

# AMBA<sup>®</sup> 4 AXI4<sup>™</sup>, AXI4-Lite<sup>™</sup>, and AXI4-Stream<sup>™</sup> Protocol Assertions

Revision: r0p1

**User Guide**



# AMBA 4 AXI4, AXI4-Lite, and AXI4-Stream Protocol Assertions

## User Guide

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### Release Information

The following changes have been made to this book.

Change history			
Date	Issue	Confidentiality	Change
30 June 2010	A	Non-Confidential	First issue for r0p0
23 July 2012	B	Non-Confidential	First issue for r0p1

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# Preface

This preface introduces the *AMBA® 4 AXI4™, AXI4-Lite™, and AXI4-Stream™ Protocol Assertions User Guide*. It contains the following sections:

- [About this book on page vi](#)
- [Feedback on page ix.](#)

## About this book

This book is for *AMBA 4 AXI4*, *AXI4-Lite*, and *AXI4-Stream Protocol Assertions*.

## Product revision status

The *rn**pn* identifier indicates the revision status of the product described in this book, where:

- rn*** Identifies the major revision of the product.
- pn*** Identifies the minor revision or modification status of the product.

## Intended audience

This book is written for system designers, system integrators, and verification engineers who want to confirm that a design complies with the relevant AMBA 4 protocol. This can be AXI4, AXI4-Lite, or AXI4-Stream.

## Using this book

This book is organized into the following chapters:

### Chapter 1 *Introduction*

Read this for a high-level description of the protocol assertions.

### Chapter 2 *Implementation and Integration*

Read this for a description of where to locate the protocol assertions in your design, the integration flow, information about specific signal connections with an example file listing, and setting up your simulator.

### Chapter 3 *Parameter Descriptions*

Read this for a description of the protocol assertions parameters.

### Chapter 4 *Protocol Assertions Descriptions*

Read this for a description of the protocol assertions module.

### Appendix A *Example Usage*

Read this for an example of a design that does not comply with the protocol.

### Appendix B *Revisions*

Read this for a description of the technical changes between released issues of this book.

## Glossary

The *ARM Glossary* is a list of terms used in ARM documentation, together with definitions for those terms. The *ARM Glossary* does not contain terms that are industry standard unless the ARM meaning differs from the generally accepted meaning.

See *ARM Glossary*, <http://infocenter.arm.com/help/topic/com.arm.doc.aeg0014-/index.html>.

## Conventions

This book uses the conventions that are described in:

- *Typographical conventions* on page vii
- *Timing diagrams* on page vii
- *Signals* on page viii.

## Typographical conventions

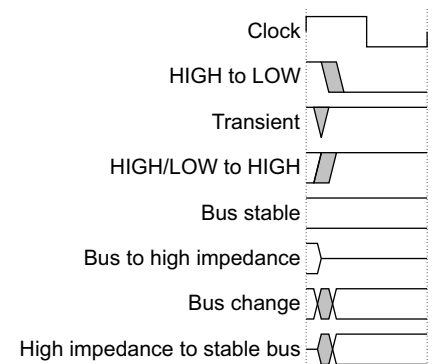
The following table describes the typographical conventions:

Style	Purpose
<i>italic</i>	Introduces special terminology, denotes cross-references, and citations.
<b>bold</b>	Highlights interface elements, such as menu names. Denotes signal names. Also used for terms in descriptive lists, where appropriate.
monospace	Denotes text that you can enter at the keyboard, such as commands, file and program names, and source code.
<u>monospace</u>	Denotes a permitted abbreviation for a command or option. You can enter the underlined text instead of the full command or option name.
monospace <i>italic</i>	Denotes arguments to monospace text where the argument is to be replaced by a specific value.
<b>monospace bold</b>	Denotes language keywords when used outside example code.
<and>	Encloses replaceable terms for assembler syntax where they appear in code or code fragments. For example: MRC p15, 0 <Rd>, <CRn>, <CRm>, <Opcode_2>
SMALL CAPITALS	Used in body text for a few terms that have specific technical meanings, that are defined in the <i>ARM glossary</i> . For example, IMPLEMENTATION DEFINED, IMPLEMENTATION SPECIFIC, UNKNOWN, and UNPREDICTABLE.

## Timing diagrams

The figure named *Key to timing diagram conventions* explains the components used in timing diagrams. Variations, when they occur, have clear labels. You must not assume any timing information that is not explicit in the diagrams.

Shaded bus and signal areas are undefined, so the bus or signal can assume any value within the shaded area at that time. The actual level is unimportant and does not affect normal operation.



### Key to timing diagram conventions

Timing diagrams sometimes show single-bit signals as HIGH and LOW at the same time and they look similar to the bus change shown in *Key to timing diagram conventions*. If a timing diagram shows a single-bit signal in this way then its value does not affect the accompanying description.

## Signals

The signal conventions are:

- |                     |   |
|---------------------|---|
| <b>Signal level</b> | The level of an asserted signal depends on whether the signal is active-HIGH or active-LOW. Asserted means: <ul style="list-style-type: none"> <li>• HIGH for active-HIGH signals</li> <li>• LOW for active-LOW signals.</li> </ul> |
| <b>Lower-case n</b> | At the start or end of a signal name denotes an active-LOW signal.  |

## Additional reading

This section lists publications by ARM and by third parties.

See Infocenter, <http://infocenter.arm.com>, for access to ARM documentation.

### ARM publications

This book contains information that is specific to this product. See the following documents for other relevant information:

- *AMBA® AXI™ and ACE™ Protocol Specification - AXI3™, AXI4™, and AXI4-Lite™ ACE and ACE-Lite™* (ARM IHI 0022)
- *AMBA 4 AXI4-Stream™ Protocol v1.0 Specification* (ARM IHI 0051).

### Other publications

This section lists relevant documents published by third parties:

- SystemVerilog technical papers, tutorials, and downloads, <http://www.systemverilog.org/>
- Accellera *SystemVerilog 3.1a Language Reference Manual*, <http://www.eda.org/s1>
- 1800-2005 *IEEE Standard for SystemVerilog: Unified Hardware Design, Specification and Verification Language*, <http://www.systemverilog.org>.



## Feedback

ARM welcomes feedback on this product and its documentation.

### Feedback on this product

If you have any comments or suggestions about this product, contact your supplier and give:

- The product name.
- The product revision or version.
- An explanation with as much information as you can provide. Include symptoms and diagnostic procedures if appropriate.

### Feedback on content

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- The title.
- The number, ARM DUI 0534B.
- The page numbers to which your comments apply.
- A concise explanation of your comments.

ARM also welcomes general suggestions for additions and improvements.

———— **Note** ————

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# Chapter 1

## Introduction

This chapter introduces the protocol assertions. It contains the following sections:

- [\*About the protocol assertions on page 1-2\*](#)
- [\*Tools on page 1-3.\*](#)

## 1.1 About the protocol assertions

You can use the protocol assertions with any interface that is designed to implement the AMBA<sup>®</sup> 4 AXI4<sup>™</sup>, AXI4-Lite<sup>™</sup>, or AXI4-Stream<sup>™</sup> Protocol. The behavior of the interface you test is checked against the protocol by a series of assertions.

This guide describes the contents of the SystemVerilog files, and how to integrate them into a design. It also describes the correct use of these assertions with simulators to flag errors, warnings, or both, during design simulation.

## 1.2 Tools

The protocol assertions are written in SystemVerilog. SystemVerilog is a *Hardware Description and Verification Language* (HDVL) standard that extends the established Verilog language. It was developed to improve productivity in the design of large gate count, IP-based, bus-intensive chips. SystemVerilog is targeted at the chip implementation and verification flow, with links to the system level design flow.

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**Note**

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The version of System Verilog supported is IEEE 1800-2005.

