



# High Speed Mezzanine Card (HSMC)

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## Specification



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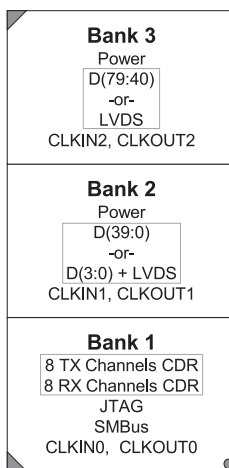
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## 1.1 Overview

The Altera High Speed Mezzanine Card (HSMC) specification defines the electrical and mechanical properties of a high speed mezzanine card adapter interface for FPGA-based motherboards. This specification should allow for the design of interoperable motherboards and add-on cards by different manufacturers that can interoperate and utilize the high-performance I/O features found in today's FPGA devices.

The connector is based on the Samtec 0.5 mm pitch, surface-mount QTH/QSH family of connectors. Compatible versions with this specification vary from 132 to 192 physical pins. The highest frequency signals are the clock-data-recovery differential signals found in bank 1. Signals between the host board FPGA device and HSMC connector are intended to be D/C coupled. Bank 1 also has dedicated JTAG, a system management bus (SMBus), and clock signals. The main CMOS/LVDS interface signals, including LVDS/CMOS clocks, are found in banks 2 and 3. Both 12-V and 3.3-V power pins are also found in banks 2 and 3.

**Figure 1–1. Signal Bank Diagram**



### 1.1.1 Objectives

The objective of this interface is to allow for multi-gigahertz differential signaling as well as slower single-ended signaling on most pins. The proper I/O connections can be programmed into the FPGA-based motherboard as required. The connector used is both low-cost and high performance. The layout requirements do not require significant motherboard space and allow for cabling options to support host-to-host connections.

The main data bus signals should allow for a mix of single-ended applications as well as source-synchronous and clock-data-recovery based differential signaling. Several other standard bus interfaces are presented through the connector including JTAG, SMBus, and dedicated clock inputs and outputs.

### 1.1.2 Scope

This HSMC specification does not define specific interconnect usage, although it is optimized for current and emerging High-Speed Serial Interconnect standards such as PCI Express, Gigabit Ethernet, AMC, SPI4.2, and others.

A mapping of several popular bus standards is provided so that a host board and mezzanine card could be developed to support such standards. It is recognized that one may not be able to develop a single host to support every known standard. Instead, it should be made possible to support at least one, if not many, of the shown I/O signal mappings.

## 1.2 Theory and Operation

The HSMC interface provides a mechanism to extend the peripheral-set of an FPGA host board by means of a mezzanine card, which can address today's high speed signaling requirement as well as standard or legacy low-speed device interface support. The mounting holes available on the mezzanine cards as well as the host boards provide mechanical support to the mezzanine card installed on the host board.

### 1.2.1 Host Boards

Host boards are defined as any board with an FPGA connected to one or more HSMC interfaces. Since FPGAs are configurable devices, the interconnect I/Os available on the HSMC connector can have all possible I/O standard and logic features that can be supported by the host FPGA, but usually they are limited by the wiring on the board, for instance, voltage referenced I/Os, single-ended (bidirectional) I/Os, differential (unidirectional) I/Os, and others.

## 1.2.2 Mezzanine Cards

Mezzanine cards are daughter cards which feature electrical components and interfaces or both. Mezzanine cards may come in several different sizes, interfaces and IO standard support, but all share some common attributes. When installed onto a host board, a mezzanine card is oriented parallel to the host board PCB plane and installed onto the HSMC connector.

## 1.2.3 HSMC Connectors

HSMC connectors provide the interface between a host board and a mezzanine card. The ‘header’ part on a mezzanine card plugs into the ‘socket’ part on a host board. Various connector foot prints are allowed, but all HSMC connectors must adhere to the defined dimensional envelopes and electrical properties described in [Chapter 2, Mechanical](#) and [Chapter 3, Electrical](#).

## 1.2.4 HSMC Power

The host board provides +12 V DC and +3.3 V DC power to the mezzanine card through the HSMC connector. Any required voltage can be developed on the mezzanine card using appropriate power supply circuitry. Refer to “Power” on [page 3–14](#) for more information.

## 1.2.5 HSMC Interconnect

In addition to power and clock signals, the host board provides access to JTAG, high speed serial I/O, and single-ended or differential I/O (as per mapping with the host board) through the HSMC connector. [Chapter 4, Pinouts](#), describes the mapping of those signals to the HSMC connectors.

## 1.2.6 Name and Logo Usage



The logo shown above should be placed near the HSMC connector on host boards. To download the HSMC logo visit, [ftp.altera.com/outgoing/hsmc\\_logo\\_fat.bmp](http://ftp.altera.com/outgoing/hsmc_logo_fat.bmp).

### 2.1 Overview

This chapter defines the essential mechanical features and requirements for host boards and mezzanine cards. The following sections describes the HSMC connector, host boards and mezzanine cards.

### 2.2 Dimensions

The controlling dimensions are in inches unless stated otherwise. The unit for the dimensions shown in square brackets is mm unless stated otherwise. Periods are used as a decimal separator throughout this specification.

Tolerances are (unless stated otherwise):

Decimals:

.XX:  $\pm .01$  [.3]

.XXX:  $\pm .005$  [.13]

.XXXX:  $\pm .0020$  [.051]

Angle:  $2^\circ$

### 2.3 HSMC Connector

The HSMC connector has a total of 172 pins, including 121 signal pins (120 signal pins + 1 PSNTn pin), 39 power pins, and 12 ground pins. The ground pins are much larger than the power pins and are located between the two rows of signal and power pins.

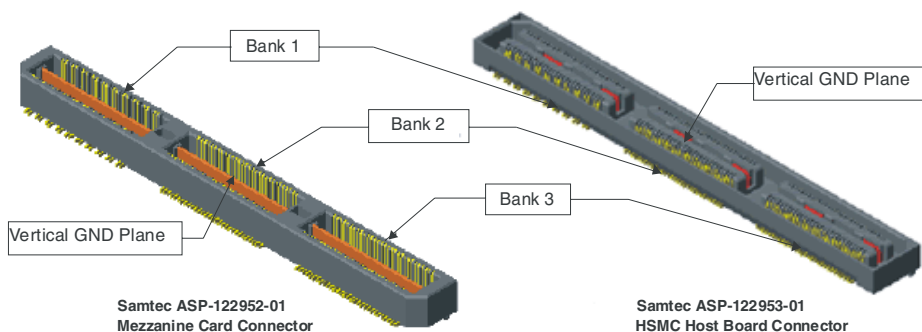
The connector is based on the 0.5 mm-pitch QSH/QTH family of high-speed board-to-board connectors from Samtec. There are three banks in this connector. Bank 1 will have every third pin removed as done in the QSH-DP/QTH-DP series. Bank 2 and Bank 3 have all of the pins populated as done in the QSH/QTH series. This configuration features 60 differential channels, or 120 single-ended I/O pins, plus special 12 V, 3.3 V, and GND plane connections with a vertical plane within the



connector that isolates the two rows of pins with 4 pins per bank. There are several connectors that can be used, each having different advantages. For more information on compatible connectors refer to the tables in the subsequent sections.

Figure 2-1 illustrate the HSMC connectors for both host boards and mezzanine cards.

**Figure 2-1. HSMC Connectors**



The default stacking height, or board to board air gap, is 5 mm. Using the smallest stacking height gives better signal integrity.

### 2.3.1 ASP-122952-01 Header (Mezzanine Cards)

The ASP-122952-01 header provides 160 total pins as well as 12 ground plane connection pins down the center. Bank 1 (containing pin 1) has 40 pins (every third pin removed). Banks 2 and 3 have 60 pins each as no pins are removed. This connector is similar to the QTH family except for the bank 1 pin de-population is as found in the QTH-DP family. Optionally, you can use either the QTH or QTH-DP family connectors in the proper 3-bank versions knowing that the QTH-DP version will not carry power and the QTH will have slightly worse signal integrity on the transceiver pins. Refer to Table 2-1 for more details about the compatible connectors.

The header (ASP122952-01) is found on mezzanine cards. Figure 2-2 shows a top view of the connector. Bank 1 is denoted as a DP Bank which indicates that every third pin in this bank is removed.

Host boards provide transceivers to bank 1 and single-ended signals to banks 2 and 3. Typically, the single-ended signals are capable of differential signaling such as LVDS.

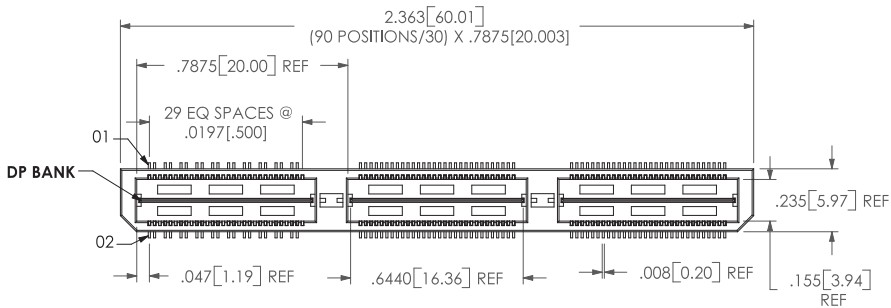
**Figure 2–2. Top View of the Samtec ASP-122952-01**

Table 2–1 below shows several compatible models of connectors from Samtec. All of these models can use the same physical footprint.

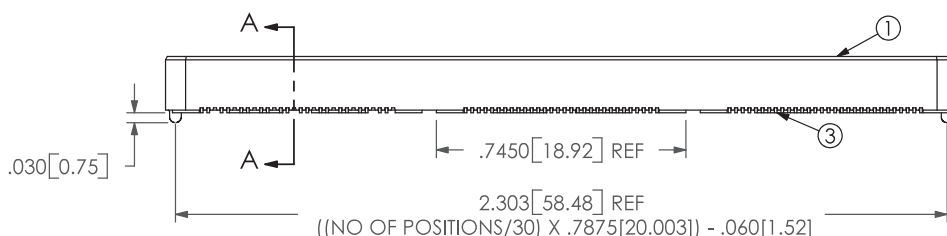
<b>Table 2–1. Mezzanine Header Compatibility</b>	
<b>Part Number</b>	<b>Description</b>
ASP-122952-01	Recommended connector for mezzanine cards. This is a customized version of the QTH family connectors with 3 banks. Bank 1 is differential only (-DP) and banks 2 and 3 are like a normal QTH. This connector has 172 physical pins.
QTH-090-01-L-D-A	QTH family connector with three banks. The difference between this connector and the ASP version is that all pins are populated in bank 1 of the connector. This difference equates to slightly lower signal integrity in that bank which typically carries multi-GHz clock-data-recovery signals. It is recommended that you do not leave the undefined pins in bank 1 floating; ground them or tie them to power. This connector has 192 physical pins.
QTH-060-01-L-D-DP-A	QTH-DP family connector with three banks. The difference between this connector and the ASP version is that every third pin is removed in banks 2 and 3. These pins are connected to the 3.3 V and 12 V power signals. When these pins are in use, no power is delivered to the HSMC add-on card. LVDS/CMOS signals in banks 2 and 3 will have slightly better signal integrity. This connector has 132 physical pins.



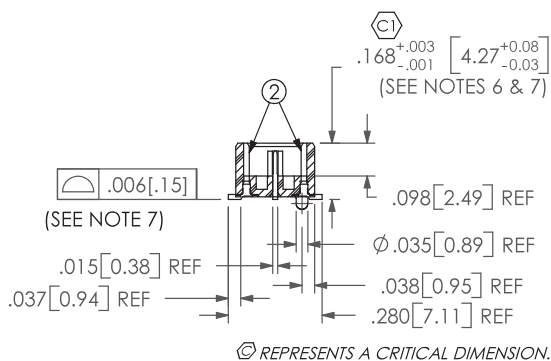
ASP-122952-01 is the recommended connector defined by the HSMC specification. If any of the compatible connectors from the above table is used, then the pin numbering will change accordingly due to different pin counts. Hence the example pinouts must be adjusted accordingly for the selected connector part.

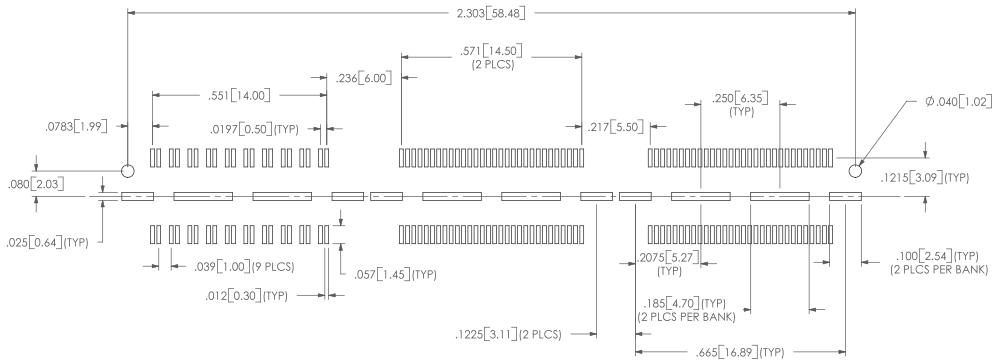
Figure 2-3, Figure 2-4, and Figure 2-5 shows the front view, side section view, and PCB footprint of the Samtec ASP-122952-01.

**Figure 2-3. Front View of the Samtec ASP-122952-01**



**Figure 2-4. Side Section View of the Samtec ASP-122952-01**



**Figure 2–5. Footprint of the Samtec ASP-122952-01**

For more information about the ASP-122952-01 connector, visit Samtec's website at [http://www.samtec.com/signal\\_integrity/altera.aspx](http://www.samtec.com/signal_integrity/altera.aspx).

### 2.3.2 ASP-122953-01 Socket (Host Boards)

The ASP-122953-01 socket provides 160 total pins as well as 12 ground plane connection pins down the center. Bank 1 (containing pin 1) has 40 pins (every third pin removed). Banks 2 and 3 have 60 pins each as no pins are removed. This connector is similar to the QSH family except for the bank 1 pin de-population is as found in the QSH-DP family. Optionally, one can use either the QSH or QSH-DP family connectors in the proper 3-bank versions knowing that the QSH-DP version will not carry power and the QSH will have slightly worse signal integrity on the transceiver pins. Refer to [Table 2–2](#) for more details about the compatible connectors.

The socket (ASP122953-01) is found on host boards. [Figure 2–6](#) shows the top view of this socket. Bank 1 is denoted as a DP Bank, meaning every third pin is removed.

As previously mentioned, host boards provide transceivers to bank 1 and single-ended signals to banks 2 and 3. Typically, the single-ended signals are capable of differential signaling as well (like LVDS, for example).

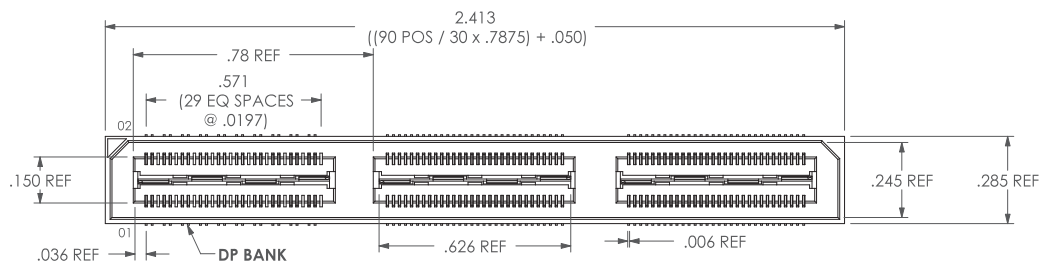
**Figure 2–6. Top View of the Samtec ASP-122953-01**

Table 2–2 shows several compatible models of connectors from Samtec. All of these models can use the same physical footprint.

<b>Table 2–2. Host/Socket Compatibility</b>	
<b>Part Number</b>	<b>Description</b>
ASP-122953-01	Recommended connector for host boards. This is a semi-custom version of the QSH family connectors with 3 banks. Bank 1 is differential only (-DP) and banks 2 and 3 are like a normal QSH. This connector has 172 physical pins.
QSH-090-01-L-D-A	QSH family connector with three banks. The difference between this connector and the ASP version is that all pins are populated in bank 1 of the connector. This equates to slightly lower signal integrity in that bank which typically carries multi-GHz clock-data-recovery signals. It is recommended that you do not leave the undefined pins in bank 1 floating; ground them or tie them to power. This connector has 192 physical pins.
QSH-060-01-L-D-DP-A	QSH-DP family connector with three banks. Difference between this connector and the ASP version is that every third pin is removed in banks 2 and 3. These pins connect to 3.3V and 12V power signals so the net result when using this pin is that no power will be delivered to the HSMC add-on card. LVDS/CMOS signals in banks 2 and 3 will have slightly better signal integrity. This connector has 132 physical pins.



