

Tsi578 Serial RapidIO Switch Hardware Manual

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About this Document

This section discusses general document information about the *Tsi578 Serial RapidIO Switch Hardware Manual*. The following topics are described:

- “Scope” on page 5
 - “Document Conventions” on page 5
 - “Revision History” on page 7
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Scope

The *Tsi578 Serial RapidIO Switch Hardware Manual* discusses electrical, physical, and board layout information for the Tsi578. It is intended for hardware engineers who are designing system interconnect applications with these devices.

Document Conventions

This document uses a variety of conventions to establish consistency and to help you quickly locate information of interest. These conventions are briefly discussed in the following sections.

Non-differential Signal Notation

Non-differential signals are either active-low or active-high. An active-low signal has an active state of logic 0 (or the lower voltage level), and is denoted by a lowercase “b”. An active-high signal has an active state of logic 1 (or the higher voltage level), and is not denoted by a special character. The following table illustrates the non-differential signal naming convention.

State	Single-line signal	Multi-line signal
Active low	NAME_b	NAME _n [3]
Active high	NAME	NAME[3]

Differential Signal Notation

Differential signals consist of pairs of complement positive and negative signals that are measured at the same time to determine a signal's active or inactive state (they are denoted by “_p” and “_n”, respectively). The following table illustrates the differential signal naming convention.

State	Single-line signal	Multi-line signal
Inactive	NAME_p = 0 NAME_n = 1	NAME_p[3] = 0 NAME_n[3] = 1
Active	NAME_p = 1 NAME_n = 0	NAME_p[3] is 1 NAME_n[3] is 0

Symbols



This symbol indicates a basic design concept or information considered helpful.



This symbol indicates important configuration information or suggestions.



This symbol indicates procedures or operating levels that may result in misuse or damage to the device.

Revision History

80B803A_MA002_07, Final, November 2007

This is the production version of the *Tsi578 Serial RapidIO Switch Hardware Manual*. The key changes include clarification to the following areas:

- Information on “**P_CLK Programming**” on page 70 was added to “**Clocking**” on page 69.
- General clarification in “**Signals and Package**” on page 11, including:
 - Any unused signal that is designated a No Connect (N/C) must be left unconnected
 - The I2C_SCLK signal description was updated
 - The BCE signal description was updated

80B803A_MA002_06, Final, August 2007

This release of the *Tsi578 Serial RapidIO Switch Hardware Manual* had the following modifications:

- A footnote has been added to the recommended terminations in “**Signal Grouping**” on page 12.
- Signals SP_RX_SWAP and SP_TX_SWAP were added to Table 2 on page 12
- The production versions of the part numbers are now listed in “**Ordering Information**” on page 83

80B803A_MA002_05, Final, January 2007

This release of the *Tsi578 Serial RapidIO Switch Hardware Manual* had the following modifications:

- Corrected information in “**Power Dissipation**” on page 32

Updated information in “**Thermal Characteristics**” on page 25

80B803A_MA002_04, Final, January 2007

This release of the *Tsi578 Serial RapidIO Switch Hardware Manual* had the following modifications:

- Added information to “**Power Sequencing**” on page 34
- The T_{storage} (Storage temperature) was changed to a minimum value of -55°C and a maximum value of 125°C in Table 6 on page 29

80B803A_MA002_03, Final, October 2006

This release of the *Tsi578 Serial RapidIO Switch Hardware Manual* had a number of modifications. A new “Clocking” on page 69 was been added, as well as power information in “Power” on page 32.

80B803A_MA002_02, Final, September 2006

This release of the *Tsi578 Serial RapidIO Switch Hardware Manual* has had a number of modifications. The electrical and packaging sections have had extensive revisions and the layout chapter has been added.

Bibliography

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| 2 | Enhancements to the RapidIO AC Specification | This document contains the AC specifications for the RapidIO physical layer. |
| 3 | ANSI/TIA/EIA-644-1995, Electrical Characteristics of Low Voltage Differential Signaling (LVDS) Interface Circuits, March 1996. | This documents the LVDS electrical characteristics. |
| 4 | I2C Specification | This specification defines the standard I2C bus interface, including specifications for all the enhancements. For more information, see www.semiconductors.philips.com document number: 9398 393 40011 |
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1. Signals and Package

This chapter describes the packaging (mechanical) features for the Tsi578. It includes the following information:

- “Pinlist” on page 11
- “Signals” on page 11
- “Package Characteristics” on page 22
- “Thermal Characteristics” on page 25

1.1 Pinlist

Refer to the Tundra website at www.tundra.com for information on the Tsi578 package pinlist and ballmap.

1.2 Signals

The following conventions are used in the signal description table:

- Signals with the suffix “_p” are the positive half of a differential pair.
- Signals with the suffix “_n” are the negative half of a differential pair.
- Signals with the suffix “_b” are active low.

Signals are classified according to the types defined in [Table 1](#).

Table 1: Signal Types

Pin Type	Definition
I	Input
O	Output
I/O	Input/Output
OD	Open Drain
SRIO	Differential driver/receiver defined by <i>RapidIO Interconnect Specification (Revision 1.3)</i>
PU	Pulled Up internal to the Tsi578

Table 1: Signal Types (Continued)

Pin Type	Definition
PD	Pulled Down internal to the Tsi578
LVTTTL	CMOS I/O with LVTTTL thresholds
Hyst	Hysteresis
Core Power	Core supply
Core Ground	Ground for core logic
I/O Power	I/O supply
N/C	No connect These signals must be left unconnected.

1.2.1 Endian Ordering

This document follows the bit-numbering convention adopted by *RapidIO Interconnect Specification (Revision 1.3)*, where [0:7] is used to represent an 8 bit bus with bit 0 as the most-significant bit.

1.2.2 Signal Grouping

Table 2 lists the signals by group and their recommended termination.

Table 2: Signal Descriptions and Recommended Termination

Pin Name	Type	Description	Recommended Termination ^a
PORT n - 1x/4x Mode Serial RapidIO PORT (n+1) - 1x Mode Serial RapidIO n = 0, 2, 4, 6, 8, 10, 12, 14			
SP{n}_TA_p	O, SRIO	Port n Lane A Differential Non-inverting Transmit Data output (4x mode) Port n Differential Non-inverting Transmit Data output (1x mode)	No termination required.
SP{n}_TA_n	O, SRIO	Port n Lane A Differential Inverting Transmit Data output (4x mode) Port n Differential Inverting Transmit Data output (1x mode)	No termination required.

Table 2: Signal Descriptions and Recommended Termination

Pin Name	Type	Description	Recommended Termination ^a
SP{n}_TB_p	O, SRIO	Port n Lane B Differential Non-inverting Transmit Data output (4x mode) Port n+1 Differential Non-inverting Transmit Data output (1x mode)	No termination required.
SP{n}_TB_n	O, SRIO	Port n Lane B Differential Inverting Transmit Data output (4x mode) Port n+1 Differential Inverting Transmit Data output (1x mode)	No termination required.
SP{n}_TC_p	O, SRIO	Port n Lane C Differential Non-inverting Transmit Data output (4x mode)	No termination required.
SP{n}_TC_n	O, SRIO	Port n Lane C Differential Inverting Transmit Data output (4x mode)	No termination required.
SP{n}_TD_p	O, SRIO	Port n Lane D Differential Non-inverting Transmit Data output (4x mode)	No termination required.
SP{n}_TD_n	O, SRIO	Port n Lane D Differential Inverting Transmit Data output (4x mode)	No termination required.
Serial Port n/n+1 Receive n = 0, 2, 4, 6, 8, 10, 12, 14			
SP{n}_RA_p	I, SRIO	Port n Lane A Differential Non-inverting Receive Data input (4x mode) Port n Differential Non-inverting Receive Data input (1x mode)	DC blocking capacitor of 0.1uF in series
SP{n}_RA_n	I, SRIO	Port n Lane A Differential Inverting Receive Data input (4x mode) Port n Differential Inverting Receive Data input (1x mode)	DC blocking capacitor of 0.1uF in series
SP{n}_RB_p	I, SRIO	Port n Lane B Differential Non-inverting Receive Data input (4x mode) Port n+1 Differential Non-inverting Receive Data input (1x mode)	DC blocking capacitor of 0.1uF in series
SP{n}_RB_n	I, SRIO	Port n Lane B Differential Inverting Receive Data input (4x mode) Port n+1 Differential Inverting Receive Data input (1x mode)	DC blocking capacitor of 0.1uF in series
SP{n}_RC_p	I, SRIO	Port n Lane C Differential Non-inverting Receive Data input (4x mode)	DC blocking capacitor of 0.1uF in series

Table 2: Signal Descriptions and Recommended Termination

Pin Name	Type	Description	Recommended Termination ^a
SP{n}_RC_n	I, SRIO	Port n Lane C Differential Inverting Receive Data input (4x mode)	DC blocking capacitor of 0.1uF in series
SP{n}_RD_p	I, SRIO	Port n Lane D Differential Non-inverting Receive Data input (4x mode)	DC blocking capacitor of 0.1uF in series
SP{n}_RD_n	I, SRIO	Port n Lane D Differential Inverting Receive Data input (4x mode)	DC blocking capacitor of 0.1uF in series
Serial Port n/n+1 Configuration n = 0, 2, 4, 6, 8, 10, 12, 14			
SP{n}_REXT		Used to connect a 190Ω (+/-1%) resistor to VSS to provide a reference current for the driver and equalization circuits.	Series resistor of 191Ω (1%) connected to VSS.
SP{n}_MODESEL	I/O, LVTTTL, PD	Selects the serial port operating mode for ports n and n+1 0 - Port n operating in 4x mode (Port n+1 not available) 1 - Ports n and n+1 operating in 1x mode Note: Output capability of this pin is only used in test mode. Must remain stable for 10 P_CLK cycles after HW_RST_B is de-asserted in order to be sampled correctly. Ignored after reset.	Pin must be tied off according to the required configuration. Either a 10K pull up to VDD_IO or a 10K pull-down to VSS_IO. Internal pull-down may be used for logic 0.
SP{n}_PWRDN	I/O, LVTTTL, PU	Port n Transmit and Receive Power Down control This signal controls the state of Port n <i>and</i> Port n+1 The PWRDN controls the state of all four lanes (A/B/C/D) of SERDES Macro. 0 - Port n Powered Up. Port n+1 controlled by SP{n+1}_PWRDN. 1 - Port n Powered Down. Port n+1 Powered Down. Override SP{n}_PWRDN using PWDN_x1 field in "SRIO MAC x Clock Selection Register" in the Tsi578 User Manual. Output capability of this pin is only used in test mode. Must remain stable for 10 P_CLK cycles after HW_RST_B is de-asserted in order to be sampled correctly. Ignored after reset.	Pin must be tied off according to the required configuration. Either a 10K pull up to VDD_IO or a 10K pull-down to VSS_IO. Internal pull-up may be used for logic 1.

Table 2: Signal Descriptions and Recommended Termination

Pin Name	Type	Description	Recommended Termination ^a
SP{n+1}_PWRDN	I/O, LVTTTL, PU	<p>Port n+1 Transmit and Receive Power Down control</p> <p>This signal controls the state of Port n+1. Note that Port n+1 is never used when 4x mode is selected for a Serial Rapid IO MAC, and it must be powered down.</p> <p>0 - Port n+1 Powered Up 1 - Port n+1 Powered Down</p> <p>Override SP{n+1}_PWRDN using PWDN_x4 field in "SRIO MAC x Clock Selection Register" in the Tsi578 User Manual.</p> <p>Output capability of this pin is only used in test mode.</p> <p>Must remain stable for 10 P_CLK cycles after HW_RST_B is de-asserted in order to be sampled correctly. Ignored after reset.</p>	<p>Pin must be tied off according to the required configuration. Either a 10K pull up to VDD_IO or a 10K pull-down to VSS_IO.</p> <p>Internal pull-up may be used for logic 1.</p>
Serial Port Speed Select			
SP_IO_SPEED[1]	I/O, LVTTTL, PD	<p>Serial Port Transmit and Receive operating frequency select, bit 1. When combined with SP_IO_SPEED[0], this pin selects the default serial port frequency for all ports.</p> <p>00 = 1.25Gbit/s; 01 = 2.5Gbit/s (default) ; 10 = 3.125Gbit/s; 11 = illegal</p> <p>Selects the speed at which the ports operates when reset is removed. This could be either due to HARD_RST_b being de-asserted or by the completion of a self-reset.</p> <p>This signal must remain stable for 10 P_CLK cycles after HW_RST_B is de-asserted in order to be sampled correctly. The signal is ignored after reset.</p> <p>The SP_IO_SPEED[1:0] setting is equal to the SCLK_SEL field in SRIO MAC x Clock Selection Register in the Tsi578 User Manual.</p> <p>Output capability of this pin is only used in test mode.</p>	<p>Pin must be tied off according to the required configuration. Either a 10K pull-up to VDD_IO or a 10K pull-down to VSS_IO.</p> <p>Internal pull-down may be used for logic 0.</p>

Table 2: Signal Descriptions and Recommended Termination

Pin Name	Type	Description	Recommended Termination ^a
SP_IO_SPEED[0]	I/O, LVTTTL, PU	See SP_IO_SPEED[1]	Pin must be tied off according to the required configuration. Either a 10K pull-up to VDD_IO or a 10K pull-down to VSS_IO. Internal pull-up may be used for logic 1.
Serial Port Lane Ordering Select			
SP_RX_SWAP	I, LVTTTL, PD	Configures the order of 4x receive lanes on serial ports [0,2,4,6,...,14]. 0 = A, B, C, D 1 = D, C, B, A Must remain stable for 10 P_CLK cycles after HARD_RST_b is de-asserted in order to be sampled correctly. Ignored after reset.	No termination required. Internal pull-down can be used for logic 0. Pull up to VDD_IO through 10K if external pull-up is desired. Pull down to VSS_IO through 10K if external pull-down is desired.
SP_TX_SWAP	I, LVTTTL, PD	Configures the order of 4x transmit lanes on serial ports [0,2,4,6,...,14]. 0 = A, B, C, D 1 = D, C, B, A Must remain stable for 10 P_CLK cycles after HARD_RST_b is de-asserted in order to be sampled correctly. Ignored after reset.	No termination required. Internal pull-down can be used for logic 0. Pull up to VDD_IO through 10K if external pull-up is desired. Pull down to VSS_IO through 10K if external pull-down is desired.
Clock and Reset			
P_CLK	I CML	This clock is used for the register bus clock. The maximum frequency of this input clock is 100 MHz.	No termination required.
S_CLK_p	I CML	Differential non-inverting reference clock. The clock is used for following purposes: SERDES reference clock, serial port system clock, ISF clock and test clock. The clock frequency is defined in the Minimum Clock Frequency Requirements section. The maximum frequency of this input clock is 156.25 MHz.	AC coupling capacitor of 0.1uF required.

Table 2: Signal Descriptions and Recommended Termination

Pin Name	Type	Description	Recommended Termination ^a
S_CLK_n	I CML	Differential inverting reference clock. The clock is used for following purposes: SerDes reference clock, serial port system clock, ISF clock and test clock. The clock frequency is defined in the Minimum Clock Frequency Requirements section. The maximum frequency of this input clock is 156.25 MHz.	AC coupling capacitor of 0.1 uF required.
HARD_RST_b	I LVTTTL, Hyst, PU	Schmidt-triggered hard reset. Asynchronous active low reset for the entire device. The Tsi578 does not contain a voltage detector to generate internal reset.	Connect to a power-up reset source. See “Reset Requirements” on page 64 for more detail.
Interrupts			
INT_b	O, OD, LVTTTL, 2mA	Interrupt signal (open drain output)	External pull-up required. Pull up to VDD_IO through 10K.
SW_RST_b	O, OD, LVTTTL, 2mA	Software reset (open drain output): This signal is asserted when a RapidIO port receives a valid reset request on a RapidIO link. If self-reset is not selected, this pin remains asserted until the reset request is cleared from the status registers. If self-reset is selected, this pin remains asserted until the self reset is complete. If the Tsi578 is reset from the HARD_RST_b pin, this pin is de-asserted and remains de-asserted after HARD_RST_b is released. For more information, refer to “Resets” in the Tsi578 User’s Manual.	External pull-up required. Pull up to VDD_IO through 10K.
Miscellaneous			
Multicast			

Table 2: Signal Descriptions and Recommended Termination

Pin Name	Type	Description	Recommended Termination ^a
MCES	I/O, LVTTTL, PD	Multicast Event Symbol pin. As an input, an edge (rising or falling) will trigger a Multicast Event Control Symbol will be sent to all ports; As an output, this pin will toggle its value every time an Multicast Event Control Symbol is received by any port which is enabled for Multicast even control symbols. Must remain stable for 10 P_CLK cycles <i>before and after</i> a transition.	No termination required. This pin must not be driven by an external source until all power supply rails are stable.
I²C			
I2C_SCLK	O, OD, LVTTTL, PU 8mA	I ² C clock, up to 100 kHz. This clock signal must be connected to the clock of the serial EEPROM on the I2C bus.	No termination required. Internal pull-up may be used for logic 1. Pull up to VDD_IO through a minimum 470 ohms resistor if higher edge rate required.
I2C_SD	I/O, OD, LVTTTL, PU 8mA	I ² C input and output data bus (bidirectional open drain)	No termination required. Internal pull-up may be used for logic 1. Pull up to VDD_IO through a minimum 470 ohms resistor if higher edge rate required.
I2C_DISABLE	I, LVTTTL, PD	Disable I ² C register loading after reset. When asserted, the Tsi578 will not attempt to load register values from I ² C.	No termination required. Pull up to VDD_IO through 10K if I2C loading is not required.
I2C_MA	I, CMOS, PU	I ² C Multibyte Address. When driven high, I ² C module will expect multi-byte peripheral addressing; otherwise, when driven low, single-byte peripheral address is assumed. Must remain stable for 10 P_CLK cycles after HW_RST_b is de-asserted in order to be sampled correctly. Ignored after reset.	No termination required. Internal pull-up may be used for logic 1. Pull up to VDD_IO through 10K resistor if external pull-up is desired. Pull down to VSS_IO to change the logic state.

