UART VVC – Quick Reference

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

uart_transmit (VVCT, vvc_instance_idx, channel, data | {num_words, randomisation}, msg, [scope])

Examples: uart_transmit(UART_VVCT, 1, TX, x"AF", "Sending data to Peripheral 1");
uart_transmit(UART_VVCT, 1, TX, 5, RANDOM, "Sending 5 random bytes");

uart_receive (VVCT, vvc_instance_idx, channel, [Coverage,] [TO_SB,] msg, [alert_level, [scope]])

Example: uart_receive(UART_VVCT, 1, RX, "Receive from Peripheral 1");
uart_receive (UART_VVCT, 1, RX, COVERAGE_FULL, TO_SB, "Receiving data until coverage reached. Passing on to SB", ERROR, C_SCOPE);

uart_expect (VVCT, vvc_instance_idx, channel, data, msg, [max_receptions, [timeout, [alert_level, [scope]]]])

Example: uart_expect(UART_VVCT, 1, RX, x"42","Expect data from Peripheral 1");

VVC

uart_vvc.vhd
uart_rx_vvc.vhd
uart_tx_vvc.vhd

UART VVC Configuration record ´**vvc_config**´ -- accessible via **shared_uart_vvc_config**

Record element	Type	C_UART_VVC_CONFIG_DEFAULT
inter_bfm_delay	t_inter_bfm_delay	C_UART_INTER_BFM_DELAY_DEFAULT
[cmd/result]_queue_count_max	natural	C_[CMD/RESULT]_QUEUE_COUNT_MAX
[cmd/result]_queue_count_threshold	natural	C_[CMD/RESULT]_QUEUE_COUNT_THRESHOLD
[cmd/result]_queue_count_threshold_severity	t_alert_level	C_[CMD/RESULT]_QUEUE_COUNT_THRESHOLD_SEVERITY
bfm_config	t_uart_bfm_config	C_UART_BFM_CONFIG_DEFAULT
error_injection	t_vvc_error_injection	C_ERROR_INJECTION_INACTIVE
bit_rate_checker	t_bit_rate_checker	C_BIT_RATE_CHECKER_DEFAULT
msg_id_panel	t_msg_id_panel	C_VVC_MSG_ID_PANEL_DEFAULT

UART VVC Status record signal ´**vvc_status**´ -- accessible via **shared_uart_vvc_status**

Record element	Type
current_cmd_idx	natural
previous_cmd_idx	natural
pending_cmd_cnt	natural

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()

UVVM™
VHDL 2008 only

VVC target parameters

Name	Type	Example(s)	Description
VVCT	t_vvc_target_record	UART_VVCT	VVC target type compiled into each VVC in order to differentiate between VVCs.
vvc_instance_idx	integer	1	Instance number of the VVC
channel	t_channel	TX, RX or ALL_CHANNELS	The VVC channel of the VVC instance

VVC functional parameters

Name	Type	Example(s)	Description
data	std_logic_vector	x"FF"	The data to be transmitted (in uart_transmit) or the expected data (in uart_expect).
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.
max_receptions	natural	1	The maximum number of receptions before the expected data must be found. Exceeding this limit results in an alert 'alert_level'.
timeout	time	100 ns	The maximum time to pass before the expected data must be found. Exceeding this limit results in an alert 'alert_level'.
scope	string	"UART VVC"	A string describing the scope from which the log/alert originates.

VVC entity signals

Name	Type	Direction	Description
clk	std_logic	Input	VVC Clock signal
uart_vvc_rx	std_logic	Input	UART VVC RX signal
uart_vvc_tx	std_logic	Inout	UART VVC TX signal

VVC entity generic constants

Name	Type	Default	Description
GC_DATA_WIDTH	natural	8	Bits in the UART byte
GC_INSTANCE_IDX	natural	1	Instance number to assign the VVC
GC_CHANNEL	t_channel	TX/RX	Channel to be assigned to this leaf VVC (only used in TX or RX implementations, not in the uart_vvc.vhd wrapper).
GC_UART_CONFIG	t_uart_bfm_config	C_UART_BFM_CONFIG_DEFAULT	Configuration for the UART BFM, see UART 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 vvc_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

uart_transmit()	**uart_transmit (VVCT, vvc_instance_idx, channel, data | {num_words, randomisation}, msg, [scope])**
	
	The uart_transmit() VVC procedure adds a transmit command to the UART TX VVC executor queue, that will run as soon as all preceding commands have completed.
	The uart_transmit() command has two variants using either just data for a basic single transaction, or num_words + randomisation for a more advanced version.
	When the basic transmit command is scheduled to run, the executor calls the UART BFM uart_transmit() procedure, described in the UART BFM QuickRef. The uart_transmit() procedure can only be called using the UART TX channel, i.e. setting 'channel' to 'TX'.
	When the more advanced randomisation command is applied the basic BFM uart_transmit() transaction is executed num_words times with new random data each time – according to the given randomisation profile.
	Current defined randomisation profiles are: RANDOM: Standard uniform random. This is provided as an example.
	Errors may be injected – depending on the error_injection_config sub-record within the vvc_config
	
