**AXI4 BFM** –Quick Reference

**BFM**

**NOTE: As of UVVM v3.x, all shared variables have been made protected. This means that any access to shared variables must be done**

**using get- and set-methods. This documentation has not yet been updated with the methods for accessing these variables, but will be very soon.**

*axi\_bfm\_pkg.vhd*

|  |  |
| --- | --- |
| axi\_write (awid\_value, awaddr\_value, awlen\_value, awsize\_value, awburst\_value, awlock\_value, awcache\_value, awprot\_value, awqos\_value, awregion\_value, awuser\_value, wdata\_value, wstrb\_value, wuser\_value, buser\_value, bresp\_value, msg, clk, axi\_if, [scope, [msg\_id\_panel, [config]]]) | |
| Example: axi\_write(  awid\_value => x”01”,  awaddr\_value => x"00000004",  awlen\_value => x"01",  awsize\_value => 4,  awburst\_value => INCR,  awlock\_value => NORMAL,  awcache\_value => “0000”,  awprot\_value => UNPRIVILEGED\_UNSECURE\_DATA,  awqos\_value => “0000”,  awregion\_value => “0000”,  awuser\_value => x“01”,  wdata\_value => t\_slv\_array'(x"12345678", x"33333333"),  wstrb\_value => t\_slv\_array'(x"F", x"F"),  wuser\_value => t\_slv\_array'(x"01", x"01"),  buser\_value => v\_buser\_value,  bresp\_value => v\_bresp\_value,  msg => "Writing data to Peripheral 1",  clk => clk,  axi\_if => axi\_if); | **Optional parameters (using named association):**   * awid\_value * awlen\_value * awsize\_value * awburst\_value * awlock\_value * awcache\_value * awprot\_value * awqos\_value * awregion\_value * awuser\_value * wstrb\_value * wuser\_value   ***Suggested usage:*** *axi\_write(*  *awaddr\_value => x"00000004",*  *awlen\_value => x"01",*  *wdata\_value => t\_slv\_array'(x"12345678", x"33333333"),*  *msg => "Writing data to Peripheral 1");*  *-- Suggested usage requires local overload (see section 5)* |



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| --- | --- |
| axi\_read (arid\_value, araddr\_value, arlen\_value, arsize\_value, arburst\_value, arlock\_value, arcache\_value, arprot\_value, arqos\_value, arregion\_value, aruser\_value, rdata\_value, rresp\_value, ruser\_value, msg, clk, axi\_if, [scope, [msg\_id\_panel, [config, [proc\_name]]]]) | |
| Example: axi\_read(  arid\_value => x“01”,  araddr\_value => x”00000004”,  arlen\_value => x”01”,  arsize\_value => 4,  arburst\_value => INCR,  arlock\_value => NORMAL,  arcache\_value => “0000”,  arprot\_value => UNPRIVILEGED\_UNSECURE\_DATA,  arqos\_value => “0000”,  arregion\_value => “0000”,  aruser\_value => x“01”,  rdata\_value => v\_rdata\_value,  rresp\_value => v\_rresp\_value,  ruser\_value => v\_ruser\_value,  msg => “Read from Peripheral 1”,  clk => clk,  axi\_if => axi\_if); | **Optional parameters (using named association):**   * arid\_value * arlen\_value * arsize\_value * arburst\_value * arlock\_value * arcache\_value * arprot\_value * arqos\_value * arregion\_value * aruser\_value   ***Suggested usage:*** *axi\_read(*  *araddr\_value => C\_ADDR\_IO,*  *arlen\_value => x”01”,*  *rdata\_value => v\_data\_out,*  *msg => “Read from IO”);*  *-- Suggested usage requires local overload (see section 5)* |

