



## ORT8850 Field-Programmable System Chip (FPSC) Eight-Channel x 850 Mbits/s Backplane Transceiver

### Introduction

Field-programmable system chips (FPSCs) bring a whole new dimension to programmable logic: FPGA logic and an embedded system solution on a single device. Lucent Technologies Microelectronics Group has developed a solution for designers who need the many advantages of FPGA-based design implementation, coupled with high-speed serial backplane data transfer. Built on the Series 4 reconfigurable embedded system-on-chips (SoC) architecture, the ORT8850 family is made up of backplane transceivers containing eight channels, each operating at up to 850 Mbits/s (6.8 Gbits/s when all eight channels are used) full-duplex synchronous interface with built-in clock and data recovery (CDR) in standard-cell logic, along with up to 600 k usable FPGA system gates. The CDR circuitry is a macrocell available from Lucent's Smart Silicon macro library, and has already been implemented in numerous applications including ASICs, standard products, and FPSCs to create interfaces for SONET/SDH STS-3/STM-1, STS-12/STM-4, STS-48/STM-16, and STS-192/STM-64 applications. With the addition of protocol and access logic such as protocol-independent framers, asynchronous transfer mode (ATM) framers, packet-over-SONET (POS) interfaces, and framers for HDLC for Internet protocol (IP), designers can build a configurable interface retaining proven backplane driver/receiver technology. Designers can also use the device to drive high-speed data transfer across buses within a system that are not SONET/SDH based. For example, designers can build a 6.8 Gbits/s PCI-to-PCI half bridge using our PCI soft core.

The ORT8850 family offers a clockless high-speed interface for interdevice communication, on a board or across a backplane. The built-in clock recovery of the ORT8850 allows for higher system performance, easier-to-design clock domains in a multiboard system, and fewer signals on the backplane. Network designers will benefit from the backplane transceiver as a network termination device. The backplane transceiver offers SONET scrambling/descrambling of data and streamlined SONET framing, pointer moving and transport overhead handling, plus the programmable logic to terminate the network into proprietary systems. For non-SONET application, all SONET functionality is hidden from the user and no prior networking knowledge is required. The 8850 also offers 8B/10B coding in addition to SONET scrambling.

Also included on the device are three full-duplex, high-speed parallel interfaces, consisting of 8-bit data, control (such as start-of-cell), and clock. The interface delivers double data rate (DDR) data at rates up to 311 MHz (622 Mbits/s per pin), and converts this data internal to the device into 32-bit wide data running at half rate on one clock edge. Functions such as centering the transmit clock in the transmit data eye are done automatically by the interface. Applications delivered by this interface include a parallel backplane interface similar to the recently proposed *RapidIO*\* packet-based interface.

\* *RapidIO* is a trademark of Motorola, Inc.

**Table 1. ORCA ORT8850 Family—Available FPGA Logic**

Device	PFU Rows	PFU Columns	Total PFUs	FPGA User I/O	LUTs	EBR Blocks	EBR Bits (k)	Usable Gates (k)
ORT8850L	26	24	624	296	4,992	8	74	260—470
ORT8850H	46	44	2024	536	16,192	16	147	530—970

† The embedded core and interface are not included in the above gate counts. The usable gate counts range from a logic-only gate count to a gate count assuming 20% of the PFUs/SLICs being used as RAMs. The logic-only gate count includes each PFU/SLIC (counted as 108 gates/PFU), including 12 gates per LUT/FF pair (eight per PFU), and 12 gates per SLIC/FF pair (one per PFU). Each of the four PIO groups are counted as 16 gates (three FFs, fast-capture latch, output logic, CLK, and I/O buffers). PFUs used as RAM are counted at four gates per bit, with each PFU capable of implementing a 32 x 4 RAM (or 512 gates) per PFU. Embedded block RAM (EBR) is counted as four gates per bit plus each block has an additional 25 K gates. 7 K gates are used for each PLL and 50K gates for the embedded system bus and microprocessor interface logic. Both the EBR and PLLs are conservatively utilized in the gate calculations.

**Table of Contents**

<b>Contents</b>	<b>Page</b>	<b>Contents</b>	<b>Page</b>
Introduction.....	1	Power Supply Decoupling LC Circuit .....	53
List of Figures.....	2	HSI Electrical and Timing Characteristics .....	54
List of Tables .....	3	Embedded Core LVDS I/O .....	55
Embedded Core Features (Serial).....	4	LVDS Receiver Buffer Requirements .....	56
Embedded Core Features (Parallel).....	4	Input/Output Buffer Measurement Conditions	
Programmable FPGA Features .....	5	(on-LVDS Buffer) .....	57
System Features .....	6	LVDS Buffer Characteristics .....	58
Description.....	7	Termination Resistor .....	58
What Is An FPSC? .....	7	LVDS Driver Buffer Capabilities .....	58
FPSC Overview .....	7	Pin Information .....	59
FPSC Gate Counting .....	7	Package Pinouts .....	72
FPGA/Embedded Core Interface .....	7	Package Thermal Characteristics Summary .....	93
ORCA Foundry 2000 Development System .....	7	ΘJA .....	93
FPSC Design Kit .....	8	ψJC .....	93
FPGA Logic Overview .....	8	ΘJC .....	93
PLC Logic .....	8	ΘJB .....	93
Programmable I/O .....	9	FPSC Maximum Junction Temperature .....	93
Routing .....	9	Package Thermal Characteristics.....	94
System Level Features.....	10	Package Coplanarity .....	94
Microprocessor Interface .....	10	Package Parasitics .....	94
System Bus .....	10	Package Outline Diagrams.....	95
Phase-locked Loops .....	10	Terms and Definitions .....	95
Embedded Block RAM .....	10	680-Pin PBGAM .....	96
Configuration .....	11	Hardware Ordering Information .....	97
Additional Information .....	11	Software Ordering Information .....	97
ORT8850 Overview .....	12		
Device Layout .....	12		
Backplane Transceiver Interface .....	12		
HSI Interface .....	15		
STM Macrocell .....	15		
8B/10B Encoder/Decoder .....	15		
FPGA Interface .....	15		
Byte-Wide Parallel Interface .....	15		
FPSC Configuration .....	16		
Generic Backplane Transceiver Application.....	17		
Synchronous Transfer Mode (STM) .....	17		
8B/10B Mode .....	17		
Backplane Transceiver Core Detailed Description ....	18		
HSI Macro .....	18		
STM Transmitter (FPGA -> Backplane) .....	20		
STM Receiver (Backplane -> FPGA) .....	24		
Powerdown Mode .....	31		
Redundancy and Protection Switching .....	31		
<i>RapidIO</i> Interface to Pi-Sched.....	32		
Overview .....	32		
Receive Cell Interface .....	32		
Transmit Cell Interface .....	34		
Memory Map.....	36		
Definition of Register Types .....	36		
Memory Map Overview .....	38		
Absolute Maximum Ratings.....	52		
Recommend Operating Conditions .....	52		

**Table of Contents**

<b>Contents</b>	<b>Page</b>	<b>Contents</b>	<b>Page</b>
<b>List of Figures</b>		<b>List of Tables</b>	
Figure 1. ORCA ORT8850 Block Diagram .....	13	Table 1. ORCA ORT8850 Family—Available FPGA Logic .....	1
Figure 2. High Level Diagram of ORT8850 Transceiver .....	14	Table 2. Transmitter TOH on LVDS Output (Transparent Mode) .....	22
Figure 3. HSI Functional Block Diagram .....	19	Table 3. Transmitter TOH on LVDS Output (TOH Insert Mode) .....	22
Figure 4. Byte Ordering of Input/Output Interface in STS-12 Mode .....	20	Table 4. Valid Starting Positions for an STS-Mc .....	27
Figure 5. Interconnect of Streams for FIFO Alignment .....	25	Table 5. Receiver TOH (Output Parallel Bus) .....	29
Figure 6. Example of Intra-STM Alignment .....	25	Table 6. SPE and C1J1 Functionality .....	30
Figure 7. Example of Inter-STM Alignment .....	25	Table 7. <i>RapidIO</i> Signals to/from FPGA .....	35
Figure 8. Example of Twin STS-12 Stream Alignment .....	25	Table 8. Signals Used as Register Bits .....	36
Figure 9. Examples of Link Alignment .....	26	Table 9. Structural Register Elements .....	37
Figure 10. Pointer Mover State Machine .....	28	Table 10. Memory Map .....	38
Figure 11. SPE and C1J1 Functionality .....	30	Table 11. Memory Map Descriptions .....	46
Figure 12. SPE Stuff Bytes .....	31	Table 12. Absolute Maximum Ratings .....	52
Figure 13. <i>RapidIO</i> Receive Cell Interface .....	33	Table 13. Recommend Operating Conditions .....	52
Figure 14. <i>RapidIO</i> Transmit Cell Interface .....	34	Table 14. Absolute Maximum Ratings .....	54
Figure 15. Sample Power Supply Filter Network for Analog HSI Power Supply Pins .....	53	Table 15. Recommended Operating Conditions .....	54
Figure 16. ac Test Loads .....	57	Table 16. Receiver Specifications .....	54
Figure 17. Output Buffer Delays .....	57	Table 17. Transmitter Specifications .....	54
Figure 18. Input Buffer Delays .....	57	Table 18. Synthesizer Specifications .....	54
Figure 19. LVDS Driver and Receiver and Associated Internal Components .....	58	Table 19. Driver dc Data .....	55
Figure 20. LVDS Driver and Receiver .....	58	Table 20. Driver ac Data .....	55
Figure 21. LVDS Driver .....	58	Table 21. Driver Power Consumption .....	55
Figure 22. Package Parasitics .....	94	Table 22. Receiver ac Data .....	56
		Table 23. Receiver Power Consumption .....	56
		Table 24. Receiver dc Data .....	56
		Table 25. LVDS Operating Parameters .....	56
		Table 26. FPGA Common-Function Pin Description .....	59
		Table 27. FPSC Function Pin Description .....	62
		Table 28. Embedded Core/FPGA Interface Signal Description .....	65
		Table 29. ORT8850H 680-Pin PBGAM Pinout .....	73
		Table 30. ORCA ORT8850 Plastic Package Thermal Guidelines .....	94
		Table 31. ORCA ORT8850 Package Parasitics .....	94
		Table 32. Device Type Options .....	97
		Table 33. Temperature Options .....	97
		Table 34. Package Type Options .....	97
		Table 35. ORCA FPSC Package Matrix (Speed Grades) .....	97

## **Embedded Core Features (Serial)**

- Implemented in an *ORCA* Series 4 FPGA array.
- Allows wide range of applications for SONET network termination application as well as generic data moving for high-speed backplane data transfer.
- No knowledge of SONET/SDH needed in generic applications. Simply supply data, 78 MHz—106 MHz clock, and a frame pulse.
- High-speed interface (HSI) function for clock/data recovery serial backplane data transfer without external clocks.
- Eight-channel HSI function provides 850 Mbits/s serial interface per channel for a total chip bandwidth of 6.8 Gbits/s (full duplex).
- HSI function uses Lucent Technologies Microelectronics Group's 850 Mbits/s serial interface core. Rates from 212 Mbits/s to 850 Mbits/s are supported directly (lower rates directly supported through decimation and interpolation).
- LVDS I/Os compliant with *EIA*\*-644 support hot insertion. All embedded LVDS I/Os include both input and output on-board termination to allow long-haul driving of backplanes.
- Low-power 1.5 V HSI core.
- Low-power LVDS buffers.
- Programmable STS-1, STS-3, and STS-12 framing.
- Independent STS-1, STS-3, and STS-12 data streams per quad channels.
- 8:1 data multiplexing/demultiplexing for 106.25 MHz byte-wide data processing in FPGA logic.
- On-chip, phase-lock loop (PLL) clock meets B jitter tolerance specification of ITU-T recommendation G.958.
- Powerdown option of HSI receiver on a per-channel basis.
- Selectable 8B/10B coder/decoder or SONET scrambler/descrambler.
- HSI automatically recovers from loss-of-clock once its reference clock returns to normal operating state.
- Frame alignment across multiple ORT8850 devices for work/protect switching at OC-192/STM-64 and above rates.
- In-band management and configuration through transport overhead extraction/insertion.
- Supports transparent modes where either the only insertion is A1/A2 framing bytes, or no bytes are inserted.
- Streamlined pointer processor (pointer mover) for 8 kHz frame alignment to system clocks.
- Built-in boundary scan (*IEEE* † 1149.1 JTAG).
- FIFOs align incoming data across all eight channels (two groups of four channels or four groups of two channels) for both SONET scrambling and 8B/10B modes. Optional ability to bypass alignment FIFOs.
- 1 + 1 protection supports STS-12/STS-48 redundancy by either software or hardware control for protection switching applications. STS-192 and above rates are supported through multiple devices.
- *ORCA* FPGA soft intellectual property core support for a variety of applications.
- Programmable STM pointer mover bypass mode.
- Programmable STM framer bypass mode.
- Programmable CDR bypass mode (clocked LVDS high-speed interface).
- Redundant outputs and multiplexed redundant inputs for CDR I/Os allow for implementation of eight channels with redundancy on a single device.

## **Embedded Core Features (Parallel)**

- Three full-duplex, double data rate (DDR) I/O groups include 8-bit data, one control, and one clock. Each interface is implemented with LVDS I/Os that include on-board termination to allow long-haul driving of backplanes, such as the industry standard *RapidIO* interface.
- External I/O speeds on DDR interface up to 311 MHz (622 Mbits/s per pin), with internal, single-edge data transferred at 1/2 rate on a 32-bit bus plus control.
- Automatic centering of transmit clock in data eye for DDR interface.
- Direct interfaces to Lucent Pi-Sched (266 MHz DDR LVDS), Pi-X (128 MHz TTL), and APC (100 MHz TTL) ATM/IP switch/port controller devices.

\* *EIA* is a registered trademark of Electronic Industries Association.

† *IEEE* is a registered trademark of The Institute of Electrical and Electronics Engineers, Inc.

## Programmable FPGA Features

- High-performance platform design:
  - 0.13  $\mu\text{m}$  7-level metal technology.
  - Internal performance of >250 MHz.
  - Over 600K usable system gates.
  - Meets multiple I/O interface standards.
  - 1.5 V operation (30% less power than 1.8 V operation) translates to greater performance.
- Traditional I/O selections:
  - LVTTTL and LVCMOS (3.3 V, 2.5 V, and 1.8 V) I/Os.
  - Per pin-selectable I/O clamping diodes provide 3.3 V PCI compliance.
  - Individually programmable drive capability: 24 mA sink/12 mA source, 12 mA sink/6 mA source, or 6 mA sink/3 mA source.
  - Two slew rates supported (fast and slew-limited).
  - Fast-capture input latch and input flip-flop (FF)/latch for reduced input setup time and zero hold time.
  - Fast open-drain drive capability.
  - Capability to register 3-state enable signal.
  - Off-chip clock drive capability.
  - Two-input function generator in output path.
- New programmable high-speed I/O:
  - Single-ended: GTL, GTL+, PECL, SSTL3/2 (class I & II), HSTL (Class I, III, IV), ZBT, and DDR.
  - Double-ended: LVDS, bused-LVDS, LVPECL.
  - LVDS include optional on-chip termination resistor per I/O and on-chip reference generation.
  - Customer defined: Ability to substitute arbitrary standard cell I/O to meet fast-moving standards.
- New capability to (de)multiplex I/O signals:
  - New DDR on both input and output at rates up to 133 MHz (266 MHz effective rate).
  - New 2x and 4x downlink and uplink capability per I/O (i.e., 50 MHz internal to 200 MHz I/O).
- Enhanced twin-quad programmable function unit (PFU):
  - Eight 16-bit look-up tables (LUTs) per PFU.
  - Nine user registers per PFU, one following each LUT, and organized to allow two nibbles to act independently, plus one extra for arithmetic operations.
  - New register control in each PFU has two independent programmable clocks, clock enables, local set/reset, and data selects.
  - New LUT structure allows flexible combinations of LUT4, LUT5, new LUT6, 4  $\rightarrow$  1 MUX, new 8  $\rightarrow$  1 MUX, and ripple mode arithmetic functions in the same PFU.
  - 32 x 4 RAM per PFU, configurable as single- or dual-port. Create large, fast RAM/ROM blocks (128 x 8 in only eight PFUs) using the SLIC decoders as bank drivers.
- Soft-wired LUTs (SWL) allow fast cascading of up to three levels of LUT logic in a single PFU through fast internal routing, which reduces routing congestion and improves speed.
- Flexible fast access to PFU inputs from routing.
- Fast-carry logic and routing to all four adjacent PFUs for nibble-wide, byte-wide, or longer arithmetic functions, with the option to register the PFU carry-out.
- Abundant high-speed buffered and nonbuffered routing resources provide 2x average speed improvements over previous architectures.
- Hierarchical routing optimized for both local and global routing with dedicated routing resources. This results in faster routing times with predictable and efficient performance.
- SLIC provides eight 3-statable buffers, up to 10-bit decoder, and PAL\*-like and-or-invert (AOI) in each programmable logic cell.
- Improved built-in clock management with dual output programmable phase-locked loops (PPLLs) provide optimum clock modification and conditioning for phase, frequency, and duty cycle from 20 MHz up to 416 MHz.
- New 200 MHz embedded quad-port RAM blocks, 2 read ports, 2 write ports, and 2 sets of byte lane enables. Each embedded RAM block can be configured as:
  - 1—512x18 (quad-port, two read/two write) with optional built in arbitration.
  - 1—256x36 (dual-port, one read/one write).
  - 1—1Kx9 (dual-port, one read/one write).
  - 2—512x9 (dual-port, one read/one write for each).
  - 2 RAMS with arbitrary number of words whose sum is 512 or less by 18 (dual-port, one read/one write).
  - Supports joining of RAM blocks.
  - Two 16x8-bit content addressable memory (CAM) support.
  - FIFO 512 x 18, 256 x 36, 1K x 9, or dual 512 x 9.
  - Constant multiply (8 x 16 or 16 x 8).
  - Dual variable multiply (8 x 8).
- Embedded 32-bit internal system bus plus 4-bit parity interconnects FPGA logic, microprocessor interface (MPI), embedded RAM blocks, and embedded backplane transceiver blocks with 100 MHz bus performance. Included are built-in system registers that act as the control and status center for the device.

