OpenCAPI 3.0
25 Gbps PHY Mechanical Specification

Version 1.0
24 February 2020

Approved

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OpenCAPI 3.0: 25 Gbps PHY Mechanical Specification

PHY Signaling Work Group
OpenCAPI Consortium

Version 1.0 (24 February 2020)

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Abstract

This document describes technical details for the design of mezzanine OpenCAPI add-in cards and 25 Gbps cable implementations. It is the work product of the OpenCAPI Consortium PHY Signaling Work Group.

This document is handled in compliance with the requirements outlined in the OpenCAPI Consortium Work Group (WG) process document. Comments, questions, etc. can be submitted to membership@opencapi.org.
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Revision log

Each release of this document supersedes all previously released versions. The revision log lists all significant changes made to the document since its initial release.

<table>
<thead>
<tr>
<th>Revision date</th>
<th>Summary of changes</th>
</tr>
</thead>
<tbody>
<tr>
<td>24 February 2020</td>
<td>Version 1.0. Initial release to OpenCAPI Consortium.</td>
</tr>
</tbody>
</table>
Preface

This specification describes technical details for the design of mezzanine OpenCAPI add-in cards and 25 Gbps cable implementations.

This specification is intended for designers who plan to develop products that use OpenCAPI. This document provides a technical overview of the mechanical component guidance for 25 Gbps OpenCAPI system design.

Conventions

The following typographical conventions are used in this document.

<table>
<thead>
<tr>
<th>Convention</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hyperlink</td>
<td>Web-based URLs are displayed in blue text to denote a virtual link to an external document.</td>
</tr>
<tr>
<td>Note: This is note text.</td>
<td>The note text denotes information that emphasizes a concept or provides critical information.</td>
</tr>
<tr>
<td>Footnote reference.¹ 1. Descriptive footnote text.</td>
<td>A footnote is an explanatory note or reference inserted at the foot of the page or under a table that explains or expands upon a point within the text or indicates the source of a citation or peripheral information.</td>
</tr>
</tbody>
</table>

Notes

This section describes Engineering and Developer notes.

Engineering notes

Engineering notes provide additional implementation details and recommendations not found elsewhere. The notes might include architectural compliance requirements. That is, the text might include Architecture compliance terminology. These notes should be read by all implementation and verification teams to ensure architectural compliance.

Engineering note:

Developer notes

Developer notes are used to document the reasoning and discussions that led to the current version of the architecture. These notes might also include recommended changes for future versions of the architecture, or warnings of approaches that have failed in the past. These notes should be read by verification teams and contributors to the architecture.

Developer note:

This is an example of a Developer note. Lorem ipsum dolor sit amet, consectetur adipiscing elit. Proin cursus hendrerit enim, vel tempus nibh omare ut. Quisque ac augue eu augue convallis hendrerit. Mauris iaculis viverra ipsum nec dapibus. Nunc at porta libero. Curabitur luctus ultrices augue non pulvinar. Vestibulum mattis non ipsum at venenatis. Suspendisse euismod, neque et suscipit luctus, odio metus semper lectus, quis volutpat est libero quis nunc. Vivamus rutrum mauris sed tristique malesuada.

Editor notes

Editor notes are reminders to the editors and other contributors of additional work that is required. Editor notes may appear as red text in the body of any section or may include an entire section. This is to indicate text that is either out of date or is speculative (unapproved) in nature. The red text might also include directions to the editor for changes to be applied to a future revision of the document. Approved versions of a document are not expected to be released with red text unless approved by the owners of the document.
# Terms

The following terms are used in this document.