|  |  |
| --- | --- |
| axi\_check (arid\_value, araddr\_value, arlen\_value, arsize\_value, arburst\_value, arlock\_value, arcache\_value, arprot\_value, arqos\_value, arregion\_value, aruser\_value, rdata\_exp, rresp\_exp, ruser\_exp, msg, clk, axi\_if, [alert\_level, [scope, [msg\_id\_panel, [config]]]]) | |
| Example: axi\_check(  arid\_value => x“01”,  araddr\_value => x”00000004”,  arlen\_value => x”01”,  arsize\_value => 4,  arburst\_value => INCR,  arlock\_value => NORMAL,  arcache\_value => “0000”,  arprot\_value => UNPRIVILEGED\_UNSECURE\_DATA,  arqos\_value => “0000”,  arregion\_value => “0000”,  aruser\_value => x“01”,  rdata\_exp => t\_slv\_array'(x"12345678", x"33333333"),  rresp\_exp => t\_slv\_array’("00", "00"),  ruser\_exp => t\_slv\_array’(x"00", x"00"),  msg => “Check data from Peripheral 1”,  clk => clk,  axi\_if => axi\_if); | **Optional parameters (using named association):**   * arid\_value * arlen\_value * arsize\_value * arburst\_value * arlock\_value * arcache\_value * arprot\_value * arqos\_value * arregion\_value * aruser\_value * rresp\_exp * ruser\_exp   ***Suggested usage:*** *axi\_check(*  *araddr\_value => C\_ADDR\_IO,*  *arlen\_value => “01”,*  *rdata\_exp => t\_slv\_array’*(x"12345678", x"33333*333"),*  *msg => “Checking data from Peripheral 1”);*  *-- Suggested usage requires local overload (see section 5)* |

|  |
| --- |
| init\_axi\_if\_signals (addr\_width, data\_width, id\_width, user\_width) |
| Example: axi\_if <= init\_axi\_if\_signals(addr\_width, data\_width, id\_width, user\_width); |

BFM Configuration record ´**t\_axi\_bfm\_config´**

|  |  |  |  |
| --- | --- | --- | --- |
| **Record element** | **Type** | **C\_AXI\_BFM\_CONFIG\_DEFAULT** | **Description** |
| max\_wait\_cycles | natural | 1000 | Used for setting the maximum cycles to wait before an alert is issued when waiting for ready and valid signals from the DUT. |
| max\_wait\_cycles\_severity | t\_alert\_level | TB\_FAILURE | The above timeout will have this severity |
| clock\_period | time | -1 ns | Period of the clock signal. |
| clock\_period\_margin | time | 0 ns | Input clock period margin to specified clock\_period |
| clock\_margin\_severity | t\_alert\_level | TB\_ERROR | The above margin will have the severity |
| setup\_time | time | -1 ns | Setup time for generated signals. Suggested value is clock\_period/4.  An alert is reported if setup\_time exceed clock\_period/2. |
| hold\_time | time | -1 ns | Hold time for generated signals. 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. |
| num\_aw\_pipe\_stages | natural | 1 | Write Address Channel pipeline steps |
| num\_w\_pipe\_stages | natural | 1 | Write Data Channel pipeline steps |
| num\_ar\_pipe\_stages | natural | 1 | Read Address Channel pipeline steps |
| num\_r\_pipe\_stages | natural | 1 | Read Data Channel pipeline steps |
| num\_b\_pipe\_stages | natural | 1 | Response Channel pipeline steps |
| id\_for\_bfm | t\_msg\_id | ID\_BFM | The message ID used as a general message ID in the AXI BFM |
| id\_for\_bfm\_wait | t\_msg\_id | ID\_BFM\_WAIT | The message ID used for logging waits in the AXI BFM |
| id\_for\_bfm\_poll | t\_msg\_id | ID\_BFM\_POLL | The message ID used for logging polling in the AXI BFM |