\* PAL is a trademark of Advanced Micro Devices, Inc.

## Programmable Features (continued)

- Built-in testability:
  - Full boundary scan (*IEEE* 1149.1 and Draft 1149.2 JTAG).
  - Programming and readback through boundary scan port compliant to *IEEE* Draft 1532:D1.7.
  - TS\_ALL testability function to 3-state all I/O pins.
  - New temperature-sensing diode.

## System Features

- PCI local bus compliant for FPGA I/Os.
- Improved *PowerPC*<sup>\*</sup> 860 and *PowerPC* II high-speed synchronous microprocessor interface can be used for configuration, readback, device control, and device status; as well as for a general-purpose interface to the FPGA logic, RAMs, and embedded backplane transceiver blocks. Glueless interface to synchronous *PowerPC* processors with user-configurable address space provided.
- New embedded *AMBA*<sup>†</sup> specification 2.0 AHB system bus (*ARM*<sup>†</sup> processor) facilitates communication among the microprocessor interface, configuration logic, embedded block RAM, FPGA logic, and backplane transceiver logic.
- New network PLLs meet ITU-T G.811 specifications and provide clock conditioning for DS-1/E-1 and STS-3/STM-1 applications.
- Flexible general purpose PPLLs offer clock multiply (up to 8x), divide (down to 1/8x), phase shift, delay compensation, and duty cycle adjustment combined.

- Variable size based readback of configuration data capability with the built-in microprocessor interface and system bus.
- Internal, 3-state, and bidirectional buses with simple control provided by the SLIC.
- New clock routing structures for global and local clocking significantly increases speed and reduces skew (<200 ps for OR4E4).
- New local clock routing structures allow creation of localized clock trees.
- New edge clock routing supports at least six fast edge clocks per side of the device
- New double-data rate (DDR) and zero-bus turn-around (ZBT) memory interfaces support the latest high-speed memory interfaces.
- New 2x/4x uplink and downlink I/O capabilities interface high-speed external I/Os to reduced speed internal logic.
- *ORCA* Foundry 2000 development system software. Supported by industry-standard CAE tools for design entry, synthesis, simulation, and timing analysis.
- Meets universal test and operations PHY interface for ATM (UTOPIA) Levels 1, 2, and 3. Also meets proposed specifications for UTOPIA Level 4 for 10 Gbits/s interfaces.

\* *PowerPC* is a registered trademark of International Business Machines, Inc.

† *AMBA* is a trademark, and *ARM* is a registered trademark of Advanced RISC Machines Limited.

## Description

### What Is An FPSC?

FPSCs, or field-programmable system chips, are devices that combine field-programmable logic with ASIC or mask-programmed logic on a single device. FPSCs provide the time to market and the flexibility of FPGAs, the design effort savings of using soft intellectual property (IP) cores, and the speed, design density, and economy of ASICs.

### FPSC Overview

Lucent's Series 4 FPSCs are created from Series 4 ORCA FPGAs. To create a Series 4 FPSC, several columns of programmable logic cells (see FPGA Logic Overview section for FPGA logic details) are added to an embedded logic core. Other than replacing some FPGA gates with ASIC gates, at greater than 10:1 efficiency, none of the FPGA functionality is changed—all of the Series 4 FPGA capability is retained: embedded block RAMs, MPI, PCMs, boundary scan, etc. The columns of programmable logic are replaced at the right of the device, allowing pins from the replaced columns to be used as I/O pins for the embedded core. The remainder of the device pins retain their FPGA functionality.

The embedded cores can take many forms and generally come from Lucent Technologies ASIC libraries. Other offerings allow customers to supply their own core functions for the creation of custom FPSCs.

### FPSC Gate Counting

The total gate count for an FPSC is the sum of its embedded core (standard-cell/ASIC gates) and its FPGA gates. Because FPGA gates are generally expressed as a usable range with a nominal value, the total FPSC gate count is sometimes expressed in the same manner. Standard-cell ASIC gates are, however, 10 to 25 times more silicon-area efficient than FPGA gates. Therefore, an FPSC with an embedded function is gate equivalent to an FPGA with a much larger gate count.

### FPGA/Embedded Core Interface

The interface between the FPGA logic and the embedded core has been enhanced to allow for a greater number of interface signals than on previous FPSC architectures. Compared to bringing embedded core

signals off-chip, this on-chip interface is much faster and requires less power. All of the delays for the interface are precharacterized and accounted for in the ORCA Foundry Development System.

Series 4 based FPSCs expand this interface by providing a link between the embedded block and the multi-master 32-bit system bus in the FPGA logic. This system bus allows the core easy access to many of the FPGA logic functions including the embedded block RAMs and the microprocessor interface.

Clock spines also can pass across the FPGA/embedded core boundary. This allows for fast, low-skew clocking between the FPGA and the embedded core. Many of the special signals from the FPGA, such as DONE and global set/reset, are also available to the embedded core, making it possible to fully integrate the embedded core with the FPGA as a system.

For even greater system flexibility, FPGA configuration RAMs are available for use by the embedded core. This allows for user-programmable options in the embedded core, in turn allowing for greater flexibility. Multiple embedded core configurations may be designed into a single device with user-programmable control over which configurations are implemented, as well as the capability to change core functionality simply by reconfiguring the device.

### ORCA Foundry 2000 Development System

The ORCA Foundry 2000 development system is used to process a design from a netlist to a configured FPGA. This system is used to map a design onto the ORCA architecture and then place and route it using ORCA Foundry's timing-driven tools. The development system also includes interfaces to, and libraries for, other popular CAE tools for design entry, synthesis, simulation, and timing analysis.

The ORCA Foundry 2000 development system interfaces to front-end design entry tools and provides the tools to produce a configured FPGA. In the design flow, the user defines the functionality of the FPGA at two points in the design flow: design entry and the bit-stream generation stage. Recent improvements in ORCA Foundry allow the user to provide timing requirement information through logical preferences only, thus, the designer is not required to have physical knowledge of the implementation.

## **Description** (continued)

Following design entry, the development system's map, place, and route tools translate the netlist into a routed FPGA. A floorplanner is available for layout feedback and control. A static timing analysis tool is provided to determine device speed and a back-annotated netlist can be created to allow simulation and timing.

Timing and simulation output files from *ORCA Foundry* are also compatible with many third-party analysis tools. Its bit stream generator is then used to generate the configuration data which is loaded into the FPGAs internal configuration RAM, embedded block RAM, and/or FPSC memory.

When using the bit stream generator, the user selects options that affect the functionality of the FPGA. Combined with the front-end tools, *ORCA Foundry* produces configuration data that implements the various logic and routing options discussed in this data sheet.

## **FPSC Design Kit**

Development is facilitated by an FPSC design kit which, together with *ORCA Foundry* and third-party synthesis and simulation engines, provides all software and documentation required to design and verify an FPSC implementation. Included in the kit are the FPSC configuration manager, *Synopsys Smart Model\**, and complete online documentation. The kit's software couples with *ORCA Foundry*, providing a seamless FPSC design environment. More information can be obtained by visiting the *ORCA* website or contacting a local sales office, both listed on the last page of this document.

## **FPGA Logic Overview**

The *ORCA* Series 4 architecture is a new generation of SRAM-based programmable devices from Lucent Technologies Microelectronics Group. It includes enhancements and innovations geared toward today's high-speed systems on a single chip. Designed with networking applications in mind, the Series 4 family incorporates system-level features that can further reduce logic requirements and increase system speed. *ORCA* Series 4 devices contain many new patented enhancements and are offered in a variety of packages and speed grades.

The hierarchical architecture of the logic, clocks, routing, RAM, and system level blocks create a seamless merge of FPGA and ASIC designs. Modular hardware and software technologies enable system-on-chip inte-

gration with true plug and play design implementation.

The architecture consists of four basic elements: programmable logic cells (PLCs), programmable I/O cells (PIOs), embedded block RAMs (EBRs), and system-level features. These elements are interconnected with a rich routing fabric of both global and local wires. An array of PLCs are surrounded by common interface blocks which provide an abundant interface to the adjacent PLCs or system blocks. Routing congestion around these critical blocks is eliminated by the use of the same routing fabric implemented within the programmable logic core. Each PLC contains a PFU, SLIC, local routing resources, and configuration RAM. Most of the FPGA logic is performed in the PFU, but decoders, *PAL*-like functions, and 3-state buffering can be performed in the SLIC. The PIOs provide device inputs and outputs and can be used to register signals and to perform input demultiplexing, output multiplexing, uplink and downlink functions, and other functions on two output signals. Large blocks of 512 x 18 quad-port RAM compliment the existing distributed PFU memory. The RAM blocks can be used to implement RAM, ROM, FIFO, multiplier, and CAM. Some of the other system-level functions include the MPI, PLLs, and the embedded system bus (ESB).

## **PLC Logic**

Each PFU within a PLC contains eight 4-input (16-bit) LUTs, eight latches/FFs, and one additional flip-flop that may be used independently or with arithmetic functions.

The PFU is organized in a twin-quad fashion; two sets of four LUTs and FFs that can be controlled independently. Each PFU has two independent programmable clocks, clock enables, local set/reset, and data selects. LUTs may also be combined for use in arithmetic functions using fast-carry chain logic in either 4-bit or 8-bit modes. The carry-out of either mode may be registered in the ninth FF for pipelining. Each PFU may also be configured as a synchronous 32 x 4 single- or dual-port RAM or ROM. The FFs (or latches) may obtain input from LUT outputs or directly from invertible PFU inputs, or they can be tied high or tied low. The FFs also have programmable clock polarity, clock enables, and local set/reset.

\* *Synopsys Smart Model* is a registered trademark of Synopsys, Inc.



## Description (continued)

The SLIC is connected from PLC routing resources and from the outputs of the PFU. It contains eight 3-state, bidirectional buffers, and logic to perform up to a 10-bit AND function for decoding, or an AND-OR with optional INVERT to perform PAL-like functions. The 3-state drivers in the SLIC and their direct connections from the PFU outputs make fast, true, 3-state buses possible within the FPGA, reducing required routing and allowing for real-world system performance.

## Programmable I/O

The Series 4 PIO addresses the demand for the flexibility to select I/Os that meet system interface requirements. I/Os can be programmed in the same manner as in previous ORCA devices, with the additional new features which allow the user the flexibility to select new I/O types that support high-speed interfaces.

Each PIO contains four programmable I/O pads and is interfaced through a common interface block to the FPGA array. The PIO is split into two pairs of I/O pads with each pair having independent clock enables, local set/reset, and global set/reset. On the input side, each PIO contains a programmable latch/flip-flop which enables very fast latching of data from any pad. The combination provides for very low setup requirements and zero hold times for signals coming on-chip. It may also be used to demultiplex an input signal, such as a multiplexed address/data signal, and register the signals without explicitly building a demultiplexer with a PFU.

On the output side of each PIO, an output from the PLC array can be routed to each output flip-flop, and logic can be associated with each I/O pad. The output logic associated with each pad allows for multiplexing of output signals and other functions of two output signals.

The output FF, in combination with output signal multiplexing, is particularly useful for registering address signals to be multiplexed with data, allowing a full clock cycle for the data to propagate to the output. The output buffer signal can be inverted, and the 3-state control can be made active-high, active-low, or always enabled. In addition, this 3-state signal can be registered or nonregistered.

The Series 4 I/O logic has been enhanced to include modes for speed uplink and downlink capabilities. These modes are supported through shift register logic, which divides down incoming data rates or multiplies up outgoing data rates. This new logic block also supports high-speed DDR mode requirements where data is clocked into and out of the I/O buffers on both edges of the clock.

The new programmable I/O cell allows designers to select I/Os which meet many new communication standards permitting the device to hook up directly without any external interface translation. They support traditional FPGA standards as well as high-speed, single-ended, and differential-pair signaling (as shown in Table 1). Based on a programmable, bank-oriented I/O ring architecture, designs can be implemented using 3.3 V, 2.5 V, 1.8 V, and 1.5 V referenced output levels.

## Routing

The abundant routing resources of the Series 4 architecture are organized to route signals individually or as buses with related control signals. Both local and global signals utilize high-speed buffered and nonbuffered routes. One PLC segmented (x1), six PLC segmented (x6), and bused half chip (xHL) routes are patterned together to provide high connectivity with fast software routing times and high-speed system performance.

Eight fully distributed primary clocks are routed on a low-skew, high-speed distribution network and may be sourced from dedicated I/O pads, PLLs, or the PLC logic. Secondary and edge-clock routing is available for fast regional clock or control signal routing for both internal regions and on device edges. Secondary clock routing can be sourced from any I/O pin, PLLs, or the PLC logic.

The improved routing resources offer great flexibility in moving signals to and from the logic core. This flexibility translates into an improved capability to route designs at the required speeds when the I/O signals have been locked to specific pins.

## System Level Features

The Series 4 also provides system-level functionality by means of its microprocessor interface, embedded system bus, quad-port embedded block RAMs, universal programmable phase-locked loops, and the addition of highly tuned networking specific phase-locked loops. These functional blocks allow for easy glueless system interfacing and the capability to adjust to varying conditions in today's high-speed networking systems.

## Microprocessor Interface

The MPI provides a glueless interface between the FPGA and *PowerPC* microprocessors. Programmable in 8-, 16-, and 32-bit interfaces with optional parity to the *Motorola\* PowerPC* 860 bus, it can be used for configuration and readback, as well as for FPGA control and monitoring of FPGA status. All MPI transactions utilize the Series 4 embedded system bus at 66 MHz performance.

A system-level microprocessor interface to the FPGA user-defined logic following configuration, through the system bus, including access to the embedded block RAM and general user-logic, is provided by the MPI. The MPI supports burst data read and write transfers, allowing short, uneven transmission of data through the interface by including data FIFOs. Transfer accesses can be single beat (1 x 4-bytes or less), 4-beat (4 x 4-bytes), 8-beat (8 x 2-bytes), or 16-beat (16 x 1-bytes).

## System Bus

An on-chip, multi-master, 8-bit system bus with 1-bit parity facilitates communication among the MPI, configuration logic, FPGA control, and status registers, embedded block RAMs, as well as user logic. Utilizing the *AMBA* specification Rev 2.0 AHB protocol, the embedded system bus offers arbiter, decoder, master, and slave elements. Master and slave elements are also available for the user-logic and embedded backplane transceiver portion of the 8850.

The system bus control registers can provide control to the FPGA such as signalling for reprogramming, reset functions, and PLL programming. Status registers monitor INIT, DONE, and system bus errors. An interrupt controller is integrated to provide up to eight possible interrupt resources. Bus clock generation can be sourced from the microprocessor interface clock, configuration clock (for slave configuration modes), internal oscillator, user clock from routing, or from the port clock (for JTAG configuration modes).

## Phase-locked Loops

Up to eight PLLs are provided on each Series 4 device, with four PLLs generally provided for FPSCs. Programmable PLLs can be used to manipulate the frequency, phase, and duty cycle of a clock signal. Each PLL is capable of manipulating and conditioning clocks from 20 MHz to 420 MHz. Frequencies can be adjusted from 1/8x to 8x, the input clock frequency. Each programmable PLL provides two outputs that have different multiplication factors but can have the same phase relationships. Duty cycles and phase delays can be adjusted in 12.5% of the clock period increments. An automatic input buffer delay compensation mode is available for phase delay. Each PLL provides two outputs that can have programmable (12.5% steps) phase differences.

Additional highly-tuned and characterized, dedicated phase-locked loops (DPLLs) are included to ease system designs. These DPLLs meet ITU-T G.811 primary-clocking specifications and enable system designers to very tightly target specified clock conditioning not traditionally available in the universal PLLs. Initial DPLLs are targeted to low-speed networking DS1 and E1, and also high-speed SONET/SDH networking STS-3 and STM-1 systems. These DPLLs are typically not included on FPSC devices and are not found on the ORT8850 family.

## Embedded Block RAM

New 512 x 18 quad-port RAM blocks are embedded in the FPGA core to significantly increase the amount of memory and compliment the distributed PFU memories. The EBRs include two write ports, two read ports, and two byte lane enables which provide four-port operation. Optional arbitration between the two write ports is available, as well as direct connection to the high-speed system bus.

Additional logic has been incorporated to allow significant flexibility for FIFO, constant multiply, and two-variable multiply functions. The user can configure FIFO blocks with flexible depths of 512k, 256k, and 1k including asynchronous and synchronous modes and programmable status and error flags. Multiplier capabilities allow a multiple of an 8-bit number with a 16-bit fixed coefficient or vice versa (24-bit output), or a multiply of two 8-bit numbers (16-bit output). On-the-fly coefficient modifications are available through the second read/write port. Two 16 x 8-bit CAMs per embedded block can be implemented in single match, multiple match, and clear modes. The EBRs can also be preloaded at device configuration time.

\* *Motorola* is a registered trademark of Motorola, Inc.

## System Level Features (continued)

### Configuration

The FPGAs functionality is determined by internal configuration RAM. The FPGAs internal initialization/configuration circuitry loads the configuration data at power up or under system control. The configuration data can reside externally in an EEPROM or any other storage media. Serial EEPROMs provide a simple, low pin-count method for configuring FPGAs.

