SoC Designer
AXIv2 Protocol Bundle User Guide

Release Information

The following changes have been made to this document.

<table>
<thead>
<tr>
<th>Date</th>
<th>Issue</th>
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</tr>
</thead>
<tbody>
<tr>
<td>March 2016</td>
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<td>Restamp Release with 8.4</td>
</tr>
</tbody>
</table>

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1 Introduction

This is the user guide for the SoC Designer AXIv2 Protocol Bundle. This protocol bundle contains SoC Designer components, probes, and the transaction port interfaces for the SoC Designer CASI Transaction Level Modeling (TLM) version 2 of the ARM AMBA3 AXI protocol.

AXI TLMv2 introduces two major fundamental changes that distinguish it from the previous version of the CASI AXI TLM definition:

- Control granularity at the AXI channel level
- Signal-level communication

The first aspect is important as both the transaction master and the slave can be initiators on the AXI channels. This is essential to supporting combinatorial paths, as will be described later in this manual.

Signal-level communication is introduced mainly to reduce the burden on the model developer and to promote hardware-accurate modeling: modeling the signals closely as represented in hardware eliminates the need to keep track of the transaction level viewpoint. The model developer is only required to model the hardware signals, and the rest of the task is left for the tool (SoC Designer) to construct the transaction views on top of the signal communication.

2 Requirements

The AXIv2 protocol bundle requires the following:

- SoC Designer version 8.4 or later.
- Compilation tools as set forth in the SoC Designer Installation Guide.

3 Bundle Contents

This bundle contains a full release of the CASI AXIv2 protocol, which is an enhanced version of the previous interface which had a limitation in handling asynchronous AXI transfers. The AXIv2 protocol bundle contains the following components.

3.1 AXIv2 Models and Examples

Generic components such as configurable bus and memory are included in this bundle. Also provided is example source code to help users develop custom AXI components:

3.2 AXIv2 Probes

Probes provide visibility into transactions between two components. AXIv2 specific probes are included in this protocol bundle.

3.3 AXIv2 Ports

AXIv2 transaction port definition header files and libraries are included in this package. These are required during runtime of any components with AXIv2 ports and also when creating components with AXIv2 ports.
3.4 AXIV2 Component Wizard Templates

The AXIV2 protocol bundle includes the template files needed by the SoC Designer Component Wizard for generation of components with AXIV2 ports.

Note on Asynchronous Clock Domains

Support for asynchronous clock domains is limited to native AXIV2 components only. This means that an AXIV1 master does not function correctly if connected to an AXIV2 slave (through an AxiToAxi2 bridge) in an asynchronous clocking scheme. There are no known issues with synchronous clocking schemes (for example, clocking which requires AXI SyncUp or SyncDn only) and AXIV1 components; however, this is not a guarantee that all AXIV1 components will work in this fashion. It is recommended to try to avoid the use of AXI TLM bridges (i.e., AxiToAxi2 and Axi2ToAxi) wherever possible.

4 Models

The following table lists the AXIV2 components included in this bundle.

<table>
<thead>
<tr>
<th>Component</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AXIV2_Master</td>
<td>This is an example AXIV2 master component.</td>
</tr>
<tr>
<td>AXIV2_Slave</td>
<td>This is an example AXIV2 slave component.</td>
</tr>
<tr>
<td>AXIV2_Mem</td>
<td>A generic AXIV2 memory component with an AXIV2 interface.</td>
</tr>
<tr>
<td>AXIV2_Stub</td>
<td>A scriptable AXIV2 master component.</td>
</tr>
<tr>
<td>AxiToAxi2</td>
<td>This is a TLM adaptor that bridges an AXIV1 master port to an AXIV2 slave port.</td>
</tr>
<tr>
<td>Axi2ToAxi</td>
<td>This is a TLM adaptor that bridges an AXIV2 master port to an AXIV1 slave port.</td>
</tr>
<tr>
<td>MxAxIV2</td>
<td>A generic AXI interconnect model supporting up to 16 masters and 16 slaves.</td>
</tr>
<tr>
<td>AXIV2PassThrough</td>
<td>This is a component that allows AXI transactions to “passthrough” the component. By altering the source code, users may enable additional features such as Lockdown by Master between the ARM Cortex-A9 and the ARM PL310 L2 Cache Controller.</td>
</tr>
</tbody>
</table>

Table 4-1 AXIV2 Components

The following components are not part of the AXIV2 bundle. However, you should be aware of them if you are implementing AXI4.

Note: These components are bundled with the AXI4 Protocol Bundle. For more information, refer to the AXI4 Protocol Bundle User Guide.
| AXI4ToAXIv2 | Bridges an AXI4 master component to an AXIv2 slave component. |
| AXIv2ToAXI4 | Bridges an AXIv2 master component to an AXI4 slave component. |

Table 4-2 Additional AXIv2-related Components

The .conf file for AXIv2 components is located under the `$MAXSIM_PROTOCOLS\AXIv2\etc` directory.

**Note**: The TLM adaptors will not improve accuracy over the original AXI TLM. These adaptors are provided as a migration path only. User custom components should be updated to use the new TLM to attain true accuracy.
4.1 AXIv2_Master

AXIv2_Master is an example AXI component using AXI TLMv2 master port. This component alternates issuing read and write transactions. Address and Data bit-widths are configurable, as well as delays on the R and B ready handshake signals.