BFM non-signal parameters

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Name** | **Type** | **Example(s)** | **Default value** | **Description** |
| awid\_value | std\_logic\_vector | x”01” | 0 | Identification tag for a write transaction |
| awaddr\_value | unsigned | x”125A” | None | The address of the first transfer in a write transaction |
| awlen\_value | unsigned(7 downto 0) | x”01” | 0 | The number of data transfers in a write transaction |
| awsize\_value | Integer range 1 to 128 | 4 | 4 | The number of bytes in each data transfer in a write transaction (Must be a power of two) |
| awburst\_value | t\_axburst | INCR | INCR | Burst type, indicates how address changes between each transfer in a write transaction |
| awlock\_value | t\_axlock | NORMAL | NORMAL | Provides information about the atomic characteristics of a write transaction |
| awcache\_value | std\_logic\_vector(3 downto 0) | “0000” | (others=>’0’) | Indicates how a write transaction is required to progress through a system |
| awprot\_value | t\_axprot | UNPRIVILEGED\_UNSECURE\_DATA | UNPRIVILEGED\_UNSECURE\_DATA | Protection attributes of a write transaction. Privilege, security level and access type |
| awqos\_value | std\_logic\_vector(3 downto 0) | “0000” | (others=>’0’) | Quality of Service identifier for a write transaction |
| awregion\_value | std\_logic\_vector(3 downto 0) | “0000” | (others=>’0’) | Region indicator for a write transaction |
| awuser\_value | std\_logic\_vector | x”01” | (others=>’0’) | User-defined extension for the write address channel |
| wdata\_value | t\_slv\_array | t\_slv\_array’(x”20D3”, x”1234”) | None | Array of data values to be written to the addressed registers |
| wstrb\_value | t\_slv\_array | t\_slv\_array’(”1111”, ”1111”) | (others=>‘1’) for all words | Array of write strobes, indicates which byte lanes hold valid data. (all ‘1’ means all bytes are updated) |
| wuser\_value | t\_slv\_array | t\_slv\_array’(x”00”, x”01”) | (others=>’0’) for all words | Array of user-defined extension for the write data channel |
| buser\_value | std\_logic\_vector | v\_buser\_value | None | Output variable containing the user-defined extension for the write response channel |
| bresp\_value | t\_xresp | v\_bresp\_value | None | Output variable containing the write response which indicates the status of a write transaction |
| arid\_value | std\_logic\_vector | x”01” | (others=>’0’) | Identification tag for a read transaction |
| araddr\_value | unsigned | x”125A” | None | The address of the first transfer in a read transaction |
| arlen\_value | unsigned(7 downto 0) | x”01” | (others=>’0’) | The number of data transfers in a read transaction |
| arsize\_value | Integer range 1 to 128 | 4 | 4 | The number of bytes in each data transfer in a read transaction (Must be a power of two) |
| arburst\_value | t\_axburst | INCR | INCR | Burst type, indicates how address changes between each transfer in a read transaction |
| arlock\_value | t\_axlock | NORMAL | NORMAL | Provides information about the atomic characteristics of a read transaction |
| arcache\_value | std\_logic\_vector(3 downto 0) | “0000” | (others=>’0’) | Indicates how a read transaction is required to progress through a system |
| arprot\_value | t\_axprot | UNPRIVILEGED\_UNSECURE\_DATA | UNPRIVILEGED\_UNSECURE\_DATA | Protection attributes of a read transaction. Privilege, security level and access type |
| arqos\_value | std\_logic\_vector(3 downto 0) | “0000” | (others=>’0’) | Quality of Service identifier for a read transaction |
| arregion\_value | std\_logic\_vector(3 downto 0) | “0000” | (others=>’0’) | Region indicator for a read transaction |
| aruser\_value | std\_logic\_vector | x”01” | (others=>’0’) | User-defined extension for the read address channel |
| rdata\_value | t\_slv\_array | v\_rdata\_value | None | Output variable containing an array of read data |
| rresp\_value | t\_xresp\_array | v\_rresp\_value | None | Output variable containing an array of read responses which indicates the status of a read transfer |
| ruser\_value | t\_slv\_array | v\_ruser\_value | None | Output variable containing an array of user-defined extensions for the read data channel |
| rdata\_exp | t\_slv\_array | t\_slv\_array’(x”ABCD”, x”1234”) | None | Array of expected read data values. A mismatch results in an alert ‘alert\_level’ |
| rresp\_exp | t\_xresp\_array | t\_xresp\_array’(OKAY, OKAY) | OKAY for all words | Array of expected read responses which indicates the status of a read transfer |
| ruser\_exp | t\_slv\_array | t\_slv\_array’(x”01”, x”01”) | (others=>’0’) for all words | Array of expected user-defined extensions for the read data channel |
| alert\_level | t\_alert\_level | ERROR or TB\_WARNING | ERROR | Set the severity for the alert that may be asserted by the procedure. |
| msg | string | “Set state active on peripheral 1” | None | A custom message to be appended in the log/alert. |
| scope | string | "AXI\_BFM" | C\_SCOPE (“AXI\_BFM”) | A string describing the scope from which the log/alert originates. In a simple single sequencer typically "AXI\_BFM". In a verification component typically "AXI\_VVC ". |
| msg\_id\_panel | t\_msg\_id\_panel | shared\_msg\_id\_panel | shared\_msg\_id\_panel | Optional msg\_id\_panel, controlling verbosity within a specified scope. Defaults to a common message ID panel defined in the UVVM-Util adaptations package. |
| config | t\_axi\_bfm\_config | C\_AXI\_BFM\_CONFIG\_DEFAULT | C\_AXI\_BFM\_CONFIG\_DEFAULT | Configuration of BFM behaviour and restrictions. See section 2 for details. |