The RAM is loaded by using one of several configuration modes. Supporting the traditional master/slave serial, master/slave parallel, and asynchronous peripheral modes, the Series 4 also utilizes its microprocessor interface and embedded system bus to perform both programming and readback. Daisy chaining of multiple devices and partial reconfiguration are also permitted.

Other configuration options include the initialization of the embedded-block RAM memories and FPSC memory as well as system bus options and bit stream error checking. Programming and readback through the JTAG (*IEEE 1149.2*) port is also available meeting in-system programming (ISP) standards (*IEEE 1532 Draft*).

### Additional Information

Contact your local Lucent Technologies representative for additional information regarding the *ORCA* Series 4 FPGA devices, or visit our website at:  
**<http://www.lucent.com/orca>**

## ORT8850 Overview

### Device Layout

The ORT8850 FPSC provides a high-speed backplane transceiver combined with FPGA logic. The device is based on 1.5 V OR4E2 or OR4E6 FPGAs. The OR4E2 has a 26 x 24 array of programmable logic cells (PLCs) and the OR4E6 has a 46 x 44 array. For the ORT8850, several columns of PLCs in these arrays were replaced with the embedded backplane transceiver core.

The ORT8850 embedded core comprises a long haul interface macro and three *RapidIO* macros for intra-board chip-to-chip or backplane communication. The long-haul interface includes the high-speed interface (HSI) macrocell, the synchronous transport module (STM) macrocell, and a 8B/10B encoder/decoder. The eight full-duplex channels perform data transfer, scrambling/descrambling or encoding/decoding, and framing at the rate of 850 Mbits/s. Each *RapidIO* block has a transmit and receive section which each contain 1 LVDS clock buffer pair, 1 LVDS start-of-cell buffer pair, and 8 LVDS clock buffer pairs which are double edge clocked by the corresponding clock. Figure 1 shows the ORT8850 block diagram.

### Backplane Transceiver Interface

The advantage of the ORT8850 FPSC is to bring specific networking functions to an early market presence using programmable logic in a system.

The 850 Mbits/s backplane transceiver core allows the ORT8850 to communicate across a backplane or on a given board at an aggregate speed of 6.8 Gbits/s, providing a physical medium for high-speed asynchronous serial data transfer between system devices. This device is intended for, but not limited to, connecting terminal equipment in SONET/SDH, ATM, and IP systems.

The backplane transceiver core is used to support a 6.8 Gbits/s interface for backplane connection to a mate TADM042G5 device or other SONET devices such as redundant central crossconnect. The interface is implemented as an eight channel 850 Mbits/s LVDS

links. The HSI macrocell is used for clock/data recovery (CDR) and serialize/deserialize between the 106.25 MHz byte-wide internal data buses and the 850 Mbits/s serial LVDS links. For a 622 Mbits/s SONET stream, the HSI will perform clock and data recovery (CDR) and MUX/deMUX between 77.76 MHz byte-wide internal data buses and 622 Mbits/s serial LVDS links.

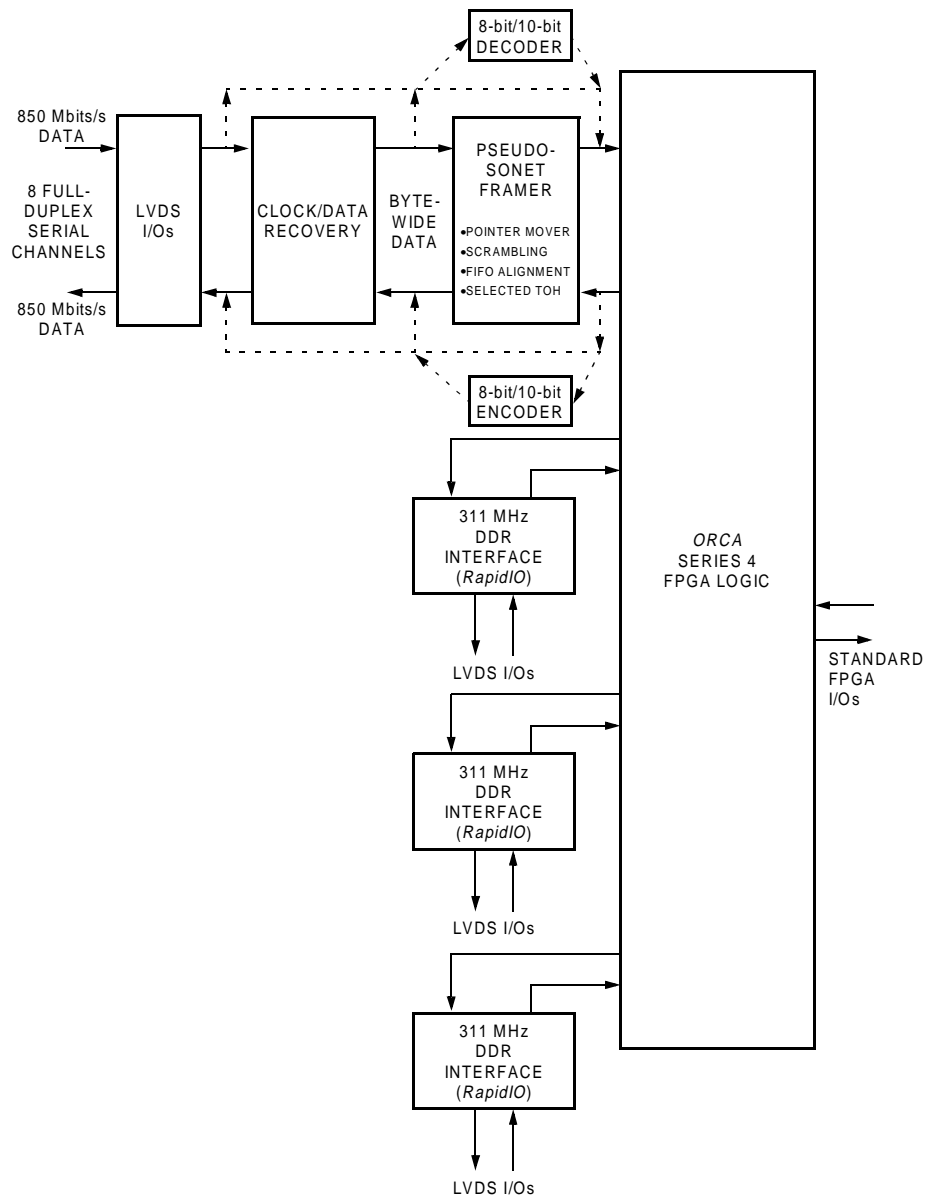
Each 850 Mbits/s serial link uses a pseudo-SONET protocol. SONET A1/A2 framing is used on the link to detect the 8 kHz frame location. The link is also scrambled using the standard SONET scrambler definition to ensure proper transitions on the link for improved CDR performance. Selectable transport overhead (TOH) bytes are insertable in the transmit direction. All the selectable bytes are inserted from software programmable registers that are accessed via a microprocessor interface.

Elastic buffers (FIFOs) are used to align each incoming STS-12 link to the 77.76 MHz clock and 8 kHz frame. These FIFOs will absorb delay variations between the four 622 Mbits/s links due to timing skews between cards and along backplane traces. For greater variations, a streamlined pointer processor (pointer mover) within the STM macro will align the 8 kHz frames regardless of their incoming frame position.

The backplane transceiver allows for SONET scrambling and frame alignment or 8-bit/10-bit (8B/10B) encoding/decoding. SONET has the advantage of reduced overhead (3.3% overhead for SONET vs. 25% overhead for 8B/10B). 8B/10B has the advantage of faster synchronization (a few bytes of transferred data for 8B/10B vs. up to 500  $\mu$ s for four frames of data for SONET). The effective data transfer rate for scrambled SONET is greater than 800 Mbits/s while the effective data transfer rate for 8B/10B is greater than 680 Mbits/s. Frame synchronization and multi channel alignment is provided in 8B/10B mode through the use of special K characters.

Figure 2 shows the architecture of the ORT8850 backplane transceiver core.

ORT8850 Overview (continued)



5-8113(F)

Figure 1. ORCA ORT8850 Block Diagram

ORT8850 Overview (continued)

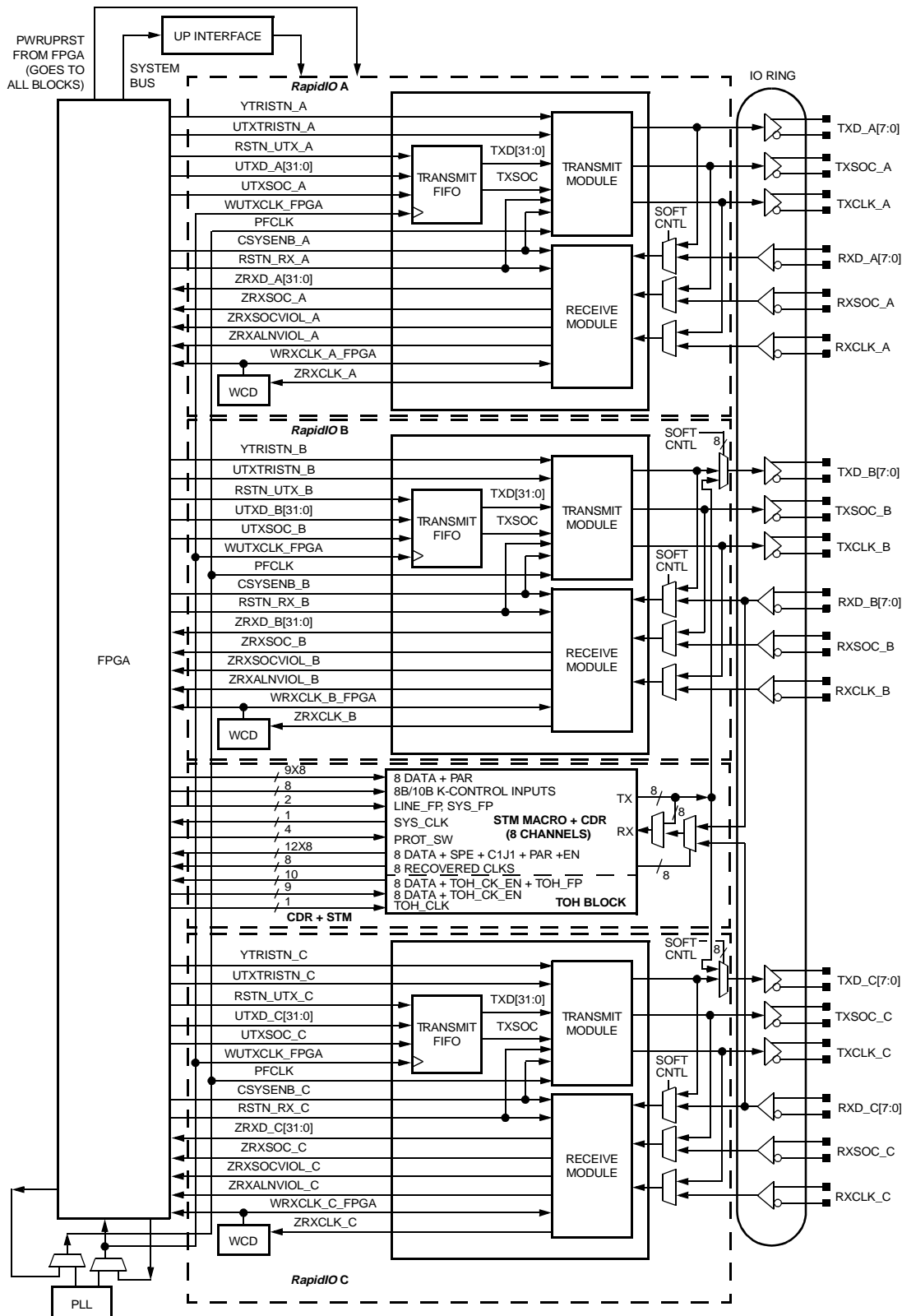


Figure 2. High Level Diagram of ORT8850 Transceiver

## ORT8850 Overview (continued)

### HSI Interface

The high-speed interconnect (HSI) macrocell is used for clock/data recovery and MUX/deMUX between 106.25 MHz byte-wide internal data buses and 850 Mbits/s external serial links.

The HSI interface receives eight 850 Mbits/s serial input data streams from the LVDS inputs and provides eight independent 106.25 MHz byte-wide data streams and recovered clock to the STM macro. There is no requirement for bit alignment since SONET type framing will take place inside the ORT850 core. For transmit, the HSI converts four byte-wide 106.25 MHz data streams to serial streams at 850 Mbits/s at the LVDS outputs.

### STM Macrocell

The STM portion of the embedded core consists of transmitter (Tx) and receiver (Rx) sections. The receiver receives eight byte-wide data streams at 106.25 MHz and the associated clocks from the HSI. In the Rx section, the incoming streams are SONET framed and descrambled before they are written into a FIFO, which absorbs phase and delay variations and allows the shift to the system clock. The TOH is then extracted and sent out on the eight serial ports. The pointer mover consists of three blocks: pointer interpreter, elastic store, and pointer generator. The pointer interpreter finds the synchronous transport signal (STS) synchronous payload envelopes (SPE) and places it into a small elastic store from which the pointer generator will produce eight byte-wide STS-12 streams of data that are aligned to the system timing pulse.

In the Tx section, transmitted data for each channel is received through a parallel bus and a serial port from the FPGA circuit. TOH bytes are received from the serial input port and can be optionally inserted from programmable registers or serial inputs to the STS-12 frame via the TOH processor. Each of the eight parallel input buses is synchronized to a free-running system clock. Then the SPE and TOH data is transferred to the HSI.

The STM macrocell also has a scrambler/descrambler disable feature, allowing the user to disable the scrambler of the transmitter and the descrambler of the receiver. Also, unused channels can be disabled to reduce power dissipation.

### 8B/10B Encoder/Decoder

The ORT8850 facilitates high-speed serial transfer of data in a variety of applications including Gigabit Ethernet, fibre channel, serial backplanes, and proprietary links. The device provides 8B/10B coding/decoding for each channel. The 8B/10B transmission code includes serial encoding/decoding rules, special characters and error detection.

Information to be transmitted over a fibre shall be encoded eight bits at a time into a 10-bit transmission character and then sent serially. The 10-bit transmission characters support all 256 eight-bit combinations. Some of the remaining transmission characters referred to as special characters, are used for functions which are to be distinguishable from the contents of a frame.

### FPGA Interface

The FPGA logic will receive/transmit frame-aligned (optional for 8B/10B mode) streams of 106.25 MHz data (maximum of eight streams in each direction) from/to the backplane transceiver embedded core. All frames transmitted to the FPGA will be aligned to the FPGA frame pulse which will be provided by the FPGA user's logic to the STM macro. If the receive pointer mover and alignment FIFOs are bypassed, then each channel will provide its own receive clock and receive frame pulse signals. Otherwise, all frames received from the FPGA logic will be aligned to the system frame pulse that will be supplied to the STM macro from the FPGA user's logic.

### Byte-Wide Parallel Interface

Three byte-wide parallel interface are provided on the ORT8850. Each interface provides for transmit and receive of byte-wide data, one control signal and one clock. Receive data is sampled on both edges of the receive clock and is converted to a 32-bit data bus which is single-edge clocked by a half-speed clock for transfer to the FPGA logic. Maximum transmit/receive clock rate is 311 MHz and 155 MHz for the internal FPGA clock. This allows for a 622 Mbits/s link data transfer rate. Other functions provided include a check for a minimum number of transferred bytes.

The first byte-wide interface (*RapidIO A* in Figure 2) is always available. The other two interfaces (*RapidIO B* and *RapidIO C*) are available when the 850 Mbits/s serial links are not being used.

## ORT8850 Overview (continued)

### FPSC Configuration

Configuration of the ORT8850 occurs in two stages, FPGA bit stream configuration, and embedded core setup.

### FPGA Configuration

Prior to becoming operational, the FPGA goes through a sequence of states, including powerup, initialization, configuration, start-up, and operation. The FPGA logic is configured by standard FPGA bitstream configuration means as discussed in the Series 4 FPGA data sheet. The options for the embedded core are set via registers that are accessed through the FPGA system bus. Optionally, the system bus can be driven by an external microprocessor via the MPI block. A simple microprocessor emulation soft intellectual property (IP) core that drives the system bus and uses very little of the FPGA logic is available from Lucent. This microprocessor core sets up the embedded core via a state machine and allows the ORT8850 to work in an independent system without an external microprocessor interface.

### Embedded Core Setup

All options for the operation of the core are configured according to the device register map, which is included with the ORT8850 FPSC simulation kit.

During the powerup sequence, the ORT8850 device (FPGA programmable circuit and the core) is held in reset. All the LVDS output buffers and other output buffers are held in 3-state. All flip-flops in core area are in reset state, with the exception of the boundary scan shift registers, which can only be reset by boundary scan reset. After powerup reset, the FPGA can start configuration. During FPGA configuration, the ORT8850 core will be held in reset and all the local bus interface signals forced high, but the following active-high signals (PROT\_SWITCH\_A, PROT\_SWITCH\_C, TX\_TOH\_CK\_EN, SYS\_FP, LINE\_FP) will be forced low. The CORE\_READY signal sent from the embedded core to FPGA is held low, indicating that the core is not ready to interact with FPGA logic. At the end of the FPGA configuration sequence, the CORE\_READY sig-

nal will be held low for six SYS\_CLK cycles after DONE, TRI\_IO and RST\_N (core global reset) are high. Then it will go active-high, indicating the embedded core is ready to function and interact with FPGA programmable circuit. During FPGA reconfiguration when DONE and TRI\_IO are low, the CORE\_READY signal sent from the core to FPGA will be held low again to indicate the embedded core is not ready to interact with FPGA logic. During FPGA partial configuration, CORE\_READY stays active. The same FPGA configuration sequence described previously will repeat again.