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# Chapter 2

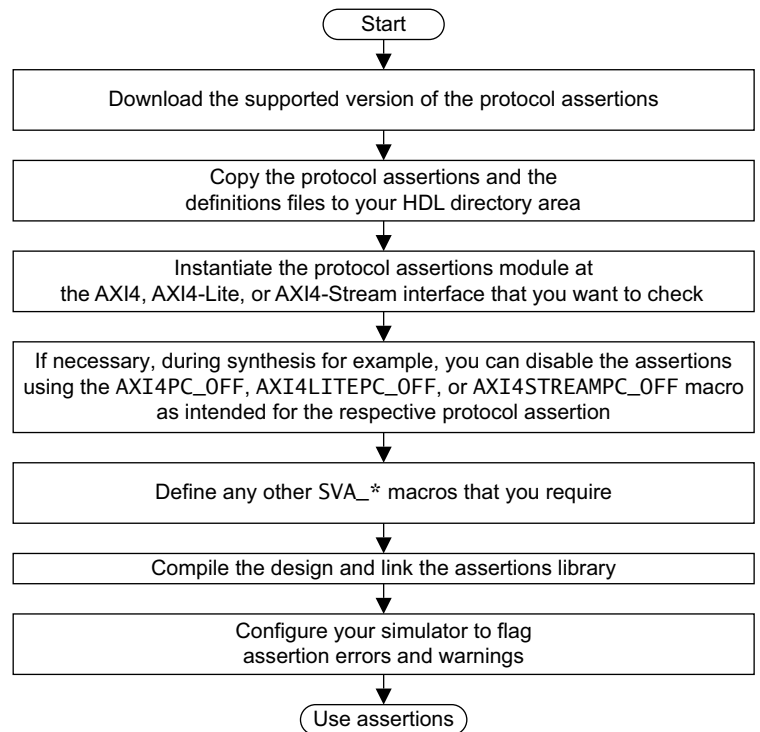
## Implementation and Integration

This chapter describes the location of the protocol assertions and the integration flow. It contains the following sections:

- [\*Implementation and integration flow on page 2-2\*](#)
- [\*Implementing the protocol assertions in your design directory on page 2-3\*](#)
- [\*Instantiating the protocol assertions module on page 2-4\*](#)
- [\*Configuring your simulator on page 2-7.\*](#)

## 2.1 Implementation and integration flow

Figure 2-1 shows the design flow for implementing and integrating the protocol assertions SystemVerilog file with a design.



**Figure 2-1 Integration flow**

## 2.2 Implementing the protocol assertions in your design directory

You can implement the protocol assertions for:

- AXI4™.
- AXI4-Lite™.
- AXI4-Stream™.

This section describes:

- [AXI4 protocol assertions files](#)
- [Location of AXI4 protocol assertions files.](#)

### 2.2.1 AXI4 protocol assertions files

Figure 2-2 shows the contents of the directory that contains the protocol assertions. It shows the files that are required for each of the different protocols, AXI4, AXI4-Lite, and AXI4-Stream.

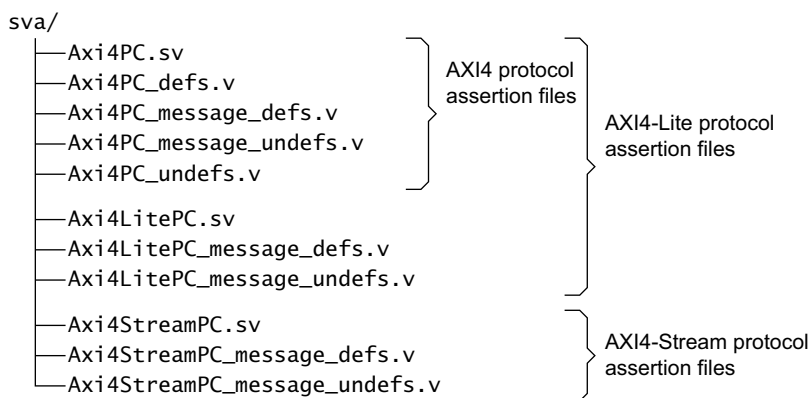


Figure 2-2 Protocol assertions directory structure for AXI4, AXI4-Lite, and AXI4-Stream

### 2.2.2 Location of AXI4 protocol assertions files

Figure 2-3 shows the location of the protocol assertions SystemVerilog files in your design RTL.

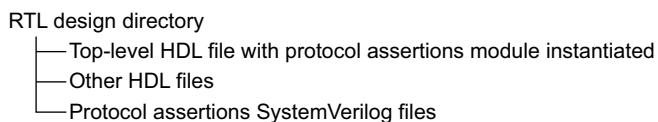


Figure 2-3 Location of the AMBA 4 AXI4 protocol assertions SystemVerilog files

## 2.3 Instantiating the protocol assertions module

The protocol assertions module contains a port list. Connect the AXI4, AXI4-Lite, or AXI4-Stream module ports to the corresponding signals in your design.

*Example Verilog file listing for AXI4 protocol assertions instantiation* shows the module instantiated in a top-level Verilog file.

See *ARM publications on page viii* for the specifications that describe the AXI4, AXI4-Lite, and AXI4-Stream signals.

Tie the low-power interface signals of the AXI interface HIGH if you are not using them. They are named:

<b>CSYSREQ</b>	For the low-power request signal.
<b>CSYSACK</b>	For the low-power request acknowledgement signal.
<b>CACTIVE</b>	For the clock active signal.

The AXI4 SystemVerilog files contain checks for user-configurable sideband signals. Tie these signals LOW if you are not using them.

### 2.3.1 Example Verilog file listing for AXI4 protocol assertions instantiation

*Example 2-1* shows part of a design HDL file instantiating the protocol assertions module for AXI4. You can, if necessary, override any of the protocol assertions parameters by using `defparam` at this level.

**Example 2-1 Example Verilog file listing for AXI**

---

```

Axi4PC u_axi4_sva
(
    .ACLK (ACLK),
    .ARESETn (ARESETn),
    .AWID (AWID),
    .AWADDR (AWADDR),
    .AWLEN (AWLEN),
    .AWSIZE (AWSIZE),
    .AWBURST (AWBURST),
    .AWLOCK (AWLOCK),
    .AWCACHE (AWCACHE),
    .AWPROT (AWPROT),
    .AWQOS (AWQOS),
    .AWREGION (AWREGION),
    .AWUSER ({32{1'b0}}),
    .AWVALID (AWVALID),
    .AWREADY (AWREADY),
    .WLAST (WLAST),
    .WDATA (WDATA),
    .WSTRB (WSTRB),
    .WUSER ({32{1'b0}}),
    .WVALID (WVALID),
    .WREADY (WREADY),
    .BID (BID),
    .BRESP (BRESP),
    .BUSER ({32{1'b0}}),
    .BVALID (BVALID),
    .BREADY (BREADY),
    .ARID (ARID),
    .ARADDR (ARADDR),

```

---



```

.ARLEN (ARLEN),
.ARSIZE (ARSIZE),
.ARBURST (ARBURST),
.ARLOCK (ARLOCK),
.ARCACHE (ARCACHE),
.ARPROT (ARPROT),
.ARQOS (ARQOS),
.ARREGION (ARREGION),
.ARUSER ({32{1'b0}}),
.ARVALID (ARVALID),
.ARREADY (ARREADY),
.RID (RID),
.RLAST (RLAST),
.RDATA (RDATA),
.RRESP (RRESP),
.RUSER ({32{1'b0}}),
.RVALID (RVALID),
.RREADY (RREADY),
.CACTIVE (CACTIVE),
.CSYSREQ (CSYSREQ),
.CSYSACK (CSYSACK)
);

```

---

### 2.3.2 Example Verilog file listing for AXI4-Lite protocol assertions instantiation

[Example 2-2](#) shows part of a design HDL file instantiating the protocol assertions module for AXI4-Lite. You can, if necessary, override any of the protocol assertions parameters by using `defparam` at this level.

#### Example 2-2 Verilog file listing for AXI4-Lite

```

Axi4LitePC u_axi4lite_sva
(
  .ACLK (ACLK),
  .ARESETn (ARESETn),
  .AWADDR (AWADDR),
  .AWPROT (AWPROT),
  .AWVALID (AWVALID),
  .AWREADY (AWREADY),
  .WDATA (WDATA),
  .WSTRB (WSTRB),
  .WVALID (WVALID),
  .WREADY (WREADY),
  .BRESP (BRESP),
  .BVALID (BVALID),
  .BREADY (BREADY),
  .ARADDR (ARADDR),
  .ARPROT (ARPROT),
  .ARVALID (ARVALID),
  .ARREADY (ARREADY),
  .RDATA (RDATA),
  .RRESP (RRESP),
  .RVALID (RVALID),
  .RREADY (RREADY)
);

```

---

### 2.3.3 Example Verilog file listing for AXI4-Stream protocol assertions instantiation

[Example 2-3](#) shows part of a design HDL file instantiating the protocol assertions module for AXI4-Stream. You can, if necessary, override any of the protocol assertions parameters by using `defparam` at this level.