Table 2: Signal Descriptions and Recommended Termination

Pin Name	Type	Description	Recommended Termination ^a
I2C_SA[1,0]	I, CMOS, PU	I ² C Slave Address pins. The values on these two pins represent the values for the lower 2 bits of the 7-bit address of Tsi578 when acting as an I ² C slave. The values at these pins can be overridden by software after reset.	No termination required. Internal pull-up may be used for logic 1. Pull up to VDD_IO through 10K resistor if external pull-up is desired. Pull down to VSS_IO to change the logic state.
I2C_SEL	I, CMOS, PU	I ² C Pin Select. Together with the I2C_SA[1,0] pins, Tsi578 will determine the lower 2 bits of the 7-bit address of the EEPROM address it boots from. When asserted, the I2C_SA[1,0] values will also be used as the lower 2 bits of the EEPROM address. When de-asserted, the I2C_SA[1,0] pins will be ignored and the lower 2 bits of the EEPROM address are default to 00. The values of the lower 2 bits of the EEPROM address can be over-riden by software after reset.	No termination required. Internal pull-up may be used for logic 1. Pull up to VDD_IO through 10K resistor if external pull-up is desired. Pull down to VSS_IO to change the logic state.
JTAG TAP Controller			
TCK	I, LVTTTL, PD	IEEE 1149.1 Test Access Port Clock input	Pull up to VDD_IO through 10K if not used.
TDI	I, LVTTTL, PU	IEEE 1149.1 Test Access Port Serial Data Input	Pull up to VDD_IO through 10K if not used or if higher edge rate is required.
TDO	O, LVTTTL, 2mA	IEEE 1149.1 Test Access Port Serial Data Output	No connect if JTAG is not used. Pull up to VDD_IO through 10K if used.
TMS	I, LVTTTL, PU	IEEE 1149.1 Test Access Port Test Mode Select	Pull up to VDD_IO through 10K if not used.

Table 2: Signal Descriptions and Recommended Termination

Pin Name	Type	Description	Recommended Termination ^a
TRST_b	I, LVTTTL, PU	IEEE 1149.1 Test Access Port TAP Reset Input This input must be asserted during the assertion of HARD-RST_b. Afterwards, it may be left in either state. Combine the HARD_RST_b and TRST_b signals with an AND gate and use the output to drive the TRST_b pin.	Tie to VSS_IO through a 10K resistor if not used.
BCE	I, LVTTTL, PU	Boundary Scan compatibility enabled pin. This input is used to aid 1149.6 testing. This signal also enables system level diagnostic capability using features built into the SerDes. For more information on this functionality, refer to the Serial RapidIO Signal Analyzer documentation available on the Tundra extranet. This signal must be tied to VDD_IO during normal operation of the device, and during JTAG accesses of the device registers	This signal should have the capability to be pulled-up or pulled-low. <ul style="list-style-type: none"> The default setting is to be pulled-up. Pulling the signal low enables the signal analyzer functionality on the SerDes A 10K resistor to VDD_IO should be used.
Power Supplies			
Port n/n+1 n = 0, 2, 4, 6, 8, 10, 12, 14			
SP{n}_AVDD	-	Port n and n+1: 3.3V supply for bias generator circuitry. This is required to be a low-noise supply.	Refer to “Decoupling Requirements” on page 57.
REF_AVDD	-	Analog 1.2V for Reference Clock (S_CLK_p/n). Clock distribution network power supply.	Refer to “Decoupling Requirements” on page 57.
Common Supply			
VDD_IO	-	Common 3.3V supply for CMOS I/O	Refer to “Decoupling Requirements” on page 57.
VSS_IO	-	Common ground supply for I/Os	Refer to “Decoupling Requirements” on page 57.

Table 2: Signal Descriptions and Recommended Termination

Pin Name	Type	Description	Recommended Termination ^a
VSS	-	Common ground supply for digital logic	Refer to “Decoupling Requirements” on page 57.
VDD	-	Common 1.2V supply for digital logic	Refer to “Decoupling Requirements” on page 57.
SP_VDD	-	1.2V supply for CDR, Tx/Rx, and digital logic for all RapidIO ports	Refer to “Decoupling Requirements” on page 57.

a. Signals for unused serial ports do not require termination and can be left as N/Cs.

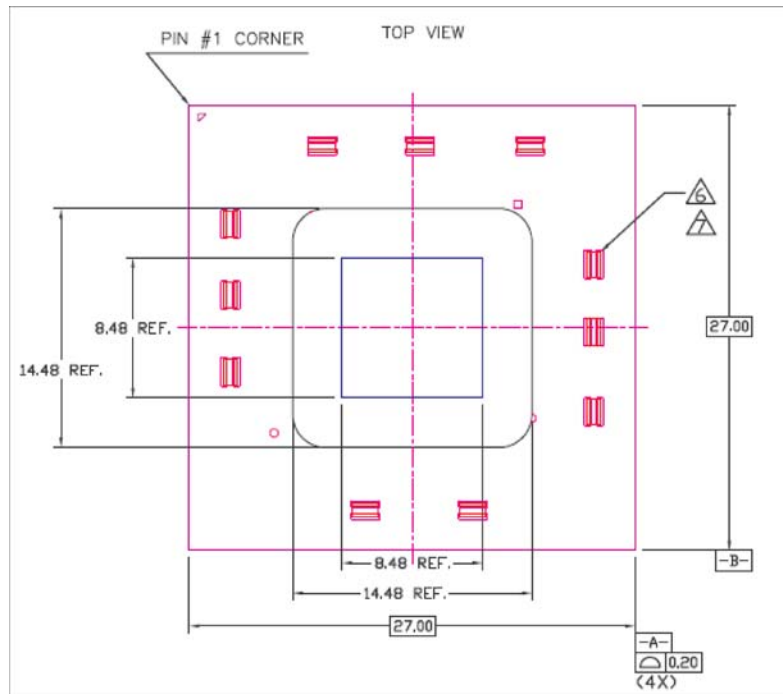
1.3 Package Characteristics

The Tsi578's package characteristics are summarized in the following table. [Figure 1](#) and [Figure 2](#) illustrates the Top and Side views of the Tsi578 package. [Figure 3](#) represents the Bottom view of the device.

Table 3: Tsi578 Package Characteristics

Feature	Description
Package Type	Flip-Chip Ball Grid Array (FCBGA)
Ball count	675-ball
Package Body Size	27 mm x 27 mm
JEDEC Specification	95-1 Section 14
Pitch	1.00 mm
Ball pad size	500 um
Soldermask opening	400 um
Moisture Sensitivity Level	4

Figure 1: Tsi578 Package Diagram — Top View



The capacitors shown may or may not be present on the Tsi578 package.

Figure 2: Tsi578 Package Diagram — Side View

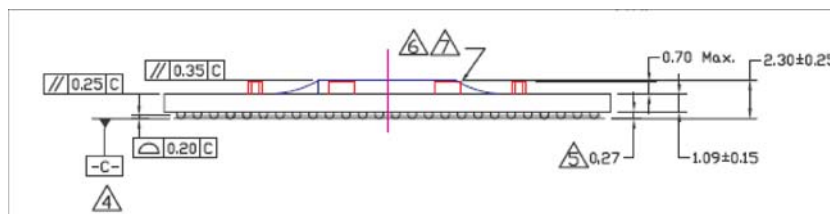
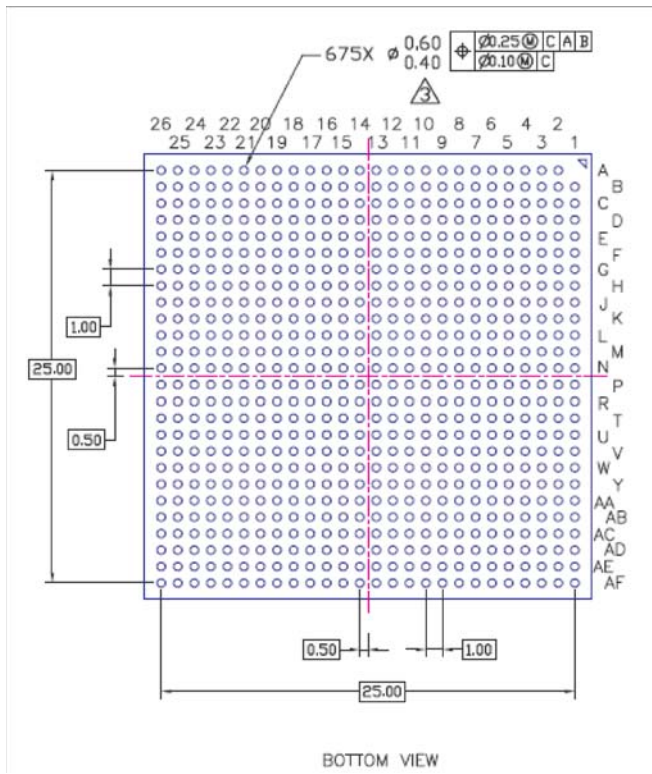


Figure 3: Tsi578 Package Diagram — Bottom View



1.4 Thermal Characteristics

Heat generated by the packaged IC has to be removed from the package to ensure that the IC is maintained within its functional and maximum design temperature limits. If heat buildup becomes excessive, the IC temperature may exceed the temperature limits. A consequence of this is that the IC may fail to meet the performance specifications and the reliability objectives may be affected.

Failure mechanisms and failure rate of a device have an exponential dependence of the IC operating temperatures. Thus, the control of the package temperature, and by extension the Junction Temperature, is essential to ensure product reliability. The Tsi578 is specified safe for operation when the Junction Temperature is within the recommended limits.

Table 4 shows the simulated Theta_{jb} and Theta_{jc} thermal characteristics of the Tsi578 FCBGA package.

Table 4: Thermal Characteristics of Tsi578

Interface	Result
Theta _{jb} (junction to board)	11.7 °C/watt
Theta _{jc} (junction to case)	0.08 °C/watt

1.4.1 Junction-to-Ambient Thermal Characteristics (Theta_{ja})

Table 5 shows the simulated Theta_{ja} thermal characteristic of the Tsi578 FCBGA package. The results in **Table 5** are based on a JEDEC Thermal Test Board configuration (JESD51-9) and do not factor in system level characteristics. As such, these values are for reference only.



The Theta_{ja} thermal resistance characteristics of a package depend on multiple system level variables.

Table 5: Simulated Junction to Ambient Characteristics

Package	Theta _{ja} at specified airflow (no Heat Sink)		
	0 m/s	1 m/s	2 m/s
Tsi578 FCBGA	14.6 C/watt	13.6 °C/watt	12.9 °C/watt

1.4.1.1 System-level Characteristics

In an application, the following system-level characteristics and environmental issues must be taken into account:

- Package mounting (vertical / horizontal)
- System airflow conditions (laminar / turbulent)
- Heat sink design and thermal characteristics (see “[Heatsink Requirement and Analysis](#)” on page 26)
- Heat sink attachment method (see “[Heatsink Requirement and Analysis](#)” on page 26)
- PWB size, layer count and conductor thickness
- Influence of the heat dissipating components assembled on the PWB (neighboring effects)

Example on Thermal Data Usage

Based on the θ_{JA} data and specified conditions, the following formula can be used to derive the junction temperature (T_j) of the Tsi578 with a 0m/s airflow:

- $T_j = \theta_{JA} * P + T_{amb}$.

Where: T_j is Junction Temperature, P is the Power consumption, T_{amb} is the Ambient Temperature

Assuming a power consumption (P) of 3.5 W and an ambient temperature (T_{amb}) of 70°C, the resulting junction temperature (T_j) would be 121.1°C.

1.4.2 Heatsink Requirement and Analysis

The Tsi578 is packaged in a Flip-Chip Ball Grid Array (FCBGA). With this package technology, the silicon die is exposed and serves as the interface between package and heatsink. Where a heatsink is required to maintain junction temperatures at or below specified maximum values, it is important that attachment techniques and thermal requirements be critically analyzed to ensure reliability of this interface. Factors to be considered include: surface preparations, selection of thermal interface materials, curing process, shock and vibration requirements, and thermal expansion coefficients, among others. Each design should be individually analyzed to ensure that a reliable thermal solution is achieved.



Both mechanical and adhesive techniques are available for heatsink attachment. Tundra makes no recommendations as to the reliability or effectiveness of either approach. The designer must critically analyze heatsink requirements, selection criteria, and attachment techniques.

1.4.2.1 Heatsink Attachment

Both mechanical and adhesive techniques are available for heatsink attachment.



Both mechanical and adhesive techniques are available for heatsink attachment. Tundra makes no recommendations as to the reliability or effectiveness of either approach. The designer must critically analyze heatsink requirements, selection criteria, and attachment techniques.

For heatsink attachment methods that induce a compressive load to the FCBGA package, the maximum force that can be applied to the package should be limited to 5 gm / BGA ball (provided that the board is supported to prevent any flexing or bowing). The maximum force for the Tsi578 package is 3.38 Kg.

2. Electrical Characteristics

This chapter provides the electrical characteristics for the Tsi578. It includes the following information:

- “Absolute Maximum Ratings” on page 29
- “Recommended Operating Conditions” on page 30
- “Power” on page 32

2.1 Absolute Maximum Ratings

Operating the device beyond the operating conditions is not recommended. Stressing the Tsi578 beyond the Absolute Maximum Rating can cause permanent damage.

Table 6 lists the absolute maximum ratings.

Table 6: Absolute Maximum Ratings

Symbol	Parameter	Min	Max	Unit
T_{storage}	Storage Temperature	-55	125	°C
$V_{\text{DD_IO}}$	3.3 V DC Supply Voltage	-0.5	4.6	V
$\text{SP}\{n\}\text{_AVDD}$	3.3 V Analog Supply Voltage	-0.5	4.6	V
$V_{\text{DD}}, \text{SP_VDD}, \text{REF_AVDD}$	1.2 V DC Supply Voltage	-0.3	1.7	V
$V_{\text{I_SP}\{n\}\text{-R}\{A\text{-D}\}\{p,n\}}$	SERDES Port Receiver Input Voltage	-0.3	3	V
$V_{\text{O_SP}\{n\}\text{-T}\{A\text{-D}\}\{p,n\}}$	SERDES Port VM Transmitter Output Voltage	-0.3	3	V
$\text{SP}\{n\}\text{_AVDD}$	Transient di/dt	-	0.0917	A/nS
SP_AVDD	Transient di/dt	-	0.136	A/nS

Table 6: Absolute Maximum Ratings

Symbol	Parameter	Min	Max	Unit
V_{O_LVTTL}	LVTTTL Output or I/O Voltage	-0.5	$V_{DD_IO} + 0.5$	V
V_{ESD_HBM}	Maximum ESD Voltage Discharge Tolerance for Human Body Model (HBM). [Test Conditions per JEDEC standard - JESD22-A114-B]	-	2000	V
V_{ESD_CDM}	Maximum ESD Voltage Discharge Tolerance for Charged Device Model (CDM). Test Conditions per JEDEC standard - JESD22-C101-A	-	500	V

2.2 Recommended Operating Conditions

Table 7 lists the recommended operating conditions. The current values provided are maximum



Continued exposure of Tundra's devices to the maximum limits of the specified junction temperature could affect the device reliability. Subjecting the devices to temperatures beyond the maximum/minimum limits could result in a permanent failure of the device.

Table 7: Recommended Operating Conditions

Symbol	Parameter	Min	Max	Unit
T_j	Junction temperature	-40	125°	°C
V_{DD_IO}	3.3 V DC Supply Voltage	2.97	3.63	V
$SP\{n\}_AVDD$	3.3 V Analog Supply Voltage	2.97	3.63	V
V_{DD,SP_VDD,REF_AVDD}	1.2 V DC Supply Voltage	1.14	1.29	V
I_{VDD_IO}	3.3 V IO Supply Current ^a	-	15	mA
I_{SP_VDD}	SerDes Digital Supply Current ^a	-	716	mA
I_{SP_AVDD}	3.3 V SerDes Supply Current ^a	-	480	mA
I_{VDD}	1.2 V Core Supply Current ^a	-	3300	mA
I_{REF_AVDD}	1.2 V Ref Clock Supply Current	-	12.5	mA

Table 7: Recommended Operating Conditions

Symbol	Parameter	Min	Max	Unit
V_{ripple1}	Power Supply ripple for Voltage Supplies: SP_VDD, VDD and VDD_IO	-	100	mV _{pp}
V_{ripple2}	Power Supply ripple for Voltage Supplies: SP{n}_AVDD, REF_AVDD	-	50	mV _{pp}
I_{REXT}	External reference resistor current	-	10	uA

- a. The current values provided are maximum values and dependent on device configuration, such as port usage, traffic, etc.

2.3 Power

The following sections describe the Tsi578's power dissipation and power sequencing.

2.3.1 Power Dissipation

The power dissipation values provided are dependent on device configuration. The line rate, port configuration, traffic all impact the Tsi578's power consumption.

The following table shows the power in both 1x and 4x modes..