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Amperes.</td>
</tr>
<tr>
<td>AAC</td>
<td>Advance accelerator cable.</td>
</tr>
<tr>
<td>AC</td>
<td>Alternating current.</td>
</tr>
<tr>
<td>ASIC</td>
<td>Application-specific integrated circuit.</td>
</tr>
<tr>
<td>BGA</td>
<td>Ball grid array.</td>
</tr>
<tr>
<td>CAPI</td>
<td>Coherent Accelerator Processor Interface.</td>
</tr>
<tr>
<td>CPU</td>
<td>Central processing unit.</td>
</tr>
<tr>
<td>C4</td>
<td>Controlled Collapse Chip Connection.</td>
</tr>
<tr>
<td>FPGA</td>
<td>Field-programmable gate array.</td>
</tr>
<tr>
<td>Gbps</td>
<td>Gigabits per second.</td>
</tr>
<tr>
<td>GND</td>
<td>Ground.</td>
</tr>
<tr>
<td>HLGA</td>
<td>Hybrid land grid array.</td>
</tr>
<tr>
<td>I2C</td>
<td>Inter-integrated circuit.</td>
</tr>
<tr>
<td>lbf</td>
<td>Pound-force.</td>
</tr>
<tr>
<td>LGA</td>
<td>Land grid array.</td>
</tr>
<tr>
<td>LSB</td>
<td>Least-significant byte.</td>
</tr>
<tr>
<td>OD</td>
<td>Open drain.</td>
</tr>
<tr>
<td>PCB</td>
<td>Printed circuit board.</td>
</tr>
<tr>
<td>-------</td>
<td>------------------------</td>
</tr>
<tr>
<td>PCIe</td>
<td>Peripheral Component Interconnect Express.</td>
</tr>
<tr>
<td>QSFP</td>
<td>Quad small form-factor pluggable.</td>
</tr>
<tr>
<td>UI</td>
<td>Unit interval (for example, 25Gbps = 1/25 = 40ps).</td>
</tr>
<tr>
<td>V</td>
<td>Volt.</td>
</tr>
</tbody>
</table>
1. **Overview**

This specification describes the technical details for the design of OpenCAPI mezzanine cards, carrier cards, and 25 Gbps cable implementations. This specification is constrained to the use of the tested and verified connector technology and I/O assignments. The scope of this document is to provide a technical overview of the mechanical requirements for 25 Gbps OpenCAPI system design.
2. Mezzanine card mechanical detail

This section describes the mechanical constraints and details of designing an OpenCAPI add-in card.

Figure 2-1. Mezzanine card

![Diagram of Mezzanine Card](image)

2.1 OpenCAPI mezzanine card connectors

OpenCAPI add-in cards use mezzanine connectors as the electrical interface to the system planar. The connector is a 400 pin, 4 mm stack-height, high-speed interconnect. The OpenCAPI add-in card requires the use of connectors that meet the electrical and mechanical performance requirements. Examples of these connectors are shown in Figure 2-2. Example of typical mezzanine connector.

Each add-in card co-docks two connectors. One connector is primarily for high-speed signals and the other connector is for power and lower-speed signals. Co-docking these connectors drives the specific PCB tolerances described in Section 2.2. OpenCAPI mezzanine card outline. The low nominal pin wipe in the connectors drives specific mechanical tolerances on the bottom-side stiffener. See Section 2.4. OpenCAPI mezzanine card mechanical and attach requirements.

2.1.1 Example of typical mezzanine connector

Figure 2-2 shows an example of a typical mezzanine connector.

Figure 2-2. Example of typical mezzanine connector

<table>
<thead>
<tr>
<th>Typical socket</th>
<th>Typical plug</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="Typical socket image" /></td>
<td><img src="image" alt="Typical plug image" /></td>
</tr>
</tbody>
</table>
2.2 OpenCAPI mezzanine card outline

The top view of the mezzanine card outline is shown in Figure 2-4. *Top view of mezzanine card outline*. The maximum add-in card planar dimensions are 78 mm × 140 mm. For orientation in the system, the north side of the card is identified on the drawing. Two alignment pins are used to orient the card within the system. The origin pin (south side) drives the alignment and docking of the card to the planar. This feature is critical for proper alignment of the add-in card and the system planar. The north-side alignment pin provides angular alignment and can be slotted on the card for hole positional tolerance.

