *Verilog Hardware Description Language*.

assertion_instantiation : : = *assert_identifier*
[*parameter_value_assignment*] *module_instance* ;

parameter_value_assignment : : = # (***severity_level*** [, *other parameter expressions*] ,
property_type, ***msg***, ***coverage_level***)

module_instance : : = *name_of_instance* ([*list_of_module_connections*])

name_of_instance : : = *module_instance_identifier*

list_of_module_connections : : = *ordered_port_connection* [, *ordered_port_connection*]
| *named_port_connection* [, *named_port_connection*]

ordered_port_connection : : = [*expression*]

named_port_connection : : = . *port_identifier* ([*expression*])

assert_identifier : : = **assert**_*type_identifier*

type_identifier : : = *identifier*

References

The following is a list of resources related to design verification and assertion checkers.

Bening, L. and Foster, H., *Principles of Verifiable RTL Design, a Functional Coding Style Supporting Verification Processes in Verilog*, 2nd Ed., Kluwer Academic Publishers, 2001.

Bergeron, J., *Writing Testbenches: Functional Verification of HDL Models*, Kluwer Academic Publishers, 2000.

CheckerWare Data Book, Release 2.3, 0-In Functional Verification Group, Mentor Graphics, 2005.

Assertions in Simulation User Guide, Release 2.3, 0-In Functional Verification Group, Mentor Graphics, 2005.

Formal Verification User Guide, Release 2.3, 0-In Functional Verification Group, Mentor Graphics, 2005.

OVL BASICS

The OVL is composed of a set of assertion checkers that verify specific properties of a design. These assertion checkers are instantiated in the design establishing a single interface for design validation.

OVL assertion checkers are instances of modules whose purpose in the design is to guarantee that some conditions hold true. Assertion checkers are composed of one or more properties, a message, a severity and coverage.

- ❏ Properties are design attributes that are being verified by an assertion. A property can be classified as a combinational or temporal property.

  A combinational property defines relations between signals during the same clock cycle while a temporal property describes the relation between the signals over several (possibly infinitely many) cycles.
- ❏ Message is the string that is displayed in the case of an assertion failure.
- ❏ Severity represents whether the error captured by the assertion library is a major or minor problem.
- ❏ Coverage consists of one or more flags that indicate whether or not specific corner-case events occur.

Assertion checkers benefit users by:

- ❏ Testing internal points of the design, thus increasing observability of the design.
- ❏ Simplifying the diagnosis and detection of bugs by constraining the occurrence of a bug to the assertion checker being checked.
- ❏ Allowing designers to use the same assertions for both simulation and formal verification.

OVL Assertion Checker Implementation

Assertion checkers address design verification concerns and can be used as follows to increase design confidence:

- ❏ Combine assertion checkers to increase the coverage of the design (for example, in interface circuits and corner cases).
- ❏ Include assertion checkers when a module has an external interface. In this case, assumptions on the correct input and output behavior should be guarded and verified.
- ❏ Include assertion checkers when interfacing with third party modules, since the designer may not be familiar with the module description (as in the case of IP cores), or may not completely understand the module. In these cases, guarding the module with assertion checkers may prevent incorrect use of the module.

Usually there is a specific assertion checker suited to cover a potential problem. In other cases, even though a specific assertion checker might not exist, a combination of two or three assertion checkers can provide the desired coverage. The number of actual assertions that must be added to a specific design may vary from a few to thousands, depending on the complexity of the design and the complexity of the properties that must be checked.

Writing assertion checkers for a given design requires careful analysis and planning for maximum efficiency. While writing too few assertions might not increase the coverage on a design, writing too many assertions may increase verification time, sometimes without increasing the coverage. In most cases, however, the runtime penalty incurred by adding assertion checkers is relatively small.

OVL Assertion Checker Characteristics

Checker Class

OVL assertion checkers are partitioned into the following checker classes:

- ❏ Combinational assertions — behavior checked with combinational logic.
- ❏ Single-cycle assertions — behavior checked in the current cycle.
- ❏ 2-cycle assertions — behavior checked for transitions from the current cycle to the next.
- ❏ *n*-cycle assertions — behavior checked for transitions over a fixed number of cycles.
- ❏ Event-bounded assertions — behavior is checked between two events.

Clock and Reset

All edge-triggered assertion checkers have a clock port named `clk`. All sampling and assertion checking of these checkers is performed on the rising-edge of `clk`. All checkers have an active-low reset port named `reset_n`. Reset on all edge-triggered assertion checkers is active-low, and is synchronous to `clk`. The reset assignments of all assertion checkers can be overridden and controlled by the following global variable:

‘OVL_GLOBAL_RESET= *reset_signal*	Overrides the *reset_n* port assignments of all assertion checkers with the specified global reset signal. Default: each checker’s reset is specified by the *reset_n* port.

Checker Parameters

Each OVL assertion checker has its own set of parameters as described in its corresponding data sheet. The following parameters are common to all checkers.

severity_level

The severity level determines how to handle an assertion violation. Possible values are:

‘OVL_FATAL	Runtime fatal error.
‘OVL_ERROR	(default) Runtime error.
‘OVL_WARNING	Runtime warning.
‘OVL_INFO	No improper design functionality.

If *severity_level* is not one of these values, the checker issues the following message:

```
Illegal option used in parameter 'severity_level'
```

property_type

The property type determines whether to use the assertion as an assert property or an assume property (for example, a property that a formal tool uses to determine legal stimulii). Possible values are:

‘OVL_ASSERT	(default) Assert property.
‘OVL_ASSUME	Assume property.

If *property_type* is not one of these values, an assertion violation occurs and the checker issues the following message:

```
Illegal option used in parameter 'property_type'
```

msg

The default message issued when an assertion fails is “VIOLATION”. The *msg* parameter changes the message for the checker.

coverage_level

The coverage level is whether or not to enable coverage monitoring for the checker. Possible values are:

‘OVL_COVER_NONE	Disable coverage monitoring.
‘OVL_COVER_ALL	(default) Enable coverage monitoring.

If *coverage_level* is not one of these values, an assertion violation occurs and the checker issues the following message:

```
Illegal option used in parameter 'coverage_level'
```

Assertion Checks

Each assertion checker verifies that its parameter values are legal. If an illegal option is specified, the assertion fails. The assertion checker also checks at least one assertion. Violation of any of these assertions is an assertion failure. The data sheet for the assertion shows the various failure types for the assertion checker (except for incorrect option values for severity_level, property_type and coverage_level).

For example, the assert_frame checker data sheet shows the following types of assertion failures:

ASSERT_FRAME	The value of *test_expr* was TRUE before *min_cks* cycles after *start_event* was sampled TRUE or its value was not TRUE before max_cks cycles transpired after the rising edge of *start_event*.
illegal start event	The *action_on_new_start* parameter is set to ‘OVL_ERROR_ON_NEW_START and *start_event* expression evaluated to TRUE while the checker was monitoring *test_expr*.
min_cks > max_cks	The *min_cks* parameter is greater than the *max_cks* parameter (and *max_cks* >0). Unless the violation is fatal, either the minimum or maximum check will fail.

Cover Points

Each assertion checker data sheet shows the coverage behaviors monitored by the checker (and their corresponding messages) when coverage is enabled (‘OVL_COVER_ON) and *coverage_level* for the checker is ‘OVL_COVER_ALL. For example the data sheet for the assert_window shows the following cover points:

window_open covered	An event window opened (*start_event* was TRUE).
window_close covered	An event window closed (*end_event* was TRUE in an open event window).

OVL Use Model

An Accellera Standard OVL library user specifies preferred control settings with standard global variables defined in the following:

- ❏ A Verilog file loaded in before the libraries.
- ❏ Specifies settings using the standard `+define` options in Verilog verification engines (via a setup file or at the command line).

Setting the Implementation Language

The Accellera Standard OVL is implemented in both of the following HDL languages: Verilog 95 and SVA 3.1a. The following global variables select the implementation language:

‘OVL_VERILOG	(default) Creates assertion checkers defined in Verilog.
‘OVL_SVA	Creates assertion checkers defined in System Verilog.

In the case a user of the library does not specify a language, by default the library is automatically set to ‘OVL_VERILOG.

Note: Only one library can be selected. If the user specifies both ‘OVL_VERILOG and ‘OVL_SVA, the ‘OVL_VERILOG is undefined in the header file. Editing the header file to disable this behavior will result in compile errors.

Instantiation in an SVA Interface Construct

If an OVL checker is instantiated in a System Verilog interface construct, the user should define the following global variable:

‘OVL_SVA_INTERFACE	Ensures OVL assertion checkers can be instantiated in a System Verilog interface construct. Default: not defined.

Enabling Assertion and Coverage Logic

The Accellera Standard OVL consists of two types of logic: assertion logic and coverage logic. These capabilities are controlled via the following standard global variables:

‘OVL_ASSERT_ON	Activates assertion logic. Default: not defined.
‘OVL_COVER_ON	Activates coverage logic. Default: not defined.

If neither of these variables is defined, the assertion checkers are not activated. The instantiations of these checkers will have no influence on the verification performed.

Asserting and Assuming Properties

The OVL checkers’ assertion logic—if activated (by the ‘OVL_ASSERT_ON global variable)—identifies a design’s legal properties. Each particular checker instance can verify one or more assertion checks (depending on the checker type and the checker’s configuration).

Whether all of a checker's properties are asserts (i.e., checks) or assumes (i.e., constraints) is controlled by the checker's *property_type* parameter:

`OVL_ASSERT	(default) All the assertion checker's checks are asserts.
`OVL_ASSUME	All the assertion checker's checks are assumes.

A single assertion checker cannot have some checks asserts and other checks assumes. However, you often can implement this behavior by specifying two checkers.

Monitoring Coverage

The `OVL_COVER_ON define activates coverage logic in the checkers. This is a global switch that turns coverage monitoring on. In addition, each individual checker definition has a *coverage_level* parameter:

`OVL_COVER_ALL	(default) Activates coverage logic for the checker if `OVL_COVER_ON is defined.
`OVL_COVER_NONE	De-activates coverage logic for the checker, even if `OVL_COVER_ON is defined.

Reporting Assertion Information

By default, (if the assertion logic is active) every assertion violation is reported and (if the coverage logic is active) every captured coverage point is reported. The user can limit this reporting and can also initiate special reporting at the start and end of simulation.

Limiting a Checker's Reporting

Limits on the number of times assertion violations and captured coverage points are reported are controlled by the following global variables:

`OVL_MAX_REPORT_ERROR	Discontinues reporting a checker's assertion violations if the number of times the checker has reported one or more violations reaches this limit. Default: unlimited reporting.
`OVL_MAX_REPORT_COVER_POINT	Discontinues reporting a checker's cover points if the number of times the checker has reported one or more cover points reaches this limit.Default: unlimited reporting.

These maximum limits are for the number of times a checker instance issues a message. If a checker issues multiple violation messages in a cycle, each message is counted as a single error report. Similarly, if a checker issues multiple coverage messages in a cycle, each message is counted as a single cover report.

Reporting Initialization Messages

The checkers' configuration information is reported at initialization time if the following global variable is defined:

`OVL_INIT_MSG	Reports configuration information for each checker when it is instantiated at the start of simulation. Default: no initialization messages reported.

For each assertion checker instance, the following message is reported:

OVL_NOTE: V1.1: *instance_name* initialized @ *hierarchy* Severity: *severity_level*, Message: *msg*

End-of-simulation Signal to assert_quiescent_state Checkers

The assert_quiescent_state assertion checker checks that the value of a state expression equals a check value when a sample event occurs. These checkers also can perform this check at the end of simulation by setting the following global variable:

‘OVL_END_OF_SIMULATION= *eos_signal*	Performs quiescent state checking at end of simulation when the *eos_signal* asserts. Default: not defined.

Generating Synthesizable Logic

If ‘OVL_VERILOG is defined, then the following global variable ensures all generated OVL logic is synthesizable:

‘OVL_SYNTHESIS_OFF	Ensures OVL logic is synthesizable. Default: not defined.

Checking of X and Z Values

Some assertion checkers have checks whose semantics vary when X and Z bit values are recognized. The user can switch to 0/1 semantics for these assertions by defining the following global variable:

‘OVL_XCHECK_OFF	Turns off checking of values with X and Z bits. Turns off all assert_never_unknown checkers. Default: 0/1/X/Z semantics assumed on assert_never, assert_never_unknown, assert_one_cold, assert_one_hot and assert_zero_one_hot checkers.

Backward Compatibility

V1.1

In V1.1, a typo was corrected in the port list of the assert_implication checker type. The port name *antecendent_expr* was changed to *antecedent_expr*.

V1.0

Backward compatibility with the non-standard OVL library is important and no changes were made for the V1.0 release in the following areas: naming of module names, naming of port names and to the extent possible the existing Verilog use model.

The name of the *options* parameter was changed to *property_type*. The only checker type that is not backward compatible in this respect is the assert_fifo_index checker.

assert_fifo_index

In previous OVL versions, the assert_fifo_index checker used the second bit of the *option* parameter to prohibit simultaneous pushes-pops in the same cycle. In V1.0, the *property_type* parameter is compatible with the first bit of previous *options* parameter. But, the second bit (if defined) is ignored. To enable the check for simultaneous pushes-pops, use the *simultaneous_push_pop* parameter (at the end of the parameter list).

OVL Verilog/SVA Library

Library Characteristics

The OVL library has the following characteristics:

- ❏ All Verilog assertion checkers conform to Verilog IEEE Standard 1364-1995.
- ❏ All System Verilog assertion checkers conform to Accellera SVA 3.1a.
- ❏ Header files use file extension .h.
- ❏ Verilog files with assertion module/interfaces use extension .vlib and include assertion logic files in the language specified by the user.
- ❏ Verilog files with assertion logic use file extension _logic.v.
- ❏ System Verilog files with assertion logic use file extension _logic.sv.
- ❏ The name of an OVL assertion checker is assert_*name*, where the *name* is a descriptive identifier.
- ❏ Parameter settings are passed via literals to make configuration of assertion checkers consistent and simple to use by end users.
- ❏ Parameters passed to assertion checkers are checked for legal values
- ❏ Each assertion checker includes std_ovl_defines.h defining all global variables and std_ovl_task.h defining all OVL system tasks.
- ❏ Global variables are named OVL_*name*.
- ❏ System tasks are named ovl_*taskname*_t.
- ❏ Assertion checkers are initialized explicitly so that they work in a deterministic way without reset.
- ❏ Assertion checkers are backward compatible in behavior with existing OVL Verilog libraries (to the extent it is possible).

Library Layout

The Accellera OVL standard library has the following structure:

$STD_OVL_DIR	Installation directory of Accellera OVL library.
$STD_OVL_DIR/vlog95	Directory with assertion logic described in Verilog 95.
$STD_OVL_DIR/sva31a	Directory with assertion logic described in SVA 3.1a.

For example:

```
shell prompt> ls -l $STD_OVL_DIR
std_ovl/assert_always.vlib
std_ovl/assert_always_on_edge.vlib
std_ovl/std_ovl_defines.h
std_ovl/std_ovl_task.h
std_ovl/sva31a:
std_ovl/sva31a/assert_always_logic.vlib
std_ovl/sva31a/assert_always_on_edge_logic.vlib
. . .
std_ovl/vlog95:
std_ovl/vlog95/assert_always_logic.v
std_ovl/vlog95/assert_always_on_edge_logic.v
. . .
```

Examples

Header File

Figure 1: $STD_OVL_DIR/std_ovl_defines.h

```
// Accellera Standard V1.1 Open Verification Library (OVL).
// Accellera Copyright (c) 2005. All rights reserved.

`ifdef OVL_STD_DEFINES_H
// do nothing
`else
`define OVL_STD_DEFINES_H

`define OVL_VERSION V1.1

`ifdef OVL_ASSERT_ON
    `ifdef OVL_VERILOG
    `else
        `define OVL_VERILOG
    `endif
    `ifdef OVL_SVA
        `undef OVL_VERILOG
    `endif
`endif

`ifdef OVL_COVER_ON
    `ifdef OVL_VERILOG
    `else
        `define OVL_VERILOG
    `endif
    `ifdef OVL_SVA
        `undef OVL_VERILOG
    `endif
`endif

`ifdef OVL_ASSERT_ON
    `ifdef OVL_SHARED_CODE
    `else
        `define OVL_SHARED_CODE
    `endif
`else
    `ifdef OVL_COVER_ON
        `ifdef OVL_SHARED_CODE
        `else
            `define OVL_SHARED_CODE
        `endif
    `endif
`endif

// specifying interface for System Verilog

`ifdef OVL_SVA_INTERFACE
    `define module interface
    `define endmodule endinterface
`else
    `define module module
    `define endmodule endmodule
`endif
```

```
`ifdef OVL_GLOBAL_RESET
    `define OVL_RESET_SIGNAL `OVL_GLOBAL_RESET
`else
    `define OVL_RESET_SIGNAL reset_n
`endif

// active edges

`define OVL_NOEDGE 0
`define OVL_POSEDGE 1
`define OVL_NEGEDGE 2
`define OVL_ANYEDGE 3

// severity levels

`define OVL_FATAL   0
`define OVL_ERROR   1
`define OVL_WARNING 2
`define OVL_INFO    3

// coverage levels

`define OVL_COVER_NONE 0
`define OVL_COVER_ALL  1

// property type

`define OVL_ASSERT 0
`define OVL_ASSUME 1

// necessary condition

`define OVL_TRIGGER_ON_MOST_PIPE    0
`define OVL_TRIGGER_ON_FIRST_PIPE   1
`define OVL_TRIGGER_ON_FIRST_NOPIPE 2

// action on new start

`define OVL_IGNORE_NEW_START   0
`define OVL_RESET_ON_NEW_START 1
`define OVL_ERROR_ON_NEW_START 2

// inactive levels

`define OVL_ALL_ZEROS 0
`define OVL_ALL_ONES  1
`define OVL_ONE_COLD  2

`endif // OVL_STD_DEFINES_H
```

Assertion Checker Interface Files

Figure 2: $STD_OVL_DIR/assert_implication.vlib

```
// Accellera Standard V1.1 Open Verification Library (OVL).
// Accellera Copyright (c) 2005. All rights reserved.
`include "std_ovl_defines.h"
`module assert_implication (clk, reset_n, antecedent_expr, consequent_expr);
    input clk, reset_n, antecedent_expr, consequent_expr;
    parameter severity_level = `OVL_ERROR;
    parameter property_type = `OVL_ASSERT;
    parameter msg="VIOLATION";
    parameter coverage_level = `OVL_COVER_ALL;
    `ifdef OVL_VERILOG
        `include "./vlog95/assert_implication_logic.v"
    `endif // OVL_VERILOG
    `ifdef OVL_SVA
        `include "./sva31a/assert_implication_logic.sv"
    `endif // OVL_SVA
`endmodule
```

Assertion Checker Logic Files (Verilog 95)

Figure 3: $STD_OVL_DIR/vlog95/assert_implication_logic.v

```
// Accellera Standard V1.1 Open Verification Library (OVL).
// Accellera Copyright (c) 2005. All rights reserved.
parameter assert_name = "ASSERT_IMPLICATION";
`include "std_ovl_task.h"

`ifdef OVL_INIT_MSG
    initial
        ovl_init_msg_t; // Call the User Defined Init Message Routine
`endif

`ifdef OVL_ASSERT_ON
    always @(posedge clk) begin
        if (`OVL_RESET_SIGNAL != 1'b0) begin
            if (antecedent_expr  == 1'b1 && consequent_expr  == 1'b0) begin
                ovl_error_t("");
            end
        end
    end
`endif // OVL_ASSERT_ON

`ifdef OVL_COVER_ON
    always @(posedge clk) begin
        if (`OVL_RESET_SIGNAL != 1'b0 && coverage_level != `OVL_COVER_NONE)
        begin
            if (antecedent_expr == 1'b1) begin
                ovl_cover_t("cover_antecedent covered");
            end
        end
    end
`endif // OVL_COVER_ON
```

Assertion Checker Logic Files (System Verilog 3.1a)

Figure 4: $STD_OVL_DIR/sva31a/assert_implication_logic.sv

```
// Accellera Standard V1.1 Open Verification Library (OVL).
// Accellera Copyright (c) 2005. All rights reserved.
parameter assert_name = "ASSERT_IMPLICATION";

`include "std_ovl_task.h"

`ifdef OVL_INIT_MSG
    initial
        ovl_init_msg_t; // Call the User Defined Init Message Routine
`endif

property ASSERT_IMPLICATION_P;
    @(posedge clk)
    disable iff (`OVL_RESET_SIGNAL != 1'b1)
    antecedent_expr |-> consequent_expr;
endproperty

`ifdef OVL_ASSERT_ON
    generate
        case (property_type)
            `OVL_ASSERT : A_ASSERT_IMPLICATION_P:
                assert property (ASSERT_IMPLICATION_P) else ovl_error_t("");
            `OVL_ASSUME : M_ASSERT_IMPLICATION_P:
                assume property (ASSERT_IMPLICATION_P);
            default     : ovl_error_t("");
        endcase
    endgenerate
`endif // OVL_ASSERT_ON

`ifdef OVL_COVER_ON
    generate
        if (coverage_level != `OVL_COVER_NONE) begin
            cover_antecedent:
            cover property (@(posedge clk) ( (`OVL_RESET_SIGNAL != 1'b0) &&
                    antecedent_expr) )
            ovl_cover_t("cover_antecedent covered");
        end
    endgenerate
`endif // OVL_COVER_ON
```

OVL ASSERTION DATA SHEETS

Each OVL assertion checker type has a data sheet that provides the specification for checkers of that type. This chapter lists the checker data sheets in alphabetical order by checker type. Data sheets contain the following information:

- ❏ Syntax

  Syntax statement for specifying a checker of the type, with:

  - Parameters — parameters that configure the checker.
  - Ports — checker ports.