There is an example system which uses AXIv2_Master located in $MAXSIM_PROTOCOLS/AXIv2/examples/MasterSlave.

This example component is provided in source code form under $MAXSIM_PROTOCOLS/src/AXIv2_Master.

![AXIv2_Master](image)

**Figure 4-1 AXIv2_Master**

The table below lists the component parameters.

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address Width</td>
<td>Width in bits of the address bus. Supported range is 1 to 64. Settable at sdcanvas time only; not settable at runtime.</td>
</tr>
<tr>
<td>B ready delay</td>
<td>Number of delay cycles for the B channel ready response.</td>
</tr>
<tr>
<td>Data Width</td>
<td>Width in bits of the data bus. It must match the data bus width of the connected model. Allowed values are 32, 64, and 128.</td>
</tr>
<tr>
<td>Enable</td>
<td>If false, the component will not generate any transactions.</td>
</tr>
<tr>
<td>Enable aw &amp; w simultaneous</td>
<td>Used to enable the AW and W channels at the same time. Usually W follows AW, but you can change this parameter so that both channels go high at the same time.</td>
</tr>
<tr>
<td>Enable Debug Messages</td>
<td>When set to true, the model debug messages are displayed as output.</td>
</tr>
<tr>
<td>Enable multiple reads</td>
<td>If true, the component will try to issue a second read transaction even if the first read transaction has not completed.</td>
</tr>
<tr>
<td>Enable output</td>
<td>Enable printing of informational messages about transactions in a SoC Designer Console window.</td>
</tr>
<tr>
<td>R ready delay</td>
<td>Number of delay cycles for the R channel ready response.</td>
</tr>
<tr>
<td>Start address</td>
<td>The starting address of transactions. Address will be incremented by the data width for each transaction.</td>
</tr>
<tr>
<td>Start address2</td>
<td>Specifies the address for the second read transaction in case Enable multiple reads is set to true.</td>
</tr>
<tr>
<td>Start with writes</td>
<td>If true, the component will issue a write as the first transaction. If false, the component will issue a read as the first transaction.</td>
</tr>
</tbody>
</table>

**Table 4-2 AXIv2_Master Parameters**
4.2 AXIv2_Slave

AXIv2_Slave is an example AXI component using AXI TLMv2 slave port. Delays on the valid and ready AXI handshake signals are configurable. Data bit-width is configurable, and must match the bit-width set on the connected master.

There is an example system which uses AXIv2_Slave, which is located in $MAXSIM_PROTOCOLS/AXIv2/examples/MasterSlave.

This example component is provided in source code form under $MAXSIM_PROTOCOLS/src/AXIv2_Slave.

```
Figure 4-2 AXIv2_Master
```

The table below lists the component parameters.

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address Width</td>
<td>Width in bits of the address bus. Supported range is 1 to 64. Settable at sdcanvas time only; not settable at runtime.</td>
</tr>
<tr>
<td>AR ready delay</td>
<td>Number of delay cycles for the AR channel ready response.</td>
</tr>
<tr>
<td>AW ready delay</td>
<td>Number of delay cycles for the AW channel ready response.</td>
</tr>
<tr>
<td>B valid delay</td>
<td>Number of delay cycles for the B channel valid response.</td>
</tr>
<tr>
<td>Data Width</td>
<td>Width in bits of the data bus. It must match the data bus width of the connected model. Allowed values are 32, 64, and 128.</td>
</tr>
<tr>
<td>Enable Debug</td>
<td>When set to true, the model debug messages are displayed as output.</td>
</tr>
<tr>
<td>Messages</td>
<td></td>
</tr>
<tr>
<td>R valid delay</td>
<td>Number of delay cycles for the R channel valid response.</td>
</tr>
<tr>
<td>W ready delay</td>
<td>Number of delay cycles for the W channel ready response.</td>
</tr>
</tbody>
</table>

Table 4-3 AXIv2_Slave Parameters
4.3 AXIv2_Mem

AXIv2_Mem is a generic AXI memory model with an AXIv2 slave interface.

Table 4-4 lists the component parameters.

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address Width</td>
<td>Width in bits of the address bus. Supported range is 32 to 64. Settable at sdcanvas time only; not settable at runtime.</td>
</tr>
<tr>
<td>AR-to-R delay</td>
<td>Amount of cycles to wait before sending the first beat of read data after an AR transfer has completed.</td>
</tr>
<tr>
<td>axi_name[0-5]</td>
<td>These parameters are obsolete and should be left at their default values.</td>
</tr>
<tr>
<td>axi_size[0-5]</td>
<td></td>
</tr>
<tr>
<td>axi_start[0-5]</td>
<td></td>
</tr>
<tr>
<td>Data width</td>
<td>Width in bits of the data bus. It must match the data bus width of the connected model. Allowed values are 32, 64, and 128.</td>
</tr>
<tr>
<td>Disk Backed Memory 2</td>
<td>When enabled, the model uses a file on the disk to hold the simulated memory contents, to limit the RAM consumption of the simulator. The default setting is Disabled.</td>
</tr>
</tbody>
</table>
| Disk Backed Memory Size(Bytes) 2 | If ‘Disk Backed Memory’ is enabled, this 32-bit integer value is used as the default value of the memory being modeled. The default value is 100 GB.  
If ‘Disk Backed Memory’ is set to False, Disk Backed Memory Size (Bytes) is ignored. |
| Disk Backed Memory-RAM Limit (MB) 2 | If ‘Disk Backed Memory’ is enabled, this parameter determines how much memory each instance can consume before swapping occurs. The default value is 250 MB.  
If ‘Disk Backed Memory’ is set to False, Disk Backed Memory RAM Limit (MB) is ignored. |
| Enable Debug Messages        | When set to true, the model debug messages are displayed as output.                                                                        |

1 ARM recommends using the Memory Map Editor (MME) in SoC Designer, which provides centralized viewing and management of the memory regions available to the components in a system. For information about migrating existing systems to use the MME, refer to the SoC Designer User Guide.