Table 8: Measured Power, 1x Mode, 16 Links in Operation

Line Rate	1.25 GBaud	2.5 GBaud	3.125 GBaud	Notes
VDD_CORE	1.07	1.74	2.10	2,9
SP_VDD	0.73	0.75	0.91	3
SPn_AVDD	1.42	1.59	1.83	4
VDD_IO	0.01	0.01	0.01	5
Total Measured Power Consumption (W)	3.23	4.09	4.84	1,6,7,8
Power Reduction per Unused Odd Port (W)	0.06	0.10	0.13	10
Power Reduction per Unused Even Port (W)	0.32	0.37	0.43	11

Notes

1. Voltage, temperature and process are all nominal
2. VDD_CORE supplies the ISF and other internal digital logic
3. SP_VDD supplies the digital portion of the SRIO SerDes
4. SPn_AVDD supplies the analog portion of the SRIO SerDes
5. VDD_IO supplies power for all non-SRIO I/O
6. Total power is independent of SRIO distance travelled due to Voltage Mode Driver technology used for SRIO I/O
7. Slight power variations must expected across different applications
8. Power is provided for fully utilized SRIO lanes
9. Core power reduces by approximately 10% under light traffic conditions

10. The corresponding even port is powered up and fully utilized
11. The corresponding odd port is already powered down. This number represents additional power reduction which is gained by powering down the even port

The following table represents the measured power in 4x mode.

Table 9: Measured Power, 4x Mode, Eight Links in Operation

Line Rate	1.25GBaud	2.5GBaud	3.125GBaud	Notes
VDD_CORE	1.03	1.65	1.92	2,9
SP_VDD	0.79	0.85	1.06	3
SPn_AVDD	1.49	1.84	2.13	4
VDD_IO	0.01	0.01	0.01	5
Total Measured Power Consumption (W)	3.32	4.34	5.11	1,6,7, 8
Power Reduction per Unused Port (W)	0.37	0.50	0.60	10

Notes

1. Voltage, temperature and process are all nominal
2. VDD_CORE supplies the ISF and other internal digital logic
3. SP_VDD supplies the digital portion of the SRIO SerDes
4. SPn_AVDD supplies the analog portion of the SRIO SerDes
5. VDD_IO supplies power for all non-SRIO I/O
6. Total power is independent of SRIO distance travelled due to Voltage Mode Driver technology used for SRIO I/O
7. Slight power variations must be expected across different applications
8. Power is provided for fully utilized SRIO lanes
9. Core power reduces by approximately 10% under light traffic conditions
10. Link pair refers to link groups 0/1, 2/3, etc. The odd numbered ports in the link pairs are powered down.

2.3.2 Power Sequencing

The Tsi578 must have the supplies powered-up in the following order:

- VDD (1.2 V) must be powered up first
- SP_VDD (1.2 V) and REF_AVDD (1.2 V) should power up at approximately the same time as VDD
- Delays between the powering up of VDD, SP_VDD, and REF_AVDD are acceptable.
- No more than 50ms after VDD is at a valid level, VDD_IO (3.3 V) should be powered up to a valid level
- VDD_IO (3.3V) must not power up before VDD (1.2 V)
- SPn_AVDD (3.3V) should power up at approximately the same time as VDD_IO
- Delays between powering up VDD_IO and SPn_AVDD are acceptable
- SPn_AVDD must not power up before SP_VDD



It is recommended that there not be more than 50ms between ramping of the 1.2 V and 3.3 V supplies. The power supply ramp rates must be kept between 10 V/s and 1×10^6 V/s to minimize power current spikes during power up.

If it is necessary to sequence the power supplies in a different order than that recommended above, the following precautions must be taken:

- Any power-up option pins must be current limited with 10 K ohms to VDD_IO or VSS_IO as required to set the desired logic level.
- Power-up option pins that are controlled by a logic device must not be driven until all power supply rails to the Tsi578 are stable.

2.3.2.1 Power-down

Power down is the reverse sequence of power up:

- VDD_IO (3.3V) and SP{n}_AVDD
- VDD (1.2V), SP_VDD and REF_AVDD power-down at the same time, or all rails falling simultaneously.

2.4 Electrical Characteristics

This section describes the AC and DC signal characteristics for the Tsi578.

2.4.1 SerDes Receiver (SP{n}_RD_p/n)

Table 10 lists the electrical characteristics for the SerDes Receiver in the Tsi578.

Table 10: SerDes Receiver Electrical Characteristics

Symbol	Parameter	Min	Typ	Max	Unit	Notes
Z_{DI}	RX Differential Input impedance	90	100	110	Ohm	-
V_{DIFFI}	RX Differential Input Voltage	170	-	1600	mV	-
L_{CR}	RX Common Mode Return Loss	-	-	6	dB	Over a range 100MHz to 0.8* Baud Frequency
L_{DR}	RX Differential Return Loss	-	-	10	dB	Over a range 100MHz to 0.8* Baud Frequency
V_{LOS}	RX Loss of Input Differential Level	55	-	-	mV	Port Receiver Input level below which Low Signal input is detected
$T_{RX_ch_skew}$	RX Channel to Channel Skew Tolerance	-	-	24	ns	Between channels in a given x4 port @ 1.25/2.5Gb/s
		-	-	22	ns	Between channels in a given x4 port @ 3.125Gb/s
R_{TR}, R_{TF}	RX Input Rise/Fall times	-	-	160	ps	Between 20% and 80% levels

2.4.2 SerDes Transmitter (SP{n}_TD_p/n)

Table lists the electrical characteristics for the SerDes transmitter in the Tsi578.

Table 11: SerDes Transmitter Electrical Characteristics

Symbol	Parameter	Min	Typ	Max	Unit	Notes
Z_{SEO}	TX Single-Ended Output impedance	45	50	55	Ohm	-
Z_{DO}	TX Differential Output Impedance	90	100	110	Ohm	-
V_{SW}	TX Output Voltage Swing (Single-ended)	425		600	mVp -p	V_{SW} (in mV) = $Z_{SEO}/2 \times I_{nom} \times R_{ldr}/I_{nom}$, where R_{ldr}/I_{nom} is the I_{dr} to I_{nom} ratio.
V_{DIFFO}	TX Differential Output Voltage Amplitude	-	$2 \cdot V_{SW}$		mVp -p	-
V_{OL}	TX Output Low-level Voltage	-	1.2 - V_{SW}		V	-
V_{OH}	TX Output High-level Voltage	-	1.2		V	-
V_{TCM}	TX common-mode Voltage	-	1.2 - $V_{SW}/2$		V	-
L_{DR1}	TX Differential Return Loss	-	-	10	dB	For (Baud Frequency)/10 < Freq(f) < 625MHz and
L_{DR2}	TX Differential Return Loss	-	-	$10 + 10 \log(f/625M \text{ Hz}) $	dB	For $625MHz \leq \text{Freq}(f) \leq \text{Baud Frequency}$
T_{TX_skew}	TX Differential signal skew	-	-	15	ps	Skew between _p and _n signals on a give Serial channel
T_{TR}, T_{TF}	TX Output Rise/Fall times	80	-	110	ps	Between 20% and 80% levels

2.4.3 Reference Clock, S_CLK_p/n

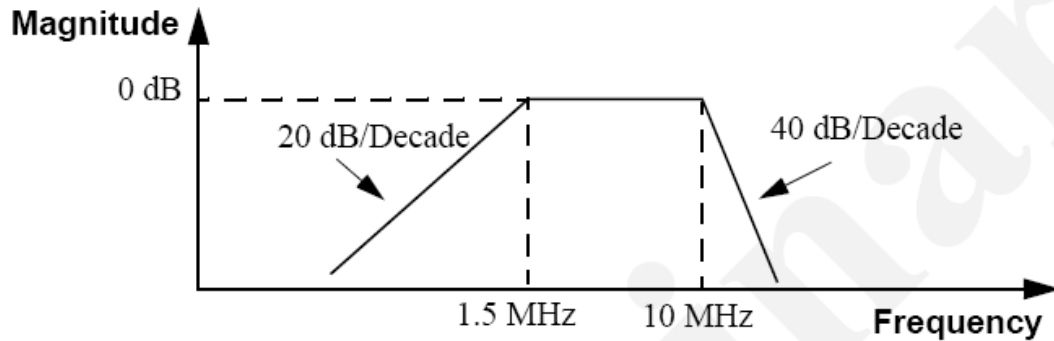
Table 12 lists the electrical characteristics for the differential SerDes Reference clock input (S_CLK_p/n) in the Tsi578.

Table 12: Reference Clock (S_CLK_p/n) Electrical Characteristics

Symbol	Parameter	Min	Typ	Max	Unit	Notes
V _{SW}	Input voltage swing	0.1	0.5	1	V	
V _{DIFF}	Differential input voltage swing	$V_{DIFF} = V_{SW} * 2$			V	
V _{CM}	Differential Input Common Mode Range ((S_CLK_p + S_CLK_n)/2)	175	-	2000	mV	The S_CLK_p/n must be AC coupled.
F _{in}	Input Clock Frequency	156.25	-	156.25	MHz	
F _{S_CLK_P/N}	Ref Clock Frequency Stability	-100	-	+100	ppm	PPM with respect to 156.25 MHz.
F _{in_DC}	Ref Clock Duty Cycle	40	50	60	%	
T _{skew}	Ref Clock Skew	-	-	0.32	ns	Between _p and _n inputs.
T _{R_SCLK} , T _{F_SCLK}	S_CLK_p/n Input Rise/Fall Time	-	-	1	ns	
J _{CLK-REF}	Total Phase Jitter, rms	-	-	3	ps _{rms}	See Below ^a
Z _{in}	Input Impedance	80	100	114	ohms	

- a. Total Permissible Phase Jitter on the Reference Clock is 3 ps rms. This value is specified with assumption that the measurement is done with a 20 G Samples/s scope with more than 1 million samples taken. The zero-crossing times of each rising edges are recorded and an average Reference Clock is calculated. This average period may be subtracted from each sequential, instantaneous period to find the difference between each reference clock rising edge and the ideal placement to produce the Phase Jitter Sequence. The PSD of the phase jitter is calculated and integrated after being weighted with the transfer function shown in Figure 4. The square root of the resulting integral is the rms Total Phase Jitter.

Figure 4: Weighing function for RMS Phase Jitter Calculation



2.4.4 LVTTTL I/O and Open Drain Signals

Table 13 lists the electrical characteristics for the 3.3 V digital LVTTTL Interface pins on the Tsi578.

Table 13: LVTTTL I/O and Open Drain Electrical Characteristics

Symbol	Parameter	Min	Typ	Max	Unit	Notes
V_{IL}	LVTTTL Input Low Voltage	-	-	0.8	V	All inputs and I/Os of LVTTTL type
V_{IH}	LVTTTL Input High Voltage	2.0	-		V	All inputs and I/Os of LVTTTL type
I_{IL}	LVTTTL Input Low Current	-	-	10	μ A	All non-PU inputs and I/Os of LVTTTL type
I_{IH}	LVTTTL Input High Current	-	-	-10	μ A	All non-PD inputs and I/Os of LVTTTL type
I_{OZL_PU}, I_{IL_PU}	LVTTTL Input Low/ Output Tristate Current	5	-	100	μ A	All PU inputs and I/Os of LVTTTL type for voltages from 0 to V_{DD_IO} on the pin.
I_{OZH_PD}, I_{IH_PD}	LVTTTL Input High/ Output Tristate Current	-5	-	-100	μ A	All PD inputs and I/Os of LVTTTL type for voltages from 0 to V_{DD_IO} on the pin.
V_{OL}	LVTTTL Output Low Voltage	-	-	0.4	V	$I_{OL}=2\text{mA}$ for INT_b, SW_RST_b, and TDO pins $I_{OL}=8\text{mA}$ for I2C_CLK and I2C_SD pins
V_{OH}	LVTTTL Output High Voltage	$V_{DD_IO} - 0.5$	-	-	V	$I_{OH}=2\text{mA}$ for INT_b, SW_RST_b, and TDO pins

Table 13: LVTTTL I/O and Open Drain Electrical Characteristics

Symbol	Parameter	Min	Typ	Max	Unit	Notes
$V_{\text{OVERSHOOT}}$	Dynamic Overshoot	-	-	0.9	V	0.9V Max with a maximum energy of 0.75 V-ns
V_{Hyst}	LVTTTL Input Hysteresis Voltage	-	200	-	mV	All Hyst inputs and I/Os of LVTTTL type
C_{Pad}	LVTTTL Pad Capacitance	-	-	10	pF	All pads of LVTTTL type
T_{cfgpS}	Configuration Pin Setup Time	100	-	-	ns	For all Configuration pins (except SP{n}_MODESEL with respect to HARD_RST_b rising edge
T_{cfgpH}	Configuration Pin Hold Time	100	-	-	ns	For all Configuration pins (except SP{n}_MODESEL) with respect to HARD_RST_b rising edge
$T_{\text{sp_modeselS}}$	SP{n}_MODESEL Setup Time	5	-	-	ns	with respect to rising edge of P_CLK. SP{n}_MODESEL pins are sampled on every rising edge of P_CLK.
$T_{\text{sp_modeselH}}$	SP{n}_MODESEL Hold Time	5	-	-	ns	with respect to rising edge of P_CLK. SP{n}_MODESEL pins are sampled on every rising edge of P_CLK.
T_{ISOV1}	INT_b/SW_RST_b Output Valid Delay from rising edge of P_CLK	-	-	15	ns	Measured between 50% points on both signals. Output Valid delay is guaranteed by design.
T_{ISOF1}	INT_b/SW_RST_b Output Float Delay from rising edge of P_CLK	-	-	15	ns	A float condition occurs when the output current becomes less than I_{LO} , where I_{LO} is $2 \times I_{\text{OZ}}$. Float delay guaranteed by design.
$F_{\text{in_P_CLK}}$	Input Clock Frequency	100	-	100	MHz	-
$F_{\text{in_STAB}}$	P_CLK Input Clock Frequency Stability	-100	-	+100	ppm	-
$F_{\text{in_PCLK_DC}}$	P_CLK Input Clock Duty Cycle	40	50	60	%	-
J_{PCLK}	P_CLK Input Jitter	-	-	300	ps _{pp}	-
$T_{\text{R_PCLK}}, T_{\text{F_PCLK}}$	P_CLK Input Rise/Fall Time	-	-	2.5	ns	-

Table 13: LVTTTL I/O and Open Drain Electrical Characteristics

Symbol	Parameter	Min	Typ	Max	Unit	Notes
f_{MCES}	MCES pin frequency	-	-	1	MHz	both as input and output
R pull-up	Resistor pull-up	82K	-	260K	ohms	@ $V_{\text{il}}=0.8\text{V}$
R pull-down	Resistor pull-down	28K	-	54K	ohms	@ $V_{\text{ih}}=2.0\text{V}$

2.4.5 I²C Interface

Table 14 lists the AC specifications for Tsi578's I²C Interface. The I2C interfaces includes balls: I2C_SCLK, I2C_SD, I2C_DISABLE, I2C_MA, I2C_SEL, I2C_SA[1:0] and I2C_SEL.

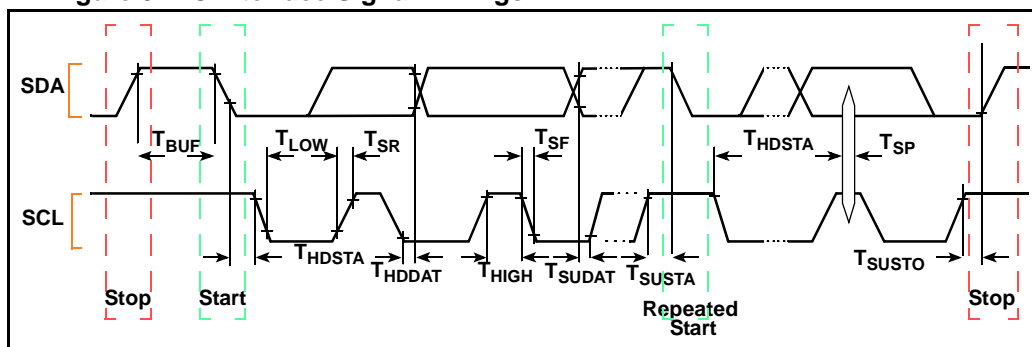
Table 14: AC Specifications for I²C Interface

Symbol	Parameter	Min	Max	Units	Notes
F _{SCL}	I2C_SD/I2C_SCLK Clock Frequency	0	100	kHz	-
T _{BUF}	Bus Free Time Between STOP and START Condition	4.7	-	μs	1
T _{LOW}	I2C_SD/I2C_SCLK Clock Low Time	4.7	-	μs	1
T _{HIGH}	I2C_SD/I2C_SCLK Clock High Time	4	-	μs	1
T _{HDSTA}	Hold Time (repeated) START condition	4	-	μs	1,2
T _{SUSTA}	Setup Time for a Repeated START condition	4.7	-	μs	1
T _{HDDAT}	Data Hold Time	0	3.45	μs	1
T _{SUDAT}	Data Setup Time	250	-	ns	1
T _{SR}	Rise Time for I2C_xxx (all I2C signals)	-	1000	ns	1
T _{SF}	Fall Time for I2C_xxx (all I2C signals)	-	300	ns	1
T _{SUSTOP}	Setup Time for STOP Condition	4	-	μs	1

Notes:

1. See Figure 5, I²C Interface Signal Timings
2. After this period, the first clock pulse is generated

Figure 5: I²C Interface Signal Timings



2.4.6 Boundary Scan Test Interface Timing

Table 15 lists the test signal timings for Tsi578.

