**SBI BFM** –Quick Reference

**BFM**

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| sbi\_write (addr\_value, data\_value, msg, clk, sbi\_if, [scope, [msg\_id\_panel, [config]]]) |
| Example: sbi\_write(x"1000", x”40”, “Set baud rate to 9600”, clk, sbi\_if);  *Suggested usage: sbi\_write(C\_ADDR\_UART\_TX, C\_BAUD\_9600, “Set baud rate to 9600”); -- Suggested usage requires local overload (see section 5)* |

*sbi\_bfm\_pkg.vhd*

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| sbi\_read (addr\_value, data\_value, msg, clk, sbi\_if, [scope, [msg\_id\_panel, [config, [proc\_name]]]]) |
| Example: sbi\_read(x"1000", v\_data\_out, “Read UART baud rate”, clk, sbi\_if);  *Suggested usage: sbi\_read(C\_ADDR\_UART\_BAUD, v\_data\_out, “Read UART baud rate”); -- Suggested usage requires local overload (see section 5)* |

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| sbi\_check (addr\_value, data\_exp, msg, clk, sbi\_if, [alert\_level, [scope, [msg\_id\_panel, [config]]]]) |
| Example: sbi\_check(x"1155", x”3B”, *“Check data from UART RX”*, clk, sbi\_if);  *Suggested usage: sbi\_check(C\_ADDR\_UART\_RX, x”3B”, “Check data from UART RX”); -- Suggested usage requires local overload (see section 5)* |

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| sbi\_poll\_until (addr\_value, data\_exp, max\_polls, timeout, msg, clk, sbi\_if, terminate\_loop, [alert\_level, [scope, [msg\_id\_panel, [config]]]]) |
| Example: sbi\_poll\_until(x"1155", x”0D”, 10, 100 ns, *“Read UART until CR is found”*, clk, sbi\_if, terminate\_loop);  *Suggested usage: sbi\_poll\_until(C\_ADDR\_UART\_RX, x”0D”, “Read UART until CR is found”); -- Suggested usage requires local overload (see section 5)* |

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| init\_sbi\_if\_signals (addr\_width, data\_width) |
| Example: sbi\_if <= init\_sbi\_if\_signals(addr\_width, data\_width); |



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| |  |  |  | | --- | --- | --- | | BFM Configuration record ´**t\_sbi\_bfm\_config´** | | | | **Record element** | **Type** | **C\_SBI\_BFM\_CONFIG\_DEFAULT** | | max\_wait\_cycles | integer | 10 | | max\_wait\_cycles\_severity | t\_alert\_level | FAILURE | | use\_fixed\_wait\_cycles\_read | boolean | false | | fixed\_wait\_cycles\_read | natural | 0 | | clock\_period | time | -1 ns | | clock\_period\_margin | time | 0 ns | | clock\_margin\_severity | t\_alert\_level | TB\_ERROR | | setup\_time | time | -1 ns | | hold\_time | time | -1 ns | | bfm\_sync | t\_bfm\_sync | SYNC\_ON\_CLOCK\_ONLY | | match\_strictness | t\_match\_strictness | MATCH\_EXACT | | id\_for\_bfm | t\_msg\_id | ID\_BFM | | id\_for\_bfm\_wait | t\_msg\_id | ID\_BFM\_WAIT | | id\_for\_bfm\_poll | t\_msg\_id | ID\_BFM\_POLL | | use\_ready\_signal | boolean | true | | |  |  | | --- | --- | | Signal record ´**t\_sbi\_if´** | | | **Record element** | **Type** | | cs | std\_logic | | addr | unsigned | | wena | std\_logic | | rena | std\_logic | | wdata | std\_logic\_vector | | ready | std\_logic | | rdata | std\_logic\_vector |   Note: BFM calls can also be made with listing of single signals rather than t\_sbi\_if.  Note: If using non-ready version, set ready to ‘1’ or set use\_ready\_signal to false. |