2 Refer to Section 4.10 for more information about using the Disk Backed Memory parameters.
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enable Warnings</td>
<td>When set to <em>true</em>, this parameter enables printing of warning messages.</td>
</tr>
<tr>
<td>Exclusive Monitor</td>
<td>When set to <em>true</em> (the default setting), the memory does additional checking for exclusive access requests and can return EXOKAY for success on RRESP or BRESP. When set to <em>false</em>, exclusive access requests always return OKAY, which is a failure code. Only the <em>true</em> value allows the memory to be fully compliant with the AMBA AXI and ACE specification.</td>
</tr>
<tr>
<td>Num of Exclusive</td>
<td>The maximum number of exclusive monitors needed. This parameter becomes active only when the <em>Exclusive Monitor</em> parameter is set to <em>true</em>. If this value is set to 0 when <em>Exclusive Monitor</em> = <em>true</em>, the exclusive monitor is not turned on.</td>
</tr>
<tr>
<td>Monitors</td>
<td></td>
</tr>
<tr>
<td>RAM Usage Limit (MB)</td>
<td>If ‘Disk backed memory’ is set to true, this integer value will set the threshold for the memory model on the RAM consumption before starting to swap its contents to the file. If ‘Disk backed memory’ is set to false, it will be Ignored.</td>
</tr>
<tr>
<td>WS Read</td>
<td>The number of wait cycles introduced for a Read access is given by this parameter.</td>
</tr>
<tr>
<td>WS Write</td>
<td>The number of wait cycles introduced for a Write access is given by this parameter.</td>
</tr>
<tr>
<td>W-to-B delay</td>
<td>Number of cycles to wait before sending the B response after the Write data transfer has completed</td>
</tr>
</tbody>
</table>

Table 4-4 AXIv2_Mem Parameters
4.4 AXIv2_SStub

AXIv2_SStub is an AXIv2 master component which can be controlled with a SoC Designer \textit{mxscr}
script.

![AXIv2_SStub](image)

\textbf{Figure 4-5 AXIv2_SStub}

\textbf{Note:} On stub components, accessing transaction slave ports using \textit{MxScript} is not supported. Use a memory component if scripting is required.

The table below lists the component parameters.

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address Width</td>
<td>Width in bits of the address bus. Supported range is 8 to 63. Settable at sdcanvas time only; not settable at runtime.</td>
</tr>
<tr>
<td>axi_name[0-5]</td>
<td>These parameters are obsolete and should be left at their default values.</td>
</tr>
<tr>
<td>axi_size[0-5]</td>
<td></td>
</tr>
<tr>
<td>axi_start[0-5]</td>
<td></td>
</tr>
<tr>
<td>CPP include path</td>
<td>Additional include path for header files to be used by script preprocessor.</td>
</tr>
<tr>
<td>Data Width</td>
<td>Width in bits of the data bus. It must match the data bus width of the connected model. Allowed values are 32, 64, and 128.</td>
</tr>
<tr>
<td>Enable Debug Messages</td>
<td>When set to \textit{true}, the model debug messages are displayed as output.</td>
</tr>
<tr>
<td>Memory Init Byte Value</td>
<td>The initial value used for each byte of the memory.</td>
</tr>
</tbody>
</table>

\textbf{Table 4-5 AXIv2_SStub Parameters}

4.4.1 AXIv2_SStub Macros

Macro definitions for AXIv2_SStub are provided in the following files:

---

\textsuperscript{3} ARM recommends using the Memory Map Editor (MME) in SoC Designer, which provides centralized viewing and management of the memory regions available to the components in a system. For information about migrating existing systems to use the MME, refer to the \textit{SoC Designer User Guide}.  

---
For information about how to use the macros, read the comments in the .h files.

4.5 **AxiToAxi2**

This component bridges an AXIv1 master port to an AXIv2 slave port. AXI signals that only exist in the v2 interface are assumed to be tied to zero when going through this bridge.

![AxiToAxi2](image)

The table below lists the component parameters.

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address width</td>
<td>Width in bits of the address bus. Supported range is 32 to 64. Settable at sdcanvas time only; not settable at runtime.</td>
</tr>
<tr>
<td>axi_name[0-5]</td>
<td>These parameters are obsolete and should be left at their default values.⁴</td>
</tr>
<tr>
<td>axi_size[0-5]</td>
<td></td>
</tr>
<tr>
<td>axi_start[0-5]</td>
<td></td>
</tr>
<tr>
<td>Data width</td>
<td>Width in bits of the data bus. It must match the data bus width of the connected model. Allowed values are 32, 64, and 128.</td>
</tr>
<tr>
<td>Enable debug messages</td>
<td>When set to true, the model debug messages are displayed as output.</td>
</tr>
<tr>
<td>Forward address regions</td>
<td>If true, the adaptor will forward address regions reported by the connected slave to the connected master.</td>
</tr>
<tr>
<td>Skip redundant transactions</td>
<td>If true, the adaptor will avoid resending redundant transactions in the same cycle. If true, it may provide speed improvements.</td>
</tr>
</tbody>
</table>

Table 4-6 AxiToAxi2 Parameters

4 ARM recommends using the Memory Map Editor (MME) in SoC Designer, which provides centralized viewing and management of the memory regions available to the components in a system. For information about migrating existing systems to use the MME, refer to the SoC Designer User Guide.

