

AXI4-Lite VVC – Quick Reference

For general information see UVVM VVC Framework Essential Mechanisms located in `uvvm_vvc_framework/doc`. **CAUTION:** shaded `code/description` is preliminary

axilite_write (VVCT, vvc_instance_idx, addr, data, [byte_enable], msg, [scope])

Example: `axilite_write(AXILITE_VVCT, 1, x"6000", x"F102", "Writing data to Peripheral 1");`

axilite_read (VVCT, vvc_instance_idx, addr, [TO_SB,] msg, [scope])

Example: `axilite_read(AXILITE_VVCT, 1, x"6000", "Read from Peripheral 1 and store data in VVC. Must be retrieved later using fetch result.");`
`axilite_read(AXILITE_VVCT, 1, x"600F", TO_SB, "Read from Peripheral and send result to scoreboard");`

axilite_check (VVCT, vvc_instance_idx, addr, data, msg, [alert_level, [scope]])

Example: `axilite_check(AXILITE_VVCT, 1, x"6000", x"393B", "Check data from Peripheral 1");`



axilite_vvc.vhd

AXI4-Lite VVC Configuration record `'vvc_config'` -- accessible via `shared_axilite_vvc_config`

Record element	Type	C_AXILITE_VVC_CONFIG_DEFAULT
<code>inter_bfm_delay</code>	<code>t_inter_bfm_delay</code>	<code>C_AXILITE_INTER_BFM_DELAY_DEFAULT</code>
<code>[cmd/result]_queue_count_max</code>	<code>natural</code>	<code>C_[CMD/RESULT]_QUEUE_COUNT_MAX</code>
<code>[cmd/result]_queue_count_threshold</code>	<code>natural</code>	<code>C_[CMD/RESULT]_QUEUE_COUNT_THRESHOLD</code>
<code>[cmd/result]_queue_count_threshold_severity</code>	<code>t_alert_level</code>	<code>C_[CMD/RESULT]_QUEUE_COUNT_THRESHOLD_SEVERITY</code>
<code>bfm_config</code>	<code>t_axilite_bfm_config</code>	<code>C_AXILITE_BFM_CONFIG_DEFAULT</code>
<code>msg_id_panel</code>	<code>t_msg_id_panel</code>	<code>C_VVC_MSG_ID_PANEL_DEFAULT</code>

AXI4-Lite VVC Status record signal `'vvc_status'` -- accessible via `shared_axilite_vvc_status`

Record element	Type
<code>current_cmd_idx</code>	<code>natural</code>
<code>previous_cmd_idx</code>	<code>natural</code>
<code>pending_cmd_cnt</code>	<code>natural</code>

Common VVC procedures applicable for this VVC

- See UVVM Methods QuickRef for details.

`await_completion()`
`enable_log_msg()`
`disable_log_msg()`
`fetch_result()`
`flush_command_queue()`
`terminate_current_command()`
`terminate_all_commands()`
`insert_delay()`
`get_last_received_cmd_idx()`



VVC target parameters

Name	Type	Example(s)	Description
VVCT	t_vvc_target_record	AXILITE_VVCT	VVC target type compiled into each VVC in order to differentiate between VVCs.
vvc_instance_idx	integer	1	Instance number of the VVC

VVC functional parameters

Name	Type	Example(s)	Description
addr	unsigned	x"325A"	The address of a SW accessible register. Could be offset or full address depending on the DUT
data	std_logic_vector	x"F1A332D3"	The data to be written (in axilite_write) or the expected data (in axilite_check).
byte_enable	std_logic_vector	(others => '1')	This argument selects which bytes to use (all '1' means all bytes are updated)
msg	string	"Send to peripheral 1"	A custom message to be appended in the log/alert
alert-level	t_alert_level	ERROR or TB_WARNING	Set the severity for the alert that may be asserted by the method.
scope	string	"AXILITE VVC"	A string describing the scope from which the log/alert originates. In a simple single sequencer typically "AXILITE BFM". In a verification component typically "AXILITE VVC".