BFM non-signal parameters

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| **Name** | **Type** | **Example(s)** | **Description** |
| addr\_value | unsigned | x”5A” | The address of a software accessible register. |
| data\_value | std\_logic\_vector | x”D3” | The data value to be written to the addressed register |
| data\_exp | std\_logic\_vector | x”0D” | The data value to expect when reading the addressed register. A mismatch results in an alert with severity ‘alert\_level’ |
| max\_polls | integer | 1 | The maximum number of polls (reads) before the expected data must be found. Exceeding this limit results in an alert with severity ‘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 with severity ‘alert\_level’. |
| alert\_level | t\_alert\_level | ERROR or TB\_WARNING | Set the severity for the alert that may be asserted by the BFM procedure. |
| msg | string | “Write to Peripheral 1” | A custom message to be appended in the log/alert. |
| scope | string | "SBI BFM" | A string describing the scope from which the log/alert originates. In a simple single sequencer typically "SBI BFM". In a verification component typically "SBI\_VVC ". |
| msg\_id\_panel | t\_msg\_id\_panel | shared\_msg\_id\_panel | Optional msg\_id\_panel, controlling verbosity within a specified scope. Defaults to a common ID panel defined in the adaptations package. |
| config | t\_sbi\_bfm\_config | C\_SBI\_BFM\_CONFIG\_DEFAULT | Configuration of BFM behaviour and restrictions. See section 2 for details. |

BFM signal parameters

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| **Name** | **Type** | **Description** |
| clk | std\_logic | The clock signal used to read and write data in/out of SBI BFM. |
| sbi\_if | t\_sbi\_if | See table “Signal record ‘t\_sbi\_if’” |
| terminate\_loop | std\_logic | External control of loop termination to e.g. stop polling prematurely |

Note 1: All signals are active high.

Note 2: Record sbi\_if can be replaced with the signals listed in said record.

BFM details

# BFM procedure details and examples

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| **Procedure** | **Description** |
| **sbi\_write()** | **sbi\_write(addr\_value, data\_value, msg, clk, sbi\_if, [scope, [msg\_id\_panel, [config]]])**  The sbi\_write() procedure writes the given data to the given address on the DUT, using the SBI protocol:   1. At ‘config.clock\_period’/4 before the first rising clock edge the bus lines are set:    1. cs and wena are set to ‘1’    2. rena is set to ‘0’    3. addr is set to addr\_value    4. wdata is set to data\_value 2. With ready-signalling:    1. on the first rising edge the DUT ready signal is evaluated:       * If ready is ‘1’, cs and wena are set to ‘0’ again ‘config.clock\_period’/4 after the last rising edge and the write procedure was successful       * If ready is ‘0’, the procedure will wait one clock cycle and evaluate the ready signal again. This will repeat until ready is set to ‘1’, or invoke an error if the process has repeated ‘config.max\_wait\_cycles’ times. A log message with ID config.id\_for\_bfm\_wait is logged at the first wait. 3. Without ready-signalling:    1. cs and wena are set to ‘0’ again ‘config.clock\_period’/4 after the first rising edge  * The default value of scope is C\_SCOPE (“SBI BFM”) * The default value of msg\_id\_panel is shared\_msg\_id\_panel, defined in UVVM\_Util. * The default value of config is C\_SBI\_BFM\_CONFIG\_DEFAULT, see table on the first page. * A log message is written if message ID ‘config.id\_for\_bfm’ is enabled for the specified message ID panel.   The procedure reports an alert if:   * ready signal is not set to ‘1’ within ‘config.max\_wait\_cycles’ after cs and wena are set to ‘1’ (alert\_level: ‘config.max\_wait\_cycles\_severity’).     Examples:  sbi\_write(x"1000", x”55”, “Write data to Peripheral 1”, clk, sbi\_if);  sbi\_write(x"1000", x”55”, “Write data to Peripheral 1”, clk, sbi\_if, C\_SCOPE, shared\_msg\_id\_panel, C\_SBI\_BFM\_CONFIG\_DEFAULT);  Suggested usage (requires local overload, see section 5):  sbi\_write(C\_ADDR\_UART\_TX, x”40”, “Set baud rate to 9600”);  Note: Record sbi\_if can be replaced with the signals cs, addr, rena, wena, ready, wdata. |