	Example:
	`uart_transmit(UART_VVCT, 1, TX, x"0D", "Transmitting carriage return to Peripheral 1", C_SCOPE);`
	`DRAFT uart_transmit(UART_VVCT, 1, TX, 5, RANDOM, "Sending 5 random bytes");`

uart_receive()

uart_receive (VVCT, vvc_instance_idx, channel, [Coverage,] [TO_SB,] msg, [alert_level, [scope]])

The uart_receive() VVC procedure adds a receive command to the UART RX VVC executor queue, that will run as soon as all preceding commands have completed. When the receive command is scheduled to run, the executor calls the UART BFM uart_receive() procedure, described in the UART BFM QuickRef.
The received data from DUT will not be returned in this procedure call since it is non-blocking for the sequencer/caller, but the received data will be stored in the VVC for a potential future fetch (see example with *fetch_result* below). The uart_receive() procedure can only be called using the UART RX channel, i.e. setting 'channel' to 'RX'.

If the option TO_SB is applied the received data will be sent to the UART_VVC dedicated scoreboard where it will be checked against the expected value (provided by the testbench).

If the Coverage option is applied the basic BFM uart_uart_receive() is executed continuously until the predefined coverage requirement is met..
Current defined Coverage profiles are: COVERAGE_FULL: All possible patterns (of 0 and 1) are covered at least once. This is provided as an example.

Example:

```
uart_receive (UART_VVCT, 1, RX, "Receiving from Peripheral 1", ERROR, C_SCOPE);
uart_receive (UART_VVCT, 1, RX, TO_SB, "Receiving data and passing on to Scoreboard", ERROR, C_SCOPE);
uart_receive (UART_VVCT, 1, RX, COVERAGE_FULL, "Receiving data until coverage reached", ERROR, C_SCOPE);
uart_receive (UART_VVCT, 1, RX, COVERAGE_FULL, TO_SB, "Receiving data until coverage reached. Passing on to SB", ERROR, C_SCOPE);
```

Example with fetch_result() call: Result is placed in **v_data**

```
variable v_cmd_idx         : natural;                                -- Command index for the last read
variable v_data            : bitvis_vip_uart.vvc_cmd_pkg.t_vvc_result; -- Result from read
(…)
uart_receive(UART_VVCT, 1, RX, "Receiving from Peripheral 1");
v_cmd_idx := get_last_received_cmd_idx(UART_VVCT, 1);
await_completion(UART_VVCT,1, v_cmd_idx, 1 us, "Wait for receive to finish");
fetch_result(UART_VVCT,1, v_cmd_idx, v_data, "Fetching result from receive operation");
```

uart_expect()

uart_expect (VVCT, vvc_instance_idx, channel, data, msg, [max_receptions, [timeout, [alert_level, [scope]]]])

The uart_expect() VVC procedure adds an expect command to the UART VVC executor queue, which will run as soon as all preceding commands have completed. When the expect command is scheduled to run, the executor calls the UART BFM uart_expect() procedure, described in the UART BFM QuickRef. The received data will not be stored by this procedure. The uart_expect() procedure can only be called using the UART RX channel, i.e. setting 'channel' to 'RX'.

Examples:

```
uart_expect(UART_VVCT, 1, RX, x"0D", "Expecting carriage return from Peripheral 1");
uart_expect(UART_VVCT, 1, RX, C_CR_BYTE, "Expecting carriage return from Peripheral 1", 5, 10 ms, ERROR, C_SCOPE);
```

2 VVC Configuration

Record element	Type	C_UART_VVC_CONFIG_DEFAULT	Description
inter_bfm_delay	t_inter_bfm_delay	C_UART_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 triggered if command count 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_uart_bfm_config	C_UART_BFM_CONFIG_DEFAULT	Configuration for UART BFM. See QuickRef for UART BFM
error_injection	t_vvc_error_injection	C_ERROR_INJECTION_INACTIVE	Sets up the error injection policy. Will use this to set the error injection record inside the bfm_config. See table below.
bit_rate_checker	t_bit_rate_checker	C_BIT_RATE_CHECKER_DEFAULT	Configure the UART property checker behaviour.
msg_id_panel	t_msg_id_panel	C_VVC_MSG_ID_PANEL_DEFAULT	VVC dedicated message ID panel