VVC entity signals

Name	Type	Description
clk	std_logic	VVC Clock signal
axilite_vvc_master_if	t_axilite_if	See AXI4-Lite BFM documentation

VVC entity generic constants

Name	Type	Default	Description
GC_ADDR_WIDTH	integer	8	Width of the AXI4-Lite address bus
GC_DATA_WIDTH	integer	32	Width of the AXI4-Lite data bus
GC_INSTANCE_IDX	natural	1	Instance number to assign the VVC
GC_AXILITE_CONFIG	t_axilite_bfm_config	C_AXILITE_BFM_CONFIG_DEFAULT	Configuration for the AXI4-Lite BFM, see AXI4-Lite BFM documentation.
GC_CMD_QUEUE_COUNT_MAX	natural	1000	Absolute maximum number of commands in the VVC command queue
GC_CMD_QUEUE_COUNT_THRESHOLD	natural	950	An alert will be generated when reaching this threshold to indicate that the command queue is almost full. The queue will still accept new commands until it reaches C_CMD_QUEUE_COUNT_MAX.
GC_CMD_QUEUE_COUNT_THRESHOLD_SEVERITY	t_alert_level	WARNING	Alert severity which will be used when command queue reaches GC_CMD_QUEUE_COUNT_THRESHOLD.
GC_RESULT_QUEUE_COUNT_MAX	natural	1000	Maximum number of unfetched results before result_queue is full.
GC_RESULT_QUEUE_COUNT_THRESHOLD	natural	950	An alert with severity 'result_queue_count_threshold_severity' will be issued if result queue exceeds this count. Used for early warning if result queue is almost full. Will be ignored if set to 0.
GC_RESULT_QUEUE_COUNT_THRESHOLD_SEVERITY	t_alert_level	WARNING	Severity of alert to be initiated if exceeding result_queue_count_threshold

VVC details

All VVC procedures are defined in `vvm_methods_pkg` (dedicated this VVC), and `uvvm_vvc_framework.td_vvc_framework_common_methods_pkg` (common VVC procedures)

It is also possible to send a multicast to all instances of a VVC with `ALL_INSTANCES` as parameter for `vvc_instance_idx`.

Note: Every procedure here can be called without the optional parameters enclosed in [].

1 VVC procedure details and examples

Procedure	Description
axilite_write()	<p>axilite_write(VVC, instance_idx, addr, data, [byte_enable,] msg, [scope])</p> <p>The <code>axilite_write()</code> VVC procedure adds a write command to the AXI4-Lite VVC executor queue, which will run as soon as all preceding commands have completed. When the write command is scheduled to run, the executor calls the AXI4-Lite BFM <code>axilite_write()</code> procedure, described in the AXI4-Lite BFM QuickRef.</p> <p><code>axilite_write</code> can be called with or without <code>byte_enable</code> constant. When not set, <code>byte_enable</code> is set to all '1', indicating that all bytes are valid.</p> <p>Examples:</p> <pre>axilite_write(AXILITE_VVCT, 1, x"0011A000", x"F102", "Writing data to Peripheral 1", C_SCOPE); axilite_write(AXILITE_VVCT, 1, C_ADDR_PERIPHERAL_1, x"F102", b"11", "Writing data to Peripheral 1", C_SCOPE); axilite_write(AXILITE_VVCT, 1, C_ADDR_DMA, x"1155F102", "Writing data to DMA", C_SCOPE);</pre>
axilite_read()	<p>axilite_read(VVC, instance_idx, addr, [TO_SB,] msg, [scope])</p> <p>The <code>axilite_read()</code> VVC procedure adds a read command to the AXI4-Lite VVC executor queue, which will run as soon as all preceding commands have completed. When the read command is scheduled to run, the executor calls the AXI4-Lite BFM <code>axilite_read()</code> procedure, described in the AXI4-Lite BFM QuickRef.</p> <p>The value read from the DUT will not be returned in this procedure call since it is non-blocking for the sequencer/caller, but the read data will be stored in the VVC for a potential future fetch (see example with <code>fetch_result()</code> below).</p> <p>If the option <code>TO_SB</code> is applied the received data will be sent to the AXI Lite VVC dedicated scoreboard where it will be checked against the expected value (provided by the testbench).</p> <p>Examples:</p> <pre>axilite_read(AXILITE_VVCT, 1, x"00099555", "Read from Peripheral 1" C_SCOPE); axilite_read(AXILITE_VVCT, 1, C_ADDR_IO, "Read from IO device" C_SCOPE);</pre> <p>Example with <code>fetch_result()</code> call. Result is placed in <code>v_data</code></p> <pre>variable v_cmd_idx : natural; -- Command index for the last read variable v_data : work.vvc_cmd_pkg.t_vvc_result; -- Result from read (...) axilite_read(AXILITE_VVCT, 1, x"112252AA", "Read from Peripheral 1"); v_cmd_idx := get_last_received_cmd_idx(AXILITE_VVCT, 1); await_completion(AXILITE_VVCT, 1, v_cmd_idx, 100 ns, "Wait for read to finish"); fetch_result(AXILITE_VVCT, 1, v_cmd_idx, v_data, "Fetching result from read operation");</pre>