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| **sbi\_read()** | **sbi\_read(addr\_value, data\_value, msg, clk, sbi\_if, [scope, [msg\_id\_panel, [config, [proc\_name]]]])**  The sbi\_read() procedure reads data from the DUT at the given address, using the SBI protocol:   1. At ‘config.clock\_period’/4 before the first rising clock edge the bus lines are set:    1. cs and rena are set to ‘1’    2. wena is set to ‘0’    3. addr is set to addr\_value 2. With ready-signalling:    1. On the first rising edge the DUT ready signal is evaluated:       * If ready is ‘1’, the data on the rdata line is returned to the reader in ‘data\_value’.       * If ready is ‘0’, the procedure will wait one clock cycle and evaluate the ready signal again. This will repeat until ready is set to ‘1’, or invoke an error if the process has repeated ‘config.max\_wait\_cycles’ times. A log message with ID config.id\_for\_bfm\_wait is logged at the first wait. 3. Without ready-signalling:    1. On the first rising edge the data on the rdata line is returned to the reader in ‘data\_value’. 4. After ‘config.clock\_period’/4 cs and rena are set to ‘0’ again  * The default value of scope is C\_SCOPE (“SBI BFM”) * The default value of msg\_id\_panel is shared\_msg\_id\_panel, defined in UVVM\_Util. * The default value of config is C\_SBI\_BFM\_CONFIG\_DEFAULT, see table on the first page. * The default value of proc\_name is “sbi\_read”. This argument is intended to be used internally, when procedure is called by sbi\_check() or sbi\_poll\_until(). * A log message is written if ‘config.id\_for\_bfm’ ID is enabled for the specified message ID panel. This will only occur if the argument proc\_name is left unchanged.   The procedure reports an alert if:   * ready signal is not set to ‘1’ within ‘config.max\_wait\_cycles’ after cs and wena are set to ‘1’ (alert\_level: ‘config.max\_wait\_cycles\_severity’)   Examples:  sbi\_read(x"1000", v\_data\_out, “Read from Peripheral 1”, clk, sbi\_if);  sbi\_read(x"1000", v\_data\_out, “Read from Peripheral 1”, clk, sbi\_if,, C\_SCOPE, shared\_msg\_id\_panel, C\_SBI\_BFM\_CONFIG\_DEFAULT);  Suggested usage (requires local overload, see section 5):  sbi\_read(C\_ADDR\_UART\_BAUD, v\_data\_out, “Read UART baud rate”);  Note: Record sbi\_if can be replaced with the signals cs, addr, rena, wena, ready, rdata. |

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| **sbi\_check()** | **sbi\_check(addr\_value, data\_exp, msg, clk, sbi\_if, [alert\_level, [scope, [msg\_id\_panel, [config]]]])**  The sbi\_check() procedure reads data from the DUT at the given address, using the SBI protocol described under sbi\_read(). After reading data from the SBI bus, the read data is compared with the expected data, ‘data\_exp’.   * The default value of alert\_level is ERROR * The default value of scope is C\_SCOPE (“SBI BFM”) * The default value of msg\_id\_panel is shared\_msg\_id\_panel, defined in UVVM\_Util. * The default value of config is C\_SBI\_BFM\_CONFIG\_DEFAULT, see table on the first page. * If the check was successful, and the read data matches the expected data, a log message is written with ID ‘config.id\_for\_bfm’ (if this ID has been enabled). * If the read data did not match the expected data, an alert with severity ‘alert\_level’ will be reported.   The procedure will also report alerts for the same conditions as the sbi\_read() procedure.  Examples:  sbi\_check(x"1155", x”3B”, “Check data from Peripheral 1”, clk, sbi\_if);  sbi\_check(x"1155", x”3B”, “Check data from Peripheral 1”, clk, sbi\_if, ERROR, C\_SCOPE, shared\_msg\_id\_panel,   C\_SBI\_BFM\_CONFIG\_DEFAULT);  Suggested usage (requires local overload, see section 5):  sbi\_check(C\_ADDR\_UART\_RX, x”3B”, “Check data from UART RX buffer”);  Note: Record sbi\_if can be replaced with the signals cs, addr, rena, wena, ready, rdata. |