BFM signal parameters

|  |  |  |
| --- | --- | --- |
| **Name** | **Type** | **Description** |
| clk | std\_logic | The clock signal used to read and write data in/out of the AXI4 BFM. |
| axi\_if | t\_axi\_if | See table “Signal record ‘axi\_if’” |

Note: All signals are active high. See AXI4 documentation for protocol description.

For more information on the AXI4 signals, please see the AXI4 specification.

Signal record ‘axi\_if’

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| |  |  | | --- | --- | | **Record element** | **Type** | | write\_address\_channel | t\_axi\_write\_address\_channel | | write\_data\_channel | t\_axi\_write\_data\_channel | | write\_response\_channel | t\_axi\_write\_response\_channel | | read\_address\_channel | t\_axi\_read\_address\_channel | | read\_data\_channel | t\_axi\_read\_data\_channel | |  |
| Write address channel record **‘t\_axi\_write\_address\_channel’**   |  |  | | --- | --- | | **Record element** | **Type** | | **write\_address\_channel** | **t\_axi\_write\_address\_channel** | | awid | std\_logic\_vector | | awaddr | std\_logic\_vector | | awlen | std\_logic\_vector(7 downto 0) | | awsize | std\_logic\_vector(2 downto 0) | | awburst | std\_logic\_vector(1 downto 0) | | awlock | std\_logic | | awcache | std\_logic\_vector(3 downto 0) | | awprot | std\_logic\_vector(2 downto 0) | | awqos | std\_logic\_vector(3 downto 0) | | awregion | std\_logic\_vector(3 downto 0) | | awuser | std\_logic\_vector | | awvalid | std\_logic | | awready | std\_logic |   Read address channel record **‘t\_axi\_read\_address\_channel’**   |  |  | | --- | --- | | **Record element** | **Type** | | **read\_address\_channel** | **t\_axi\_read\_address\_channel** | | arid | std\_logic\_vector | | araddr | std\_logic\_vector | | arlen | std\_logic\_vector(7 downto 0) | | arsize | std\_logic\_vector(2 downto 0) | | arburst | std\_logic\_vector(1 downto 0) | | arlock | std\_logic | | arcache | std\_logic\_vector(3 downto 0) | | arprot | std\_logic\_vector(2 downto 0) | | arqos | std\_logic\_vector(3 downto 0) | | arregion | std\_logic\_vector(3 downto 0) | | aruser | std\_logic\_vector | | arvalid | std\_logic | | arready | std\_logic | | Write data channel record **‘t\_axi\_write\_data\_channel’**   |  |  | | --- | --- | | **Record element** | **Type** | | **write\_data\_channel** | **t\_axi\_write\_data\_channel** | | wdata | std\_logic\_vector | | wstrn | std\_logic\_vector | | wlast | std\_logic | | wuser | std\_logic\_vector | | wvalid | std\_logic | | wready | std\_logic |   Write response channel record **‘t\_axi\_write\_response\_channel’**   |  |  | | --- | --- | | **Record element** | **Type** | | **write\_response\_channel** | **t\_axi\_write\_response\_channel** | | bid | std\_logic\_vector | | bresp | std\_logic\_vector(1 downto 0) | | buser | std\_logic\_vector | | bvalid | std\_logic | | bready | std\_logic |   Read data channel record **‘t\_axi\_read\_data\_channel’**   |  |  | | --- | --- | | **Record element** | **Type** | | **read\_data\_channel** | **t\_axi\_read\_data\_channel** | | rid | std\_logic\_vector | | rdata | std\_logic\_vector | | rresp | std\_logic\_vector(1 downto 0) | | rlast | std\_logic | | ruser | std\_logic\_vector | | rvalid | std\_logic | | rready | std\_logic | |