axilite_check()

axilite_check(VVC, instance_idx, addr, data, msg, [alert_level, [scope]])

The axilite_check() VVC procedure adds a check command to the AXI4-Lite VVC executor queue, which will run as soon as all preceding commands have completed. When the check command is scheduled to run, the executor calls the AXI4-Lite BFM axilite_check() procedure, described in the AXI4-Lite BFM QuickRef. The axilite_check() procedure will perform a read operation, then check if the read data is equal to the 'data' parameter. If the read data is not equal to the expected 'data' parameter, an alert with severity 'alert_level' will be issued. The read data will not be stored by this procedure.

Example:

```
axilite_check(AXILITE_VVCT, 1, x"00099555", x"393B", "Check data from Peripheral 1", ERROR, C_SCOPE);
```

2 VVC Configuration

Record element	Type	C_AXILITE_BFM_CONFIG_DEFAULT	Description
inter_bfm_delay	t_inter_bfm_delay	C_AXILITE_INTER_BFM_DELAY_DEFAULT	Delay between any requested BFM accesses towards the DUT. - TIME_START2START: Time from a BFM start to the next BFM start (A TB_WARNING will be issued if access takes longer than TIME_START2START). - TIME_FINISH2START: Time from a BFM end to the next BFM start. Any insert_delay() command will add to the above minimum delays, giving for instance the ability to skew the BFM starting time.
cmd_queue_count_max	natural	C_MAX_COMMAND_QUEUE	Maximum pending number in command queue before queue is full. Adding additional commands will result in an ERROR.
cmd_queue_count_threshold	natural	C_CMD_QUEUE_COUNT_THRESHOLD	An alert with severity "cmd_queue_count_threshold_severity" will be issued if command queue exceeds this count. Used for early warning if command queue is almost full. Will be ignored if set to 0.
cmd_queue_count_threshold_severity	t_alert_level	C_CMD_QUEUE_COUNT_THRESHOLD_SEVERITY	Severity of alert to be initiated if exceeding cmd_queue_count_threshold
result_queue_count_max	natural	C_RESULT_QUEUE_COUNT_MAX	Maximum number of unfetched results before result_queue is full.
result_queue_count_threshold	natural	C_RESULT_QUEUE_COUNT_THRESHOLD	An alert with severity 'result_queue_count_threshold_severity' will be issued if result queue exceeds this count. Used for early warning if result queue is almost full. Will be ignored if set to 0.
result_queue_count_threshold_severity	t_alert_level	C_RESULT_QUEUE_COUNT_THRESHOLD_SEVERITY	Severity of alert to be initiated if exceeding result_queue_count_threshold
bfm_config	t_axilite_bfm_config	C_AXILITE_BFM_CONFIG_DEFAULT	Configuration for AXI4-Lite BFM. See quick reference for AXI4-Lite BFM
msg_id_panel	t_msg_id_panel	C_VVC_MSG_ID_PANEL_DEFAULT	VVC dedicated message ID panel. See section 16 of uvvm_vvc_framework/doc/UVVM_VVC_Framework_Essential_Mechanisms.pdf for how to use verbosity control.