The mounting hole dimensions, alignment holes, and pins A1 and K40 are depicted in Figure 2-3. The orientation and connector identification (1 and 2) are also defined in this view, as well as the location of two copper grounding pads located between the connector pair.

2.2.1 OpenCAPI mezzanine physical card diagram

*Figure 2-3 shows the OpenCAPI mezzanine physical card diagram with pin numbering details.*

*Figure 2-3. Front-side view of mezzanine card layout*
2.2.2 Top view of the mezzanine card

Figure 2-4 shows the top view of the mezzanine card outlines with a North direction indicator. Figure 2-4 includes datum identification, connector placement, and pin identification. Dimensions are in millimeters.

Figure 2-4. Top view of mezzanine card outline
2.2.3 Bottom view of the mezzanine card

Figure 2-5 shows the bottom view of the mezzanine card outlines with a North direction indicator. The figure includes datum identification, connector placement, and pin identification. Dimensions are in millimeters.

Figure 2-5. Bottom view of mezzanine card outline

For a 2U chassis, the maximum component height on the top side of the card is approximately 66 mm. The total height of the OpenCAPI cards must be less than 71.75 mm. It is preferred that the card extend the full height (including the heat sink) or provide airflow blocking features.
2.3 Mechanical drawing for the co-docking connector pads

Figure 2-6 shows the mechanical drawing for the co-docking connector pads.

Figure 2-6. Reference dimension scheme for co-docking connector pads
2.3.1 Thermal guidance

Unless the mezzanine card design is known to be significantly lower power, the thermal solution should be capable of dissipating a maximum of 305 W, which is the limit of the input power for the mezzanine card. Because the mezzanine card is intended to be mounted inside a host chassis, any cooling airflow must be assumed to be approximately 5 °C above ambient inlet air temperature to account for pre-heating by the host chassis and motherboard component.

2.4 OpenCAPI mezzanine card mechanical and attach requirements

A stiffener is required on the bottom side of the add-in cards to ensure that the connectors are loaded appropriately. The stiffener requires a minimum thickness of 3.93 ±0.1 mm with a minimum insulator thickness of 0.125 mm on the bottom of the stiffener. The total thickness of stiffener and insulators (bottom and top insulators with adhesive) is 4.18 ±0.12 mm.

2.5 Overall mechanical stack

*Figure 2-7* illustrates the overall mechanical stack.

*Figure 2-7. Overall mechanical stack*

The stiffener is required to be full thickness around the mounting locations. However, the stiffener can be less than full thickness in other locations, which allows the placement of components on the bottom side of the mezzanine card. The design of the stiffener should allow full-force insertion of the connectors (approximately 31 lbf connector) and maintain integrity of the BGA grid on the connector. Care should be taken when designing a bottom-side stiffener (as well as a top-side stiffener if required). Minimize board strain in the area around the connector BGA to reduce damage to the connector and solder joints during card insertion and extraction.

The stiffener requires including two conductive-fabric-over-foam gaskets to touch the copper grounding pads. (The gasket-attach plane is nominally inset 0.35 mm from the bottom-stiffener plane to achieve this
compression.) This fabric-over-foam gasket must also connect electrically to the OpenCAPI bottom stiffener and provide a ground path for the card. This is a chassis ground.

The system planar should have a package keep-out for the full 78 mm × 140 mm on the top side on the main planar. However, top-side traces are allowed in this region. Add-in cards must ensure that areas of the OpenCAPI card that are in contact with the main planar are electrically isolated (except for the conductive foam gaskets). It is recommended that a thin insulator (0.125 mm) be used for this purpose. Nonconductive coatings can be used but might not be considered the primary method of isolation and damage mitigation to the planar card.

Attachment to the planar is by eight threaded fasteners at the mounting locations. These eight mounting locations are defined as M3 × 0.5 and the threaded depth is 5 mm. Accounting for a planar thickness of 3.01 mm, the maximum threaded depth beyond the bottom surface for the OpenCAPI card is 8 mm. Use an exposed threaded fastener with a length between 6.5 - 7.5 mm from the bottom of the OpenCAPI card.