#### Example 2-3 Example Verilog file listing for AXI4-Stream

---

```
Axi4StreamPC u_axi4stream_sva
(
    .ACLK (ACLK),
    .ARESETn (ARESETn),
    .TDATA (TDATA),
    .TSTRB (TSTRB),
    .TKEEP (TKEEP),
    .TLAST (TLAST),
    .TID (TID),
    .TDEST (TDEST),
    .TUSER ({32{1'b0}}),
    .TVALID (TVALID),
    .TREADY (TREADY)
);
```

---

## 2.4 Configuring your simulator

Most simulators support the use of assertions in RTL, and enable you to configure the simulator appropriately using command variables that define the available assertion options. These can include:

- Suppress or enable assertion warnings.
- Select assertion report messages to display.
- Set a minimum severity level for which assertion report messages are output.
- Set a minimum severity level for which an assertion causes the simulator to stop.

The protocol assertions are written using SystemVerilog IEEE 1800-2005, and are tested with a number of simulators. Contact your simulator supplier and see your documentation for more information on using SystemVerilog Assertions.

# Chapter 3

## Parameter Descriptions

This chapter provides descriptions of the protocol assertions parameters. It contains the following sections:

- [\*Interface\* on page 3-2](#)
- [\*Performance checking\* on page 3-3](#)
- [\*Disabling recommended rules\* on page 3-4](#)
- [\*End of simulation rules\* on page 3-5](#)
- [\*X-check rules\* on page 3-6](#)
- [\*Disabling protocol assertions\* on page 3-7.](#)

---

### Caution

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An additional set of defined parameters are derived from the base set of parameters that this chapter describes. Do not modify them.

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## 3.1 Interface

This section describes:

- [AXI4 and AXI4-Lite interfaces](#)
- [AXI4-Stream interface](#).

### 3.1.1 AXI4 and AXI4-Lite interfaces

[Table 3-1](#) shows the user-defined parameters for setting the interface characteristics for AXI4™ and AXI4-Lite™. Change them to match your design specification.

**Table 3-1 Interface parameters for AXI4 and AXI4-Lite**

Name	Description	AXI4 default	AXI4-Lite default
DATA_WIDTH	Width of the system data buses.	64	64
RID_WIDTH	Number of read channel ID bits required.	4	-
WID_WIDTH	Number of write channel ID bits required.	4	-
MAXRBURSTS	Size of FIFOs for storing outstanding read bursts. This must be greater than or equal to the maximum number of outstanding read bursts that can be active at the slave interface.	16	16
MAXWBURSTS	Size of FIFOs for storing outstanding write bursts. This must be greater than or equal to the maximum number of outstanding write bursts that can be active at the slave interface.	16	16
ADDR_WIDTH	Width of the address bus.	32	32
EXMON_WIDTH	Width of the exclusive access monitor required.	4	-
AWUSER_WIDTH	Width of the user AW sideband field.	32	-
WUSER_WIDTH	Width of the user W sideband field.	32	-
BUSER_WIDTH	Width of the user B sideband field.	32	-
ARUSER_WIDTH	Width of the user AR sideband field.	32	-
RUSER_WIDTH	Width of the user R sideband field.	32	-

### 3.1.2 AXI4-Stream interface

[Table 3-2](#) shows the user-defined parameters for setting the interface characteristics for AXI4-Stream™. Change them to match your design specification.

**Table 3-2 Interface parameters for AXI4-Stream**

Name	Description	Default
DATA_WIDTH_BYTES	Width of the data bus in bytes	4
DEST_WIDTH	Width of <b>TDEST</b> in bits	4
ID_WIDTH	Number of channel ID bits required for <b>TID</b>	4
USER_WIDTH	Width of the <b>TUSER</b> bus in bits	32

## 3.2 Performance checking

[Table 3-3](#) shows the user-defined parameter for performance checking.

**Table 3-3 Performance checking parameter**

Name	Description	Default
MAXWAITS	Maximum number of cycles between <b>VALID</b> to <b>READY</b> HIGH before a warning is generated	16

### 3.3 Disabling recommended rules

This section describes:

- [Disabling recommended rules for AXI4 and AXI4-Lite](#)
- [Disabling recommended rules for AXI4-Stream](#).

#### 3.3.1 Disabling recommended rules for AXI4 and AXI4-Lite

Table 3-4 shows the user-defined parameters for configuring recommended rules from the protocol assertions.

**Table 3-4 Display parameters**

Name	Description	Default
RecommendOn	Enable or disable reporting of protocol recommendations	1'b1, that is, enabled
RecMaxWaitOn	Enable or disable the recommended MAX_WAIT rules	1'b1, that is, enabled

**Note**

RecMaxWaitOn is a subset of RecommendOn, and if RecommendOn is 1'b0, that is, disabled, then the MAX\_WAIT rules are disabled regardless of the settings of RecMaxWaitOn.

If RecommendOn is disabled, the following warning is issued:

AXI4\_WARN: All recommended AXI rules have been disabled by the RecommendOn parameter

If RecommendOn is enabled, the default, but RecMaxWaitOn is disabled, the following warning is issued:

AXI4\_WARN: All recommended MAX\_WAIT rules have been disabled by the RecMaxWaitOn parameter

#### 3.3.2 Disabling recommended rules for AXI4-Stream

Table 3-5 shows the user-defined parameter for configuring recommended rules from the protocol assertions.

**Table 3-5 Display parameters**

Name	Description	Default
RecommendOn	Enable or disable reporting of protocol recommendations	1'b1, that is, enabled
RecMaxWaitOn	Enable or disable the recommend MAX_WAIT rules	1'b1, that is, enabled

If RecommendOn is disabled, the following AXI4-Stream warning is issued:

AXI4STREAM\_WARN: All recommended AXI rules have been disabled by the RecommendOn parameter

If RecommendOn is enabled, the default, but RecMaxWaitOn is disabled, the following warning is issued:

AXI4STREAM\_WARN: All recommended MAX\_WAIT rules have been disabled by the RecMaxWaitOn parameter

## 3.4 End of simulation rules

This section describes the end of simulation rules for:

- [AXI4 and AXI4-Lite](#)
- [AXI4-Stream](#).

### 3.4.1 AXI4 and AXI4-Lite

Some of the rules in the assertions report whether there are outstanding transactions at the end of simulation. These checks are always run unless AXI4PC\_EOS\_OFF is defined. If you want to disable these *end of simulation* assertions, you must use the following when compiling:

```
+define+AXI4PC_EOS_OFF
```

### 3.4.2 AXI4-Stream

Some of the rules in the assertions report whether there are active streams at the end of the simulation. To use these assertions you must ensure that:

- The testbench that you are using has a signal called **EOS\_signal**. You must drive **EOS\_signal** HIGH at the end of the simulation for at least one clock cycle.
- You use +define+AXI4STREAM\_END\_OF\_SIMULATION=tb.EOS\_signal when compiling.



## 3.5 X-check rules

If you want to disable the X-propagation assertions on AXI4 or AXI4-Lite interfaces, you must use the following rule when compiling:

```
+define+AXI4_XCHECK_OFF
```

If you want to disable the X-propagation assertions on AXI4-Stream interfaces, you must use the following rule when compiling:

```
+define+AXI4STREAM_XCHECK_OFF
```

## 3.6 Disabling protocol assertions

In circumstances where the protocol assertion module has been automatically inserted in a testbench, and you want to disable it without editing the testbench, you can compile with the following options:

`+define+AXI4PC_OFF`

To disable the AXI4PC protocol assertions module.

`+define+AXI4LITEPC_OFF`

To disable the AXI4LITEPC protocol assertions module.

`+define+AXI4STREAMPC_OFF`

To disable the AXI4STREAMPC protocol assertions module.