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

```
shared_uart_vvc_config(TX,1).inter_bfm_delay.delay_in_time := 10 ms;
shared_uart_vvc_config(RX,1).bfm_config.num_data_bits      := 8;
```

VVC Error injection record (inside the VVC configuration record above)

Record element	Type	DEFAULT	Description
parity_bit_error_prob	real	0,0	The probability that the VVC will request a parity_bit_error when calling a BFM transmission procedure. (See BFM doc)
stop_bit_error_prob	real	0,0	The probability that the VVC will request a stop_bit_error when calling a BFM transmission procedure. (See BFM doc)

Note 1: A value of 1.0 means every transmission should have this error injection, whereas 0.0 means error injection is turned off. Anything in between means randomisation with the given probability
Note 2: The error_injection_config in the VVC config will override any error injection specified in the BFM config.

Error injection in general is explained in ‘UVVM Essential Mechanisms’ located in uvvm_vvc_framework/doc.

VVC Property checking record (inside the VVC configuration record above)

Record element	Type	DEFAULT	Description
enable	boolean	FALSE	Enables or disables the complete bit rate checker
min_period	time	0,0	The minimum allowed bit period for any bit (any bit level change to the next)
alert_level	t_alert_level	ERROR	Alert generated if minimum requirement is violated

Property checking and controlling this is explained in general in 'UVVM Essential Mechanisms' located in uvvm_vvc_framework/doc.

3 VVC Status

The current status of the VVC can be retrieved during simulation. This is done by reading from the shared variable shared_uart_vvc_status record from the test sequencer. The record contains status for both channels, specified with the channel axis of the shared_uart_vvc_status array.The record contents can be seen below:

Record element	Type	Description
current_cmd_idx	natural	Command index currently running
previous_cmd_idx	natural	Previous command index to run
pending_cmd_cnt	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_testcase_inactivity_watchdog signal, during simulations.

Include `activity_watchdog(num_exp_vvc, timeout, alert_level, msg)` in the testbench to start using the activity watchdog.
Note that each channel is counted in the number of registered VVCs in the activity watchdog register, thus the UART VVC is counted as two VVCs.
More information can be found in UVVM Essential Mechanisms PDF in the UVVM VVC Framework doc folder.

5 Additional Documentation

Additional documentation about UVVM and its features can be found under "/uvvm_vvc_framework/doc/".
For additional documentation on the UART protocol, please see the UART specification.

6 Compilation

The UART VVC must be compiled with VHDL 2008.
It is dependent on the following libraries

- ***UVVM Utility Library (UVVM-Util), version 2.10.0 and up***
- ***UVVM VVC Framework, version 2.6.0 and up***
- ***UART BFM***
- ***Bitvis VIP Scoreboard***

Before compiling the UART VVC, make sure 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 UART VVC:

Compile to library	File	Comment
bitvis_vip_uart	uart_bfm_pkg.vhd	UART BFM
bitvis_vip_uart	transaction_pkg.vhd	UART transaction package for the VVC, BFM, Model, Scoreboard etc.
bitvis_vip_uart	vvc_cmd_pkg.vhd	UART VVC command types and operations
bitvis_vip_uart	**[** monitor_cmd_pkg.vhd **]**	UART Monitor package. Only include this file if you intend to use Monitor.
bitvis_vip_uart	../uvvm_vvc_framework/src_target_dependent/td_target_support_pkg.vhd	UVVM VVC target support package, compiled into the UART VVC library.
bitvis_vip_uart	../uvvm_vvc_framework/src_target_dependent/td_vvc_framework_common_methods_pkg.vhd	UVVM framework common methods compiled into the UART VVC library
bitvis_vip_uart	vvc_methods_pkg.vhd	UART VVC methods
bitvis_vip_uart	../uvvm_vvc_framework/src_target_dependent/td_queue_pkg.vhd	UVVM queue package for the VVC
bitvis_vip_uart	../uvvm_vvc_framework/src_target_dependent/td_vvc_entity_support_pkg.vhd	UVVM VVC entity methods compiled into the UART VVC library
bitvis_vip_uart	uart_rx_vvc.vhd	UART RX VVC
bitvis_vip_uart	uart_tx_vvc.vhd	UART TX VVC
bitvis_vip_uart	uart_vvc.vhd	UART VVC wrapper for the RX and TX VVCs
bitvis_vip_uart	**[** uart_monitor.vhd **]**	UART Monitor. Only include this file if you intend to use Monitor.
bitvis_vip_uart	vvc_context.vhd	Common UART VIP use declarations.

7 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 UART TX and RX.
The given VIP complies with the basic UART protocol and thus allows a normal access towards a UART interface. This VIP is not a UART protocol checker.
For a more advanced VIP please contact Bitvis AS at support@bitvis.no