Removing the mezzanine card from the system planar requires an upward force to un-mate the connectors.
3. Mezzanine card electrical references

This section details the power delivery capability and pinout of the mezzanine connectors labeled 1 and 2. Detailed requirements are found in the OpenCAPI 25 Gbps Physical Signaling Specification.

3.1 Mezzanine loss budget

Table 3-1 lists the mezzanine loss budget for the following:
CPU ↔ Host board ↔ Mezzanine Card CONNECTOR ↔ Mezzanine card trace ↔ ASIC or FPGA

Table 3-1. Mezzanine loss budget

<table>
<thead>
<tr>
<th>Component</th>
<th>Loss Budget (dB)</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPU socket</td>
<td>4.5</td>
<td>34 mm trace, LGA 7-2-7 laminate package</td>
</tr>
<tr>
<td>Reference mother board trace</td>
<td>8.5</td>
<td></td>
</tr>
<tr>
<td>Mezzanine card connector</td>
<td>0.3</td>
<td></td>
</tr>
<tr>
<td>Mezzanine card trace</td>
<td>6.7</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>20</td>
<td>Receiver specification</td>
</tr>
</tbody>
</table>

3.2 Mezzanine card power-delivery capability

Table 3-2 details typical power delivery capability of the system as a function of voltage domain per add-in card. All amperages are assumed to be equally distributed amongst all pins on that domain.

Table 3-2. System power delivery capability per add-in card (set of two connectors)

<table>
<thead>
<tr>
<th>Voltage domain</th>
<th>Amperage</th>
<th>Allowable excursion</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 V</td>
<td>25 A</td>
<td>30% for &lt; 100 ms</td>
</tr>
<tr>
<td>5 V</td>
<td>1 A</td>
<td>30% for &lt; 100 ms</td>
</tr>
</tbody>
</table>
3.3 Mezzanine pinout

3.3.1 Connector 1 pinout

*Figure 3-1* shows a detailed pinout of connector 1. The top view of the mezzanine card outlines with a North direction indicator for placement definition.

*Figure 3-1. Detailed pinout of connector 1*

**Connector directivity example:** OP3_RX7_N means that the receiver is on the OpenCAPI card and the transmitter is on the system planar, while OP3_TX7_N means that the transmitter is on the OpenCAPI card and the receiver is on the system planar.
3.3.2 Connector 2 pinout

Figure 3-2 shows a detailed pinout of connector 2. The top view of the mezzanine card outlines with a North direction indicator for placement definition.

Figure 3-2. Detailed pinout of connector 2

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>J</th>
<th>K</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>GND</td>
<td>PE1_RX5_N</td>
<td>GND</td>
<td>PE1_RX5_P</td>
<td>GND</td>
<td>GND</td>
<td>PE1_TX5_N</td>
<td>GND</td>
<td>PE1_TX5_P</td>
<td>GND</td>
</tr>
<tr>
<td>2</td>
<td>PE1_RX4_N</td>
<td>PE1_RX7_P</td>
<td>PE1_RX4_N</td>
<td>PE1_RX7_P</td>
<td>GND</td>
<td>GND</td>
<td>PE1_TX4_N</td>
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<td>PE1_TX4_P</td>
<td>GND</td>
</tr>
<tr>
<td>3</td>
<td>PE1_RX4_P</td>
<td>PE1_RX7_P</td>
<td>PE1_RX4_P</td>
<td>PE1_RX7_P</td>
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<td>GND</td>
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<td>4</td>
<td>GND</td>
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<td>PE1_RX5_P</td>
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<td>GND</td>
<td>PE1_TX5_P</td>
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<td>PE1_TX5_P</td>
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<tr>
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<td>GND</td>
<td>PE1_TX5_P</td>
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<td>PE1_TX5_P</td>
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<td>6</td>
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<td>PE1_TX7_P</td>
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<td>PE1_TX7_P</td>
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<tr>
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<td>INT_RST_P</td>
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<td>PE0_RX7_P</td>
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<tr>
<td>11</td>
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<td>PE0_RX7_P</td>
<td>PE0_RX7_P</td>
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<td>GND</td>
<td>GND</td>
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<td>GND</td>
</tr>
<tr>
<td>12</td>
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<td>PE0_RX5_P</td>
<td>PE0_RX5_P</td>
<td>GND</td>
<td>GND</td>
<td>PE0_TX5_P</td>
<td>GND</td>
<td>PE0_TX5_P</td>
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3.4 Mezzanine card device wiring

Figure 3-3 shows the OpenCAPI mezzanine card lane identification.