AXI parameter record types

|  |  |
| --- | --- |
| **Type name** | **Allowed value** |
| t\_axburst | FIXED |
|  | INCR |
|  | WRAP |
| t\_axlock | NORMAL |
|  | EXCLUSIVE |
| t\_axprot | UNPRIVILEGED\_NONSECURE\_DATA |
|  | UNPRIVILEGED\_NONSECURE\_INSTRUCTION |
|  | UNPRIVILEGED\_SECURE\_DATA |
|  | UNPRIVILEGED\_SECURE\_INSTRUCTION |
|  | PRIVILEGED\_NONSECURE\_DATA |
|  | PRIVILEGED\_NONSECURE\_INSTRUCTION |
|  | PRIVILEGED\_SECURE\_DATA |
|  | PRIVILEGED\_SECURE\_INSTRUCTION |
| t\_xresp | OKAY |
|  | EXOKAY |
|  | SLVERR |
|  | DECERR |

BFM details

# BFM procedure details and examples

|  |  |
| --- | --- |
| **Procedure** | **Description** |
| **axi\_write()** | **axi\_write(awid\_value, awaddr\_value, awlen\_value, awsize\_value, awburst\_value, awlock\_value, awcache\_value, awprot\_value, awqos\_value, awregion\_value, awuser\_value, wdata\_value, wstrb\_value, wuser\_value, buser\_value, bresp\_value, msg, clk, axi\_if, [scope, [msg\_id\_panel, [config]]])**  The axi\_write() procedure writes the given data to the given address of the DUT, using the AXI4 protocol. For protocol details, see the AXI4 specification.   * A log message is written if ID\_BFM is enabled for the specified message ID panel.   The procedure reports an alert if:   * wready does not occur within max\_wait\_cycles clock cycles (alert level: max\_wait\_cycles\_severity, set in the config) * awready does not occur within max\_wait\_cycles clock cycles (alert level: max\_wait\_cycles\_severity, set in the config) * bvalid is not set within max\_wait\_cycles clock cycles (alert level: max\_wait\_cycles\_severity, set in the config)     Examples:  axi\_write(  awid\_value => x”01”,  awaddr\_value => x"00000004",  awlen\_value => x"01",  awsize\_value => 4,  awburst\_value => INCR,  awlock\_value => NORMAL,  awcache\_value => “0000”,  awprot\_value => UNPRIVILEGED\_UNSECURE\_DATA,  awqos\_value => “0000”,  awregion\_value => “0000”,  awuser\_value => x“01”,  wdata\_value => t\_slv\_array'(x"12345678", x"33333333"),  wstrb\_value => t\_slv\_array'(x"F", x"F"),  wuser\_value => t\_slv\_array'(x"01", x"01"),  buser\_value => v\_buser\_value,  bresp\_value => v\_bresp\_value,  msg => "Writing data to Peripheral 1",  clk => clk,  axi\_if => axi\_if,  scope => C\_SCOPE,  msg\_id\_panel => shared\_msg\_id\_panel,  config => C\_AXI\_BFM\_CONFIG\_DEFAULT);  axi\_write(  awaddr\_value => x"00000004",  wdata\_value => t\_slv\_array'(x"12345678", x"33333333"),  buser\_value => v\_buser\_value,  bresp\_value => v\_bresp\_value,  msg => "Writing data to Peripheral 1");  Suggested usage (requires local overload, see section 5):  axi\_write(C\_ADDR\_DMA, x”AAAA”, “Writing data to DMA”);  axi\_write(C\_ADDR\_MEMORY, x”FF”, v\_data\_array, “Writing 256 data words to MEMORY”); |
| **axi\_read()** | **axi\_read(arid\_value, araddr\_value, arlen\_value, arsize\_value, arburst\_value, arlock\_value, arcache\_value, arprot\_value, arqos\_value, arregion\_value, aruser\_value, rdata\_value, rresp\_value, ruser\_value, msg, clk, axi\_if, [scope, [msg\_id\_panel, [config, [proc\_name]]]])**  The axi\_read() procedure reads data from the DUT at the given address, using the AXI4 protocol. For protocol details, see the AXI4 specification. The read data is placed on the output ‘rdata\_value’ when the read has completed.   * The argument “ext\_proc\_call” is intended to be used internally, when the procedure is called by axi\_check(). * A log message is written if ID\_BFM 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:   * The received rid is different from the transmitted arid\_value * arready does not occur within max\_wait\_cycles clock cycles (alert level: max\_wait\_cycles\_severity, set in the config) * rvalid is not set within max\_wait\_cycles clock cycles (alert level: max\_wait\_cycles\_severity, set in the config)   Examples:  axi\_read(  arid\_value => x“01”,  araddr\_value => x”00000004”,  arlen\_value => x”01”,  arsize\_value => 4,  arburst\_value => INCR,  arlock\_value => NORMAL,  arcache\_value => “0000”,  arprot\_value => UNPRIVILEGED\_UNSECURE\_DATA,  arqos\_value => “0000”,  arregion\_value => “0000”,  aruser\_value => x“01”,  rdata\_value => v\_rdata\_value,  rresp\_value => v\_rresp\_value,  ruser\_value => v\_ruser\_value,  msg => “Read from Peripheral 1”,  clk => clk,  axi\_if => axi\_if,  scope => C\_SCOPE,  msg\_id\_panel => shared\_msg\_id\_panel,  config => C\_AXI\_BFM\_CONFIG\_DEFAULT);  axi\_read(  araddr\_value => x”00000004”,  rdata\_value => v\_rdata\_value,  rresp\_value => v\_rresp\_value,  ruser\_value => v\_ruser\_value,  msg => “Read from Peripheral 1”,  clk => clk,  axi\_if => axi\_if);  Suggested usage (requires local overload, see section 5):  axi\_read(C\_ADDR\_IO, v\_data\_out, “Reading from IO device”);  axi\_read(C\_ADDR\_MEMORY, x”FF”, v\_data\_array\_out, “Reading 256 data words from MEMORY”); |
| **axi\_check()** | **axi\_check(arid\_value, araddr\_value, arlen\_value, arsize\_value, arburst\_value, arlock\_value, arcache\_value, arprot\_value, arqos\_value, arregion\_value, aruser\_value, rdata\_exp, rresp\_exp, ruser\_exp, msg, clk, axi\_if, [alert\_level, [scope, [msg\_id\_panel, [config]]]])**  The axi\_check() procedure reads data from the DUT at the given address, using the AXI4 protocol. For protocol details, see the AXI4 specification. After reading data from the AXI4 bus, the read data is compared with the expected data, ‘rdata\_exp’.   * If the check was successful, and the read data matches the expected data, a log message is written with ID\_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 also report alerts for the same conditions as the axi\_read() procedure.  Examples:  axi\_check(  arid\_value => x“01”,  araddr\_value => x”00000004”,  arlen\_value => x”01”,  arsize\_value => 4,  arburst\_value => INCR,  arlock\_value => NORMAL,  arcache\_value => “0000”,  arprot\_value => UNPRIVILEGED\_UNSECURE\_DATA,  arqos\_value => “0000”,  arregion\_value => “0000”,  aruser\_value => x“01”,  rdata\_exp => t\_slv\_array'(x"12345678", x"33333333"),  rresp\_exp => t\_xresp\_array’(OKAY, OKAY),  ruser\_exp => t\_slv\_array’(x"00", x"00"),  msg => “Check data from Peripheral 1”,  clk => clk,  axi\_if => axi\_if,  alert\_level => ERROR,  scope => C\_SCOPE,  msg\_id\_panel => shared\_msg\_id\_panel,  config => C\_AXI\_BFM\_CONFIG\_DEFAULT);  axi\_check(  araddr\_value => x”00000004”,  rdata\_exp => v\_rdata\_exp,  msg => “Check data from Peripheral 1”,  clk => clk,  axi\_if => axi\_if);  Suggested usage (requires local overload, see section 5):  axi\_check(C\_ADDR\_UART\_RX, x”3B”, “Checking data in UART RX register”);  axi\_check(C\_ADDR\_MEMORY, x”FF”, v\_rdata\_exp\_array, “Checking 256 data words from MEMORY”); |
| **init\_axi\_if\_signals()** | **init\_axi\_if\_signals(addr\_width, data\_width, id\_width, user\_width)**  This function initializes the AXI4 interface. All the BFM outputs are set to zeros ('0') and BFM inputs are set to 'Z'.  Note: This function assumes that awid, bid, arid and rid shares a common width (id\_width) and that awuser, buser, aruser, ruser also share a common width (user\_width)  Example:  axi\_if <= init\_axi\_if\_signals(addr\_width, data\_width, id\_width, user\_width); |