- ❏ Description

  Description of the functionality and usage of checkers of the type, with:

  - Assertion Checks — violation types (or messages) with descriptions of failures.
  - Cover Points — cover messages with descriptions.
  - Errors* — possible errors that are not assertion failures.

- ❏ Notes*

  Notes describing any special features or requirements.

- ❏ See also

  List of other similar checker types.

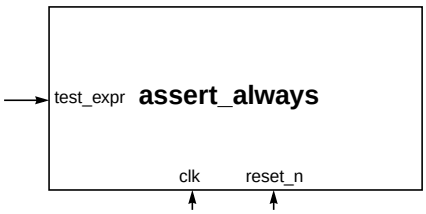
- ❏ Examples

  Examples of directives and checker applications.

* not applicable to all checker types.

assert_always

Ensures that the value of a specified expression is TRUE.



Parameters:
severity_level
property_type
msg
coverage_level

Class:
single-cycle assertion

Syntax

```
assert_always
    [#(severity_level, property_type, msg, coverage_level)]
    instance_name (clk, reset_n, test_expr);
```

Parameters

severity_level	Severity of the failure. Default: ‘OVL_ERROR.
property_type	Property type. Default: ‘OVL_ASSERT.
msg	Error message printed when assertion fails. Default: “VIOLATION”.
coverage_level	Coverage level. Default: ‘OVL_COVER_ALL.

Ports

clk	Clock event for the assertion. The checker samples on the rising edge of the clock.
reset_n	Active low synchronous reset signal indicating completed initialization.
test_expr	Expression that should evaluate to TRUE on the rising clock edge.

Description

The assert_always assertion checker checks the single-bit expression *test_expr* at each rising edge of *clk* to verify the expression evaluates to TRUE.

Assertion Check

ASSERT_ALWAYS	Expression did not evaluate to TRUE.

Cover Points

none

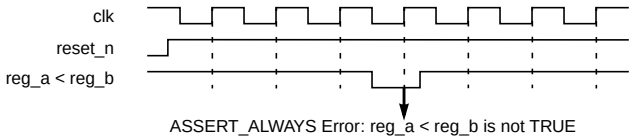
See also

assert_always_on_edge, assert_implication, assert_never, assert_proposition

Example

```
assert_always #(
    ‘OVL_ERROR,                                  // severity_level
    ‘OVL_ASSERT,                                 // property_type
    “Error: reg_a < reg_b is not TRUE”,          // msg
    ‘OVL_COVER_ALL)                              // coverage_level
    reg_a_lt_reg_b (
        clk,                                     // clock
        reset_n,                                 // reset
        reg_a < reg_b );                         // test_expr
```

Ensures that (`reg_a < reg_b`) is TRUE at each rising edge of `clk`.



assert_always_on_edge

Ensures that the value of a specified expression is TRUE when a sampling event undergoes a specified transition.

Parameters:
severity_level
edge_type
property_type
msg
coverage_level

Class:
2-cycle assertion

Syntax

```
assert_always_on_edge
    [#(severity_level, edge_type, property_type, msg, coverage_level)]
    instance_name (clk, reset_n, sampling_event, test_expr);
```

Parameters

severity_level	Severity of the failure. Default: ‘OVL_ERROR.
edge_type	Transition type for sampling event: ‘OVL_NOEDGE, ‘OVL_POSEDGE, ‘OVL_NEGEDGE or ‘OVL_ANYEDGE. Default: ‘OVL_NOEDGE.
property_type	Property type. Default: ‘OVL_ASSERT.
msg	Error message printed when assertion fails. Default: “VIOLATION”.
coverage_level	Coverage level. Default: ‘OVL_COVER_ALL.

Ports

clk	Clock event for the assertion. The checker samples on the rising edge of the clock.
reset_n	Active low synchronous reset signal indicating completed initialization.
sampling_event	Expression that (along with *edge_type*) identifies when to evaluate and test *test_expr*.
test_expr	Expression that should evaluate to TRUE on the rising clock edge.

Description

The assert_always_on_edge assertion checker checks the single-bit expression *sampling_event* for a particular type of transition. If the specified transition of the sampling event occurs, the single-bit expression *test_expr* is evaluated at the rising edge of *clk* to verify the expression does not evaluate to FALSE.

The *edge_type* parameter determines which type of transition of *sampling_event* initiates the check:

- ‘OVL_POSEDGE performs the check if *sampling_event* transitions from FALSE to TRUE.
- ‘OVL_NEGEDGE performs the check if *sampling_event* transitions from TRUE to FALSE.
- ‘OVL_ANYEDGE performs the check if *sampling_event* transitions from TRUE to FALSE or from FALSE to TRUE.
- ‘OVL_NOEDGE always initiates the check. This is the default value of *edge_type*. In this case, *sampling_event* is never sampled and the checker has the same functionality as assert_always.

The checker is a variant of assert_always, with the added capability of qualifying the assertion with a sampling event transition. This checker is useful when events are identified by their transition in addition to their logical state.

Assertion Check

ASSERT_ALWAYS_ON_EDGE	Expression evaluated to FALSE when the sampling event transitioned as specified by *edge_type*.

Cover Points

none

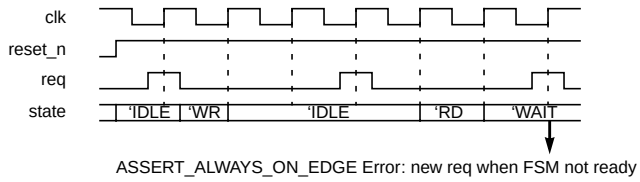
See also

assert_always, assert_implication, assert_never, assert_proposition

Examples

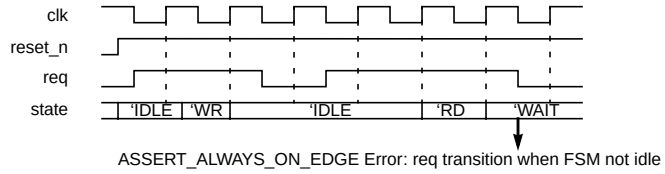
```
assert_always_on_edge #(
    ‘OVL_ERROR,                              // severity_level
    ‘OVL_POSEDGE,                            // edge_type
    ‘OVL_ASSERT,                             // property_type
    “Error: new req when FSM not ready”,     // msg
    ‘OVL_COVER_ALL)                          // coverage_level
    request_when_FSM_idle (
        clk,                                 // clock
        reset_n,                             // reset
        req,                                 // sampling_event
        state == ‘IDLE);                     // test_expr
```

Ensures that (state == ‘IDLE) is TRUE at each rising edge of clk when req transitions from FALSE to TRUE.



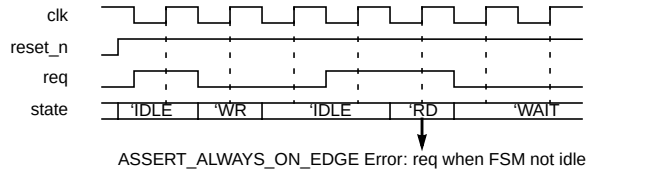
```
assert_always_on_edge #(
    ‘OVL_ERROR,                                  // severity_level
    ‘OVL_ANYEDGE,                                // edge_type
    ‘OVL_ASSERT,                                 // property_type
    “Error: req transition when FSM not idle”,   // msg
    ‘OVL_COVER_ALL)                              // coverage_level
    req_transition_when_FSM_idle (
        clk,                                     // clock
        reset_n,                                 // reset
        req,                                     // sampling_event
        state == ‘IDLE);                         // test_expr
```

Ensures that (state == ‘IDLE) is TRUE at each rising edge of clk when req transitions from TRUE to FALSE or from FALSE to TRUE.



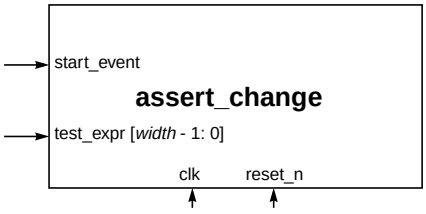

```
assert_always_on_edge #(
    ‘OVL_ERROR,                                  // severity_level
    ‘OVL_NOEDGE,                                 // edge_type
    ‘OVL_ASSERT,                                 // property_type
    “Error: req when FSM not idle”,              // msg
    ‘OVL_COVER_ALL)                              // coverage_level
    req_when_FSM_idle (
        clk,                                     // clock
        reset_n,                                 // reset
        1’b0,                                    // sampling_event
        !req || (state == ‘IDLE) );              // test_expr
```

Ensures that (!req || (state == ‘IDLE)) is TRUE at each rising edge of clk.



assert_change

Ensures that the value of a specified expression changes within a specified number of cycles after a start event initiates checking.



Parameters:
severity_level
width
num_cks
action_on_new_start
property_type
msg
coverage_level

Class:
n-cycle assertion

Syntax

```
assert_change
    [ # ( severity_level,  width, num_cks, action_on_new_start, property_type,
    msg,  coverage_level ) ]
    instance_name ( clk, reset_n, start_event, test_expr ) ;
```

Parameters

severity_level	Severity of the failure. Default: ‘OVL_ERROR.
width	Width of the *test_expr* argument. Default: 1.
num_cks	Number of cycles to check for a change in the value of *test_expr*. Default: 1.
action_on_new_start	Method for handling a new start event that occurs before *test_expr* changes value or *num_cks* clock cycles transpire without a change. Values are: ‘OVL_IGNORE_NEW_START, ‘OVL_RESET_ON_NEW_START and ‘OVL_ERROR_ON_NEW_START. Default: ‘OVL_IGNORE_NEW_START.
property_type	Property type. Default: ‘OVL_ASSERT.
msg	Error message printed when assertion fails. Default: “VIOLATION”.
coverage_level	Coverage level. Default: ‘OVL_COVER_ALL.

Ports

clk		Clock event for the assertion. The checker samples on the rising edge of the clock.
reset_n		Active low synchronous reset signal indicating completed initialization.
start_event		Expression that (along with *action_on_new_start*) identifies when to start checking *test_expr* .
test_expr	[*width* - 1 : 0]	Expression that should change value within *num_cks* cycles from the start event unless the check is interrupted by a valid new start event.

Description

The assert_change assertion checker checks the expression *start_event* at each rising edge of *clk* to determine if it should check for a change in the value of *test_expr*. If *start_event* is sampled TRUE, the checker evaluates *test_expr* and re-evaluates *test_expr* at each of the subsequent *num_cks* rising edges of *clk*. If the value of *test_expr* has not been sampled changed from its start value by the last of the *num_cks* cycles, the assertion fails.

The method used to determine how to handle a new start event, when the checker is in the state of checking for a change in *test_expr,* is controlled by the *action_on_new_start* parameter. The checker has the following actions:

- ‘OVL_IGNORE_NEW_START

  The checker does not sample *start_event* for the next *num_cks* cycles after a start event.

- ‘OVL_RESET_ON_NEW_START

  The checker samples *start_event* every cycle. If a check is pending and the value of *start_event* is TRUE, the checker terminates the check and initiates a new check with the current value of *test_expr* (even on the last cycle of a check).

- ‘OVL_ERROR_ON_NEW_START

  The checker samples *start_event* every cycle. If a check is pending and the value of *start_event* is TRUE, the assertion fails with an illegal start event violation. In this case, the checker does not initiate a new check and does not terminate a pending check.

The checker is useful for ensuring proper changes in structures after various events, such as verifying synchronization circuits respond after initial stimuli. For example, it can be used to check the protocol that an “acknowledge” occurs within a certain number of cycles after a “request”. It also can be used to check that a finite-state machine changes state after an initial stimulus.

Assertion Check

ASSERT_CHANGE	The *test_expr* expression did not change value for *num_cks* cycles after *start_event* was sampled TRUE.
illegal start event	The *action_on_new_start* parameter is set to ‘OVL_ERROR_ON_NEW_START and *start_event* expression evaluated to TRUE while the checker was in the state of checking for a change in the value of *test_expr.*

Cover Points

window_open	A change check was initiated.
window_close	A change check lasted the full *num_cks* cycles. If no assertion failure occurred, the value of *test_expr* changed in the last cycle.
window_resets	The *action_on_new_start* parameter is ‘OVL_RESET_ON_NEW_START, and *start_event* was sampled TRUE while the checker was monitoring *test_expr,* but it had not changed value.

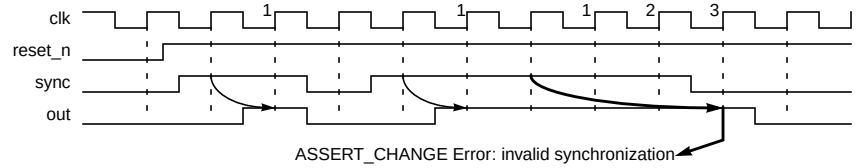
See also

assert_time, assert_unchange, assert_win_change, assert_win_unchange, assert_window

Examples

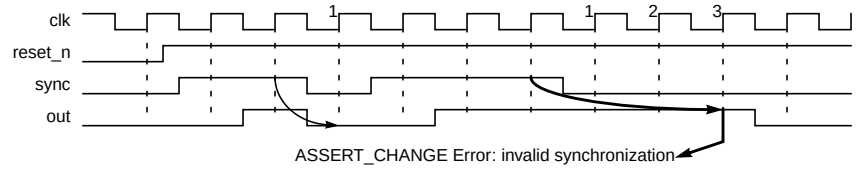
```
assert_change #(
    ‘OVL_ERROR,                          // severity_level
    1,                                   // width
    3,                                   // num_cks
    ‘OVL_IGNORE_NEW_START,               // action_on_new_start
    ‘OVL_ASSERT,                         // property_type
    “Error: invalid synchronization”,    // msg
    ‘OVL_COVER_ALL)                      // coverage_level
    valid_sync_out (
        clk,                             // clock
        reset_n,                         // reset
        sync == 1,                       // start_event
        out );                           // test_expr
```

Ensures that out changes within 3 cycles after sync asserts. New starts are ignored.



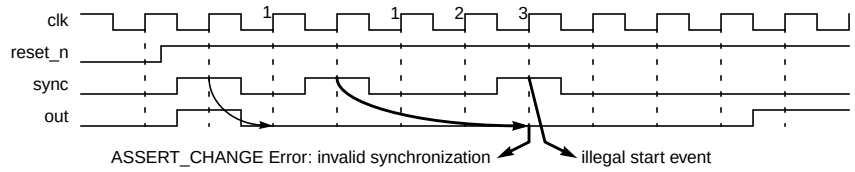

```
assert_change #(
    ‘OVL_ERROR,                          // severity_level
    1,                                   // width
    3,                                   // num_cks
    ‘OVL_RESET_ON_NEW_START,             // action_on_new_start
    ‘OVL_ASSERT,                         // property_type
    “Error: invalid synchronization”,    // msg
    ‘OVL_COVER_ALL)                      // coverage_level
    valid_sync_out (
        clk,                             // clock
        reset_n,                         // reset
        sync == 1,                       // start_event
        out );                           // test_expr
```

Ensures that out changes within 3 cycles after sync asserts. A new start terminates the pending check and initiates a new check.



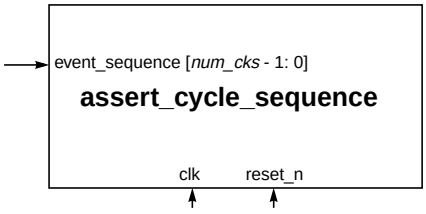
```
assert_change #(
    'OVL_ERROR,                          // severity_level
    1,                                   // width
    3,                                   // num_cks
    'OVL_ERROR_ON_NEW_START,             // action_on_new_start
    'OVL_ASSERT,                         // property_type
    "Error: invalid synchronization",    // msg
    'OVL_COVER_ALL)                      // coverage_level
    valid_sync_out (
        clk,                             // clock
        reset_n,                         // reset
        sync == 1,                       // start_event
        out );                           // test_expr
```

Ensures that out changes within 3 cycles after sync asserts. A new start reports an illegal start event violation (without initiating a new check) but any pending check is retained (even on the last check cycle).



assert_cycle_sequence

Ensures that if a specified necessary condition occurs, it is followed by a specified sequence of events.



Parameters:
severity_level
num_cks
necessary_condition
property_type
msg
coverage_level

Class:
n-cycle assertion

Syntax

```
assert_cycle_sequence
    [#(severity_level, num_cks, necessary_condition, property_type, msg, coverage_level)]
    instance_name (clk, reset_n, event_sequence);
```

Parameters

severity_level	Severity of the failure. Default: ‘OVL_ERROR.
num_cks	Width of the *event_sequence* argument. This parameter must not be less than 2. Default: 2.
necessary_condition	Method for determining the necessary condition that initiates the sequence check and whether or not to pipeline checking. Values are: ‘OVL_TRIGGER_ON_MOST_PIPE, ‘OVL_TRIGGER_ON_FIRST_PIPE and ‘OVL_TRIGGER_ON_FIRST_NOPIPE. Default: ‘OVL_TRIGGER_ON_MOST_PIPE.
property_type	Property type. Default: ‘OVL_ASSERT.
msg	Error message printed when assertion fails. Default: “VIOLATION”.
coverage_level	Coverage level. Default: ‘OVL_COVER_ALL.

Ports

clk	Clock event for the assertion. The checker samples on the rising edge of the clock.
reset_n	Active low synchronous reset signal indicating completed initialization.
event_sequence [*num_cks* - 1: 0]	Expression that is a concatenation where each bit represents an event.

Description

The assert_cycle_sequence assertion checker checks the expression *event_sequence* at the rising edges of *clk* to identify whether or not the bits in *event_sequence* assert sequentially on successive rising edges of *clk*. For example, the following series of 4-bit values (where *b* is any bit value) is a valid sequence:

1*bbb* —> *b*1*bb* —> *bb*1*b* —> *bbb*1

This series corresponds to the following series of events on successive rising edges of *clk*:

cycle 1	event_sequence[3] == 1
cycle 2	event_sequence[2] == 1
cycle 3	event_sequence[1] == 1
cycle 4	event_sequence[0] == 1

The checker also has the ability to pipeline its analysis. Here, one or more new sequences can be initiated and recognized while a sequence is in progress. For example, the following series of 4-bit values (where *b* is any bit value) constitutes two overlapping valid sequences:

```
1bbb —> b1bb —> 1b1b —> b1b1 —> bb1b —> bbb1
```

This series corresponds to the following sequences of events on successive rising edges of clk:

cycle 1	event_sequence[3] == 1	
cycle 2	event_sequence[2] == 1	
cycle 3	event_sequence[1] == 1	event_sequence[3] == 1
cycle 4	event_sequence[0] == 1	event_sequence[2] == 1
cycle 5		event_sequence[1] == 1
cycle 6		event_sequence[0] == 1

When the checker determines that a specified necessary condition has occurred, it subsequently verifies that a specified event or event sequence occurs and if not, the assertion fails.

The method used to determine what constitutes the necessary condition and the resulting trigger event or event sequence is controlled by the *necessary_condition* parameter. The checker has the following actions:

- ‘OVL_TRIGGER_ON_MOST_PIPE

  The necessary condition is that the bits:

  event_sequence [*num_cks* - 1], . . . , *event_sequence* [1]

  are sampled equal to 1 sequentially on successive rising edges of *clk*. When this condition occurs, the checker verifies that the value of *event_sequence*[0] is 1 at the next rising edge of *clk*. If not, the assertion fails.

  The checking is pipelined, which means that if *event_sequence*[*num_cks* -1] is sampled equal to 1 while a sequence (including *event_sequence*[0]) is in progress and subsequently the necessary condition is satisfied, the check of *event_sequence*[0] is performed (unless the first sequence resulted in a fatal assertion violation).

- ‘OVL_TRIGGER_ON_FIRST_PIPE

  The necessary condition is that the *event_sequence* [*num_cks* -1] bit is sampled equal to 1 on a rising edge of *clk*. When this condition occurs, the checker verifies that the bits:

  event_sequence [*num_cks* - 2], . . . , *event_sequence* [0]

  are sampled equal to 1 sequentially on successive rising edges of *clk*. If not, the assertion fails.

  The checking is pipelined, which means that if *event_sequence*[*num_cks* -1] is sampled equal to 1 while a check is in progress, an additional check is initiated.

- ‘OVL_TRIGGER_ON_FIRST_NOPIPE

  The necessary condition is that the *event_sequence* [*num_cks* -1] bit is sampled equal to 1 on a rising edge of *clk*. When this condition occurs, the checker verifies that the bits:

  event_sequence [*num_cks* - 2], . . . , *event_sequence* [0]

  are sampled equal to 1 sequentially on successive rising edges of *clk*. If not, the assertion fails.

  The checking is not pipelined, which means that if *event_sequence*[*num_cks* -1] is sampled equal to 1 while a check is in progress, it is ignored, even if the check is verifying the last bit of the sequence (*event_sequence* [0]).

Assertion Check

ASSERT_CYCLE_SEQUENCE	The necessary condition occurred, but it was not followed by the event or event sequence.
illegal num_cks parameter	The *num_cks* parameter is less than 2.

Cover Point

sequence_trigger	The trigger sequence occurred.

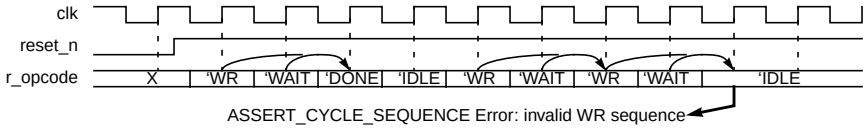
See also

assert_change, assert_unchange

Examples

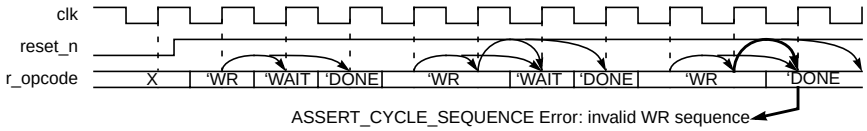
```
assert_cycle_sequence #(
    ‘OVL_ERROR,                                  // severity_level
    3,                                           // num_cks
    ‘OVL_TRIGGER_ON_MOST_PIPE,                   // necessary_condition
    ‘OVL_ASSERT,                                 // property_type
    “Error: invalid WR sequence”,                // msg
    ‘OVL_COVER_ALL)                              // coverage_level
    valid_write_sequence (
        clk,                                     // clock
        reset_n,                                 // reset
        { r_opcode == ‘WR,                       // event_sequence
        r_opcode == ‘WAIT,
        (r_opcode == ‘WR) ||  (r_opcode == ‘DONE)}  );
```

Ensures that a ‘WR, ‘WAIT sequence in consecutive cycles is followed by a ‘DONE or ‘WR. The sequence checking is pipelined.