ASP-122953-01 is the recommended connector defined by the HSMC specification. If any of the compatible connectors from the above table is used, then the pin numbering will change accordingly due to different pin counts. Hence the example pinouts must be adjusted accordingly for the selected connector part.





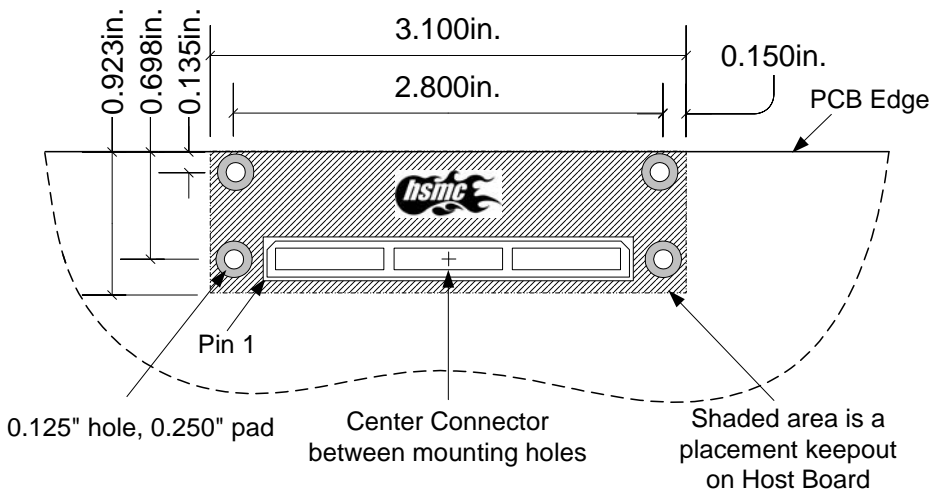
For more information about the ASP-122952-01 connector, visit Samtec's website at [http://www.samtec.com/signal\\_integrity/altera.aspx](http://www.samtec.com/signal_integrity/altera.aspx).

## 2.4 Host Board Layout

The HSMC connector is to be located on the edge of the PCB to minimize the keepout area required on both host boards and mezzanine cards. The connector should be placed far enough from the board's edge to allow for two mounting holes. This will ensure a rigid connection between the host board and mezzanine card.

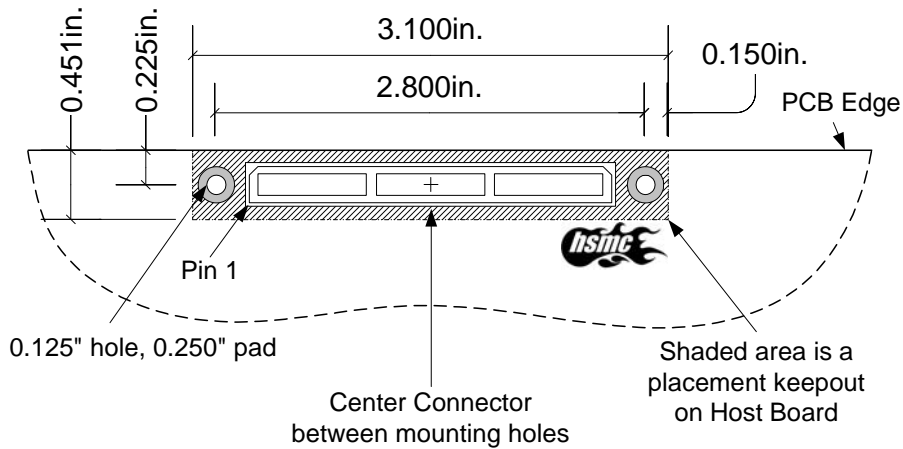
Figure 2-10 shows the dimensions of the keepout area and mounting holes.

**Figure 2-10. Dimensions of Keep-Out Area and Mounting Holes**



The connector should be placed far enough from the board's edge to allow for two mounting holes, but in some cases this may not be possible. Figure 2-11 shows the dimensions of keepout area and mounting holes for a host board with room for only one mounting hole on each side.

**Figure 2–11. Minimum Keep-Out Board Edge Layout**



## 2.5 Mezzanine Card Layout

As with the host board, the mezzanine card connector is to be placed on the edge of the PCB to minimize the keep-out area. The length of the HSMC is unimportant but the dimensions for the width and the mounting holes must be observed. [Figure 2–12](#) shows the top view of mezzanine card.



Figure 2-12. Mezzanine Card Top View

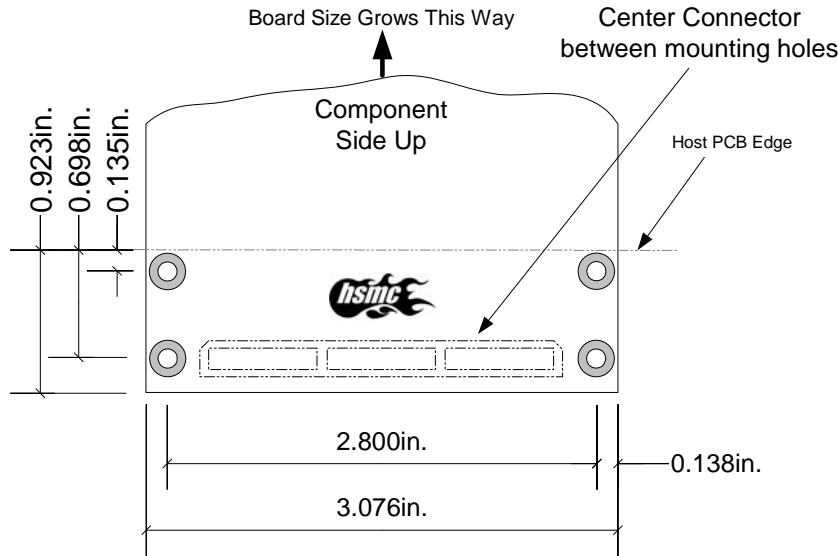
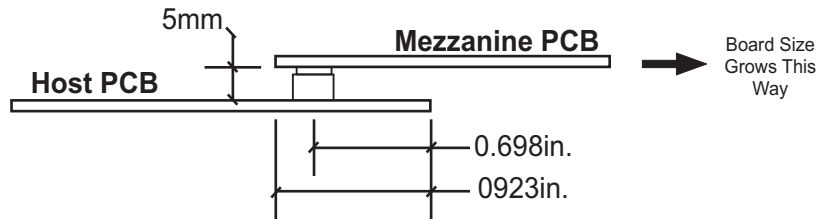


Figure 2-13 shows the side view layout of mezzanine card.

Figure 2-13. Mezzanine Card Side View



## 3.1 Overview

This chapter defines the electrical properties of various signal groups in an HSMC interface as well as timing methodologies for data transfers.

## 3.2 Board Classes

Four classes of HSMC boards are defined within this specification to include low-cost platforms as well as high performance platforms. Table 3–1 shows the four HSMC board classes.

<i>Table 3–1. HSMC Board Classes</i>				
Type	HSMC Class	Bank 1	Bank 2 and Bank 3	
		CDR-based PCML SERDES	Source-Sync LVDS SERDES	Single-Ended CMOS Signals
I	SE (1)	—	—	✓
II	SE (1) + LVDS	—	✓	✓
III	Universal	✓	✓	✓
IV	Transceiver	✓	—	—

*Note:*

(1) SE is an abbreviation for single-ended signals



Type I, II, and III represents the host boards, while the Transceiver class is observed in mezzanine cards only.

A low-cost host may only support single-ended signals whereas a high-performance host may support programmable CMOS/LVDS or single-ended. A universal host adds clock-data recovery serializer/deserializer (SERDES). It is anticipated that other permutations of the above chart can exist but the three classes shown are the only ones defined herein.

The FPGA bank choices for I/O standards dictate how and which type of mezzanine card would be compatible with the host board (The I/O configuration on the host board usually determines which mezzanine cards will be supported by it and in what capacity). For example, if a mezzanine card with bidirectional single-ended

I/O standard (for example, LVTTTL/CMOS) is used with a host board having unidirectional I/O support (for example, LVDS), then the interface requirements must be observed to see the compatibility between the host and the mezzanine card. The reconfigurable FPGA may allow for using LVDS I/Os as single-ended I/Os, but voltage standard compatibility, dedicated I/O signal direction and availability of all I/Os must be observed to confirm the interoperability of the host board and the mezzanine card.

## 3.3 Signal Classes

The HSMC interface defines eight classes of signals. These signal classes define the signaling type, or I/O standard, as well as assumptions on the way data is timed and clocked or both into transmitters and receivers.



Follow the standard differential host pinout for mezzanine cards that support a mix of LVDS and CMOS signals. This type of mezzanine cards contains four CMOS signals, 17 full-duplex differential channels (including two input and output clocks), and CLKIN0/CLKOUT0. Other perturbations may result in host board FPGA compilation errors due to I/O fitter rules such as single-ended and differential signal spacing.

### 3.3.1 Signal/Pin Naming Conventions

All signals are active high unless denoted by a trailing n (negative) symbol. Differential signals are denoted by trailing p (positive) or n (negative) symbol.

### 3.3.2 Signal/Pin Numbering Conventions

All the pinouts shown in this document are common to host boards as well as mezzanine cards. As the connector pin numbering on the HSMC header is mirrored for the HSMC socket, the pinout numbering remains the same for the HSMC header on the mezzanine card and connecting HSMC socket on the host board.

### 3.3.3 Signal/Pin Direction Conventions

Signal directions for transceivers as well as LVDS and other differential signals, or both are assumed to be unidirectional. Signal directions for CMOS are assumed to be bidirectional. Signal directions for clock input pins are assumed to be input only but may be bidirectional.

The signal naming conventions are relative to the host FPGA (from signal direction's perspective). Hence care must be taken in the host and mezzanine card design when using unidirectional signals for transceivers, LVDS and other differential signals, or

both, especially for the differential and single-ended clock signals. If the direction specification (in or out) is not observed in the board design, it may render the mezzanine board unusable in the end host-daughter card system.

### 3.3.4 Signal/Pin Definitions

The following section describes signal/pin definitions for the HSMC specification.

#### 3.3.4.1 Transceiver

##### Definition

The *Transceiver* class pins are intended to connect directly to PCML-compatible clock data- recovery SERDES pins for signaling of up to 6 Gbps or higher. These signals are always unidirectional and assume scrambling or encoding such that a clock can be recovered from the data stream. Run lengths and encoding or scrambling details are beyond the scope of this specification. This information needs to be documented on each host board and mezzanine card based on the device specifications.

##### Signal Direction

The signal direction naming conventions are relative to the host FPGA. For example, pin 1 (XCVR\_TXp0) and pin 3 (XCVR\_TXn0) should connect to transceiver output pins on a host board whereas pin 2 (XCVR\_RXp0) and pin 4 (XCVR\_RXn0) should connect to transceiver input pins on a host board.

##### Reduced Bus Widths

If a host cannot support eight transceiver channels due to limited channel counts then the lower bus numbers should be used. For example, if only four channels can be supplied to the HSMC connector, they would go to channels 0, 1, 2, and 3. If transceiver channels are not supported on a host then these pins should be left unconnected. Optionally, these pins can be connected to either *CMOS/LVDS* or *CMOS* class pins to extend the differential bus width to single-ended bus width to 112 signals (as shown in the generic single-ended/differential pinouts). It is considered a **standard** implementation to implement these pins as CMOS as host cards are encouraged to keep their pins limited to the standard 80 signal width with signals D80 through D111 being considered a special case. Host boards without *Transceiver* class pins should populate these only when many extra pins are available on the FPGA.

##### Coupling

All signals of this class must be DC-coupled on the host. Mezzanine card design can add A/C coupling as required but common-mode levels must be translated to HSMC compliant levels for this class of signal.

### Termination

Receive signals require termination of 100  $\Omega$  differential. This termination should be on-die but board-level termination is acceptable.

### Impedance

These traces must support 100  $\Omega$  differential impedances and can be routed as loosely coupled or tightly coupled (edge or broadside).

### Layout Guidelines

Trace widths should be kept at or above 5 mils to reduce skin-effect losses and should reference a ground layer with no split plane crossings. These signals should be kept under 6 inches on a host if at all possible. Adherence to these simple guidelines, as well as those in the signal integrity section of this document will ensure the best performance and broadest compatibility with mezzanine cards of different types. Any traces designed to go over 1 Gbps should be simulated.

See [Chapter 6, Signal Integrity](#) for more details.

## 3.3.4.2 CMOS/LVDS

### Definition

The *CMOS/LVDS* class pins are intended to connect directly to I/O pins on the host FPGA that can be configured either as LVDS-compatible differential pairs or LVTTTL compatible single-ended I/O standards. The active I/O type can be programmed either by changing the FPGA configuration file or by modifying the signaling standard in-circuit.

### Signal Directions

When programmed in single-ended mode on the host FPGA, these signals must support bidirectional operation. When programmed in differential mode, these signals are unidirectional with a naming convention to be based on the host. For example, pin 47 (LVDS\_TXp0) and pin 49 (LVDS\_TXn0) should connect to LVDS-compatible output pins whereas pin 48 (LVDS\_RXp0) and pin 50 (LVDS\_RXn0) should connect to LVDS compatible input pins.

### Reduced Bus Widths

It is strongly suggested that host boards are designed to support the full specified bus widths. This interface is the main data bus portion of the HSMC specification and full support will guarantee inter-operability with the greatest number of mezzanine cards. If absolutely necessary due to pin limitations, signals should be populated starting at pin 41 and continue to the higher numbered signals. Note that pins 41, 42, 43, and 44 are intended to be single-ended only as described in the *CMOS* class section. These signals should be populated before those starting at pin 47 where signals become *CMOS/LVDS* class. Pins 41, 42, 43, and 44 are guaranteed

to operate at full speed concurrently with other host pins that are configured as differential. This configuration is important because designers of host boards must account for restrictions in I/O placement when both single-ended and differential pins are used. These rules are FPGA family and device specific but must be followed on any host board design to maintain the highest level of inter-operability with the greatest number of mezzanine cards. For pin numbers and data bus numbering, refer to “[Standard Differential Host Pinout](#)” on page 4-4.

### Coupling

All signals of this class must be DC-coupled on the host. Mezzanine card design can add A/C coupling as required but common-mode levels must be translated to HSMC compliant levels for this class of signal.

### Termination

Because these pins can be programmed to either differential or single-ended standards, the termination requirements require careful consideration.

For **single-ended** operation, it is ideal if the host FPGA supports driver strength control where 50- $\Omega$  output impedances can be selected. This output impedances will match the characteristic impedance of the traces themselves. For long trace lengths or heavy loads, drive strength could be increased as necessary until optimal signal integrity is achieved for the specific host board or mezzanine card combination. When impedance control is not possible, it is recommended to place series resistors on each line of a host board to allow for tuning through resistor value changes. Default resistors should be 0  $\Omega$  nominally since signal direction can not be assumed on a host board and higher values resistors found near a receiver can degrade signal integrity significantly. Programmable input termination is also ideally available so that a particular mezzanine card can be optimized but no input termination should be placed on a board or be permanently enabled on-die because signal direction is unknown on a generic host board.

For **differential** operation it is ideal if the host FPGA supports on-die 100  $\Omega$  differential termination between designated receiver pin pairs. For example, signals on a host that are connected to pin 48 (LVDS\_RXp0) and pin 50 (LVDS\_RXn0) must have the capability to allow for either on-die or on-board termination between the two pins, pin 47 (LVDS\_TXp0) and pin 49 (LVDS\_TXn0). This termination must be able to be disabled or removed to allow for less coupling when these pins are used as single-ended signals. For host boards which require to provide these as on-board resistors, it is recommended that they are not to be populated by default. It is anticipated that more mezzanine cards will use this class of pins in a single-ended configuration versus a differential configuration.

### Impedance

These traces must have 50  $\Omega$  single-ended impedances and must be routed as loosely coupled pairs to minimize cross talk between p and n signals as they can also be used in a differential configuration.

### Layout Guidelines

These signals should be matched in length to support high-speed source-synchronous connections. It is recommended that host boards match traces within 100 mils so that rise-times are not severely affected when the signals are operated as differential pairs. If a host board FPGA supports dynamic phase alignment (DPA) and does not require trace length matching, it is still recommended to match traces within 100 mils so that operation with mezzanine cards having devices which do not support this feature can still function. Trace widths can vary according to the stack up and intended frequency of operation or rise times.

See [Chapter 6, Signal Integrity](#) for more details.

### 3.3.4.3 CMOS

The *CMOS* class pins are intended to connect directly to pins that support LVTTTL compatible single-ended I/O standards such as 3.3-V LVTTTL/LVCMOS or 2.5-V LVTTTL/LVCMOS.

#### Signal Directions

All *CMOS* class pins must support bidirectional operation.