4.6 **Axi2ToAxi**

This component bridges an AXIv2 master port to an AXIv1 slave port. AXI signals that only exist in the v2 interface are assumed to be tied to zero when going through this bridge.
The table below lists the component parameters.

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address width</td>
<td>Width in bits of the address bus. Supported range is 32 to 64.</td>
</tr>
<tr>
<td></td>
<td>Settable at sdcanvas time only; not settable at runtime.</td>
</tr>
<tr>
<td>axi_name[0-5]</td>
<td>These parameters are obsolete and should be left at their default values.</td>
</tr>
<tr>
<td>axi_size[0-5]</td>
<td></td>
</tr>
<tr>
<td>axi_start[0-5]</td>
<td></td>
</tr>
<tr>
<td>Data width</td>
<td>Width in bits of the data bus. It must match the data bus width of the</td>
</tr>
<tr>
<td></td>
<td>connected model. Allowed values are 32, 64, and 128.</td>
</tr>
<tr>
<td>Enable debug messages</td>
<td>When set to true, the model debug messages are displayed as output.</td>
</tr>
<tr>
<td>Forward address</td>
<td>If true, the adaptor will forward address regions reported by the connected</td>
</tr>
<tr>
<td>regions</td>
<td>slave to the connected master.</td>
</tr>
<tr>
<td>Skip redundant</td>
<td>If true, the adaptor will avoid resending redundant transactions in the</td>
</tr>
<tr>
<td>transactions</td>
<td>same cycle. If true, it may provide speed improvements.</td>
</tr>
</tbody>
</table>

Table 4-7 Axi2ToAxi Parameters

---

5 ARM recommends using the Memory Map Editor (MME) in SoC Designer, which provides centralized viewing and management of the memory regions available to the components in a system. For information about migrating existing systems to use the MME, refer to the SoC Designer User Guide.
4.7 MxAXIv2

This is a generic model of an AXI interconnect. This model supports up to 16 masters and 16 slaves. Each AXIv2 slave port supports up to 4 independent memory regions which can be configured through the component parameters or via SD Memory Map Editor. 32, 64 and 128-bit data widths are supported. All ports have the same data width. External bridges can be used to convert the data widths on different ports. An example system is shown below which uses a 3x2 MxAXIv2.

![Diagram of MxAXIv2 with 3 masters and 2 slaves](image)

Figure 4-8 MxAXIv2 with 3 masters and 2 slaves

The table below lists the component parameters.

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address Width</td>
<td>Width in bits of the address bus. Supported range is 32 to 64. Settable at sdcanvas time only; not settable at runtime.</td>
</tr>
<tr>
<td>Data width</td>
<td>Data bus width. Applies to all ports. Supported widths are 32, 64 and 128-bit.</td>
</tr>
<tr>
<td>sXX_nameY</td>
<td>The name for memory region ( Y ) on port ( XX ). ( Y: 0 – 3. \ XX: 00 – 15. )</td>
</tr>
<tr>
<td>sXX_sizeY</td>
<td>The size for memory region ( Y ) on port ( XX ). ( Y: 0 – 3. \ XX: 00 – 15. )</td>
</tr>
<tr>
<td>sXX_startY</td>
<td>The start address for memory region ( Y ) on port ( XX ). ( Y: 0 – 3. \ XX: 00 – 15. )</td>
</tr>
<tr>
<td>Use MME</td>
<td>Use the SoC Designer Memory Map Editor (MME) for configuring memory regions. If set to false, component parameters are used instead.</td>
</tr>
<tr>
<td>Enable Debug Messages</td>
<td>When set to true, the model debug messages are displayed as output.</td>
</tr>
</tbody>
</table>

Table 4-8 MxAXIv2 Parameters
### 4.8 AXIv2PassThrough

The AXIv2PassThrough component provides users source code so that they may alter the source destination port hook-ups for particular AXI signals. An example would be to support the feature Lockdown by Master in the ARM PL310 L2 Cache Controller when driven by a multi-core ARM Cortex A9.

Signal forwarding is done in the `driveTransactionCB_*` callback methods. Each method copies the signals from one side to the other and immediately drives them out by calling `driveTransaction`.

The source code and Makefile (or Visual Studio project files for Windows) for this component are located under `$MAXSIM_PROTOCOLS/src/AXIv2PassThrough`.

![AXIv2PassThrough component](image)

The table below lists the component parameters.

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address width</td>
<td>Width in bits of the address bus. Supported range is 1 to 64. Settable at sdcanvas time only; not settable at runtime.</td>
</tr>
<tr>
<td>Data width</td>
<td>Width in bits of the data bus. It must match the data bus width of the connected model. Allowed values are 32, 64, and 128.</td>
</tr>
<tr>
<td>Enable debug messages</td>
<td>When set to <code>true</code>, the model debug messages are displayed as output.</td>
</tr>
</tbody>
</table>

4-9 AXIv2PassThrough Parameters
4.9 Example System

A simple example system using the example master/slave components can be found in $MAXSIM_PROTOCOLS/AXIv2/examples/SimpleMasterSlave.mxp.