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| **sbi\_poll\_until()** | **sbi\_poll\_until(addr\_value, data\_exp, max\_polls, timeout, msg, clk, sbi\_if, terminate\_loop, [alert\_level, [scope, [msg\_id\_panel, [config]]]])**  The sbi\_poll\_until() procedure reads data from the DUT at the given address, using the SBI protocol described under sbi\_read(). After reading data from the DUT, the read data is compared with the expected data, ‘data\_exp’. If the read data does not match the expected data, the process is repeated until one or more of the following occurs:   1. The read data matches the expected data, ‘data\_exp’ 2. The number of read retries is equal to ‘max\_polls’ 3. The time between start of sbi\_poll\_until procedure and now is greater than ‘timeout’ 4. ‘terminate\_loop’ signal is set to ‘1’   If the procedure exits because of 2. or 3. an alert with severity ‘alert\_level’ is issued. If either ‘max\_polls’ or ‘timeout’ is set to 0 (ns), this constraint will be ignored and interpreted as no limit.   * The default value of alert\_level is ERROR * The default value of scope is C\_SCOPE (“SBI BFM”) * The default value of msg\_id\_panel is shared\_msg\_id\_panel, defined in UVVM\_Util. * The default value of config is C\_SBI\_BFM\_CONFIG\_DEFAULT, see table on the first page. * If the check was successful, and the read data matches the expected data, a log message is written with ID ‘config.id\_for\_bfm’ (if this ID has been enabled). * If the procedure is terminated using ‘terminate\_loop’ a log message with ID ID\_TERMINATE\_CMD will be issued. * If the read data did not match the expected data, an alert with severity ‘alert\_level’ will be reported.   The procedure will also report alerts for the same conditions as the sbi\_read() procedure.  Examples:  sbi\_poll\_until(x"1155", x”0D”, 10, 100 ns, “Poll for data from Peripheral 1”, clk, sbi\_if, terminate\_loop);  sbi\_poll\_until(x"1155", x”0D”, 10, 100 ns, “Poll for data from Peripheral 1”, clk, sbi\_if, terminate\_loop, ERROR, C\_SCOPE,   shared\_msg\_id\_panel, C\_SBI\_BFM\_CONFIG\_DEFAULT);  Suggested usage (requires local overload, see section 5):  sbi\_poll\_until(C\_ADDR\_UART\_RX, x”0D”, “Poll UART RX buffer until CR is found”);  sbi\_poll\_until(C\_ADDR\_UART\_RX, x”0D”, C\_MAX\_POLLS, C\_TIMEOUT, “Poll UART RX buffer until CR is found”);  Note: Record sbi\_if can be replaced with the signals cs, addr, rena, wena, ready, rdata. |
| **init\_sbi\_if\_signals()** | **init\_sbi\_if\_signals(addr\_width, data\_width)**  This function initializes the SBI interface. All the BFM outputs are set to zeros ('0'), and BFM inputs are set to 'Z'.  Example:  sbi\_if <= init\_sbi\_if\_signals(addr\_width, data\_width) |