# Chapter 4

## Protocol Assertions Descriptions

This chapter describes the protocol assertions and indicates the area of the *AMBA® AXI™ and ACE™ Protocol Specification - AXI3™, AXI4™, and AXI4-Lite™* to which they apply. It contains the following sections:

- [\*AXI4™ and AXI4-Lite™ protocol assertion descriptions on page 4-2\*](#)
- [\*AXI4-Stream™ protocol assertion descriptions on page 4-11.\*](#)

## 4.1 AXI4™ and AXI4-Lite™ protocol assertion descriptions

This section contains the following subsections:

- [Write address channel checks](#)
- [Write data channel checks on page 4-4](#)
- [Write response channel checks on page 4-5](#)
- [Read address channel checks on page 4-6](#)
- [Read data channel checks on page 4-8](#)
- [Low-power interface rules on page 4-9](#)
- [Exclusive access checks on page 4-9](#)
- [Internal logic checks on page 4-10.](#)

### 4.1.1 Write address channel checks

Table 4-1 shows the write address channel checking rules.

**Table 4-1 Write address channel checking rules**

Assertion	Description	Specification reference	AXI4-Lite
AXI4_ERRM_AWID_STABLE	<b>AWID</b> must remain stable when <b>AWVALID</b> is asserted and <b>AWREADY</b> is LOW	Section A3.2.1	-
AXI4_ERRM_AWID_X	A value of X on <b>AWID</b> is not permitted when <b>AWVALID</b> is HIGH	Section A3.2.2	-
AXI4_ERRM_AWADDR_BOUNDARY	A write burst cannot cross a 4KB boundary	Section A3.4.1	-
AXI4_ERRM_AWADDR_WRAP_ALIGN	A write transaction with burst type WRAP has an aligned address	Section A3.4.1	-
AXI4_ERRM_AWADDR_STABLE	<b>AWADDR</b> remains stable when <b>AWVALID</b> is asserted and <b>AWREADY</b> is LOW	Section A3.2.1	Valid
AXI4_ERRM_AWADDR_X	A value of X on <b>AWADDR</b> is not permitted when <b>AWVALID</b> is HIGH	Section A3.2.2	Valid
AXI4_ERRM_AWLEN_WRAP	A write transaction with burst type WRAP has a length of 2, 4, 8, or 16	Section A3.4.1	-
AXI4_ERRM_AWLEN_STABLE	<b>AWLEN</b> remains stable when <b>AWVALID</b> is asserted and <b>AWREADY</b> is LOW	Section A3.2.1	-
AXI4_ERRM_AWLEN_X	A value of X on <b>AWLEN</b> is not permitted when <b>AWVALID</b> is HIGH	Section A3.2.2	-
AXI4_ERRM_AWSIZE_STABLE	<b>AWSIZE</b> remains stable when <b>AWVALID</b> is asserted and <b>AWREADY</b> is LOW	Section A3.2.1	-
AXI4_ERRM_AWSIZE	The size of a write transfer does not exceed the width of the data interface	Section A3.4.1	-
AXI4_ERRM_AWSIZE_X	A value of X on <b>AWSIZE</b> is not permitted when <b>AWVALID</b> is HIGH	Section A3.2.2	-
AXI4_ERRM_AWBURST	A value of 2'b11 on <b>AWBURST</b> is not permitted when <b>AWVALID</b> is HIGH	Table A3-3	-
AXI4_ERRM_AWBURST_STABLE	<b>AWBURST</b> remains stable when <b>AWVALID</b> is asserted and <b>AWREADY</b> is LOW	Section A3.2.1	-

Table 4-1 Write address channel checking rules (continued)

Assertion	Description	Specification reference	AXI4-Lite
AXI4_ERRM_AWBURST_X	A value of X on <b>AWBURST</b> is not permitted when <b>AWVALID</b> is HIGH	Section A3.2.2	-
AXI4_ERRM_AWLOCK_STABLE	<b>AWLOCK</b> remains stable when <b>AWVALID</b> is asserted and <b>AWREADY</b> is LOW	Section A3.2.1	-
AXI4_ERRM_AWLOCK_X	A value of X on <b>AWLOCK</b> is not permitted when <b>AWVALID</b> is HIGH	Section A3.2.2	-
AXI4_ERRM_AWCACHE	When <b>AWVALID</b> is HIGH and <b>AWCACHE</b> [1] is LOW, then <b>AWCACHE</b> [3:2] are also LOW	Table A4-5	-
AXI4_ERRM_AWCACHE_STABLE	<b>AWCACHE</b> remains stable when <b>AWVALID</b> is asserted and <b>AWREADY</b> is LOW	Section A3.2.1	-
AXI4_ERRM_AWCACHE_X	A value of X on <b>AWCACHE</b> is not permitted when <b>AWVALID</b> is HIGH	Section A3.2.2	-
AXI4_ERRM_AWPROT_STABLE	<b>AWPROT</b> remains stable when <b>AWVALID</b> is asserted and <b>AWREADY</b> is LOW	Section A3.2.1	Valid
AXI4_ERRM_AWPROT_X	A value of X on <b>AWPROT</b> is not permitted when <b>AWVALID</b> is HIGH	Section A3.2.2	Valid
AXI4_ERRM_AWVALID_RESET	<b>AWVALID</b> is LOW for the first cycle after <b>ARESETn</b> goes HIGH	Figure A3-1	Valid
AXI4_ERRM_AWVALID_STABLE	When <b>AWVALID</b> is asserted, then it remains asserted until <b>AWREADY</b> is HIGH	Section A3.2.2	Valid
AXI4_ERRM_AWVALID_X	A value of X on <b>AWVALID</b> is not permitted when not in reset	Section A3.1.2	Valid
AXI4_ERRS_AWREADY_X	A value of X on <b>AWREADY</b> is not permitted when not in reset	Section A3.1.2	Valid
AXI4_RECS_AWREADY_MAX_WAIT	Recommended that <b>AWREADY</b> is asserted within MAXWAITS cycles of <b>AWVALID</b> being asserted	-	Valid
AXI4_ERRM_AWUSER_STABLE	<b>AWUSER</b> remains stable when <b>AWVALID</b> is asserted and <b>AWREADY</b> is LOW	Section A3.2.1	-
AXI4_ERRM_AWUSER_X	A value of X on <b>AWUSER</b> is not permitted when <b>AWVALID</b> is HIGH	Section A3.2.2	-
AXI4_ERRM_AWQOS_STABLE	<b>AWQOS</b> remains stable when <b>AWVALID</b> is asserted and <b>AWREADY</b> is LOW	Section A3.2.1	-
AXI4_ERRM_AWQOS_X	A value of X on <b>AWQOS</b> is not permitted when <b>AWVALID</b> is HIGH	Section A3.2.2	-
AXI4_ERRM_AWREGION_STABLE	<b>AWREGION</b> remains stable when <b>AWVALID</b> is asserted and <b>AWREADY</b> is LOW	Section A3.2.1	-
AXI4_ERRM_AWREGION_X	A value of X on <b>AWREGION</b> is not permitted when <b>AWVALID</b> is HIGH	Section A3.2.2	-
AXI4_ERRM_AWLEN_FIXED	Transactions of burst type FIXED cannot have a length greater than 16 beats	Section A3.4.1	-

Table 4-1 Write address channel checking rules (continued)

Assertion	Description	Specification reference	AXI4-Lite
AXI4_ERRM_AWLEN_LOCK	Exclusive access transactions cannot have a length greater than 16 beats	Section A7.2.4	-
AXI4_ERRM_AWUSER_TIEOFF	<b>AWUSER</b> must be stable when <b>AWUSER_WIDTH</b> has been set to zero	-	-
AXI4_ERRM_AWID_TIEOFF	<b>AWID</b> must be stable when <b>ID_WIDTH</b> has been set to zero	-	-

#### 4.1.2 Write data channel checks

Table 4-2 shows the write data channel checking rules.

