

SPI BFM – Quick Reference

spi_master|slave_transmit_and_receive (tx_data, rx_data, msg, spi_if, [scope, [msg_id_panel, [config]]])

Example: spi_master|slave_transmit_and_receive(x"AA", v_data_out, "Sending data to Peripheral 1 and receiving data from Peripheral 1", spi_if);

Suggested usage: spi_master|slave_transmit_and_receive(x"AA", v_data_out, "Transmitting 0xAA and receiving data from DUT"); -- Suggested usage requires local overload (see section 5)

spi_master|slave_transmit_and_check (tx_data, data_exp, msg, spi_if, [scope, [msg_id_panel, [config]]])

Example: spi_master|slave_transmit_and_check(x"AA", x"F5", "Sending data to Peripheral 1 and checking received data from Peripheral 1", spi_if);

Suggested usage: spi_master|slave_transmit_and_check(x"AA", x"F5", "Transmitting 0xAA and expecting 0xF5 from DUT"); -- Suggested usage requires local overload (see section 5)

spi_master|slave_transmit (tx_data, msg, spi_if, [scope, [msg_id_panel, [config]]])

Example: spi_master|slave_transmit(x"AA", "Sending data to Peripheral 1", spi_if);

Suggested usage: spi_master|slave_transmit(C_ASCII_A, "Transmitting ASCII A to DUT"); -- Suggested usage requires local overload (see section 5)

spi_master|slave_receive (rx_data, msg, spi_if, [scope, [msg_id_panel, [config]]])

Example: spi_master|slave_receive(v_data_out, "Receive from Peripheral 1", spi_if);

Suggested usage: spi_master|slave_receive(v_data_out, "Receive from Peripheral 1"); -- Suggested usage requires local overload (see section 5)

spi_master|slave_check (data_exp, msg, spi_if, [alert_level, [scope, [msg_id_panel, [config]]]])

Example: spi_master|slave_check(x"3B", "Expecting data from SPI", spi_if);

Suggested usage: spi_master|slave_check(C_DATA_BYTE, "Expecting data byte"); -- Suggested usage requires local overload (see section 5)

init_spi_if_signals (config, [master_model])

Example: spi_if <= init_spi_if_signals(C_SPI_BFM_CONFIG_DEFAULT);

BFM



spi_bfm_pkg.vhd



BFM Configuration record 't_spi_bfm_config'

Name	Type	C_SPI_BFM_CONFIG_DEFAULT
CPOL	std_logic	'0'
CPHA	std_logic	'0'
spi_bit_time	time	200 ns
spi_bit_time_severity	t_alert_level	failure
ss_n_to_sclk	time	20 ns
ss_n_to_sclk_severity	t_alert_level	failure
sclk_to_ss_n	time	20 ns
sclk_to_ss_n_severity	t_alert_level	failure
max_wait_ss_n	time	1000 ns
max_wait_ss_n_severity	t_alert_level	failure
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

Signal record 't_spi_if'

Name	Type
ss_n	std_logic
sclk	std_logic
mosi	std_logic
miso	std_logic

BFM non-signal parameters

Name	Type	Example(s)	Description
tx_data	std_logic_vector	x"D3"	The data value to be transmitted to the DUT
rx_data	std_logic_vector	x"D3"	SLV where the received data will be stored
data_exp	std_logic_vector	x"0D"	The data value to expect when receiving data from the slave. A mismatch results in an alert 'alert_level'
alert_level	t_alert_level	ERROR or TB_WARNING	Set the severity for the alert that may be asserted by the method.
msg	string	"Receiving data"	A custom message to be appended in the log/alert.
scope	string	"SPI BFM"	A string describing the scope from which the log/alert originates. In a simple single sequencer typically "SPI BFM". In a verification component, typically "SPI_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_spi_bfm_config	C_SPI_BFM_CONFIG_DEFAULT	Configuration of BFM behaviour and restrictions. See section 2 for details.