Table 15: Boundary Scan Test Signal Timings

Symbol	Parameter	Min	Max	Units	Notes
T_{BSF}	TCK Frequency	0	25	MHz	-
T_{BSCH}	TCK High Time	50	-	ns	<ul style="list-style-type: none"> Measured at 1.5V Note test
T_{BSCL}	TCK Low Time	50	-	ns	<ul style="list-style-type: none"> Measured at 1.5V Note test
T_{BSCR}	TCK Rise Time	-	25	ns	<ul style="list-style-type: none"> 0.8V to 2.0V Note test
T_{BSCF}	TCK Fall Time	-	25	ns	<ul style="list-style-type: none"> 2.0V to 0.8V Note test
T_{BSIS1}	Input Setup to TCK	10	-	ns	-
T_{BSIH1}	Input Hold from TCK	10	-	ns	-
T_{BSOV1}	TDO Output Valid Delay from falling edge of TCK. ^a	-	15	ns	-
T_{OF1}	TDO Output Float Delay from falling edge of TCK	-	15	ns	-
$T_{BSTRST1}$	TRST_B release before HARD_RST_b release	-	10	ns	TRST_b must become asserted while HARD_RST_b is asserted during device power-up
$T_{BSTRST2}$	TRST_B release before TMS or TDI activity	1	-	ns	-

a. Outputs precharged to VDD.

3. Layout Guidelines

This chapter describes the layout guidelines for the Tsi578. It includes the following information:

- “Impedance Requirements” on page 43
- “Tracking Topologies” on page 44
- “Power Distribution” on page 56
- “Decoupling Requirements” on page 57
- “Clocking and Reset” on page 61
- “Modeling and Simulation” on page 65
- “Testing and Debugging Considerations” on page 66
- “Reflow Profile” on page 68

3.1 Overview

The successful implementation of a Tsi578 in a board design is dependent on properly routing the Serial RapidIO signals and maintaining good signal integrity with a resultant low bit error rate. The sections that follow contain information for the user on principals that will maximize the signal quality of the links.

Since every situation is different, Tundra urges the designer to model and simulate their board layout and verify that the layout topologies chosen will provide the performance required of the product.

3.2 Impedance Requirements

The impedance requirement of the Serial RapidIO interface is 100 ohms differential.

3.3 Tracking Topologies

The tracking topologies required to maintain a consistent differential impedance of 100 ohms to the signal placed on the transmission line are limited to Stripline and Microstrip types. The designer must decide whether the signalling must be moved to an outer layer of the board using a Microstrip topology, or if the signalling may be placed on an inner layer as stripline where shielding by ground and power planes above and below is possible.



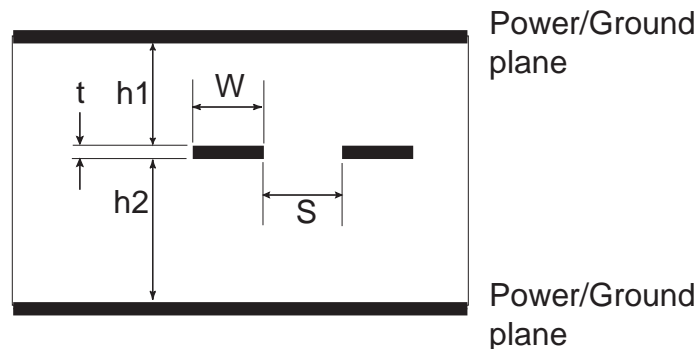
In order to prevent consuming received eye margin, the \pm track skew of a lane should be constrained to a maximum of 15pS.

3.3.1 Stripline

The RapidIO buses should be routed in a symmetrical edge-coupled stripline structure in order to ensure a constant impedance environment. The symmetrical stripline construction is shown in [Figure 6](#). This method also provides clean and equal return paths through VSS and VDD from the I/O cell of the Tsi578 to the adjacent RapidIO device. The use of broadside coupled stripline construction as shown in [Figure 7](#) is discouraged because of its inability to maintain a constant impedance throughout the entire board signal layer.

The minimum recommended layer count of a board design consists of 12 layers. The optimum design consists of 16 layers. The designer should consider both of these designs and weigh their associated costs versus performance.

Figure 6: Recommended Edge Coupled Differential Stripline (symmetric when $h1=h2$)



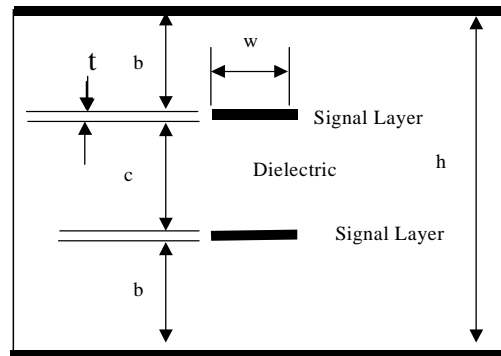
Equations for Stripline and Differential Stripline Impedance (in Ohms):

$$Z_o = \frac{60}{\sqrt{\epsilon_r}} \times \ln \left(\frac{1.9(2(h1 + h2) + t)}{0.67 \pi (0.8w + t)} \right)$$

$$Z_{diff} = 2 \times Z_o \left(1 - 0.374 e^{-2.9 \left[\frac{s}{h1+h2} \right]} \right)$$

The broadside coupled stripline construction is not recommended for use with RapidIO because of the manufacturing variations in layer spacings. These variations will cause impedance mismatch artifacts in the signal waveforms and will degrade the performance of the link.

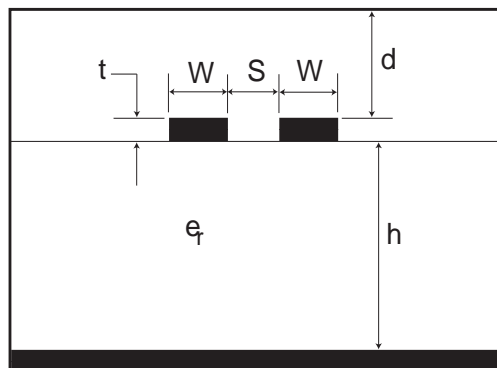
Figure 7: Not Recommended Broadside Coupled or Dual Stripline Construction



3.3.1.1 Microstrip

When it is necessary to place the differential signal pairs on the outer surfaces of the board, the differential microstrip construction is used. Figure 8 shows the construction of the microstrip topology. Below the figure are the design equations for calculating the impedance of the trace pair.

Figure 8: Differential Microstrip Construction



Equations for the Differential Microstrip construction:

$$Z_o = \frac{60}{\sqrt{0.475\epsilon_r + 0.67}} \ln \left[\frac{4h}{0.67(0.8w + t)} \right] \text{ohms}$$

$$Z_{diff} \cong 2Z_o \left(1 - 0.48e^{-0.96\frac{s}{h}} \right) \text{ohms}$$

3.3.1.2 Signal Return Paths

The return path is the route that current takes to return to its source. It can take a path through ground planes, power planes, other signals, or integrated circuits. The return path is based on electro-magnetic field effects. The return path follows the path of least resistance nearest to the signal conductor. Discontinuities in the return path often have signal integrity and timing effects that are similar to the discontinuities in the signal conductor. Therefore, the return paths need to be given similar consideration. A simple way to evaluate return path parasitic inductance is to draw a loop that traces the current from the driver through the signal conductor to the receiver, then back through the ground/power plane to the driver again. The smaller the area of the loop, the lower the parasitic inductance.

If via densities are large and most of the signals switch at the same time (as would be the case when a whole data group switches layers), the layer to layer bypass capacitors may fail to provide an acceptably short signal return path to maintain timing and noise margins.

When the signals are routed using symmetric stripline, return current is present on both the VDD and VSS planes. If a layer change must occur, then both VCC and VSS vias must be placed as close to the signal via as possible in order to provide the shortest possible path for the return current.

The following return path rules apply to all designs:

- Always trace out the return current path and provide as much care to the return path as the path of the signal conductor.
- Do not route impedance controlled signals over splits in the reference planes.
- Do not route signals on the reference planes in the vicinity of system bus signals.
- Do not make signal layer changes that force the return path to make a reference plane change.
- Decoupling capacitors do not adequately compensate for a plane split.
- Do not route over via anti-pads or socket anti-pads.

If reference plane changes must be made:

- Change from a VSS reference plane to another VSS reference plane and place a minimum of one via connecting the two planes as close as possible to the signal via. This also applies when making a reference plane change from one VCC plane to another VCC plane.
- For symmetric stripline, provided return path vias for both VSS and VCC.
- Do not switch the reference plane from VCC to VSS or vice versa.

3.3.1.3 Guard Traces

Guard traces are used to minimize crosstalk. Guard traces are tracks that run parallel to a signal trace for the entire length and are connected to the reference plane to which the signal(s) are associated. Guard traces can lower the radiated crosstalk by as much as 20dB.

The use of guard tracks requires some planning and foresight. The guard tracks will consume board real estate but in a dense routing where the potential for crosstalk is present, guard traces will save overall space that would have been consumed by separation space. Simulation has shown that a 5 mil ground trace with 5 mil spaces between the aggressor and receptor traces offers as much isolation as a 20 mil space between aggressor and receptor traces. The aggressor trace is the trace with a driven waveform on it. The receptor trace is the trace onto which the crosstalk is coupled.

Guard tracks are required to be “stitched” or connected with vias, to the reference plane associated with the signal. To ensure that there is no resonance on the guard traces, the stitching vias should be spaced at intervals that equal $1/20\lambda$ of the 3rd harmonic.

Figure 9: Equation

$$\lambda = \sqrt{\epsilon} \times c / f$$

$$1/20 \lambda_{3rd} = \frac{3 \times 10^8 \text{ m/s}}{20 \times f_{3rd}} \sqrt{\epsilon}$$

In the case of the 3.125 Gb/s data rate, the rise and fall times must be less than 40 pS. This relates to an upper frequency of 25Ghz and a corresponding wavelength of 25 mm based on a permittivity of 4.3. Therefore, the stitching vias must not be further apart than 8 mm.

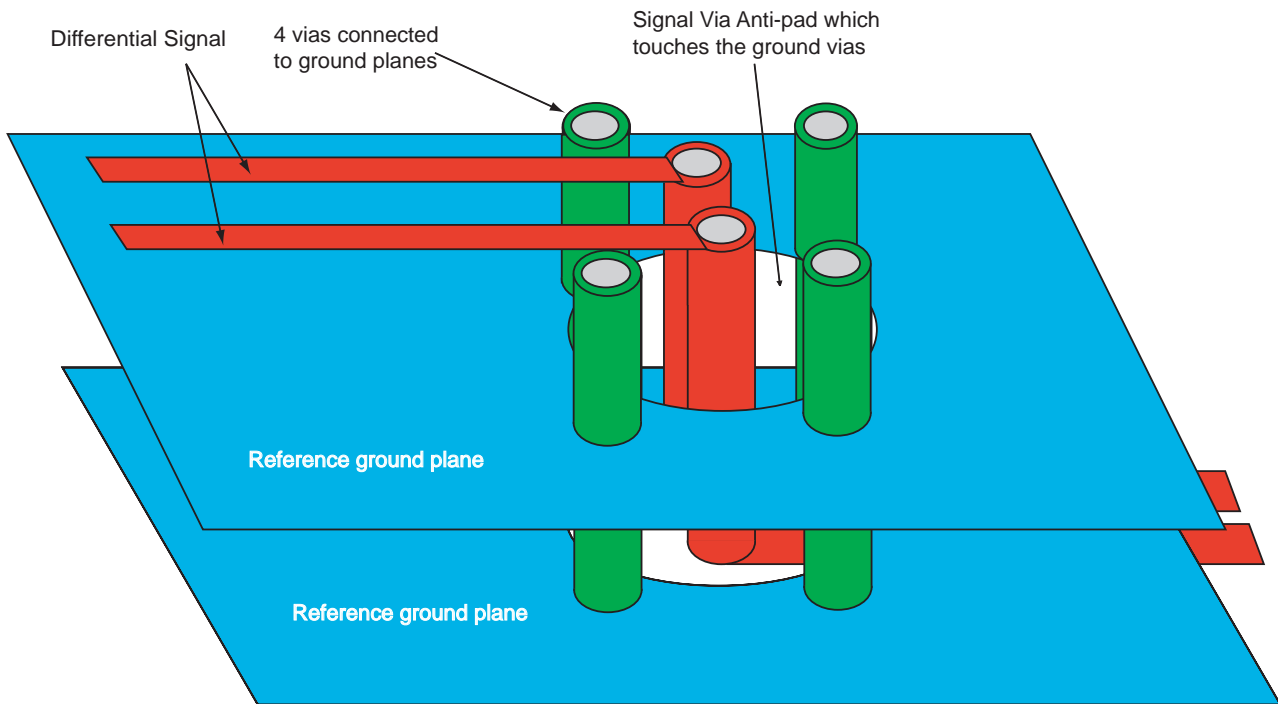
3.3.1.4 Via Construction

Due to the high frequency content of the Serial RapidIO signals, it is necessary to minimize the discontinuities imposed by crossing ground and power planes when it is necessary to transition to different signal layers. The use of a controlled impedance via is recommended. The construction of a differential via is shown in [Figure 10](#).



Detailed design information can be found in bibliography entry 15, “*Designing Controlled Impedance Vias*” by Thomas Neu, EDN Magazine October 2, 2003.

Figure 10: Differential Controlled Impedance Via



3.3.1.5 Layer Transitioning with Vias

The basic rule in high speed signal routing is to keep vias in the signal path down to a minimum. Vias can represent a significant impedance discontinuity and should be minimized. When routing vias, try to ensure that signals travel through the via rather than across the via.

A via where the signal goes through the via, has a much different effect than a via where the signal travels across the via. These two cases are shown in [Figure 13](#) and in [Figure 14](#). The “in” and “out” nodes of the via model are shown on their corresponding locations in the figures.

Transitioning across a via that is not blind or buried leaves a stub which appears as a capacitive impedance discontinuity. The portion of the via that conducts current appears inductive while the stub that develops only an electric field will appear capacitive.

In order to minimize the effects of a via on a signal, the following equations may be used to approximate the capacitance and inductance of the via design. It can be seen that the proximity of the pad and antipad have a direct relationship on the capacitance, and that the length of the barrel (h) has a direct effect on the inductance.

Figure 11: Equation

$$L = 5.08h \left[\ln \left(\frac{4h}{d} \right) + 1 \right]$$

$$C = \frac{1.41\epsilon_r T D_1}{D_2 - D_1}$$

C is the capacitance in pF.

T is the thickness of the circuit board or thickness of pre-preg.

D_1 is the diameter of the via pad.

D_2 is the diameter of the antipad.

ϵ_r is the dielectric constant of the circuit board material.

L is the inductance in nH.

h is the overall length of the via barrel.

d is the diameter of the via barrel.

Figure 12: Via Construction

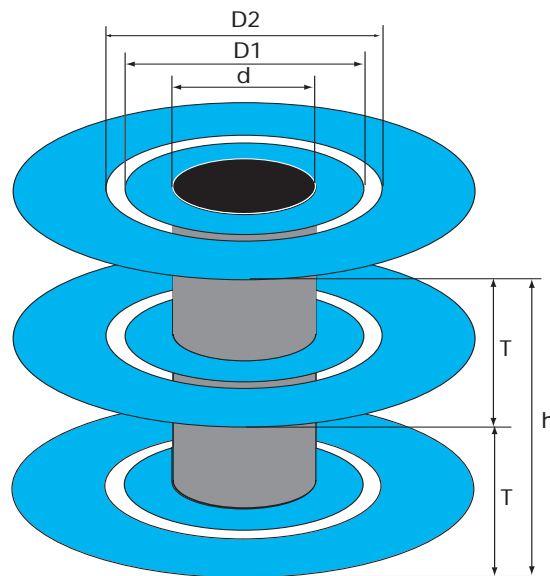
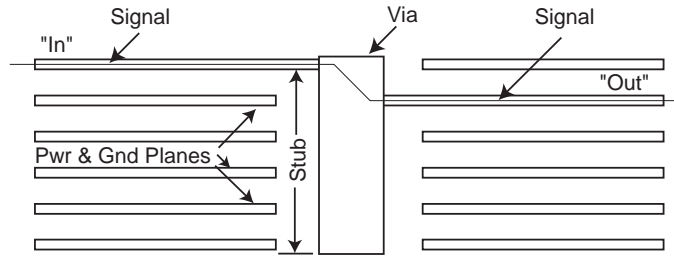
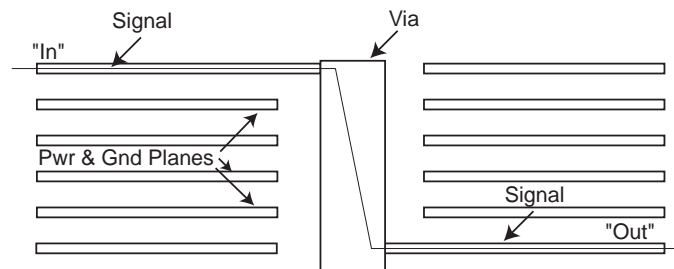


Figure 13: Signal Across a Via**Figure 14: Signal Through a Via**

Because of the high frequencies present in the RapidIO signal, vias become a significant contributor to signal degradation. Most vias are formed by a cylinder going through the PCB board. Because the via has some length, there is an inductance associated with the via. Parasitic capacitance comes from the power and ground planes through which the via passes. From this structure we model the via in RLC lumps as shown in [Figure 15](#) and [Figure 16](#). C_{via} is the total capacitance of the via to ground or power, R_{via} is the total resistance through the via, and L_{via} is the total inductance of the via. These parameters may be extracted using 3D parasitic extraction tools. By distributing the R, L, and C, the model better represents the fact that the capacitance, resistance and inductance are distributed across the length of the via. For the Via model to be accurate in simulation, the propagation delay of each LC section should be less than 1/10 of the signal risetime. This is to ensure the frequency response of the via is modeled correctly up to the frequencies of interest. More information may be found in reference [16].