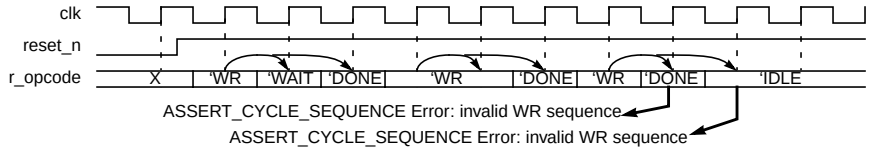

```
assert_cycle_sequence #(
    ‘OVL_ERROR,                                  // severity_level
    3,                                           // num_cks
    ‘OVL_TRIGGER_ON_FIRST_PIPE,                  // necessary_condition
    ‘OVL_ASSERT,                                 // property_type
    “Error: invalid WR sequence”,                // msg
    ‘OVL_COVER_ALL)                              // coverage_level
    valid_write_sequence (
        clk,                                     // clock
        reset_n,                                 // reset
        { r_opcode == ‘WR,                       // event_sequence
        (r_opcode == ‘WAIT) || (r_opcode == ‘WR),
        (r_opcode == ‘WAIT) || (r_opcode == ‘DONE)}  );
```

Ensures that a ‘WR is followed by a ‘WAIT or another ‘WR, which is then followed by a ‘WAIT or a ‘DONE (in consecutive cycles). The sequence checking is pipelined: a new ‘WR during a sequence check initiates an additional check.



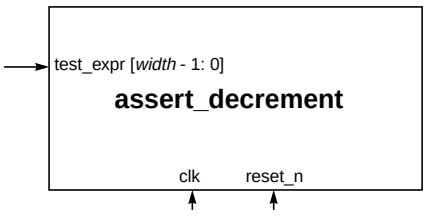
```
assert_cycle_sequence #(
    ‘OVL_ERROR,                                  // severity_level
    3,                                           // num_cks
    ‘OVL_TRIGGER_ON_FIRST_NOPIPE,                // necessary_condition
    ‘OVL_ASSERT,                                 // property_type
    “Error: invalid WR sequence”,                // msg
    ‘OVL_COVER_ALL)                              // coverage_level
    valid_write_sequence (
        clk,                                     // clock
        reset_n,                                 // reset
        { r_opcode == ‘WR,                       // event_sequence
        (r_opcode == ‘WAIT) || (r_opcode == ‘WR),
        (r_opcode == ‘DONE)}  );
```

Ensures that a ‘WR is followed by a ‘WAIT or another ‘WR, which is then followed by a ‘DONE (in consecutive cycles). The sequence checking is not pipelined: a new ‘WR during a sequence check does not initiate an additional check.



assert_decrement

Ensures that the value of a specified expression changes only by the specified decrement value.



Parameters:
severity_level
width
value
property_type
msg
coverage_level

Class:
2-cycle assertion

Syntax

```
assert_decrement
    [#(severity_level, width, value, property_type, msg, coverage_level)]
    instance_name (clk, reset_n, test_expr);
```

Parameters

severity_level	Severity of the failure. Default: ‘OVL_ERROR.
width	Width of the *test_expr* argument. Default: 1.
value	Decrement value for *test_expr*. Default: 1.
property_type	Property type. Default: ‘OVL_ASSERT.
msg	Error message printed when assertion fails. Default: “VIOLATION”.
coverage_level	Coverage level. Default: ‘OVL_COVER_ALL.

Ports

clk		Clock event for the assertion. The checker samples on the rising edge of the clock.
reset_n		Active low synchronous reset signal indicating completed initialization.
test_expr	[*width* - 1: 0]	Expression that should decrement by *value* whenever its value changes from the rising edge of clk to the next rising edge of clk.

Description

The assert_decrement assertion checker checks the expression *test_expr* at each rising edge of *clk* to determine if its value has changed from its value at the previous rising edge of *clk*. If so, the checker verifies that the new value equals the previous value decremented by *value*. The checker allows the value of *test_expr* to wrap, if the total change equals the decrement *value*. For example, if width is 5 and value is 4, then the following change in *test_expr* is valid:

```
5'b00010 —> 5'b11110
```

The checker is useful for ensuring proper changes in structures such as counters and finite-state machines. For example, the checker is useful for circular queue structures with address counters that can wrap. Do not use this checker for variables or expressions that can increment. Instead consider using the assert_delta checker.

Assertion Check

ASSERT_DECREMENT	Expression evaluated to a value that is not its previous value decremented by *value*.

Cover Point

test_expr_change	Expression changed value.

Notes

1. The assertion check compares the current value of *test_expr* with its previous value. Therefore, checking does not start until the second rising clock edge of *clk* after *reset_n* deasserts.

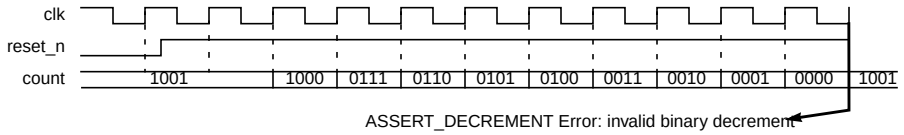
See also

assert_delta, assert_increment, assert_no_underflow

Example

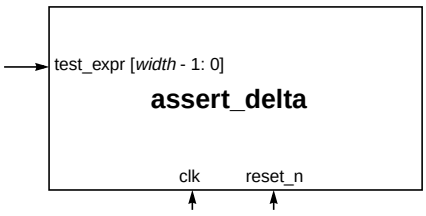
```
assert_decrement #(
    ‘OVL_ERROR,                          // severity_level
    4,                                   // width
    1,                                   // value
    ‘OVL_ASSERT,                         // property_type
    “Error: invalid binary decrement”,   // msg
    ‘OVL_COVER_ALL)                      // coverage_level
    valid_count (
        clk,                             // clock
        reset_n,                         // reset
        count  );                        // test_expr
```

Ensures that the programmable counter’s count variable only decrements by 1. If count wraps, the assertion fails, because the change is not a binary decrement.



assert_delta

Ensures that the value of a specified expression changes only by a value in the specified range.



Parameters:
severity_level
width
min
max
property_type
msg
coverage_level

Class:
2-cycle assertion

Syntax

```
assert_delta
    [ # ( severity_level,  width, min, max, property_type,  msg,  coverage_level ) ]
    instance_name  ( clk, reset_n, test_expr ) ;
```

Parameters

severity_level		Severity of the failure. Default: ‘OVL_ERROR.
width		Width of the *test_expr* argument. Default: 1.
min		Minimum delta value allowed for *test_expr*. Default: 1.
max		Maximum delta value allowed for *test_expr*. Default: 1.
property_type		Property type. Default: ‘OVL_ASSERT.
msg		Error message printed when assertion fails. Default: “VIOLATION”.
coverage_level		Coverage level. Default: ‘OVL_COVER_ALL.

Ports

clk		Clock event for the assertion. The checker samples on the rising edge of the clock.
reset_n		Active low synchronous reset signal indicating completed initialization.
test_expr	[*width* - 1: 0]	Expression that should only change by a delta value in the range min to max.

Description

The assert_delta assertion checker checks the expression *test_expr* at each rising edge of *clk* to determine if its value has changed from its value at the previous rising edge of *clk*. If so, the checker verifies that the difference between the new value and the previous value (i.e., the delta value) is in the range from *min* to *max*, inclusive. If the delta value is less than *min* or greater than *max*, the assertion fails.

The checker is useful for ensuring proper changes in control structures such as up-down counters. For these structures, assert_delta can check for underflow and overflow. In datapath and arithmetic circuits, assert_delta can check for “smooth” transitions of the values of various variables (for example, for a variable that controls a physical variable that cannot detect a severe change from its previous value).

Assertion Check

ASSERT_DELTA	Expression changed value by a delta value not in the range *min* to *max*.

Cover Point

test_expr_change	Expression changed value.

Errors

The parameters *min* and *max* must be specified such that *min* is less than or equal to *max*. Otherwise, the assertion fails on each tested clock cycle.

Notes

1. The assertion check compares the current value of *test_expr* with its previous value. Therefore, checking does not start until the second rising clock edge of *clk* after *reset_n* deasserts.
2. The assertion check allows the value of *test_expr* to wrap. The overflow or underflow amount is included in the delta value calculation.

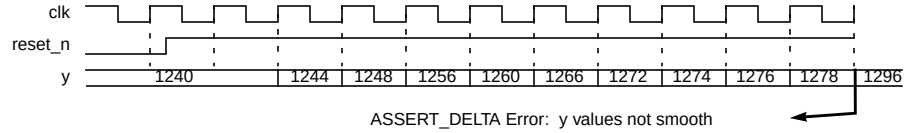
See also

assert_decrement, assert_increment, assert_no_overflow, assert_no_underflow, assert_range

Example

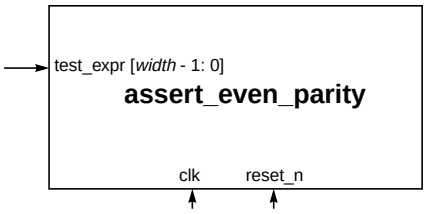
```
assert_delta #(
    ‘OVL_ERROR,                          // severity_level
    16,                                  // width
    0,                                   // min
    8,                                   // max
    ‘OVL_ASSERT,                         // property_type
    “Error: y values not smooth”,        // msg
    ‘OVL_COVER_ALL)                      // coverage_level
    valid_smooth (
        clk,                             // clock
        reset_n,                         // reset
        y  );                            // test_expr
```

Ensures that the y output only changes by a maximum of 8 units each cycle (*min* is 0).



assert_even_parity

Ensures that the value of a specified expression has even parity.



Parameters:
severity_level
width
property_type
msg
coverage_level

Class:
single-cycle assertion

Syntax

```
assert_even_parity
    [#(severity_level, width, property_type, msg, coverage_level)]
    instance_name (clk, reset_n, test_expr);
```

Parameters

severity_level		Severity of the failure. Default: ‘OVL_ERROR.
width		Width of the *test_expr* argument. Default: 1.
property_type		Property type. Default: ‘OVL_ASSERT.
msg		Error message printed when assertion fails. Default: “VIOLATION”.
coverage_level		Coverage level. Default: ‘OVL_COVER_ALL.

Ports

clk		Clock event for the assertion. The checker samples on the rising edge of the clock.
reset_n		Active low synchronous reset signal indicating completed initialization.
test_expr	[*width* - 1: 0]	Expression that should evaluate to a value with even parity on the rising clock edge.

Description

The assert_even_parity assertion checker checks the expression *test_expr* at each rising edge of *clk* to verify the expression evaluates to a value that has even parity. A value has even parity if it is 0 or if the number of bits set to 1 is even.

The checker is useful for verifying control circuits, for example, it can be used to verify a finite-state machine with error detection. In a datapath circuit the checker can perform parity error checking of address and data buses.

Assertion Check

ASSERT_EVEN_PARITY	Expression evaluated to a value whose parity is not even.

Cover Point

test_expr_change	Expression has changed value.

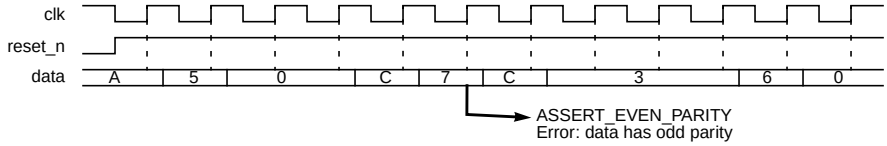
See also

assert_odd_parity

Examples

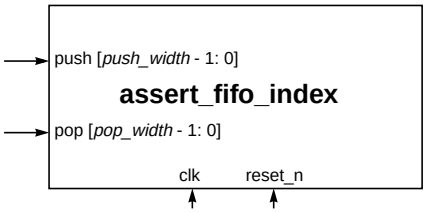
```
assert_even_parity #(
    ‘OVL_ERROR,                          // severity_level
    8,                                   // width
    ‘OVL_ASSERT,                         // property_type
    “Error: data has odd parity”,        // msg
    ‘OVL_COVER_ALL)                      // coverage_level
    valid_data_even_parity (
        clk,                             // clock
        reset_n,                         // reset
        data );                          // test_expr
```

Ensures that data has even parity at each rising edge of clk.



assert_fifo_index

Ensures that a FIFO-type structure never overflows or underflows. This checker can be configured to support multiple pushes (FIFO writes) and pops (FIFO reads) during the same clock cycle.



Parameters:
severity_level
depth
push_width
pop_width
property_type
msg
coverage_level
simultaneous_push_pop

Class:
n-cycle assertion

Syntax

```
assert_fifo_index
    [#( severity_level, depth, push_width, pop_width, property_type,
    msg, coverage_level, simultaneous_push_pop )]
    instance_name ( clk, reset_n, push, pop );
```

Parameters

severity_level	Severity of the failure. Default: ‘OVL_ERROR.
depth	Maximum number of elements in the FIFO or queue structure. This parameter must be > 0. Default: 1.
push_width	Width of the *push* argument. Default: 1.
pop_width	Width of the *pop* argument. Default: 1.
property_type	Property type. Default: ‘OVL_ASSERT.
msg	Error message printed when assertion fails. Default: “VIOLATION”.
coverage_level	Coverage level. Default: ‘OVL_COVER_ALL.
simultaneous_push_pop	Whether or not to allow simultaneous push/pop operations in the same clock cycle. When set to 0, if push and pop operations occur in the same cycle, the assertion fails. Default: 1 (simultaneous push/pop operations are allowed).

Ports

clk		Clock event for the assertion. The checker samples on the rising edge of the clock.
reset_n		Active low synchronous reset signal indicating completed initialization.
push	[*push_width* - 1: 0]	Expression that indicates the number of push operations that will occur during the current cycle.
pop	[*pop_width* - 1: 0]	Expression that indicates the number of pop operations that will occur during the current cycle.

Description

The assert_fifo_index assertion checker tracks the numbers of pushes (writes) and pops (reads) that occur for a FIFO or queue memory structure. This checker does permit simultaneous pushes/pops on the queue within the same clock cycle. It ensures the FIFO never overflows (i.e., too many pushes occur without enough pops) and never underflows (i.e., too many pops occur without enough pushes). This checker is more complex than the assert_no_overflow and

assert_no_underflow checkers, which check only the boundary conditions (overflow and underflow respectively).

Assertion Checks

OVERLOW	Push operation overflowed the FIFO.
UNDERFLOW	Pop operation underflowed the FIFO.
ILLEGAL PUSH AND POP	Push and pop operations performed in the same clock cycle, but the simultaneous_push_pop parameter is set to 0.

Cover Points

fifo_push	Push operation.
fifo_pop	Pop operation.
fifo_full	FIFO full.
fifo_empty	FIFO empty.
fifo_simultaneous_push_pop	Push and pop operations in the same clock cycle.

Errors

Depth parameter value must be > 0	Depth parameter is set to 0.

Notes

1. The checker checks the values of the *push* and *pop* expressions. By default, (i.e., simultaneous_push_pop is 1), “simultaneous” push/pop operations are allowed. In this case, the checker assumes the design properly handles simultaneous push/pop operations, so it only ensures that the FIFO buffer index at the *end of the cycle* has not overflowed or underflowed. The assertion cannot ensure the FIFO buffer index does not overflow between a push and pop performed in the same cycle. Similarly, the assertion cannot ensure the FIFO buffer index does not underflow between a pop and push performed in the same cycle.

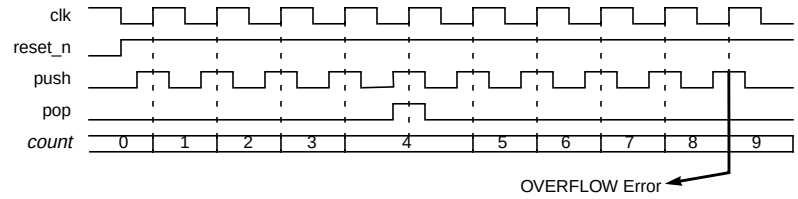
See also

assert_no_overflow, assert_no_underflow

Examples

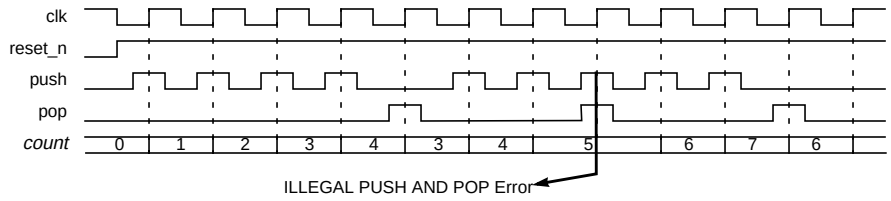
```
assert_fifo_index #(
    ‘OVL_ERROR,                 // severity_level
    8,                          // depth
    1,                          // push_width
    1,                          // pop_width
    ‘OVL_ASSERT,                // property_type
    “Error”,                    // msg
    ‘OVL_COVER_ALL,             // coverage_level
    1)                          // simultaneous_push_pop
    no_over_underflow (
        clk,                    // clock
        reset_n,                // reset
        push,                   // push
        pop);                   // pop
```

Ensures that an 8-element FIFO never overflows or underflows. Only single pushes and pops can occur in a clock cycle (*push_width* and *pop_width* values are 1). A push and pop operation in the same clock cycle is allowed (value of *simultaneous_push_pop* is 1).



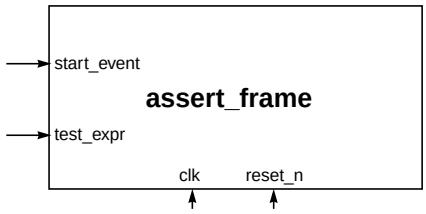

```
assert_fifo_index #(
    ‘OVL_ERROR,                     // severity_level
    8,                              // depth
    1,                              // push_width
    1,                              // pop_width
    ‘OVL_ASSERT,                    // property_type
    “violation”,                    // msg
    ‘OVL_COVER_ALL                  // coverage_level
    0)                              // simultaneous_push_pop
    no_over_underflow (
        clk,                        // clock
        reset_n,                    // reset
        push,                       // push
        pop);                       // pop
```

Ensures that an 8-element FIFO never overflows or underflows and that in no cycle do both push and pop operations occur.



assert_frame

Ensures that when a specified start event is TRUE, then a specified expression must not evaluate TRUE before a minimum number of clock cycles and must transition to TRUE no later than a maximum number of clock cycles.



Parameters:
severity_level
min_cks
max_cks
action_on_new_start
property_type
msg
coverage_level

Class:
n-cycle assertion

Syntax

```
assert_frame
    [#( severity_level, min_cks, max_cks, action_on_new_start, property_type,
    msg, coverage_level )]
    instance_name ( clk, reset_n, start_event, test_expr ) ;
```

Parameters

severity_level	Severity of the failure. Default: ‘OVL_ERROR.
min_cks	Number of cycles after the start event that *test_expr* must not evaluate to TRUE. The special case where *min_cks* is 0 turns off minimum checking (i.e., *test_expr* can be TRUE in the same clock cycle as the start event). Default: 0.
max_cks	Number of cycles after the start event that during which *test_expr* must transition to TRUE. The special case where *max_cks* is 0 turns off maximum checking (i.e., *test_expr* does not need to transition to TRUE). Default: 0.
action_on_new_start	Method for handling a new start event that occurs while a check is pending. Values are: ‘OVL_IGNORE_NEW_START, ‘OVL_RESET_ON_NEW_START and ‘OVL_ERROR_ON_NEW_START. Default: ‘OVL_IGNORE_NEW_START.
property_type	Property type. Default: ‘OVL_ASSERT.
msg	Error message printed when assertion fails. Default: “VIOLATION”.
coverage_level	Coverage level. Default: ‘OVL_COVER_ALL.

Ports

clk	Clock event for the assertion. The checker samples on the rising edge of the clock.
start_event	Expression that (along with *action_on_new_start*) identifies when to initiate checking of *test_expr*.
test_expr	Expression that should not evaluate to TRUE for *min_cks -1* cycles after *start_event* initiates a check (unless *min_cks* is 0) and that should evaluate to TRUE before *max_cks* cycles transpire (unless *max_cks* is 0).

Description

The assert_frame assertion checker checks for a start event at each rising edge of *clk.* A start event occurs if *start_event* has transitioned to TRUE, either at the clock edge or in the previous cycle. A start event also occurs if *start_event* is TRUE at the rising clock edge after a checker reset.

When a start event occurs, the checker performs the following steps:

1. Unless it is disabled by setting *min_cks* to 0, a minimum check is initiated. The check evaluates *test_expr* at each subsequent rising edge of *clk* for the next *min_cks* cycles. However, if a sampled value of *test_expr* is TRUE, the minimum check fails and the checker returns to the state of waiting for a start event.
2. Unless it is disabled by setting *max_cks* to 0 (or a minimum violation has occurred), a maximum check is initiated. The check evaluates *test_expr* at each subsequent rising edge of *clk* for the next (*max_cks - min_cks*) cycles. However, if a sampled value of *test_expr* is TRUE, the checker returns to the state of waiting for a start event. If its value does not transition to TRUE by the time *max_cks* cycles transpire (from the start of checking), the maximum check fails at cycle *max_cks.*
3. The checker returns to the state of waiting for a start event.

The method used to determine how to handle *start_event* when the checker is in the state of checking *test_expr* is controlled by the *action_on_new_start* parameter. The checker has the following actions:

- ‘OVL_IGNORE_NEW_START

  The checker does not sample *start_event* until it returns to the state of waiting for a start event.