#### Reduced Bus Widths

It is strongly suggested that host boards are designed to support the full 80-bit data bus width. This interface is the main interface for an HSMC for address, data, and control. Full support will guarantee inter-operability with the greatest number of mezzanine cards. If absolutely necessary due to pin limitations, signals should be populated starting at pin 41 and continue to the higher numbered signals. For pin numbers and data bus numbering, refer to “[Standard Single-Ended Host Pinout](#)” on [page 4-1](#). For more information about the optional signals, D80 through D111, listed in the “[Standard Single-Ended Host Pinout](#)” section, refer to the Reduced Bus Width section in “[Transceiver](#)” on [page 3-3](#).

#### Coupling

All signals of this class must be DC-coupled on the host. Mezzanine cards are assumed to be DC-coupled as well though there is no requirement.

#### Termination

It is ideal if the host FPGA supports driver strength control where 50  $\Omega$  output impedances can be selected. This output impedance will match the characteristic impedance of the traces themselves. For long trace lengths or heavy loads, drive strength could be increased as necessary until optimal signal integrity is achieved for the specific host board or mezzanine card combination. When impedance control is not possible, it is recommended to place series resistors on each line of a host board to allow for tuning through resistor value changes. Default resistors should be 0  $\Omega$  nominally since signal direction can not be assumed on a host board and

higher values resistors found near a receiver can degrade signal integrity significantly. Programmable input termination on the host FPGA is also ideally available so that a particular mezzanine card can be optimized but no input termination should be placed on a board or be permanently enabled on-die because signal direction is unknown on a generic host board.

### Impedance

These traces must have 50  $\Omega$  single-ended impedances.

### Layout Guidelines

These signals should be matched in length to support high-speed source-synchronous connections. It is recommended that host boards match traces within 250 mils to enable tight timing constraints to be achieved across a variety of mezzanine card timing requirements. Trace widths can vary according to the stack up and intended frequency of operation or rise times.

See [Chapter 6, Signal Integrity](#) for more details.

## 3.3.4.4 CMOS CLK

### Definition

The *CMOS CLK* class pins are intended to connect directly to pins that support LVTTTL compatible single-ended I/O standards such as 3.3-V LVTTTL/LVCMOS or 2.5-V LVTTTL/LVCMOS. These pins should also be operable as clocks in host FPGA devices relative to other signals in banks 2 and 3 of the “[Standard Single-Ended Host Pinout](#)” or “[Standard Differential Host Pinout](#)” sections. It is recommended to use dedicated clock pins on host FPGA devices even if any pin can be connected to FPGA clock networks. Any LVTTTL-compatible pin can be used for output clocks as long as it can operate synchronously with the pins listed in the “[Standard Single-Ended Host Pinout](#)” or “[Standard Differential Host Pinout](#)” sections with a known static delay.

### Signal Directions

Pin 40 (CLKIN0) must be connected to an input pin on the host FPGA. Pin 39 (CLKOUT0) must be connected to an output pin on the FPGA.

### Reduced Bus Widths

Every host board must provide these two clock signals. These two pins are the recommended default clock signal pins for timing data transfers between host board FPGA devices and mezzanine cards for single-data-rate applications.

### Coupling

All signals of this class must be DC-coupled on the host. Mezzanine cards are assumed to be DC-coupled as well though there is no requirement.



### Termination

It is ideal if the host FPGA supports driver strength control where 50  $\Omega$  output impedances can be selected. This output impedances will match the characteristic impedance of the traces themselves. For long trace lengths or heavy loads, drive strength could be increased as necessary until optimal signal integrity is achieved for the specific host board/mezzanine card combination. When impedance control is not possible it is recommended to place series resistors on each line of a host board to allow for tuning through resistor value changes. Default resistor values should be calculated using simulations assuming worst-case trace lengths on the host board and 3 inches trace lengths on a mezzanine card.

### Impedance

These traces must have 50  $\Omega$  single-ended impedances.

### Layout Guidelines

These signals should match in length to the signals listed in the “[Standard Single-Ended Host Pinout](#)” or “[Standard Differential Host Pinout](#)” sections. It is recommended that host boards match traces within 250 mils to enable tight timing constraints to be achieved across a variety of mezzanine card timing requirements. Trace widths can vary according to the stack up and intended frequency of operation or rise times.

See [Chapter 6, Signal Integrity](#) for more details.

## 3.3.4.5 CMOS/LVDS CLK

### Definition

The *CMOS/LVDS CLK* class pins are intended to connect directly to pins that support both either differential or LVTTTL-compatible single-ended I/O standards such as 3.3-V LVTTTL/LVCMOS or 2.5-V LVTTTL/LVCMOS. If a host board FPGA cannot support the programmability of the input pins as either differential or single-ended then these pins should be connected as *CMOS* class pins. These pins should also be operable as clocks in host FPGA devices relative to other signals in banks 2 and 3 of the “[Standard Single-Ended Host Pinout](#)” or “[Standard Differential Host Pinout](#)” sections. It is recommended to use dedicated clock pins on host FPGA devices even if any pin can be connected to FPGA clock networks. Any LVTTTL-compatible pin can be used for output clocks as long as it can operate synchronously with the pins listed in the “[Standard Single-Ended Host Pinout](#)” or “[Standard Differential Host Pinout](#)” sections with a known static delay.



Clock 2, found in bank 2 of the connector, is considered the primary clock of the two in or out pairs. If there is a limit on the number of dedicated clock input pins on a host FPGA, Clock 2 should be chosen over Clock 1 for these connections.

### Signal Directions

When programmed in single-ended mode on the host FPGA, these signals must support bidirectional operation. When programmed in differential mode, these signals are unidirectional with a naming convention to be based on the host. For example, pin 95 (CLKOUT1P) and pin 97 (CLKOUT1N) should connect to LVDS-compatible output pins and pin 96 (CLKIN1P) and pin 98 (CLKIN1N) should connect to LVDS-compatible input pins.

### Reduced Bus Widths

It is strongly suggested that host boards are designed to support the full 80-bit data bus width. This interface is the main interface for an HSMC for address, data, and control. Full support will guarantee inter-operability with the greatest number of mezzanine cards.

### Coupling

All signals of this class must be DC-coupled on the host. Mezzanine cards are assumed to be DC-coupled as well though there is no requirement.

### Termination

It is ideal if the host FPGA supports driver strength control where 50  $\Omega$  output impedances can be selected. This output impedances will match the characteristic impedance of the traces themselves. For long trace lengths or heavy loads, drive strength could be increased as necessary until optimal signal integrity is achieved for the specific host board or mezzanine card combination. When impedance control is not possible it is recommended to place series resistors on each line of a host board to allow for tuning through resistor value changes. Default resistors should be 0  $\Omega$  nominally since signal direction can not be assumed on a host board and higher values resistors found near a receiver can degrade signal integrity significantly. Programmable input termination on the host FPGA is also ideally available so that a particular mezzanine card can be optimized but no input termination should be placed on a board or be permanently enabled on-die because signal direction is unknown on a generic host board.

### Impedance

These traces must have 50  $\Omega$  single-ended impedances.

### Layout Guidelines

These signals should match in length to the signals listed in the “[Standard Single-Ended Host Pinout](#)” or “[Standard Differential Host Pinout](#)” sections. It is recommended that host boards match traces within 100 mils as are signals in the *CMOS/LVDS* pin class description. Trace widths can vary according to the stack up and intended frequency of operation or rise times.

See [Chapter 6, Signal Integrity](#) for more details.

### 3.3.4.6 JTAG/CMOS

The JTAG/CMOS signals are intended to connect to dedicated JTAG pins on the host FPGA and be part of the host FPGA device's JTAG chain. If a host has multiple JTAG chains then the one that includes the host FPGA should also include the HSMC JTAG pins. A host must provide a switch or jumper to remove the HSMC from the chain if an installed HSMC does not have a JTAG chain or an HSMC is not installed. JTAG is assumed to be LVTTTL-compatible. If the host has low-voltage pins on TDO then the signal must be **up-converted** to LVTTTL-compatible levels. A host should be driving JTAG data to pin 38 and receiving JTAG data from pin 37.

Mezzanine card designs should connect TDI to TDO if JTAG-compatible devices are not present.

<i>Table 3–2. JTAG Signals</i>	
Signal Name	Description
JTAG TCK	JTAG Clock — output from Host Board
JTAG TMS	JTAG Mode Select — output from Host Board
JTAG TDI	JTAG Data In — output from Host Board
JTAG TDO	JTAG Data Out — input to Host Board

### 3.3.4.7 SMBUS/CMOS

The *SMBUS/CMOS* signals are intended to connect directly to LVTTTL-compatible I/O pins on the host FPGA and to serial EEPROM device on a mezzanine card. For active mezzanine cards, the EEPROM device should contain information regarding the card that is installed. For passive adapters, the signals can optionally route through to compatible pins on the card being plugged into the HSMC adapter (for example, PCI Express has SMBUS pins).

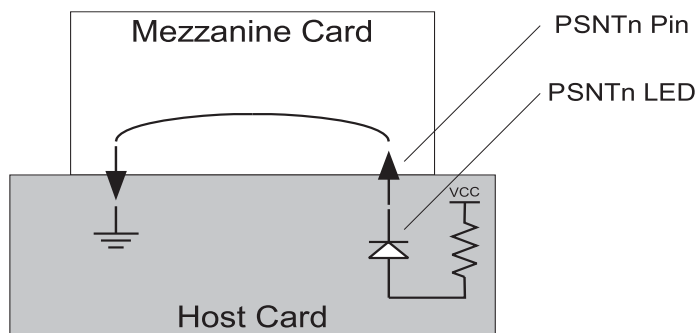
<i>Table 3–3. SMBUS Signals</i>	
Signal Name	Description
SCL	Serial Clock — driven from host FPGA
SDA	Serial Data — bidirectional data

### 3.3.4.8 PSNTn

The PSNTn pin is meant to drive an LED when the card is present, meaning correctly installed on a host. This signal should connect to GND on a mezzanine card design. A host should provide a single green LED near either pin 1 or pin 159 outside the host keep out area that is powered from an appropriate voltage such that, when an HSMC is inserted, the LED turns on with current flowing from the host through the

LED and resistor to pin 160 of the host Samtec socket to GND on pin 160 of the mezzanine card pin 160. A typical setup would use 3.3 V to an LED anode, an LED cathode to a current limiting resistor, to pin 160 of the Samtec socket on the host.

**Figure 3–1. Mezzanine Card**



## 3.4 Signaling Levels

The HSMC interface supports three basic types of signaling standards: LVTTTL, LVDS, and PCML. Host boards and mezzanine cards that claim to have HSMC-compliant interfaces do not have to support all three signal types but they must support at least one that is compatible.

In general, most single-ended 2.5-V and 3.3-V components are compatible using LVTTTL levels. Table 3–4 shows the compatible signaling levels. LVDS pins may be able to drive other standards such as mini-LVDS or RSDS but the default operation should match with Table 3–4. Directions are relative to the host FPGA. Signal levels are taken at the connector. Some headroom has been added to industry standard levels for loss due to the host itself and unknown mezzanine card losses.

<b>Table 3–4. Signaling Levels (Part 1 of 2)</b>			
<b>Signal Type</b>	<b>Parameter</b>	<b>Minimum</b>	<b>Maximum</b>
LVTTTL	$V_{CC_{IO}}$	2.50 V (1)	3.30 V (1)
	$V_{IH}$	1.80 V	$V_{CC_{IO}} + 300 \text{ mV}$
	$V_{IL}$	GND – 300 mV	0.90 V
	$V_{OH}$	2.00 V	$V_{CC_{IO}}$
	$V_{OL}$	GND	0.45 V

**Table 3–4. Signaling Levels (Part 2 of 2)**

Signal Type	Parameter	Minimum	Maximum
LVDS	$V_{ID}$	200 mV	900 mV
	$V_{ICM}$	200 mV	1800 mV
	$V_{OD}$	250 mV	450 mV
	$V_{OCM}$	1125 mV	1375 mV
	$VCC_{IO}$	2.50 V (1)	3.30 V (1)
	$R_{TERM}$	85 $\Omega$	115 $\Omega$
PCML	$V_{ID}$	400 mV	2000 mV
	$V_{ICM}$	N/A (2)	N/A (2)
	$V_{OD}$	500 mV	1200 mV
	$V_{OCM}$	300 mV	1000 mV
	$VCC_{IO}$	N/A	N/A
	$R_{TERM}$	85 $\Omega$	115 $\Omega$

**Notes to Table 3–4:**

- (1) These values should be considered typical.
- (2) PCML interface assumes A/C-coupling. D/C-coupled applications need to be designed to meet the HSMC host board's FPGA actual common mode range.

It is desirable for host boards to be able to support either LVDS or LVTTL-compatible single-ended signaling by reprogramming the FPGA. In this case one would typically choose a  $VCC_{IO}$  level that accommodates both standards if possible. For example, Stratix II and Stratix III FPGA devices use 2.5-V power levels for LVDS signaling. These same devices can use 2.5 V or 3.3 V for LVTTL-compatible signaling levels in single-ended applications. The 2.5-V level should be chosen for the board because this supports both LVDS and the LVTTL-compatible 2.5-V CMOS standard.

Because overshoot and undershoot can be a greater concern for smaller process geometry devices in 65 nm and 40 nm, the designer needs to consider the acceptable overshoot to make sure device damage does not occur.

## 3.5 Trace Impedance

All traces are assumed to be 50  $\Omega$  single-ended traces. For LVDS or CMOS signals, the recommendation is to route those as loosely coupled meaning the traces are closer to the reference plane than they are to each other.

## 3.6 Trace Lengths

Both maximum trace lengths and trace length matching need to be considered for both host boards and mezzanine cards. In general the host boards have the most stringent constraints and the mezzanine card can vary based on the application-specific constraints. These constraints vary by the signal type and board class.

Table 3–5 shows the trace length matching.

<b>Table 3–5. Trace Length Matching</b>				
Type	Board Class	Signal Type	Constraint	Value
I	SE	CMOS	MAX Length	8000 mils
			Length Matching	± 250 mils
II	SE + LVDS	CMOS/LVDS	MAX Length	8000 mils
			Length Matching	± 50 mils
			P/N Length Matching	± 10 mils
III	Universal	CMOS/LVDS	MAX Length	8000 mils
			Length Matching	± 50 mils
			P/N Length Matching	± 10 mils
		PCML	MAX Length	6000 mils
			Length Matching	± 250 mils (1)
			P/N Length Matching	± 5 mils
IV	Transceiver	PCML	MAX Length	6000 mils
			Length Matching	± 250 mils (1)
			P/N Length Matching	± 5 mils

Note to Table 3–5:

(1) Within a four-channel group such as XCVR\_TX(7:4) or XCVR\_TX(3:0).

## 3.7 Cross Talk

The allowable cross talk for this specification is 10% of the signal swing. For example, 3.3-V CMOS should be designed for 330 mV or less, and 2.5-V CMOS should be designed for 25 mV or less. These cross talk rules are enforced by setting up parallelism rules for PCB design.

The cross talk spacing rules shown in Table 3–6 reflect a PCB with a 4 mil plane to signal distance. If the stack up is different, the rules should be scaled accordingly using the **Trace Spacing versus Reference Plane Distance** column though simulation. This scaling is the only way to ensure compatibility with the cross-talk allowance.

<i>Table 3–6. Cross Talk Spacing Rules</i>		
Trace Spacing (Air Gap)	Parallel Trace Maximum Run Length	Trace Spacing versus Reference Plane Distance
4 mils	< 500 mils	1× plane to trace
8 mils	500 to 1500 mils	2× plane to trace
12 mils	>1500 mils	3× plane to trace

## 3.8 Power

The HSMC interface is designed such that it can carry well distributed +12 V, +3.3 V power and numerous GND lines. These power lines can be converted on the mezzanine card to any voltage required. The following sections provide detailed information about the power capability and power pinout.

### 3.8.1 Connector Current Capability

The power connections include 19 pins of 12 V and 20 pins of 3.3 V through Bank 2 and 3 respectively. The ground connection consists of 12 very wide center beams that are part of the Samtec QSH-DP connector's center ground rail. The ground plane connections are rated at 7.8 A. Table 3–7 shows the ratings for these connections assuming the pinout in the following section. These numbers should be used as approximations. Actual ratings for the connections should be obtained from Samtec.

<i>Table 3–7. Connector Current Capability (Part 1 of 2)</i>					
Bank	Pin Class	Voltage	Pin Count	Current	Wattage
Bank 1	Signal	12 V	0	—	—
		3.3 V	0	—	—
	Plane	GND	4	2.0 A / ea	—
Bank 2	Signal	12 V	10	1.0 A / ea	120.0 W
		3.3 V	10	1.0 A / ea	33 W
	Plane	GND	4	2.0 A / ea	—

**Table 3–7. Connector Current Capability (Part 2 of 2)**

Bank	Pin Class	Voltage	Pin Count	Current	Wattage
Bank 3	Signal	12 V	9	1.0 A / ea	108.0 W
		3.3 V	10	1.0 A / ea	33 W
	Plane	GND	4	2.0 A / ea	—
Total	Signal	12 V	19	20 A	228.0 W
		3.3 V	20	20 A	66.0 W
	Plane	GND	12	24 A	—

It is suggested that host boards are designed to provide the following minimum current levels to the connectors (see [Table 3–8](#)) in order to allow for broad support of various card and host designs. If possible, the current level supported can be placed on the board directly in silkscreen on a host.