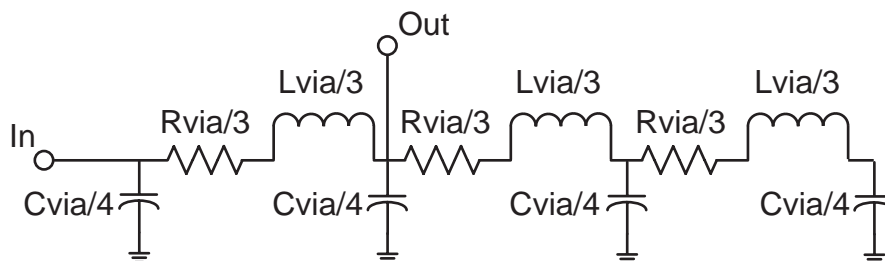
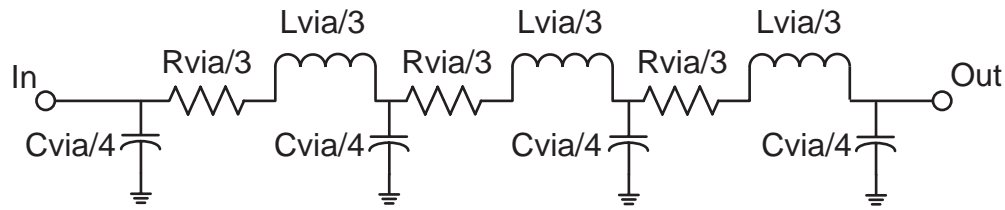
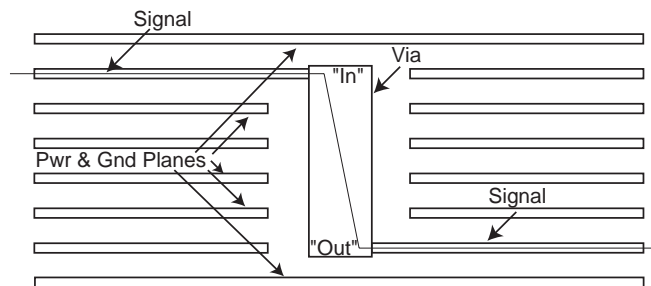
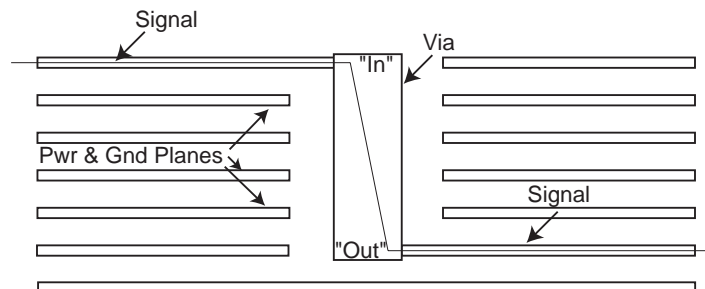
Figure 15: Signal Transitioning Across a Via Simulation Model

Figure 16: Signal Transitioning Through a Via Simulation Model

3.3.1.6 Buried Vs. Blind

The use of buried and blind vias is recommended because in both cases the signal travels through the via and not across it. Examples of these two types of structures are shown in [Figure 17](#) and [Figure 18](#).

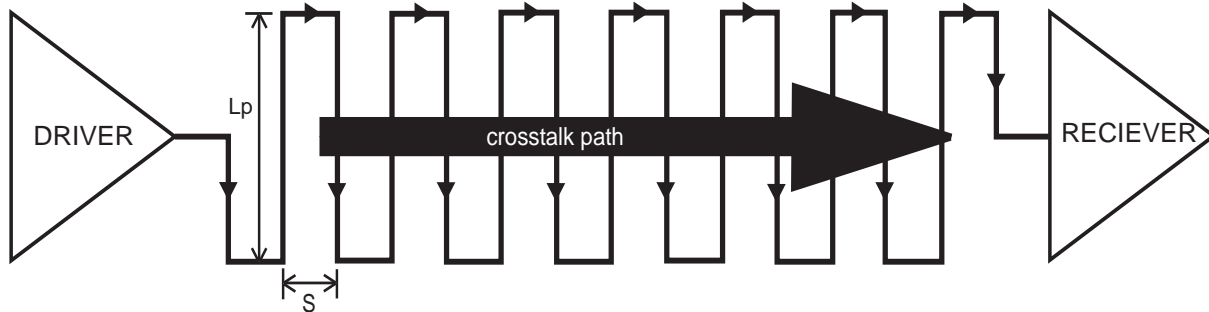
Figure 17: Buried Via Example**Figure 18: Blind Via Example**

3.3.1.7 Serpentine Traces

During layout, it is necessary to adjust the lengths of tracks in order to accommodate the requirements of equal track lengths for pairs of signals. In the case of the differential signals, this ensures that both the negative and positive halves of the signals arrive at the receiver simultaneously, thus maximizing the data sampling window in the eye diagram. Creating a serpentine track is a method of adjusting the track length.

Ensure that the wave front does not propagate along the trace and through the crosstalk path perpendicular to the parallel sections, as shown in **Figure 19**. The arrival of a wave front at the receiver ahead of the wave front travelling along the serpentine route is caused by the self-coupling between the parallel sections of the transmission line (L_p).

Figure 19: Serpentine Signal Routing



To maximize the signal integrity, clock lines should not be serpentine.

Figure 22 describes the guidelines for length matching a differential pair. If it is necessary to serpentine a trace, follow these guidelines:

- Make the minimum spacing between parallel sections of the serpentine trace (see “ S ” in **Figure 19**) at least 3 to 4 times the distance between the signal conductor and the reference ground plane.
- Minimize the total length (see “ L_p ” in **Figure 19**) of the serpentine section in order to minimize the amount of coupling.
- Use an embedded microstrip or stripline layout instead of a microstrip layout.



For a detailed discussion about serpentine layouts, refer to Section 12.8.5 of “*High-Speed Signal Propagation, Advanced Black Magic*” by Howard Johnson and Martin Graham.

3.3.2 Crosstalk Considerations

The Serial RapidIO signals easily capacitively couple to adjacent signals due to their high frequency. It is therefore recommended that adequate space be used between different differential pairs, and that channel transmit and receive be routed on different layers. Cross coupling of differential signals results in an effect called Inter-Symbol Interference (ISI). This coupling causes pattern dependent errors on the receptor, and can substantially increase the bit error rate of the channel.

3.3.3 Receiver DC Blocking Capacitors

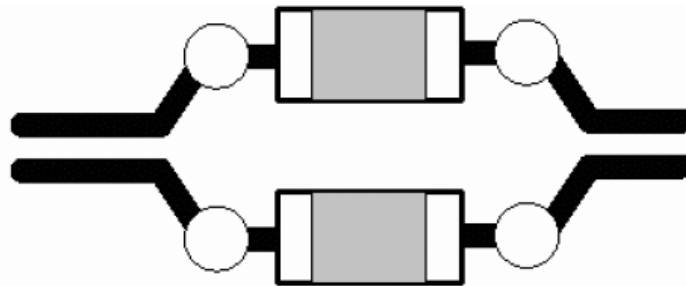
The Serial RapidIO interface requires that the port inputs be capacitor coupled in order to isolate the receiver from any common mode offset that may be present in the transmitter outputs. DC blocking capacitors should be selected such that they have low dissipation factor and low series inductance. The recommended capacitor value is 0.1 μ F ceramic in an 0402 size.

Figure 20 shows the recommended tracking and capacitor pad placement required. It will be necessary to model and simulate the effects of the changed track spacing on the channel quality and determine if any changes are required to the topology. An often used method of correcting the decreased impedance caused by the larger capacitor mounting pads is to create a slot in the shield plane below the capacitor bodies and soldering pads. Since the impedance change caused by the slot is dependent on the capacitor geometry, core thickness, core material characteristics and layer spacings, the size and shape of the slot will have to be determined by simulation.



Do not place the capacitors along the signal trace at a $\lambda/4$ increment from the driver in order to avoid possible standing wave effects.

Figure 20: Receiver Coupling Capacitor Positioning Recommendation



3.3.4 Escape Routing

All differential nets should maintain a uniform spacing throughout a route. Separation of differential pairs to go around objects should not be allowed. Figure 21 illustrates several options for breaking out a differential pair from the Tsi578 device. The order of preference is from A to D.

Case D below has a small serpentine section used to match the inter-pair skew of the differential pair. In this case each serpentine section should be greater than $3 \times W$ (W =width), and the gap should not increase by more than $2x$. Figure 22 illustrates these requirements.

Figure 21: Escape Routing for Differential Signal Pairs

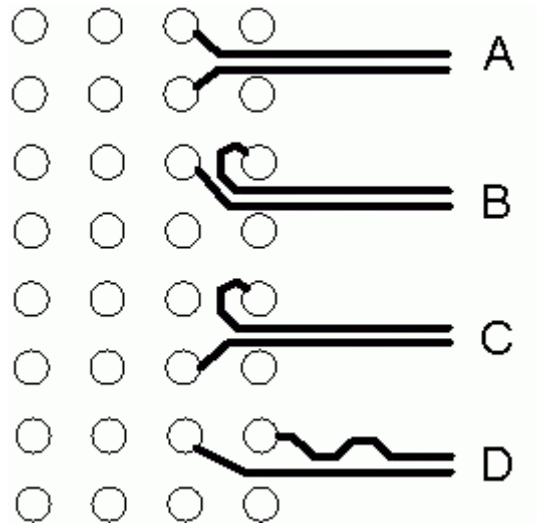
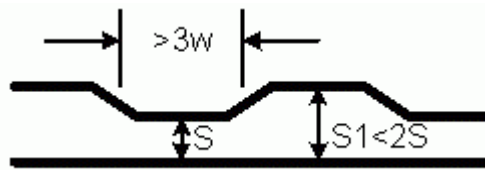


Figure 22: Differential Skew Matching Serpentine

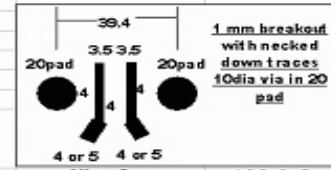


3.3.5 Board Stackup

The recommended board stack up is shown in [Figure 23](#). This design makes provision for four stripline layers and two outer microstrip layers. Layers eight and nine are provisioned as orthogonal low speed signal routing layers.

Figure 23: Recommended Board Stackup

Layers	Thks.	Cross Section Diagram	Layer Type	Layer Definition	stripline		edge coupled diff	
					Trace Width	Impedance	Trace Width	Impedance
			mask					
L01	1.6		plating	PRI				
	0.6		.5oz foil					
L02	7.9		prepreg	pwr				
L03	2.0		1/1zbc	gnd				
	1.2							
L04	5.3		prepreg	sig	5	50.0 Ω	4line6sp	100.0 Ω
	0.6							
L05	5.0		.5/1core	gnd				
	1.2							
L06	5.3		prepreg	sig	5	50.0 Ω	4line6sp	100.0 Ω
	0.6							
L07	5.0		.5/1core	gnd				
	1.2							
L08	4.4		prepreg	sig	5	50.0 Ω		
	0.6							
L09	5.0		.5/.5core	sig	5	50.0 Ω		
	0.6							
L10	4.4		prepreg	gnd				
	1.2							
L11	5.0		.5/1core	sig	5	50.0 Ω		
	0.6							
L12	5.3		prepreg	gnd				
	1.2							
L13	5.0		.5/1core	sig	5	50.0 Ω		
	0.6							
L14	5.3		prepreg	gnd				
	1.2							
L15	2.0		1/1zbc	pwr				
	1.2							
L16	7.9		prepreg	sec				
	0.6		.5 oz foil					
	1.6		plating					
			mask					
Total:	88	Finish thickness over laminate +-10%						
	92	Finish thickness over plating +-10%						



3.4 Power Distribution

The Tsi578 is a high speed device with both digital and analogue components in its design. The core logic has a high threshold of noise sensitivity within its 1.2 V operating range. However, the analogue portion of the switch is considerably more sensitive.

The correct treatment of the power rails, plane assignments, and decoupling is important to maximize Tsi578 performance. The largest indicator of poor performance on the Serial RapidIO interfaces is the presence of jitter. The die, I/O, and package designs have all been optimized to provide jitter performance well below the limits required by the Serial RapidIO specifications. The guidelines provided below will assist the user in achieving a board layout that will provide the best performance possible. The required decoupling by each voltage rail can be found in [Table 16 on page 59](#). The ripple specifications for each rail are maximums, and every effort should be made to target the layout to achieve lower values in the design.

A solid, low impedance plane must be provided for the VDD 1.2V core supply referenced to VSS. It is strongly recommended that the VDD and VSS planes be constructed with the intent of creating a buried capacitance. The connection to the power supply must also be low impedance in order to minimize noise conduction to the other supply planes.

A solid, low impedance plane must be provided for the SP_VDD 1.2V SerDes supply, referenced to the VSS plane. This supply can be derived from the same power supply as VDD, as long as a *Kelvin connection* is used. The preference however, is to use a separate power supply.



The term *Kelvin connection* is used to describe a single point of contact so that power from one power plane does not leak past the power supply pin into the other power plane. The leakage can be caused by the fact the output of a power supply is a very low impedance point in order to be able to supply a large amount of current. Because it is such a low impedance point, any noise presented to it by the power plane is sent to ground.

A kelvin connection enables two power planes to be connected together at a single point. Using this technique, the same power supply module can be used to provide power to a noisy digital power plane (VDD), as well as a quiet analog power plane (SP_AVDD).

The SPn_AVDD 3.3V SerDes analogue supply also needs low impedance supply plane. This supply voltage powers the RapidIO receivers and transmitters, and their associated PLLs. Connect all of the SPn_AVDD pins to this plane and decouple the plane directly to VSS. The plane must be designed as a low impedance plane in order to minimize transmitter jitter and maximize receiver sensitivity. Construction of this plane as a buried capacitance referenced to VSS is suggested.

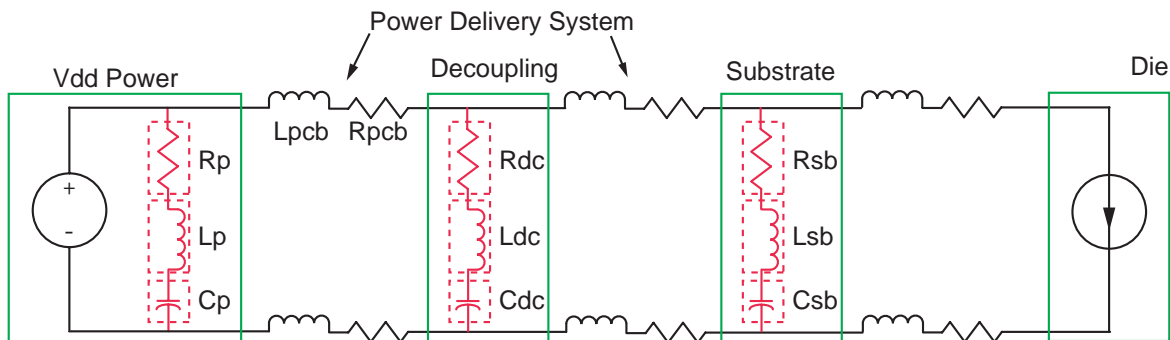
The REF_AVDD pins provide power to the S_CLK distribution circuits in the switch. The voltage should be derived from the SPn_VDD plane. One ferrite will suffice to isolate the SPn_VDD from the REF_AVDD. Two decoupling capacitors should be assigned to each pin.

The VDD_IO supply powers the 3.3V I/O cells on the switch. This supply requires no special filtering other than the decoupling to the VSS_IO plane. Connect the VSS_IO plane to the VSS plane using a Kelvin connection.

3.5 Decoupling Requirements

This section deals with the subject of decoupling capacitors required by the Tsi578. To accomplish the goal of achieving maximum performance and reliability, the power supply distribution system needs to be broken down into its individual pieces, and each designed carefully. The standard model for representing the components of a typical system are shown in [Figure 24](#). This figure graphically represents the parasitics present in a power distribution system.

Figure 24: System Power Supply Model



3.5.1 Component Selection

The recommended decoupling capacitor usage for the Tsi578 is shown in [Table 16 on page 59](#). The capacitors should be selected with the smallest surface mount body that the applied voltage permits in order to minimize the body inductance. Ceramic X7R type are suggested for all of the values listed. The larger value capacitors should be low ESR type.

The components should be distributed evenly around the device in order to provide filtering and bulk energy evenly to all of the ports.

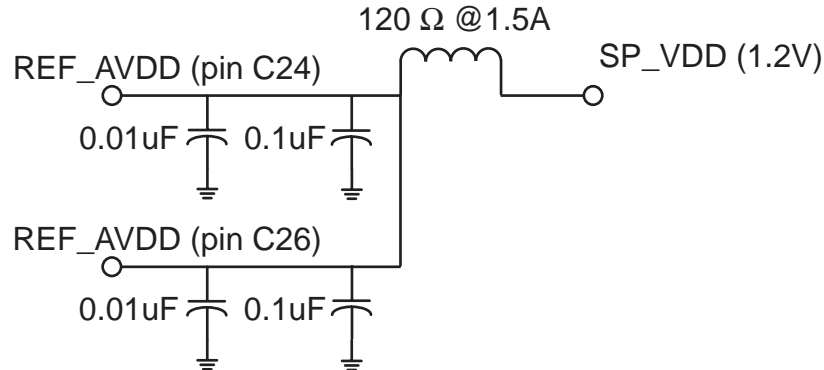


Use the Tsi578 ball map (available at www.tundra.com) to aid in the distribution of the capacitors.

3.5.1.1 REF_AVDD

The REF_AVDD pins require extra care in order to minimize jitter on the transmitted signals. The circuit shown in [Figure 25](#) is recommended for the REF_AVDD signal. One filter is required for the two pins.