The initialization of the embedded core consists of two steps: register configuration and synchronization of the alignment FIFO. In order to configure the embedded core, the registers need to be unlocked by writing 0x04 to address 0x04 and writing 0x01 to address 0x05. Control registers 0x04 and 0x05 are lock registers. If the output bus of the data, serial TOH port, and TOH clock and TOH frame pulse are controlled by 3-state registers (the use of the registers for 3-state output control is optional; these output 3-state enable signals are brought across the local bus interface and available to the FPGA side), the next step is to activate the 3-state output bus and signals by taking them to functional state from high-impedance state. This can be done by writing 0x01 to correspond bits of the channel registers 0x20, 0x38, 0x50, 0x68, 0x80, 0x98, 0xB0, and 0xC8.

In addition, the synchronization of selected streams is recommended for some networking systems applications. This is a resync of the alignment FIFO after the enabled channels have a valid frame pulse. Here are the following procedures: Put all of the streams to be aligned, including disabled streams, into their required alignment mode. Force AIS-L in all streams to be synchronized (refer to register map, write 0x01 to DB1 of register 0x20, 0x38, 0x50, 0x68, 0x80, 0x98, 0xB0 and 0xC8). Wait four frames. Write a 0x01 to the FIFO alignment resync register, bit DB1 of register 0x06. Wait four frames. Release the AIS-L in all streams (write 1 to DB1 of register 0x20, 0x38, 0x50, 0x68, 0x80, 0x98, 0xB0, and 0xC8). This procedure allows normal data flow through the embedded core.

Synchronization of the alignment FIFOs in 8B/10B mode is similar and will be described in the next version of this datasheet.



## Generic Backplane Transceiver Application

### Synchronous Transfer Mode (STM)

The combination of ORT8850 and soft IP cores provides a generic data moving solution for non-SONET applications. There is no requirement for SONET knowledge to the users. All that is needed is to supply the Pseudo-SONET framer with data, clock, and a 8 kHz frame pulse. The provision registers may also need to be set up, and this can be done through either the FPGA MPI, or in a state machine in the FPGA section (VHDL code available from Lucent).

The 8 kHz frame pulse must be supplied to the SYS\_FP signal. For generic applications, the frame pulse can be created in FPGA logic from the 77.76 MHz SYS\_CLK using a simple resettable counter (the frame pulse should only be high for one cycle of the SYS\_CLK). A VHDL core that automatically provides the 8 kHz frame pulse is available from Lucent. Byte-wide data is then sent to each of the transmit channels as follows: the first 36 bytes transferred will be invalid data (replaced by overhead), where the first byte is sent on the rising edge of SYS\_CLK when SYS\_FP is high. The next 1044 byte positions can be filled with valid data. This will repeat a total of nine times (36 invalid bytes followed by 1044 valid bytes) at which time the next 8 kHz frame pulse will be found. Thus, 87 out of 90 (96.7%) of the data bytes sent are valid user data. The ORT8850 also supports a transparent mode where only the first 24 bytes are invalid data (A1/A2 frame bytes) followed by 9,684 bytes of valid user data.

On the receive side, an 8 kHz pulse must again be supplied to SYS\_FP. In this case, however, only the signal DOUT<channel>\_SPE (where the 8 channels are labeled AA, AB, AC, AD, BA, BB, BC, and BD) must be monitored for each channel, where a high value on this signal means valid data. Again 87 out 90 bytes received (96.7%) will be valid data. Transparent mode is also supported for receive data.

In order to provide an easy user interface to transfer arbitrary data streams through the ORT8850, Lucent provides a soft intellectual property (IP) core called the protocol independent framer, or PI-Framer. This block transfers user format to the one described above and allows for smoothing/rate transfer of this user data. This framer works with a single channel at 850 Mbits/s, two channels at 1.7 Gbits/s, four channels at 3.4 Gbits/s, or across eight channels at 6.8 Gbit/s.

### 8B/10B Mode

The ORT8850 facilitates high-speed serial transfer of data in a variety of applications including Gigabit Ethernet, fibre channel, serial backplanes, and proprietary links. In place of the STM interface, the 8850 also provides 8B/10B coding/decoding for each channel. The 8B/10B transmission code includes serial encoding/decoding rules, special characters, and error detection.

#### Transmitter Description

The data input to the transmitter of each channel is an eight-bit word and a K-control input. The K input is used to identify data or a special character. For each channel, the input data byte is clocked into a FIFO. When K-control is 1, the data on the parallel input is mapped into its corresponding control character. The transmit FIFOs must be initialized upon the deassertion of the RST\_N signal.

#### Receiver Description

Clock recovery is performed by the HSI on the input data stream for each channel of the ORT8850. The recovered data is then aligned to the 10-bit word boundary. Word alignment is accomplished by detecting and aligning to the 8B/10B K28.5 codeword. The HSI will detect and align to either polarity of the K28.5. The 10-bit word aligned data is then passed to the alignment FIFOs. Each receive channel provides a FIFO in order to adjust for the skew between the channels and ensure that the first valid data following the comma character (K28.5) is transmitted simultaneously from all the channels.

#### Channel Sync Block

In order to account for skews between the channels, it is necessary to align multiple channels on the K28.5 (comma) character boundary. The sync algorithm assumes that either all 8 channels, two groups of four channels, or four groups of two channels will be aligned. The ORT8850 powers up in the RESET state in which no channel alignment is done. Setup and use of the 8B/10B channel sync block is similar to that of the STM block.

## Backplane Transceiver Core Detailed Description

### HSI Macro

The 850 high speed interface (HSI) provides a physical medium for high speed asynchronous serial data transfer between ASIC devices. The devices can be mounted on the same PC board or mounted on different boards and connected through the shelf backplane. The 850 CDR macro is an eight-channel clock-phase select (CPS) and data retiming function with serial-to-parallel demultiplexing for the incoming data stream and parallel-to-serial multiplexing for outgoing data. The macrocell can be used as a 8-channel or 16 channel configuration. The ORT8850 uses an eight-channel HSI macro cell. The HSI macro consists of three functionally independent blocks: receiver, transmitter, and PLL synthesizer as shown in Figure 3.

The PLL synthesizer block generates the necessary or 850 MHz clock for operation from a 212 MHz, 106 MHz or 85 MHz reference. The PLL synthesizer block is a common asset shared by all eight receive and transmit channels. The PLL reference clock must match the interface frequency.

The HSI\_RX block receives a differential 850 Mbits/s (or subrates 424 Mbits/s, 212 Mbits/s) serial data without clock at its LVDS receiver input. Based on data transitions, the receiver selects an appropriate

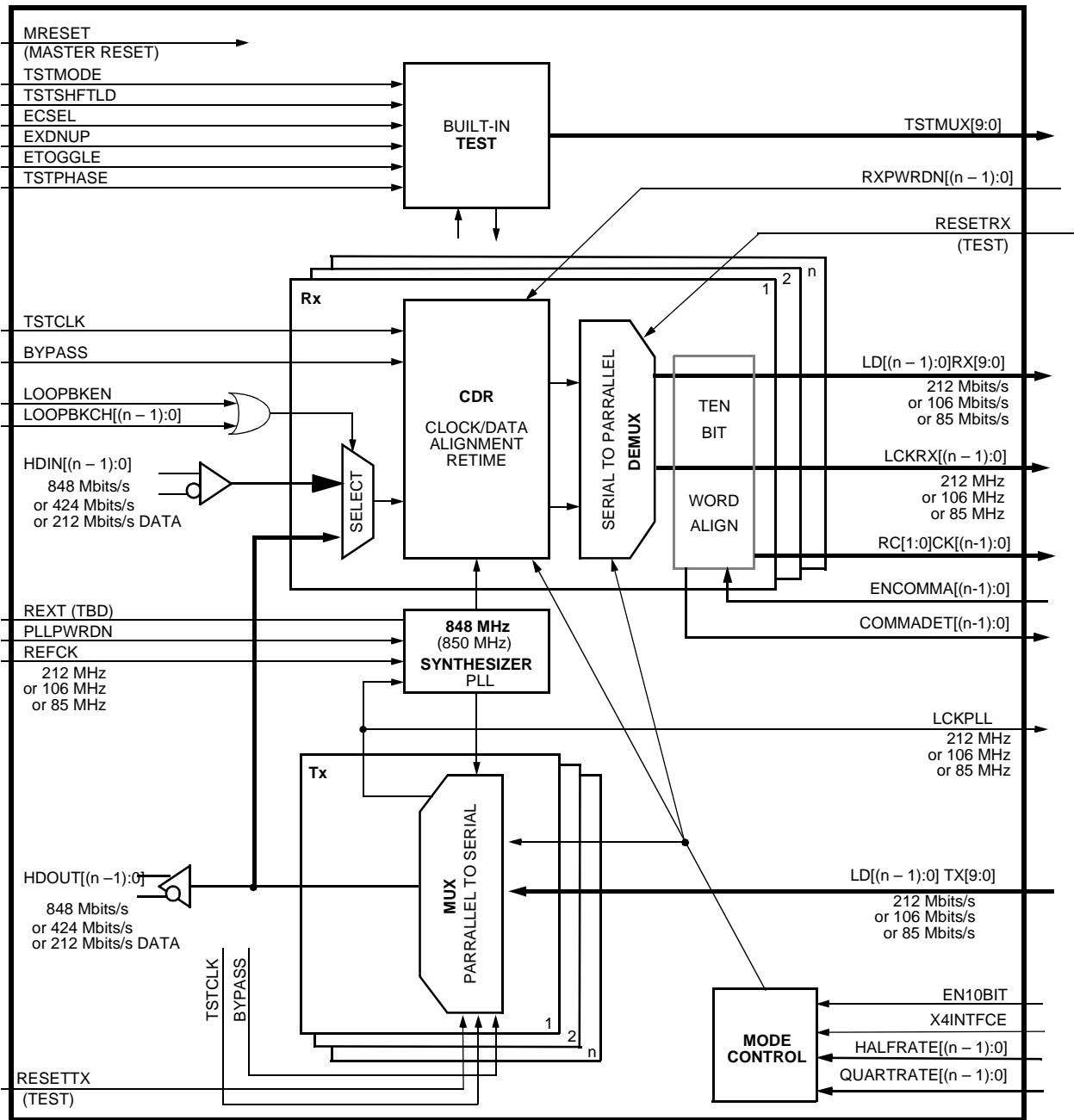
850 MHz clock phase for each channel to retiming the data. The retimed data and clock are then passed to the deMUX (Deserializier) module. DeMUX module performs serial-to-parallel conversion and provides three possible parallel rates, 212 Mbits/s, 106 Mbits/s, or 85 Mbits/s, where the 106 Mbits/s data is used in SONET mode and the 85 Mbits/s data is used in 8B/10B mode (212 Mbits/s is currently unused).

The HSI\_TX block receives 212 Mbits/s (unused), 106 Mbits/s (SONET mode), or 85 Mbits/s (8B/10B mode) parallel data at its input. MUX (Serializer) module performs a parallel-to-serial conversion using an 850 MHz clock provided by the PLL/synthesizer block. The resulting 850 Mbits/s serial data stream is then transmitted through the LVDS driver.

The loopback feature built into the HSI macro provides looping of the transmitter data output into the receiver input when desired.

All rate examples described here are the maximum rates possible. The actual HSI internal clock rate is determined by the provided reference clock rate. For example, if a 78 MHz reference clock is provided, the HSI macro will operate at 622 Mbits/s.

Backplane Transceiver Core Detailed Description (continued)



5-8592 (F)

Figure 3. HSI Functional Block Diagram

## Backplane Transceiver Core Detailed Description (continued)

### STM Transmitter (FPGA -> Backplane)

The synchronous transport module (STM) portion of the embedded core consists of two slices: STM A and B. Each STM slice has four STS-12 transmit channels which can be treated as a single STS-48 channel. In general, the transmitter circuit receives four byte-wide 77.76 MHz data from the FPGA, which nominally represents four STS-12 streams (A, B, C, and D). This data is synchronized to the system (reference) clock, and an 8 kHz system frame pulse from the FPGA logic. Transport overhead bytes are then optionally inserted into these streams, and the streams are forwarded to the HSI. All byte timing pulses required to isolate individual overhead bytes (e.g., A1, A2, B1, D1—D3, etc.) are generated internally based on the system frame pulse (SYS\_FP) received from the FPGA logic. All streams operate byte-wide at 77.76 MHz in all modes. The TOH processor operates from 25 MHz to 77.76 MHz and supports the following TOH signals: A1 and A2 insertion and optional corruption; H1, H2, and H3 pass transparently; BIP-8 parity calculation (after scrambling) and B1 byte insertion and optional corruption (before scrambling); optional K1 and K2 insert; optional S1/M0 insert; optional E1/F1/E2 insert; optional section data communication channel (DCC,

D1—D3) and line data communication channel (DCC, D4—D12) insertion (for intercard communications channel); scrambling of outgoing data stream with optional scrambler disabling; and optional stream disabling. All streams operate byte wide at 77.76 MHz (622 Mbits/s) or 106.25 MHz (850 Mbits/s) in all modes.

When the ORT8850 is used in non-networking applications as a generic high-speed backplane data mover, the TOH serial ports are unused or can be used for slow-speed off-channel communication between devices. An optional transparent mode is available where only the twelve A1 and twelve A2 bytes are used for frame alignment and synchronization.

Data received on the parallel bus is optionally scrambled and transferred to LVDS outputs.

### Byte Ordering Information

The STM macro slice (i.e., A, B) supports quad STS-12, quad STS-3, and quad STS-1 modes of operation on the input/output ports. STS-48 is also supported but it must be received in the quad STS-12 format. When operating in quad STS-12 mode, each of the independent byte streams carries an entire STS-12 within it. Figure 4 reveals the byte ordering of the individual STS-12 streams and for STS-48 operation. Note that the recovered data will always continue to be in the same order as transmitted.

12	9	6	3	11	8	5	2	10	7	4	1	→ STS-12 A
24	21	18	15	23	20	17	14	22	19	16	13	→ STS-12 B
36	33	30	27	35	32	29	26	34	31	28	25	→ STS-12 C
48	45	42	39	47	44	41	38	46	43	40	37	→ STS-12 D

STS-48 IN QUAD STS-12 FORMAT

1, 12	1, 9	1, 6	1, 3	1, 11	1, 8	1, 5	1, 2	1, 10	1, 7	1, 4	1, 1	→ STS-12 A
2, 12	2, 9	2, 6	2, 3	2, 11	2, 8	2, 5	2, 2	2, 10	2, 7	2, 4	2, 1	→ STS-12 B
3, 12	3, 9	3, 6	3, 3	3, 11	3, 8	3, 5	3, 2	3, 10	3, 7	3, 4	3, 1	→ STS-12 C
4, 12	4, 9	4, 6	4, 3	4, 11	4, 8	4, 5	4, 2	4, 10	4, 7	4, 4	4, 1	→ STS-12 D

QUAD STS-12

5-8574 (F)

Figure 4. Byte Ordering of Input/Output Interface in STS-12 Mode

## Backplane Transceiver Core Detailed Description (continued)

### Transport Overhead for In Band Communication

The TOH byte can be used for in band configuration, service, and management since it is carried along the same channel as data. In ORT8850, in band signaling can be efficiently utilized, since the total cost of overhead is only 3.3%.

### Transport Overhead Insertion (Serial Link)

The TOH serial links are used to insert TOH bytes into the transmit data. The transmit TOH data and TOH\_CLK\_EN get retimed by TOH\_CLK in order to meet setup and hold specifications of the device.

The retimed TOH data is shifted into a 288-bit (36-byte by 8-bit) shift register and then multiplexed as an 8-bit bus to be inserted into the byte-wide data stream. Insertion from these serial links or pass-through of TOH from the byte-wide data is under software control.

### Transport Overhead Byte Ordering (FPGA to Backplane)

In the transparent mode, SPE and TOH data received on parallel input bus is transferred, unaltered, to the serial LVDS output. However, B1 byte of STS#1 is always replaced with a new calculated value (the 11 bytes following B1 are replaced with all zeros). Also, A1 and A2 bytes of all STS-1s are always regenerated. TOH serial port is not used in the transparent mode of operation.

In the TOH insert mode, SPE bytes are transferred, unaltered, from the input parallel bus to the serial LVDS output. On the other hand, TOH bytes are received from the serial input port and are inserted in the STS-12 frame before being sent to the LVDS output. Although all TOH bytes from the 12 STS-1s are transferred into the device from each serial port, not all of them get inserted in the frame. There are three hard-coded exceptions to the TOH byte insertion:

- Framing bytes (A1/A2 of all STS-1s) are not inserted from the serial input bus. Instead, they can always be regenerated.
- Parity byte (B1 of STS#1) is not inserted from the serial input bus. Instead, it is always recalculated (the 11 bytes following B1 are replaced with all zeros).
- Pointer bytes (H1/H2/H3 of all STS-1s) are not inserted from the serial input bus. Instead, they always flow transparently from parallel input to LVDS output.