Figure 3-3. OpenCAPI mezzanine card lane identification

The OpenCAPI mezzanine card pinout is pre-defined and contains six, 8-lane ports (OP0 - OP5). The implementation and assignment of the available ports is determined by the developer's requirements.

Potential usage cases are as follows:

- Develop the mezzanine card for a predefined back plane. Care must be taken to ensure that the chosen ports and pin assignments of the mezzanine card match the back-plane wiring. The chosen lanes must be attached to valid OpenCAPI lanes.
- Develop the mezzanine card and the back plane. The developer has more freedom in this case to maximize the lane use and back-plane wiring. The port use is determined by the developer's application, which would potentially factor in system planar component layout, number of CPUs, and wiring plane restrictions. The chosen lanes must attach to the valid OpenCAPI lanes from the processor module.
3.5 Mezzanine sideband signals

The following sideband signals are present:

- **REFCLK_100MHz** – PCIE reference clock (from system logic).
- **REFCLK_133MHz** – 156.25 MHz reference clock (from the CPU).
  Can also be configured to be 133 MHz.
- **I2C_ADDR0/1** – I2C bus address LSBs. Pulled high (1.8 V only) or pulled low on motherboard. These are used to set the physical address of the OPEN_CAPI device. These pins must be at a steady state voltage before the OPEN_CAPI device is taken out of reset.
- **SMB_CLK/DAT** – SMBUS. Only supports operation at 1.8 V. Care must be taken that this signal does not activate before PWR_EN and PWR_GOOD is valid. It is recommended that this signal be ANDed with PWR_EN at minimum because PWR_GOOD is optional.
- **JTAG_SEL** – Control signal into OPEN_CAPI device to enable JTAG debug interface. 1.8 V signal. Pull down on motherboard for normal operation. Pull high on mezzanine card for JTAG operation.
- **JTAG_TCK/TMS/TDI/TDO/TRST_N** – JTAG interface for debug. Scan rings can span multiple riser sites. Ring accessible through debug connector on motherboard. 1.8 V operation only.
- **PERST_N** – “PERST” signal to OPEN_CAPI device. Effectively is the master reset. 1.8 V level signal.
- **PWR_EN** – Master “on/off” switch to OPEN_CAPI device power subsystem. 1.8 V level signal only (OD, pull up is on motherboard). Signal is generated by logic on the system planar and is controlled by the power sequencer. This signal indicates to the OPEN_CAPI card that the OPEN_CAPI card power is enabled. The system asserts this signal to power on the module and may be asserted only after all input rails are stable.
- **PWR_BRAKE_N** – “throttle” signal to OPEN_CAPI device. 1.8 V signal. OD. Pull up on motherboard. Motherboard logic contribution from CPU and power supply throttle signal.
- **PWR_GOOD** – OPEN_CAPI device PGOOD signal-to-system. 1.8 V OD. Pull up with 10 KΩ on motherboard. Indicates to the power sequencer that OPEN_CAPI regulators are good. Module power good. The module will assert this signal when all of its internal power regulators are stable. Use by system is optional.
- **TH_OVERT_N** – emergency “panic” signal from an OPEN_CAPI device to the system that a catastrophic thermal condition is imminent and the device is going to shut down. 1.8 V level signal to motherboard. Signals for each OPEN_CAPI device gathered together and fed to the power sequencer. Care must be taken that this signal does not activate before PWR_EN and PWR_GOOD is valid. It is recommended that this signal be ANDed with PWR_EN at a minimum because PWR_GOOD is optional and pulled up when not used.
- **INT_RST_N** – Reset to OpenCAPI FPGA controlled by the processor I2C bus. This signal must have a pull up to 3.3 V on the mezzanine card.
- **PRSNT_1A/2A/1B/2B** – presence detect loop. Short PRSNT_1A to PRSNT_1B and short PRSNT_2A to PRSNT_2B on OPEN_CAPI device. Motherboard uses these to form a presence detect loop that is only ‘true’ when the card is fully and correctly seated. Signal is used by JTAG scan ring bypass logic and PCIe device prsnt detect logic.