The configuration record can be accessed from the Central Testbench Sequencer through the shared variable array, e.g.:

```
shared_axilite_vvc_config(1).inter_bfm_delay.delay_in_time := 50 ns;
shared_axilite_vvc_config(1).bfm_config.clock_period      := 10 ns;
```

3 VVC Status

The current status of the VVC can be retrieved during simulation. This is achieved by reading from the shared variable `shared_axilite_vvc_status` record from the test sequencer. The record contents can be seen below:

Record element	Type	Description
<code>current_cmd_idx</code>	natural	Command index currently running
<code>previous_cmd_idx</code>	natural	Previous command index to run
<code>pending_cmd_cnt</code>	natural	Pending number of commands in the command queue

4 Activity watchdog

The VVCs support an activity watchdog which monitors VVC activity and will alert if no VVC activity is registered within a selected timeout value. The VVCs will register their presence to the activity watchdog at start-up, and report when busy and not, using dedicated activity watchdog methods and triggering the `global_trigger_activity_watchdog` signal, during simulations.

Include `activity_watchdog(num_exp_vvc, timeout, alert_level, msg)` in the testbench to start using the activity watchdog. More information can be found in UVVM Essential Mechanisms PDF in the UVVM VVC Framework doc folder.

5 Transaction Info

This VVC supports transaction info, a UVVM concept for distributing transaction information in a controlled manner within the complete testbench environment. The transaction info may be used in many different ways, but the main purpose is to share information directly from the VVC to a DUT model.

Table 5.1 AXI4-Lite transaction info record fields. Transaction type: `t_base_transaction` (BT)

Info field	Type	Default	Description
<code>operation</code>	<code>t_operation</code>	<code>NO_OPERATION</code>	Current VVC operation, e.g. <code>INSERT_DELAY</code> , <code>POLL_UNTIL</code> , <code>READ</code> , <code>WRITE</code> .
<code>addr</code>	<code>unsigned(31 downto 0)</code>	<code>0x0</code>	Address of the AXILITE read or write transaction.
<code>data</code>	<code>slv(255 downto 0)</code>	<code>0x0</code>	Data for AXILITE read or write transaction.
<code>byte_enable</code>	<code>slv(31 downto 0)</code>	<code>0x0</code>	Byte enable for the AXILITE read or write transaction.
<code>vvc_meta</code>	<code>t_vvc_meta</code>	<code>C_VVC_META_DEFAULT</code>	VVC meta data of the executing VVC command.
→ <code>msg</code>	<code>string</code>	<code>" "</code>	Message of executing VVC command.
→ <code>cmd_idx</code>	<code>integer</code>	<code>-1</code>	Command index of executing VVC command.
<code>transaction_status</code>	<code>t_transaction_status</code>	<code>C_TRANSACTION_STATUS_DEFAULT</code>	Set to <code>INACTIVE</code> , <code>IN_PROGRESS</code> , <code>FAILED</code> or <code>SUCCEEDED</code> during a transaction.

See UVVM VVC Framework Essential Mechanisms PDF, section 6, for additional information about transaction types and transaction info usage.

6 Scoreboard

This VVC has built in Scoreboard functionality where data can be routed by setting the TO_SB parameter in supported method calls, i.e. `axilite_read()`. Note that the data is only stored in the scoreboard and not accessible with the `fetch_result()` method when the TO_SB parameter is applied.

The AXI Lite VVC scoreboard is per default 128 bits wide std logic vector. When sending expected data to the scoreboard, where the data width is smaller than the default scoreboard width, we recommend zero-padding the data with the `pad_sb_slv()` function. E.g. `AXILITE_VVC_SB.add_expected(<AXI Lite VVC instance number>, pad_sb_slv(<exp_data>))`;

See the Generic Scoreboard Quick Reference PDF in the Bitvis VIP Scoreboard document folder for a complete list of available commands and additional information. The AXI4-Lite VVC scoreboard is accessible from the testbench as a shared variable `AXILITE_VVC_SB`, located in the `vcv_methods_pkg.vhd`. All of the listed Generic Scoreboard commands are available for the AXI4-Lite VVC scoreboard using this shared variable.