# BFM Configuration record

Type name: t\_sbi\_bfm\_config

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| **Record element** | **Type** | **C\_SBI\_BFM\_CONFIG\_DEFAULT** | **Description** |
| max\_wait\_cycles | integer | 10 | The maximum number of clock cycles to wait for the DUT ready signal before reporting a timeout alert. |
| max\_wait\_cycles\_severity | t\_alert\_level | failure | The above timeout will have this severity |
| use\_fixed\_wait\_cycles\_read | boolean | false | When true, wait 'fixed\_wait\_cycles\_read' after asserting ‘rena’ signal, before sampling ‘rdata from DUT’ |
| fixed\_wait\_cycles\_read | natural | 0 | Number of clock cycles to wait after asserting ‘rena’ signal, before sampling ‘rdata’ from DUT. |
| clock\_period | time | -1 ns | Period of the clock signal. |
| clock\_period\_margin | time | 0 ns | Input clock period margin to specified clock\_period. Will check T/2 if input clock is low when BFM is called and T if input clock is high |
| clock\_margin\_severity | t\_alert\_level | TB\_ERROR | The above margin will have this severity |
| setup\_time | time | -1 ns | Generated signals setup time. Suggested value is clock\_period/4.  An alert is reported if setup\_time exceed clock\_period/2. |
| hold\_time | time | -1 ns | Generated signals hold time. Suggested value is clock\_period/4.  An alert is reported if hold\_time exceed clock\_period/2. |
| bfm\_sync | t\_bfm\_sync | SYNC\_ON\_CLOCK\_ONLY | When set to SYNC\_ON\_CLOCK\_ONLY the BFM will enter on the first falling edge, estimate the clock period, synchronise the output signals and exit ¼ clock period after a succeeding rising edge. When set to SYNC\_WITH\_SETUP\_AND\_HOLD the BFM will use the configured setup\_time, hold\_time and clock\_period to synchronise output signals with clock edges. |
| match\_strictness | t\_match\_strictness | MATCH\_EXACT | Matching strictness for std\_logic values in check procedures.  MATCH\_EXACT requires both values to be the same. Note that the expected value  can contain the don’t care operator ‘-‘.  MATCH\_STD allows comparisons between ‘H’ and ‘1’, ‘L’ and ‘0’ and ‘-‘ in both values. |
| id\_for\_bfm | t\_msg\_id | ID\_BFM | The message ID used as a general message ID in the SBI BFM |
| id\_for\_bfm\_wait | t\_msg\_id | ID\_BFM\_WAIT | The message ID used for logging waits in the SBI BFM |
| id\_for\_bfm\_poll | t\_msg\_id | ID\_BFM\_POLL | The message ID used for logging polling in the SBI BFM |
| use\_ready\_signal | boolean | true | Whether or not to use the interface ‘ready’ signal |

# Additional Documentation

The SBI BFM is used in the IRQC example provided with the UVVM Utility Library. Thus, you can find info under:

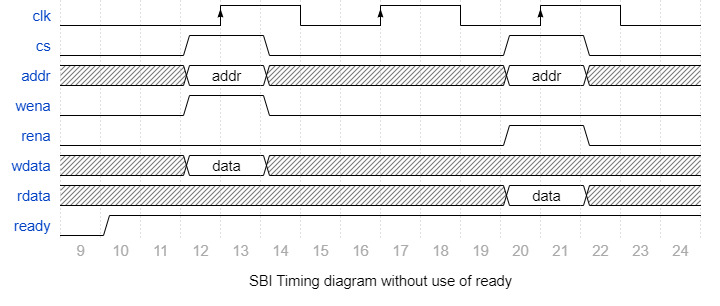
* ‘Making a simple, structured and efficient VHDL testbench – Step-by-step’ (PPT)

There is also a webinar available on ‘Making a simple, structured and efficient VHDL testbench – Step-by-step’ (via Aldec1.)