In addition to the above hard-coded exceptions, the source of some TOH bytes can be further controlled by software. When configured to be in pass-through mode, the specific bytes must flow transparently from the parallel input. Note that blocks of 12 STS-1 bytes forming an STS-12 are controlled as a whole. There are 15 software controls per channel, as listed below:

- Source of K1 and K2 bytes of the 12 STS-1s (24 bytes) is specified by a control bit (per channel control).
- Source of S1 and M0 bytes of the 12 STS-1s (24 bytes) is specified by a control bit (per channel control).
- Source of E1, F1, E2 bytes of the STS-1s (36 bytes) is specified by a control bit (per channel control).
- Source of D1 bytes of the STS-1s (12 bytes) is specified by a control bit (per channel control).
- Source of D2 bytes of the 12 STS-1s (12 bytes) is specified by a control bit (per channel control).
- Source of D3 bytes of the 12 STS-1s (12 bytes) is specified by a control bit (per channel control).
- Source of D4 bytes of the 12 STS-1s (12 bytes) is specified by a control bit (per channel control).
- Source of D5 bytes of the 12 STS-1s (12 bytes) is specified by a control bit (per channel control).
- Source of D6 bytes of the 12 STS-1s (12 bytes) is specified by a control bit (per channel control).
- Source of D7 bytes of the 12 STS-1s (12 bytes) is specified by a control bit (per channel control).
- Source of D8 bytes of the 12 STS-1s (12 bytes) is specified by a control bit (per channel control).
- Source of D9 bytes of the 12 STS-1s (12 bytes) is specified by a control bit (per channel control).
- Source of D10 bytes of the 12 STS-1s (12 bytes) is specified by a control bit (per channel control).
- Source of D11 bytes of the 12 STS-1s (12 bytes) is specified by a control bit (per channel control).
- Source of D12 bytes of the 12 STS-1s (12 bytes) is specified by a control bit (per channel control).

TOH reconstruction is dependent on the transmitter mode of operation. In the transparent mode, TOH bytes on LVDS output are as shown in Table 2.

A new capability in the ORT8850 allows the user to choose not to insert the B1 byte and the following eleven bytes of zeros. This option is also available for the A1 and A2 bytes.



## Backplane Transceiver Core Detailed Description (continued)

### B1 Calculation and Insertion

A bit interleaved parity –8 (BIP-8) error check set for even parity over all the bits of an STS-1 frame. B1 is defined for the first STS-1 in an STS-N only, the B1 calculation block computes a BIP-8 code, using even parity over all bits of the previous STS-12 frame after scrambling and is inserted in the B1 byte of the current STS-12 frame before scrambling. Per-bit B1 corruption is controlled by the force BIP-8 corruption register (register address 0F). For any bit set in this register, the corresponding bit in the calculated BIP-8 is inverted before insertion into the B1 byte position. Each stream has an independent fault insert register that enables the inversion of the B1 bytes. B1 bytes in all other STS-1s in the stream are filled with zeros. For the ORT8850, it is optionally possible to not insert B1 and the subsequent eleven bytes of zeros.

### Stream Disable

When disabled via the appropriate bit in the stream enable register, the prescrambled data for a stream is set to all ones, feeding the HSI. The HSI macro is powered down on a per-stream basis, as are its LVDS outputs.

### Scrambler

The data stream is scrambled using a frame-synchronous scrambler with a sequence length of 127. The scrambling function can be disabled by software. The generating polynomial for the scrambler is  $1 + x^6 + x^7$ . This polynomial conforms to the standard SONET STS-12 data format. The scrambler is reset to 1111111 on the first byte of the SPE (byte following the Z0 byte in the twelfth STS-1). That byte and all subsequent bytes to be scrambled are exclusive-ORed, with the output from the byte-wise scrambler. The scrambler runs continuously from that byte on throughout the remainder of the frame. A1, A2, J0, and Z0 bytes are not scrambled.

### System Frame Pulse and Line Frame Pulse

System frame pulse (for transmitter) and line frame pulse (for receiver) are generated in FPGA logic. A1/A2 framing is used on the link for locating the 8 kHz frame location. All frames sent to the FPGA are aligned to the FPGA frame pulse LINE\_FP which is provided by the FPGA to the STM macro. All frames sent from the FPGA to the STM will be aligned to the frame pulse SYS\_FP that is supplied to the STM macro. In either direction, the system frame pulse and line frame pulse

are active for one system clock cycle, indicating the location of A1 byte of STS#1. They are common to all eight channels except when the pointer mover and alignment FIFOs are bypassed. In that case, a line frame pulse for each receive channel is generated by the STM macro and passed to the FPGA interface.

### Repeater

This block is essentially the inverse of the sampler block. It receives byte wide STS-12 rate data from the TOH insert block. In order to support the quad STS-1 and STS-3 modes of operation the HSI (622 Mbits/s) can be connected to a slower speed device (e.g., 155 Mbits/s or 52 Mbits/s). The purpose of this block is to rearrange the data being fed to the HSI so that each bit is transmitted four or twelve times thus simulating 155 Mbits/s or 51.84 Mbits/s serial data. For example, in STS-3 mode the incoming STS-12 stream is composed of four identical STS-3s so only every fourth byte is used. The bit expansion process takes a single byte and stretches it to take up four bytes each consisting of 4 copies of the 8 bits from the original byte. In STS-1 mode, every twelfth byte is used and 4 groups of 3 bytes of the form AAAAAAAAA, AAAABBBB & BBBB BBBB are forwarded to the HSI. An alternate method for supplying STS-1 mode is to set the HSI to run at 207.36 MHz and using the four times repeater function.

## Backplane Transceiver Core Detailed Description (continued)

### STM Receiver (Backplane -> FPGA)

Each of the two STM slices of the ORT8850 has four receiving channels that can be treated as one STS-48 stream, or treated as independent channels. Incoming data is received through LVDS serial ports at the data rate of 622 Mbits/s. The receiver can handle the data streams with frame offsets of up to  $\pm 12$  bytes which would be due to timing skews between cards and along backplane traces. The received data streams are processed in the HSI and the STM, and then passed through the CIC boundary to the FPGA logic.

### Framer Block

The framer block takes byte-wide data from the HSI, and outputs a byte-aligned, byte-wide data stream and 8 kHz sync pulse. The framer algorithm determines the out-of-frame/in-frame status of the incoming data and will cause interrupts on both an errored frame and an out-of-frame (OOF) state. The framer detects the A1/A2 framing pattern and generates the 8 kHz frame pulse. When the framer detects OOF, it will generate an interrupt. Also, the framer detects an errored frame and increments an A1/A2 frame error counter. The counter can be monitored by a processor to compile performance status on the quality of the backplane.

Because the ORT8850 is intended for use between it and another ORT8850 or other devices via a backplane, there is only one errored frame state. Thus after two transitions are missed, the state machine goes into the OOF state and there is no severely errored frame (SEF) or loss-of-frame (LOF) indication.

### B1 Calculate and Descramble (Backplane -> FPGA)

Each Rx block receives byte-wide scrambled 77.76 MHz data and a frame sync from the framer. Since each HSI is independently clocked, the Rx block operates on individual streams. Timing signals required to locate overhead bytes to be extracted are generated internally based on the frame sync. The Rx block produces byte-wide (optionally) descrambled data and an output frame sync for the alignment FIFO block. The frame sync signals are also sent to the FPGA logic for use when the alignment FIFO block is bypassed.

The B1 calculation block computes a BIP-8 (bit interleaved parity 8 bits) code, using even parity over all bits of the previous STS-12 frame before descrambling; this value is checked against the B1 byte of the current frame after descrambling. A per-stream B1 error counter is incremented for each bit that is in error. The

error counter may be read via the CPU interface.

**Descrambling.** The streams are descrambled using a frame synchronous descrambler with a sequence length of 127 with a generating polynomial of  $1 + x^6 + x^7$ . The A1/A2 framing bytes, the section trace byte (J0) and the growth bytes (Z0) are not descrambled. The descrambling function can be disabled by software.

**Sampler.** This block operates on the byte-wide data directly from the HSI macro. The HSI external interface always runs at 622 Mbits/s (STS-12), or 850 Mbits/s, but it can be connected directly to a 155 Mbits/s STS-3 stream or a 51.84 Mbits/s STS-1 stream. If connected to either a 155 Mbits/s or 51.84 Mbits/s stream, each incoming data is received either 4 or 12 times respectively. This block is used to return the byte stream to the expected STS-12 format. The mode of operation is controlled by a register and can either be STS-12 (pass-through), STS-3 (every 4th bit), or STS-1 (every 12th bit). The output from this block is not bit aligned (i.e., and 8 bit sample does not necessarily contain an entire SONET byte) but it is in standard SONET STS-12 format (i.e., four STS-3s or 12 STS-1s), and is suitable for framing.

**AIS-L Insertion.** Alarm indication signal (AIS) is a continuous stream of unframed 1s sent to alert downstream equipment that the near-end terminal has failed, lost its signal source, or has been temporarily taken out of service. If enabled in the AIS\_L force register, AIS-L is inserted into the received frame by writing all ones for all bytes of the descrambled stream.

**AIS-L Insertion on Out-of-Frame.** If enabled via a register, AIS-L is inserted into the received frame by writing all ones for all bytes of the descrambled stream when the framer indicates that an out-of-frame condition exists.

### Internal Parity Generation

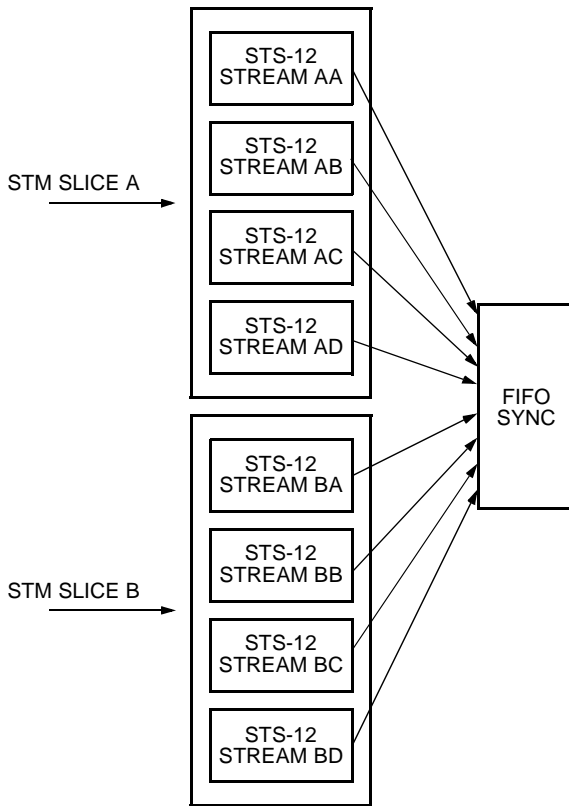
Even parity is generated on all data bytes and is routed in parallel with the data to be checked before the protection switch MUX at the parallel output.

### FIFO Alignment (Backplane -> FPGA)

The alignment FIFO allows the transfer of all data to the system clock. The FIFO sync block (Figure 5) allows the system to be configured to allow the frame alignment of multiple slightly varying data streams. This optional alignment ensures that matching STS-12 streams will arrive at the FPGA end in perfect data sync. The frame alignment is configurable to allow for the possibility of fully independent (i.e., total frame misalignment) STS-12s.



## Backplane Transceiver Core Detailed Description (continued)



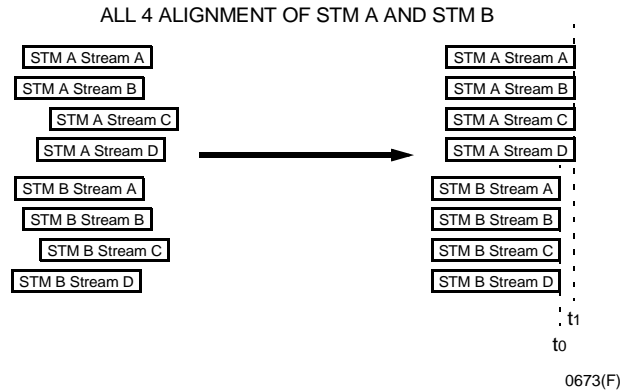
5-8577 (F)

**Figure 5. Interconnect of Streams for FIFO Alignment**

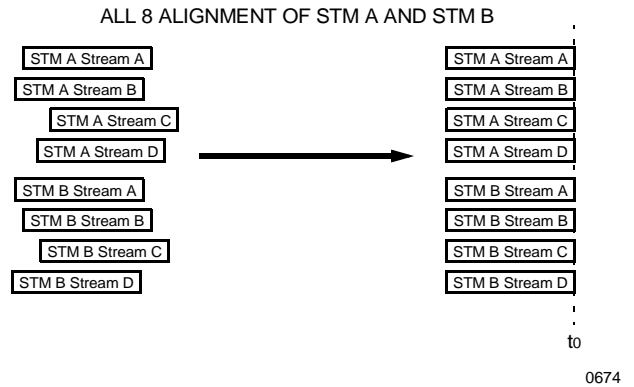
The incoming data from the HSI (also referred to as CDRM850) can be separated into 4 STS-12 channels (A, B, C, and D) per slice. Thus there are STS-12 channels AA to AD from slice A of the STM and STS-12 channels BA to BD of slice B. These streams can be frame-aligned in the following patterns: In STS-48 mode, all four STS-12s of each STM slice are aligned with each other (i.e., AA, AB, AC, AD). Optionally, in STS-48 mode, all eight STS-12s (STMs A and B) can be aligned (to allow hitless switching at the STS-48 level). Multiple devices can be aligned to enable STS-192 or higher modes. Streams can also be aligned on a twin STS-12 basis. There is also a provision to allow certain streams to be disabled (i.e., not producing interrupts or affecting synchronization). These streams can be enabled at a later time without disrupting other streams. If the selected stream needs to be a part of a bigger group (i.e., STM A), then either the entire group must be resynched or the affected stream must have been in the correct mode (i.e., align all STM A) when the initial synchronization was performed. As long as

all four streams in STM A are in the correct mode when synchronization takes place then those streams may be enabled or disabled without affecting synchronization.

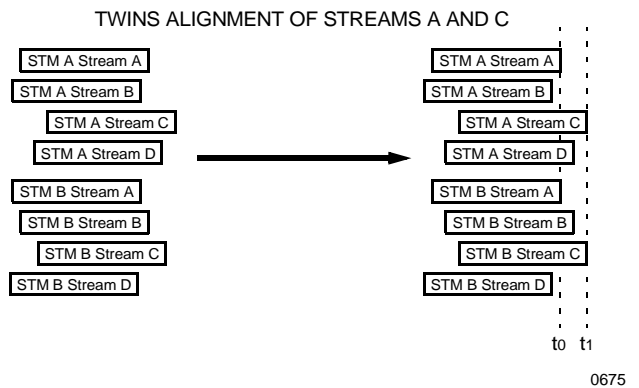
These streams can be frame aligned in the patterns shown in Figure 6, Figure 7, and Figure 8.



**Figure 6. Example of Intra-STM Alignment**



**Figure 7. Example of Inter-STM Alignment**



**Figure 8. Example of Twin STS-12 Stream Alignment**

**Backplane Transceiver Core Detailed Description** (continued)

The FIFO block consists of a 24-bit by 10-bit FIFO per link. This FIFO is used to align up to ±154.3 ns of inter-link skew and to transfer to the system clock. The FIFO sync circuit takes metastable hardened frame pulses from the write control blocks and produces sync signals that indicate when the read control blocks should begin reading from the first FIFO location. On top of the sync signals, this block produces an error indicator which indicates that the signals to be aligned are too far apart for alignment (i.e., greater than 18 clocks apart). Sync and error signals are sent to read control block for alignment. The read control block is synched only once on start-up; any further synchronization is software controlled. The action of resynching a read control block will always cause loss of data. A register allows the read control block to be resynched.

**Link Alignment**

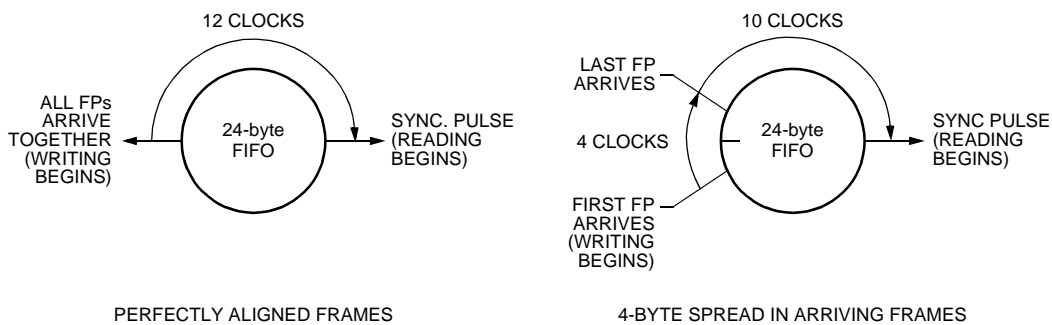
The general operation of the link alignment algorithm is to wait 12 clocks (i.e., half the FIFO) from the arriving frame pulse and then signal the read control block to begin reading. For perfectly aligned frame pulses across the links, it is simply a matter of counting down 12 and then signaling the read control block.

The algorithm down counts by one until all of the frame pulses have arrived and then by two when they are all present. For example (Figure 9), if all pulses arrive together, then alignment algorithm would count 24 (12 clocks); if, however, the arriving pulses are spread

out over four clocks, then it would count one for the first four pulses and then two per clock afterward, which gives a total of 14 clocks between first frame pulse and the first read. This puts the center of arriving frame pulses at the halfway point in the buffer. This is the extent of the algorithm, and it has no facility for actively correcting problems once they occur.

The write control block receives byte-wide data at 77.76 MHz and a frame pulse two clocks before the first A1 byte of the STS-12 frame. It generates the write address for the FIFO block. The first A1 in every STS-12 stream is written in the same location (address 0) in the FIFO. Also, a frame bit is passed through the FIFO along with the first byte before the first A1 of the STS-12. The read control block synchronizes the reading of the FIFO for streams that are to be aligned. Reading begins when the FIFO sync signals that all of the applicable A1s and the appropriate margin have been written to the FIFO. All of the read blocks to be synchronized begin reading at the same time and same location in memory (address 0).