**Table 3–8. Recommended Host Power Delivery**

Voltage	Min Current from Host	Min Wattage
12 V	1.0 A	12.0 W
3.3 V	2.0 A	6.6 W
<b>Total</b>		<b>18.6 W per HSMC</b>

If a host is unable to deliver the above listed power then it needs to be documented and some method of external powering should be provided using a jack or test point at a minimum. Mezzanine cards that exceed these levels should provide a similar jack or test point.



## 3.8.2 Power Pinout

Table 3–9 shows the power pin positions within the HSMC connector. The center-rail ground plane connections (four per bank) are shown numbered at the end after the signal pin numbering is complete.

<i>Table 3–9. Power Pin Positions within Samtec Connector (Part 1 of 4)</i>				
Pin Number	Function	Bank Number	Function	Pin Number
1	Signal	Bank 1	Signal	2
3	Signal		Signal	4
5	Signal		Signal	6
7	Signal		Signal	8
9	Signal		Signal	10
11	Signal		Signal	12
13	Signal		Signal	14
15	Signal		Signal	16
17	Signal		Signal	18
19	Signal		Signal	20
21	Signal		Signal	22
23	Signal		Signal	24
25	Signal		Signal	26
27	Signal		Signal	28
29	Signal		Signal	30
31	Signal		Signal	32
33	Signal		Signal	34
35	Signal		Signal	36
37	Signal		Signal	38
39	Signal		Signal	40

**Table 3–9. Power Pin Positions within Samtec Connector (Part 2 of 4)**

Pin Number	Function	Bank Number	Function	Pin Number
41	Signal	Bank 2	Signal	42
43	Signal		Signal	44
45	3.3 V		12 V	46
47	Signal		Signal	48
49	Signal		Signal	50
51	3.3 V		12 V	52
53	Signal		Signal	54
55	Signal		Signal	56
57	3.3 V		12 V	58
59	Signal		Signal	60
61	Signal		Signal	62
63	3.3 V		12 V	64
65	Signal		Signal	66
67	Signal		Signal	68
69	3.3 V		12 V	70
71	Signal		Signal	72
73	Signal		Signal	74
75	3.3 V		12 V	76
77	Signal		Signal	78
79	Signal		Signal	80
81	3.3 V		12 V	82
83	Signal		Signal	84
85	Signal		Signal	86
87	3.3 V		12 V	88
89	Signal		Signal	90
91	Signal		Signal	92
93	3.3 V		12 V	94
95	Signal		Signal	96
97	Signal		Signal	98
99	3.3 V		12 V	100

**Table 3–9. Power Pin Positions within Samtec Connector (Part 3 of 4)**

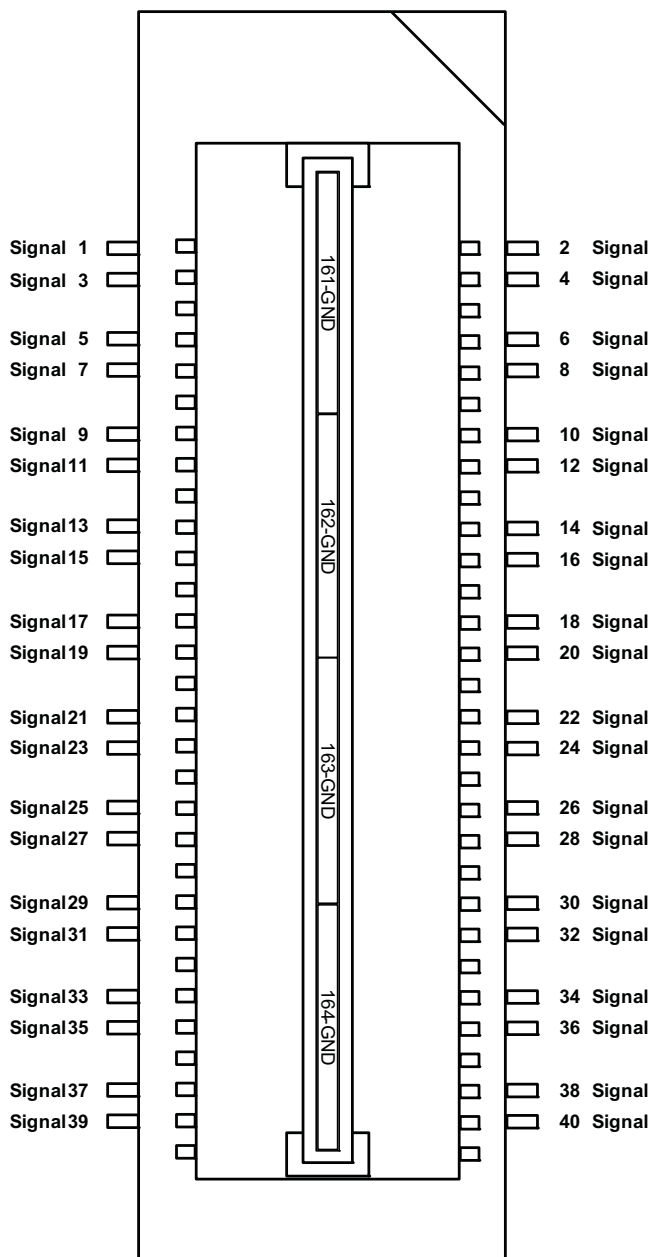
Pin Number	Function	Bank Number	Function	Pin Number
101	Signal	Bank 3	Signal	102
103	Signal		Signal	104
105	3.3 V		12 V	106
107	Signal		Signal	108
109	Signal		Signal	110
111	3.3 V		12 V	112
113	Signal		Signal	114
115	Signal		Signal	116
117	3.3 V		12 V	118
119	Signal		Signal	120
121	Signal		Signal	122
123	3.3 V		12 V	124
125	Signal		Signal	126
127	Signal		Signal	128
129	3.3 V		12 V	130
131	Signal		Signal	132
133	Signal		Signal	134
135	3.3 V		12 V	136
137	Signal		Signal	138
139	Signal		Signal	140
141	3.3 V	12 V	142	
143	Signal	Signal	144	
145	Signal	Signal	146	
147	3.3 V	12 V	148	
149	Signal	Signal	150	
151	Signal	Signal	152	
153	3.3 V	12 V	154	
155	Signal	Signal	156	
157	Signal	Signal	158	
159	3.3 V	PSNTn (1)	160	
161	Bank 1 GND Rail 1			
162	Bank 1 GND Rail 2			
163	Bank 1 GND Rail 3			
164	Bank 1 GND Rail 4			

<i>Table 3–9. Power Pin Positions within Samtec Connector (Part 4 of 4)</i>				
Pin Number	Function	Bank Number	Function	Pin Number
165		Bank 2 GND Rail 1		
166		Bank 2 GND Rail 2		
167		Bank 2 GND Rail 3		
168		Bank 2 GND Rail 4		
169		Bank 3 GND Rail 1		
170		Bank 3 GND Rail 2		
171		Bank 3 GND Rail 3		
172		Bank 3 GND Rail 4		

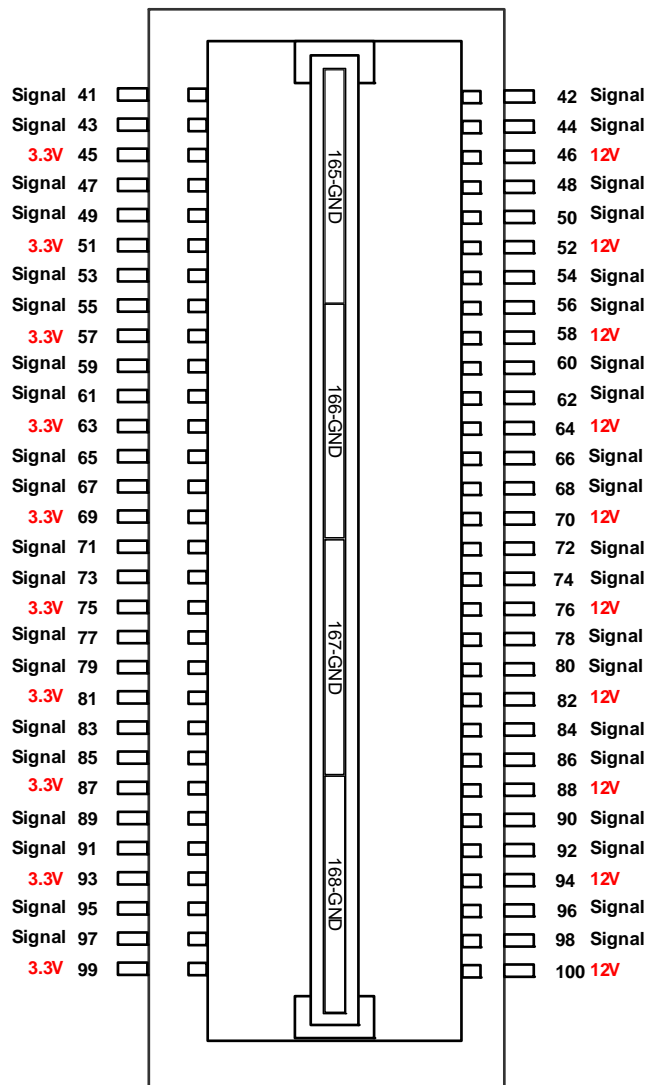
*Note to Table 3–9:*

(1) PSNTn connects to GND on mezzanine card.

Figure 3–2, Figure 3–3, and Figure 3–4 shows pin distribution for the HSMC socket (ASP-122953-01).

**Figure 3–2. HSMC Socket (ASP-122953-01) - Bank 1**

**Figure 3–3. HSMC Socket (ASP-122953-01) - Bank2**



**Figure 3–4. HSMC Socket (ASP-122953-01) - Bank3**

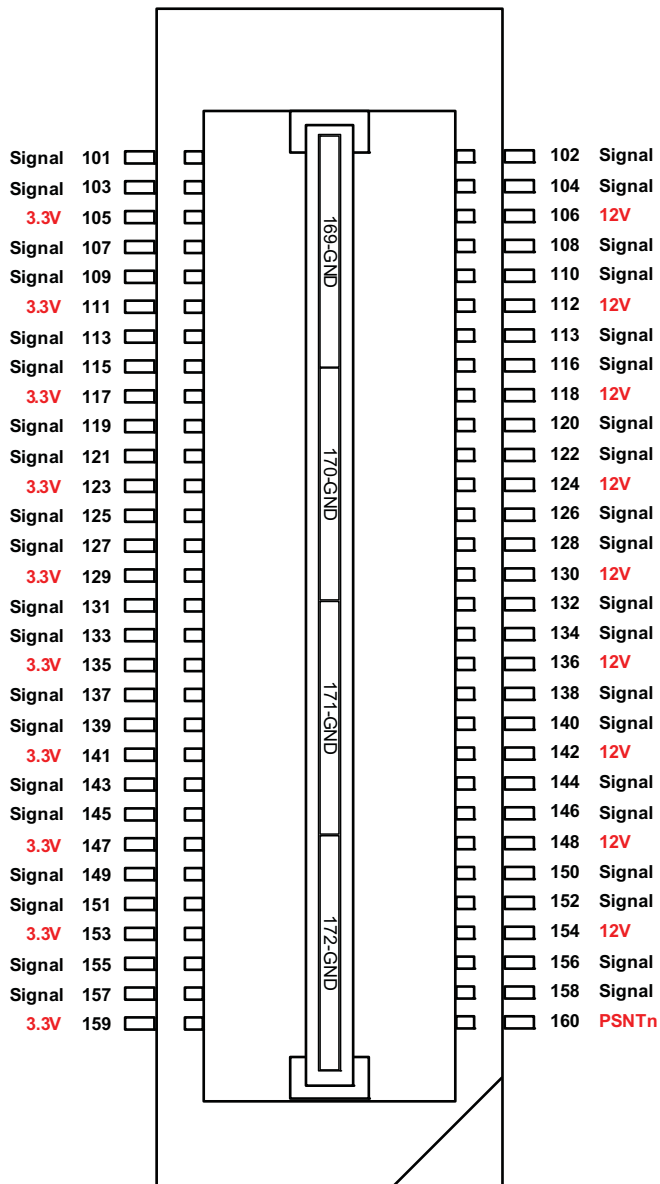
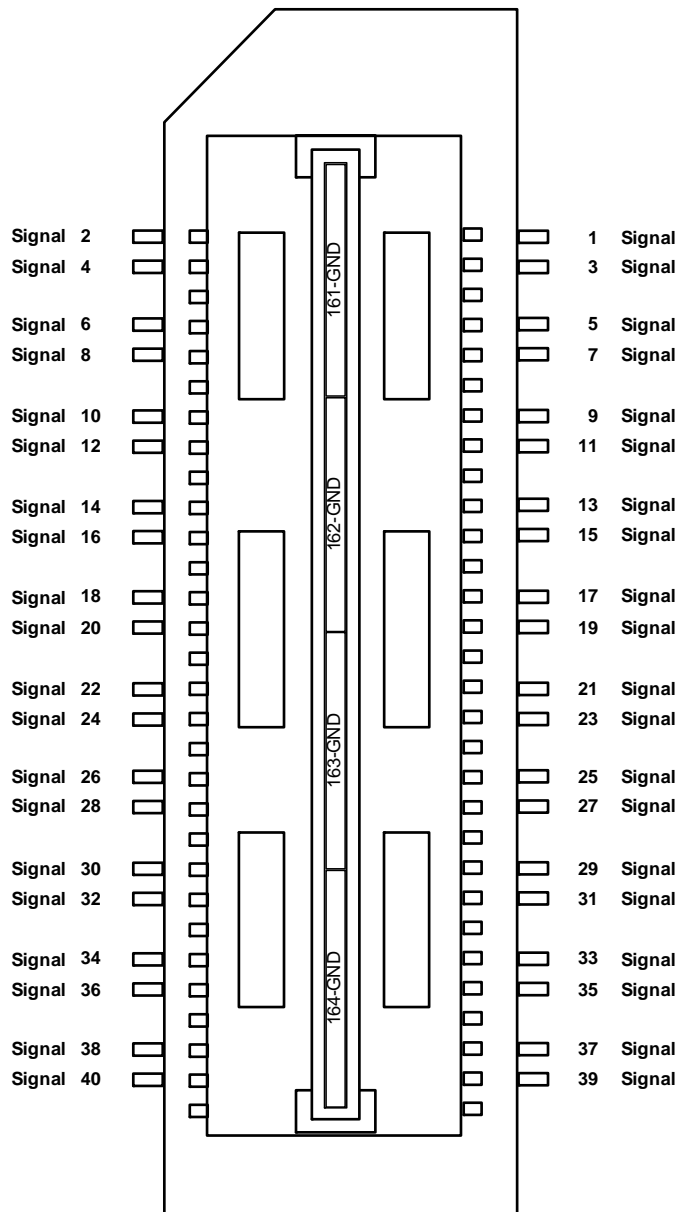
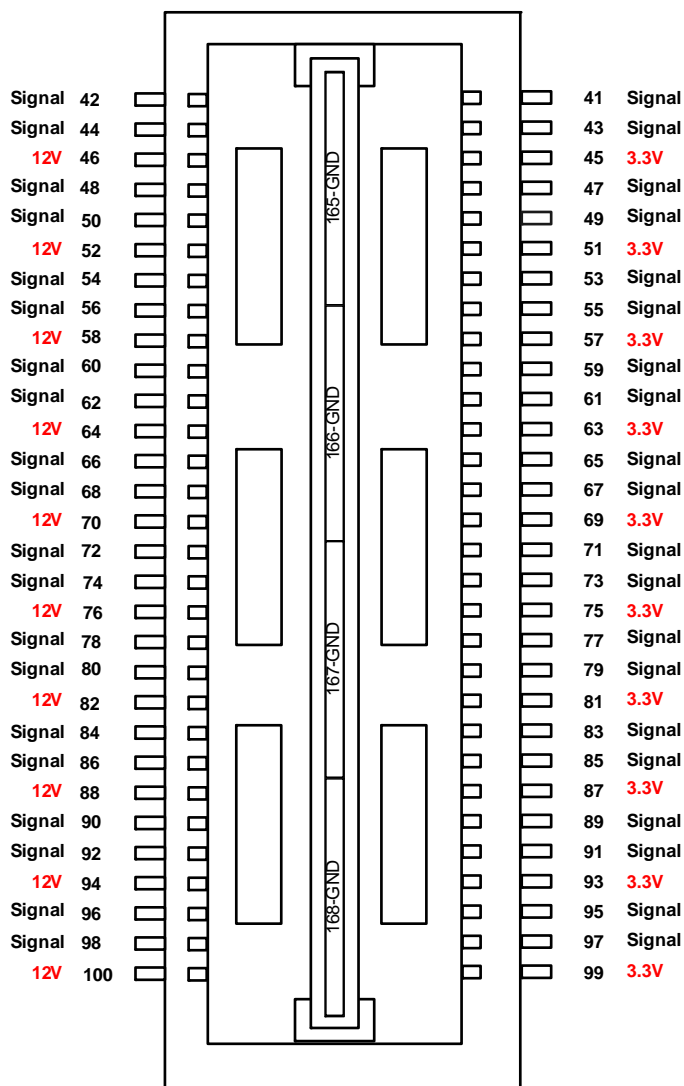