![Image](image.png)

**Figure 4-10 AXIv2 Example System**

The example is a simple single-master/single-slave configuration executing AXI read and write burst transactions in a loop. The master and the slave each pop up an output window to show the transaction status.
4.10 Disk Backed Memory Functionality

The AXI4*_Mem component allows systems to model very large memories (several GBs) using a feature called Disk Backed Memory. This feature helps contain SoC Designer memory usage within the limits imposed by the operating systems.

Disk Backed Memory achieves this by swapping the contents of the simulated memory to the disk when the simulated memory exceeds a certain limit. The content swapped to the disk is usually the oldest content, while the most recent content remains in memory.

As general guidelines, this feature should be enabled if the memory being modeled is larger than 2GB.

**Note:** Be aware that enabling disk backed memory may affect performance. By default, the functionality is disabled.

This feature is enabled and controlled using the following parameters:

- **Disk Backed Memory** – This parameter enables/disables Disk Backed Memory functionality. It is disabled by default.

- **Disk Backed Memory Size (Bytes)** – This parameter should match the size of addressable space of the memory instance. For example, if an AXI4*_Mem instance called **Mem1** is required to address 0x8000:0000 to 0xFFFF:FFFF (2GB), then this parameter should be set to 0x80000000 (0xFFFF:FFFF minus 0x8000:0000) for **Mem1**. The default is 100 GB.

- **Disk Backed Memory-RAM Limit (MB)** – This parameter determines how much physical RAM each instance consumes before swapping starts. The default setting of 250 MB should work well for most users; however, if you want to fine-tune these settings, allocate more RAM to the most frequently-accessed memory instance.

**Note:** The sum of all RAM Limit settings should not exceed 4GB (this is the current implementation limit). This does not limit the amount of memory being modeled; rather, it limits the RAM consumption of SoC Designer.
Disk Backed Memory Use Case

The following figure shows a sample use case in which Disk Backed Memory is enabled. In this use case, there are two instances of modeled memory.

The AXI4_mem component limits the RAM consumption on each instance to the value specified by the RAM Limit parameter. In this example, the total RAM used by the disk memory instances is 100 MB + 1 GB. Because MEM2 is more frequently accessed than MEM1 in this use case, the RAM Limit parameter for MEM2 has been set significantly higher (1 GB) than the RAM Limit parameter for MEM1 (100 MB). When the limit set for each instance is reached, the oldest data is swapped to disk.
## 5 Probes

The following simulation probes are included in the AXIv2 Protocol Bundle.

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AXIv2 Tracer</td>
<td>Enables tracing of AXI signals on an AXIv2 connection. Traced signals can be viewed in the SoC Designer simulator waveform window.</td>
</tr>
<tr>
<td>AXIv2 BreakPoint</td>
<td>Transaction breakpoint on an AXIv2 connection.</td>
</tr>
<tr>
<td>AXIv2 Profiler</td>
<td>Profiles AXIv2 transactions. Profiled data can be viewed in the SoC Designer Simulator Profiler window.</td>
</tr>
<tr>
<td>AXIv2 Monitor</td>
<td>View the activity over the connection for each cycle.</td>
</tr>
</tbody>
</table>

**Table 5-1 AXIv2 Probes**
5.1 Tracer

This probe allows tracing of AXI signals. Traced signals can be viewed in the SoC Designer waveform window. To add a tracer probe, right-click on an AXIv2 connection and select “Enable/Disable Tracing”. This brings up the dialog shown in Figure 5-1.

![Tracer Properties dialog](image)

Figure 5-1 Tracer Properties

By default, all signals are traced. This can be changed by using the checkboxes located on the left side of the signal.
5.2 Breakpoint

To insert a breakpoint probe, either double-click on the connection or right-click on the connection and select “Insert/Remove Breakpoint”. By default, the breakpoint will be activated and will break on any active AXI transaction across the connection. To configure breakpoint conditions, bring up the breakpoint property dialog by right-clicking on the connection and selecting “Edit Breakpoint Properties”.

![Breakpoint Property Dialog](image)

Figure 5-2 Breakpoint Properties

5.3 Profiling

This probe enables latency profiling over an AXIv2 connection. To enable this probe, right-click on a connection and select “Profiler”, then “Enable”. Then select the “Display” option to bring up the Operation vs. Cycles profiling window.
Figure 5-3 Profiling Display

To view other available profiling streams, open the Profiling Manager and locate the connection to which the profiling probe was attached. There are four separate streams available for profiling an AXIv2 connection:

- **Latency**: latency for each operation type
- **Address**: plots the accessed address location
- **Channels Usage**: AXI events when channel is active
- **Channels Transfers**: AXI events when a transfer is completed

5.4 Monitor

This probe enables monitoring of an AXIv2 connection for each cycle. To enable this probe, right-click on a connection and select “Insert/Remove Monitor”.

The default view shows the basic information for each of the 5 AXI channels. The “>>” button on the top-left can be used to expand the monitor to window to show the transaction details.

5.5 Monitor Details
The combo box on the top can be used to switch to view the open transactions or the history of all completed transactions. The closed transaction view is shown below.

5-6 Closed Transactions view

5-7 Write to File

From the Channels view, you can dump out the monitor contents to a file by checking the “Write to file” option as shown above. You can use the “Browse…” button to specify the output file.