BFM signal parameters

Name	Type	Description
spi_if	t_spi_if	See table "Signal record 't_spi_if'"

Note: All signals are active high.

BFM details

1 BFM procedure details and examples

Procedure	Description
spi_master_transmit_and_receive()	<p>spi_master_transmit_and_receive (tx_data, rx_data, msg, spi_if, [scope, [msg_id_panel, [config]]])</p> <p>The spi_master_transmit_and_receive() procedure transmits the data in 'tx_data' to the DUT and stores the received data in 'rx_data', using the SPI protocol. For protocol details, see the SPI specification. When called, the spi_master_transmit_and_receive() procedure will set ss_n low. For a slave DUT to be able to transmit to a receiving master BFM, the master BFM must drive the sclk and ss_n signals and transmit data to the slave DUT.</p> <ul style="list-style-type: none"> - This procedure is responsible for driving sclk and ss_n. - The SPI bit timing is given by config.spi_bit_time, config.spi_ss_n_to_sclk and config.sclk_to_ss_n. - The default value of scope is C_SCOPE ("SPI BFM") - The default value of msg_id_panel is shared_msg_id_panel, defined in UVVM_Util. - The default value of config is C_SPI_BFM_CONFIG_DEFAULT, see table on page 2. - A log message is written if ID_BFM ID is enabled for the specified message ID panel. - An error is reported if ss_n is not kept low during the entire transmission. <p>Examples:</p> <ul style="list-style-type: none"> - spi_master_transmit_and_receive(x"AA", v_data_out, "Transmitting data to peripheral 1 and receiving data from peripheral 1", spi_if); - spi_master_transmit_and_receive(x"AA", v_data_out, "Transmitting data to peripheral 1 and receiving data from peripheral 1", spi_if, C_SCOPE, shared_msg_id_panel, C_SPI_BFM_CONFIG_DEFAULT); <p>Suggested usage (requires local overload, see section 5):</p> <ul style="list-style-type: none"> - spi_master_transmit_and_receive(C_ASCII_A, v_data_out, "Transmitting ASCII A to DUT and receiving data from DUT");
spi_master_transmit_and_check()	<p>spi_master_transmit_and_check (tx_data, data_exp, msg, spi_if, [alert_level, [scope, [msg_id_panel, [config]]]])</p> <p>The spi_master_transmit_and_check() procedure transmits the data in 'tx_data' and receives data from the DUT, using the transmit and receive procedure as described in the spi_master_transmit_and_receive() procedure. After receiving data from the DUT, the data is compared with the expected data, 'data_exp'. If the received data does not match the expected data, an alert with severity 'alert_level' will be triggered. If the received data matches 'data_exp', a message with ID config.id_for_bfm will be logged. In addition to the specifications listed in procedure spi_master_transmit_and_receive(), the following applies to the spi_master_transmit_and_check() procedure:</p> <ul style="list-style-type: none"> - When called, the spi_master_transmit_and_check() procedure will in turn call spi_master_transmit_and_receive(). - The default value of alert_level is ERROR - The procedure will report alerts for the same conditions as the spi_master_transmit_and_receive() procedure. <p>Example usage:</p> <ul style="list-style-type: none"> - spi_master_transmit_and_check(x"AA", x"3B", "Transmitting data and checking received data on SPI interface", spi_if); <p>Suggested usage (requires local overload, see section 5):</p> <ul style="list-style-type: none"> - spi_master_transmit_and_check(x"AA", C_CR_BYTE, "Transmitting 0xAA and expecting carriage return");

spi_master_transmit()

spi_master_transmit (tx_data, msg, spi_if, [scope, [msg_id_panel, [config]]])

The spi_master_transmit() procedure transmits the data in 'tx_data' to the DUT, using the transmit and receive procedure as described in the spi_master_transmit_and_receive() procedure.

In addition to the specifications listed in procedure spi_master_transmit_and_receive(), the following applies to the spi_master_transmit() procedure:

- When called, the spi_master_transmit() procedure will in turn call spi_master_transmit_and_receive().
- The received data from the slave DUT is ignored.
- The procedure will report alerts for the same conditions as the spi_master_transmit_and_receive() procedure.