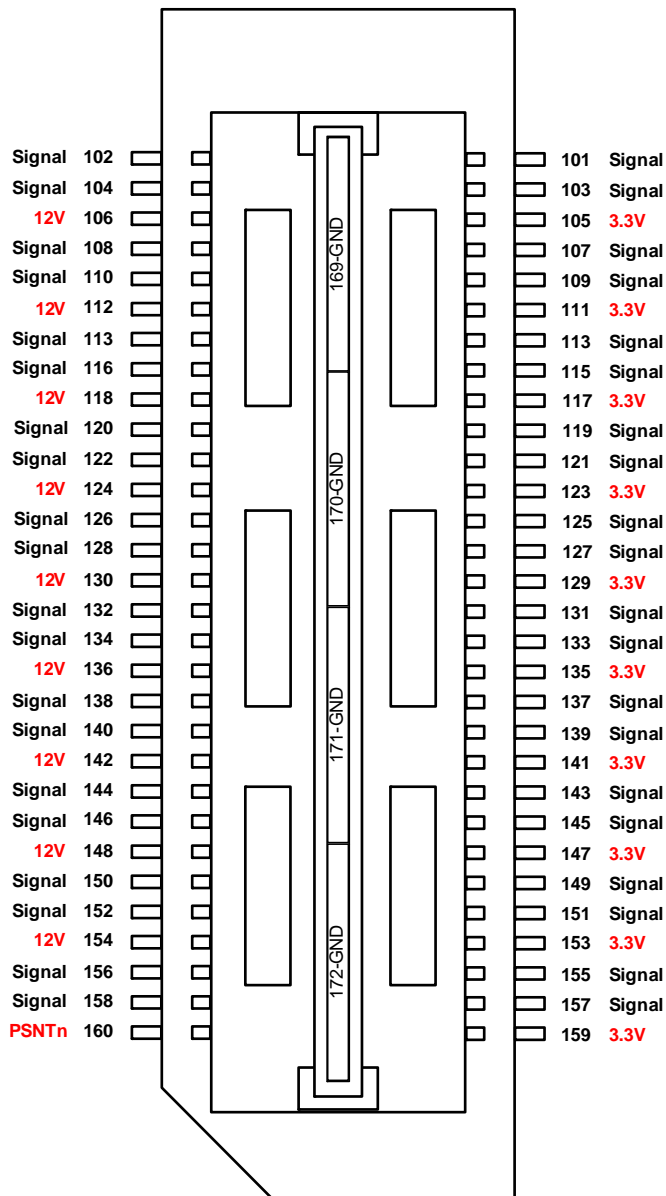
Figure 3–5, Figure 3–6, and Figure 3–7 shows pin distribution for the mezzanine card header (ASP-122952-01).

**Figure 3–5. Mezzanine Card Header (ASP 122952-01) - Bank 1**



**Figure 3–6. Mezzanine Card Header (ASP-122952-01) - Bank 2**



**Figure 3–7. Mezzanine Card Header (ASP-122952-01) - Bank 3**

## 4.1 Overview

This chapter details the generic pinouts for use on host boards for both differential and single-ended standards, followed by recommended pinout mappings based on standard HSMC board classes.

## 4.2 Standard Host Pinouts

The following sections describe the intended generic pinouts both in physical location and electrical definition. The generic pin tables shown in the following sections are considered the **standard** pinout schemes for single-ended, differential, or both. Adhering to these pinouts allows a single host to use the maximum number of adapter cards. It is assumed that the LVDS pins double as CMOS per the host-board's programming for **Class II or Universal Class IV**. This assumption requires the layout to use single-ended routing to minimize cross talk when single-ended applications are used.

### 4.2.1 Standard Single-Ended Host Pinout

Table 4–1 lists the standard single-ended host pinout. This table represents Class I and Class II host boards and mezzanine cards.

Table 4–1. Standard Single-Ended Host Pinout (Part 1 of 4)				
Pin Number	Function	Function	Pin Number	Description
1	XCVR_TXp7	XCVR_RXp7	2	CMOS (1) <sup>(1)</sup>
3	XCVR_TXn7	XCVR_RXn7	4	CMOS (1) <sup>(1)</sup>
5	XCVR_TXp6	XCVR_RXp6	6	CMOS (1) <sup>(1)</sup>
7	XCVR_TXn6	XCVR_RXn6	8	CMOS (1) <sup>(1)</sup>
9	XCVR_TXp5	XCVR_RXp5	10	CMOS (1) <sup>(1)</sup>
11	XCVR_TXn5	XCVR_RXn5	12	CMOS (1) <sup>(1)</sup>
13	XCVR_TXp4	XCVR_RXp4	14	CMOS (1) <sup>(1)</sup>
15	XCVR_TXn4	XCVR_RXn4	16	CMOS (1) <sup>(1)</sup>
17	XCVR_TXp3	XCVR_RXp3	18	CMOS (1) <sup>(1)</sup>

**Table 4–1. Standard Single-Ended Host Pinout (Part 2 of 4)**

Pin Number	Function	Function	Pin Number	Description
19	XCVR_TXn3	XCVR_RXn3	20	CMOS (1) <sup>(1)</sup>
21	XCVR_TXp2	XCVR_RXp2	22	CMOS (1) <sup>(1)</sup>
23	XCVR_TXn2	XCVR_RXn2	24	CMOS (1) <sup>(1)</sup>
25	XCVR_TXp1	XCVR_RXp1	26	CMOS (1) <sup>(1)</sup>
27	XCVR_TXn1	XCVR_RXn1	28	CMOS (1) <sup>(1)</sup>
29	XCVR_TXp0	XCVR_RXp0	30	CMOS (1) <sup>(1)</sup>
31	XCVR_TXn0	XCVR_RXn0	32	CMOS (1) <sup>(1)</sup>
33	SDA	SCL	34	SMBUS/CMOS
35	JTAG_TCK	JTAG_TMS	36	JTAG/CMOS
37	JTAG_TDO	JTAG_TDI	38	JTAG/CMOS
39	CLKOUT0	CLKIN0	40	CMOS CLK
41	D0	D1	42	CMOS
43	D2	D3	44	CMOS
45	3.3 V	12 V	46	Power
47	D4	D5	48	CMOS
49	D6	D7	50	CMOS
51	3.3 V	12 V	52	Power
53	D8	D9	54	CMOS
55	D10	D11	56	CMOS
57	3.3 V	12 V	58	Power
59	D12	D13	60	CMOS
61	D14	D15	62	CMOS
63	3.3 V	12 V	64	Power
65	D16	D17	66	CMOS
67	D18	D19	68	CMOS
69	3.3 V	12 V	70	Power
71	D20	D21	72	CMOS
73	D22	D23	74	CMOS
75	3.3 V	12 V	76	Power
77	D24	D25	78	CMOS
79	D26	D27	80	CMOS

**Table 4–1. Standard Single-Ended Host Pinout (Part 3 of 4)**

Pin Number	Function	Function	Pin Number	Description
81	3.3 V	12 V	82	Power
83	D28	D29	84	CMOS
85	D30	D31	86	CMOS
87	3.3 V	12 V	88	Power
89	D32	D33	90	CMOS
91	D34	D35	92	CMOS
93	3.3 V	12 V	94	Power
95	D36	D37	96	LVDS CLKp/CMOS
97	D38	D39	98	LVDS CLKn/CMOS
99	3.3 V	12 V	100	Power
101	D40	D41	102	CMOS
103	D42	D43	104	CMOS
105	3.3 V	12 V	106	Power
107	D44	D45	108	CMOS
109	D46	D47	110	CMOS
111	3.3 V	12 V	112	Power
113	D48	D49	114	CMOS
115	D50	D51	116	CMOS
117	3.3 V	12 V	118	Power
119	D52	D53	120	CMOS
121	D54	D55	122	CMOS
123	3.3 V	12 V	124	Power
125	D56	D57	126	CMOS
127	D58	D59	128	CMOS
129	3.3 V	12 V	130	Power
131	D60	D61	132	CMOS
133	D62	D63	134	CMOS
135	3.3 V	12 V	136	Power
137	D64	D65	138	CMOS
139	D66	D67	140	CMOS
141	3.3 V	12 V	142	Power
143	D68	D69	144	CMOS

<b>Table 4–1. Standard Single-Ended Host Pinout (Part 4 of 4)</b>				
<b>Pin Number</b>	<b>Function</b>	<b>Function</b>	<b>Pin Number</b>	<b>Description</b>
145	D70	D71	146	CMOS
147	3.3 V	1.2 V	148	Power
149	D72	D73	150	CMOS
151	D74	D75	152	CMOS
153	3.3 V	1.2 V	154	Power
155	D76	D77	156	LVDS CLKp/CMOS
157	D78	D79	158	LVDS CLKn/CMOS
159	3.3 V	PSNTn <sup>(2)</sup>	160	Power/PSNTn <sup>(2)</sup>

**Notes to Table 4–1:**

- (1) Use of these signals for CMOS is considered outside the scope of this specification as these pins are intended for transceivers, which typically can neither drive CMOS levels or accept them as inputs. A mezzanine card that is designed to use these for CMOS should ensure that these pins can be tri-stated to NOT damage a potential Class III or Class IV transceiver-enabled board.
- (2) PSNTn connects to GND on mezzanine card.

## 4.2.2 Standard Differential Host Pinout

Table 4–2 lists the standard differential host pinout.

<b>Table 4–2. Standard Differential Host Pinout (Part 1 of 4)</b>				
<b>Pin Number</b>	<b>Function</b>	<b>Function</b>	<b>Pin Number</b>	<b>Description</b>
1	XCVR_TXp7	XCVR_RXp7	2	Transceiver
3	XCVR_TXn7	XCVR_RXn7	4	Transceiver
5	XCVR_TXp6	XCVR_RXp6	6	Transceiver
7	XCVR_TXn6	XCVR_RXn6	8	Transceiver
9	XCVR_TXp5	XCVR_RXp5	10	Transceiver
11	XCVR_TXn5	XCVR_RXn5	12	Transceiver
13	XCVR_TXp4	XCVR_RXp4	14	Transceiver
15	XCVR_TXn4	XCVR_RXn4	16	Transceiver
17	XCVR_TXp3	XCVR_RXp3	18	Transceiver
19	XCVR_TXn3	XCVR_RXn3	20	Transceiver
21	XCVR_TXp2	XCVR_RXp2	22	Transceiver

**Table 4–2. Standard Differential Host Pinout (Part 2 of 4)**

Pin Number	Function	Function	Pin Number	Description
23	XCVR_TXn2	XCVR_RXn2	24	Transceiver
25	XCVR_TXp1	XCVR_RXp1	26	Transceiver
27	XCVR_TXn1	XCVR_RXn1	28	Transceiver
29	XCVR_TXp0	XCVR_RXp0	30	Transceiver
31	XCVR_TXn0	XCVR_RXn0	32	Transceiver
33	SDA	SCL	34	SMBUS/CMOS
35	JTAG_TCK	JTAG_TMS	36	JTAG/CMOS
37	JTAG_TDO	JTAG_TDI	38	JTAG/CMOS
39	CLKOUT0	CLKIN0	40	CMOS CLK
41	D0	D1	42	CMOS
43	D2	D3	44	CMOS
45	3.3 V	12 V	46	Power
47	LVDS_TXp0	LVDS_RXp0	48	CMOS/LVDS
49	LVDS_TXn0	LVDS_RXn0	50	CMOS/LVDS
51	3.3 V	12 V	52	Power
53	LVDS_TXp1	LVDS_RXp1	54	CMOS/LVDS
55	LVDS_TXn1	LVDS_RXn1	56	CMOS/LVDS
57	3.3 V	12 V	58	Power
59	LVDS_TXp2	LVDS_RXp2	60	CMOS/LVDS
61	LVDS_TXn2	LVDS_RXn2	62	CMOS/LVDS
63	3.3 V	12 V	64	Power
65	LVDS_TXp3	LVDS_RXp3	66	CMOS/LVDS
67	LVDS_TXn3	LVDS_RXn3	68	CMOS/LVDS
69	3.3 V	12 V	70	Power
71	LVDS_TXp4	LVDS_RXp4	72	CMOS/LVDS
73	LVDS_TXn4	LVDS_RXn4	74	CMOS/LVDS
75	3.3 V	12 V	76	Power
77	LVDS_TXp5	LVDS_RXp5	78	CMOS/LVDS
79	LVDS_TXn5	LVDS_RXn5	80	CMOS/LVDS
81	3.3 V	12 V	82	Power
83	LVDS_TXp6	LVDS_RXp6	84	CMOS/LVDS
85	LVDS_TXn6	LVDS_RXn6	86	CMOS/LVDS

**Table 4–2. Standard Differential Host Pinout (Part 3 of 4)**

Pin Number	Function	Function	Pin Number	Description
87	3.3 V	12 V	88	Power
89	LVDS_TXp7	LVDS_RXp7	90	CMOS/LVDS
91	LVDS_TXn7	LVDS_RXn7	92	CMOS/LVDS
93	3.3 V	12 V	94	Power
95	CLKOUT1p	CLKIN1p	96	LVDS CLKp/CMOS
97	CLKOUT1n	CLKIN1n	98	LVDS CLKn/CMOS
99	3.3 V	12 V	100	Power
101	LVDS_TXp8	LVDS_RXp8	102	CMOS/LVDS
103	LVDS_TXn8	LVDS_RXn8	104	CMOS/LVDS
105	3.3 V	12 V	106	Power
107	LVDS_TXp9	LVDS_RXp9	108	CMOS/LVDS
109	LVDS_TXn9	LVDS_RXn9	110	CMOS/LVDS
111	3.3 V	12 V	112	Power
113	LVDS_TXp10	LVDS_RXp10	114	CMOS/LVDS
115	LVDS_TXn10	LVDS_RXn10	116	CMOS/LVDS
117	3.3 V	12 V	118	Power
119	LVDS_TXp11	LVDS_RXp11	120	CMOS/LVDS
121	LVDS_TXn11	LVDS_RXn11	122	CMOS/LVDS
123	3.3 V	12 V	124	Power
125	LVDS_TXp12	LVDS_RXp12	126	CMOS/LVDS
127	LVDS_TXn12	LVDS_RXn12	128	CMOS/LVDS
129	3.3 V	12 V	130	Power
131	LVDS_TXp13	LVDS_RXp13	132	CMOS/LVDS
133	LVDS_TXn13	LVDS_RXn13	134	CMOS/LVDS
135	3.3 V	12 V	136	Power
137	LVDS_TXp14	LVDS_RXp14	138	CMOS/LVDS
139	LVDS_TXn14	LVDS_RXn14	140	CMOS/LVDS
141	3.3 V	12 V	142	Power
143	LVDS_TXp15	LVDS_RXp15	144	CMOS/LVDS
145	LVDS_TXn15	LVDS_RXn15	146	CMOS/LVDS
147	3.3 V	12 V	148	Power
149	LVDS_TXp16	LVDS_RXp16	150	CMOS/LVDS



<b>Table 4–2. Standard Differential Host Pinout (Part 4 of 4)</b>				
<b>Pin Number</b>	<b>Function</b>	<b>Function</b>	<b>Pin Number</b>	<b>Description</b>
151	LVDS_TXn16	LVDS_RXn16	152	CMOS/LVDS
153	3.3 V	12 V	154	Power
155	CLKOUT2p	CLKIN2p	156	LVDS CLKp/CMOS
157	CLKOUT2n	CLKIN2n	158	LVDS CLKn/CMOS
159	3.3 V	PSNTn <sup>(1)</sup>	160	Power/PSNTn <sup>(1)</sup>

**Note to Table 4–2:**

(1) PSNTn connects to GND on mezzanine card.

### 5.1 Overview

Several cabling options are available for the HSMC interface. Samtec offers a variety of off-the-shelf and custom cabling solutions compatible with this connector. The solutions include twin-ax, micro-coax, flex cable, ribbon, and SMA adapters for host-to-host, host to add-on card, and host to SMA or other connector configurations.