6 Component Wizard

The SoC Designer component wizard supports generation of AXIv2 master and slave ports.

Note: Refer to the SoC Designer User Guide for general information regarding the Component Wizard.

6.1 Generating AXIv2 Ports

To generate a model with AXIv2 ports, launch the component wizard from SoC Designer Canvas and proceed to the port definition step. Click on New to create a new port, and select the desired AXIv2 port type from the port type drop-down list, as shown below:
This will generate a .cpp and an .h file for each AXIv2 port that was selected. The port class will inherit from one of the specialized template AXIv2 port classes.

7 AXIv2 Port Interfaces

The original AXI TLM had a limitation where combinatorial paths across a SoC Designer component could not be fully supported. AXI TLMv2 was developed mainly to remove this limitation, but it also has other improvements over the original specification which will also be covered in this manual. The v2 interfaces are described in this section.

Note: Do not confuse “v2” with the AMBA protocol version. “v2” refers to the SoC Designer transaction interface version for AMBA AXI, and has no relation to the AMBA protocol specification version number.

7.1 Port Classes

The new port class header files are located under the $MAXSIM_PROTOCOLS/AXIv2/include directory. These header files are needed for building SoC Designer components with AXI TLMv2 ports.

7.2 Channel Ports

AMBA3 AXI uses five independent channels that build up the overall transaction interface. Although the master initiates transactions, not all five channels are initiated from the master. Address (AR, AW) and write data (W) have the master-to-slave direction, whereas the read data (R) and the write response (B) are initiated from the slave. For this reason, AXI TLMv2 utilizes the concept of sub-ports to represent each of the five AXI channels.
Using these channel ports encapsulated in the parent AXI TLMv2 master and slave ports, the model developer is able to control the communication at the AXI channel level.

*Note:* The channel ports are internal to the AXI TLMv2 port. They are not visible in SoC Designer Canvas or in the Simulator. The connection for the channel ports are established based on the connection of the parent AXI TLMv2 ports.
Figure 8-2 depicts where the internal ports reside for the master port (left figure) and slave port (right figure).

![Diagram showing internal ports for master and slave ports](image)

Figure 7-2 Master and Slave Ports showing Internal Channel Ports

### 7.3 Master Interface

#### 7.3.1 AXI_Master_Port

The AXI_Master_Port class implements the parent port that encapsulates the five AXI channel ports underneath, and provides the necessary APIs to the port owner for controlling the channel communication. AXI ports implementing the AXI master interface need to derive off this class. The file is located at: $MAXSIM_PROTOCOLS/AXIv2/include/AXI_Master_Port.h
### 7.3.2 AXI Sender and Receiver Ports for AXI Master Interface

AXI_Master_Port instantiates the five AXI channel ports. Channel ports are further distinguished into two sub-categories: sender ports and receiver ports. For the AXI master interface, the sender ports, or the initiating channel ports, are the AR, AW, and W channels – the B and R channels would be categorized as receiver ports.

AXI_Master_Port serves as the interface for accessing each of the five channels: it is not necessary or recommended for the owner to access the channels directly. AXI_Master_Port provides the methods for setting and retrieving channel signal values. Signals are transferred over the channels via CASI driveTransaction/notifyEvent calls. The relationship between the AXI master port and the channel ports are depicted in the figure below. setX methods (X refers the channel) are used for setting the channel signals, which actually occurs when driveTransaction is called for that channel.

![AXI Master Port and its Channel Ports](image)

**Note:** AXI_Master_Port implements CASI connect and disconnect methods, which handle the interconnection of all internal channel ports.

### 7.3.3 Methods for Setting Channel Signal Values

The following methods are provided for setting individual signals on the sender ports.

```c
void setAW (bool valid, uint16_t id, uint64_t addr, uint8_t len, uint8_t size, uint8_t burst, bool lock, uint8_t cache, uint8_t prot, uint32_t user=0);
void setAR (bool valid, uint16_t id, uint64_t addr, uint8_t len, uint8_t size, uint8_t burst, bool lock, uint8_t cache, uint8_t prot, uint32_t user=0);
void setW  (bool valid, uint16_t id, uint32_t strb, bool last, uint32_t user=0);
void setWData(uint32_t data, uint8_t idx = 0);
```
The methods above should only be called during the SoC Designer update phase. The new values are buffered until the next communicate phase where they will be sent out via driveTransaction() calls. The only time these methods can be called in the communicate phase is when they are inside a driveTransactionCB_X call and signals need to be forwarded onto a different channel sender port. In this case, the channel sender port that receives this forwarded data requires that it’s driveTransaction() method be called also inside the driveTransactionCB_X for the values to be truly forwarded.

For the receiver ports, the following methods are provided for responding with the AXI ready signal.

```c
void setRReady(bool ready);
void setBReady(bool ready);
```

These methods should normally be called during the update phase. However, if combinatorial ready-on-valid behavior needs to be modeled, the above methods need to be called from the driveTransactionCB_X callback function. See section 7.3.6 for information on handling combinatorial ready-on-valid channel handshake.

The clear() method is useful for resetting the signal values. As with other methods for setting new values on the channel signals, this method must be called during the update phase.

### 7.3.4 sendDrive

`sendDrive()` should only be called from the component’s communicate method. This transfers the signal values across the channels via CASI driveTransaction method on each channel sender port.