Table 4-2 Write data channel checking rules

Assertion	Description	Specification reference	AXI4-Lite
AXI4_ERRM_WDATA_NUM	The number of write data items matches <b>AWLEN</b> for the corresponding address. This is triggered when any of the following occurs: <ul style="list-style-type: none"> <li>Write data arrives and <b>WLAST</b> is set, and the <b>WDATA</b> count is not equal to <b>AWLEN</b>.</li> <li>Write data arrives and <b>WLAST</b> is not set, and the <b>WDATA</b> count is equal to <b>AWLEN</b>.</li> <li><b>ADDR</b> arrives, <b>WLAST</b> is already received, and the <b>WDATA</b> count is not equal to <b>AWLEN</b>.</li> </ul>	Section A3.4.1	-
AXI4_ERRM_WDATA_STABLE	<b>WDATA</b> remains stable when <b>WVALID</b> is asserted and <b>WREADY</b> is LOW.	Section A3.2.1	Valid
AXI4_ERRM_WDATA_X	A value of X on <b>WDATA</b> valid byte lanes is not permitted when <b>WVALID</b> is HIGH.	Section A3.2.2	Valid
AXI4_ERRM_WSTRB	Write strobes must only be asserted for the correct byte lanes as determined from the: <ul style="list-style-type: none"> <li>Start address.</li> <li>Transfer size.</li> <li>Beat number.</li> </ul>	Section A3.4.3	Valid
AXI4_ERRM_WSTRB_STABLE	<b>WSTRB</b> remains stable when <b>WVALID</b> is asserted and <b>WREADY</b> is LOW.	Section A3.2.1	Valid
AXI4_ERRM_WSTRB_X	A value of X on <b>WSTRB</b> is not permitted when <b>WVALID</b> is HIGH.	Section A3.2.2	Valid
AXI4_ERRM_WLAST_STABLE	<b>WLAST</b> remains stable when <b>WVALID</b> is asserted and <b>WREADY</b> is LOW.	Section A3.2.1	-
AXI4_ERRM_WLAST_X	A value of X on <b>WLAST</b> is not permitted when <b>WVALID</b> is HIGH.	Section A3.2.2	-
AXI4_ERRM_WVALID_RESET	<b>WVALID</b> is LOW for the first cycle after <b>ARESETn</b> goes HIGH.	Figure A3-1	Valid
AXI4_ERRM_WVALID_STABLE	When <b>WVALID</b> is asserted, then it must remain asserted until <b>WREADY</b> is HIGH.	Section A3.2.2	Valid
AXI4_ERRM_WVALID_X	A value of X on <b>WVALID</b> is not permitted when not in reset.	Section A3.2.2	Valid

Table 4-2 Write data channel checking rules (continued)

Assertion	Description	Specification reference	AXI4-Lite
AXI4_RECS_WREADY_MAX_WAIT	Recommended that <b>WREADY</b> is asserted within MAXWAITTS cycles of <b>WVALID</b> being asserted.	-	Valid
AXI4_ERRS_WREADY_X	A value of X on <b>WREADY</b> is not permitted when not in reset.	Section A3.2.2	Valid
AXI4_ERRM_WUSER_STABLE	<b>WUSER</b> must remain constant whilst <b>WVALID</b> is asserted and <b>WREADY</b> is de-asserted.	Section A3.2.1	-
AXI4_ERRM_WUSER_X	A value of X on <b>WUSER</b> is not permitted when <b>WVALID</b> is HIGH.	Section A3.2.2	-
AXI4_ERRM_WUSER_TIEOFF	<b>WUSER</b> must be stable when <b>WUSER_WIDTH</b> has been set to zero.	-	-

### 4.1.3 Write response channel checks

Table 4-3 shows the write response channel checking rules.

Table 4-3 Write response channel checking rules

Assertion	Description	Specification reference	AXI4-Lite
AXI4_ERRS_BID_STABLE	<b>BID</b> remains stable when <b>BVALID</b> is asserted and <b>BREADY</b> is LOW	Section A3.2.1	-
AXI4_ERRS_BID_X	A value of X on <b>BID</b> is not permitted when <b>BVALID</b> is HIGH	Section A3.2.2	-
AXI4_ERRS_BRESP_ALL_DONE_EOS	All write transaction addresses are matched with a corresponding buffered response	-	Valid
AXI4_ERRS_BRESP_EXOKAY	An EXOKAY write response can only be given to an exclusive write access	Section A7.2	Valid
AXI4_ERRS_BRESP_STABLE	<b>BRESP</b> remains stable when <b>BVALID</b> is asserted and <b>BREADY</b> is LOW	Section A3.2.1	Valid
AXI4_ERRS_BRESP_X	A value of X on <b>BRESP</b> is not permitted when <b>BVALID</b> is HIGH	Section A3.2.2	Valid
AXI4_ERRS_BVALID_RESET	<b>BVALID</b> is LOW for the first cycle after <b>ARESETn</b> goes HIGH	Figure A3-1	Valid
AXI4_ERRS_BVALID_STABLE	When <b>BVALID</b> is asserted, then it must remain asserted until <b>BREADY</b> is HIGH	Section A3.2.2	Valid
AXI4_ERRS_BVALID_X	A value of X on <b>BVALID</b> is not permitted when not in reset	Section A3.2.2	Valid
AXI4_RECM_BREADY_MAX_WAIT	Recommended that <b>BREADY</b> is asserted within MAXWAITTS cycles of <b>BVALID</b> being asserted	-	Valid
AXI4_ERRM_BREADY_X	A value of X on <b>BREADY</b> is not permitted when not in reset	Section A3.1.2	Valid
AXI4_ERRS_BRESP_AW	A slave must not take <b>BVALID</b> HIGH until after the write address is handshaken	Section A3.3.1, Figure A3-7	Valid
AXI4_ERRS_BUSER_STABLE	<b>BUSER</b> remains stable when <b>BVALID</b> is asserted and <b>BREADY</b> is LOW	Section A3.2.1	-
AXI4_ERRS_BUSER_X	A value of X on <b>BUSER</b> is not permitted when <b>BVALID</b> is HIGH	Section A3.2.2	-

Table 4-3 Write response channel checking rules (continued)

Assertion	Description	Specification reference	AXI4-Lite
AXI4_ERRS_BRESP_WLAST	A slave must not take <b>BVALID</b> HIGH until after the last write data is handshaken	Section A3.3.1, Figure A3-7	Valid
AXI4_ERRS_BUSER_TIEOFF	<b>BUSER</b> must be stable when <b>BUSER_WIDTH</b> has been set to zero	-	-
AXI4_ERRS_BID_TIEOFF	<b>BID</b> must be stable when <b>ID_WIDTH</b> has been set to zero	-	-

#### 4.1.4 Read address channel checks

Table 4-4 shows the read address channel checking rules.

Table 4-4 Read address channel checking rules

Assertion	Description	Specification reference	AXI4-Lite
AXI4_ERRM_ARID_STABLE	<b>ARID</b> remains stable when <b>ARVALID</b> is asserted, and <b>ARREADY</b> is LOW	Section A3.2.1	-
AXI4_ERRM_ARID_X	A value of X on <b>ARID</b> is not permitted when <b>ARVALID</b> is HIGH	Section A3.2.2	-
AXI4_ERRM_ARADDR_BOUNDARY	A read burst cannot cross a 4KB boundary	Section A3.4.1	-
AXI4_ERRM_ARADDR_STABLE	<b>ARADDR</b> remains stable when <b>ARVALID</b> is asserted and <b>ARREADY</b> is LOW	Section A3.2.1	Valid
AXI4_ERRM_ARADDR_WRAP_ALIGN	A read transaction with a burst type of WRAP must have an aligned address	Section A3.4.1	-
AXI4_ERRM_ARADDR_X	A value of X on <b>ARADDR</b> is not permitted when <b>ARVALID</b> is HIGH	Section A3.2.2	Valid
AXI4_ERRM_ARLEN_STABLE	<b>ARLEN</b> remains stable when <b>ARVALID</b> is asserted and <b>ARREADY</b> is LOW	Section A3.2.1	-
AXI4_ERRM_ARLEN_WRAP	A read transaction with burst type of WRAP must have a length of 2, 4, 8, or 16	Section A3.4.1	-
AXI4_ERRM_ARLEN_X	A value of X on <b>ARLEN</b> is not permitted when <b>ARVALID</b> is HIGH	Section A3.2.2	-
AXI4_ERRM_ARSIZE	The size of a read transfer must not exceed the width of the data interface	Section A3.4.1	-
AXI4_ERRM_ARSIZE_STABLE	<b>ARSIZE</b> remains stable when <b>ARVALID</b> is asserted, and <b>ARREADY</b> is LOW	Section A3.2.1	-
AXI4_ERRM_ARSIZE_X	A value of X on <b>ARSIZE</b> is not permitted when <b>ARVALID</b> is HIGH	Section A3.2.2	-
AXI4_ERRM_ARBURST	A value of 2'b11 on <b>ARBURST</b> is not permitted when <b>ARVALID</b> is HIGH	Table A3-3	-
AXI4_ERRM_ARBURST_STABLE	<b>ARBURST</b> remains stable when <b>ARVALID</b> is asserted, and <b>ARREADY</b> is LOW	Section A3.2.1	-
AXI4_ERRM_ARBURST_X	A value of X on <b>ARBURST</b> is not permitted when <b>ARVALID</b> is HIGH	Section A3.2.2	-