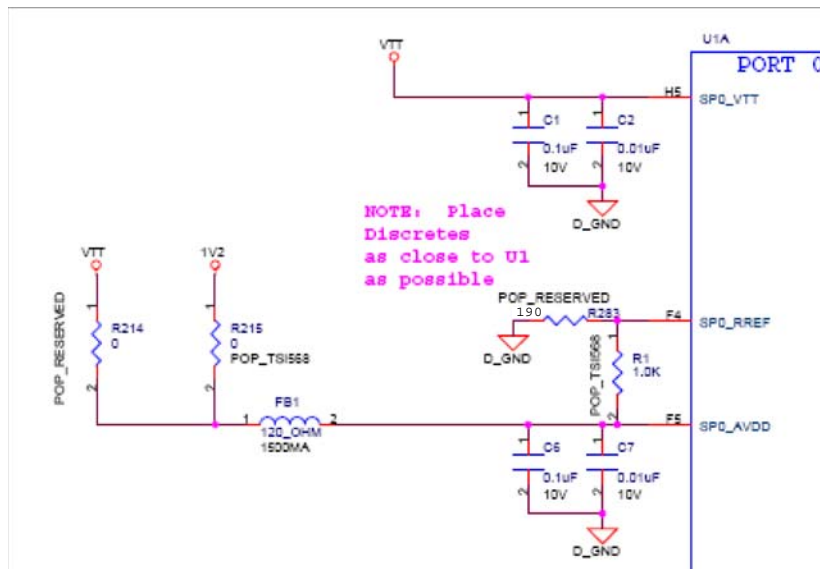
Figure 25: PLL Filter



3.5.1.2 SPn_AVDD

The circuit shown in [Figure 26](#) is recommended for the SPn_AVDD signal.

Figure 26: Analog Resistor



In this design Vtt can be controlled to be between 1.2 V and 3.3 V. For the Tsi578 operation Vtt is set to be 3.3V which provides the required voltage for SPx_AVDD.

Table 16: Decoupling Capacitor Quantities and Values Recommended for the Tsi578

Voltage	Usage	Acronym	Component Requirements				
1.2V	Logic Core	VDD	20 x 0.1uF	20 x 0.01uF	16 x 1nF	-	16 x 22uF
1.2V	SerDes core, SerDes bias	SP_VDD	16 x 0.1uF	16 x 0.01uF	32 x 1nf	8 x 10uF	8 x 100uF
3.3V	SerDes transceivers	SPn_AVDD	16 x 0.1uF	16 x 0.01uF	-	-	-
3.3V	Single ended I/O ports	VDD_IO	12 x 0.1uF	12 x 0.01uF	-	-	-
1.2V	Clock distribution circuit	REF_AVDD	2 x 0.1uF	2 x 0.01uF	-	1 x ferrite bead 120 ohm @ 1.5Amp	

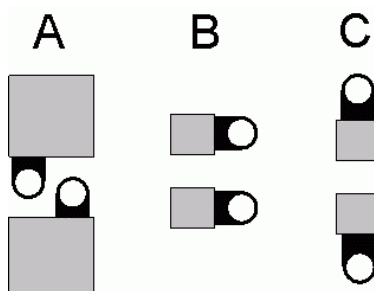
3.5.2 Effective Pad Design

Breakout vias for the decoupling capacitors should be kept as close together as possible. The trace connecting the pad to the via should also be kept as short as possible with a maximum length of 50mils. The width of the breakout traces should be 20mils, or the width of the pad.



Via sharing should not be used in board design with the Tsi578.

Figure 27: Recommended Decoupling Capacitor Pad Designs

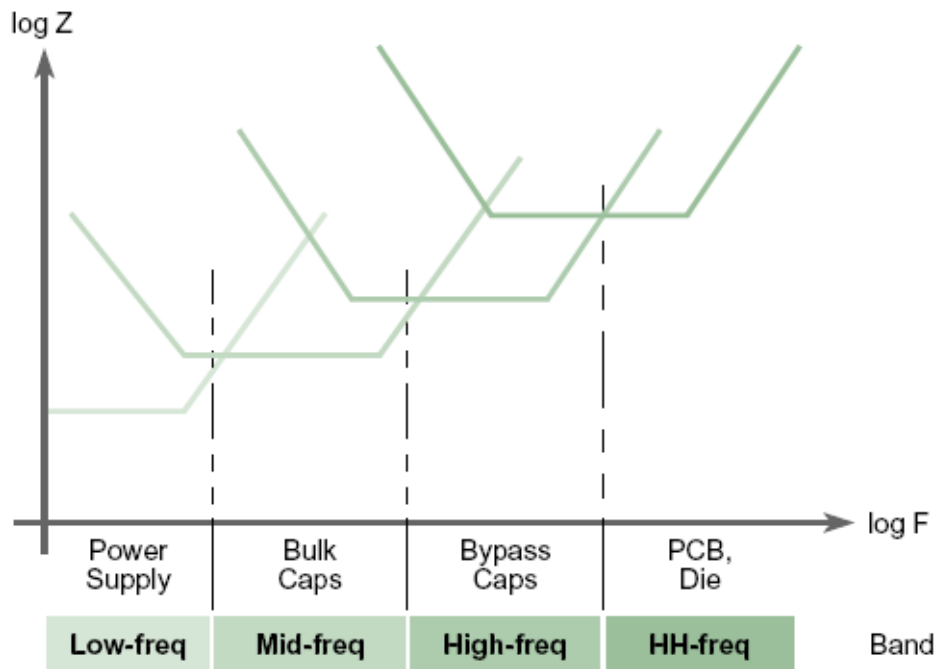


3.5.3 Power Plane Impedance and Resonance

The intent of adding decoupling to a board is to lower the impedance of the power supply to the devices on the board. It is necessary to pay attention to the resonance of the combined bulk capacitance and to stagger the values in order to spread the impedance valleys broadly across the operating frequency range. [Figure 29](#) demonstrates the concept of staggered bands of decoupling. Calculate the impedance of each of the capacitor values at the knee frequency to determine their impact on resonance.

Figure 28: Equation

$$F_{knee} = \frac{0.5}{T_{rise}} \text{ where } T_{rise} = \text{time from 10\% to 90\%}$$

Figure 29: Decoupling Bypass Frequency Bands

As the frequency changes, each part of the power distribution system responds proportionally; the low-impedance power supply responds to slow events, bulk capacitors to mid-frequency events, and so forth.

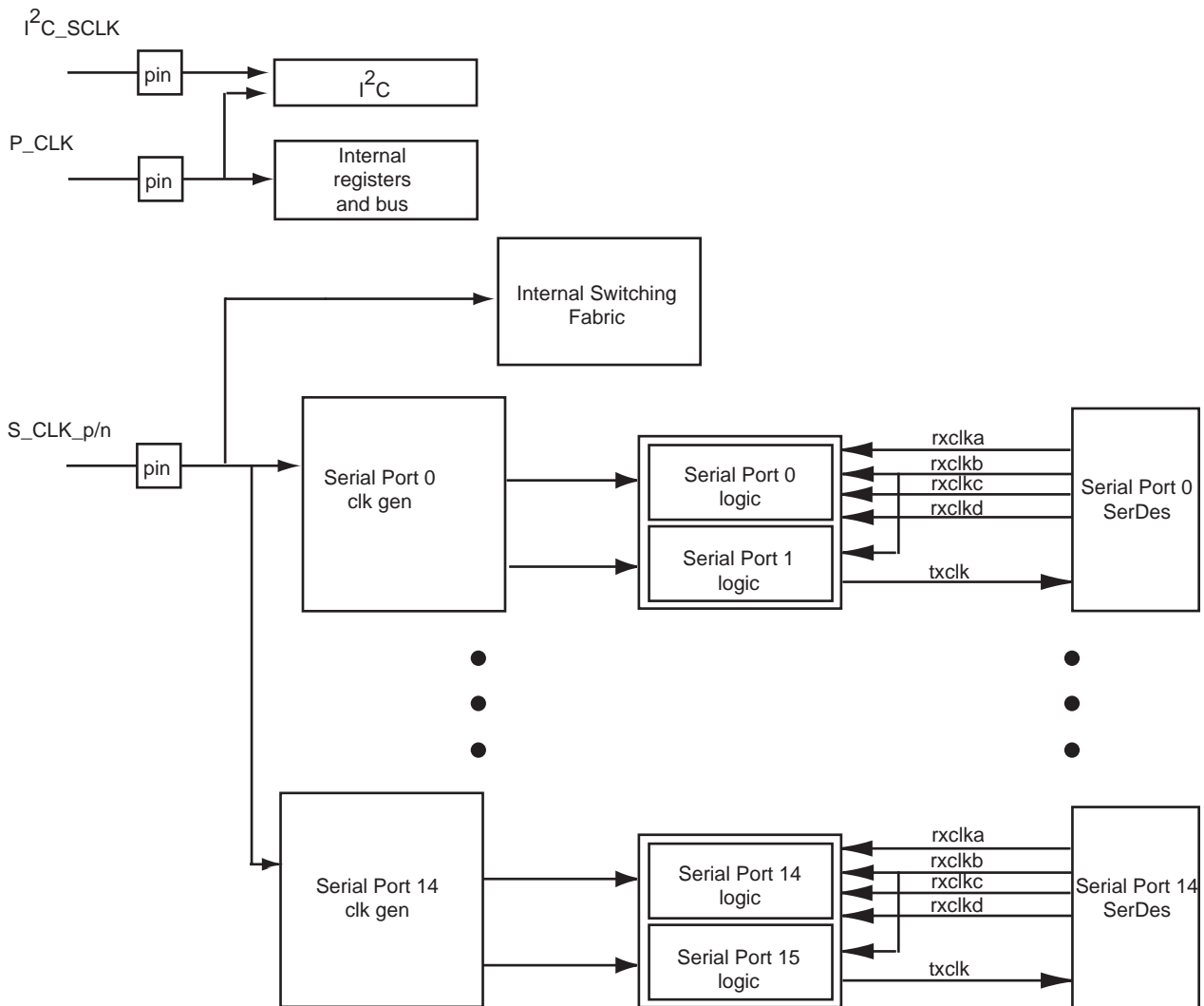
3.6 Clocking and Reset

This section discusses the requirements of the clock and reset inputs.

3.6.1 Clock Overview

The Tsi578 switch input reference clocks that are used to drive the switch's internal clock domains.

Figure 30: Tsi578 Clocking Architecture



The reference clocks are described in [Table 17](#). For more information about special line rate support see [“Clocking” on page 69](#).

Table 17: Clock Input Sources

Clock Input Pin	Type	Maximum Frequency	Clock Domain
S_CLK_[p/n]	Differential	156.25 MHz	Serial Transmit Domain (Nominally 156.25MHz) Internal Switching Fabric (ISF) Domain
P_CLK	Single Ended	100 MHz	Internal Register Domain and I ² C Domain

3.6.1.1 Frequencies Required

The clock signals should be shielded from neighboring signal lines using ground traces on either side. This reduces jitter by minimizing crosstalk from the neighboring signal lines. Since P_CLK is single-ended, extra precaution should be taken so that noise does not get coupled onto it.

In order to preserve the quality of the low jitter 156.25 MHz clock, the shielding requirement of the clock lines is critical. It is possible that low-frequency noise can interfere with the operation of PLLs, which can cause the PLLs to modulate at the same frequency as the noise. The high-frequency noise is generally beyond the PLL bandwidth which is about 1/10th the S_CLK frequency. For more information, refer to [Figure 4 on page 38](#).

3.6.1.2 Stability, Jitter and Noise Content

The maximum input jitter on the S_CLK input is 3pS RMS from 1.5 to 10 Mhz to avoid passing through the PLL loop filter in the SerDes and affecting the transmit data streams. The maximum input jitter allowable on the P_CLK input is 300 pSpp. Jitter on this input would be reflected outside of the chip on the I²C bus. For more information, refer to [Figure 4 on page 38](#).

Jitter Equation

The following equation can be used to convert Phase Noise in dBc to RMS jitter:

$$\text{RMSjitter pS(rms)} = [((10^{(\text{dBc}/10)})^{1/2}) * 2] / [2 * \pi * (\text{frequency in hz})]$$

Using this equation, an example of 312.5 MHz and a phase noise of -63dBc, would produce 0.72pS RMS jitter.

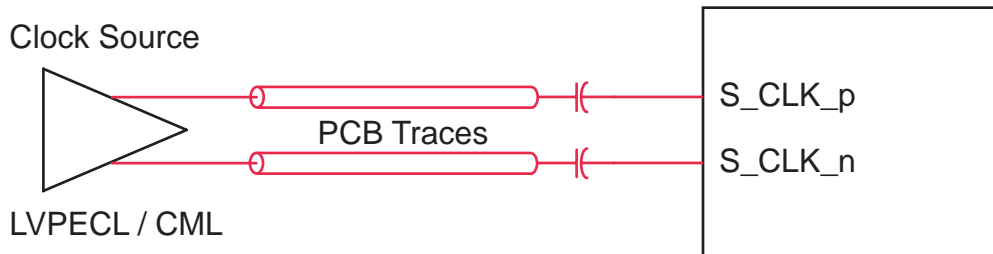
3.6.2 Clock Domains

Table 18: Tsi578 Clock Domains

Clock Domain	Clock Source	Description
Internal Register Domain	P_CLK	This clock domain includes all of the internal registers and their interconnect bus. The domain uses the input P_CLK directly.
Internal Switching Fabric Domain	S_CLK_[p/n]	This clock domain includes the switching matrix of the ISF and the portion of each RapidIO block that interfaces to the ISF.
I ² C Domain	P_CLK divided by 1000	This clock domain is responsible for driving the I2C output clock pin I2C_SCLK. This clock domain is generated by dividing the P_CLK input by 1000. The majority of the I2C logic runs in the Internal Register Domain
Serial Transmit Domain	S_CLK_[p/n]	This clock domain is used to clock all of the Serial RapidIO transmit ports.

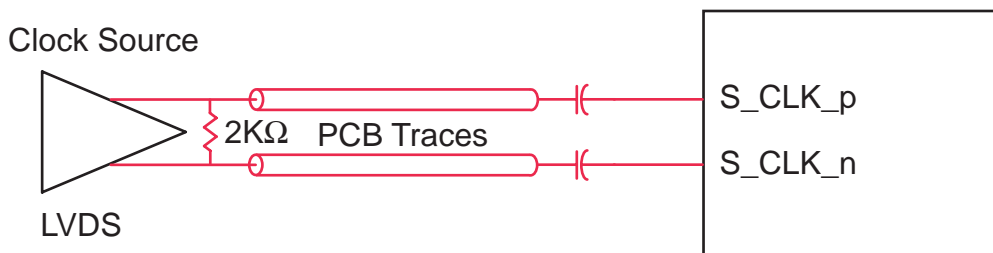
3.6.2.1 Interfacing to the S_CLK_x inputs

The interface for a LVPECL clock source to the receiver input cell is shown in [Figure 31](#). Note that an AC-coupled interface is required so that only the AC information of the clock source is transmitted to the clock inputs of the Tsi578.

Figure 31: Tsi578 driven by LVPECL or CML clock source

The interface for an LVDS clock source to the converter cell is shown in [Figure 32](#). Since an LVDS driver requires a DC termination path, a 2-K. resistor should be inserted before the capacitors. This resistor can be placed anywhere along the signal path between the clock source and the AC-coupling capacitors, although Tundra recommends placing it close to the clock source.

Note that the effective termination resistance seen by the clock source is about 95Ω due to the parallel combination of this external resistor and the integrated termination resistor of the converter cell. Again, an AC-coupled interface is required so that only the AC information of the clock source is transmitted to the clock inputs of the Tsi578.

Figure 32: Tsi578 driven by an LVDS clock source

3.6.3 Reset Requirements

The Tsi578 requires only one reset input, `HARD_RST_b`. The signal provided to the device must be a monotonic 3.3V swing that de-asserts a minimum of 1mS after supply rails are stable. The signal de-assertion is used to release synchronizers based on `P_CLK` which control the release from reset of the internal logic. `P_CLK` must therefore be operating and stable before the 1mS `HARD_RST_b` countdown begins.

TRST_b must be asserted while HARD_RST_b is asserted following a device power-up to ensure the correct setup of the tap controller. TRST_b is not required to be re-asserted for non power cycle assertions of HARD_RST_b.



The most versatile solution to this requirement is to AND the HARD_RST_b and TRST_b signals together to form an output with which to drive the TRST_b pin on the switch.

Power up option pins are double sampled at the release of HARD_RST_b. As such, there is no set-up time requirement, but the signals must be stable at the release of HARD_RST_b. There is a hold time requirement of 100nS or 10 P_CLK cycles minimum.

3.7 Modeling and Simulation

The need for verifying the signal integrity of the board design is very important for designs using GHz signalling. Tundra recommends that the designer invest in a simulation tool as an aid to a successful RapidIO design. Tools are available from companies such as Mentor Graphics (HyperLynx GHZ), Ansoft (SIwave) and SiSoft (SiAuditor). This is by no means a complete list, only a sample of known suppliers.

3.7.1 IBIS

The use of IBIS for signal integrity checking at the high frequencies of the Serial RapidIO link have been found to be too inaccurate to be useful. Also, we have found that most tools do not yet support the *IBIS Specification (Revision 3.2)* for the support of multi-staged slew rate controlled buffers. Tundra is making available an IBIS file which supports the LVTTTL pins on the device. Please contact Tundra Applications Engineering to obtain the file.

3.7.2 Encrypted HSPICE

Please contact the Tundra Applications Engineering through the web based form at www.tundra.com/support to request the necessary Model License Agreement form required to acquire the encrypted model.