### 7.3.5 Initialization and Reset

```c
void init(uint32_t addrWidth, uint32_t dataWidth);
```

Call `init()` to initialize the port with the correct address and data bit-widths. Valid range for address bit-width is from 32 to 64, and for data, it is between 8 and 1024 (powers of 2). This method should be called from the component’s `init()`.

```c
void reset();
```

`reset()` must be called in order to properly reset the channel ports. This should be called from the component’s `reset()` routine.

### 7.3.6 Supporting Combinatorial Ready-On-Valid

`AXI_Marker_Port` provides the following interface for supporting combinatorial ready-on-valid behavior:

```c
virtual void driveTransactionCB_R() {};
virtual void driveTransactionCB_B() {};
```

It is not mandatory for the port owner to implement the above methods; however, they must be implemented if the master component needs to model combinatorial ready-on-valid behavior. The above methods are called during the communicate phase when the slave’s R and/or B channel is initiated. Setting the AXI ready signal high in these methods would mean that the ready signal goes high combinatorially based on the valid signal in the same cycle.
7.4 Slave Interface

7.4.1 AXI_Slave_Port
The AXI_Slave_Port class, similar to AXI_Master_Port, implements the parent transaction slave port that encapsulates the five AXI channel ports underneath, and provides the necessary APIs to the port owner for controlling the channel communication. AXI ports implementing the AXI slave interface need to derive off this class.

The file is located at: $MAXSIM_PROTOCOLS/AXIv2/include/AXI_Slave_Port.h

7.4.2 AXI Sender and Receiver Ports for AXI Slave Interface
AXI_Slave_Port instantiates the five AXI channel ports. Channel directions take the complement of those used in AXI_Master_Port, namely, AR, AW, and W channels are defined as receiver ports, whereas B and R channels serve as sender ports. Similarly with AXI_Master_Port, methods are provided for accessing the channel data.

```c
void setAWReady(bool ready);

void setWReady(bool ready);

void setB(bool valid, uint16_t id, uint8_t resp, uint32_t user=0);

void setARReady(bool ready);

void setR(bool valid, uint16_t id, uint8_t resp, bool last, uint32_t user=0);

void setRData(uint32_t data, uint8_t ldx = 0);
```

Figure 7-4 AXI Slave Port and its Channel Ports
7.4.3 Methods for Setting Channel Signal Values

The following methods are provided for setting individual signals on the sender ports.

```c
void setR (bool valid, uint16_t id, uint8_t resp, bool last, uint32_t user=0);
void setRData(uint32_t data, uint8_t idx = 0);
void setB (bool valid, uint16_t id, uint8_t resp, uint32_t user=0);
```

The methods above should only be called during the SoC Designer update phase. The new values are buffered until the next communicate phase, where they will be sent out via driveTransaction() calls.

The clear() method is useful for resetting the signal values. As with other methods for setting new values on the channel signals, this method must be called during the update phase.

For the receiver ports, the following methods are provided for responding with the AXI ready signal.

```c
void setARReady(bool ready);
void setAWReady(bool ready);
void setWReady(bool ready);
```

These methods are the same as the AXI_Master_Port’s setXReady methods in terms of their usage.

7.4.4 sendDrive

sendDrive() should only be called from the component’s communicate method. This transfers the signal values across the channels via CASI driveTransaction method for each sender channel port.

7.4.5 Initialization and Reset

```c
void init(uint32_t addrWidth, uint32_t dataWidth);
```

Call init() to initialize the port with the correct address and data bit-widths. Valid range for address bit-width is from 32 to 64, and for data, it is between 8 and 1024 (powers of 2). This method should be called from the component’s init().

```c
void reset();
```

reset() must be called in order to properly reset the channel ports. This should be called from the component’s reset() routine.

7.5 Note on using large AXI ID widths

AXIv2 master and slave channel access methods have a limit of 16 bits for accessing the AXI ID field. If your design uses wider ID widths, you can overload the AXIv2 set methods as shown below.

```c
class MyLargeIDWidthMasterPort : public AXI_Master_Port {
public:
    // overloaded setAW method
    void setAW(bool valid, uint64_t id, uint64_t addr, uint8_t len, uint8_t size, uint8_t burst, bool lock, uint8_t cache, uint8_t prot, uint32_t user=0) {
        AXI_Master_Port::setAW(valid, id, addr, len, size, burst, lock, cache, prot, user);
        setSig(AW_ID, id);
    }
};
```
As can be seen from above, AXI_Master_Port::setAW() is used for setting the values for fields other than the ID, then a setSig() is called for setting the ID value, which can be larger than 16 bits. An example for overloading the setAW method is shown here; you can take a similar approach for overloading the set method for other channels.

### 7.6 Examples

Pseudo-code examples are presented in this section for AXI master and slave using AXI TLMv2 ports.

#### 7.6.1 AXI Master

##### 7.6.1.1 AXI Master Port

Derive the port from AXI_Master_Port class, and inherit driveTransactionCB_X methods for supporting ready-on-valid.

```cpp
#include "AXI_Master_Port.h"

class MyAxiMasterPort : public AXI_Master_Port
{
public:
    MyAxiMasterPort(CASIModule* owner, std::string name);

    virtual void driveTransactionCB_R();
    virtual void driveTransactionCB_B();
};
```

Here is what driveTransactionCB_X method implementation may look like:

```cpp
void MyAxiMasterPort::driveTransactionCB_R()
{
    if (getSig(R_VALID))
        this->setRReady(1);
}
void MyAxiMasterPort::driveTransactionCB_B()
{
    if (getSig(B_VALID))
        this->setBReady(1);
}
```

Note: driveTransactionCB_X need only be defined if the master port needs to model ready-on-valid behavior.