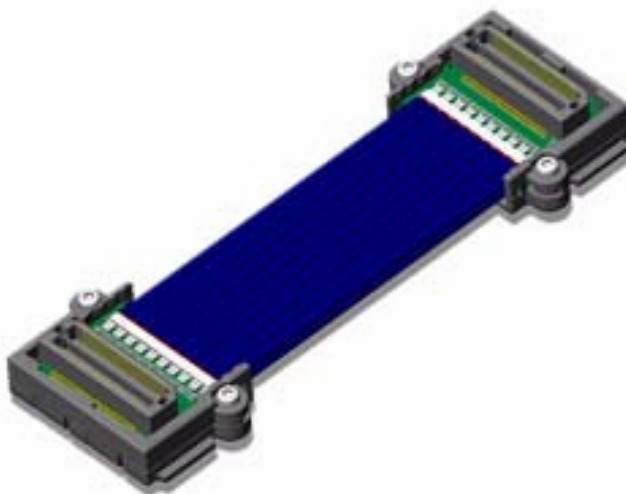
See [http://www.samtec.com/signal\\_integrity/altera.aspx](http://www.samtec.com/signal_integrity/altera.aspx) for more information on cables.

### 5.2 Ribbon Cables

Samtec offers off-the-shelf ribbon cable assemblies that allow for host-to-host connections as well as host-to-mezzanine-card connections (that is, extensions). These cables are available in both single-ended and differential configurations.

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**Figure 5–1. Data Rate Ribbon Cable**



### 5.2.1 Web-based Configuration

The cable configurations can be customized using a web-based tool and ordered using a credit card or by using the correct part number and ordering direct. The screen shots below show some of the web pages in 2006. Contact Samtec for more information on how to order the cables.

---

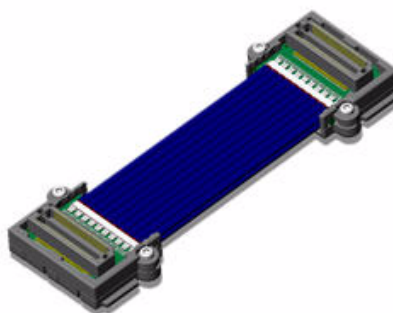
**Figure 5–2. Build a Data Rate Cable Assembly - Step 3**

Select from the options below **and** click the Continue button.

Step 3 of 8

Pitch	Series
0.5 mm	HQDP

No. of Pairs
<input type="radio"/> 20 (40 Signal Lines, 1 Bank)
<input type="radio"/> 40 (80 Signal Lines, 2 Banks)
<input checked="" type="radio"/> 60 (120 Signal Lines, 3 Banks)
<input type="radio"/> 80 (160 Signal Lines, 4 Banks)



◀ Back

Continue ▶

**Figure 5–3. Build a Data Rate Cable Assembly - Step 5****Step 5 of 8****Previously Selected Information**

Pitch:	0.5 mm
Series:	HQDP
No. of Pairs:	60 (120 Signal Lines, 3 Banks)
LENGTH (XX.XX) INCHES:	06.00 inches (152.40 mm)
Mapping Scheme:	Pin 1 to Pin 2

**End Assembly Configuration**

For both the First and Second Ends, select the position of the connector (**T**op, **E**dgemount, **B**ottom or **P**anelmount) and then choose from the available options in the chart to the right the connector type (**S**ocket or **T**erminal) and orientation (notch **L**eft, notch **R**ight, notch **U**p or notch **D**own) required.

Click the Continue button when you are finished.

First End      Second End

Back      Continue

TTR	TTL	TBR	TBL
STR	STL	SBR	SBL
TEU	TED	TEU	TED
SEU	SED	SEU	SED

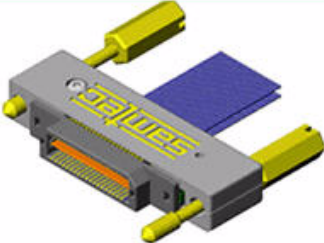
**Figure 5–4. Build a Data Rate Cable Assembly - Step 7**

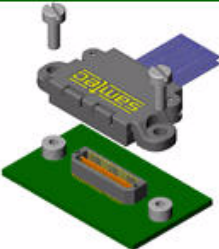
Step 7 of 8

Previously Selected Information	
Pitch:	0.5 mm
Series:	HQDP
No. of Pairs:	60 (120 Signal Lines, 3 Banks)
LENGTH (XX.XX) INCHES:	06.00 inches (152.40 mm)
FIRST END ASSEMBLY:	TBR (Gender: Terminal, Orientation: Bottom, Notch: Right)
SECOND END ASSEMBLY:	TTL (Gender: Terminal, Orientation: Top, Notch: Left)
Mapping Scheme:	Pin 1 to Pin 2

SCREW OPTION

- ☒ No Option
- ☐ Both Ends
- ☐ First End Only
- ☐ Second End Only

  
**Edge Mount**

  
**Vertical**

◀ BackContinue ▶

After completing the steps, an exact datasheet is provided in PDF format that can be saved and can be ordered from [http://www.samtec.com/signal\\_integrity/altera.aspx](http://www.samtec.com/signal_integrity/altera.aspx).

## 5.2.2 Host-to-Host Example

Figure 5–5 shows an example of one of these cables. The end-points shown are called vertical launch in the **SCREW OPTION** page of the web tool. The pin 1 orientations shown are for a host-to-host configuration with a pin 1 to pin 2 mapping. You can connect two typical HSMC host Altera development kits together using this method.

**Figure 5–5. Host-to-Host Cable**

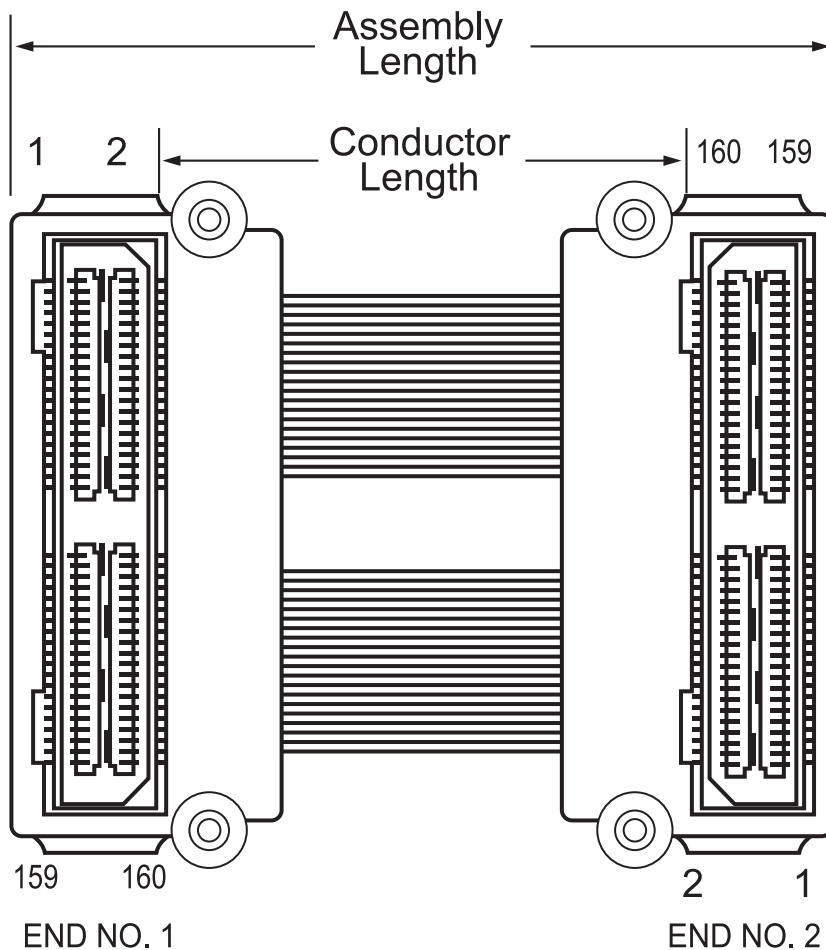


Table 5–1 shows two popular options for cabling a host-to-host configuration and the manufacturer part numbers.

<b>Table 5–1. Host-to-Host Cable Part Numbers</b>	
<b>Part Number</b>	<b>Description</b>
HQDP-060-06.00-TBR-TTL-2	6" Data Rate Cable, Host-to-Host (pin1-pin2), – DP different pairs only, 30 AWG twin-ax 100-Ω, –3 dB @ 1.92 GHz
HQDP-060-12.00-TBR-TTL-2	12" Data Rate Cable, Host-to-Host (pin1-pin2), – DP different pairs only, 30 AWG twin-ax 100-Ω, –3 dB @ 2.12 GHz

### 5.2.3 Special Considerations

For a host-to-host configuration, the ribbon cable in the middle will actually need to twist as END NO. 1 is mounted to the opposite side as END NO. 2. Thus the cable must be physically long enough to allow for the twisting of three sets of twin-ax that are somewhat stiff. Also, three banks exist in the connector though the diagram shows only two. Note that JTAG and SMBus features will not work in most configurations as these pinouts are not as symmetrical as the data pins. Small modifications can enable this functionality. Power connections must be considered as the HSMC specification calls for power on the pins populated only on QTH/QSH family connectors and not on QTH-DP/QSH-DP family connectors. The recommended ASP connectors carry power as do the QTH/QSH family connectors.

## 5.3 SMA Breakout Cables

Altera and Samtec designed a breakout cable for adapting a single bank of the 3-bank HSMC connector to SMA cables. Only the differential pins (pins found in the QSH-DP/QTH-DP) are used. Though fairly large and mechanically challenging, this cable offers the highest signal integrity and is the only completely flexible connection scheme by using SMA connectors.

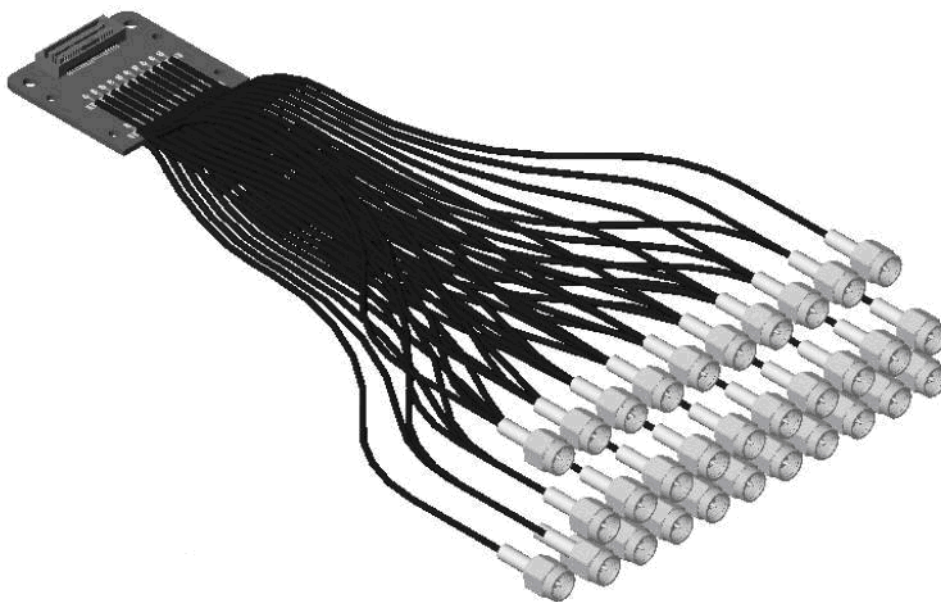
**Figure 5–6. SMA Breakout Cable**

Table 5–2 lists the SMA breakout cable part number description.

Table 5–2. SMA Breakout Cable Part Number	
Part Number	Description
HDR-128291-XX	12" RF Cable, – DP diff. pairs only, RG316, –3 dB @ ~ 3 GHz



### 6.1 Overview

The HSMC interface is designed to support very high data rates. Thus, signal integrity is an important topic. Careful layout will ensure that cards can interoperate successfully.

### 6.2 Performance

This section provides the performance data obtained for the HSMC interface.

#### 6.2.1 Insertion Loss

The preferred stacking height for a mezzanine card and a host board is a minimum 5 mm board-to-board. Using the smallest stacking height gives better high frequency performance.

Table 6–1 shows the insertion loss data for the various available stacking heights.

<b>Table 6–1. Insertion Loss Data for the Various Stacking Heights</b>	
<b>0, 50 mm QTH/QSH-DP</b>	<b>Rated @ –3 dB Insertion Loss</b>
<b>5 mm Stack Height</b>	
Differential Pair Signaling	9.5 GHz / 19 Gbps
<b>11 mm Stack Height</b>	
Differential Pair Signaling	6.0 GHz / 12 Gbps
<b>16 mm Stack Height</b>	
Differential Pair Signaling	5.5 GHz / 11 Gbps
<b>30 mm Stack Height</b>	
Differential Pair Signaling	7.0 GHz / 14 Gbps

There are also some off-the-shelf micro-coax cables with good high speed performance that have been used by Altera for more than 1 Gbps applications at lengths of 6 inches. This same style of connector shows insertion loss data good enough (3 dB) for up to 6 inches cables at data rates of 3.125 Gbps. Samtec also offers flex-circuit cables that have even better high speed properties.

## 6.3 Guidelines

This section gives the guidelines for CMOS, LVDS and transceiver signals' interface on the HSMC connector.

### 6.3.1 LVDS / CMOS Signals

In order to support an I/O standard of either LVDS or CMOS, one must design for high-speed on a host board. These signals are defined to operate up to 1.25 Gbps (625 MHz). The following rules should be applied to these signals in order to claim “full” compatibility with the LVDS and CMOS connections.

1. 50- $\Omega$  single-ended impedance target.
2. All traces must be matched to  $\pm 50$  mils.
3. Loosely coupled routing of P and N pairs must be used to minimize cross talk in single-ended systems.
  - a. Traces should be closer to the reference plane than each other.
4. All signals are to maintain a spacing that is based on its parallelism with other nets. The spacing is based on a ratio of signal to plane versus signal to signal (4 mil plane distance shown below).
  - a. 4 mils for parallel runs < 0.5 inches.  
(~1 $\times$  spacing relative to plane distance)
  - b. 8 mils for parallel runs between 0.5 and 1.0 inches.  
(~2 $\times$  spacing relative to plane distance)
  - c. 12 mils for parallel runs between 1.0 and 6.0 inches.  
(~3 $\times$  spacing relative to plane distance)
5. Signals to have a maximum length of 8 inches on the host or the mezzanine card.

### 6.3.2 Transceiver Signals

The HSMC interface is designed to support up to two XAUI interfaces and one SPI4.2 interface simultaneously. Future expansions of the HSMC may include 6.3 Gbps interface links. Careful attentions should be paid to the board material and board routing on both the host and mezzanine cards to avoid crosstalk and impedance discontinuities. Layout and routing design rules should include but not be limited to the following:

- High speed routes restricted to top, bottom, and bottom-most stripline or microstrip layers to minimize diff-via and connector pin stubs.
- Diff-vias spread on .04 inches pitch.
- Blocking caps use plane clearances (and signal keep-out) .03 inches deep surface mount lands should be referenced to a lower plane depending on land width.
- Large antipads ovals around differential glutathione disulfide (GSSG) vias structures and antipad.
- Route all multi-gigabit signals on the top (or bottom) layer for at least short distance to allow room for GSSG differential vias.
- Via placement should avoid “moating” which affects power delivery and ground reference.
- Symmetrical routing into and out of transitions (vias, connector, BGAs, and so on).
- Ground vias used at transitions to accommodate any common-mode signal.
- 45° corners and jog-outs used to equalize lengths.
- Differential pairs spaced to meet crosstalk constraints.
- All positive (p) or negative (n) lengths between transitions matched.

### 6.3.3 Differential Via

The most common transition is the differential via, or “diff-via” where you must transition from an upper stripline layer or top microstrip to a lower stripline layer or the bottom microstrip.

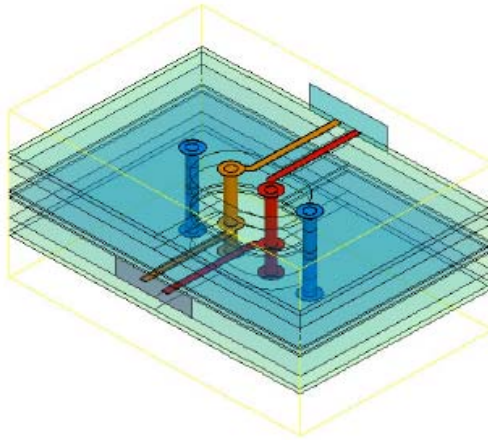
General design practices:

- Use ~0.012 inches vias – larger if needed due to thicker board.
- Use .022 inches pads (5 mil annular ring)
- Use GSSG vias on .040 inches pitches.
- Oblong antipads shown are roughly .055 inches × .095 inches (aligns with ground pad).