- ‘OVL_RESET_ON_NEW_START

  Each time the checker samples *test_expr*, it also samples *start_event.* If *start_event* is TRUE, the checker first checks whether a pending minimum check is just failing. If so, the assertion failed. Then—unless the assertion failed and it was fatal—the checker terminates the current checks and initiates a new pair of checks.

- ‘OVL_ERROR_ON_NEW_START

  Each time the checker samples *test_expr*, it also samples *start_event.* If *start_event* is TRUE, the assertion fails with an illegal start event error. If the error is not fatal, the checker returns to the state of waiting for a start event at the next rising clock edge.

Assertion Checks

ASSERT_FRAME	The value of *test_expr* was TRUE before *min_cks* cycles after *start_event* was sampled TRUE or its value was not TRUE before *max_cks* cycles transpired after the rising edge of *start_event.*
illegal start event	The *action_on_new_start* parameter is set to ‘OVL_ERROR_ON_NEW_START and *start_event* expression evaluated to TRUE while the checker was monitoring *test_expr.*
min_cks > max_cks	The *min_cks* parameter is greater than the *max_cks* parameter (and *max_cks* >0). Unless the violation is fatal, either the minimum or maximum check will fail.

Cover Point

start_event	The value of *start_event* was TRUE on a rising edge of *clk.*

Notes

1. The special case where *min_cks* and *max_cks* are both 0 is the default. Here, *test_expr* must be TRUE every cycle there is a start event.

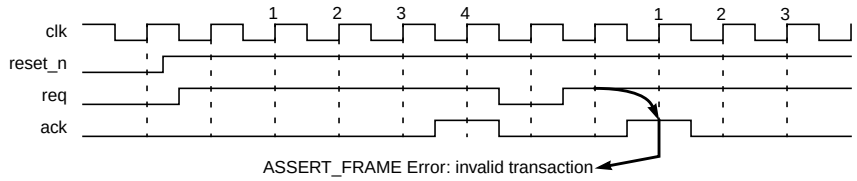
See also

assert_change, assert_next, assert_time, assert_unchange, assert_width

Examples

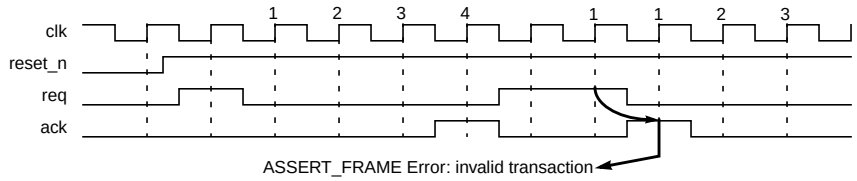
```
assert_frame #(
    'OVL_ERROR,                          // severity_level
    2,                                   // min_cks
    4,                                   // max_cks
    'OVL_IGNORE_NEW_START,               // action_on_new_start
    'OVL_ASSERT,                         // property_type
    "Error: invalid transaction",        // msg
    'OVL_COVER_ALL)                      // coverage_level
    valid_transaction (
        clk,                             // clock
        reset_n,                         // reset
        req,                             // start_event
        ack);                            // test_expr
```

Ensures that after a rising edge of `req`, `ack` goes high between 2 and 4 cycles later. New start events during transactions are not considered to be new transactions and are ignored.



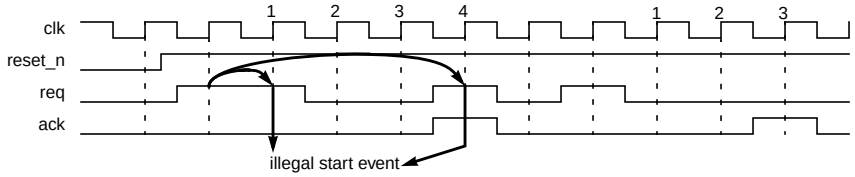

```
assert_frame #(
    'OVL_ERROR,                          // severity_level
    2,                                   // min_cks
    4,                                   // max_cks
    'OVL_RESET_ON_NEW_START,             // action_on_new_start
    'OVL_ASSERT,                         // property_type
    "Error: invalid transaction",        // msg
    'OVL_COVER_ALL)                      // coverage_level
    valid_transaction (
        clk,                             // clock
        reset_n,                         // reset
        req,                             // start_event
        ack);                            // test_expr
```

Ensures that after a rising edge of `req`, `ack` goes high between 2 and 4 cycles later. A new start event during a transaction restarts the transaction.



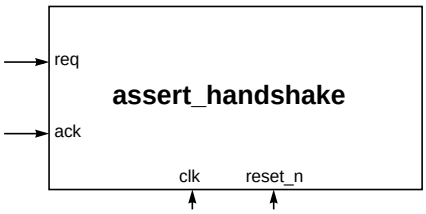
```
assert_frame #(
    ‘OVL_ERROR,                          // severity_level
    2,                                   // min_cks
    4,                                   // max_cks
    ‘OVL_ERROR_ON_NEW_START,             // action_on_new_start
    ‘OVL_ASSERT,                         // property_type
    “Error: invalid transaction”,        // msg
    ‘OVL_COVER_ALL)                      // coverage_level
    valid_transaction (
        clk,                             // clock
        reset_n,                         // reset
        req,                             // start_event
        ack);                            // test_expr
```

Ensures that after a rising edge of `req`, `ack` goes high between 2 and 4 cycles later. Also ensures that a new transaction does not start before the previous transaction is acknowledged. If a start event occurs during a transaction, the checker does does not initiate a new check.



assert_handshake

Ensures that specified request and acknowledge signals follow a specified handshake protocol.



Parameters:
severity_level
min_ack_cycle
max_ack_cycle
req_drop
deassert_count
max_ack_length
property_type
msg
coverage_level

Class:
event-bounded assertion

Syntax

```
assert_handshake
    [#( severity_level, min_ack_cycle, max_ack_cycle, req_drop, deassert_count,
    max_ack_length, property_type, msg, coverage_level )]
    instance_name ( clk, reset_n, req, ack );
```

Parameters

severity_level	Severity of the failure. Default: ‘OVL_ERROR.
min_ack_cycle	Minimum number of clock cycles before acknowledge. A value of 0 turns off the ack min cycle check. Default: 0.
max_ack_cycle	Maximum number of clock cycles before acknowledge. A value of 0 turns off the ack max cycle check. Default: 0.
req_drop	If greater than 0, value of *req* must remain TRUE until acknowledge. A value of 0 turns off the req drop check. Default: 0.
deassert_count	Maximum number of clock cycles after acknowledge that *req* can remain TRUE (i.e., *req* must not be stuck active). A value of 0 turns off the req deassert check. Default: 0.
max_ack_length	Maximum number of clock cycles that *ack* can be TRUE. A value of 0 turns off the max ack length check. Default: 0.
property_type	Property type. Default: ‘OVL_ASSERT.
msg	Error message printed when assertion fails. Default: “VIOLATION”.
coverage_level	Coverage level. Default: ‘OVL_COVER_ALL.

Ports

clk	Clock event for the assertion. The checker samples on the rising edge of the clock.
reset_n	Active low synchronous reset signal indicating completed initialization.
req	Expression that starts a transaction.
ack	Expression that indicates the transaction is complete.

Description

The assert_handshake assertion checker checks the single-bit expressions *req* and *ack* at each rising edge of *clk* to verify their values conform to the request-acknowledge handshake protocol specified by the checker parameters. A request event (where *req* transitions to TRUE) initiates a transaction on the rising edge of the clock and an acknowledge event (where *ack* transitions to

TRUE) signals the transaction is complete on the rising edge of the clock. The transaction must not include multiple request events and every acknowledge must have a pending request. Other checks—to ensure the acknowledge is received in a specified window, the request is held active until the acknowledge, the requests and acknowledges are not stuck active and the pulse length is not too long—are enabled and controlled by the checker's parameters.

When a violation occurs, the checker discards any pending request. Checking is restarted the next cycle that ack is sampled FALSE.

Assertion Checks

multiple req violation	The value of *req* transitioned to TRUE while waiting for an acknowledge or while acknowledge was asserted. Extra requests do not initiate new transactions.
ack without req violation	The value of *ack* transitioned to TRUE without a pending request.
ack min cycle violation	The value of ack transitioned to TRUE before *min_ack_cycle* clock cycles transpired after the request.
ack max cycle violation	The value of *ack* did not transition to TRUE before *max_ack_cycle* clock cycles transpired after the request.
req drop violation	The value of *req* transitioned from TRUE before an acknowledge.
req deassert violation	The value of req did not transition from TRUE before *deassert_count* clock cycles transpired after an acknowledge.
ack max length violation	The value of ack did not transition from TRUE before *max_ack_length* clock cycles transpired after an acknowledge.

Cover Points

req_asserted	A transaction initiated.
ack_asserted	A transaction completed.

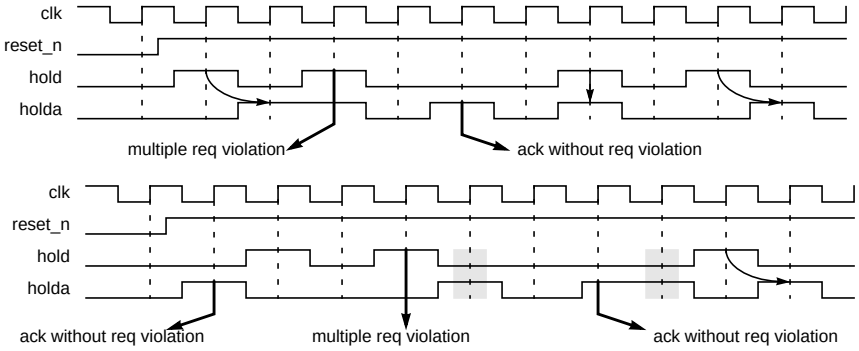
See also

assert_window, assert_win_change, assert_win_unchange

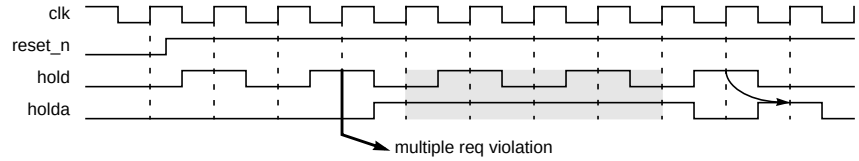
Examples

```
assert_handshake #(
    'OVL_ERROR,                          // severity_level
    0,                                   // min_ack_cycle
    0,                                   // max_ack_cycle
    0,                                   // req_drop
    0,                                   // deassert_count
    0,                                   // max_ack_length
    'OVL_ASSERT,                         // property_type
    "hold-holda handshake error",        // msg
    'OVL_COVER_ALL)                      // coverage_level
    valid_hold_holda (
        clk,                             // clock
        reset_n,                         // reset
        hold,                            // req
        holda);                          // ack
```

Ensures that multiple hold requests are not made while waiting for a holda acknowledge and that every holda acknowledge is in response to a unique hold request.

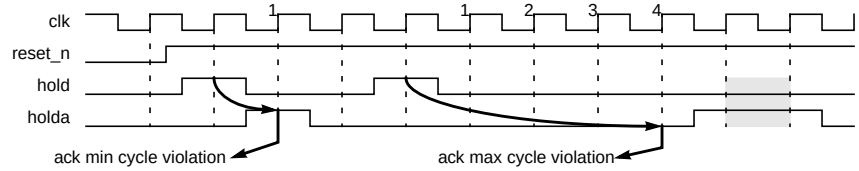


After a violation, checking is turned off until holda acknowledge is sampled deasserted.



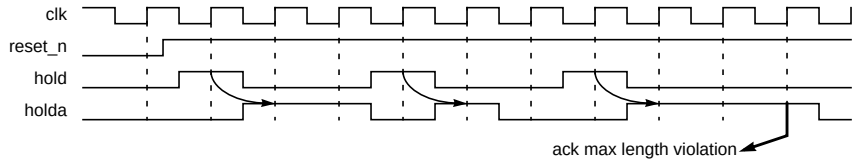

```
assert_handshake #(
    ‘OVL_ERROR,                          // severity_level
    2,                                   // min_ack_cycle
    3,                                   // max_ack_cycle
    0,                                   // req_drop
    0,                                   // deassert_count
    0,                                   // max_ack_length
    ‘OVL_ASSERT,                         // property_type
    “hold-holda handshake error”,        // msg
    ‘OVL_COVER_ALL)                      // coverage_level
    valid_hold_holda (
        clk,                             // clock
        reset_n,                         // reset
        hold,                            // req
        holda);                          // ack
```

Ensures that multiple hold requests are not made while waiting for a holda acknowledge and that every holda acknowledge is in response to a unique hold request. Ensures holda acknowledge asserts 2 to 3 cycles after each hold request.



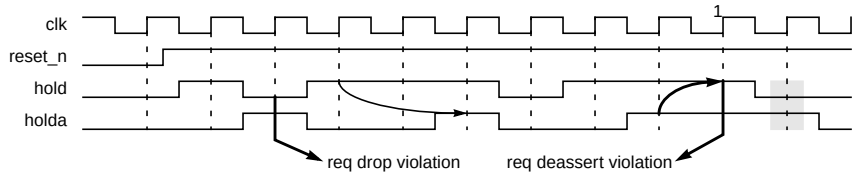
```
assert_handshake #(
    ‘OVL_ERROR,                          // severity_level
    0,                                   // min_ack_cycle
    0,                                   // max_ack_cycle
    0,                                   // req_drop
    0,                                   // deassert_count
    2,                                   // max_ack_length
    ‘OVL_ASSERT,                         // property_type
    “hold-holda handshake error”,        // msg
    ‘OVL_COVER_ALL)                      // coverage_level
    valid_hold_holda (
        clk,                             // clock
        reset_n,                         // reset
        hold,                            // req
        holda);                          // ack
```

Ensures that multiple hold requests are not made while waiting for a holda acknowledge and that every holda acknowledge is in response to a unique hold request. Ensures holda acknowledge asserts for 2 cycles.



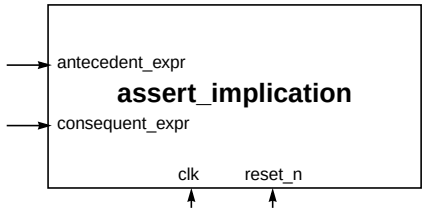

```
assert_handshake #(
    ‘OVL_ERROR,                          // severity_level
    0,                                   // min_ack_cycle
    0,                                   // max_ack_cycle
    1,                                   // req_drop
    1,                                   // deassert_count
    0,                                   // max_ack_length
    ‘OVL_ASSERT,                         // property_type
    “hold-holda handshake error”,        // msg
    ‘OVL_COVER_ALL)                      // coverage_level
    valid_hold_holda (
        clk,                             // clock
        reset_n,                         // reset
        hold,                            // req
        holda);                          // ack
```

Ensures that multiple hold requests are not made while waiting for a holda acknowledge and that every holda acknowledge is in response to a unique hold request. Ensures hold request remains asserted until its holda acknowledge and then deasserts in the next cycle.



assert_implication

Ensures that a specified consequent expression is TRUE if the specified antecedent expression is TRUE.



Parameters:
severity_level
property_type
msg
coverage_level

Class:
single-cycle assertion

Syntax

```
assert_implication
    [#(severity_level, property_type, msg, coverage_level)]
    instance_name (clk, reset_n, antecedent_expr, consequent_expr);
```

Parameters

severity_level	Severity of the failure. Default: ‘OVL_ERROR.
property_type	Property type. Default: ‘OVL_ASSERT.
msg	Error message printed when assertion fails. Default: “VIOLATION”.
coverage_level	Coverage level. Default: ‘OVL_COVER_ALL.

Ports

clk	Clock event for the assertion. The checker samples on the rising edge of the clock.
reset_n	Active low synchronous reset signal indicating completed initialization.
antecedent_expr	Antecedent expression that is tested at the clock event.
consequent_expr	Consequent expression that should evaluate to TRUE if *antecedent_expr* evaluates to TRUE when tested.

Description

The assert_implication assertion checker checks the single-bit expression *antecedent_expr* at each rising edge of *clk*. If *antecedent_expr* is TRUE, then the checker verifies that the value of *consequent_expr* is also TRUE. If *antecedent_expr* is not TRUE, then the assertion is valid regardless of the value of *consequent_expr*.

Assertion Check

ASSERT_IMPLICATION	Expression evaluated to FALSE.

Cover Point

cover_antecedent	The *antecedent_expr* evaluated to TRUE.

Notes

1. This assertion checker is equivalent to:

```
assert_always
    [#(severity_level, property_type, msg, coverage_level)]
    instance_name (clk, reset_n, (antecedent_expr ? consequent_expr : 1'b1 ));
```

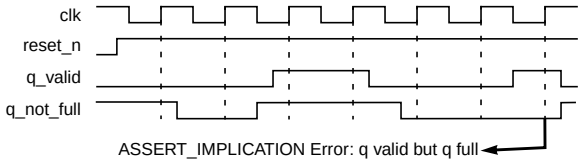
See also

assert_always, assert_always_on_edge, assert_never, assert_proposition

Example

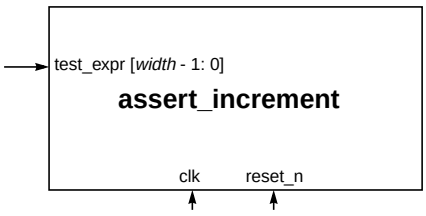
```
assert_implication #(
    'OVL_ERROR,                          // severity_level
    'OVL_ASSERT,                         // property_type
    "Error: q valid but q full",         // msg
    'OVL_COVER_ALL)                      // coverage_level
    not_full (
        clk,                             // clock
        reset_n,                         // reset
        q_valid,                         // antecedent_expr
        q_not_full );                    // consequent_expr
```

Ensures that q_not_full is TRUE at each rising edge of clk for which q_valid is TRUE.



assert_increment

Ensures that the value of a specified expression changes only by the specified increment value.



Parameters:
severity_level
width
value
property_type
msg
coverage_level

Class:
2-cycle assertion

Syntax

```
assert_increment
    [#(severity_level, width, value, property_type, msg, coverage_level)]
    instance_name (clk, reset_n, test_expr);
```

Parameters

severity_level	Severity of the failure. Default: ‘OVL_ERROR.
width	Width of the *test_expr* argument. Default: 1.
value	Increment value for *test_expr*. Default: 1.
property_type	Property type. Default: ‘OVL_ASSERT.
msg	Error message printed when assertion fails. Default: “VIOLATION”.
coverage_level	Coverage level. Default: ‘OVL_COVER_ALL.

Ports

clk		Clock event for the assertion. The checker samples on the rising edge of the clock.
reset_n		Active low synchronous reset signal indicating completed initialization.
test_expr	[*width* - 1: 0]	Expression that should increment by *value* whenever its value changes from the rising edge of clk to the next rising edge of clk.

Description

The assert_increment assertion checker checks the expression *test_expr* at each rising edge of *clk* to determine if its value has changed from its value at the previous rising edge of *clk*. If so, the checker verifies that the new value equals the previous value incremented by *value*. The checker allows the value of *test_expr* to wrap, if the total change equals the increment *value*. For example, if *width* is 5 and *value* is 4, then the following change in *test_expr* is valid:

```
5'b11110 —> 5'b00010
```

The checker is useful for ensuring proper changes in structures such as counters and finite-state machines. For example, the checker is useful for circular queue structures with address counters that can wrap. Do not use this checker for variables or expressions that can decrement. Instead consider using the assert_delta checker.

Assertion Check

ASSERT_INCREMENT	Expression evaluated to a value that is not its previous value incremented by *value*.

Cover Point

test_expr_change	Expression changed value.

Notes

1. The assertion check compares the current value of *test_expr* with its previous value. Therefore, checking does not start until the second rising clock edge of *clk* after *reset_n* deasserts.

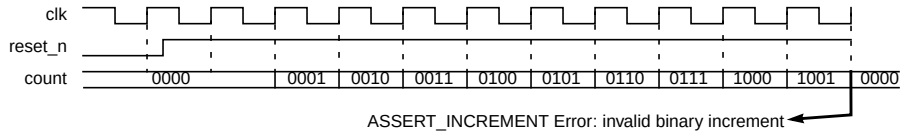
See also

assert_decrement, assert_delta, assert_no_overflow

Example

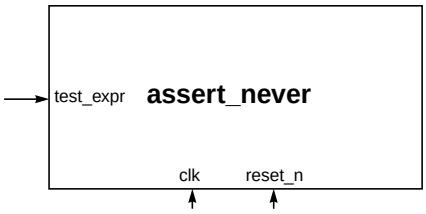
```
assert_increment #(
    ‘OVL_ERROR,                          // severity_level
    4,                                   // width
    1,                                   // value
    ‘OVL_ASSERT,                         // property_type
    “Error: invalid binary increment”,   // msg
    ‘OVL_COVER_ALL)                      // coverage_level
    valid_count (
        clk,                             // clock
        reset_n,                         // reset
        count  );                        // test_expr
```

Ensures that the programmable counter’s count variable only increments by 1. If count wraps, the assertion fails, because the change is not a binary increment.



assert_never

Ensures that the value of a specified expression is not TRUE.



Parameters:
severity_level
property_type
msg
coverage_level

Class:
single-cycle assertion

Syntax

```
assert_never
        [#(severity_level, property_type, msg, coverage_level)]
        instance_name (clk, reset_n, test_expr);
```

Parameters

severity_level	Severity of the failure. Default: ‘OVL_ERROR.
property_type	Property type. Default: ‘OVL_ASSERT.
msg	Error message printed when assertion fails. Default: “VIOLATION”.
coverage_level	Coverage level. Default: ‘OVL_COVER_ALL.

Ports

clk	Clock event for the assertion. The checker samples on the rising edge of the clock.
reset_n	Active low synchronous reset signal indicating completed initialization.
test_expr	Expression that should not evaluate to TRUE on the rising clock edge.