Examples:

- spi_master_transmit(x"AA", "Transmitting data to peripheral 1", spi_if);
- spi_master_transmit(x"AA", "Transmitting data to peripheral 1", spi_if, C_SCOPE, shared_msg_id_panel, C_SPI_BFM_CONFIG_DEFAULT);

Suggested usage (requires local overload, see section 5):

- spi_master_transmit(C_ASCII_A, "Transmitting ASCII A to DUT");

spi_master_receive()

spi_master_receive (rx_data, msg, spi_if, [scope, [msg_id_panel, [config]]])

The spi_master_receive() procedure receives data from the DUT at the given address, using the transmit and receive procedure as described in the spi_master_transmit_and_receive() procedure.

In addition to the specifications listed in procedure spi_master_transmit_and_receive(), the following applies to the spi_master_receive() procedure:

- When called, the spi_master_receive() procedure will in turn call spi_master_transmit_and_receive().
- The spi_master_receive() procedure will transmit dummy data (0x0) to the DUT.
- The procedure will report alerts for the same conditions as the spi_master_transmit_and_receive() procedure.

Example

- spi_master_receive(v_data_out, "Receive from Peripheral 1", spi_if);
- spi_master_receive(v_data_out, "Receive from Peripheral 1", spi_if, C_SCOPE, shared_msg_id_panel, C_SPI_BFM_CONFIG_DEFAULT);

Suggested usage (requires local overload, see section 5):

- spi_master_receive(v_data_out, "Receive from Peripheral 1");

spi_master_check()

spi_master_check (data_exp, msg, spi_if, [alert_level, [scope, [msg_id_panel, [config]]])

The spi_master_check() procedure receives data from the DUT, using the transmit and receive procedure as described in the spi_master_transmit_and_receive() procedure.

After receiving data from the DUT, the data is compared with the expected data, 'data_exp'. If the received data does not match the expected data, an alert with severity 'alert_level' will be triggered. If the received data matches 'data_exp', a message with ID config.id_for_bfm will be logged.

In addition to the specifications listed in procedure spi_master_transmit_and_receive(), the following applies to the spi_master_check() procedure:

- When called, the spi_master_check() procedure will in turn call procedure spi_master_transmit_and_receive().
- The default value of alert_level is ERROR.
- The procedure will report alerts for the same conditions as the spi_master_transmit_and_receive() procedure.
- The spi_master_check() procedure will transmit dummy data (0x0) to the DUT.

Example usage:

- spi_master_check(x"3B", "Checking data on SPI interface", spi_if);

Suggested usage (requires local overload, see section 5):

- spi_master_check(C_CR_BYTE, "Expecting carriage return");
-

spi_slave_transmit_and_receive()
spi_slave_transmit_and_receive (tx_data, rx_data, msg, spi_if, [scope, [msg_id_panel, [config]]])

The spi_slave_transmit_and_receive() procedure transmits the data in 'tx_data' to the DUT and stores the received data in 'rx_data', using the SPI protocol.

For protocol details, see the SPI specification.

- When called, the spi_slave_transmit_and_receive() procedure will wait for ss_n to be set low and start transmitting data to and receiving data from a master DUT. This await function has a timeout of config.max_wait_ss_n.
- The default value of scope is C_SCOPE ("SPI BFM")
- The default value of msg_id_panel is shared_msg_id_panel, defined in UVVM_Util.
- The default value of config is C_SPI_BFM_CONFIG_DEFAULT, see table on the first page.
- A log message is written if ID_BFM ID is enabled for the specified message ID panel.
- An error is reported if ss_n is not kept low during the entire transmission.