# BFM Configuration record

Type name: t\_axi\_bfm\_config

|  |  |  |  |
| --- | --- | --- | --- |
| **Record element** | **Type** | **C\_AXI\_BFM\_CONFIG\_DEFAULT** | **Description** |
| max\_wait\_cycles | natural | 10 | Used for setting the maximum cycles to wait before an alert is issued when waiting for ready and valid signals from the DUT. |
| max\_wait\_cycles\_severity | t\_alert\_level | TB\_FAILURE | The above timeout will have this severity |
| clock\_period | time | -1 ns | Period of the clock signal. |
| clock\_period\_margin | time | 0 ns | Input clock period margin to specified clock\_period |
| clock\_margin\_severity | t\_alert\_level | TB\_ERROR | The above margin will have the severity |
| setup\_time | time | -1 ns | Setup time for generated signals. Suggested value is clock\_period/4.  An alert is reported if setup\_time exceed clock\_period/2. |
| hold\_time | time | -1 ns | Hold time for generated signals. 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. |
| num\_aw\_pipe\_stages | natural | 1 | Write Address Channel pipeline steps |
| num\_w\_pipe\_stages | natural | 1 | Write Data Channel pipeline steps |
| num\_ar\_pipe\_stages | natural | 1 | Read Address Channel pipeline steps |
| num\_r\_pipe\_stages | natural | 1 | Read Data Channel pipeline steps |
| num\_b\_pipe\_stages | natural | 1 | Response Channel pipeline steps |
| id\_for\_bfm | t\_msg\_id | ID\_BFM | The message ID used as a general message ID in the AXI BFM |
| id\_for\_bfm\_wait | t\_msg\_id | ID\_BFM\_WAIT | The message ID used for logging waits in the AXI BFM |
| id\_for\_bfm\_poll | t\_msg\_id | ID\_BFM\_POLL | The message ID used for logging polling in the AXI BFM |