Description

The assert_never assertion checker checks the single-bit expression *test_expr* at each rising edge of *clk* to verify the expression does not evaluate to TRUE.

Assertion Checks

ASSERT_NEVER	Expression evaluated to TRUE.
test_expr contains X/Z value	Expression evaluated to X or Z, and ‘OVL_XCHECK_OFF is not set.

Cover Points

none

Notes

1. By default, the assert_never assertion is pessimistic and the assertion fails if *test_expr* is not 0 (i.e.equals 1, X, Z, etc.). However, if ‘OVL_XCHECK_OFF is set, the assertion fails if and only if *test_expr* is 1.

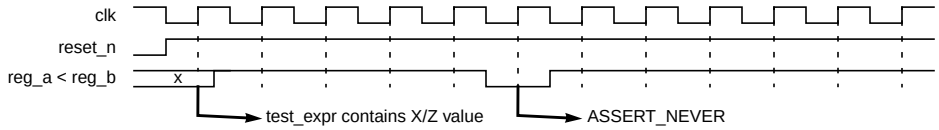
See also

assert_always, assert_always_on_edge, assert_implication, assert_proposition

Example

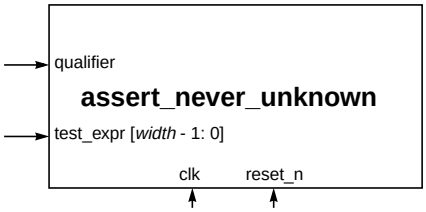
```
assert_never #(
    ‘OVL_ERROR,                          // severity_level
    ‘OVL_ASSERT,                         // property_type
    “”,                                  // msg
    ‘OVL_COVER_ALL)                      // coverage_level
    valid_count (
        clk,                             // clock
        reset_n,                         // reset
        reg_a < reg_b );                 // test_expr
```

Ensures that (`reg_a < reg_b`) is FALSE at each rising edge of `clk`.



assert_never_unknown

Ensures that the value of a specified expression contains only 0 and 1 bits when a qualifying expression is TRUE.



Parameters:
severity_level
width
property_type
msg
coverage_level

Class:
single-cycle assertion

Syntax

```
assert_never_unknown
    [ # ( severity_level,  width, property_type,  msg,  coverage_level ) ]
    instance_name ( clk, reset_n, qualifier, test_expr ) ;
```

Parameters

severity_level		Severity of the failure. Default: ‘OVL_ERROR.
width		Width of the *test_expr* argument. Default: 1.
property_type		Property type. Default: ‘OVL_ASSERT.
msg		Error message printed when assertion fails. Default: “VIOLATION”.
coverage_level		Coverage level. Default: ‘OVL_COVER_ALL.

Ports

clk		Clock event for the assertion. The checker samples on the rising edge of the clock.
reset_n		Active low synchronous reset signal indicating completed initialization.
qualifier		Expression that indicates whether or not to check *test_expr* .
test_expr	[*width* - 1: 0]	Expression that should contain only 0 or 1 bits when qualifier is TRUE.

Description

The assert_never_unknown assertion checker checks the expression *qualifier* at each rising edge of *clk* to determine if it should check *test_expr*. If *qualifier* is sampled TRUE, the checker evaluates *test_expr* and if the value of *test_expr* contains a bit that is not 0 or 1, the assertion fails.

The checker is useful for ensuring certain data have only known values following a reset sequence. It also can be used to verify tristate input ports are driven and tristate output ports drive known values when necessary.

Assertion Checks

test_expr contains X/Z value	The *test_expr* expression contained at least one bit that was not 0 or 1; *qualifier* was sampled TRUE; and ‘OVL_XCHECK_OFF is not set.

Cover Points

qualifier	A never_unknown check was initiated.
test_expr_change	Expression changed value.

Notes

1. If ‘OVL_XCHECK_OFF is set, all assert_never_unknown checkers are turned off.

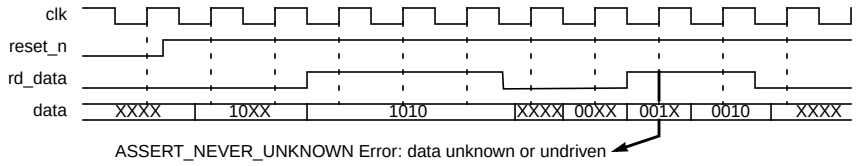
See also

assert_never, assert_one_cold, assert_one_hot, assert_zero_one_hot

Example

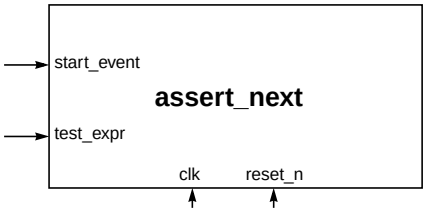
```
assert_never_unknown #(
    ‘OVL_ERROR,                          // severity_level
    8,                                   // width
    ‘OVL_ASSERT,                         // property_type
    “Error: data unknown or undriven”,   // msg
    ‘OVL_COVER_ALL)                      // coverage_level
    valid_data (
        clk,                             // clock
        reset_n,                         // reset
        rd_data,                         // qualifier
        data);                           // test_expr
```

Ensures that values of data are known and driven when rd_data is TRUE.



assert_next

Ensures that the value of a specified expression is TRUE a specified number of cycles after a start event.



Parameters:
severity_level
num_cks
check_overlapping
check_missing_start
property_type
msg
coverage_level

Class:
n-cycle assertion

Syntax

```
assert_next
    [ # ( severity_level, num_cks, check_overlapping,  check_missing_start, property_type,
    msg, coverage_level ) ]
    instance_name ( clk, reset_n, start_event, test_expr ) ;
```

Parameters

severity_level	Severity of the failure. Default: ‘OVL_ERROR.
num_cks	Number of cycles after *start_event* is TRUE to wait to check that the value of *test_expr* is TRUE. Default: 1.
check_overlapping	Whether or not to perform overlap checking. Default: 1 (overlap checking off). • If set to 0, overlap checking is performed. From the rising edge of *clk* after *start_event* is sampled TRUE to the rising edge of *clk* that *test_expr* is sampled for the current next check, the checker performs an overlap check. During this interval, if *start_event* is TRUE at a rising edge of *clk*, then the overlap check fails (illegal overlapping condition). The current next check continues but a new next check is not initiated. • If set to 1, overlap checking is not performed. A separate next check is initiated each time *start_event* is sampled TRUE (overlapping start events are allowed).
check_missing_start	Whether or not to perform missing-start checking. Default: 0 (missing-start checking off). • If set to 0, missing start checks are not performed. • If set to 1, missing start checks are performed. The checker samples *test_expr* every rising edge of *clk*. If the value of *test_expr* is TRUE, then *num_cks* rising edges of *clk* prior to the current time, *start_event* must have been TRUE (initiating a next check). If not, the missing-start check fails (start_event without test_expr).
property_type	Property type. Default: ‘OVL_ASSERT.
msg	Error message printed when assertion fails. Default: “VIOLATION”.
coverage_level	Coverage level. Default: ‘OVL_COVER_ALL.

Ports

clk	Clock event for the assertion. The checker samples on the rising edge of the clock.
reset_n	Active low synchronous reset signal indicating completed initialization.

start_event	Expression that (along with *num_cks*) identifies when to check *test_expr.*
test_expr	Expression that should evaluate to TRUE *num_cks* cycles after *start_event* initiates a next check.

Description

The assert_next assertion checker checks the expression *start_event* at each rising edge of *clk.* If *start_event* is TRUE, a check is initiated. The check waits for *num_cks* cycles (i.e., for *num_cks* additional rising edges of *clk*) and evaluates *test_expr.* If *test_expr* is not TRUE, the assertion fails.

If overlap checking is off (*check_overlapping* is 1), additional checks can start while a current check is pending. If overlap checking is on, the assertion fails if *start_event* is sampled TRUE while a check is pending.

If missing-start checking is off (*check_missing_start* is 0), *test_expr* can be TRUE any time. If missing-start checking is on, the assertion fails if *test_expr* is TRUE without a corresponding start event (*num_cks* cycles previously).

Assertion Checks

start_event without test_expr	The value of *start_event* was TRUE on a rising edge of *clk*, but *num_cks* cycles later the value of *test_expr* was not TRUE.
illegal overlapping condition detected	The *check_overlapping* parameter is set to 0 and *start_event* was TRUE on the rising edge of *clk*, but a previous check was pending.
test_expr without start_event	The *check_missing_start* parameter is set to 1 and *start_event* was not TRUE on the rising edge of *clk*, but *num_cks* cycles later *test_expr* was TRUE.
num_cks parameter<=0	The *num_cks* parameter is less than 2.

Cover Points

start_event	The value of *start_event* was TRUE on a rising edge of *clk.*
overlapping_start_events	The value of *start_event* was TRUE on a rising edge of *clk* while a check was pending.

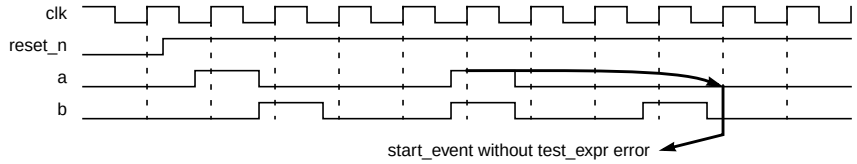
See also

assert_change, assert_frame, assert_time, assert_unchange

Examples

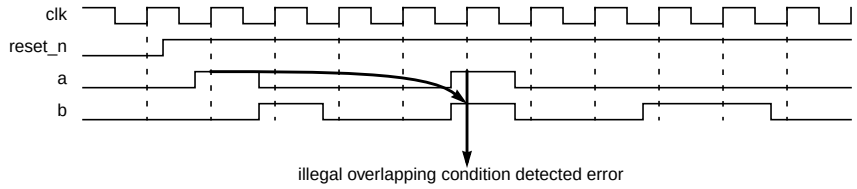
```
assert_next #(
    ‘OVL_ERROR,                 // severity_level
    4,                          // num_cks
    1,                          // check_overlapping (off)
    0,                          // check_missing_start (off)
    ‘OVL_ASSERT,                // property_type
    “error:”,                   // msg
    ‘OVL_COVER_ALL)             // coverage_level
    valid_next_a_b (
        clk,                    // clock
        reset_n,                // reset
        a,                      // start_event
        b );                    // test_expr
```

Ensures that b is TRUE 4 cycles after a is TRUE.



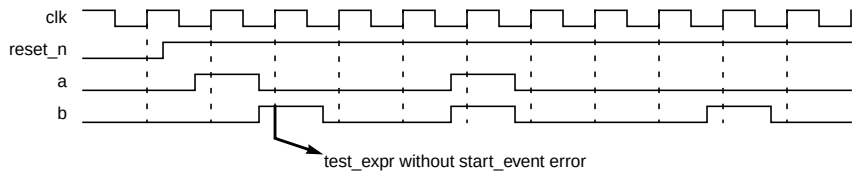

```
assert_next #(
    ‘OVL_ERROR,                 // severity_level
    4,                          // num_cks
    0,                          // check_overlapping (on)
    0,                          // check_missing_start (off)
    ‘OVL_ASSERT,                // property_type
    “error:”,                   // msg
    ‘OVL_COVER_ALL)             // coverage_level
    valid_next_a_b (
        clk,                    // clock
        reset_n,                // reset
        a,                      // start_event
        b );                    // test_expr
```

Ensures that b is TRUE 4 cycles after a is TRUE. Overlaps are not allowed



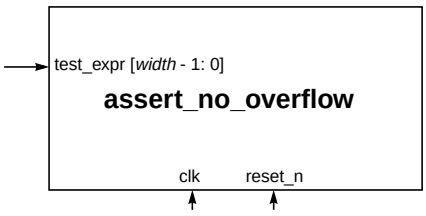

```
assert_next #(
    ‘OVL_ERROR,                 // severity_level
    4,                          // num_cks
    1,                          // check_overlapping (off)
    1,                          // check_missing_start (on)
    ‘OVL_ASSERT,                // property_type
    “error:”,                   // msg
    ‘OVL_COVER_ALL)             // coverage_level
    valid_next_a_b (
        clk,                    // clock
        reset_n,                // reset
        a,                      // start_event
        b );                    // test_expr
```

Ensures that b is TRUE 4 cycles after a is TRUE. Missing-start check is on.



assert_no_overflow

Ensures that the value of a specified expression does not overflow.



Parameters:
severity_level
width
min
max
property_type
msg
coverage_level

Class:
2-cycle assertion

Syntax

```
assert_no_overflow
    [ # ( severity_level,  width, min, max, property_type,  msg,  coverage_level ) ]
    instance_name  ( clk, reset_n, test_expr ) ;
```

Parameters

severity_level	Severity of the failure. Default: ‘OVL_ERROR.
width	Width of the *test_expr* argument. Width must be less than or equal to 32. Default: 1.
min	Minimum value in the test range of *test_expr*. Default: 0.
max	Maximum value in the test range of *test_expr*. Default: 2**_width_ - 1.
property_type	Property type. Default: ‘OVL_ASSERT.
msg	Error message printed when assertion fails. Default: “VIOLATION”.
coverage_level	Coverage level. Default: ‘OVL_COVER_ALL.

Ports

clk		Clock event for the assertion. The checker samples on the rising edge of the clock.
reset_n		Active low synchronous reset signal indicating completed initialization.
test_expr	[*width* - 1: 0]	Expression that should not change from a value of *max* to a value out of the test range or to a value equal to *min*.

Description

The assert_no_overflow assertion checker checks the expression *test_expr* at each rising edge of *clk* to determine if its value has changed from a value (at the previous rising edge of *clk*) that was equal to *max*. If so, the checker verifies that the new value has not overflowed *max*. That is, it verifies the value of *test_expr* is not greater than *max* or less than or equal to *min* (in which case, the assertion fails).

The checker is useful for verifying counters, where it can ensure the counter does not wrap from the highest value to the lowest value in a specified range. For example, it can be used to check that memory structure pointers do not wrap around. For a more general test for overflow, use assert_delta or assert_fifo_index.

Assertion Check

ASSERT_NO_OVERFLOW	Expression changed value from *max* to a value not in the range *min* + 1 to *max* - 1.

Cover Points

test_expr_change	Expression changed value.
test_expr_at_min	Expression evaluated to *min*.
test_expr_at_max	Expression evaluated to *max*.

Errors

The parameters *min* and *max* must be specified such that *min* is less than or equal to *max*. Otherwise, the assertion fails on each tested clock cycle for which *test_expr* changed from *max*.

Notes

1. The assertion check compares the current value of *test_expr* with its previous value. Therefore, checking does not start until the second rising clock edge of *clk* after *reset_n* deasserts.

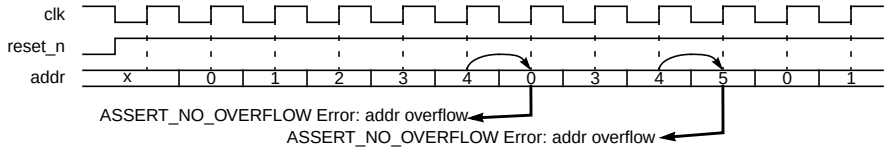
See also

assert_delta, assert_fifo_index, assert_increment, assert_no_overflow

Example

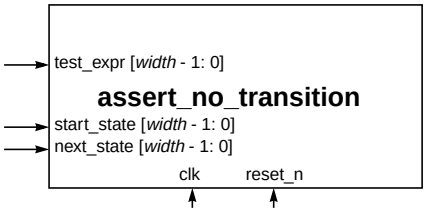
```
assert_no_overflow #(
    ‘OVL_ERROR,                     // severity_level
    3,                              // width
    0,                              // min
    4,                              // max
    ‘OVL_ASSERT,                    // property_type
    “Error: addr overflow”,         // msg
    ‘OVL_COVER_ALL)                 // coverage_level
    addr_with_overflow (
        clk,                        // clock
        reset_n,                    // reset
        addr  );                    // test_expr
```

Ensures that addr does not overflow (i.e., change from a value of 4 at the rising edge of clk to a value of 0 or a value greater than 4 at the next rising edge of clk).



assert_no_transition

Ensures that the value of a specified expression does not transition from a start state to the specified next state.



Parameters:
severity_level
width
property_type
msg
coverage_level

Class:
2-cycle assertion

Syntax

```
assert_no_transition
    [ # ( severity_level,  width, property_type,  msg,  coverage_level ) ]
    instance_name ( clk, reset_n, test_expr, start_state, next_state ) ;
```

Parameters

severity_level	Severity of the failure. Default: ‘OVL_ERROR.
width	Width of the *test_expr* argument. Default: 1.
property_type	Property type. Default: ‘OVL_ASSERT.
msg	Error message printed when assertion fails. Default: “VIOLATION”.
coverage_level	Coverage level. Default: ‘OVL_COVER_ALL.

Ports

clk		Clock event for the assertion. The checker samples on the rising edge of the clock.
reset_n		Active low synchronous reset signal indicating completed initialization.
test_expr	[*width* - 1: 0]	Expression that should not transition to *next_state* on the rising edge of *clk* if its value at the previous rising edge of *clk* is the same as the current value of *start_state*.
start_state	[*width* - 1: 0]	Expression that indicates the start state for the assertion check. If the start state matches the value of *test_expr* on the previous rising edge of *clk*, the check is performed.
next_state	[*width* - 1: 0]	Expression that indicates the invalid next state for the assertion check. If the value of *test_expr* was *start_state* at the previous rising edge of *clk*, then the value of *test_expr* should not equal *next_state* on the current rising edge of *clk*.

Description

The assert_no_transition assertion checker checks the expression *test_expr* and *start_state* at each rising edge of *clk* to see if the value of *test_expr* at the previous rising edge of *clk* equals the current value of *start_state*. If so, the checker verifies that the current value of *test_expr* does not equal the current value of *next_state*. The assertion fails if *test_expr* is equal to *next_state*.

The *start_state* and *next_state* expressions are verification events that can change. In particular, the same assertion checker can be coded to verify multiple types of transitions of *test_expr*.

The checker is useful for ensuring certain control structure values (such as counters and finite-state machine values) do not transition to invalid values.

Assertion Check

ASSERT_no_transition	Expression transitioned from *start_state* to a value equal to *next_state*.

Cover Point

start_state	Expression assumed a start state value.

Notes

1. The assertion check compares the current value of *test_expr* with its previous value. Therefore, checking does not start until the second rising clock edge of *clk* after *reset_n* deasserts.

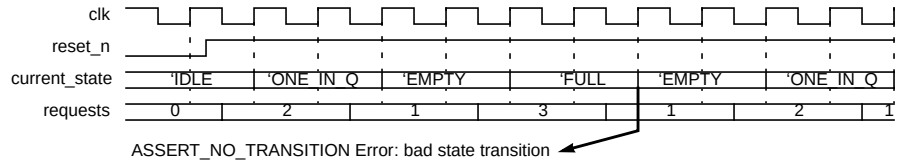
See also

assert_transition

Example

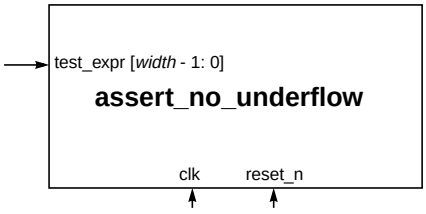
```
assert_no_transition #(
    ‘OVL_ERROR,                          // severity_level
    3,                                   // width
    ‘OVL_ASSERT,                         // property_type
    “Error: bad state transition”,       // msg
    ‘OVL_COVER_ALL)                      // coverage_level
    valid_transition (
        clk,                             // clock
        reset_n,                         // reset
        current_state,                   // test_expr
        requests > 2 ? ‘FULL : ‘ONE_IN_Q,  // start_state
        ‘EMPTY;                          // next_state
```

Ensures that current_state does not transition to ‘EMPTY improperly. If requests is greater than 2 and the current_state is ‘FULL, current_state should not transition to ‘EMPTY in the next cycle. If requests is not greater than 2 and current_state is ‘ONE_IN_Q, current_state should not transition to ‘EMPTY in the next cycle.



assert_no_underflow

Ensures that the value of a specified expression does not underflow.



Parameters:
severity_level
width
min
max
property_type
msg
coverage_level

Class:
2-cycle assertion

Syntax

```
assert_no_underflow
    [ # ( severity_level,  width, min, max, property_type,  msg,  coverage_level ) ]
    instance_name ( clk, reset_n, test_expr ) ;
```

Parameters

severity_level		Severity of the failure. Default: ‘OVL_ERROR.
width		Width of the *test_expr* argument. Width must be less than or equal to 32. Default: 1.
min		Minimum value in the test range of *test_expr*. Default: 0.
max		Maximum value in the test range of *test_expr*. Default: 2**_width_ - 1.
property_type		Property type. Default: ‘OVL_ASSERT.
msg		Error message printed when assertion fails. Default: “VIOLATION”.
coverage_level		Coverage level. Default: ‘OVL_COVER_ALL.

Ports

clk		Clock event for the assertion. The checker samples on the rising edge of the clock.
reset_n		Active low synchronous reset signal indicating completed initialization.
test_expr	[*width* - 1: 0]	Expression that should not change from a value of *min* to a value out of range or to a value equal to *max*.

Description

The assert_no_underflow assertion checker checks the expression *test_expr* at each rising edge of *clk* to determine if its value has changed from a value (at the previous rising edge of *clk*) that was equal to *min*. If so, the checker verifies that the new value has not underflowed *min*. That is, it verifies the value of *test_expr* is not less than *min* or greater than or equal to *max* (in which case, the assertion fails).

The checker is useful for verifying counters, where it can ensure the counter does not wrap from the lowest value to the highest value in a specified range. For example, it can be used to check that memory structure pointers do not wrap around. For a more general test for underflow, use assert_delta or assert_fifo_index.

Assertion Check

ASSERT_NO_UNDERFLOW	Expression changed value from *min* to a value not in the range *min* + 1 to *max* - 1.