7 VVC Interface

In this VVC, the interface has been encapsulated in a signal record of type `t_axilite_if` in order to improve readability of the code. Since the AXI4-Lite interface busses can be of arbitrary size, the interface `std_logic_vectors` have been left unconstrained. These unconstrained SLVs needs to be constrained when the interface signals are instantiated. For this interface, the could look like:

```
signal axilite_if_1 : t_axilite_if( write_address_channel( awaddr( C_ADDR_WIDTH  -1 downto 0)),
                                   write_data_channel    ( wdata ( C_DATA_WIDTH  -1 downto 0),
                                                            wstrb(( C_DATA_WIDTH/8)-1 downto 0)),
                                   read_address_channel   ( araddr( C_ADDR_WIDTH  -1 downto 0)),
                                   read_data_channel      ( rdata ( C_DATA_WIDTH  -1 downto 0)) );
```

8 Additional Documentation

Additional documentation about UVVM and its features can be found under `"/uvvm_vvc_framework/doc/".`

For additional documentation on the AXI4-Lite standard, please see the AXI4-Lite specification "AMBA® AXI™ and ACE™ Protocol Specification - AXI3™, AXI4™, and AXI4-Lite™ ACE and ACE-Lite™", available from ARM.

9 Compilation

AXI4-Lite VVC must be compiled with VHDL 2008.

It is dependent on the following libraries

- **UVVM Utility Library (UVVM-Util), version 2.13.0 and up**
- **UVVM VVC Framework, version 2.8.0 and up**
- **AXI4-Lite BFM**
- **Bitvis VIP Scoreboard**

Before compiling the AXI4-Lite VVC, assure that `uvvm_vvc_framework`, `uvvm_util` and `bitvis_vip_scoreboard` have been compiled.

See UVVM Essential Mechanisms located in `uvvm_vvc_framework/doc` for information about compile scripts.

Compile order for the AXI4-Lite VVC:

Compile to library	File	Comment
<code>bitvis_vip_axilite</code>	<code>axilite_bfm_pkg.vhd</code>	AXI4-Lite BFM
<code>bitvis_vip_axilite</code>	<code>transaction_pkg</code>	AXI4-Lite transaction package with DTT types, constants etc.
<code>bitvis_vip_axilite</code>	<code>vvc_cmd_pkg.vhd</code>	AXI4-Lite VVC command types and operations
<code>bitvis_vip_axilite</code>	<code>../uvvm_vvc_framework/src_target_dependent/td_target_support_pkg.vhd</code>	UVVM VVC target support package, compiled into the AXI4-Lite VVC library.
<code>bitvis_vip_axilite</code>	<code>../uvvm_vvc_framework/src_target_dependent/td_vvc_framework_common_methods_pkg.vhd</code>	UVVM framework common methods compiled into the AXI4-Lite VVC library
<code>bitvis_vip_axilite</code>	<code>vvc_methods_pkg.vhd</code>	AXI4-Lite VVC methods
<code>bitvis_vip_axilite</code>	<code>../uvvm_vvc_framework/src_target_dependent/td_queue_pkg.vhd</code>	UVVM queue package for the VVC
<code>bitvis_vip_axilite</code>	<code>../uvvm_vvc_framework/src_target_dependent/td_vvc_entity_support_pkg.vhd</code>	UVVM VVC entity support compiled into the AXI4-Lite VVC library
<code>bitvis_vip_axilite</code>	<code>axilite_vvc.vhd</code>	AXI4-Lite VVC

10 Simulator compatibility and setup

See README.md for a list of supported simulators.

For required simulator setup see **UVVM-Util** Quick reference.

IMPORTANT

This is a simplified Verification IP (VIP) for AXI4-Lite. The given VIP complies with the basic AXI4-Lite protocol and thus allows a normal access towards an AXI4-Lite interface. This VIP is not AXI4-Lite protocol checker. For a more advanced VIP please contact Bitvis AS at support@bitvis.no

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