The alignment algorithm takes the difference between read address and write address to indicate the relative clock alignments between STS-12 streams. If this depth indication exceeds certain limits (12 clocks), then an interrupt is given to the microprocessor (alignment overflow). Each STS-12 stream can be realigned by software if it gets too far out of line (this would cause a loss of data). For background applications that have less than 154.3 ns of interlink skew, misalignment will not occur.



**Figure 9. Examples of Link Alignment**

5-8584 (F)

## Backplane Transceiver Core Detailed Description (continued)

### Pointer Mover Block (Backplane -> FPGA)

The pointer mover maps incoming frames to the line framing that is supplied by the FPGA logic. There is a separate pointer mover for the two STM macro slices, A and B, each of which handles up to one STS-48 (4 channels). The K1/K2 bytes and H1-SS bits are also passed through to the pointer generator so that the FPGA can receive them. The pointer mover handles both concatenations inside the STS-12, and to other STS-12s inside the core.

The pointer mover block can correctly process any length of concatenation of STS frames (multiple of three) as long as it begins on an STS-3 boundary (i.e., STS-1 number one, four, seven, ten, etc.) and is contained within the smaller of STS-3, 12, or 48. See details in Table 4.

**Table 4. Valid Starting Positions for an STS-Mc**

STS-1 Number	STS-3cSPE	STS-6cSPE	STS-9cSPE	STS-12cSPE	STS-15cSPE	STS-18c to STS-48c SPEs
1	Yes	Yes	Yes	Yes	Yes	Yes
4	Yes	Yes	Yes	No	Yes	—
7	Yes	Yes	No	No	Yes	—
10	Yes	No	No	No	Yes	—
13	Yes	Yes	Yes	Yes	Yes	—
16	Yes	Yes	Yes	No	Yes	—
19	Yes	Yes	No	No	Yes	—
22	Yes	No	No	No	Yes	—
25	Yes	Yes	Yes	Yes	Yes	—
28	Yes	Yes	Yes	No	Yes	—
31	Yes	Yes	No	No	Yes	—
34	Yes	No	No	No	Yes	No
37	Yes	Yes	Yes	Yes	No	No
40	Yes	Yes	Yes	No	No	No
43	Yes	Yes	No	No	No	No
46	Yes	No	No	No	No	No

Note: Yes = STS-Mc SPE can start in that STS-1.

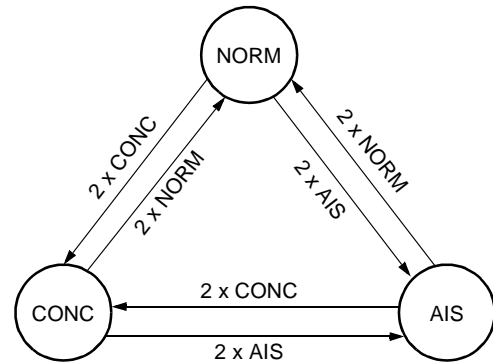
No = STS-Mc SPE cannot start in that STS-1.

— = Yes or no, depending on the particular value of M.

## Backplane Transceiver Core Detailed Description (continued)

**Pointer Interpreter State Machine.** The pointer interpreter's highest priority is to maintain accurate data flow (i.e., valid SPE only) into the elastic store. This will ensure that any errors in the pointer value will be corrected by a standard, fully SONET compliant, pointer interpreter without any data hits. This means that error checking for increment, decrement, and new data flag (NDF) (i.e., 8 of 10) is maintained in order to ensure accurate data flow. A single valid pointer (i.e., 0—782) that differs from the current pointer will be ignored. Two consecutive incoming valid pointers that differ from the current pointer will cause a reset of the J1 location to the latest pointer value (the generator will then produce an NDF). This block is designed to handle single bit errors without affecting data flow or changing state.

The pointer interpreter has only three states (NORM, AIS, and CONC). NORM state will begin whenever two consecutive NORM pointers are received. If two consecutive NORM pointers that both differ from the current offset are received, then the current offset will be reset to the last received NORM pointer. When the pointer interpreter changes its offset, it causes the pointer generator to receive a J1 value in a new position. When the pointer generator gets an unexpected J1, it resets its offset value to the new location and declares an NDF. The interpreter is only looking for two consecutive pointers that are different from the current value. These two consecutive NORM pointers do not have to have the same value. For example, if the current pointer is ten and a NORM pointer with offset of 15 and a second NORM pointer with offset of 25 are received, then the interpreter will change the current pointer to 25. The receipt of two consecutive CONC pointers causes CONC state to be entered. Once in this state, offset values from the head of the concatenation chain are used to determine the location of the STS SPE for each STS in the chain. Two consecutive AIS pointers cause the AIS state to occur. Any two consecutive normal or concatenation pointers will end this AIS state. This state will cause the data leaving the pointer generator to be overwritten with 0xFF.



5-8589 (F)

Figure 10. Pointer Mover State Machine

**Pointer Generator.** The pointer generator maps the corresponding bytes into their appropriate location in the outgoing byte stream. The generator also creates offset pointers based on the location of the J1 byte as indicated by the pointer interpreter. The generator will signal NDFs when the interpreter signals that it is coming out of AIS state. The pointer generator resets the pointer value and generates NDF every time a byte marked J1 is read from the elastic store that doesn't match the previous offset.

Increment and decrement signals from the pointer interpreter are latched once per frame on either the F1 or E2 byte times (depending on collisions); this ensures constant values during the H1 through H3 times. The choice of which byte time to do the latching on is made once when the relative frame phases (i.e., received and system) are determined. This latch point is then stable unless the relative framing changes and the received H byte times collide with the system F1 or E2 times, in which case the latch point would be switched to the collision-free byte time.

There is no restriction on how many or how often increments and decrements are processed. Any received increment or decrement is immediately passed to the generator for implementation regardless of when the last pointer adjustment was made. The responsibility for meeting the SONET criteria for maximum frequency of pointer adjustments is left to an upstream pointer processor.

When the interpreter signals an AIS state, the generator will immediately begin sending out 0xFF in place of data and H1, H2, H3. This will continue until the interpreter returns to NORM or CONC (pointer mover state machine) states and a J1 byte is received.

**Backplane Transceiver Core Detailed Description** (continued)

**Transport Overhead Extraction**

Transport overhead is extracted from the receive data stream by the TOH extract block. The incoming data gets loaded into a 36-byte shift register on the system clock domain. This, in turn, is clocked onto the TOH clock domain at the start of the SPE time, where it can be clocked out.

During the SPE time, the receiver TOH frame pulse is generated, RX\_TOH\_FP, which indicates the start of the row of 36 TOH bytes. This pulse, along with the receive TOH clock enable, RX\_TOH\_CK\_EN, as well as the TOH data, are all launched on the rising edge of the TOH clock TOH\_CLK.

**TOH Byte Ordering (Backplane to FPGA)**

The TOH processor is responsible for dropping all TOH bytes of each channel through one of four corresponding serial ports. The four TOH serial ports are synchronized to the TOH clock (the same clock that is being used by the serial ports on the transmitter side). This free-running TOH clock is provided to the core by external circuitry and operates at a minimum frequency of 25 MHz and a maximum frequency of 77.76 MHz. Data is transferred over serial links in a bursty fashion as controlled by the Rx TOH clock enable signal, which is generated by the ASIC and common to the four channels. All TOH bytes of STS-12 streams are transferred over the appropriate serial link in the same order in which they appear in a standard STS-12 frame. Data transfer should be performed on a row-by-row basis such that internal data buffering needs is kept to a minimum. Data transfers on the serial links will be synchronized relative to the Rx TOH frame signal.

**Receiver TOH Reconstruction**

Receiver TOH reconstruction on output parallel bus is as shown in the following table (if the pointer mover is not bypassed).

**Table 5. Receiver TOH (Output Parallel Bus)**

A1	A1	A1	A1	A1	A1	A1	A1	A1	A1	A1	A1	A1	A2	A2	A2	A2	A2	A2	A2	A2	A2	A2	A2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0										
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0				
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
H1	H1	H1	H1	H1	H1	H1	H1	H1	H1	H1	H1	H1	H2	H2	H2	H2	H2	H2	H2	H2	H2	H2	H2	H2	H3	H3	H3	H3	H3	H3	H3	H3	H3	H3	H3	H3	H3	H3	H3	H3	H3	H3	H3	H3	H3	H3	H3	H3	H3	H3			
0	0	0	0	0	0	0	0	0	0	0	0	0	K1	0	0	0	0	0	0	0	0	0	0	0	K2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Regenerated bytes.
Regenerated bytes (under pointer generator control-SS bits must be transparent-AIS-P must be supported).
Bytes taken from Elastic Store Buffer, on negative stuff opportunity-else, forced to all zeros.
Transparent or all zeros (K1/K2 are either taken from K1/K2 buffer or forced to all zeros-soft, control). In transparent mode, AIS-L must be supported.
All zero bytes.

On the TOH serial port, all TOH bytes are dropped as received on the LVDS input (MSB first). The only exception is the most significant bit of byte A1 of STS#1, which is replaced with an even parity bit. This parity bit is calculated over the previous TOH frame. Also, on AIS-L (either resulting from LOF or forced through software), all TOH bits are forced to all ones with proper parity (parity we automatically ends up being set to 1 on AIS-L).

**Special TOH Byte Functions**

**K1 and K2 Handling.** The K1 and K2 bytes are used in automatic protection switch (APS) applications. K1 and K2 bytes can be optionally passed through the pointer mover under software control, or can be set to zero with the other TOH bytes.

**A1 and A2 Handling.** As discussed previously, the A1 and A2 bytes are used for a framing header. A1 and A2 bytes are always regenerated and set to hexadecimal F6 and 28, respectively.

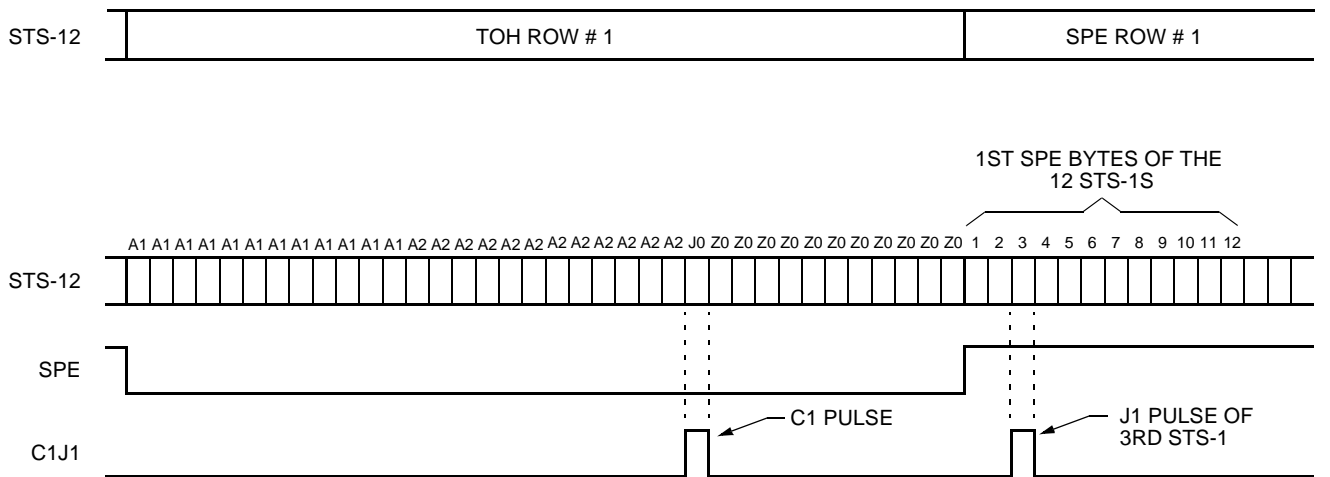
**Backplane Transceiver Core Detailed Description** (continued)

**SPE and C1J1 Outputs.** These two signals for each channel are passed to the FPGA logic to allow a pointer processor or other function to extract payload without interpreting the pointers. For the ORT8850, each frame has 12 STS-1s. In the SPE region, there are 12 J1 pulses for each STS-1s. There is one C1(J0, new SONET specifications use J0 instead of C1 as section trace to identify each STS-1 in an STS-N) pulse in the TOH area for one frame. Thus, there is a total of 12 J1 pulses and one C1(J0) pulse per frame. C1(J0) pulse is coincident with the J0 of STS1 #1. In each frame, the SPE flag is active when the data stream is in SPE area. SPE behavior is dependent on pointer movement and concatenation. Note that in the TOH area, H3 can also carry valid data. When valid SPE data is carried in this H3 slot, SPE is high in this particular TOH time slot. In the SPE region, if there is no valid data during any SPE column, the SPE signal will be set to low. SPE allow a pointer processor to extract payload without interpreting the pointers. The SPE and C1J1 functionality are described in Table 6. For generic data operation, valid data is available when SPE is 1 and the C1J1 signal is ignored.

**Table 6. SPE and C1J1 Functionality**

SPE	C1J1	Description
0	0	TOH information excluding C1(J0) of STS1 #1.
0	1	Position of C1(J0) of STS1 #1 (one per frame). Typically used to provide a unique link identification (256 possible unique links) to help ensure cards are connected into the backplane correctly or cables are connected correctly.
1	0	SPE information excluding the 12 J1 bytes.
1	1	Position of the 12 J1 bytes.

Note: The following rules are observed for generating SPE and C1J1 signals: on occurrence of AIS-P on any of the STS-1, there is no corresponding J1 pulse. In case of concatenated payloads (up to STS48c), only the head STS-1 of the group has an associated J1 pulse. C1J1 signal tracks any pointer movements. During a negative justification event, SPE is set high during the H3 byte to indicate that payload data is available. During a positive justification event, SPE is set low during the positive stuff opportunity byte to indicate that payload data is not available.

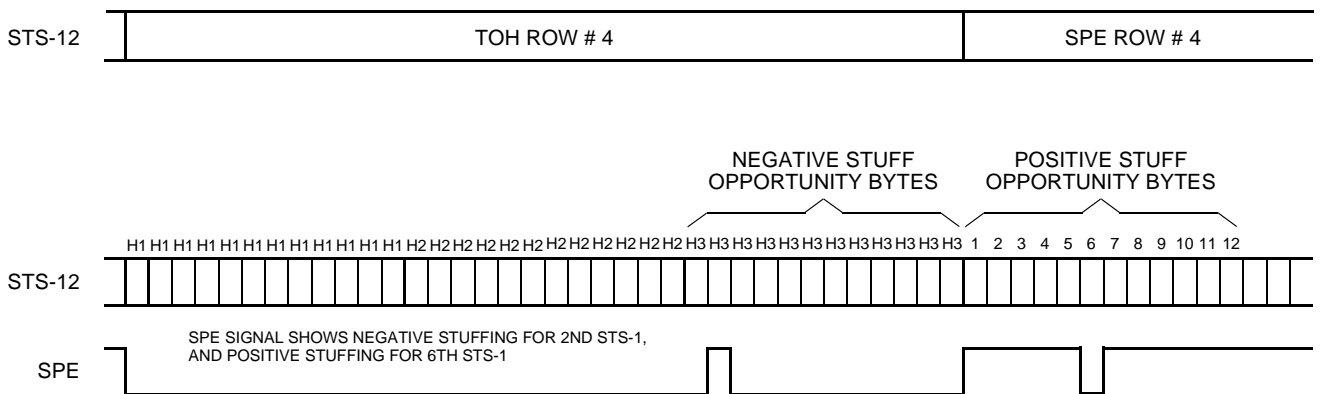


5-9330(F)

Note: C1J1 signal behavior shown in this figure is just for illustration purposes: C1 pulse position must always be as shown; however, position of J1 pulses vary based on path overhead location of each STS-1 within the STS-12 stream. C1J1 signal must always be active during C1(J0) time slot of STS#1. C1J1 signal must also be active during the twelve J1 time slots. However, C1J1 must not be active for any STS-1 for which AIS-P is generated. Also, on concatenated payloads, only the head of the group must have a J1 pulse.

**Figure 11. SPE and C1J1 Functionality**

## Backplane Transceiver Core Detailed Description (continued)



5-9331

Note: SPE signal behavior shown in this figure is just for illustration purposes: SPE behavior is dependent on pointer movements and concatenation.

SPE signal must be high during negative stuff opportunity byte time slots (H3) for which valid data is carried (negative stuffing).

SPE signal must be low during positive stuff opportunity byte time slots for which there is no valid data (positive stuffing).

**Figure 12. SPE Stuff Bytes**

### Powerdown Mode

Powerdown mode will be entered when the corresponding channel is disabled. Channels can be independently enabled or disabled under software control.

Parallel data bus output enable and TOH serial data output enable signals are made available to the FPGA logic. The HSI macrocell's corresponding channel is also powered down. The device will power up with all eight channels in powerdown mode.

In addition, an LVDS\_EN pin has been added to control the LVDS pins during boundary scan. During functional operation, enabling/disabling LVDS buffers is controlled by software registers. When in boundary scan mode, LVDS\_EN controls the enabling/disabling of LVDS buffers instead of software registers. This LVDS\_EN pin should be pulled high on the board for functional operation, and pulled low during boundary scan.

### Redundancy and Protection Switching

The ORT8850 supports STS-12/STS-48 redundancy by either software or hardware control for protection switching applications. For the transmitter mode, no additional functionality is required for redundant operation. For receiving data, STS-12 and STS-48 data redundancy can be implemented within the same device, while STS-192 and above data stream requires multiple ORT8850 devices to support redundancy.