##### 7.6.1.2 AXI Master Component

Summarizing the requirements from the previous section:

- Driving output values on the channel ports must only occur during the communicate phase
- Setting signal values must only occur during the update phase
 Accordingly, the following shows the sequence of events for an AXI master’s communicate and update methods.

```c
void AXI_Master::communicate()
{
    // send out the channel signals from previous update
    AXI_TMaster->sendDrive();
}

void AXI_Master::update()
{
    AXI_TMaster->clear();

    // handle active channel requests and responses
    if (AXI_TMaster->getSig(R_VALID) && AXI_TMaster->getSig(R_READY))
    {
        // process RDATA
        My_RDATA = AXI_TMaster->getRData(i);
        ...
    }
    if (AXI_TMaster->getSig(B_VALID) && AXI_TMaster->getSig(B_READY))
    {
        // done with a write transaction
    }
    if (AXI_TMaster->getSig(AR_VALID) && AXI_TMaster->getSig(AR_READY))
    {
        ...
    }
    ...

    // new channel requests
    AXI_TMaster->setAR(...);
    AXI_TMaster->setAW(...);
}
```

### 7.6.2 AXI Slave

#### 7.6.2.1 AXI Slave Port

Derive the port from AXI_Slave_Port class, and inherit driveTransactionCB_X methods for supporting ready-on-valid.

```c
#include "AXI_Slave_Port.h"
#include "AXI_Receiver_Port.h"

class MyAxiSlavePort : public AXI_Slave_Port
{
public:
    MyAxiSlavePort(CASIModule* owner, std::string name);
    virtual void driveTransactionCB_AR();
    virtual void driveTransactionCB_AW();
    virtual void driveTransactionCB_W();
};
```
Here is what `driveTransactionCB_X` method implementations may look like:

```c
void MyAxiSlavePort::driveTransactionCB_AR()
{
    if (getSig(AR_VALID))
        this->setARReady(1);
}
void MyAxiSlavePort::driveTransactionCB_AW()
{
    if (getSig(AW_VALID))
        this->setAWReady(1);
}
void MyAxiSlavePort::driveTransactionCB_W()
{
    if (getSig(W_VALID))
        this->setWReady(1);
}
```

### 7.6.2.2 AXI Slave Component

Modeling requirements for an AXI slave component are the same as those for an AXI master component: channel communication, or driving out of channel signal values during `communicate`, and sequential logic and setting of new signal values during `update`.

```c
void AXI_Slave::communicate()
{
    AXI_TSlave->sendDrive();
}
void AXI_Slave::update()
{
    // clear signals
    AXI_TSlave->setR(false, 0, 0, 0);
    AXI_TSlave->setB(false, 0, 0);
    AXI_TSlave->setAWReady(false);
    AXI_TSlave->setARReady(false);
    AXI_TSlave->setWReady(false);

    // handle active channel requests
    if (AXI_TSlave->getSig(AR_VALID) && AXI_TSlave->getSig(AR_READY))
    {
        ...
    }

    // handle new channel requests
    AXI_TSlave->setR(true, it->first, 0, isLastBeat);
}
```
Appendix: Example of altering AxiV2PassThrough for ARM Cortex-A9 and ARM PL310 support for Lockdown by Master feature.

The AxiV2PassThrough component, in an unaltered form, forwards AXIv2 transactions from its slave port to its master port exactly as they are received. However, one can also alter the included source code to make customized versions of this component. For example when connecting an ARM Cortex-A9 and an ARM PL310 L2 Cache, the AxUser signals from the Cortex-A9 may need to be connected to the AxIDM pins of the PL310 for the support of the Lockdown by Master feature of the PL310 as described in ARM’s PL310 Technical Reference Manual.

To make these types of changes, one needs to alter the port classes in the AxiV2PassThrough component. By examining the CB methods in the port classes, one would discover the forwarding methods defined for the component. Each forwarding method simply copies the signals from the input of the component to the output of the component and immediately call driveTransaction send out the signals. Additionally, each forwarding method subsequently returns the ready signal so that the ready signal can be sent back to the originating port of the transaction.

An example of this would be if one wanted to modify how the AW Channel responds and handles the AW User Signals. To do this, modify the forwardAW() method in AxiV2PassThrough.cpp as follows:

```cpp
bool AXIv2PassThrough::forwardAW()
{
    // forward the AW signals and alter the User Signals based on the AW ID
    idVal = axi_s_TSlave->getSig(AW_ID);

    for (AXI_SIGNAL_IDX idx=AW_VALID; idx<=AW_PROT; ++idx)
    {
        // Take the AW_ID value and mask out all but lower 2 bits. Then shift that to bit location 5 of the AW_USER signals.
        if (idx == AW_USER)
        {
            idVal = ((idVal & 0x3)<<5);
            axi_m_TMaster->setSig(AW_USER, (axi_s_TSlave->getSig(AW_USER)|idVal));
        }
        else {
            axi_m_TMaster->setSig(idx, axi_s_TSlave->getSig(idx));
        }
    }

    // immediately drive the forwarded signals out
    axi_m_TMaster->AW_TMaster->driveTransaction(NULL);

    return axi_m_TMaster->getSig(AW_READY);
}
```