Table 4-4 Read address channel checking rules (continued)

Assertion	Description	Specification reference	AXI4-Lite
AXI4_ERRM_ARLOCK_STABLE	<b>ARLOCK</b> remains stable when <b>ARVALID</b> is asserted, and <b>ARREADY</b> is LOW	Section A3.2.1	-
AXI4_ERRM_ARLOCK_X	A value of X on <b>ARLOCK</b> is not permitted when <b>ARVALID</b> is HIGH	Section A3.2.2	-
AXI4_ERRM_ARCACHE	When <b>ARVALID</b> is HIGH, if <b>ARCACHE</b> [1] is LOW, then <b>ARCACHE</b> [3:2] must also be LOW	Table A4-5	-
AXI4_ERRM_ARCACHE_STABLE	<b>ARCACHE</b> remains stable when <b>ARVALID</b> is asserted, and <b>ARREADY</b> is LOW	Section A3.2.1	-
AXI4_ERRM_ARCACHE_X	A value of X on <b>ARCACHE</b> is not permitted when <b>ARVALID</b> is HIGH	Section A3.2.2	-
AXI4_ERRM_ARPROT_STABLE	<b>ARPROT</b> remains stable when <b>ARVALID</b> is asserted, and <b>ARREADY</b> is LOW	Section A3.2.1	Valid
AXI4_ERRM_ARPROT_X	A value of X on <b>ARPROT</b> is not permitted when <b>ARVALID</b> is HIGH	Section A3.2.2	Valid
AXI4_ERRM_ARVALID_RESET	<b>ARVALID</b> is LOW for the first cycle after <b>ARESETn</b> goes HIGH	Figure A3-1	Valid
AXI4_ERRM_ARVALID_STABLE	When <b>ARVALID</b> is asserted, then it remains asserted until <b>ARREADY</b> is HIGH	Section A3.2.1	Valid
AXI4_ERRM_ARVALID_X	A value of X on <b>ARVALID</b> is not permitted when not in reset	Section A3.1.2	Valid
AXI4_ERRS_ARREADY_X	A value of X on <b>ARREADY</b> is not permitted when not in reset	Section A3.1.2	Valid
AXI4_RECS_ARREADY_MAX_WAIT	Recommended that <b>ARREADY</b> is asserted within MAXWAITS cycles of <b>ARVALID</b> being asserted	-	Valid
AXI4_ERRM_ARUSER_STABLE	<b>ARUSER</b> remains stable when <b>ARVALID</b> is asserted, and <b>ARREADY</b> is LOW	Section A3.2.1	-
AXI4_ERRM_ARUSER_X	A value of X on <b>ARUSER</b> is not permitted when <b>ARVALID</b> is HIGH	Section A3.2.2	-
AXI4_ERRM_ARQOS_STABLE	<b>ARQOS</b> remains stable when <b>ARVALID</b> is asserted, and <b>ARREADY</b> is LOW	Section A3.2.1	-
AXI4_ERRM_ARQOS_X	A value of X on <b>ARQOS</b> is not permitted when <b>ARVALID</b> is HIGH	Section A3.2.2	-
AXI4_ERRM_ARREGION_STABLE	<b>ARREGION</b> remains stable when <b>ARVALID</b> is asserted, and <b>ARREADY</b> is LOW	Section A3.2.1	-
AXI4_ERRM_ARREGION_X	A value of X on <b>ARREGION</b> is not permitted when <b>ARVALID</b> is HIGH	Section A3.2.2	-
AXI4_ERRM_ARLEN_FIXED	Transactions of burst type FIXED cannot have a length greater than 16 beats	Section A3.4.1	-
AXI4_ERRM_ARLEN_LOCK	Exclusive access transactions cannot have a length greater than 16 beats	Section A7.2.4	-
AXI4_ERRM_ARUSER_TIEOFF	<b>ARUSER</b> must be stable when <b>ARUSER_WIDTH</b> has been set to zero	-	-
AXI4_ERRM_ARID_TIEOFF	<b>ARID</b> must be stable when <b>ID_WIDTH</b> has been set to zero	-	-

#### 4.1.5 Read data channel checks

Table 4-5 shows the read data channel checking rules.

**Table 4-5 Read data channel checking rules**

Assertion	Description	Specification reference	AXI4-Lite
AXI4_ERRS_RID	The read data must always follow the address that it relates to. Therefore, a slave can only give read data with an ID to match an outstanding read transaction.	Section A5.3.1	-
AXI4_ERRS_RID_STABLE	<b>RID</b> remains stable when <b>RVALID</b> is asserted, and <b>RREADY</b> is LOW.	Section A3.2.1	-
AXI4_ERRS_RID_X	A value of X on <b>RID</b> is not permitted when <b>RVALID</b> is HIGH.	Section A3.2.2	-
AXI4_ERRS_RDATA_NUM	The number of read data items must match the corresponding <b>ARLEN</b> .	Section A3.4.1	Valid
AXI4_ERRS_RDATA_STABLE	<b>RDATA</b> remains stable when <b>RVALID</b> is asserted, and <b>RREADY</b> is LOW.	Section A3.2.1	Valid
AXI4_ERRS_RDATA_X	A value of X on <b>RDATA</b> valid byte lanes is not permitted when <b>RVALID</b> is HIGH.	Section A3.2.2	Valid
AXI4_ERRS_RRESP_EXOKAY	An EXOKAY read response can only be given to an exclusive read access.	Section A7.2.3	Valid
AXI4_ERRS_RRESP_STABLE	<b>RRESP</b> remains stable when <b>RVALID</b> is asserted, and <b>RREADY</b> is LOW.	Section A3.2.1	Valid
AXI4_ERRS_RRESP_X	A value of X on <b>RRESP</b> is not permitted when <b>RVALID</b> is HIGH.	Section A3.2.2	Valid
AXI4_ERRS_RLAST_ALL_DONE_EOS	All outstanding read bursts must have completed.	-	-
AXI4_ERRS_RLAST_STABLE	<b>RLAST</b> remains stable when <b>RVALID</b> is asserted, and <b>RREADY</b> is LOW.	Section A3.2.1	-
AXI4_ERRS_RLAST_X	A value of X on <b>RLAST</b> is not permitted when <b>RVALID</b> is HIGH.	Section A3.2.2	-
AXI4_ERRS_RVALID_RESET	<b>RVALID</b> is LOW for the first cycle after <b>ARESETn</b> goes HIGH.	Figure A3-1	Valid
AXI4_ERRS_RVALID_STABLE	When <b>RVALID</b> is asserted, then it must remain asserted until <b>RREADY</b> is HIGH.	Section A3.2.1	Valid
AXI4_ERRS_RVALID_X	A value of X on <b>RVALID</b> is not permitted when not in reset.	Section A3.1.2	Valid
AXI4_ERRM_RREADY_X	A value of X on <b>RREADY</b> is not permitted when not in reset.	Section A3.1.2	Valid
AXI4_RECM_RREADY_MAX_WAIT	Recommended that <b>RREADY</b> is asserted within MAXWAITS cycles of <b>RVALID</b> being asserted.	-	Valid
AXI4_ERRS_RUSER_X	A value of X on <b>RUSER</b> is not permitted when <b>RVALID</b> is HIGH.	Section A3.2.2	-
AXI4_ERRS_RUSER_STABLE	<b>RLAST</b> remains stable when <b>RVALID</b> is asserted, and <b>RREADY</b> is LOW.	Section A3.2.1	-
AXI4_ERRS_RUSER_TIEOFF	<b>RUSER</b> must be stable when <b>RUSER_WIDTH</b> has been set to zero.	-	-
AXI4_ERRS_RID_TIEOFF	<b>RID</b> must be stable when <b>ID_WIDTH</b> has been set to zero.	-	-

#### 4.1.6 Low-power interface rules

Table 4-6 shows the low-power interface checking rules.