Cover Points

test_expr_change	Expression changed value.
test_expr_at_min	Expression evaluated to *min*.
test_expr_at_max	Expression evaluated to *max*.

Errors

The parameters *min* and *max* must be specified such that *min* is less than or equal to *max*. Otherwise, the assertion fails on each tested clock cycle for which *test_expr* changed from *max*.

Notes

1. The assertion check compares the current value of *test_expr* with its previous value. Therefore, checking does not start until the second rising clock edge of *clk* after *reset_n* deasserts.

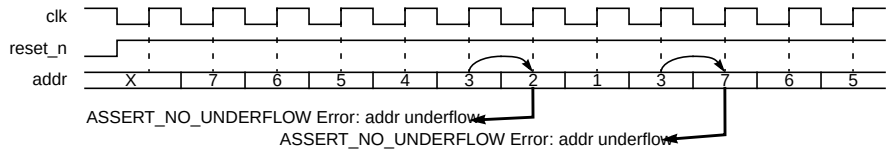
See also

assert_delta, assert_fifo_index, assert_decrement, assert_no_overflow

Example

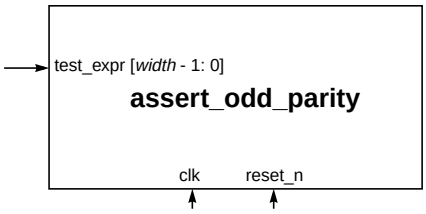
```
assert_no_underflow #(
    ‘OVL_ERROR,                          // severity_level
    3,                                   // width
    3,                                   // min
    7,                                   // max
    ‘OVL_ASSERT,                         // property_type
    “Error: addr underflow”,             // msg
    ‘OVL_COVER_ALL)                      // coverage_level
    addr_with_underflow (
        clk,                             // clock
        reset_n,                         // reset
        addr  );                         // test_expr
```

Ensures that addr does not underflow (i.e., change from a value of 3 at the rising edge of clk to a value of 7 or a value less than 3 at the next rising edge of clk).



assert_odd_parity

Ensures that the value of a specified expression has odd parity.



Parameters:
severity_level
width
property_type
msg
coverage_level

Class:
single-cycle assertion

Syntax

```
assert_odd_parity
    [#(severity_level, width, property_type, msg, coverage_level)]
    instance_name (clk, reset_n, test_expr);
```

Parameters

severity_level		Severity of the failure. Default: ‘OVL_ERROR.
width		Width of the *test_expr* argument. Default: 1.
property_type		Property type. Default: ‘OVL_ASSERT.
msg		Error message printed when assertion fails. Default: “VIOLATION”.
coverage_level		Coverage level. Default: ‘OVL_COVER_ALL.

Ports

clk		Clock event for the assertion. The checker samples on the rising edge of the clock.
reset_n		Active low synchronous reset signal indicating completed initialization.
test_expr	[*width* - 1: 0]	Expression that should evaluate to a value with odd parity on the rising clock edge.

Description

The assert_odd_parity assertion checker checks the expression *test_expr* at each rising edge of *clk* to verify the expression evaluates to a value that has odd parity. A value has odd parity if the number of bits set to 1 is odd.

The checker is useful for verifying control circuits, for example, it can be used to verify a finite-state machine with error detection. In a datapath circuit the checker can perform parity error checking of address and data buses.

Assertion Check

ASSERT_ODD_PARITY	Expression evaluated to a value whose parity is not odd.

Cover Point

test_expr_change	Expression has changed value.

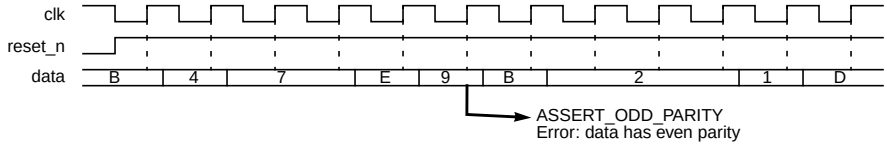
See also

assert_even_parity

Example

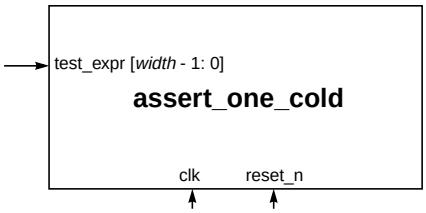
```
assert_odd_parity #(
    ‘OVL_ERROR,                          // severity_level
    8,                                   // width
    ‘OVL_ASSERT,                         // property_type
    “Error: data has even parity”,       // msg
    ‘OVL_COVER_ALL)                      // coverage_level
    valid_data_odd_parity (
        clk,                             // clock
        reset_n,                         // reset
        data );                          // test_expr
```

Ensures that data has odd parity at each rising edge of clk.



assert_one_cold

Ensures that the value of a specified expression is one-cold (or equals an inactive state value, if specified).



Parameters:
severity_level
width
inactive
property_type
msg
coverage_level

Class:
single-cycle assertion

Syntax

```
assert_one_cold
    [ # ( severity_level, width, inactive, property_type, msg, coverage_level ) ]
    instance_name ( clk, reset_n, test_expr ) ;
```

Parameters

severity_level	Severity of the failure. Default: ‘OVL_ERROR.
width	Width of the *test_expr* argument. Default: 32.
inactive	Inactive state of *test_expr*: ‘OVL_ALL_ZEROS, ‘OVL_ALL_ONES or ‘OVL_ONE_COLD. Default: ‘OVL_ONE_COLD.
property_type	Property type. Default: ‘OVL_ASSERT.
msg	Error message printed when assertion fails. Default: “VIOLATION”.
coverage_level	Coverage level. Default: ‘OVL_COVER_ALL.

Ports

clk		Clock event for the assertion. The checker samples on the rising edge of the clock.
reset_n		Active low synchronous reset signal indicating completed initialization.
test_expr	[*width* - 1: 0]	Expression that should evaluate to a one-cold or inactive value on the rising clock edge.

Description

The assert_one_cold assertion checker checks the expression *test_expr* at each rising edge of *clk* to verify the expression evaluates to a one-cold or inactive state value. A one-cold value has exactly one bit set to 0. The inactive state value for the checker is set by the *inactive* parameter. Choices are: ‘OVL_ALL_ZEROS (e.g., 4‘b0000), ‘OVL_ALL_ONES (e.g.,4‘b1111) or ‘OVL_ONE_COLD. The default *inactive* parameter value is ‘OVL_ONE_COLD, which indicates *test_expr* has no inactive state (so only a one-cold value is valid for each check).

The checker is useful for verifying control circuits, for example, it can ensure that a finite-state machine with one-cold encoding operates properly and has exactly one bit asserted low. In a datapath circuit the checker can ensure that the enabling conditions for a bus do not result in bus contention.

Assertion Checks

ASSERT_ONE_COLD	Expression assumed an active state with multiple bits set to 0.
test_expr contains X/Z value	Expression evaluated to a value with an X or Z bit, and ‘OVL_XCHECK_OFF is not set.

Cover Points

all_one_colds_checked	Expression evaluated to all possible combinations of one-cold values.
test_expr_all_zeros	Expression evaluated to the inactive state and the *inactive* parameter was set to ‘OVL_ALL_ZEROS.
test_expr_all_ones	Expression evaluated to the inactive state and the *inactive* parameter was set to ‘OVL_ALL_ONES.
test_expr_change	Expression has changed value.

Notes

1. By default, the assert_one_cold assertion is pessimistic and the assertion fails if *test_expr* is active and multiple bits are not 1 (i.e.equals 0, X, Z, etc.). However, if ‘OVL_XCHECK_OFF is set, the assertion fails if and only if *test_expr* is active and multiple bits are 0.

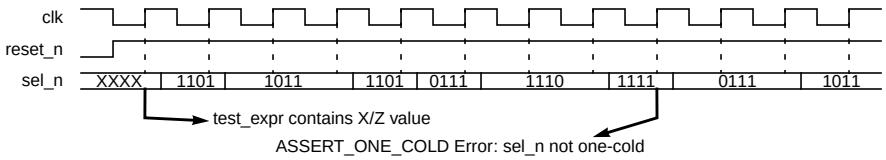
See also

assert_one_hot, assert_zero_one_hot

Examples

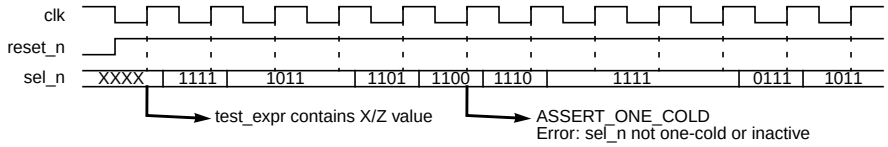
```
assert_one_cold #(
    ‘OVL_ERROR,                          // severity_level
    4,                                   // width
    ‘OVL_ONE_COLD,                       // inactive (no inactive state)
    ‘OVL_ASSERT,                         // property_type
    “Error: sel_n not one-cold”,         // msg
    ‘OVL_COVER_ALL)                      // coverage_level
    valid_sel_n_one_cold (
        clk,                             // clock
        reset_n,                         // reset
        sel_n );                         // test_expr
```

Ensures that sel_n is one-cold at each rising edge of clk.



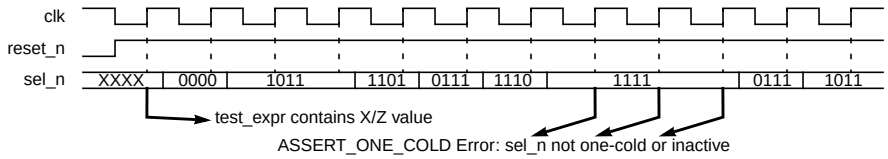
```
assert_one_cold #(
    ‘OVL_ERROR,                                  // severity_level
    4,                                           // width
    ‘OVL_ALL_ONES,                               // inactive
    ‘OVL_ASSERT,                                 // property_type
    “Error: sel_n not one-cold or inactive”,     // msg
    ‘OVL_COVER_ALL)                              // coverage_level
    valid_sel_n_one_cold (
        clk,                                     // clock
        reset_n,                                 // reset
        sel_n );                                 // test_expr
```

Ensures that sel_n is one-cold or inactive (4’b1111) at each rising edge of clk.



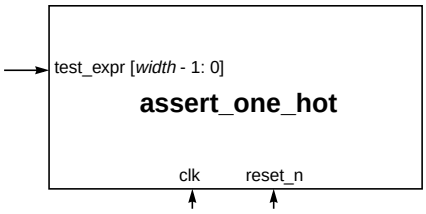

```
assert_one_cold #(
    ‘OVL_ERROR,                                  // severity_level
    4,                                           // width
    ‘OVL_ALL_ZEROS,                              // inactive
    ‘OVL_ASSERT,                                 // property_type
    “Error: sel_n not one-cold”,                 // msg
    ‘OVL_COVER_ALL)                              // coverage_level
    valid_sel_n_one_cold (
        clk,                                     // clock
        reset_n,                                 // reset
        sel_n );                                 // test_expr
```

Ensures that sel_n is one-cold or inactive (4’b0000) at each rising edge of clk.



assert_one_hot

Ensures that the value of a specified expression is one-hot.



Parameters:
severity_level
width
property_type
msg
coverage_level

Class:
single-cycle assertion

Syntax

```
assert_one_hot
    [ # ( severity_level, width, property_type, msg, coverage_level ) ]
    instance_name ( clk, reset_n, test_expr ) ;
```

Parameters

severity_level		Severity of the failure. Default: ‘OVL_ERROR.
width		Width of the *test_expr* argument. Default: 32.
property_type		Property type. Default: ‘OVL_ASSERT.
msg		Error message printed when assertion fails. Default: “VIOLATION”.
coverage_level		Coverage level. Default: ‘OVL_COVER_ALL.

Ports

clk		Clock event for the assertion. The checker samples on the rising edge of the clock.
reset_n		Active low synchronous reset signal indicating completed initialization.
test_expr	[*width* - 1: 0]	Expression that should evaluate to a one-hot value on the rising clock edge.

Description

The assert_one_hot assertion checker checks the expression *test_expr* at each rising edge of *clk* to verify the expression evaluates to a one-hot value. A one-hot value has exactly one bit set to 1.

The checker is useful for verifying control circuits, for example, it can ensure that a finite-state machine with one-hot encoding operates properly and has exactly one bit asserted high. In a datapath circuit the checker can ensure that the enabling conditions for a bus do not result in bus contention.

Assertion Checks

ASSERT_ONE_HOT	Expression evaluated to zero or to a value with multiple bits set to 1.
test_expr contains X/Z value	Expression evaluated to a value with an X or Z bit, and ‘OVL_XCHECK_OFF is not set.

Cover Points

all_one_hots_checked	Expression evaluated to all possible combinations of one-hot values.
test_expr_change	Expression has changed value.

Notes

1. By default, the assert_one_hot assertion is optimistic and the assertion fails if *test_expr* is zero or has multiple bits not set to 0 (i.e.equals 1, X, Z, etc.). However, if ‘OVL_XCHECK_OFF is set, the ASSERT_ONE_HOT assertion fails if and only if *test_expr* is zero or has multiple bits that are 1.

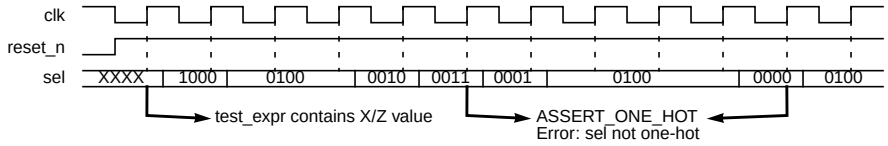
See also

assert_one_cold, assert_zero_one_hot

Example

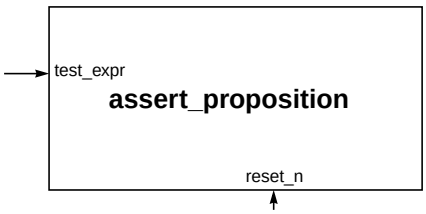
```
assert_one_hot #(
    ‘OVL_ERROR,                          // severity_level
    4,                                   // width
    ‘OVL_ASSERT,                         // property_type
    “Error: sel not one-hot”,            // msg
    ‘OVL_COVER_ALL)                      // coverage_level
    valid_sel_one_hot (
        clk,                             // clock
        reset_n,                         // reset
        sel );                           // test_expr
```

Ensures that sel is one-hot at each rising edge of clk.



assert_proposition

Ensures that the value of a specified expression is always combinationally TRUE.



Parameters:
severity_level
property_type
msg
coverage_level

Class:
combinational assertion

Syntax

```
assert_proposition
    [#(severity_level, property_type, msg, coverage_level)]
    instance_name (reset_n, test_expr);
```

Parameters

severity_level	Severity of the failure. Default: ‘OVL_ERROR.
property_type	Property type. Default: ‘OVL_ASSERT.
msg	Error message printed when assertion fails. Default: “VIOLATION”.
coverage_level	Coverage level. Default: ‘OVL_COVER_ALL.

Ports

reset_n	Active low synchronous reset signal indicating completed initialization.
test_expr	Expression that should always evaluate to TRUE.

Description

The assert_proposition assertion checker checks the single-bit expression *test_expr* when it changes value to verify the expression evaluates to TRUE.

Assertion Check

ASSERT_PROPOSITION	Expression evaluated to FALSE.

Cover Points

none

Notes

1. Formal verification tools and hardware emulation/acceleration systems might ignore this checker. To verify propositional properties with these tools, consider using assert_always.

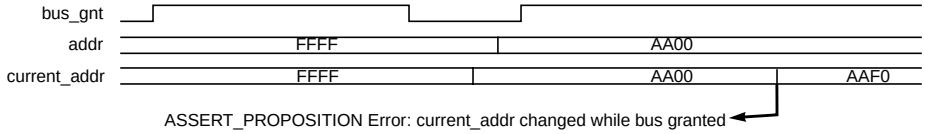
See also

assert_always, assert_always_on_edge, assert_implication, assert_never

Example

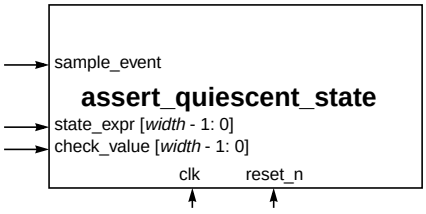
```
assert_proposition #(
    ‘OVL_ERROR,                                  // severity_level
    ‘OVL_ASSERT,                                 // property_type
    “Error: current_addr changed while bus granted”,  // msg
    ‘OVL_COVER_ALL)                              // coverage_level
    valid_current_addr (
        bus_gnt,                                 // reset
        current_addr == addr );                  // test_expr
```

Ensures that current_addr equals addr while bus_gnt is TRUE.



assert_quiescent_state

Ensures that the value of a specified state expression equals a corresponding check value if a specified sample event has transitioned to TRUE.



Parameters:
severity_level
width
property_type
msg
coverage_level

Class:
2-cycle assertion

Syntax

```
assert_quiescent_state
    [ # ( severity_level,  width, property_type,  msg,  coverage_level ) ]
    instance_name ( clk, reset_n, state_expr, check_value, sample_event ) ;
```

Parameters

severity_level	Severity of the failure. Default: ‘OVL_ERROR.
width	Width of the *state_expr* and *check_value* arguments. Default: 1.
property_type	Property type. Default: ‘OVL_ASSERT.
msg	Error message printed when assertion fails. Default: “VIOLATION”.
coverage_level	Coverage level. Default: ‘OVL_COVER_ALL.

Ports

clk		Clock event for the assertion. The checker samples on the rising edge of the clock.
reset_n		Active low synchronous reset signal indicating completed initialization.
state_expr	[*width* - 1: 0]	Expression that should have the same value as *check_value* on the rising edge of *clk* if *sample_event* transitioned to TRUE in the previous clock cycle (or is currently transitioning to TRUE).
check_value	[*width* - 1: 0]	Expression that indicates the value *state_expr* should have on the rising edge of *clk* if *sample_event* transitioned to TRUE in the previous clock cycle (or is currently transitioning to TRUE).
sample_event		Expression that initiates the quiescent state check when its value transitions to TRUE.

Description

The assert_quiescent_state assertion checker checks the expression *sample_event* at each rising edge of *clk* to see if its value has transitioned to TRUE (i.e., its current value is TRUE and its value on the previous rising edge of *clk* is not TRUE). If so, the checker verifies that the current value of *state_expr* equals the current value of *check_value*. The assertion fails if *state_expr* is not equal to *check_value*.

The *state_expr* and *check_value* expressions are verification events that can change. In particular, the same assertion checker can be coded to compare different check values (if they are checked in different cycles).

The checker is useful for verifying the states of state machines when transactions complete.

Assertion Check

ASSERT_QUIESCENT_STATE	The *sample_event* expression transitioned to TRUE, but the values of *state_expr* and *check_value* were not the same.

Cover Points

none

Notes

1. The assertion check compares the current value of *sample_event* with its previous value. Therefore, checking does not start until the second rising clock edge of *clk* after *reset_n* deasserts.
2. The checker recognizes the Verilog macro ‘OVL_END_OF_SIMULATION=*eos_signal*. If set, the quiescent state check is also performed at the end of simulation, when *eos_signal* asserts (regardless of the value of *sample_event*).
3. Formal verification tools and hardware emulation/acceleration systems might ignore this checker.

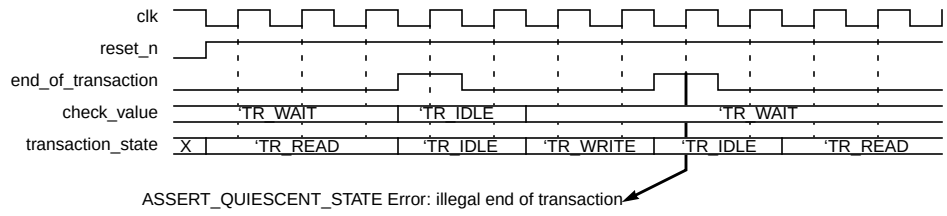
See also

assert_no_transition, assert_transition

Example

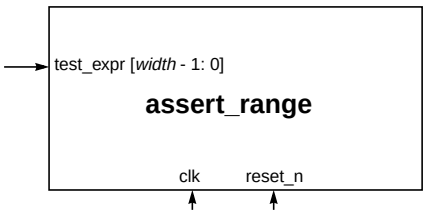
```
assert_quiescent_state #(
    ‘OVL_ERROR,                                  // severity_level
    4,                                           // width
    ‘OVL_ASSERT,                                 // property_type
    “Error: illegal end of transaction”,         // msg
    ‘OVL_COVER_ALL)                              // coverage_level
    valid_end_of_transaction_state (
        clk,                                     // clock
        reset_n,                                 // reset
        transaction_state,                       // state_expr
        prev_tr == ‘TR_READ ? ‘TR_IDLE : ‘TR_WAIT // check_value
        end_of_transaction);                     // sample_event
```

Ensures that whenever end_of_transaction asserts at the completion of each transaction, the value of transaction_state is ‘TR_IDLE (if prev_tr is ‘TR_READ) or ‘TR_WAIT (otherwise).



assert_range

Ensures that the value of a specified expression is in a specified range.



Parameters:
severity_level
width
min
max
property_type
msg
coverage_level

Class:
single-cycle assertion

Syntax

```
assert_range
        [ # ( severity_level,  width, min, max, property_type,  msg,  coverage_level ) ]
        instance_name  ( clk, reset_n, test_expr ) ;
```

Parameters

severity_level		Severity of the failure. Default: ‘OVL_ERROR.
width		Width of the *test_expr* argument. Default: 1.
min		Minimum value allowed for *test_expr*. Default: 0.
max		Maximum value allowed for *test_expr*. Default: 2**_width_ - 1.
property_type		Property type. Default: ‘OVL_ASSERT.
msg		Error message printed when assertion fails. Default: “VIOLATION”.
coverage_level		Coverage level. Default: ‘OVL_COVER_ALL.