Examples:

- spi_slave_transmit_and_receive(x"AA", v_data_out, "Transmitting and receiving data from peripheral 1", spi_if);
- spi_slave_transmit_and_receive(x"AA", v_data_out, "Transmitting and receiving data from peripheral 1", spi_if, C_SCOPE, shared_msg_id_panel, C_SPI_BFM_CONFIG_DEFAULT);

Suggested usage (requires local overload, see section 5):

- spi_slave_transmit_and_receive(C_ASCII_A, v_data_out, "Transmitting ASCII A to DUT and receiving data from DUT");

spi_slave_transmit()
spi_slave_transmit (tx_data, msg, spi_if, [scope, [msg_id_panel, [config]]])

The spi_slave_transmit() procedure transmits the data in 'tx_data' to the DUT, using the spi_slave_transmit_and_receive() procedure.

In addition to the specifications listed in procedure spi_slave_transmit_and_receive(), the following applies to the spi_slave_transmit() procedure:

- When called, the spi_slave_transmit() procedure will in turn call procedure spi_slave_transmit_and_receive().
- The received data from the DUT is ignored.
- The procedure will report alerts for the same conditions as the spi_slave_transmit_and_receive() procedure.

Examples:

- spi_slave_transmit(x"AA", "Transmitting data to peripheral 1", spi_if);
- spi_slave_transmit(x"AA", "Transmitting data to peripheral 1", spi_if, C_SCOPE, shared_msg_id_panel, C_SPI_BFM_CONFIG_DEFAULT);

Suggested usage (requires local overload, see section 5):

- spi_slave_transmit(C_ASCII_A, "Transmitting ASCII A to DUT");

spi_slave_receive()
spi_slave_receive (rx_data, msg, spi_if, [scope, [msg_id_panel, [config]]])

The spi_slave_receive() procedure receives data from the DUT, using the transmit and receive procedure as described in the spi_slave_transmit_and_receive() procedure.

In addition to the specifications listed in procedure spi_slave_transmit_and_receive(), the following applies to the spi_slave_receive() procedure:

- When called, the spi_slave_receive() procedure will in turn call spi_slave_transmit_and_receive().
- The spi_slave_receive() procedure will transmit dummy data (0x0) to the DUT.
- The procedure will report alerts for the same conditions as the spi_slave_transmit_and_receive() procedure.

Example

- spi_slave_receive(v_data_out, "Receive from Peripheral 1", spi_if);
- spi_slave_receive(v_data_out, "Receive from Peripheral 1", spi_if, C_SCOPE, shared_msg_id_panel, C_SPI_BFM_CONFIG_DEFAULT);

Suggested usage (requires local overload, see section 5):

- spi_slave_receive(v_data_out, "Receive from Peripheral 1");
-

spi_slave_check()

spi_slave_check (data_exp, msg, spi_if, [alert_level, [scope, [msg_id_panel, [config]]]])

The spi_slave_check() procedure receives data from the DUT, using the transmit and receive procedure as described in the spi_slave_transmit_and_receive() procedure. After receiving data from the DUT, the data is compared with the expected data, 'data_exp'. If the received data does not match the expected data, an alert with severity 'alert_level' will be triggered. If the received data matches 'data_exp', a message with ID config.id_for_bfm will be logged.

In addition to the specifications listed in procedure spi_slave_transmit_and_receive(), the following applies to the spi_slave_check() procedure:

- When called, the spi_slave_check() procedure will in turn call procedure spi_slave_transmit_and_receive().
- The default value of alert_level is ERROR
- The spi_slave_check() procedure transmit dummy data (0x0) to the DUT.
- The procedure will report alerts for the same conditions as the spi_slave_transmit_and_receive() procedure.

Example usage:

- spi_slave_check(x"3B", "Checking data on SPI interface", spi_if);

Suggested usage (requires local overload, see section 5):

- spi_slave_check(C_CR_BYTE, "Expecting carriage return");

init_spi_if_signals

init_spi_if_signals(config, [master_mode])

This function initializes the SPI interface.