3.6 Mezzanine PCIe interface

Each mezzanine card has an X2 PCI Express (PCIe) interface that can be used in many ways, with one being a sideband support. These buses are labeled PE0 and PE1 in the connector table. This interface is compliant with the PCIe base specifications.
4. Carrier card and advanced accelerator cable

The internal cable connecting the CPU board to the PCIe carrier card is shown in Figure 4-1. There are two connector slots on the CPU board for 25 Gbps ×8 connection. One ×8 cable is assumed for this guideline. If a vertical connector is selected, select a right-angle connector and place it at the end of the PCIe card, toward the CPU side, to avoid interference with the next PCIe card.

Figure 4-1. Carrier card connecting to CPU board

4.1 Carrier card size

The carrier card design should conform to the size requirements for PCIe add-in cards defined by the PCI Express® Card Electromechanical Specification Revision 3.0 or later. It is recommended that the carrier card be kept to the half or three-quarter lengths per the specification to better accommodate the Advanced Accelerator connector routing in the chassis.

4.2 Carrier card connector

Only power is being removed from the PCIe slot for the carrier card, so the size of the PCIe edge connector can be determined by the amount of card power required and the mounting stability and flexibility required. The X1 connector size provides full power and is most universal but might not provide the best retention and mechanical stability compared to a ×8 connector.

4.3 Carrier card power

The power available from the PCIe edge connector is limited to 75 W. Additional power requirements may be addressed by the Auxiliary Power Connector options identified in the PCI Express® Card Electromechanical Specification.

4.4 Carrier card cooling

Refer to the PCI Express® Card Electromechanical Specification for information on cooling requirements for
the carrier card.

4.5 Advance accelerator cable

The OpenCAPI platform supports the optional 25 Gbps interface to the advance accelerator processor unit in a different drawer of the rack or the riser card plug-in to the PCIe slot in the same system. This section only contains information on topologies, connectivity, and routing guidelines for the advance accelerator cable (AAC) interface.

4.5.1 Accelerator cable circuit schematic

*Figure 4-2* illustrates an accelerator cable circuit schematic.

*Figure 4-2. Accelerator cable circuit schematic*

4.5.2 Accelerator cable signal definition

The interconnect allows lane and polarity reversal. Pin swapping is not allowed. Signal direction is defined as follows:

- Tx – is from the Host (CPU) perspective
- Rx – is from the Host (CPU) perspective
- Tx from Amphenol SlimSAS connectors to Rx of FPGA on OpenCAPI adapter
- Rx from Amphenol SlimSAS connectors to Tx of FPGA on OpenCAPI adapter
- AC Coupling must be done on both the 8 Rx and 8 Tx differential data signals on the carrier card

The following sideband signals are present:

- Ref Clk – Differential reference clock. Driven by the CPU. 156.25 MHz for OIF applications or 133.33 MHz for JEDEC applications. This differential clock is HSICL. External reference clock electrical specification can be found in the *OpenCAPI 25 Gbps Physical Signaling Specification* (Table 5-1).
- I2C (SCL/SDA) – I2C bus clock and data. I2C on the carrier card is only a slave implementation. The CPU drives these signals to a 3.3 V level from the main 3.3 V power supply. Recommended to have level translators on the carrier card to translate to 1.8 V. Pulled high (1.8 V) on the carrier card. These pins must be at a steady state voltage before the OPEN_CAPI device is taken out of reset.
- INT/RST – Reset to OpenCAPI FPGA controlled by the processor I2C bus. The CPU drives these signals to a 3.3 V level from the main 3.3 V power supply. This signal must have a pull-up resistor on the host side. Level translators are recommended on the carrier card to translate to 1.8 V. This signal
must have a pull-up resistor on the carrier side as well after the level translation.