In STS-12 mode, the channel A receive data bus port is used for both channel A and channel B. Similarly, the channel C receive data bus port is used for both channel C and channel D. Channel B and channel D become the redundant channels. The channel B and channel D receive data bus ports are unused. Soft registers provide independent control to the protection switching MUXes for both parallel data ports and serial TOH data ports. When direct hardware control for protection switching is needed, external protection switch pins are available for channels A and B, and also channels C and D. The external protection switch pins only support parallel SPE/TOH data protection switching, but not the serial TOH data.

For STS-48 redundancy, the two 4-channel macro blocks are both used -4 channels for work and 4 channels for protect. The switching between work and protect is extended to either be between 4-channel macros or between the A/B and C/D channels within both macros.

In STS-192 mode, multiple independent devices are required to work and protect for redundancy. Parallel and serial port output pins on the FPGA side should be 3-stated as the basis for supporting redundancy. The existing local bus enable signals at the CIC can be used as 3-state controls for FPGA data bus if needed, which can be easily accessed by software control. Users can also create their own protection switch 3-state enable signals either in FPGA logic or external to the device, depending on the specific application.

## RapidIO Interface to Pi-Sched

### Overview

The ORT8850 includes three byte-wide full duplex DDR *RapidIO* interfaces running at up to 311 MHz (622 Mbits/s) per line for a total of 5.0 Gbits/s for each interface. Each input and output interface includes byte-wide data, one control signal (such as start-of-cell), and one clock signal. One of the three *RapidIO* interfaces is always available. The other two *RapidIO* interface are available only if the eight CDR channels are not being used.

One function of the ORT8850 is to interface with the Protocol Independent Scheduler (Pi-Sched) device on a port card. The Pi-Sched IC is part of the high-speed switching (HSSW) family of devices. It offers a highly-integrated, innovative, and complete VLSI solution for implementing the scheduling and buffer management functionality of a cell (e.g., ATM) or packet (e.g., IP) switching system port at OC-48c.

The *RapidIO* in the ORT8850 will support the dedicated receive and transmit interfaces for off-chip communication. Both interfaces drive or receive off-chip through LVDS I/O pads. The LVDS I/Os are fully terminated on-chip to allow for driving high-speed parallel backplanes at speeds up to 311 MHz. Internally, each 8-bit *RapidIO* interface is connected to a 32-bit interface which is single-edge clocked and connected to the FPGA logic array. For example, byte-wide 311 MHz DDR data is converted to 155 MHz 32-bit wide data at the FPGA interface.

The primary task of the *RapidIO* is to process bytes of data known as octets transmitted as a group known as a cell. An octet is described as 8 bits found within a cell. Once the first octet of a cell is received, subsequent octets are part of an uninterrupted data stream until the entire cell has been received. The beginning of the next cell will determine the boundary of the previous cell. The beginning of a cell is indicated by a pulse on the start-of-cell, SOC signal. The SOC signal always accompanies the cell data. At the I/O boundary,

cell data is present on an 8-bit data bus with the first octet and SOC aligned with the rising edge of the clock. At the FPGA end, cell data is present on a 32-bit data bus. Thus the *RapidIO* is used to translate between the 32-bit data bus and the 8-bit I/O data bus while monitoring the integrity of the cells being processed.

### Receive Cell Interface

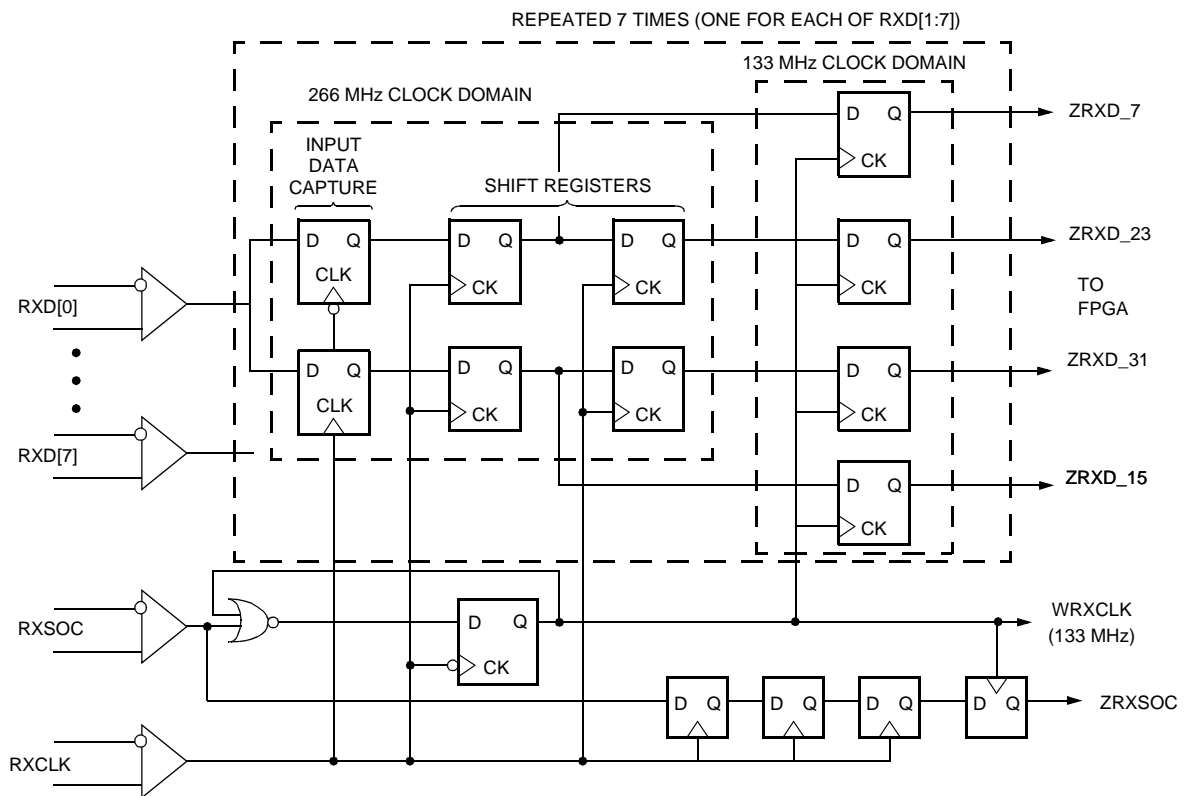
The receive interface performs de-multiplexing from 4 sequential octets of 8 pairs of LVDS pins using both edges of the high-speed clock onto internal 32-bit buses at the low speed clock. The interface includes the following signals (See Figure 13):

- One LVDS clock pair running at 120 -311 MHz. Its relationship is intended to be in the "eye" of the receive cell data.
- One LVDS start-of-cell pair which indicates that word 0 of a data cell is on the receive data port.
- Eight LVDS data pairs, double edge clocked by the LVDS clock.

The eight LVDS data pairs are double-edge clocked by the LVDS receive clock (RXCLK). The RXCLK is aligned to the center of the eye of the received data and start-of-cell (RXD and RXSOC). To achieve optimal timing margin, the receiver is required to maintain this alignment. The *RapidIO* Interface requires that the SOC spacing is an integer multiple of two clock cycles for proper operation and that SOCs occur only on the rising edge of the receive clock (RXCLK).



**RapidIO Interface to Pi-Sched** (continued)



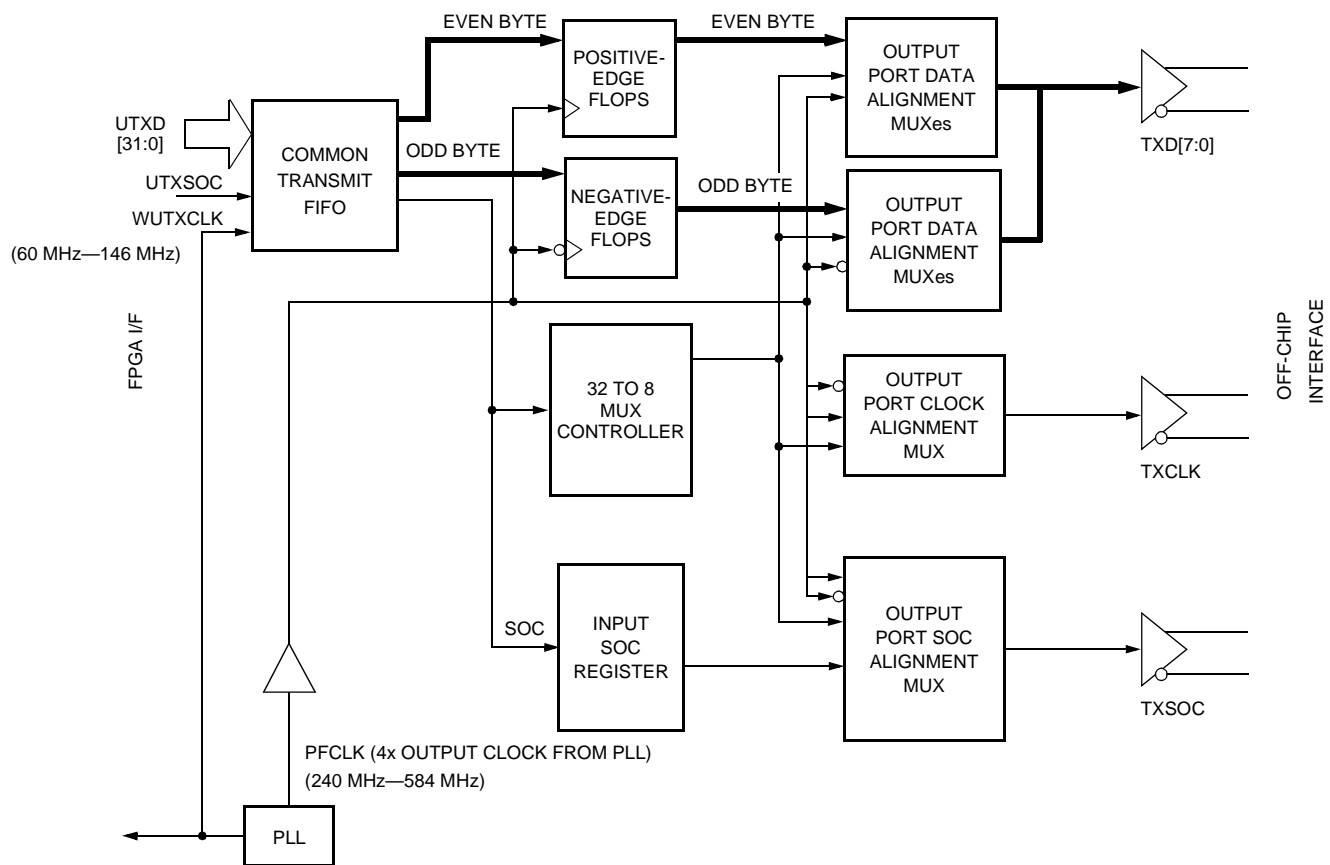
0676

**Figure 13. RapidIO Receive Cell Interface**

**Octets and Start of Cell**

Cells will be transmitted on the high-speed LVDS inputs as octets. The first octet o0 (consisting of d0\_0, d1\_0...d7\_0) will be present on bits 31:24 on the low-speed 32-bit FPGA bus. Similarly, octet o1 (consisting of d0\_1, d1\_1... d7\_1) will be present on bits 23:16 on the 32-bit bus. Thus, octets will always be transmitted from 1st octet to last. The minimum number of octets present on the high-speed ports should always be divisible by 4, evenly representing the relationship with the 32-bit core of the ASIC interface. The Start-Of-Cell signal is always aligned with the first octet of each cell. Once the first octet of a cell is received, subsequent octets are part of an uninterrupted data stream until the entire cell has been received. The number of octets in a cell is determined by the register bits OCELLSIZE. The *RapidIO* can support varying minimum cell sizes from 4 octets up to 124 in increments of 4. The *RapidIO* is programmed with the cell size by writing to the OCELLSIZE register via the micro-processor interface. If the transmitted cell size is less than the programmed cell size, a violation occurs and the IRXSOCVIOL flag is active. This flag can be ignored if a given minimum cell size is not needed.

**RapidIO Interface to Pi-Sched** (continued)



0677

**Figure 14. RapidIO Transmit Cell Interface**

**Transmit Cell Interface**

The transmit interface performs multiplexing of 32 bits of low-speed data onto 4 sequential octets of 8 pairs of LVDS signal pins using both edges of a high-speed clock. The transmitter module consists of the following 10 LVDS signal pairs (see Figure 14):

- Eight LVDS data pairs (TXD) double edge clocked by the LVDS clock TXCLK. The data pairs carry biphasic data at 120-311 MHz.
- One start-of-cell LVDS pair that indicates that octet 0 of a data cell is on TXD. The transitions of this signal are at 90 degrees also with the crossing points of the LVDS clock (TXCLK).
- One LVDS clock pair output TXCLK operating at 120 to 311 MHz. Its relationship is intended to be exactly in 90 degree phase with the transitions of TXD data and TXSOC.

The high-speed data outputs (TXD[0:7]) as well as the start-of-cell signal TXSOC are generated as a result of the positive edge of PFCLK. This is accomplished by multiplexing between the even and odd bytes of the data at a 1/2 PFCLK rate. PFCLK is derived from the internal PLL and operates at 4x the base frequency or between 240 MHz and 284 MHz. The PFCLK is expected to have a duty cycle of 47% to 53% with no more than  $\pm 150$  ps of jitter. The duty cycle of PFCLK will directly affect the accuracy of the high speed clock and its ability to maintain the “eye” of the data. The 90 degree phase shift of the output clock puts TXCLK in the eye of the data.

**RapidIO Interface to Pi-Sched** (continued)

Table 7. *RapidIO* Signals to/from FPGA

Interface Name (All end with _A, _B, or _C depending on channel)	From FPGA	To FPGA	Description
<b>Receive Cell Interface</b>			
ZRXD<31:0>	—	32	32-bit data from the receive module. The bus contains 4 octets and reflects data received via the high-speed RXD data bus.
ZRXSOC	—	1	Indicates the presence of the 1st octet of a new cell within the first 32-bit data word on the bus RXD in bit positions [31:24].
ZRXSOCVIOL	—	1	Indicates a minimum cell violation within the receive module. This signal will transition active high coincident with RXSOC. An active state signals the new cell overran the previous cell and the previous cell is in violation of the minimum cell size.
ZRXALNVIOL	—	1	Signals an alignment error. An active state signals RXSOC was captured on a negative RXCLK edge. The violation condition on this signal will stay high for a single WRXCLK_[chan]_FPGA cycle coincident with RXSOC.
ZCLKSTAT	—	—	Indicates the loss or absence of a clock on the LVDS clock (RXCLK). This signal will be present for the duration of the absence of the clock, following a period to validate its absence.
CSYSENB	1	—	System cell processing enable. After reset is released, drive this signal high when the <i>RapidIO</i> is ready to transmit cells. This signal should be active after all control signals into the <i>RapidIO</i> are stable.
RSTN_RX	1	—	Synchronous reset for all memory elements clocked by WRXCLK_[chan]_FPGA (derived from PLL)
WRXCLK_[chan]_FPGA	—	1	Derived from high speed LVDS clock RXCLK (RXCLK/2).
<b>Transmit Cell Interface</b>			
UTXD[31:0]	32	—	Transmit data bs containing 4 octets synchronized with the rising edge of the 60 MHz—146 MHz WUTXCLK_FPGA (derived from PLL) is clocked into the transmit FIFO within the <i>RapidIO</i> .
UTXSOC	1	—	Start of cell, originating within core, synchronized with the rising edge of WUTXCLK_FPGA into the transmit FIFO. Indicates the first data word on TXD bus includes the first octet of a new cell in bit positions [31:24].
RSTN_UTX	1	—	Synchronous reset for all memory elements in the WUTXCLK domain.
UTXTRISTN	1	—	Output 3-state enable (active-low). When active, the TXD, TXSOC and TXCLK LVDS drivers are 3-stated. 0 - 3-state TXD, TXSOC and TXCLK drivers. 1 - Normal operation.
<b>FPGA Interface Clocks (common to all channels)</b>			
WUTXCLK_FPGA	—	1	One X core clock generated from an internal PLL circuit. Synchronous to UTXD and UTXSOC data inputs.
HALFCLK_FPGA	—	1	1/2 X main PLL output clock. Phase aligned with PFCLK. Nominal frequency = 30 MHz to 73 MHz. Duty cycle spec = 47%/53%.

**RapidIO Interface to Pi-Sched** (continued)

**Table 8. Signals Used as Register Bits**

Register Bit(s)	Description
OSHLBENB	Used during the internal built-in-self-test mode. Indicates that the single-ended versions of the transmit module outputs should be looped back into the single ended inputs of the receive module. OSHLENB = 0 : No loopback. OSHLENB = 1 : Loopback.
OCELLSIZE[4:0]	This value indicates the minimum cell size and will be used to detect cell under-run errors. This value should be set and stable prior to initialization of operation and stable thereafter.
OTESTENB	Enables the internal self test of the <i>RapidIO</i> block. Two loopback paths exist during test, internal and external. During both tests, data is passed through all modules and verified.
ITESTDONE	Indicates the completion of the internal test. Only valid during a test when OTESTENB is high. ITESTDONE = 0 Test running. ITESTDONE = 1 Test complete.
ITESTPASS	Indicates the success of the internal test. This signal is valid only when ITESTDONE is high. ITESTPASS = 0 Test failed. ITESTPASS = 1 Test passed.
TRISTN	Active-low. 3-state override for Transmit outputs. This signal is ignored during reset, but takes priority over all 3-state control signals when active.

**Memory Map**

**Definition of Register Types**

There are six structural register elements: sreg, creg, preg, iareg, isreg, and iereg. There are no mixed registers in the chip. This means that all bits of a particular register (particular address) are structurally the same. All of these registers are accessed via the FPGA system bus which in turn can be accessed by the MPI block or through FPGA logic.