- If larger or smaller diameter vias are used, then scale all dimensions accordingly.
- Remove annular rings on unrouted layers.

---

**Figure 6–1. Differential Via structure**



---

Every attempt to eliminate or reduce via stub lengths on via structures should be made. Techniques like routing from top microstrip to bottom microstrip, routing from top microstrip to the lowest available stripline should be used. If striplines on lower layers are not available then route to other striplines and consider back drilling via stubs. If design rules allow then use blind and buried via or both.

### 6.3.4 A/C Coupling Capacitors

Use DC blocking (AC coupling) capacitors if needed. These capacitors should be designed onto the mezzanine card to meet the application's data rate and run length requirements.

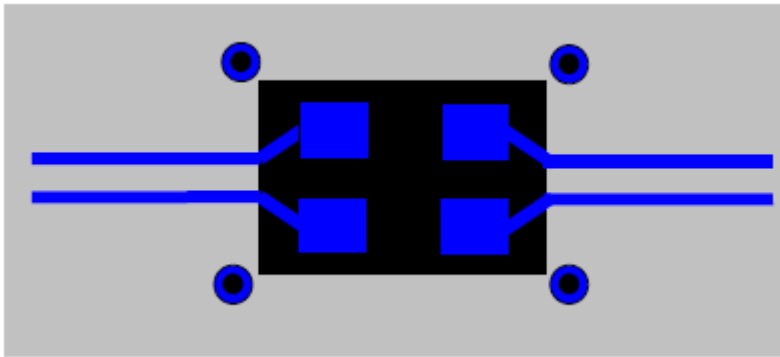
General design practices:

- Use 0402 differential caps on .050 inches spacing.
- Plane clearances .110 inches wide and .120 inches high clearing all planes up to .030 inches depths.
- Differential microstrip pairs are on (minimum of) .100 inches pitch and caps centered on these microstrips.

- Stagger capacitor pairs to reduce crosstalk.
- Check the capacitor equivalent series inductance (ESL) to see if it is low enough for 6.5 Gbps operation.
- Reference surface mount pads to a lower layer if possible.
- Never route signals under plane cutouts.
- Use ground vias for common mode return paths and electromagnetic interference (EMI) considerations.

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**Figure 6–2. Plane clearance and ground via arrangement to reduce EMI**

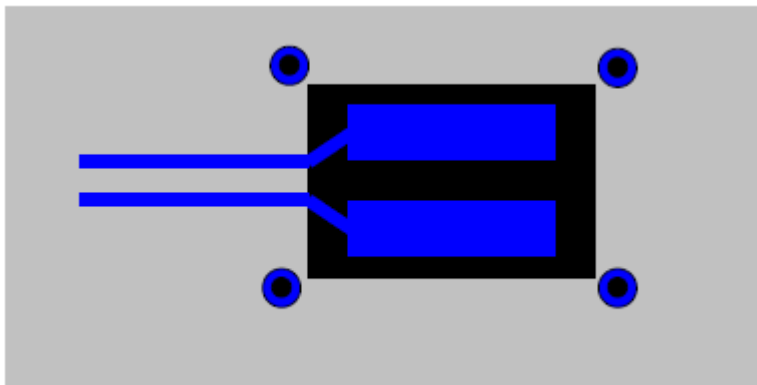


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### 6.3.5 Surface Mount Pads

In the HSMC interface, signals will encounter surface mount pads at that Samtec QSH and QTH connectors. Many times the traces attached to the surface mount pads are much thinner than the pads. For example, if a 100  $\Omega$  differential trace is 5 mils wide and are attached to a pair of pads that are 20 mils wide there will be an impedance drop at the pad. A cut out can be made on the plane layer just below the SMT pad. The pads can therefore be referenced to a lower plane that would be more appropriate for a 100  $\Omega$  differential signaling environment. Ground via should be placed close to the plane cut out so that common mode components of the signal are referenced to ground as well.

*Figure 6–3. Cut out underneath SMD Pads*





## Appendix A. Example Pinout Mappings

### Introduction

The examples below represent how one might map a standard bus format into one of the generic pinouts listed in the previous sections. The signal names reflect the naming conventions of the target bus being mapped. These pinouts are relative to the HSMC host.

### AMC Pinout

Table A–1 lists the pinout of AMC (single sided).

<i>Table A–1. AMC (Single Sided) Pinout (Part 1 of 3)</i>				
Pin Number	Function	Function	Pin Number	Description
1	COMMON_TXp3	COMMON_RXp3	2	Transceiver
3	COMMON_TXn3	COMMON_RXn3	4	Transceiver
5	COMMON_TXp2	COMMON_RXp2	6	Transceiver
7	COMMON_TXn2	COMMON_RXn2	8	Transceiver
9	COMMON_TXp1	COMMON_RXp1	10	Transceiver
11	COMMON_TXn1	COMMON_RXn1	12	Transceiver
13	COMMON_TXp0	COMMON_RXp0	14	Transceiver
15	COMMON_TXn0	COMMON_RXn0	16	Transceiver
17	FATPIPES_TXp7	FATPIPES_RXp7	18	Transceiver
19	FATPIPES_TXn7	FATPIPES_RXn7	20	Transceiver
21	FATPIPES_TXp6	FATPIPES_RXp6	22	Transceiver
23	FATPIPES_TXn6	FATPIPES_RXn6	24	Transceiver
25	FATPIPES_TXp5	FATPIPES_RXp5	26	Transceiver
27	FATPIPES_TXn5	FATPIPES_RXn5	28	Transceiver
29	FATPIPES_TXp4	FATPIPES_RXp4	30	Transceiver
31	FATPIPES_TXn4	FATPIPES_RXn4	32	Transceiver
33	SDA	SCL	34	SMBUS/CMOS
35	JTAG_TCK	JTAG_TMS	36	JTAG/CMOS
37	JTAG_TDO	JTAG_TDI	38	JTAG/CMOS
39	CLKOUT0	CLKIN0	40	CMOS CLK
41	ENABLEn	PSn0	42	CMOS*
43	GA0	PSn1	44	CMOS*

**Table A–1. AMC (Single Sided) Pinout (Part 2 of 3)**

Pin Number	Function	Function	Pin Number	Description
45	3.3 V	12 V	46	Power
47	GA1	GA2	48	CMOS
49	—	—	50	—
51	3.3 V	12 V	52	Power
53	—	—	54	—
55	—	—	56	—
57	3.3 V	12 V	58	Power
59	—	—	60	—
61	—	—	62	—
63	3.3 V	12 V	64	Power
65	—	—	66	—
67	—	—	68	—
69	3.3 V	12 V	70	Power
71	—	—	72	—
73	—	—	74	—
75	3.3 V	12 V	76	Power
77	—	—	78	—
79	—	—	80	—
81	3.3 V	12 V	82	Power
83	—	—	84	—
85	—	—	86	—
87	3.3 V	12 V	88	Power
89	—	—	90	—
91	—	—	92	—
93	3.3 V	12 V	94	Power
95	CLKOUT1p	CLKIN1p	96	LVDS CLKp/CMOS
97	CLKOUT1n	CLKIN1n	98	LVDS CLKn/CMOS
99	3.3 V	12 V	100	Power
101	—	—	102	—
103	—	—	104	—
105	3.3 V	12 V	106	Power
107	—	—	108	—
109	—	—	110	—



<b>Table A–1. AMC (Single Sided) Pinout (Part 3 of 3)</b>				
<b>Pin Number</b>	<b>Function</b>	<b>Function</b>	<b>Pin Number</b>	<b>Description</b>
111	3.3 V	12 V	112	Power
113	—	—	114	—
115	—	—	116	—
117	3.3 V	12 V	118	Power
119	—	—	120	—
121	—	—	122	—
123	3.3 V	12 V	124	Power
125	—	—	126	—
127	—	—	128	—
129	3.3 V	12 V	130	Power
131	—	—	132	—
133	—	—	134	—
135	3.3 V	12 V	136	Power
137	—	—	138	—
139	—	—	140	—
141	3.3 V	12V	142	Power
143	—	—	144	—
145	—	—	146	—
147	3.3 V	12 V	148	Power
149	—	—	150	—
151	—	—	152	—
153	3.3 V	12 V	154	Power
155	CLKOUT2p	CLKIN2p	156	LVDS CLKp/CMOS
157	CLKOUT2n	CLKIN2n	158	LVDS CLKn/CMOS
159	3.3 V	PSNTn (1)	160	Power/PSNTn (1)

**Note to Table A–1:**

(1) PSNTn connects to GND on mezzanine card.

## PCI Express x8 Pinout

Table A–2 lists the pinout of PCI express x8.

<b>Table A–2. PCI Express x8 Pinout (Part 1 of 3)</b>				
<b>Pin Number</b>	<b>Function</b>	<b>Function</b>	<b>Pin Number</b>	<b>Description</b>
1	PETp7	PERp7	2	Transceiver
3	PETn7	PERn7	4	Transceiver
5	PETp6	PERp6	6	Transceiver
7	PETn6	PERn6	8	Transceiver
9	PETp5	PERp5	10	Transceiver
11	PETn5	PERn5	12	Transceiver
13	PETp4	PERp4	14	Transceiver
15	PETn4	PERn4	16	Transceiver
17	PETp3	PERp3	18	Transceiver
19	PETn3	PERn3	20	Transceiver
21	PETp2	PERp2	22	Transceiver
23	PETn2	PERn2	24	Transceiver
25	PETp1	PERp1	26	Transceiver
27	PETn1	PERn1	28	Transceiver
29	PETp0	PERp0	30	Transceiver
31	PETn0	PERn0	32	Transceiver
33	SDA	SCL	34	SMBUS/CMOS
35	JTAG_TCK	JTAG_TMS	36	JTAG/CMOS
37	JTAG_TDO	JTAG_TDI	38	JTAG/CMOS
39	—	—	40	—
41	PRSENT#	WAKE#	42	CMOS*
43	PERST#	—	44	CMOS
45	3.3 V	12 V	46	Power
47	—	—	48	—
49	—	—	50	—
51	3.3 V	12 V	52	Power
53	—	—	54	—
55	—	—	56	—
57	3.3 V	12 V	58	Power
59	—	—	60	—

**Table A–2. PCI Express x8 Pinout (Part 2 of 3)**

Pin Number	Function	Function	Pin Number	Description
61	—	—	62	—
63	3.3 V	12 V	64	Power
65	–	–	66	–
67	–	–	68	–
69	3.3 V	12 V	70	Power
71	–	–	72	–
73	–	–	74	–
75	3.3 V	12 V	76	Power
77	–	–	78	–
79	–	–	80	–
81	3.3 V	12 V	82	Power
83	–	–	84	–
85	–	–	86	–
87	3.3 V	12 V	88	Power
89	–	–	90	–
91	–	–	92	–
93	3.3 V	12 V	94	Power
95	REFCLK_TXp	REFCLK_RXp	96	LVDS CLKp / CMOS
97	REFCLK_TXn	REFCLK_RXn	98	LVDS CLKn / CMOS
99	3.3 V	12 V	100	Power
101	–	–	102	–
103	–	–	104	–
105	3.3 V	12 V	106	Power
107	–	–	108	–
109	–	–	110	–
111	3.3 V	12 V	112	Power
113	–	–	114	–
115	–	–	116	–
117	3.3 V	12 V	118	Power
119	–	–	120	–
121	–	–	122	–
123	3.3 V	12 V	124	Power
125	–	–	126	–

**Table A–2. PCI Express x8 Pinout (Part 3 of 3)**

Pin Number	Function	Function	Pin Number	Description
127	–	–	128	–
129	3.3 V	12 V	130	Power
131	–	–	132	–
133	–	–	134	–
135	3.3 V	12 V	136	Power
137	–	–	138	–
139	–	–	140	–
141	3.3 V	12 V	142	Power
143	–	–	144	–
145	–	–	146	–
147	3.3 V	12 V	148	Power
149	–	–	150	–
151	–	–	152	–
153	3.3 V	12 V	154	Power
155	–	–	156	–
157	–	–	158	–
159	3.3 V	PSNTn (1)	160	Power/PSNTn (1)

Note to **Table A–2**:

(1) PSNTn connects to GND on mezzanine card.

## SPI4.2 Pinout

**Table A–3** lists the pinout of SPI4.2.

**Table A–3. SPI4.2 Pinout (Part 1 of 4)**

Pin Number	Function	Function	Pin Number	Description
1	–	–	2	–
3	–	–	4	–
5	–	–	6	–
7	–	–	8	–
9	–	–	10	–
11	–	–	12	–
13	–	–	14	–
15	–	–	16	–

**Table A–3. SPI4.2 Pinout (Part 2 of 4)**

Pin Number	Function	Function	Pin Number	Description
17	—	—	18	—
19	—	—	20	—
21	—	—	22	—
23	—	—	24	—
25	—	—	26	—
27	—	—	28	—
29	—	—	30	—
31	—	—	32	—
33	—	—	34	—
35	—	—	36	—
37	—	—	38	—
39	RSCLK	TSCLK	40	CMOS CLK
41	RDAT0	TDAT0	42	CMOS*
43	RDAT1	TDAT1	44	CMOS*
45	3.3 V	12 V	46	Power
47	SPI_TDATp0	SPI_RDATp0	48	LVDS
49	SPI_TDATn0	SPI_RDATn0	50	LVDS
51	3.3 V	12 V	52	Power
53	SPI_TDATp1	SPI_RDATp1	54	LVDS
55	SPI_TDATn1	SPI_RDATn1	56	LVDS
57	3.3 V	12 V	58	Power
59	SPI_TDATp2	SPI_RDATp2	60	LVDS
61	SPI_TDATn2	SPI_RDATn2	62	LVDS
63	3.3 V	12 V	64	Power
65	SPI_TDATp3	SPI_RDATp3	66	LVDS
67	SPI_TDATn3	SPI_RDATn3	68	LVDS
69	3.3 V	12 V	70	Power
71	SPI_TDATp4	SPI_RDATp4	72	LVDS
73	SPI_TDATn4	SPI_RDATn4	74	LVDS
75	3.3 V	12 V	76	Power
77	SPI_TDATp5	SPI_RDATp5	78	LVDS
79	SPI_TDATn5	SPI_RDATn5	80	LVDS
81	3.3 V	12 V	82	Power

**Table A–3. SPI4.2 Pinout (Part 3 of 4)**

Pin Number	Function	Function	Pin Number	Description
83	SPI_TDATp6	SPI_RDATp6	84	LVDS
85	SPI_TDATn6	SPI_RDATn6	86	LVDS
87	3.3 V	12 V	88	Power
89	SPI_TDATp7	SPI_RDATp7	90	LVDS
91	SPI_TDATn7	SPI_RDATn7	92	LVDS
93	3.3 V	12 V	94	Power
95	—	—	96	—
97	—	—	98	—
99	3.3 V	12 V	100	Power
101	SPI_TDATp8	SPI_RDATp8	102	LVDS
103	SPI_TDATn8	SPI_RDATn8	104	LVDS
105	3.3 V	12 V	106	Power
107	SPI_TDATp9	SPI_RDATp9	108	LVDS
109	SPI_TDATn9	SPI_RDATn9	110	LVDS
111	3.3 V	12 V	112	Power
113	SPI_TDATp10	SPI_RDATp10	114	LVDS
115	SPI_TDATn10	SPI_RDATn10	116	LVDS
117	3.3 V	12 V	118	Power
119	SPI_TDATp11	SPI_RDATp11	120	LVDS
121	SPI_TDATn11	SPI_RDATn11	122	LVDS
123	3.3 V	12 V	124	Power
125	SPI_TDATp12	SPI_RDATp12	126	LVDS
127	SPI_TDATn12	SPI_RDATn12	128	LVDS
129	3.3 V	12 V	130	Power
131	SPI_TDATp13	SPI_RDATp13	132	LVDS
133	SPI_TDATn13	SPI_RDATn13	134	LVDS
135	3.3 V	12 V	136	Power
137	SPI_TDATp14	SPI_RDATp14	138	LVDS
139	SPI_TDATn14	SPI_RDATn14	140	LVDS
141	3.3 V	12 V	142	Power
143	SPI_TDATp15	SPI_RDATp15	144	LVDS
145	SPI_TDATn15	SPI_RDATn15	146	LVDS
147	3.3 V	12 V	148	Power

**Table A–3. SPI4.2 Pinout (Part 4 of 4)**

Pin Number	Function	Function	Pin Number	Description
149	SPI_TCTLp	SPI_RCTLp	150	LVDS
151	SPI_TCTLn	SPI_RCTLn	152	LVDS
153	3.3 V	12 V	154	Power
155	SPI_TDCLKp	SPI_RDCLKp	156	LVDS CLKp/CMOS
157	SPI_TDCLKn	SPI_RDCLKn	158	LVDS CLKn/CMOS
159	3.3 V	PSNTn	160	Power/PSNTn

## CX-4 10G Ethernet Pinout

Table A–4 lists the pinout of CX-4 10G Ethernet.