Ports

clk		Clock event for the assertion. The checker samples on the rising edge of the clock.
reset_n		Active low synchronous reset signal indicating completed initialization.
test_expr	[*width* - 1: 0]	Expression that should evaluate to a value in the range from *min* to *max* (inclusive) on the rising clock edge.

Description

The assert_range assertion checker checks the expression *test_expr* at each rising edge of *clk* to verify the expression falls in the range from *min* to *max*, inclusive. The assertion fails if *test_expr* < *min* or *max* < *test_expr*.

The checker is useful for ensuring certain control structure values (such as counters and finite-state machine values) are within their proper ranges. The checker is also useful for ensuring datapath variables and expressions are in legal ranges.

Assertion Check

ASSERT_RANGE	Expression evaluated outside the range *min* to *max*.

Cover Points

cover_test_expr_change	Expression changed value.
cover_test_expr_at_min	Expression evaluated to *min*.
cover_test_expr_at_max	Expression evaluated to *max*.

Errors

The parameters *min* and *max* must be specified such that *min* is less than or equal to *max*. Otherwise, the assertion fails on each tested clock cycle.

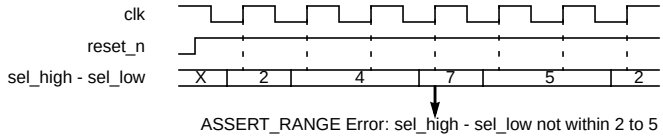
See also

assert_always, assert_implication, assert_never, assert_proposition

Example

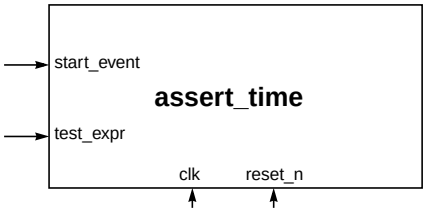
```
assert_range #(
    ‘OVL_ERROR,                                  // severity_level
    3,                                           // width
    2,                                           // min
    5,                                           // max
    ‘OVL_ASSERT,                                 // property_type
    “Error: sel_high - sel_low not within 2 to 5”,  // msg
    ‘OVL_COVER_ALL)                              // coverage_level
    valid_sel (
        clk,                                     // clock
        reset_n,                                 // reset
        sel_high - sel_low );                    // test_expr
```

Ensures that (sel_high - sel_low) is in the range 2 to 5 at each rising edge of clk.



assert_time

Ensures that the value of a specified expression remains TRUE for a specified number of cycles after a start event.



Parameters:
severity_level
num_cks
action_on_new_start
property_type
msg
coverage_level

Class:
n-cycle assertion

Syntax

```
assert_time
    [#(severity_level, num_cks, action_on_new_start, property_type, msg, coverage_level)]
    instance_name (clk, reset_n, start_event, test_expr);
```

Parameters

severity_level	Severity of the failure. Default: ‘OVL_ERROR.
num_cks	Number of cycles after *start_event* is TRUE that *test_expr* must be held TRUE. Default: 1.
action_on_new_start	Method for handling a new start event that occurs while a check is pending. Values are: ‘OVL_IGNORE_NEW_START, ‘OVL_RESET_ON_NEW_START and ‘OVL_ERROR_ON_NEW_START. Default: ‘OVL_IGNORE_NEW_START.
property_type	Property type. Default: ‘OVL_ASSERT.
msg	Error message printed when assertion fails. Default: “VIOLATION”.
coverage_level	Coverage level. Default: ‘OVL_COVER_ALL.

Ports

clk	Clock event for the assertion. The checker samples on the rising edge of the clock.
reset_n	Active low synchronous reset signal indicating completed initialization.
start_event	Expression that (along with *num_cks*) identifies when to check *test_expr.*
test_expr	Expression that should evaluate to TRUE for *num_cks* cycles after *start_event* initiates a check.

Description

The assert_time assertion checker checks the expression *start_event* at each rising edge of *clk* to determine whether or not to initiate a check. Once initiated, the check evaluates *test_expr* each rising edge of *clk* for *num_cks* cycles to verify that its value is TRUE. During that time, the assertion fails each cycle a sampled value of *test_expr* is not TRUE.

The method used to determine what constitutes a start event for initiating a check is controlled by the *action_on_new_start* parameter. If no check is in progress when *start_event* is sampled TRUE, a new check is initiated. But, if a check is in progress when *start_event* is sampled TRUE, the checker has the following actions:

- ‘OVL_IGNORE_NEW_START

  The checker does not sample *start_event* for the next *num_cks* cycles after a start event.

- ‘OVL_RESET_ON_NEW_START

  The checker samples *start_event* every cycle. If a check is pending and the value of *start_event* is TRUE, the checker terminates the check and initiates a new check without sampling *test_expr.*

- ‘OVL_ERROR_ON_NEW_START

  The checker samples *start_event* every cycle. If a check is pending and the value of *start_event* is TRUE, the assertion fails with an illegal start event violation. In this case, the checker does not initiate a new check, does not terminate a pending check and reports an additional assertion violation if *test_expr* is FALSE.

Assertion Checks

ASSERT_TIME	The value of *test_expr* was not TRUE within *num_cks* cycles after *start_event* was sampled TRUE.
illegal start event	The *action_on_new_start* parameter is set to ‘OVL_ERROR_ON_NEW_START and *start_event* expression evaluated to TRUE while the checker was monitoring *test_expr.*

Cover Points

window_open	A time check was initiated.
window_close	A time check lasted the full *num_cks* cycles.
window_resets	The *action_on_new_start* parameter is ‘OVL_RESET_ON_NEW_START, and *start_event* was sampled TRUE while the checker was monitoring *test_expr.*

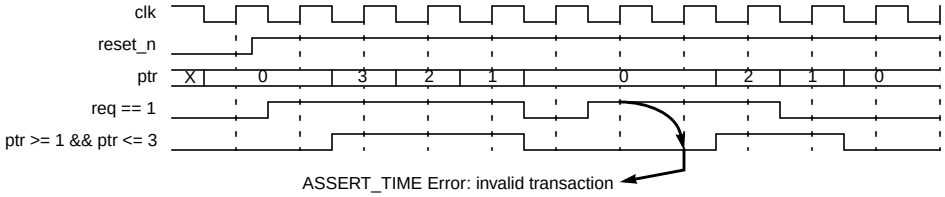
See also

assert_change, assert_next, assert_frame, assert_unchange, assert_win_change, assert_win_unchange, assert_window

Examples

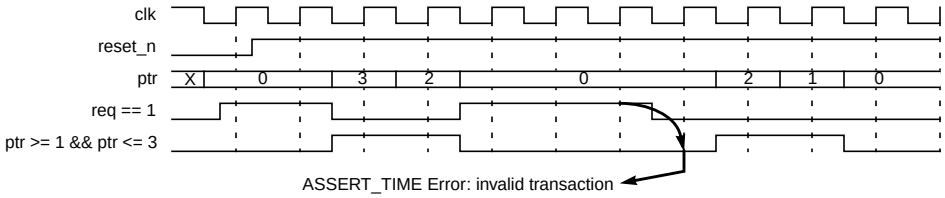
```
assert_time #(
    'OVL_ERROR,                          // severity_level
    3,                                   // num_cks
    'OVL_IGNORE_NEW_START,               // action_on_new_start
    'OVL_ASSERT,                         // property_type
    "Error: invalid transaction",        // msg
    'OVL_COVER_ALL)                      // coverage_level
    valid_transaction (
        clk,                             // clock
        reset_n,                         // reset
        req == 1,                        // start_event
        ptr >= 1 && ptr <= 3);           // test_expr
```

Ensures that ptr is sampled in the range 1 to 3 for three cycles after req is sampled equal to 1 at the rising edge of clk. If req is sampled equal to 1 when the checker samples ptr, a new check is not initiated (i.e., the new start is ignored).



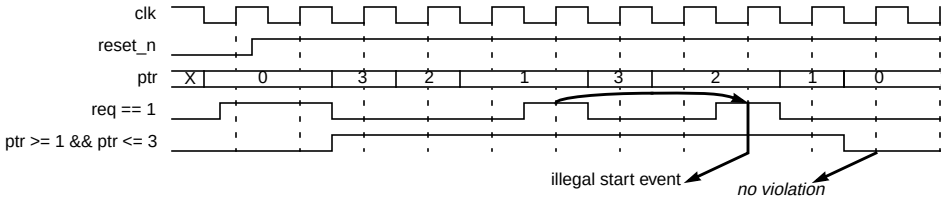

```
assert_time #(
    'OVL_ERROR,                          // severity_level
    3,                                   // num_cks
    'OVL_RESET_ON_NEW_START,             // action_on_new_start
    'OVL_ASSERT,                         // property_type
    "Error: invalid transaction",        // msg
    'OVL_COVER_ALL)                      // coverage_level
    valid_transaction (
        clk,                             // clock
        reset_n,                         // reset
        req == 1,                        // start_event
        ptr >= 1 && ptr <= 3);           // test_expr
```

Ensures that ptr is sampled in the range 1 to 3 for three cycles after req is sampled equal to 1 at the rising edge of clk. If req is sampled equal to 1 when the checker samples ptr, a new check is initiated (i.e., the new start restarts a check).



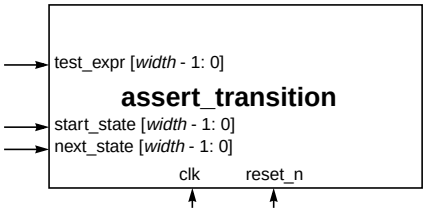
```
assert_time #(
    ‘OVL_ERROR,                          // severity_level
    3,                                   // num_cks
    ‘OVL_ERROR_ON_NEW_START,             // action_on_new_start
    ‘OVL_ASSERT,                         // property_type
    “Error: invalid transaction”,        // msg
    ‘OVL_COVER_ALL)                      // coverage_level
    valid_transaction (
        clk,                             // clock
        reset_n,                         // reset
        req == 1,                        // start_event
        ptr >= 1 && ptr <= 3);           // test_expr
```

Ensures that ptr is sampled in the range 1 to 3 for three cycles after req is sampled equal to 1 at the rising edge of clk. If req is sampled equal to 1 when the checker samples ptr, the checker issues an illegal start event violation and does not start a new check.



assert_transition

Ensures that the value of a specified expression transitions properly from a start state to the specified next state.



Parameters:
severity_level
width
property_type
msg
coverage_level

Class:
2-cycle assertion

Syntax

```
assert_transition
    [ # ( severity_level,  width, property_type,  msg,  coverage_level ) ]
    instance_name ( clk, reset_n, test_expr, start_state, next_state ) ;
```

Parameters

severity_level	Severity of the failure. Default: ‘OVL_ERROR.
width	Width of the *test_expr* argument. Default: 1.
property_type	Property type. Default: ‘OVL_ASSERT.
msg	Error message printed when assertion fails. Default: “VIOLATION”.
coverage_level	Coverage level. Default: ‘OVL_COVER_ALL.

Ports

clk		Clock event for the assertion. The checker samples on the rising edge of the clock.
reset_n		Active low synchronous reset signal indicating completed initialization.
test_expr	[*width* - 1: 0]	Expression that should transition to *next_state* on the rising edge of *clk* if its value at the previous rising edge of *clk* is the same as the current value of *start_state*.
start_state	[*width* - 1: 0]	Expression that indicates the start state for the assertion check. If the start state matches the value of *test_expr* on the previous rising edge of *clk*, the check is performed.
next_state	[*width* - 1: 0]	Expression that indicates the only valid next state for the assertion check. If the value of *test_expr* was *start_state* at the previous rising edge of *clk*, then the value of *test_expr* should equal *next_state* on the current rising edge of *clk*.

Description

The assert_transition assertion checker checks the expression *test_expr* and *start_state* at each rising edge of *clk* to see if they are the same. If so, the checker evaluates and stores the current value of *next_state*. At the next rising edge of clk, the checker re-evaluates test_expr to see if its value equals the stored value of *next_state*. If not, the assertion fails. The checker returns to checking *start_state* in the current cycle (unless a fatal failure occurred)

The *start_state* and *next_state* expressions are verification events that can change. In particular, the same assertion checker can be coded to verify multiple types of transitions of *test_expr*.

The checker is useful for ensuring certain control structure values (such as counters and finite-state machine values) transition properly.

Assertion Check

ASSERT_TRANSITION	Expression transitioned from *start_state* to a value different from *next_state*.

Cover Point

start_state	Expression assumed a start state value.

Notes

1. The assertion check compares the current value of *test_expr* with its previous value. Therefore, checking does not start until the second rising clock edge of *clk* after *reset_n* deasserts.

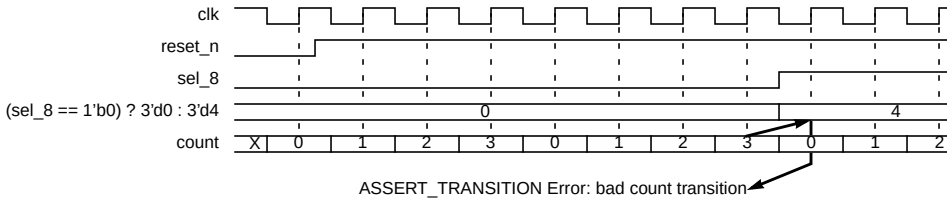
See also

assert_no_transition

Example

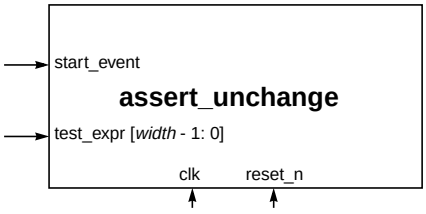
```
assert_transition #(
    ‘OVL_ERROR,                                  // severity_level
    3,                                           // width
    ‘OVL_ASSERT,                                 // property_type
    “Error: bad count transition”,               // msg
    ‘OVL_COVER_ALL)                              // coverage_level
    valid_count (
        clk,                                     // clock
        reset_n,                                 // reset
        count,                                   // test_expr
        3’d3,                                    // start_state
        (sel_8 == 1’b0) ? 3’d0 : 3’d4  );        // next_state
```

Ensures that count transitions from 3’d3 properly. If sel_8 is 0, count should have transitioned to 3’d0. Otherwise, count should have transitioned to 3’d4.



assert_unchange

Ensures that the value of a specified expression does not change for a specified number of cycles after a start event initiates checking.



Parameters:
severity_level
width
num_cks
action_on_new_start
property_type
msg
coverage_level

Class:
n-cycle assertion

Syntax

```
assert_unchange
    [#( severity_level,  width, num_cks, action_on_new_start, property_type,
    msg,  coverage_level )]
    instance_name ( clk, reset_n, start_event, test_expr ) ;
```

Parameters

severity_level	Severity of the failure. Default: ‘OVL_ERROR.
width	Width of the *test_expr* argument. Default: 1.
num_cks	Number of cycles *test_expr* should remain unchanged after a start event. Default: 1.
action_on_new_start	Method for handling a new start event that occurs before *num_cks* clock cycles transpire without a change in the value of *test_expr*. Values are: ‘OVL_IGNORE_NEW_START, ‘OVL_RESET_ON_NEW_START and ‘OVL_ERROR_ON_NEW_START. Default: ‘OVL_IGNORE_NEW_START.
property_type	Property type. Default: ‘OVL_ASSERT.
msg	Error message printed when assertion fails. Default: “VIOLATION”.
coverage_level	Coverage level. Default: ‘OVL_COVER_ALL.

Ports

clk		Clock event for the assertion. The checker samples on the rising edge of the clock.
reset_n		Active low synchronous reset signal indicating completed initialization.
start_event		Expression that (along with *action_on_new_start*) identifies when to start checking *test_expr* .
test_expr	[*width* - 1: 0]	Expression that should not change value for *num_cks* cycles from the start event unless the check is interrupted by a valid new start event.

Description

The assert_unchange assertion checker checks the expression *start_event* at each rising edge of *clk* to determine if it should check for a change in the value of *test_expr*. If *start_event* is sampled TRUE, the checker evaluates *test_expr* and re-evaluates *test_expr* at each of the subsequent *num_cks* rising edges of *clk*. Each time the checker re-evaluates *test_expr*, if its value has changed from its value in the previous cycle, the assertion fails.

The method used to determine how to handle a new start event, when the checker is in the state of checking for a change in *test_expr*, is controlled by the *action_on_new_start* parameter. The checker has the following actions:

- ‘OVL_IGNORE_NEW_START

  The checker does not sample *start_event* for the next *num_cks* cycles after a start event.

- ‘OVL_RESET_ON_NEW_START

  The checker samples *start_event* every cycle. If a check is pending and the value of *start_event* is TRUE, the checker terminates the check and initiates a new check.

- ‘OVL_ERROR_ON_NEW_START

  The checker samples *start_event* every cycle. If a check is pending and the value of *start_event* is TRUE, the assertion fails with an illegal start event violation. In this case, the checker does not initiate a new check and does not terminate a pending check.

The checker is useful for ensuring proper changes in structures after various events. For example, it can be used to check that multiple-cycle operations with enabling conditions function properly with the same data. It can be used to check that single-cycle operations function correctly with data loaded at different cycles. It also can be used to verify synchronizing conditions that require date to be stable after an initial triggering event.

Assertion Checks

ASSERT_UNCHANGE	The *test_expr* expression changed value within *num_cks* cycles after *start_event* was sampled TRUE.
illegal start event	The *action_on_new_start* parameter is set to ‘OVL_ERROR_ON_NEW_START and *start_event* expression evaluated to TRUE while the checker was in the state of checking for a change in the value of *test_expr*.

Cover Points

window_open	A change check was initiated.
window_close	A change check lasted the full *num_cks* cycles.
window_resets	The *action_on_new_start* parameter is ‘OVL_RESET_ON_NEW_START, and *start_event* was sampled TRUE while the checker was monitoring *test_expr* without detecting a changed value.

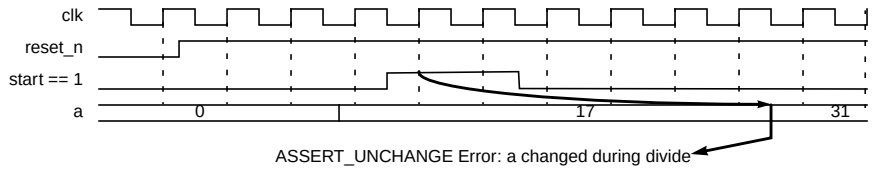
See also

assert_change, assert_time, assert_win_change, assert_win_unchange, assert_window

Examples

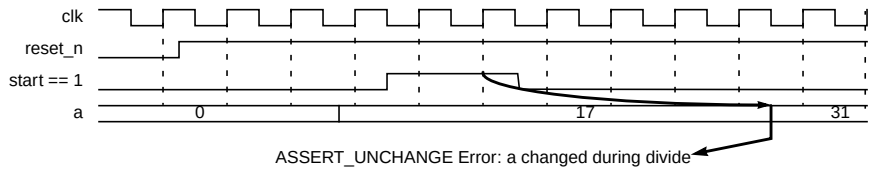
```
assert_unchange #(
    ‘OVL_ERROR,                          // severity_level
    8,                                   // width
    8,                                   // num_cks
    ‘OVL_IGNORE_NEW_START,               // action_on_new_start
    ‘OVL_ASSERT,                         // property_type
    “Error: a changed during divide”,    // msg
    ‘OVL_COVER_ALL)                      // coverage_level
    valid_div_unchange_a (
        clk,                             // clock
        reset_n,                         // reset
        start == 1,                      // start_event
        a);                              // test_expr
```

Ensures that a remains unchanged while a divide operation is performed (8 cycles). Restarts during divide operations are ignored.



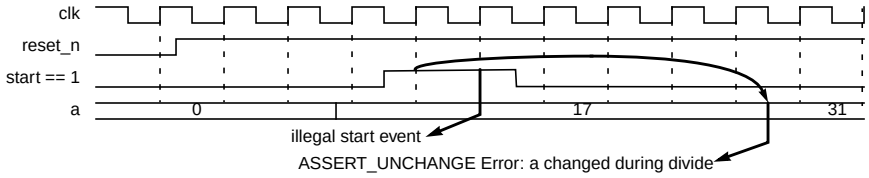

```
assert_unchange #(
    ‘OVL_ERROR,                          // severity_level
    8,                                   // width
    8,                                   // num_cks
    ‘OVL_RESET_ON_NEW_START,             // action_on_new_start
    ‘OVL_ASSERT,                         // property_type
    “Error: a changed during divide”,    // msg
    ‘OVL_COVER_ALL)                      // coverage_level
    valid_div_unchange_a (
        clk,                             // clock
        reset_n,                         // reset
        start == 1,                      // start_event
        a);                              // test_expr
```

Ensures that a remains unchanged while a divide operation is performed (8 cycles). A restart during a divide operation starts the check over.



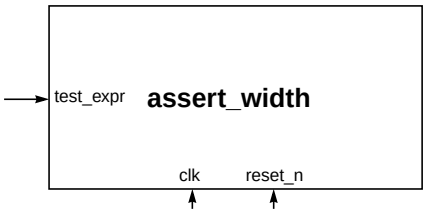
```
assert_unchange #(
    ‘OVL_ERROR,                          // severity_level
    8,                                   // width
    8,                                   // num_cks
    ‘OVL_ERROR_ON_NEW_START,             // action_on_new_start
    ‘OVL_ASSERT,                         // property_type
    “Error: a changed during divide”,    // msg
    ‘OVL_COVER_ALL)                      // coverage_level
    valid_div_unchange_a (
        clk,                             // clock
        reset_n,                         // reset
        start == 1,                      // start_event
        a);                              // test_expr
```

Ensures that a remains unchanged while a divide operation is performed (8 cycles). A restart during a divide operation is a violation.



assert_width

Ensures that when value of a specified expression is TRUE, it remains TRUE for a minimum number of clock cycles and transitions from TRUE no later than a maximum number of clock cycles.