Master mode set true:

- ss_n initialized to 'H'
- if config.CPOL = '1', sclk initialized to 'H'. Otherwise, sclk initialized to 'L'
- miso and mosi initialized to 'Z'

Master mode set false:

- All signals initialized to 'Z'

Example

- spi_if <= init_spi_if_signals(C_SPI_BFM_CONFIG_DEFAULT); -- implicitly master mode since default is 'true'
- spi_if <= init_spi_if_signals(C_SPI_BFM_CONFIG_DEFAULT, true); -- explicitly indicating master mode
- spi_if <= init_spi_if_signals(C_SPI_BFM_CONFIG_DEFAULT, false); -- master_mode is false, i.e., shall act as a slave

2 BFM Configuration record

Type name: t_spi_bfm_config

Name	Type	C_SPI_BFM_CONFIG_DEFAULT	Description
CPOL	std_logic	'0'	sclk polarity, i.e. the base value of the clock. If CPOL is '0', the clock will be set to '0' when inactive, i.e., ordinary positive polarity.
CPHA	std_logic	'0'	sclk phase, i.e. when data is sampled and transmitted w.r.t. sclk. If '0', sampling occurs on the first sclk edge and data is transmitted on the sclk active to idle state. If '1', data is sampled on the second sclk edge and transmitted on sclk idle to active state.
spi_bit_time	time	200 ns	Used in master for dictating setting sclk period
spi_bit_time_severity	t_alert_level	failure	Alert severity used if slave detects that the received sclk period is incorrect
ss_n_to_sclk	time	20 ns	Time from ss_n low until sclk active
ss_n_to_sclk_severity	t_alert_level	failure	Alert severity used if time from ss_n low to sclk active is exceeded
sclk_to_ss_n	time	20 ns	Time from last sclk until ss_n is released
sclk_to_ss_n_severity	t_alert_level	failure	Alert severity used if ss_n is not released within sclk_to_ss_n time after last sclk
max_wait_ss_n	time	1000 ns	Maximum time a slave will wait for ss_n
max_wait_ss_n_severity	t_alert_level	failure	Alert severity used if slave does not detect ss_n within max_wait_ss_n time.
id_for_bfm	t_msg_id	ID_BFM	The message ID used as a general message ID in the SPI BFM
id_for_bfm_wait	t_msg_id	ID_BFM_WAIT	The message ID used for logging waits in the SPI BFM
id_for_bfm_poll	t_msg_id	ID_BFM_POLL	The message ID used for logging polling in the SPI BFM

3 Additional Documentation

For additional documentation on the SPI protocol, please see the SPI specification.

4 Compilation

The SPI 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 spi_bfm_pkg.vhd BFM can be compiled into any desired library.

4.1 Simulator compatibility and setup

This BFM has been compiled and tested with Modelsim version 10.3d and Riviera-PRO version 2015.10.85.

For required simulator setup see UVVM-Util Quick reference.

5 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.

```
spi_master_transmit_and_receive(C_ASCII_A, v_data_out, "Transmitting ASCII A");
```

rather than

```
spi_master_transmit_and_receive(C_ASCII_A, v_data_out, "Transmitting ASCII A", spi_if, C_SCOPE,  
                                shared_msg_id_panel, C_SPI_BFM_CONFIG_DEFAULT);
```

By defining the local overload as e.g.:

```
procedure spi_master_transmit(  
    constant tx_data      : in std_logic_vector;  
    variable rx_data      : out std_logic_vector;  
    constant msg          : in string) is  
begin  
    spi_master_transmit(tx_data,                -- keep as is  
                        rx_data,                -- keep as is  
                        msg,                    -- keep as is  
                        spi_if,                 -- Signals must be visible in local process scope  
                        C_SCOPE,                -- Just use the default  
                        shared_msg_id_panel,    -- Use global, shared msg id panel  
                        C_SPI_CONFIG_LOCAL);    -- Use locally defined configuration or C_SPI_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 message ID panel to allow dedicated verbosity control

IMPORTANT

This is a simplified Bus Functional Model for SPI.

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

For a more advanced BFM please contact Bitvis AS at support@bitvis.no

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