**Table A–4. CX-4 10G Ethernet Pinout (Part 1 of 3)**

Pin Number	Function	Function	Pin Number	Description
1	—	—	2	—
3	—	—	4	—
5	—	—	6	—
7	—	—	8	—
9	—	—	10	—
11	—	—	12	—
13	—	—	14	—
15	—	—	16	—
17	SLTXp3 - S10	DLRXp3 - S7	18	Transceiver
19	SLTXn3 - S9	DLRXn3 - S8	20	Transceiver
21	SLTXp2 - S12	DLRXp2 - S5	22	Transceiver
23	SLTXn2 - S11	DLRXn2 - S6	24	Transceiver
25	SLTXp1 - S14	DLRXp1 - S3	26	Transceiver
27	SLTXn1 - S13	DLRXn1 - S4	28	Transceiver
29	SLTXp0 - S16	DLRXp0 - S1	30	Transceiver
31	SLTXn0 - S15	DLRXn0 - S2	32	Transceiver
33	—	—	34	—
35	—	—	36	—
37	—	—	38	—
39	—	—	40	—

**Table A–4. CX-4 10G Ethernet Pinout (Part 2 of 3)**

Pin Number	Function	Function	Pin Number	Description
41	—	—	42	—
43	—	—	44	—
45	3.3 V	12 V	46	Power
47	—	—	48	—
49	—	—	50	—
51	3.3 V	12 V	52	Power
53	—	—	54	—
55	—	—	56	—
57	3.3 V	12 V	58	Power
59	—	—	60	—
61	—	—	62	—
63	3.3 V	12 V	64	Power
65	—	—	66	—
67	—	—	68	—
69	3.3 V	12 V	70	Power
71	—	—	72	—
73	—	—	74	—
75	3.3 V	12 V	76	Power
77	—	—	78	—
79	—	—	80	—
81	3.3 V	12 V	82	Power
83	—	—	84	—
85	—	—	86	—
87	3.3 V	12 V	88	Power
89	—	—	90	—
91	—	—	92	—
93	3.3 V	12 V	94	Power
95	—	—	96	—
97	—	—	98	—
99	3.3 V	12 V	100	Power
101	—	—	102	—
103	—	—	104	—
105	3.3 V	12 V	106	Power



**Table A–4. CX-4 10G Ethernet Pinout (Part 3 of 3)**

Pin Number	Function	Function	Pin Number	Description
107	—	—	108	—
109	—	—	110	—
111	3.3 V	12 V	112	Power
113	—	—	114	—
115	—	—	116	—
117	3.3 V	12 V	118	Power
119	—	—	120	—
121	—	—	122	—
123	3.3 V	12 V	124	Power
125	—	—	126	—
127	—	—	128	—
129	3.3 V	12 V	130	Power
131	—	—	132	—
133	—	—	134	—
135	3.3 V	12 V	136	Power
137	—	—	138	—
139	—	—	140	—
141	3.3 V	12 V	142	Power
143	—	—	144	—
145	—	—	146	—
147	3.3 V	12 V	148	Power
149	—	—	150	—
151	—	—	152	—
153	3.3 V	12 V	154	Power
155	—	—	156	—
157	—	—	158	—
159	3.3 V	PSNTn (1)	160	Power/PSNTn (1)

**Note to Table A–4:**

(1) PSNTn connects to GND on mezzanine card.

# Altera Daughter Card Pinout

Table A–5 lists the pinouts of Altera Daughter Card (also known as Santa Cruz Card).

<i>Table A–5. Altera Daughter Card (also known as Santa Cruz Card) Pinout (Part 1 of 3)</i>				
Pin Number	Function	Function	Pin Number	Description
1	—	—	2	—
3	—	—	4	—
5	—	—	6	—
7	—	—	8	—
9	—	—	10	—
11	—	—	12	—
13	—	—	14	—
15	—	—	16	—
17	—	—	18	—
19	—	—	20	—
21	—	—	22	—
23	—	—	24	—
25	—	—	26	—
27	—	—	28	—
29	—	—	30	—
31	—	—	32	—
33	—	—	34	—
35	—	—	36	—
37	—	—	38	—
39	—	—	40	—
41	PROTO1_D1	PROTO1_D0	42	CMOS
43	PROTO1_D3	PROTO1_D2	44	CMOS
45	3.3 V	12 V	46	Power
47	PROTO1_D5	PROTO1_D4	48	CMOS
49	PROTO1_D7	PROTO1_D6	50	CMOS
51	3.3 V	12 V	52	Power
53	PROTO1_D9	PROTO1_D8	54	CMOS
55	PROTO1_D11	PROTO1_D10	56	CMOS
57	3.3 V	12 V	58	Power
59	PROTO1_D13	PROTO1_D12	60	CMOS

**Table A–5. Altera Daughter Card (also known as Santa Cruz Card) Pinout (Part 2 of 3)**

Pin Number	Function	Function	Pin Number	Description
61	PROTO1_D15	PROTO1_D14	62	CMOS
63	3.3 V	12 V	64	Power
65	PROTO1_D17	PROTO1_D16	66	CMOS
67	PROTO1_D19	PROTO1_D18	68	CMOS
69	3.3 V	12 V	70	Power
71	PROTO1_D21	PROTO1_D20	72	CMOS
73	PROTO1_D23	PROTO1_D22	74	CMOS
75	3.3 V	12 V	76	Power
77	PROTO1_D25	PROTO1_D24	78	CMOS
79	PROTO1_D27	PROTO1_D26	80	CMOS
81	3.3 V	12 V	82	Power
83	PROTO1_D29	PROTO1_D28	84	CMOS
85	PROTO1_D31	PROTO1_D30	86	CMOS
87	3.3 V	12 V	88	Power
89	PROTO1_D33	PROTO1_D32	90	CMOS
91	PROTO1_D35	PROTO1_D34	92	CMOS
93	3.3 V	12 V	94	Power
95	PROTO1_D37	PROTO1_D36	96	CMOS
97	PROTO1_D39	PROTO1_D38	98	CMOS
99	3.3 V	12 V	100	Power
101	PROTO2_D1	PROTO2_D0	102	CMOS
103	PROTO2_D3	PROTO2_D2	104	CMOS
105	3.3 V	12 V	106	Power
107	PROTO2_D5	PROTO2_D4	108	CMOS
109	PROTO2_D7	PROTO2_D6	110	CMOS
111	3.3 V	12 V	112	Power
113	PROTO2_D9	PROTO2_D8	114	CMOS
115	PROTO2_D11	PROTO2_D10	116	CMOS
117	3.3 V	12 V	118	Power
119	PROTO2_D13	PROTO2_D12	120	CMOS
121	PROTO2_D15	PROTO2_D14	122	CMOS
123	3.3 V	12 V	124	Power
125	PROTO2_D17	PROTO2_D16	126	CMOS

<b>Table A–5. Altera Daughter Card (also known as Santa Cruz Card) Pinout (Part 3 of 3)</b>				
<b>Pin Number</b>	<b>Function</b>	<b>Function</b>	<b>Pin Number</b>	<b>Description</b>
127	PROTO2_D19	PROTO2_D18	128	CMOS
129	3.3 V	12 V	130	Power
131	PROTO2_D21	PROTO2_D20	132	CMOS
133	PROTO2_D23	PROTO2_D22	134	CMOS
135	3.3 V	12 V	136	Power
137	PROTO2_D25	PROTO2_D24	138	CMOS
139	PROTO2_D27	PROTO2_D26	140	CMOS
141	3.3 V	12 V	142	Power
143	PROTO2_D29	PROTO2_D28	144	CMOS
145	PROTO2_D31	PROTO2_D30	146	CMOS
147	3.3 V	12 V	148	Power
149	PROTO2_D33	PROTO2_D32	150	CMOS
151	PROTO2_D35	PROTO2_D34	152	CMOS
153	3.3 V	12 V	154	Power
155	PROTO2_D37	PROTO2_D36	156	LVDS CLKp/CMOS
157	PROTO2_D39	PROTO2_D38	158	LVDS CLKn/CMOS
159	3.3 V	PSNTn (1)	160	Power/PSNTn (1)

**Note to Table A–5:**

(1) PSNTn connects to GND on mezzanine card.



## Appendix B. Glossary

### Introduction

HSMC is the abbreviation of High Speed Mezzanine Card and is used throughout the document as such. The following table lists other terms or acronyms used throughout this document.

TERM or ACRONYM	DESCRIPTION
A	Amps
HSMC	High Speed Mezzanine Card
LVDS	Refers to Low Voltage Differential Signaling and defined in ANSI/EIA-644-A.
Pin	The elementary connectivity provided by the connector
MHz	Megahertz
In	Inch
GbE	Gigabit Ethernet
Gbps	Gigabit per second
JTAG	Joint Test Action Group (test bus, IEEE 1149.1)
I/O	Input/Output
AMC	Advanced Mezzanine Card
V	Volts



## Revision History

The table below displays the revision history of this document.

Date	Version	Description
06/26/2009	1.7	<ul style="list-style-type: none"><li>• Corrected Figure 3-2. HSMC Socket (ASP-122953-01) – Bank 1 to show notch on upper right instead of upper left to match physical connector.</li><li>• Corrected Figure 3-4. HSMC Socket (ASP-122953-01) – Bank 3 to show notch on lower right instead of lower left to match physical connector.</li></ul>
04/03/2009	1.6	<ul style="list-style-type: none"><li>• Removed JTAG figures.</li><li>• Updated PCML length matching value in table 3-5.</li><li>• Updated coupling section in chapter 3.</li><li>• Removed recommended pinouts section in chapter 4.</li><li>• Updated standard host pinouts section and corrected signal names for pin 1 to 32 in table 4-1.</li><li>• Corrected insertion loss data table.</li><li>• Removed example mezzanine cards section in appendix.</li></ul>
09/27/2008	1.5	<ul style="list-style-type: none"><li>• Rearranged document structure.</li><li>• Added more mechanical details from samtec datasheet.</li><li>• Added notes for usability of compatible connectors.</li><li>• Added pin indicator in mezzanine card layout.</li><li>• Corrected dimension details in mezzanine card layout section.</li><li>• Added transceiver class (Type IV) into HSMC board classes to classify AMC &amp; other high-speed mezzanine cards.</li><li>• Elaborated signal/pin naming, numbering and direction conventions.</li><li>• Added figures in JTAG/CMOS section for host JTAG chain and host with JTAG mastering capability.</li><li>• Corrected PSNTn figure for text and VCC indication.</li><li>• Updated trace length matching table for the addition of Transceiver class.</li><li>• Corrected connector current capability table.</li><li>• Added power pinout figures for HSMC header and socket for visual clarity.</li><li>• Modified Generic Single-Ended pinout.</li><li>• Added recommended pinouts for all of the HSMC board classes (Type I, II, III, IV).</li><li>• Added performance section in signal integrity.</li><li>• Moved example mezzanine cards, example pinout mappings and glossary to Appendix.</li></ul>

Date	Version	Description
04/10/2007	1.4	<ul style="list-style-type: none"> <li>Added standoffs, screws, and spacer info.</li> <li>Added some headroom for I/O voltages in table 2-4 and specified measurements to be at connector.</li> <li>Corrected CLK naming convention in example pinout mappings for AMC and S# connections in example pinout mappings for CX4.</li> </ul>
03/01/2008	1.3	<ul style="list-style-type: none"> <li>Added Design Goals, Theory and Operation of Usage, Name and Logo Usage, Signal and Naming Conventions and Glossary section to chapter 1.</li> <li>Added Interconnect chapter and moved Generic Pinout and Example Pinout Mapping section from Electrical chapter to this chapter.</li> <li>Added Recommended Pinout Mapping chapter which includes Type I, Type II, Type III, and Transceiver based pinouts.</li> </ul>
08/08/2006	1.2	<ul style="list-style-type: none"> <li>Fixed AMC pin mapping to map to new swapped transceiver channels from version 1.1 and added all 8 channels.</li> <li>Added CX-4 GigE pin mapping.</li> <li>Reversed single-ended only version channel ordering (D80-D111).</li> </ul>
02/16/2006	1.1	<ul style="list-style-type: none"> <li>Reversed channel order on transceiver lines (XCVR_TX[x], XCVR_RX[x]) to match pin order of Stratix GX and Stratix II GX FPGAs.</li> <li>Updated PCIe and AMC signal mappings according to these swaps.</li> </ul>
01/23/2005	1.0	<ul style="list-style-type: none"> <li>Added CMOS* and CMOS** pin definitions and table entries.</li> <li>Updated layout drawings and dimensions to reflect removal of power headers, changed connector to Samtec ASP, changed PCI Express signal names, changed HSMC and HSM to HMC, added Impact-font "hmc" logos.</li> </ul>
12/20/2005	0.6	<ul style="list-style-type: none"> <li>Changed Samtec data header to custom connector version.</li> <li>Removed small power headers.</li> <li>Swapped even and odd pins in pinout tables for Samtec header.</li> <li>Added HSMC present pin &amp; LED.</li> <li>Updated pin class (style) definitions for new pin numbers.</li> </ul>
12/13/2005	0.5	<ul style="list-style-type: none"> <li>Added additional power header diagrams.</li> <li>Updated layout drawing for new power connectors.</li> <li>Changed example HSMC illustration section to include both passive and active card examples.</li> <li>Updated power section to reflect total power levels.</li> </ul>
11/30/2005	0.4	<ul style="list-style-type: none"> <li>Added jitter table from Samtec BERT testing.</li> <li>Updated layout examples with separate power connectors.</li> </ul>
11/17/2005	0.3	<ul style="list-style-type: none"> <li>Added second 2mm 4-pin connector for power.</li> <li>Added additional differential clock.</li> <li>Added 4 new CMOS pins.</li> <li>Changed all pinouts relative to the general change in available signal pins.</li> </ul>

Date	Version	Description
10/31/2005	0.2	<ul style="list-style-type: none"> <li>Added signal integrity sections for LVDS/CMOS and transceiver signals.</li> <li>Added side-view mezzanine drawing.</li> <li>Changed power pins.</li> <li>Added min. power spec.</li> <li>Added signal type definitions.</li> <li>Shrunk pinout tables to single page per set.</li> </ul>
10/13/2005	0.1	<ul style="list-style-type: none"> <li>Created.</li> </ul>

## How to Contact Altera

For the most up-to-date information about Altera® products, refer to the following table.

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Technical support	<a href="http://www.altera.com/mysupport/">www.altera.com/mysupport/</a>
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*Note to table:*





(1) You can also contact your local Altera sales office or sales representative.

## Typographic Conventions

This document uses the typographic conventions shown below.

Visual Cue	Meaning
<b>Bold Type with Initial Capital Letters</b>	Command names, dialog box titles, checkbox options, and dialog box options are shown in bold, initial capital letters. Example: <b>Save As</b> dialog box.
<b>bold type</b>	External timing parameters, directory names, project names, disk drive names, filenames, filename extensions, and software utility names are shown in bold type. Examples: <b>f<sub>MAX</sub></b> , <b>lqdesigns</b> directory, <b>d:</b> drive, <b>chiptrip.gdf</b> file.
<i>Italic Type with Initial Capital Letters</i>	Document titles are shown in italic type with initial capital letters. Example: <i>AN 75: High-Speed Board Design</i> .



Visual Cue	Meaning
<i>Italic type</i>	Internal timing parameters and variables are shown in italic type. Examples: $t_{PIA}$ , $n + 1$ .  Variable names are enclosed in angle brackets (< >) and shown in italic type. Example: <file name>, <project name>.pdf file.
Initial Capital Letters	Keyboard keys and menu names are shown with initial capital letters. Examples: Delete key, the Options menu.
“Subheading Title”	References to sections within a document and titles of on-line help topics are shown in quotation marks. Example: “Typographic Conventions.”
Courier type	Signal and port names are shown in lowercase Courier type. Examples: data1, tdi, input. Active-low signals are denoted by suffix n, e.g., resetn.  Anything that must be typed exactly as it appears is shown in Courier type. For example: c:\qdesigns\tutorial\chiptrip.gdf. Also, sections of an actual file, such as a Report File, references to parts of files (e.g., the AHDL keyword SUBDESIGN), as well as logic function names (e.g., TRI) are shown in Courier.
1., 2., 3., and a., b., c., etc.	Numbered steps are used in a list of items when the sequence of the items is important, such as the steps listed in a procedure.
■ ● •	Bullets are used in a list of items when the sequence of the items is not important.
✓	The checkmark indicates a procedure that consists of one step only.
	The hand points to information that requires special attention.
	A caution calls attention to a condition or possible situation that can damage or destroy the product or the user's work.
	A warning calls attention to a condition or possible situation that can cause injury to the user.
↵	The angled arrow indicates you should press the Enter key.
	The feet direct you to more information on a particular topic.