**Table 4-6 Low-power interface checking rules**

Assertion	Description	Specification reference	AXI4-Lite
AXI4_ERRL_CSYSREQ_FALL	<b>CSYSREQ</b> is only permitted to change from HIGH to LOW when <b>CSYSACK</b> is HIGH	Figure A9-1	-
AXI4_ERRL_CSYSREQ_RISE	<b>CSYSREQ</b> is only permitted to change from LOW to HIGH when <b>CSYSACK</b> is LOW	Figure A9-1	-
AXI4_ERRL_CSYSREQ_X	A value of X on <b>CSYSREQ</b> is not permitted when not in reset	Section A9.2	-
AXI4_ERRL_CSYSACK_FALL	<b>CSYSACK</b> is only permitted to change from HIGH to LOW when <b>CSYSREQ</b> is LOW	Figure A9-1	-
AXI4_ERRL_CSYSACK_RISE	<b>CSYSACK</b> is only permitted to change from LOW to HIGH when <b>CSYSREQ</b> is HIGH	Figure A9-1	-
AXI4_ERRL_CSYSACK_X	A value of X on <b>CSYSACK</b> is not permitted when not in reset	Section A9.2	-
AXI4_ERRL_CACTIVE_X	A value of X on <b>CACTIVE</b> is not permitted when not in reset	Section A9.2	-

#### 4.1.7 Exclusive access checks

Table 4-7 shows the address channel exclusive access checking rules.

**Table 4-7 Address channel exclusive access checking rules**

Assertion	Description	Specification reference	AXI4-Lite
AXI4_ERRM_EXCL_ALIGN	The address of an exclusive access is aligned to the total number of bytes in the transaction	Section A7.2.4	-
AXI4_ERRM_EXCL_LEN	The number of bytes to be transferred in an exclusive access burst is a power of 2, that is, 1, 2, 4, 8, 16, 32, 64, or 128 bytes	Section A7.2.4	-
AXI4_RECM_EXCL_MATCH	Recommended that the address, size, and length of an exclusive write with a given ID is the same as the address, size, and length of the preceding exclusive read with the same ID	Section A7.2.4	-
AXI4_ERRM_EXCL_MAX	The maximum number of bytes that can be transferred in an exclusive burst is 128	Section A7.2.4	-
AXI4_RECM_EXCL_PAIR	Recommended that every exclusive write has an earlier outstanding exclusive read with the same ID	Section A7.2.2	-
AXI4_RECM_EXCL_R_W	Recommended that exclusive reads and writes with the same ID not be issued at the same time	Section A7.2.2	-

#### 4.1.8 Internal logic checks

Table 4-8 shows the internal logic checks.

**Table 4-8 Internal logic checks**

Assertion	Description	Specification Reference	AXI4-Lite
AXI4_AUX_DATA_WIDTH	DATA_WIDTH parameter is 32, 64, 128, 256, 512, or 1024	-	-
AXI4_AUX_RCAM_OVERFLOW	Read CAM overflow, increase MAXRBURSTS parameter	-	Valid
AXI4_AUX_RCAM_UNDERFLOW	Read CAM underflow	-	Valid
AXI4_AUX_WCAM_OVERFLOW	Write CAM overflow, increase MAXWBURSTS parameter	-	Valid
AXI4_AUX_WCAM_UNDERFLOW	Write CAM underflow	-	Valid
AXI4_AUX_ADDR_WIDTH	The ADDR_WIDTH parameter must be between 32 bits and 64 bits inclusive	-	Valid
AXI4_AUX_EXMON_WIDTH	The EXMON_WIDTH parameter must be greater than or equal to 1	-	-
AXI4_AUX_MAXRBURSTS	The MAXRBURSTS parameter must be greater than or equal to 1	-	Valid
AXI4_AUX_MAXWBURSTS	The MAXWBURSTS parameter must be greater than or equal to 1	-	Valid
AXI4_AUX_EXCL_OVERFLOW	Exclusive access monitor overflow, increase EXMON_WIDTH parameter	-	-

#### 4.1.9 Additional checks for AXI4-Lite

Table 4-9 shows the additional rules for AXI4-Lite.

**Table 4-9 Additional AXI4-Lite checks**

Assertion	Description	Specification Reference
AXI4LITE_ERRS_RRESP_EXOKAY	A slave must not give an EXOKAY response on an AXI4-Lite interface	Section B1.1.1
AXI4LITE_ERRS_BRESP_EXOKAY	A slave must not give an EXOKAY response on an AXI4-Lite interface	Section B1.1.1
AXI4LITE_AUX_DATA_WIDTH	DATA_WIDTH parameter is 32 or 64	-

## 4.2 AXI4-Stream™ protocol assertion descriptions

This section describes the protocol assertions, and indicates the area of the AMBA 4 AXI4-Stream Protocol v1.0 specification to which they apply. [Table 4-10](#) shows the streaming interface checking rules.

**Table 4-10 Streaming channel assertion rules**

Assertion	Description	Specification reference
AXI4STREAM_ERRM_TVALID_RESET	<b>TVALID</b> is LOW for the first cycle after <b>ARESETn</b> goes HIGH	Reset on Page 2-11
AXI4STREAM_ERRM_TID_STABLE	<b>TID</b> remains stable when <b>TVALID</b> is asserted, and <b>TREADY</b> is LOW	<i>Handshake process</i> on Page 2-3
AXI4STREAM_ERRM_TDEST_STABLE	<b>TDEST</b> remains stable when <b>TVALID</b> is asserted, and <b>TREADY</b> is LOW	<i>Handshake process</i> on Page 2-3
AXI4STREAM_ERRM_TDATA_STABLE	<b>TDATA</b> remains stable when <b>TVALID</b> is asserted, and <b>TREADY</b> is LOW	<i>Handshake process</i> on Page 2-3
AXI4STREAM_ERRM_TSTRB_STABLE	<b>TSTRB</b> remains stable when <b>TVALID</b> is asserted, and <b>TREADY</b> is LOW	<i>Handshake process</i> on Page 2-3
AXI4STREAM_ERRM_TLAST_STABLE	<b>TLAST</b> remains stable when <b>TVALID</b> is asserted, and <b>TREADY</b> is LOW	<i>Handshake process</i> on Page 2-3
AXI4STREAM_ERRM_TKEEP_STABLE	<b>TKEEP</b> remains stable when <b>TVALID</b> is asserted, and <b>TREADY</b> is LOW	<i>Handshake process</i> on Page 2-3
AXI4STREAM_ERRM_TVALID_STABLE	When <b>TVALID</b> is asserted, then it must remain asserted until <b>TREADY</b> is HIGH	<i>Handshake process</i> on Page 2-3
AXI4STREAM_RECS_TREADY_MAX_WAIT	Recommended that <b>TREADY</b> is asserted within <b>MAXWAITS</b> cycles of <b>TVALID</b> being asserted	-
AXI4STREAM_ERRM_TID_X	A value of X on <b>TID</b> is not permitted when <b>TVALID</b> is HIGH	-
AXI4STREAM_ERRM_TDEST_X	A value of X on <b>TDEST</b> is not permitted when <b>TVALID</b> is HIGH	-
AXI4STREAM_ERRM_TDATA_X	A value of X on <b>TDATA</b> is not permitted when <b>TVALID</b> is HIGH	-
AXI4STREAM_ERRM_TSTRB_X	A value of X on <b>TSTRB</b> is not permitted when <b>TVALID</b> is HIGH	-
AXI4STREAM_ERRM_TLAST_X	A value of X on <b>TLAST</b> is not permitted when <b>TVALID</b> is HIGH	-
AXI4STREAM_ERRM_TKEEP_X	A value of X on <b>TKEEP</b> is not permitted when <b>TVALID</b> is HIGH	-
AXI4STREAM_ERRM_TVALID_X	A value of X on <b>TVALID</b> is not permitted when not in reset	-
AXI4STREAM_ERRS_TREADY_X	A value of X on <b>TREADY</b> is not permitted when not in reset	-
AXI4STREAM_ERRM_TUSER_X	A value of X on <b>TUSER</b> is not permitted when not in reset	-