3.8 Testing and Debugging Considerations

It is prudent to make provision for debugging and testing tools in order to speed board bring-up. This section provides information on the probing requirements for monitoring the serial RapidIO link between two devices. At GHz frequencies, standard probing techniques are intrusive and cause excessive signal degradation introducing additional errors in the link stream. The recommended solution is an ultra low capacitance probe that operates in conjunction with a logic analyzer. The addition of the appropriate disassembler software to the analyzer makes it a very powerful tool for examining the traffic on a link and aiding in software debugging. Please contact your local test equipment vendor for appropriate solutions for your requirements.

3.8.1 Logic Analyzer Connection Pads

The pinout for a recommended SRIO 8-channel probe is given in [Table 19](#). This pin/signal assignment has been adopted by several tool vendors including Tektronix, but is not an established standard.

These notes are given here:

Footprint Channel vs. Lane/Link Designations

- Channel = either an upstream OR downstream differential pair for a given lane
- C<letter> = the designator for a channel which accepts a given differential pair of signals
- C<letter><p or n> = the two signals of the differential pair. The signals within a given pair may be assigned to either P or N regardless of polarity.

3.8.1.1 General Rules for Signal Pair Assignment of Analyzer Probe

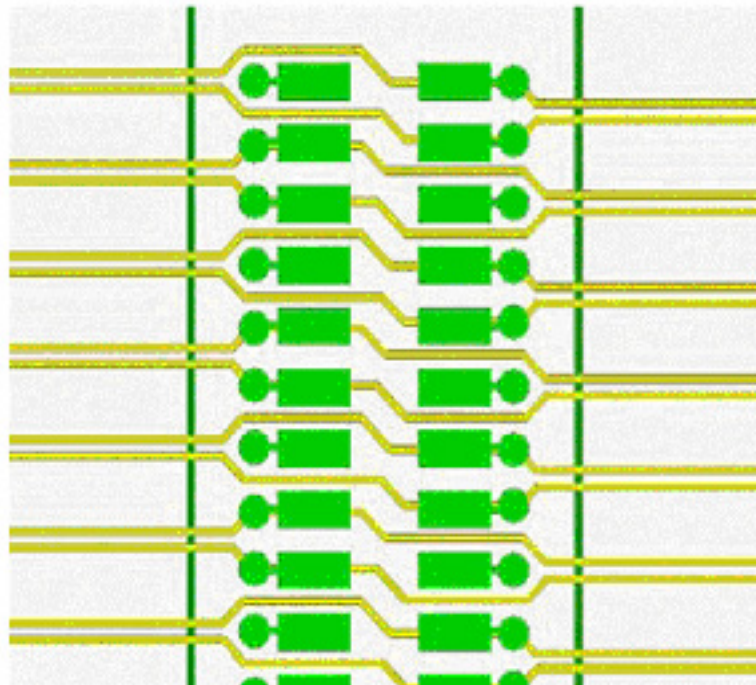
The differential pairs that make up the SRIO links must be assigned to specific pins of the footprint in order to take advantage of the pre-assigned channel assignments provided by Nexus when purchasing the SRIO pre-processor.

Table 19: 8-Channel Probe Pin Assignment

Pin #	Signal Name	Pin #	Signal Name
2	GND	1	CAp/Tx0
4	CBp/Rx0	3	CAn/Tx0
6	CBn/Rx0	5	GND
8	GND	7	CCp/Tx1
10	CDp/Rx1	9	CCn/Tx1
12	CDn/Rx1	11	GND

Table 19: 8-Channel Probe Pin Assignment

Pin #	Signal Name	Pin #	Signal Name
14	GND	13	CEp/Tx2
16	CFp/Rx2	15	CEn/Tx2
18	CFn/Rx2	17	GND
20	GND	19	CGp/Tx3
22	CHp/Rx3	21	CGn/Tx3
24	CHn/rX3	23	GND

Figure 33: Analyzer Probe Pad Tracking Recommendation

3.8.2 JTAG Connectivity

The Joint Test Action Group (JTAG) created the boundary-scan testing standard (documented in the *IEEE 1149.1 Standard*) for testing printed circuit boards (PCBs).

The boundary-scan approach involves designing boundary-scan circuitry into the integrated circuit. PCBs populated with 1149.1 compliant devices can be then tested for connectivity, correct device orientation, correct device location, and device identification. All the pins on compliant devices can be controlled and observed using (typically) five pins that are routed to the board edge connector. Board designers can develop a standard test for all 1149.1 compliant devices regardless of device manufacturer, package type, technology, or device speed.

In addition to the 1149.1 compliant boundary scan TAP controller, the Tsi578 also contains an 1149.6 compliant TAP controller to aid in the production testing of the SERDES pins.

The Tsi578 also has the capability to read and write all internal registers through the JTAG interface. Through this interface, users may load and modify configuration registers and look up tables without the use of RapidIO maintenance transactions or an I²C EEPROM. Please visit the Tundra web site at www.tundra.com to download the JTAG software to use to access the internal registers.

Please visit the Tundra web site to download the BSDL file for the Tsi578.

3.9 Reflow Profile

The Tsi578 adheres to JEDEC-STD-020C for its reflow profile. For the leaded version, the peak reflow temperature is 225°C (+0/-5°C). For the lead-free version, the peak reflow temperature is 260°C (+0/-5°C).

A. Clocking

This appendix describes device behaviour outside the specified or recommended operating line rates and clock frequencies.

The following topics are discussed:

- “Line Rate Support” on page 69
- “P_CLK Programming” on page 70

A.1 Line Rate Support

The Tundra Tsi578 supports all of the *RapidIO Interconnect Specification (Revision 1.3)* specified line rates of 1.25, 2.50, and 3.125 Gbaud. The device also supports line rates that are outside of the RapidIO specification. The ability to support multiple line rates gives the Tsi578 flexibility in both application support and power consumption.

Table 20 shows the supported line rates for the Tsi578. The Serial Port Select pin, SP_IO_SPEED[1,0] must be set to the values shown in Table 20 to achieve the documented line rates.

Table 20: Tsi578 Supported Line Rates¹

S_CLK_p/n (MHz)	Baud Rate (Gbaud)	SP_IO_SPEED[1,0] Bit Settings
153.60	1.2288	0,0
153.60	2.4576	0,1
153.60	3.0720	1,0
156.25	1.2500	0,0
156.25	2.5000	0,1
156.25	3.1250	1,0
125.00	2.5000	1,0

1. This information assumes a +/- 100 ppm clock tolerance that must be obeyed between link partners

All bit and register settings that are documented for operation with S_CLK = 156.25 Mhz also apply to the use of 153.6 Mhz and 125 Mhz. Refer to “Clocking and Reset” on page 61 for more clocking information.

A.2 P_CLK Programming

The Tsi578 recommends a P_CLK operating frequency of 100 MHz. However, the device also supports P_CLK frequencies less than the recommended 100 MHz. The ability to support other P_CLK frequencies gives the Tsi578 flexibility in both application support and design.



The minimum frequency supported by the P_CLK input is 25 Mhz. Operation above 100 Mhz or below 25 Mhz is not tested or guaranteed.

The following sections describe the effects on the Tsi578 when the input frequency of the P_CLK source is decreased from the recommended 100 Mhz operating frequency.

A.2.1 RapidIO Specifications Directly Affected by Changes in the P_CLK Frequency

The following sections describe how changing the P_CLK frequency to below the recommended 100 MHz operation affect the counters and state machines in the Tsi578 that are defined in the *RapidIO Interconnect Specification (Revision 1.3)*.

A.2.1.1 Port Link Time-out CSR

RapidIO Part 6: 1x/4x LP-Serial Physical Layer Specification Revision 1.3: Section 6.6.2.2 Port Link Time-out CSR (Block Offset 0x20)

The *RapidIO Interconnect Specification (Revision 1.3)* defines the Port Link Time-out CSR as follows:

The port-link time-out control register contains the time-out timer value for all ports on a device. This time-out is for link events, such as sending a packet to receiving the corresponding acknowledge and sending a link-request to receiving the corresponding link-response. The reset value is the maximum time-out interval, and represents between three and six seconds.

Tundra Implementation

The Tsi578 supports this timer in the “**RIO Switch Port Link Time Out Control CSR**” on page 280. Effects of changing the P_CLK frequency are shown in the following formula:

- Time-out = $32/F \times \text{TVAL}$
 - F is P_CLK frequency in MHz
 - TVAL is the 24-bit counter setting
 - Maximum TVAL decimal value of 16,777,215 (0xFFFFFFFF)

Effects of changing the P_CLK frequency and TVAL setting can be seen in [Table 21](#).

Table 21: Timer Values with P_CLK and TVAL Variations

P_CLK Setting	TVAL Setting	Equation	Timer Value
25 MHz	2,343,750 (0x23C346)	$32/25 \times 2,343,750$	3 seconds
25 MHz	4,687,500 (0x47868C)	$32/25 \times 4,687,500$	6 seconds
50 MHz	4,687,500 (0x47868C)	$32/50 \times 4,687,500$	3 seconds
50 MHz	9,375,000 (0x8F0D18)	$32/50 \times 9,375,000$	6 seconds
50 MHz	16,777,215 (0xFFFFF)	$32/50 \times 16,777,215$	10.4 seconds
100 MHz	9,375,000 (0x8F0D18)	$32/100 \times 9,375,000$	3 seconds
100 MHz	16,777,215 (0xFFFFF)	$32/100 \times 16,777,215$	5.4 seconds

A.2.1.2 **RapidIO Part 6: 1x/4x LP-Serial Physical Layer Specification Revision 1.3: Section 4.7.3.2 State Machine Variables and Functions**

SILENCE_TIMER_DONE

The *RapidIO Interconnect Specification (Revision 1.3)* defines the SILENCE_TIMER_DONE as follows:

Asserted when the SILENCE_TIMER_EN has been continuously asserted for 120 +/- 40μs and the state machine is in the SILENT state. The assertion of SILENCE_TIMER_DONE causes SILENCE_TIMER_EN to be deasserted. When the state machine is not in the SILENT state, SILENCE_TIMER_DONE is deasserted

Tundra Implementation

The Tsi578's silence timer does not have user programmable registers. The silence timer is sourced from the P_CLK and any changes to P_CLK are directly reflected in the timer timeout period.

DISCOVERY_TIMER_DONE

The *RapidIO Interconnect Specification (Revision 1.3)* defines the `DISCOVERY_TIMER_DONE` as follows:

Asserted when `DISCOVERY_TIMER_EN` has been continuously asserted for 12 +/- 4msec and the state machine is in the `DISCOVERY` state. The assertion of `DISCOVERY_TIMER_DONE` causes `DISCOVERY_TIMER_EN` to be deasserted. When the state machine is not in the `DISCOVERY` state, `DISCOVERY_TIMER_DONE` is deasserted.

Tundra Implementation

The Tsi578's discovery timer is programmed in the “**RIO Port x Discovery Timer**” on page 322. The `DISCOVERY_TIMER` field is used by serial ports configured to operate in 4x mode. The `DISCOVERY_TIMER` allows time for the link partner to enter its discovery state, and if the link partner supports 4x mode, for all four lanes to be aligned.



The `DISCOVERY_TIMER` field is a 4-bit field whose value is used as a pre-scaler for a 17-bit counter clocked by `P_CLK`.

The `DISCOVERY_TIMER` has a default value of 9 decimal, but can be programmed to various values. The results of changing the `DISCOVERY_TIMER` value and `P_CLK` are shown in [Table 22](#).

Table 22: Timer Values with `DISCOVERY_TIMER` and `P_CLK` Variations

P_CLK Setting	DISCOVERY_TIMER Setting	Equation	Timer Value
100 MHz	9 decimal	$9 * 0x1FFFF * 1 / P_CLK$	11.79 mS
100 MHz	9 decimal	$9 * 131071 * 1 / P_CLK$	11.79 mS
25 MHz	1 decimal	$1 * 131071 * 1 / 25 \text{ MHz}$	5.24 mS
25 MHz	2 decimal	$2 * 131071 * 1 / 25 \text{ MHz}$	10.48 mS
25 MHz	15 decimal	$15 * 131071 * 1 / 25 \text{ MHz}$	78.6 mS
50 MHz	1 decimal	$1 * 131071 * 1 / 50 \text{ MHz}$	2.62 mS
50 MHz	5 decimal	$5 * 131071 * 1 / 50 \text{ MHz}$	13.1 mS
50 MHz	15 decimal	$15 * 131071 * 1 / 50 \text{ MHz}$	19.7 mS
100 MHz	1 decimal	$1 * 131071 * 1 / 100 \text{ MHz}$	1.31 mS
100 MHz	9 decimal	$9 * 131071 * 1 / 100 \text{ MHz}$	11.79 mS
100 MHz	15 decimal	$15 * 131071 * 1 / 100 \text{ MHz}$	19.7 mS

A.2.1.3 **RapidIO Part 8: RapidIO Error Management Extensions Specification: Section 2.3.2.9 Packet Time-to-live CSR (Block Offset 0x2C)**

The *RapidIO Interconnect Specification (Revision 1.3)* defines the Packet Time-to-live register as follows:

The Packet Time-to-live register specifies the length of time that a packet is allowed to exist within a switch device. The maximum value of the Time-to-live variable (0xFFFF) shall correspond to 100 msec. +/-34%. The resolution (minimum step size) of the Time-to-live variable shall be (maximum value of Time-to-live)/(2e16-1). The reset value is all logic 0s, which disables the Time-to-live function so that a packet never times out. This register is not required for devices without switch functionality.

Tundra Implementation

The Tsi578's "**RIO Packet Time-to Live CSR**" on page 303 specifies the length of time that a packet is allowed to exist within a switch device. The maximum value of the Time-to-live variable (0xFFFF) corresponds to 100 msec +/-34%. The resolution (minimum step size) of the Time-to-live variable is:

- (maximum value of Time-to-live)/(2e16-1).

Due to the uncertainty of the arrival of a packet relative to clock edges, a packet's time to live expiry time is not precise, but falls within a range. The range is as follows:

- Minimum time-to-live nS = {1/P_CLK x 132} x TTLVAL
- Maximum time-to-live nS = {1/P_CLK x 198} x TTLVAL

The TTL field in the "**RIO Packet Time-to Live CSR**" on page 303 is a 16-bit counter with a maximum decimal value of 65535.



The default value of TTL is 0, which disables the Time-to-live counter.

Table 23 shows the TTL counter values using different values for P_CLK.

Table 23: TTL Values with P_CLK Variations

P_CLK Setting	Equation	Timer Value
25 MHz	Minimum time-to-live nS = {1/25Mhz x 132} x 1	5.28 uS
	{1/25Mhz x 132} x 15782 (3DA6)	83.3 mS
	{1/25Mhz x 198} x 15782 (3DA6)	124.9 mS
	Minimum time-to-live nS = {1/25Mhz x 198} x 65535	519 mS

Table 23: TTL Values with P_CLK Variations

P_CLK Setting	Equation	Timer Value
50 MHz	Minimum time-to-live nS = $\{1/50\text{MHz} \times 132\} \times 1$	10.56 μ S
	$\{1/50\text{MHz} \times 132\} \times 31566$ (7B4E)	83.3 mS
	$\{1/50\text{MHz} \times 198\} \times 31566$ (7B4E)	125 mS
	Maximum time-to-live nS = $\{1/50\text{MHz} \times 198\} \times 65535$	259.5 mS
100 MHz	Minimum time-to-live nS = $\{1/100\text{MHz} \times 132\} \times 1$	132 nS
	$\{1/100\text{MHz} \times 132\} \times 63132$ (F69C)	83.3 mS
	$\{1/100\text{MHz} \times 198\} \times 63132$ (F69C)	125 mS
	Maximum time-to-live nS = $\{1/100\text{MHz} \times 198\} \times 65535 =$	129.8 mS

A.2.2 Tundra Specific Timers

The following sections describe how changing the P_CLK frequency to below the recommended 100 MHz operation affect the Tundra-specific counters and state machines in the Tsi578.

A.2.2.1 Dead Link Timer

The Dead Link Timer period is controlled by the DLT_THRESH field in the “SRIO MAC x Digital Loopback and Clock Selection Register” on page 403.

Each time a silence is detected on a link, the counter is reloaded from this register and starts to count down. When the count reaches 0, the link is declared dead, which means that all packets are flushed from the transmit queue and no new packets are admitted to the queue until the link comes up.

The duration of the dead link timer is computed by the following formula:

- $2^{13} * DLT_THRESH * P_CLK \text{ period}$
 - P_CLK is 100Mhz (which gives a P_CLK period of 10nS)
 - Default value of DLT_THRESH is 0x7FFF (which corresponds to 32767)
- Using these parameters, the populated formula is $8192 * 32767 * 10e-9 = 2.68 \text{ seconds}$

When enabled, this timer is used to determine when a link is powered up and enabled, but dead (that is, there is no link partner responding). When a link is declared dead, the transmitting port on the Tsi578 removes all packets from its transmit queue and ensure that all new packets sent to port are dropped rather than placed in the transmit queue.

The DLT_THRESH is a 15-bit counter with a maximum value of 32767. Table 24 shows equations using different values for DLT_THRESH and P_CLK.