## SBI protocol

SBI is our name for the simplest bus interface possible, one that has been used for decades in the electronics industry. Some think of it as a simple SRAM interface, but that is not a standard, and is probably understood and used in many different ways. Thus, we have defined a name and an exact behaviour, with some flexibility.

SBI is a single cycle bus with an optional ready-signalling. The protocol for SBI with and without ready-signalling is given below (Note that ready is always high in the without case). Data is sampled on rising edge **a** and **b**.



As can be seen from the figure all required signals including data input must be ready on the rising edge of the clock. This also applies for a read access, but the actual data output is provided combinatorial as soon as the combinational logic allows

Note that an active 'cs', a valid 'addr' and an active 'wena' or 'rena' is needed on the same active clock edge to be registered as a valid read or write. (Being active on two consecutive rising clocks will result in two consecutive accesses - with or without side-effects depending on the module's internal functional logic.) 'rdata' will just ripple out for the right combination of 'cs', 'addr' and 'rena'.

With this simple version, the designer has the option to provide input and/or output registers externally to allow a higher frequency (with added latency).

SBI has optional ready-signalling (You may choose to have ready always high). When 'ready' is used it applies to both read and write accesses. For both read and write accesses all input signals must be held until 'ready' is active. For a read access, the output data may not be used (sampled) until 'ready' is active, but must do so on the first rising edge of the clock after 'ready' active.

# Compilation

The SBI BFM may only be compiled with VHDL 2008. It is dependent on the UVVM Utility Library (UVVM-Util), which is only compatible with VHDL 2008.

See the separate UVVM-Util documentation for more info. After UVVM-Util has been compiled, the sbi\_bfm\_pkg.vhd BFM can be compiled into any desired library.

See UVVM Essential Mechanisms located in uvvm\_vvc\_framework/doc for information about compile scripts.

## Simulator compatibility and setup

See README.md for a list of supported simulators.

For required simulator setup see UVVM-Util Quick reference.

\*1 <https://www.aldec.com/en/support/resources/multimedia/webinars/1673>

# Local BFM overloads

A good approach for better readability and maintainability is to make simple, local overloads for the BFM procedures in the TB process.

This allows calling the BFM procedures with the key parameters only

e.g.

sbi\_write(C\_ADDR\_UART\_BAUDRATE, C\_BAUDRATE\_9600, “Set Baudrate to 9600”);

rather than

sbi\_write(C\_ADDR\_UART\_BAUDRATE, C\_BAUDRATE\_9600, “Set Baudrate to 9600”, clk, sbi\_if,

C\_CLK\_PERIOD, C\_SCOPE, shared\_msg\_id\_panel, C\_SBI\_CONFIG\_DEFAULT);

By defining the local overload as e.g.:

procedure sbi\_write(

constant addr\_value : in unsigned;

constant data\_value : in std\_logic\_vector;

constant msg : in string) is

begin

sbi\_write(addr\_value, -- keep as is

data\_value, -- keep as is

msg, -- keep as is

sbi\_if, -- Signal must be visible in local process scope

C\_CLK\_PERIOD, -- Just use the default

C\_SCOPE, -- Just use the default

shared\_msg\_id\_panel, -- Use global, shared msg\_id\_panel

C\_SBI\_CONFIG\_LOCAL); -- Use locally defined configuration or C\_SBI\_CONFIG\_DEFAULT

end;

Using a local overload like this also allows the following – if wanted:

* Have address value as natural – and convert in the overload
* Set up defaults for constants. May be different for two overloads of the same BFM
* Apply dedicated message ID panel to allow dedicated verbosity control

IMPORTANT   
This is a simplified Bus Functional Model (BFM) for SBI.  
The given BFM complies with the basic SBI protocol and thus allows a normal access towards a SBI interface. This BFM is not a SBI protocol checker.   
For a more advanced BFM please contact UVVM at [info@uvvm.org](mailto:info@uvvm.org)

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