Parameters:
severity_level
min_cks
max_cks
property_type
msg
coverage_level

Class:
n-cycle assertion

Syntax

```
assert_width
    [#( severity_level, min_cks, max_cks, property_type,  msg,  coverage_level )]
    instance_name ( clk, reset_n, test_expr );
```

Parameters

severity_level	Severity of the failure. Default: ‘OVL_ERROR.
min_cks	Minimum number of cycles *test_expr* must remain TRUE after it is sampled TRUE. The special case where *min_cks* is 0 turns off minimum checking (i.e., *test_expr* can transition from TRUE in the next clock cycle). Default: 1.
max_cks	Maximum number of cycles *test_expr* can remain TRUE after it is sampled TRUE. The special case where *max_cks* is 0 turns off maximum checking (i.e., *test_expr* can remain TRUE for any number of cycles). Default: 1.
property_type	Property type. Default: ‘OVL_ASSERT.
msg	Error message printed when assertion fails. Default: “VIOLATION”.
coverage_level	Coverage level. Default: ‘OVL_COVER_ALL.

Ports

clk	Clock event for the assertion. The checker samples on the rising edge of the clock.
test_expr	Expression that should evaluate to TRUE for at least *min_cks* cycles and at most *max_cks* cycles after it is sampled TRUE.

Description

The assert_width assertion checker checks the single-bit expression *test_expr* at each rising edge of *clk*. If the value of *test_expr* is TRUE, the checker performs the following steps:

1. Unless it is disabled by setting *min_cks* to 0, a minimum check is initiated. The check evaluates *test_expr* at each subsequent rising edge of *clk*. If its value is not TRUE, the minimum check fails. Otherwise, after *min_cks* cycles transpire, the minimum check terminates.
2. Unless it is disabled by setting *max_cks* to 0, a maximum check is initiated. The check evaluates *test_expr* at each subsequent rising edge of *clk*. If its value does not transition from TRUE by the time *max_cks +1* cycles transpire (from the start of checking), the maximum check fails (at cycle *max_cks + 1*).
3. The checker returns to checking *test_expr* in the next cycle. In particular if *test_expr* is TRUE, a new set of checks is initiated.

Assertion Checks

MIN_CHECK	The value of *test_expr* was held TRUE for less than *min_cks* cycles.
MAX_CHECK	The value of *test_expr* was held TRUE for more than *max_cks* cycles.
min_cks > max_cks	The *min_cks* parameter is greater than the *max_cks* parameter (and *max_cks* >0). Unless the violation is fatal, either the minimum or maximum check will fail.

Cover Points

test_expr_asserts	A check was initiated (i.e., *test_expr* was sampled TRUE).
test_expr_asserted_for_min_cks	The expression *test_expr* was held TRUE for exactly *min_cks* cycles (*min_cks* > 0).
test_expr_asserted_for_max_cks	The expression *test_expr* was held TRUE for exactly *max_cks* cycles (*max_cks* > 0).

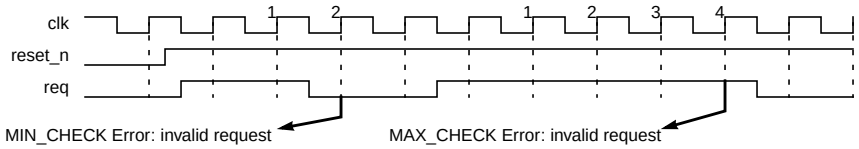
See also

assert_change, assert_time, assert_unchange

Example

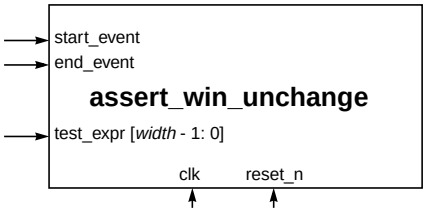
```
assert_width #(
    ‘OVL_ERROR,                          // severity_level
    2,                                   // min_cks
    3,                                   // max_cks
    ‘OVL_ASSERT,                         // property_type
    “Error: invalid request”,            // msg
    ‘OVL_COVER_ALL)                      // coverage_level
    valid_request (
        clk,                             // clock
        reset_n,                         // reset
        req == 1);                       // test_expr
```

Ensures req asserts for 2 or 3 cycles.



assert_win_change

Ensures that the value of a specified expression changes in a specified window between a start event and an end event.



Parameters:
severity_level
width
property_type
msg
coverage_level

Class:
event-bounded assertion

Syntax

```
assert_win_change
    [ # ( severity_level,  width, property_type,  msg,  coverage_level ) ]
    instance_name ( clk, reset_n, start_event, test_expr, end_event ) ;
```

Parameters

severity_level	Severity of the failure. Default: ‘OVL_ERROR.
width	Width of the *test_expr* argument. Default: 1.
property_type	Property type. Default: ‘OVL_ASSERT.
msg	Error message printed when assertion fails. Default: “VIOLATION”.
coverage_level	Coverage level. Default: ‘OVL_COVER_ALL.

Ports

clk		Clock event for the assertion. The checker samples on the rising edge of the clock.
reset_n		Active low synchronous reset signal indicating completed initialization.
start_event		Expression that opens an event window.
test_expr	[*width* - 1: 0]	Expression that should change value in the event window
end_event		Expression that closes an event window.

Description

The assert_win_change assertion checker checks the expression *start_event* at each rising edge of *clk* to determine if it should open an event window at the start of the next cycle. If *start_event* is sampled TRUE, the checker evaluates *test_expr*. At each subsequent rising edge of *clk*, the checker evaluates *end_event* and re-evaluates *test_expr*. If *end_event* is TRUE, the checker closes the event window and if all sampled values of *test_expr* equal its value at the start of the window, then the assertion fails. The checker returns to the state of monitoring *start_event* at the next rising edge of *clk* after the event window is closed.

The checker is useful for ensuring proper changes in structures in various event windows. A typical use is to verify that synchronization logic responds after a stimulus (for example, bus transactions occurs without interrupts or write commands are not issued during read cycles). Another typical use is verifying a finite-state machine responds correctly in event windows.

Assertion Check

ASSERT_WIN_CHANGE	The *test_expr* expression did not change value during an open event window.

Cover Points

window_open	An event window opened (*start_event* was TRUE).
window_close	An event window closed (*end_event* was TRUE in an open event window).

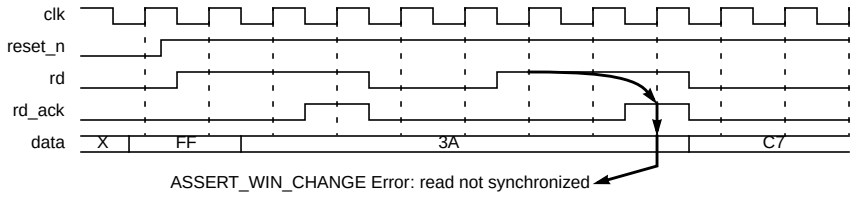
See also

assert_change, assert_time, assert_unchange, assert_win_unchange, assert_window

Example

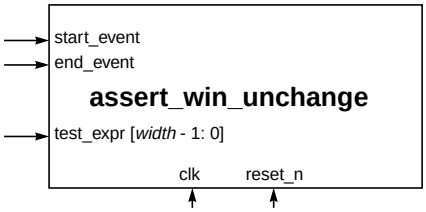
```
assert_win_change #(
    ‘OVL_ERROR,                          // severity_level
    32,                                  // width
    ‘OVL_ASSERT,                         // property_type
    “Error: read not synchronized”,      // msg
    ‘OVL_COVER_ALL)                      // coverage_level
    valid_sync_data_bus_rd (
        clk,                             // clock
        reset_n,                         // reset
        rd,                              // start_event
        data,                            // test_expr
        rd_ack );                        // end_event
```

Ensures that data changes value in every data read window.



assert_win_unchange

Ensures that the value of a specified expression does not change in a specified window between a start event and an end event.



Parameters:
severity_level
width
property_type
msg
coverage_level

Class:
event-bounded assertion

Syntax

```
assert_win_unchange
    [ # ( severity_level,  width, property_type,  msg,  coverage_level ) ]
    instance_name ( clk, reset_n, start_event, test_expr, end_event ) ;
```

Parameters

severity_level	Severity of the failure. Default: ‘OVL_ERROR.
width	Width of the *test_expr* argument. Default: 1.
property_type	Property type. Default: ‘OVL_ASSERT.
msg	Error message printed when assertion fails. Default: “VIOLATION”.
coverage_level	Coverage level. Default: ‘OVL_COVER_ALL.

Ports

clk		Clock event for the assertion. The checker samples on the rising edge of the clock.
reset_n		Active low synchronous reset signal indicating completed initialization.
start_event		Expression that opens an event window.
test_expr	[*width* - 1: 0]	Expression that should not change value in the event window
end_event		Expression that closes an event window.

Description

The assert_win_unchange assertion checker checks the expression *start_event* at each rising edge of *clk* to determine if it should open an event window at the start of the next cycle. If *start_event* is sampled TRUE, the checker evaluates *test_expr*. At each subsequent rising edge of *clk*, the checker evaluates *end_event* and re-evaluates *test_expr*. If a sampled value of *test_expr* is changed from its value in the previous cycle, then the assertion fails. If *end_event* is TRUE, the checker closes the event window and returns to the state of monitoring *start_event* at the next rising edge of *clk*.

The checker is useful for ensuring certain variables and expressions do not change in various event windows. A typical use is to verify that synchronization logic responds after a stimulus (for example, bus transactions occurs without interrupts or write commands are not issued during read cycles). Another typical use is to verify that non-deterministic multiple-cycle operations with enabling conditions function properly with the same data.

Assertion Check

ASSERT_WIN_UNCHANGE	The *test_expr* expression changed value during an open event window.

Cover Points

window_open	An event window opened (*start_event* was TRUE).
window_close	An event window closed (*end_event* was TRUE in an open event window).

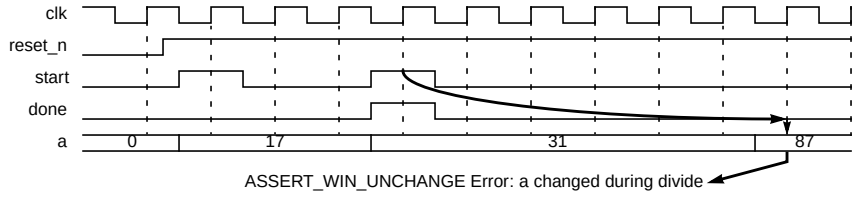
See also

assert_change, assert_time, assert_unchange, assert_win_change, assert_window

Example

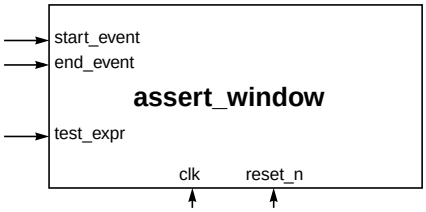
```
assert_win_unchange #(
    ‘OVL_ERROR,                          // severity_level
    8,                                   // width
    ‘OVL_ASSERT,                         // property_type
    “Error: a changed during divide”,    // msg
    ‘OVL_COVER_ALL)                      // coverage_level
    valid_div_win_unchange_a (
        clk,                             // clock
        reset_n,                         // reset
        start,                           // start_event
        a,                               // test_expr
        done);                           // end_event
```

Ensures that the a input to the divider remains unchanged while a divide operation is performed (i.e., in the window from start to done).



assert_window

Ensures that the value of a specified expression is TRUE in a specified window between a start event and an end event.



Parameters:
severity_level
property_type
msg
coverage_level

Class:
event-bounded assertion

Syntax

```
assert_window
    [#(severity_level, property_type, msg, coverage_level)]
    instance_name (clk, reset_n, start_event, test_expr, end_event);
```

Parameters

severity_level	Severity of the failure. Default: ‘OVL_ERROR.
property_type	Property type. Default: ‘OVL_ASSERT.
msg	Error message printed when assertion fails. Default: “VIOLATION”.
coverage_level	Coverage level. Default: ‘OVL_COVER_ALL.

Ports

clk	Clock event for the assertion. The checker samples on the rising edge of the clock.
reset_n	Active low synchronous reset signal indicating completed initialization.
start_event	Expression that opens an event window.
test_expr	Expression that should be TRUE in the event window
end_event	Expression that closes an event window.

Description

The assert_window assertion checker checks the expression *start_event* at each rising edge of *clk* to determine if it should open an event window at the start of the next cycle. If *start_event* is sampled TRUE, at each subsequent rising edge of *clk*, the checker evaluates *end_event* and *test_expr*. If a sampled value of *test_expr* is not TRUE, then the assertion fails. If *end_event* is TRUE, the checker closes the event window and returns to the state of monitoring *start_event* at the next rising edge of *clk*.

The checker is useful for ensuring proper changes in structures after various events. For example, it can be used to check that multiple-cycle operations with enabling conditions function properly with the same data. It can be used to check that single-cycle operations function correctly with data loaded at different cycles. It also can be used to verify synchronizing conditions that require date to be stable after an initial triggering event.

Assertion Check

ASSERT_WINDOW	The *test_expr* expression changed value during an open event window.

Cover Points

window_open	A change check was initiated.
window_close	A change check lasted the full *num_cks* cycles.

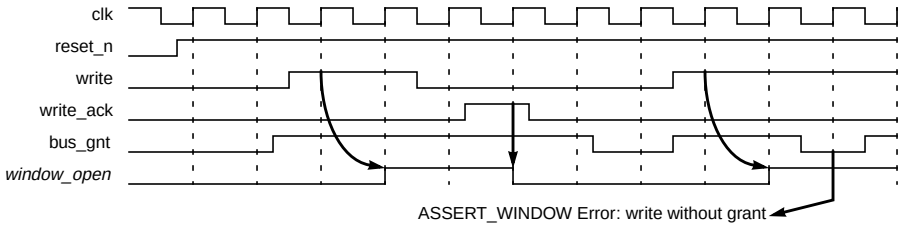
See also

assert_change, assert_time, assert_unchange, assert_win_change, assert_win_unchange

Example

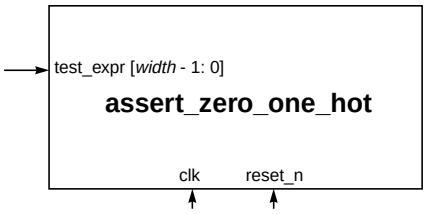
```
assert_window #(
    ‘OVL_ERROR,                          // severity_level
    ‘OVL_ASSERT,                         // property_type
    “Error: write without grant”,        // msg
    ‘OVL_COVER_ALL)                      // coverage_level
    valid_sync_data_bus_write (
        clk,                             // clock
        reset_n,                         // reset
        write,                           // start_event
        bus_gnt,                         // test_expr
        write_ack );                     // end_event
```

Ensures that the bus grant is not deasserted during a write cycle.



assert_zero_one_hot

Ensures that the value of a specified expression is zero or one-hot.



Parameters:
severity_level
width
property_type
msg
coverage_level

Class:
single-cycle assertion

Syntax

```
assert_zero_one_hot
    [#(severity_level, width, property_type, msg, coverage_level)]
    instance_name (clk, reset_n, test_expr);
```

Parameters

severity_level		Severity of the failure. Default: ‘OVL_ERROR.
width		Width of the *test_expr* argument. Default: 32.
property_type		Property type. Default: ‘OVL_ASSERT.
msg		Error message printed when assertion fails. Default: “VIOLATION”.
coverage_level		Coverage level. Default: ‘OVL_COVER_ALL.

Ports

clk		Clock event for the assertion. The checker samples on the rising edge of the clock.
reset_n		Active low synchronous reset signal indicating completed initialization.
test_expr	[*width* - 1: 0]	Expression that should evaluate to either 0 or a one-hot value on the rising clock edge.

Description

The assert_zero_one_hot assertion checker checks the expression *test_expr* at each rising edge of *clk* to verify the expression evaluates to a one-hot value or is zero. A one-hot value has exactly one bit set to 1.

The checker is useful for verifying control circuits, circuit enabling logic and arbitration logic. For example, it can ensure that a finite-state machine with zero-one-cold encoding operates properly and has exactly one bit asserted high—or else is zero. In a datapath circuit the checker can ensure that the enabling conditions for a bus do not result in bus contention.

Assertion Checks

ASSERT_ZERO_ONE_HOT	Expression evaluated to a value with multiple bits set to 1.
test_expr contains X/Z value	Expression evaluated to a value with an X or Z bit, and ‘OVL_XCHECK_OFF is not set.

Cover Points

all_one_hots_checked	Expression evaluated to all possible combinations of one-hot values.
test_expr_all_zeros	Expression evaluated to 0.
test_expr_change	Expression has changed value.

Notes

1. By default, the assert_zero_one_hot assertion is optimistic and the assertion fails if *test_expr* has multiple bits not set to 0 (i.e.equals 1, X, Z, etc.). However, if ‘OVL_XCHECK_OFF is set, the assertion fails if and only if *test_expr* has multiple bits that are 1.

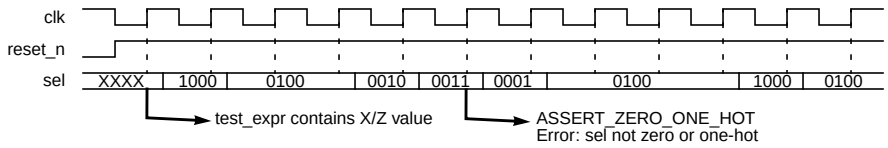
See also

assert_one_cold, assert_one_hot

Example

```
assert_zero_one_hot #(
    ‘OVL_ERROR,                          // severity_level
    4,                                   // width
    ‘OVL_ASSERT,                         // property_type
    “Error: sel not zero or one-hot”,    // msg
    ‘OVL_COVER_ALL)                      // coverage_level
    valid_sel_zero_one_hot (
        clk,                             // clock
        reset_n,                         // reset
        sel );                           // test_expr
```

Ensures that sel is zero or one-hot at each rising edge of clk.



OVL DEFINES

Global Defines

Type	DEFINE	Description
Language	‘OVL_VERILOG	(default) Creates assertion checkers defined in Verilog.
	‘OVL_SVA	Creates assertion checkers defined in System Verilog.
	‘OVL_SVA_INTERFACE	Ensures OVL assertion checkers can be instantiated in an SVA interface construct. Default: not defined.
Synthesizable Logic	‘OVL_SYNTHESIS_OFF	Ensures OVL logic is synthesizable. Default: not defined.
Function	‘OVL_ASSERT_ON	Activates assertion logic. Default: not defined.
	‘OVL_COVER_ON	Activates coverage logic. Default: not defined.
Reset	‘OVL_GLOBAL_RESET=*reset_signal*	Overrides the *reset_n* port assignments of all assertion checkers with the specified global reset signal. Default: each checker’s reset is specified by the *reset_n* port.
Reporting	‘OVL_MAX_REPORT_ERROR	Discontinues reporting a checker’s assertion violations if the number of times the checker has reported one or more violations reaches this limit. Default: unlimited reporting.
	‘OVL_MAX_REPORT_COVER_POINT	Discontinues reporting a checker’s cover points if the number of times the checker has reported one or more cover points reaches this limit.Default: unlimited reporting.
	‘OVL_INIT_MSG	Reports configuration information for each checker when it is instantiated at the start of simulation. Default: no initialization messages reported.
	‘OVL_END_OF_SIMULATION=*eos_signal*	Performs quiescent state checking at end of simulation when the *eos_signal* asserts. Default: not defined.
X/Z Values	‘OVL_XCHECK_OFF	Turns off checking of values with X and Z bits. Disables all assert_never_unknown checkers. Default: 0/1/X/Z semantics assumed on assert_never, assert_never_unknown, assert_one_cold, assert_one_hot and assert_zero_one_hot checkers.

Internal Global Defines

The following global variables are for internal use and the user should not redefine them:

‘endmodule
‘module
‘OVL_RESET_SIGNAL
‘OVL_SHARED_CODE
‘OVL_STD_DEFINES_H
‘OVL_VERSION

Defines Common to All Assertions

Parameter	DEFINE	Description
severity_level	‘OVL_FATAL	Runtime fatal error.
	‘OVL_ERROR	(default) Runtime error.
	‘OVL_WARNING	Runtime Warning.
	‘OVL_INFO	Assertion failure has no specific severity.
property_type	‘OVL_ASSERT	(default) All the assertion checker’s checks are asserts.
	‘OVL_ASSUME	All the assertion checker’s checks are assumes.
coverage_level	‘OVL_COVER_NONE	(default) Activates coverage logic for the checker if ‘OVL_COVER_ON is defined.
	‘OVL_COVER_ALL	De-activates coverage logic for the checker, even if ‘OVL_COVER_ON is defined.

Defines for Specific Assertions

Parameter	Checkers	DEFINE	Description
action_on_new_start	assert_change assert_frame assert_time assert_unchange	‘OVL_IGNORE_NEW_START	(default) Ignore new start events.
		‘OVL_RESET_ON_NEW_START	Restart check on new start events.
		‘OVL_ERROR_ON_NEW_START	Assert fail on new start events.
edge_type	assert_always_on_edge	‘OVL_NOEDGE	(default) Always initiate check.
		‘OVL_POSEDGE	Initiate check on rising edge of sampling event.
		‘OVL_NEGEDGE	Initiate check on falling edge of sampling event.
		‘OVL_ANYEDGE	Initiate check on both edges of sampling event.
necessary_condition	assert_cycle_sequence	‘OVL_TRIGGER_ON_MOST_PIPE	(default) Necessary condition is full sequence. Pipelining enabled.
		‘OVL_TRIGGER_ON_FIRST_PIPE	Necessary condition is first in sequence. Pipelining enabled.
		‘OVL_TRIGGER_ON_FIRST_NOPIPE	Necessary condition is first in sequence. Pipelining disabled.
inactive	assert_one_cold	‘OVL_ALL_ZEROS	Inactive state is all 0’s.
		‘OVL_ALL_ONES	Inactive state is all 1’s.
		‘OVL_ONE_COLD	(default) No inactive state.

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