- Cable Pre-Detect – Presence detect. Cable Pre-Detect must have a 49.9 Ω pull-down to GND resistor located on the adapter card.
- SPARE_1/2 – Spare pins. May be left floating.

4.5.3 **Advanced accelerator cable loss budget**

*Table 4-1 lists the advanced accelerator cable loss budget.*

*Table 4-1. Advanced accelerator cable loss budget*

<table>
<thead>
<tr>
<th>Component</th>
<th>Loss Budget (dB)</th>
<th>Notes</th>
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<tbody>
<tr>
<td>PCB connector</td>
<td>0.3</td>
<td>PCB connector</td>
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<tr>
<td>Cable connector</td>
<td>0.15</td>
<td>Connector on cable end</td>
</tr>
<tr>
<td>Cable</td>
<td>5.6</td>
<td>Cable</td>
</tr>
<tr>
<td>Cable connector</td>
<td>0.15</td>
<td>Connector on cable end</td>
</tr>
<tr>
<td>PCB connector</td>
<td>0.3</td>
<td>PCB connector</td>
</tr>
<tr>
<td>Total</td>
<td>6.5</td>
<td>Assembly</td>
</tr>
</tbody>
</table>
4.5.4 Accelerator-cable pin definition

Figure 4-3 illustrates the accelerator cable pin definition.

Figure 4-3. Accelerator cable pin definition
4.5.5 Internal cable pin ordering and mapping

The interconnect allows lane and polarity reversal. Pin swapping is not allowed. The GRD board pin ordering and list are shown in Figure 4-4. Also shown is a generic pin list for the cable connection.

Figure 4-4. GRD board pin ordering

Note: The raw wire within the cable is 12 inches, 30 AWG (6 dB/meter). The I/O assignments are referenced from the CPU board side.
4.5.6 AAC connector escape routing example

*Figure 4-5* shows some AAC connector escape routing examples. The connector antipad goes through the top two GND plane layers. The signal must not cross the antipad void.

Connector break-out P and N: The connector break out P and N should be matched immediately to the first via.

*Figure 4-5. AAC connector escape routing example*

4.6 Cabled CPU to carrier card interconnect and loss budget

4.6.1 CPU-to-QSFP carrier card configuration

The end-to-end AAC interconnection consists of three channels: the reference design board, the AAC cable, and the carrier card as shown in *Figure 4-6*. The path includes the internal cable.

The board topology consists, from right-to-left: the processor module socket; the CPU board trace; vertical connector; 12 in., 30 AWG twin-ax cable; vertical and right-angle connector; carrier card trace; and the connector receptacle. Also shown is the loss-budget break down for each electrical component in the link.

The worst-case loss budget requirement is 20 dB. *Table 4-2* and *Table 4-3* show examples of end-to-end loss budget for the CPU-to-QSFP carrier card and the CPU-to-accelerator topologies.
4.6.2 CPU-to-QSFP carrier card loss budget

CPU ↔ Host board ↔ Cable ↔ Carrier card ↔ Active cable to external drawer

Table 4-2 shows an example of the cabled CPU to accelerator interconnect loss budget for a typical 25G interconnection scheme.