Table 24: Timer Values with P_CLK and DLT_THRESH Variations

P_CLK Setting	Equation	Timer Value
25 MHz	$8192 * 1 * 1/25 \text{ MHz}$	327 uS
	$8192 * 32767 * 1/25 \text{ MHz}$	10.74 seconds
50 MHz	$8192 * 1 * 1/50 \text{ MHz}$	163.8 uS
	$8192 * 32767 * 1/50 \text{ MHz}$	5.37 seconds
100 MHz	$8192 * 1 * 1/100\text{Mhz}$	81.9 uS
	$8192 * 32767 * 1/100\text{Mhz}$	2.68 seconds

A.2.3 I²C interface and Timers

The I²C interface clock is derived from the P_CLK. Decreasing the frequency of P_CLK causes a proportional decrease in the I²C serial clock and affects the I²C timers. The timer values can be re-programmed during boot loading but the changes does not take effect until after the boot load has completed. As a result, a decrease from 100 Mhz to 50 Mhz of P_CLK causes a doubling of the boot load time of the EEPROM. Once boot loading has completed, the new values take effect and the I²C interface can operate at the optimum rate of the attached devices.

A.2.3.1 I²C Time Period Divider Register

The “**I²C Time Period Divider Register**” This register provides programmable extension of the reference clock period into longer periods used by the timeout and idle detect timers.

USDIV Period Divider for Micro-Second Based Timers

The USDIV field divides the reference clock down for use by the Idle Detect Timer, the Byte Timeout Timer, the I2C_SCLK Low Timeout Timer, and the Milli-Second Period Divider.

- $\text{Period}(\text{USDIV}) = \text{Period}(\text{P_CLK}) * (\text{USDIV} + 1)$
- P_CLK is 10 ns
- Tsi578 reset value is 0x0063

MSDIV Period Divider for Milli-Second Based Timers

The MSDIV field divides the USDIV period down further for use by the Arbitration Timeout Timer, the Transaction Timeout Timer, and the Boot/Diagnostic Timeout Timer.

- $\text{Period}(\text{MSDIV}) = \text{Period}(\text{USDIV}) * (\text{MSDIV} + 1)$
- Tsi578 reset value is 0x03E7

A.2.3.2 I2C Start Condition Setup/Hold Timing Register

The “**I²C Start Condition Setup/Hold Timing Register**” programs the setup and hold timing for the start condition when generated by the master control logic. The timer periods are relative to the reference clock.

This register is shadowed during boot loading, and can be reprogrammed prior to a chain operation without affecting the bus timing for the current EEPROM.

START_SETUP Count for the START Condition Setup Period

The START_SETUP field defines the minimum setup time for the START condition; that is, both I2C_SCLK and I2C_SD seen high prior to I2C_SD pulled low. This is a master-only timing parameter.



This value also doubles as the effective Stop Hold time.

- $\text{Period}(\text{START_SETUP}) = (\text{START_SETUP} * \text{Period}(\text{PCLK}))$
— PCLK is 10ns

- Reset time is 4.71 microseconds.
- Tsi578 reset value is 0x01D7

START_HOLD Count for the START Condition Hold Period

The START_HOLD field defines the minimum hold time for the START condition; that is, from I2C_SD seen low to I2C_SCLK pulled low. This is a master only timing parameter.

- $\text{Period}(\text{START_HOLD}) = (\text{START_HOLD} * \text{Period}(\text{P_CLK}))$
- P_CLK is 10 ns
- Reset time is 4.01 microseconds
- Tsi578 reset value is 0x0191

A.2.3.3 I2C Stop/Idle Timing Register

The “**I2C Stop/Idle Timing Register**” programs the setup timing for the Stop condition when generated by the master control logic and the Idle Detect timer.



The START_SETUP time doubles as the Stop Hold.

The Stop/Idle register is broken down as follows:

- The timer period for the STOP_SETUP is relative to the reference clock
- The timer period for the Idle Detect is relative to the USDIV period
- The STOP_SETUP time is shadowed during boot loading, and can be reprogrammed prior to a chain operation without affecting the bus timing for the current EEPROM.

STOP_SETUP Count for STOP Condition Setup Period

The STOP_SETUP field defines the minimum setup time for the STOP condition (that is, both I2C_SCLK seen high and I2C_SD seen low prior to I2C_SD released high). This is a master-only timing parameter.

- $\text{Period}(\text{STOP_SETUP}) = (\text{STOP_SETUP} * \text{Period}(\text{P_CLK}))$
 - P_CLK is 10ns
 - Reset time is 4.01 microseconds
 - Tsi578 reset value is 0x0191

IDLE_DET Count for Idle Detect Period

The IDLE_DET field is used in two cases. First, it defines the period after reset during which the I2C_SCLK signal must be seen high in order to call the bus idle. This period is needed to avoid interfering with an ongoing transaction after reset. Second, it defines the period before a master transaction during which the I2C_SCLK and I2C_SD signals must both be seen high in order to call the bus idle.

This period is a protection against external master devices not correctly idling the bus.

- $\text{Period}(\text{IDLE_DET}) = (\text{IDLE_DET} * \text{Period}(\text{USDIV}))$, where USDIV is the microsecond time defined in the “**I2C Time Period Divider Register**”



A value of zero results in no idle detect period, meaning the bus will be sensed as idle immediately.

- Reset time is 51 microseconds
- Tsi578 reset value is 0x0033

A.2.3.4 I2C_SD Setup and Hold Timing Register

The “**I2C_SD Setup and Hold Timing Register**” programs the setup and hold times for the I2C_SD signal when output by either the master or slave interface. It is shadowed during boot loading, and can be reprogrammed prior to a chain operation without affecting the bus timing for the current EEPROM.

SDA_SETUP Count for the I2C_SD Setup Period

The SDA_SETUP field defines the minimum setup time for the I2C_SD signal; that is, I2C_SD is set to a desired value prior to rising edge of I2C_SCLK. This applies to both slave and master interface.



This value should be set to the sum of the I2C_SD setup time and the maximum rise/fall time of the I2C_SD signal in order to ensure that the signal is valid on the output at the correct time. This time is different than the raw I2C_SD setup time in the *I²C Specification*.

- $\text{Period}(\text{SDA_SETUP}) = (\text{SDA_SETUP} * \text{Period}(\text{P_CLK}))$, where P_CLK is 10ns.
 - Reset time is 1260 nanoseconds
 - Tsi578 reset value is 0x007E

SDA_HOLD Count for I2C_SD Hold Period

The SDA_HOLD field defines the minimum hold time for the I2C_SD signal; that is, I2C_SD valid past the falling edge of I2C_SCLK. This applies to both slave and master interface.

- $\text{Period}(\text{SDA_HOLD}) = (\text{SDA_HOLD} * \text{Period}(\text{P_CLK}))$, where P_CLK is 10 ns.
 - Reset time is 310 nanoseconds
 - Tsi578 reset value is 0x001F

A.2.3.5 I2C_SCLK High and Low Timing Register

The “**I2C_SCLK High and Low Timing Register**” programs the nominal high and low periods of the I2C_SCLK signal when generated by the master interface.

It is shadowed during boot loading, and can be reprogrammed prior to a chain operation without affecting the bus timing for the current EEPROM.

SCL_HIGH Count for I2C_SCLK High Period

The SCL_HIGH field defines the nominal high period of the clock, from rising edge to falling edge of I2C_SCLK. This is a master-only parameter.

The actual observed period may be shorter if other devices pull the clock low.

- $\text{Period}(\text{SCL_HIGH}) = (\text{SCL_HIGH} * \text{Period}(\text{P_CLK}))$
 - P_CLK is 10 ns
 - Reset time is 5.00 microseconds (100 kHz)
 - Tsi578 reset value is 0x01F4

SCL_LOW Count for I2C_SCLK Low Period

The SCL_LOW field defines the nominal low period of the clock, from falling edge to rising edge of I2C_SCLK. This is a master-only parameter.

The actual observed period may be longer if other devices pull the clock low.

- $\text{Period}(\text{SCL_LOW}) = (\text{SCL_LOW} * \text{Period}(\text{P_CLK}))$
 - P_CLK is 10 ns
 - Reset time is 5.00 microseconds (100 kHz)
 - Tsi578 reset value is 0x01F4

A.2.3.6 I2C_SCLK Minimum High and Low Timing Register

The “**I2C_SCLK Minimum High and Low Timing Register**” programs the minimum high and low periods of the I2C_SCLK signal when generated by the master interface. It is shadowed during boot loading, and can be reprogrammed prior to a chain operation without affecting the bus timing for the current EEPROM.

SCL_MINH Count for I2C_SCLK High Minimum Period

The SCL_MINH field defines the minimum high period of the clock, from rising edge seen high to falling edge of I2C_SCLK. This is a master-only parameter.

The actual observed period may be shorter if other devices pull the clock low.

- $\text{Period}(\text{SCL_MINH}) = (\text{SCL_MINH} * \text{Period}(\text{P_CLK}))$
 - P_CLK is 10 ns
 - Reset time is 4.01 microseconds
 - Tsi578 reset value is 0x0191

SCL_MINL Count for I2C_SCLK Low Minimum Period

The SCL_MINL defines the minimum low period of the clock, from falling edge seen low to rising edge of I2C_SCLK. This is a master-only parameter.

The actual observed period may be longer if other devices pull the clock low.

- $\text{Period}(\text{SCL_MINL}) = (\text{SCL_MINL} * \text{Period}(\text{P_CLK}))$
 - P_CLK is 10 ns
 - Reset time is 4.71 microseconds
 - Tsi578 reset value is 0x01D7

A.2.3.7 I2C_SCLK Low and Arbitration Timeout Register

The “**I2C_SCLK Low and Arbitration Timeout Register**” programs the I2C_SCLK low timeout and the Arbitration timeout. The arbitration timer period is relative to the MSDIV period, and the I2C_SCLK low timeout period is relative to the USDIV period.

SCL_TO Count for I2C_SCLK Low Timeout Period

The SCL_TO field defines the maximum amount of time for a slave device holding the I2C_SCLK signal low. This timeout covers the period from I2C_SCLK falling edge to the next I2C_SCLK rising edge. A value of 0 disables the timeout.

- $\text{Period}(\text{SCL_TO}) = (\text{SCL_TO} * \text{Period}(\text{USDIV}))$
 - USDIV is the microsecond time defined in the “**I2C Time Period Divider Register**”.
 - The reset value of this timeout is 26 milliseconds
 - Tsi578 reset value is 0x65BB

ARB_TO Count for Arbitration Timeout Period

The ARB_TO field defines the maximum amount of time for the master interface to arbitrate for the bus before aborting the transaction. This timeout covers the period from master operation start (see setting the START bit in the “**I2C Master Control Register**”) until the ACK/NACK is received from the external slave for the slave device address. A value of 0 disables the timeout.

- $\text{Period}(\text{ARB_TO}) = (\text{ARB_TO} * \text{Period}(\text{MSDIV}))$
 - MSDIV is the millisecond time defined in “**I2C Time Period Divider Register**”.
 - The reset value of this timeout is 51 milliseconds
 - This timeout is not active during the boot load sequence.
 - Tsi578 reset value is 0x0033

A.2.3.8 I2C Byte/Transaction Timeout Register

The “**I2C Byte/Transaction Timeout Register**” programs the Transaction and Byte time-outs. The timer periods are relative to the USDIV period for the byte timeout, and relative to the MSDIV period for the transaction timeout.

BYTE_TO Count for Byte Timeout Period

The BYTE_TO field defines the maximum amount of time for a byte to be transferred on the I²C bus. This covers the period from Start condition to next ACK/NACK, between two successive ACK/NACK bits, or from ACK/NACK to Stop/Restart condition. A value of 0 disables the timeout.

- $\text{Period}(\text{BYTE_TO}) = (\text{BYTE_TO} * \text{Period}(\text{USDIV}))$
 - USDIV is the microsecond time defined in “**I2C Time Period Divider Register**”.
 - This timeout is disabled on reset, and is not used during boot load.
 - Tsi578 reset value is 0x0000

TRAN_TO Count for Transaction Timeout Period

The TRAN_TO field defines the maximum amount of time for a transaction on the I2C bus. This covers the period from Start to Stop. A value of 0 disables the timeout.

- $\text{Period}(\text{TRAN_TO}) = (\text{TRAN_TO} * \text{Period}(\text{MSDIV}))$
 - MSDIV is the millisecond time defined in “**I2C Time Period Divider Register**”.
 - This timeout is disabled on reset, and is not used during boot load
 - Tsi578 reset value is 0x0000

A.2.3.9 I2C Boot and Diagnostic Timer

The “**I2C Boot and Diagnostic Timer**” programs a timer used to timeout the boot load sequence, and can be used after boot load as a general purpose timer.

COUNT Count for Timer Period

The COUNT field defines the period for the timer. The initial reset value is used for overall boot load timeout. A value of 0 disables the timeout.



During normal operation, this timer can be used for any general purpose timing.

The timer begins counting when this register is written. If this register is written while the counter is running, the timer is immediately restarted with the new COUNT, and the DTIMER/BLTO event is not generated.

When the timer expires, either the BLTO or DTIMER event is generated, depending on whether the boot load sequence is active. If FREERUN is set to 1 when timer expires, then the timer is restarted immediately (the event is still generated), providing a periodic interrupt capability.

- $\text{Period}(\text{DTIMER}) = (\text{COUNT} * \text{Period}(\text{MSDIV}))$

- MSDIV is the millisecond period define in “**I2C Time PeriodDivider Register**”.
- The reset value for the boot load timeout is four seconds. If the boot load completes before the timer expires, the timer is set to zero (disabled).
- Tsi578 reset value is 0x0FA0

A.2.4 Other Performance Factors

This section describes any other factors that may impact the performance of the Tsi578 if P-CLK is programmed to operate lower than the recommended 100 MHz frequency.

A.2.4.1 Internal Register Bus Operation

The internal register bus, where all the internal registers reside, is a synchronous bus clocked by the P_CLK source. A decrease in the P_CLK frequency causes a proportional increase in register access time during RapidIO maintenance transactions, JTAG registers accesses, and I²C register accesses.

RapidIO Maintenance Transaction

Maintenance transactions use the internal register bus to read and write registers in the Tsi578. If the P_CLK frequency is decreased, it may be necessary to review the end point’s response latency timer value to ensure that it does not expire before the response is returned.



Changing the frequency of the P_CLK does not affect the operation or performance of the RapidIO portion of the switch, in particular its ability to route or multicast packets between ports.

JTAG Register Interface

Changing the P_CLK frequency affects accesses to the internal registers through the JTAG register interface because the interface uses the internal register bus. However, since access to the registers using the JTAG interface is largely a manual command line terminal operation using the Tundra JTAG Register Interface Software (see www.tundra.com for more information), the decreased performance will not be perceivable.

Boundary scan operations are not affected by a change in the P_CLK frequency because these transactions use the JTAG TCK clock signal and do not access the internal register bus.

B. Ordering Information

This chapter discusses ordering information and describes the part numbering system for the Tsi578.

B.1 Ordering Information

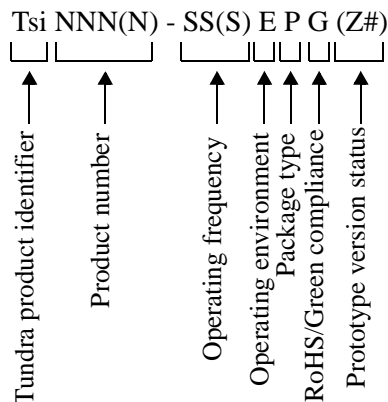
When ordering the Tsi578 please refer to the device by its full part number, as displayed in [Table 25](#).

Table 25: Tsi578 Ordering Information

Part Number	Frequency	Temperature	Package	Pin Count
Tsi578-10GCL	1.25 - 3.125 Gbit/s	Commercial	FCBGA	675
Tsi578-10GCLY	1.25 - 3.125 Gbit/s	Commercial	FCBGA (RoHS)	675
Tsi578-10GIL	1.25 - 3.125 Gbit/s	Industrial	FCBGA	675
Tsi578-10GILY	1.25 - 3.125 Gbit/s	Industrial	FCBGA (RoHS)	675

B.2 Part Numbering Information

The Tundra part numbering system is explained as follows.



- () – Indicates optional characters.
- Tsi – Tundra system interconnect product identifier. All Tundra semiconductor product numbers start with “Tsi.”
- NNNN – Product number (may be three or four digits).
- SS(S) – Maximum operating frequency or data transfer rate of the fastest interface. For operating frequency numbers, M and G represent MHz and GHz. For transfer rate numbers, M and G represent Mbps and Gbps.

- E – Operating environment in which the product is guaranteed. This code may be one of the following characters:
 - C - Commercial temperature range (0 to +70°C)
 - I - Industrial temperature range (-40 to +85°C)
 - E - Extended temperature range (-55 to +125°C)
- P – The Package type of the product:
 - B - Ceramic ball grid array (CBGA)
 - E, L, J, and K - Plastic ball grid array (PBGA)
 - G - Ceramic pin grid array (CPGA)
 - M - Small outline integrated circuit (SOIC)
 - Q - Plastic quad flatpack
- G – Tundra products fit into three RoHS-compliance categories:
 - Y - RoHS Compliant (6of6) – These products contain none of the six restricted substances above the limits set in the EU Directive 2002/95/EC.
 - Y - RoHS Compliant (Flip Chip) – These products contain only one of the six restricted substances: Lead (Pb). These flip-chip products are RoHS compliant through the Lead exemption for Flip Chip technology, Commission Decision 2005/747/EC, which allows Lead in solders to complete a viable electrical connection between semiconductor die and carrier within integrated circuit Flip Chip packages.
 - V - RoHS Compliant/Green - These products follow the above definitions for RoHS Compliance and meet JIG (Joint Industry Guide) Level B requirements for Brominated Flame Retardants (other than PBBs and PBDEs).
- Z# – Prototype version status (optional). If a product is released as a prototype then a “Z” is added to the end of the part number. Further revisions to the prototype prior to production release would add a sequential numeric digit. For example, the first prototype version of device would have a “Z,” a second version would have “Z1,” and so on. The prototype version code is dropped once the product reaches production status.