# Additional Documentation

For additional documentation on the AXI4 standard, please see the AXI4 specification “AMBA® AXI™ and ACE™ Protocol Specification”, available from ARM.

# Compilation

The AXI4 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 axi\_bfm\_pkg.vhd BFM can be compiled into any desired library.

See the 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.

# 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.

axi\_write(C\_ADDR\_PERIPHERAL\_1, C\_TEST\_DATA, “Sending data to Peripheral 1”);

rather than

axi\_write(

awid\_value => x”01”,

awaddr\_value => x"00000004",

awlen\_value => x"01",

awsize\_value => 4,

awburst\_value => INCR,

awlock\_value => NORMAL,

awcache\_value => “0000”,

awprot\_value => UNPRIVILEGED\_UNSECURE\_DATA,

awqos\_value => “0000”,

awregion\_value => “0000”,

awuser\_value => x“01”,

wdata\_value => t\_slv\_array'(x"12345678", x"33333333"),

wstrb\_value => t\_slv\_array'(x"F", x"F"),

wuser\_value => t\_slv\_array'(x"01", x"01"),

buser\_value => v\_buser\_value,

bresp\_value => v\_bresp\_value,

msg => "Writing data to Peripheral 1",

clk => clk,

axi\_if => axi\_if,

scope => C\_SCOPE,

msg\_id\_panel => shared\_msg\_id\_panel,

config => C\_AXI\_BFM\_CONFIG\_DEFAULT);

By defining the local overload as e.g.:

procedure axi\_write(

constant addr\_value : in unsigned;

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

constant msg : in string

) is

variable v\_buser\_value : std\_logic\_vector(C\_USER\_WIDTH-1 downto 0);

variable v\_bresp\_value : t\_xresp;

begin

axi\_write(

awid\_value => x"00", -- Setting a default value

awaddr\_value => addr\_value, -- keep as is

awlen\_value => x"00", -- Set to length=1

awsize\_value => 4, -- Setting a default value

awburst\_value => INCR, -- Setting a default value

awlock\_value => NORMAL, -- Setting a default value

awcache\_value => "0000", -- Setting a default value

awprot\_value => UNPRIVILEGED\_UNSECURE\_DATA, -- Setting a default value

awqos\_value => "0000", -- Setting a default value

awregion\_value => "0000", -- Setting a default value

awuser\_value => x"01", -- Setting a default value

wdata\_value => data\_value, -- keep as is

wstrb\_value => x"f" -- Setting a default value

wuser\_value => x"01", -- Setting a default value

buser\_value => v\_buser\_value, -- Assigning to a local variable

bresp\_value => v\_bresp\_value, -- Assigning to a local variable

msg => msg, -- keep as is

clk => clk, -- Clock signal

axi\_if => axi\_if, -- Signal must be visible in local process scope

scope => C\_SCOPE, -- Setting a default value

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

config => C\_AXI\_BFM\_CONFIG\_LOCAL); -- Use locally defined configuration or C\_AXI\_BFM\_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 msg\_id\_panel to allow dedicated verbosity control

IMPORTANT

This is a simplified Bus Functional Model (BFM) for AXI4.

The given BFM complies with the AXI4 protocol and thus allows a normal access towards an AXI4 interface. This BFM is not AXI4 protocol checker.

For a more advanced BFM please contact Bitvis AS at [support@bitvis.no](mailto:support@bitvis.no)

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