Table 4-2. Example of CPU-to-QSFP carrier card loss budget

<table>
<thead>
<tr>
<th>Component</th>
<th>Loss Budget (dB)</th>
<th>Notes</th>
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<tbody>
<tr>
<td>CPU socket</td>
<td>4.1</td>
<td>34 mm trace, LGA 7-2-7 laminate package</td>
</tr>
<tr>
<td>CPU board trace</td>
<td>5.1</td>
<td>3.2&quot;; trace and via</td>
</tr>
<tr>
<td>Cable assembly</td>
<td>6.5</td>
<td>12.5' 30 AWG twin-axial cable (with connectors)</td>
</tr>
<tr>
<td>Carrier card (PCIe)</td>
<td>1.6</td>
<td>1&quot; trace; blind via PCB</td>
</tr>
<tr>
<td>Cable plug</td>
<td>1.6</td>
<td>1.2&quot; trace; blind via PCB</td>
</tr>
<tr>
<td>Worst-case PCB</td>
<td>0.9</td>
<td>Account for ±10 PCB tolerance</td>
</tr>
<tr>
<td>Total</td>
<td>19.8</td>
<td>Receiver specification</td>
</tr>
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</table>

**Note:** The worst-case loss budget requirement is 20 dB.
4.6.3 CPU-to-accelerator configuration

Figure 4-7 illustrates a CPU-to-accelerator configuration.

Figure 4-7. Example of a CPU-to-accelerator configuration

![Diagram of CPU-to-accelerator configuration]

4.6.4 CPU-to-accelerator loss budget

CPU ↔ Host board ↔ Cable ↔ Carrier card ↔ OpenCAPI module (for example, an FPGA).

Table 4-3 an example of the CPU-to-accelerator loss budget.

Table 4-3. Example of CPU-to-accelerator loss budget (OpenCAPI module)

<table>
<thead>
<tr>
<th>Components</th>
<th>Loss Budget (dB)</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPU socket</td>
<td>4.1</td>
<td>LGA plus 34 mm trace</td>
</tr>
<tr>
<td>CPU board trace</td>
<td>5.1</td>
<td>3.2&quot; trace and via</td>
</tr>
<tr>
<td>74-pin Vertical Connector</td>
<td>0.45</td>
<td></td>
</tr>
<tr>
<td>Cable assembly</td>
<td>6.5</td>
<td>12.5&quot; 30 AWG twin-ax cable</td>
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<tr>
<td>74-pin Vertical Connector</td>
<td>0.45</td>
<td></td>
</tr>
<tr>
<td>Carrier card</td>
<td>2.5</td>
<td>2&quot; trace, 0201 AC capacitor, blind via PCB</td>
</tr>
<tr>
<td>Advance accelerator socket/package</td>
<td>1.8</td>
<td>11 mm trace, laminate package</td>
</tr>
<tr>
<td>Total</td>
<td>20.9</td>
<td>Receiver specification</td>
</tr>
</tbody>
</table>

Note: The worst-case loss budget requirement is 20 dB.
4.7 Accelerator card design supplement

This section is intended to provide additional information that is necessary for accelerator card design.

Systems based on the host processor are designed so that each x8 OpenCAPI bus has a total card wiring skew budget (processor module die C4 to accelerator module die C4) of 10 UI. This skew budget is the same for both the Tx and Rx directions. When designing an accelerator card for an existing system, skew budget information is provided below for each of three topologies. Note that hardware manufacturing tolerances and PCB glass-weave skew effects should be considered as part of the allotted skew budget.

4.7.1 Topology 1

Figure 4-8 illustrates the direct-attach accelerator card. The MEG-array connector resides on the same planar with the host processor. Skew budget allowance for the accelerator card is 3.3 UI.

Figure 4-8. Example of a direct-attach accelerator card

4.7.2 Topology 2

Figure 4-9 illustrates a cable-attached accelerator carrier card. The CPU module and accelerator FPGA reside on different cards with a cable connection between them. The skew budget allowance for the accelerator carrier card is 3.3 UI and the skew budget allowance for the cable is 1.5 UI.

Figure 4-9. Example of a cable-attached accelerator carrier card
4.8 Carrier card stack-up

*Figure 4-10* is an example stack-up for the PCIe carrier card that supports the advance accelerator cable interface. Skip or blind via technology is assumed. The signal should be on the top layers where the connector resides.

*Figure 4-10. Example of a carrier card stack up*