Table 4-10 Streaming channel assertion rules (continued)

Assertion	Description	Specification reference
AXI4STREAM_ERRM_TUSER_STABLE	<b>TUSER</b> payload signals must remain constant while <b>TVALID</b> is asserted, and <b>TREADY</b> is de-asserted	<i>Handshake process</i> on Page 2-3
AXI4STREAM_ERRM_STREAM_ALL_DONE_EOS	At the end of simulation, all streams have had their corresponding <b>TLAST</b> transfer	-
AXI4STREAM_ERRM_TKEEP_TSTRB	If <b>TKEEP</b> is de-asserted, then <b>TSTRB</b> must also be de-asserted	Table 2-2 on Page 2-9
AXI4STREAM_ERRM_TDATA_TIEOFF	<b>TDATA</b> must be stable while <b>DATA_WIDTH_BYTES</b> has been set to zero	-
AXI4STREAM_ERRM_TKEEP_TIEOFF	<b>TKEEP</b> must be stable while <b>DATA_WIDTH_BYTES</b> has been set to zero	-
AXI4STREAM_ERRM_TSTRB_TIEOFF	<b>TSTRB</b> must be stable while <b>DATA_WIDTH_BYTES</b> has been set to zero	-
AXI4STREAM_ERRM_TID_TIEOFF	<b>TID</b> must be stable while <b>ID_WIDTH</b> has been set to zero	-
AXI4STREAM_ERRM_TDEST_TIEOFF	<b>TDEST</b> must be stable while <b>DEST_WIDTH</b> has been set to zero	-
AXI4STREAM_ERRM_TUSER_TIEOFF	<b>TUSER</b> must be stable while <b>USER_WIDTH</b> has been set to zero	-
AXI4STREAM_AUXM_TID_TDTEST_WIDTH	The value of <b>ID_WIDTH</b> + <b>DEST_WIDTH</b> must not exceed 24	-

# Appendix A

## Example Usage

This appendix provides an example transcript from the protocol assertions. It contains the following section:

- [\*RDATA stable failure\*](#) on page A-2.

## A.1 RDATA stable failure

Figure A-1 shows the timing diagram for a failure of the AXI4\_ERRS\_RDATA\_STABLE check.

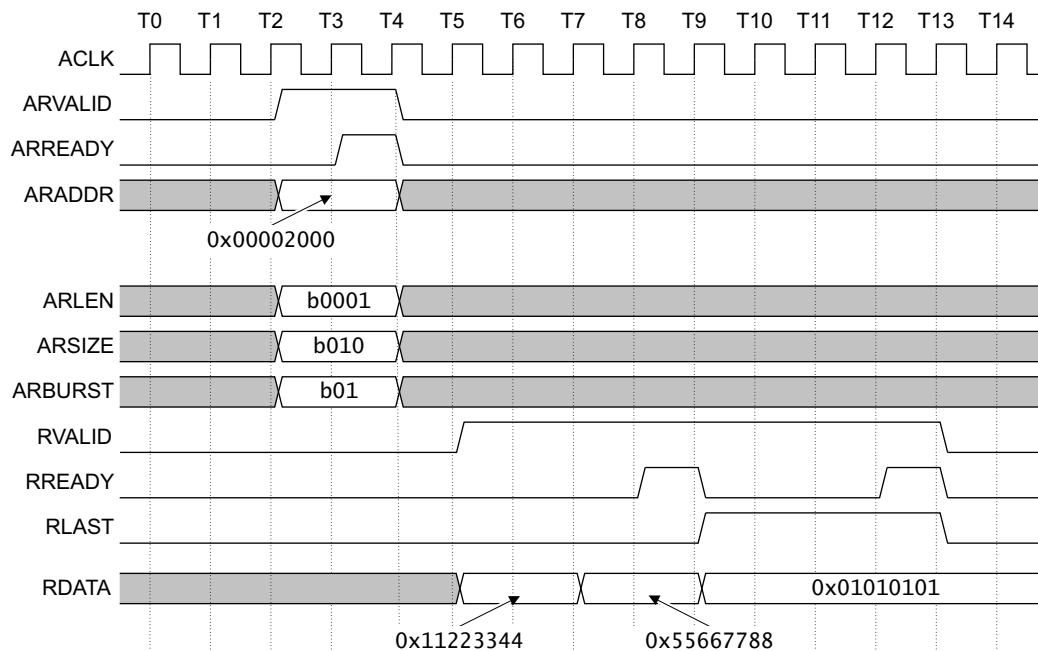


Figure A-1 RDATA stable failure

**RDATA** changes at T7 when **RVALID** is HIGH and **RREADY** is LOW. The protocol assertion samples the change at T8.

Example A-1 shows the protocol assertions transcript for this failure.

Example A-1 RDATA stable failure

```
# Loading sv_std.std
# Loading work.avip_testbench
# Loading work.Axi4PC
# Loading work.BaseClk
# do startup.do
# AXI4_INFO: Running Axi4PC $State
# ** Error: AXI4_ERRS_RDATA_STABLE. RDATA must remain stable when RVALID is asserted and RREADY low.
#   Spec: section 3.1, and figure 3-1 on page 3-2.
# Time: 1050 ns Started: 950 ns Scope: avip_testbench.uAxi4PC.axi4_errs_rdata_stable File: ../Axi4PC.sv
#   Line: 2595 Expr: $stable(RDATA|~RdataMask)
# ** Note: $finish : stim.svh(84)
# Time: 3960 ns Iteration: 1 Instance: /avip_testbench
```



# Appendix B

## Revisions

This appendix describes the technical changes between released issues of this book.

**Table B-1 Issue A**

Change	Location	Affects
No changes, first release	-	-

**Table B-2 Differences between issue A and issue B**

Change	Location	Affects
The name of the AMBA AXI Protocol v2.0 Specification changed to: <i>AMBA® AXI™ and ACE™ Protocol Specification - AXI3™, AXI4™, and AXI4-Lite™ ACE and ACE-Lite™</i> . So the reference to it also changed.	<a href="#">ARM publications on page viii</a>	r0p1
Removed Axi4PC_coverage_undefs.v and Axi4PC_no_coverage_macros.v from the Protocol assertions directory structure for AXI4, AXI4-Lite, and AXI4-Stream diagram.	<a href="#">Figure 2-2 on page 2-3</a>	r0p1
Low-power interface signals must be tied HIGH when not used.	<a href="#">Instantiating the protocol assertions module on page 2-4</a>	r0p1
The version of SystemVerilog changed from version 3.1a to IEEE 1800-2005.	<a href="#">Configuring your simulator on page 2-7</a>	r0p1
Split the ID_WIDTH parameter into the following: <ul style="list-style-type: none"><li>RID_WIDTH</li><li>WID_WIDTH.</li></ul>	<a href="#">Table 3-1 on page 3-2</a>	r0p1

**Table B-2 Differences between issue A and issue B (continued)**

<b>Change</b>	<b>Location</b>	<b>Affects</b>
Changed the description for the AXI4 and AXI4-Lite <i>end of simulation</i> rules.	<a href="#">AXI4 and AXI4-Lite on page 3-5</a>	r0p1
Updated specification references for AXI4 and AXI4-Lite.	<a href="#">AXI4™ and AXI4-Lite™ protocol assertion descriptions on page 4-2</a>	r0p1
Added a new assertion called AXI4_RECM_EXCL_R_W to the address channel exclusive access checking rules.	<a href="#">Table 4-7 on page 4-9</a>	r0p1
Changed the AUXM string to AUX within the assertion names for internal logic checks.	<a href="#">Table 4-8 on page 4-10</a>	r0p1
Removed the Glossary from the end of the book and replaced with a link in the Preface to the on-line Glossary.	<a href="#">Glossary on page vi</a>	r0p1