## Memory Map (continued)

**Table 9. Structural Register Elements**

Element	Register	Description
sreg	Status Register	A status register is read only, and, as the name implies, is used to convey the status information of a particular element or function of the ORT8850 core. The reset value of an sreg is really the reset value of the particular element or function that is being read. In some cases, an sreg is really a fixed value. An example of which is the fixed ID and revision registers.
creg	Control Register	A control register is read and writable memory element inside core control. The value of a creg will always be the value written to it. Events inside the ORT8850 core cannot effect creg value. The only exception is a soft reset, in which case the creg will return to its default value.
preg	Pulse Register	Each element, or bit, of a pulse register is a control or event signal that is asserted and then deasserted when a value of one is written to it. This means that each bit is always of value 0 until it is written to, upon which it is pulsed to the value of one and then returned to a value of 0. A pulse register will always have a read value of 0.
iareg	Interrupt Alarm Register	Each bit of an interrupt alarm register is an event latch. When a particular event is produced in the ORT8850 core, its occurrence is latched by its associated iareg bit. To clear a particular iareg bit, a value of one must be written to it. In the ORT8850 core, all isreg reset values are 0.
isreg	Interrupt Status Register	Each bit of an interrupt status register is physically the logical-OR function. It is a consolidation of lower level interrupt alarms and/or isreg bits from other registers. A direct result of the fact that each bit of the isreg is a logical-OR function means that it will have a read value of one if any of the consolidation signals are of value one, and will be of value 0 if and only if all consolidation signals are of value 0. In the ORT8850 core, all isreg default values are 0.
ereg	Interrupt Enable Register	Each bit of a status register or alarm register has an associated enable bit. If this bit is set to value one, then the event is allowed to propagate to the next higher level of consolidation. If this bit is set to zero, then the associated iareg or isreg bit can still be asserted but an alarm will not propagate to the next higher level. An interrupt enable bit is an interrupt mask bit when it is set to value 0.

### Registers Access and General Description

The memory map comprises three address blocks:

- Generic register block: ID, revision, scratch pad, lock, FIFO alignment, and reset registers.
- Device register block: control and status bits, common to the four channels in each of the two quad interfaces.
- Channel register blocks: each of the four channels in both quads have an address block. The four address blocks in both quads have the same structure, with a constant address offset between channel register blocks.

All registers are write-protected by the lock register, except for the scratch pad register. The lock register is a 16-bit read/write register. Write access is given to registers only when the key value 0xA001 is present in the lock register. An error flag will be set upon detecting a write access when write permission is denied. The default value is 0x0000.

After powerup reset or soft reset, unused register bits will be read as zeros. Unused address locations are also read as zeros. Write only register bits will be read as zeros. The detailed information on register access and function are described on the tables, memory map, and memory map bit description.

A full memory map is included in Table 10, followed by detailed descriptions in Table 11.

Memory Map (continued)

Memory Map Overview

Table 10. Memory Map

ADDR [6:0]	Reg. Type	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0	Default Value (hex)	Notes
<b>Generic Register Block</b>											
00	sreg	fixed rev [7:0]								01	1
01	sreg	fixed ID LSB [7:0]								01	
02	sreg	fixed ID MSB [7:0]								A0	
03	creg	scratch pad [7:0]								00	
04	creg	lockreg MSB [7:0]								00	
05	creg	lockreg LSB [7:0]								00	
06	preg	—	—	—	—	—	—	FIFO alignment command	global reset command	NA	
<b>Device Register Block</b>											
08	creg	—	—	—	Rx TOH frame and Rx TOH clock enable control	ext prot sw en	ext prot sw function	STS-48 STS-12 sel	LVDS lpbk control	00	2
09	creg	—	—	—	—	parallel port output MUX select for ch C	parallel port output MUX select for ch A	serial port output MUX select for ch C	serial port output MUX select for ch A	0F	
0a	creg	—	—	—	FIFO aligner threshold value (min) [4:0]				02		
0b	creg	—	—	—	FIFO aligner threshold value (max) [4:0]				15		
0c	creg	—	scrambler/descrambler control	input/output parallel bus parity control	line loop-back control	number of consecutive A1/A2 errors to generate [3:0]			60	3	
0d	creg	A1 error insert value [7:0]									00
0e	creg	A2 error insert value [7:0]									00
0f	creg	transmitter B1 error insert mask [7:0]									00

Memory Map (continued)

Table 10. Memory Map (continued)

ADDR [7:0]	Register Type	Register Name	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0	Reset Value (hex)	Comments	
00	sreg	ds_1_sreg, all_spif_regsel [0]	fixed rev [7:0]									01	Generic Register Block
01	sreg	ds_2_sreg, all_spif_regsel [1]	fixed id lsb [7:0]									01	
02	sreg	ds_3_sreg, all_spif_regsel [2]	fixed id msb [7:0]									A0	
03	creg	dl_1_creg, lock_regsel [0]	scratch pad [7:0]									00	
04	creg	dl_2_creg, ock_regsel [1]	lockreg msb [7:0]									00	
05	creg	dl_3_creg, ock_regsel [2]	lockreg lsb [7:0]									00	
06	preg	—	—	—	—	—	—	—	—	global reset command	N.A.		
<b>Device Register Block</b>													
08	creg	ds_4_creg, all_spif_regsel [3]	—	—	—	“rx toh frame” and “rx toh clk enable” hiz control	ext protsw en	ext protsw func	—	lvds lpbk control	00	device reg. blk - rx	
09	creg	ds_5_creg, all_spif_regsel [4]	parallel port output mux select for ch#7	parallel port output mux select for ch#5	serial port output mux select for ch#7	serial port output mux select for ch#5	parallel port output mux select for ch#3	parallel port output mux select for ch#1	serial port output mux select for ch#3	serial port output mux select for ch#1	FF (4 ch was 0F)		
0a	creg	ds_6_creg, all_spif_regsel [5]	—	—	—	fifo aligner threshold value (min) [4:0]				02			
0b	creg	ds_7_creg, all_spif_regsel [6]	—	—	—	fifo aligner threshold value (max) [4:0]				15			

Memory Map (continued)

Table 10. Memory Map (continued)

ADDR [7:0]	Register Type	Register Name	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0	Reset Value (hex)	Comments
0c	creg	ds_8_creg, all_spif_regsel [7]	—	scrambler/descrambler control	input/output parallel bus parity control	line lpbk control	number of consecutive A1 A2 errors to generate [3:0]				60	device reg blk - tx
0d	creg	ds_9_creg, all_spif_regsel [8]	a1 error insert value [7:0]								00	
0e	creg	ds_10_creg, all_spif_regsel [9]	a2 error insert value [7:0]								00	
0f	creg	ds_11_creg, all_spif_regsel [10]	transmitter B1 error insert mask [7:0]								00	
10	isreg	ds_12_isr, all_spif_regsel [11]	—	—	—	per device int	ch 4 int	ch 3 int	ch 2 int	ch 1 int	00	top level interrupts
11	iereg	ds_13_ier, all_spif_regsel [12]	—	—	—	enable/mask register [4:0]				00		
12	iareg	ds_14_iar, all_spif_regsel [13]	—	—	—	—	—	—	write to locked register error flag	frame offset error flag	00	
13	iereg	ds_15_ier, all_spif_regsel [14]	—	—	—	—	—	—	enable/mask register [1:0]		00	
14	isreg	ds_16_isr, all_spif_regsel [15]	—	—	—	—	ch 8 int	ch 7 int	ch 6 int	ch 5 int	00	
15	iereg	ds_17_ier, all_spif_regsel [16]	—	—	—	—	enable/mask register [3:0]				00	
16	creg	—	—	—	—	—	STM-A mode control	STM-A mode control	STM-B mode control	STM-B mode control	0x00	



Memory Map (continued)

Table 10. Memory Map (continued)

ADDR [7:0]	Register Type	Register Name	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0	Reset Value (hex)	Comments
17	creg	—	STMA Stream A resync.	STMA Stream B resync.	STMA Stream C resync.	STMA Stream D resync.	STMB Stream A resync.	STMB Stream B resync.	STMB Stream C resync.	STMB Stream D resync.	0x00	—
18	creg	—	—	STMA and B resync (all 8 streams AA to BD)	STMA Resync (all 4 streams AA, AB, AC and AD)	STMB Resync (all 4 streams BA, BB, BC and BD)	Twins AA Resync (streams AA and BA)	Twins BB resync (streams AB and BB)	Twins CC resync (streams AC and BC)	Twins DD resync (streams AD and BD)	0x00	—
<b>Channel Register Block</b>												
20, 38, 50, 68, 80, 98, b0, c8	creg	dsbr_1_1/2/3/4_creg all_spif_regsel[15, 33, 51, 69]	hi-z control of TOH data output	hi-z control of parallel output bus	channel enable / disable control	parallel output bus parity err ins cmd	rx k1/k2 source select	TOH serial output port par err ins cmd	force ais-l control	rx behavior in lof	01	rx control signals
21, 39, 51, 69, 81, 99, b1, c9	creg	dsbr_2_1/2/3/4_creg all_spif_regsel[16, 34, 52, 70]	tx mode of operation	tx e1 f1 e2 source select	tx s1 m0 source select	tx k1 k2 source select	tx d12 source select	tx d11 source select	tx d10 source select	tx d9 source select	00	tx control signals
22, 3a, 52, 6a, 82, 9a, b2, ca	creg	dsbr_3_1/2/3/4_creg all_spif_regsel[17, 35, 53, 71]	tx d8 source select	tx d7 source select	tx d6 source select	tx d5 source select	tx d4 source select	tx d3 source select	tx d2 source select	tx d1 source select	00	
23, 3b, 53, 6b, 83, 9b, b3, cb	creg	dsbr_4_1/2/3/4_creg all_spif_regsel[18, 36, 54, 72]	—	—	—	—	disable A1/A2 insert	disable B1 insert	b1 error insert command	a1 a2 error ins command	00	

Memory Map (continued)

Table 10. Memory Map (continued)

ADDR [7:0]	Register Type	Register Name	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0	Reset Value (hex)	Comments
24, 3c, 54, 6c, 84, 9c, b4, cc	sreg	dsbr_5_1/ 2/3/4_sreg all_spif_re gsel[19, 37, 55, 73	—	—	—	—	Concat indicati on 12	Concat indicati on 9	Concat indicati on 6	Concat indicati on 3	N.A.	per sts#1 cos flag
25, 3d, 55, 6d, 85, 9d, b5, cd	sreg	dsbr_6_1/ 2/3/4_sreg all_spif_re gsel[20, 38, 56, 74	Concat indicati on 11	Concat indicati on 8	Concat indicati on 5	Concat indicati on 2	Concat indicati on 10	Concat indicati on 7	Concat indicati on 4	Concat indicati on 1	N.A.	
26, 3e, 56, 6e, 86, 9e, b6, ce	isreg	dsbr_7_1/ 2/3/4_isr all_spif_re gsel[21, 39, 57,75	—	—	—	—	—	elastic store overflo w flag	ais-p flag	per sts-12 alarm flag	00	per channel interrupt consolidation
27, 3f, 57, 6f, 87, 9f, b7, cf	ireg	dsbr_8_1/ 2/3/4_ier all_spif_re gsel[22, 40, 58, 76, 94	—	—	—	—	—	enable/mask register [2:0]		00		
28, 40, 58, 70, 88, a0, b8, d0	iareg	dsbr_9_[1: 8]_iar all_spif_re gsel[23, 41, 59, ...	—	fifo OOS error flag	TOH serial input port parity error flag	input parallel bus parity error flag	LVDS link B1 parity error flag	LOF flag	Receiv er interna l path parity error flag	fifo aligner thresh old error flag	00	per sts-12 interrupt flags
29, 41, 59, 71, 89, a1 b9, d1	ireg	dsbr_10_1/ 2/3/4_ier all_spif_re gsel[24, 42, 60,	—	—	enable/mask register [5:0]					00		

Memory Map (continued)

Table 10. Memory Map (continued)

ADDR [7:0]	Register Type	Register Name	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0	Reset Value (hex)	Comments
2a, 42, 5a, 72, 8a, a2, ba, d2	iareg	dsbr_11_1/ 2/3/4_iar all_spif_re gsel[25, 43, 61,	—	—	—	—	AIS interru pt flags 12	AIS interru pt flag 9	AIS interru pt flags 6	AIS interru pt flags 3	00	per sts-1 interrupt flags
2b, 43, 5b, 73, 8b, a3, bb, d3	iareg	dsbr_12_1/ 2/3/4_iar all_spif_re gsel[26, 44, 62,	AIS interru pt flag 11	AIS interru pt flag 8	AIS interru pt flag 5	AIS interru pt flag 2	AIS interru pt flag 10	AIS interru pt flag 7	AIS interru pt flag 4	AIS interru pt flag 1	00	
2c, 44, 5c, 74, 8c, a4, bc, d4	iereg	dsbr_13_1/ 2/3/4_ier all_spif_re gsel[27, 45, 63,	—	—	—	—	enable /mask AIS interru pt flags 12	enable /mask AIS interru pt flag 9	enable /mask AIS interru pt flags 6	enable /mask AIS interru pt flags 3	00	
2d, 45, 5d, 75, 8d, a5, bd, d5	iereg	dsbr_14_1/ 2/3/4_ier all_spif_re gsel[28, 46, 64,	enable /mask AIS interru pt flag 11	enable /mask AIS interru pt flag 8	enable /mask AIS interru pt flag 5	enable /mask AIS interru pt flag 2	enable /mask AIS interru pt flag 10	enable /mask AIS interru pt flag 7	enable /mask AIS interru pt flag 4	enable /mask AIS interru pt flag 1	00	
2e, 46, 5e, 76, 8e, a6, be, d6	iareg	dsbr_15_1/ 2/3/4_iar all_spif_re gsel[29, 47, 65,	—	—	—	—	ES overflo w flags 12	ES overflo w flag 9	ES overflo w flags 6	ES overflo w flags 3	00	
2f, 47, 5f, 77, 8f, a7, bf, d7	iareg	dsbr_16_1/ 2/3/4_iar all_spif_re gsel[30, 48, 66,	ES overflo w flag 11	ES overflo w flag 8	ES overflo w flag 5	ES overflo w flag 2	ES overflo w flag 10	ES overflo w flag 7	ES overflo w flag 4	ES overflo w flag 1	00	

Memory Map (continued)

Table 10. Memory Map (continued)

ADDR [7:0]	Register Type	Register Name	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0	Reset Value (hex)	Comments
30, 48, 60, 78, 90, a8, c0, d8	iereg	dsbr_17_1/2/3/4_ier all_spif_registers[31, 49, 67,	—	—	—	—	enable /mask ES overflow flags 12	enable /mask ES overflow flag 9	enable /mask ES overflow flags 6	enable /mask ES overflow flags 3	00	
31, 49, 61, 79, 91, a9, c1, d9	iereg	dsbr_18_1/2/3/4_ier all_spif_registers[32, 50, 68,	enable /mask ES overflow flag 11	enable /mask ES overflow flag 8	enable /mask ES overflow flag 5	enable /mask ES overflow flag 2	enable /mask ES overflow flag 10	enable /mask ES overflow flag 7	enable /mask ES overflow flag 4	enable /mask ES overflow flag 1	00	
32, 4a, 62, 7a, 92, aa, c2, da	counter	NULL_RE GSEL[0, 3, 6, 9, 12, 15, 18, 21]	overflow	lvds link b1 BIP-8 parity error counter							00	binning
33, 4b, 63, 7b, 93, ab, c3, db	counter	NULL_RE GSEL[1, 4, 7, 10, 13, 16, 19, 22]	overflow	lof counter							00	
34, 4c, 64, 7c, 94, ac, c4, dc	counter	NULL_RE GSEL[2, 5, 8, 11, 14, 17, 20, 23]	overflow	A1 A2 frame error counter							00	
35, 4d, 65, 7d, 95, ad, c5, dd	creg	—	Reserved	—	—	FIFO Depth register				0x0c	—	

Memory Map (continued)

Table 10. Memory Map (continued)

ADDR [7:0]	Register Type	Register Name	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0	Reset Value (hex)	Comments
36, 4e, 66, 7e, 96, ae, c6, de	counter	—	Sampler Phase error count								0x00	—
37, 4f, 67, 7f, 97, af, c7, df	creg	—	—	—	Framer Disable	Sync Control		LVDS redundant select	Bypass Alignment FIFO+ Pointer Mover	Bypass Alignment FIFO only	0x00	—
<b>CDR specific registers</b>												
e0	creg	cdr_ctl_reg 1		TSTM ODE	BYPASS	LOOP BKEN	TSTP HASE	X4INT FCE	EN10BIT	Shim Mode	—	—
e1	creg	cdr_ctl_reg 2	HALFRATE[7:0]								0x0	Is this needed?
e2	creg	cdr_ctl_reg 3	QUARTRATE[7:0]								0x0	Is this needed?
e3	creg	cdr_ctl_reg 4	ENCOMMA[7:0]								—	—
<b>Pi-Sched registers</b>												
f0	creg	pi_ctl_reg1	—	OSHL BENB	OPIM ODE (Reserved)	OCELLSIZE[4:0]					—	—
f1	sreg	pi_stat_reg 1	—	—	—	—	—	—	ITEST DONE	ITEST PASS	0x0	—
f2	creg	pi_ctl_reg2	—	—	—	—	—	—	IBYPASS	OTES TENB	—	—
f3	creg	pll_ctl_reg 1	OPLL[5:0]						OPLL LFB	OPLL MAN	0x0	Test control signals for PLL

Memory Map (continued)

Table 11. Memory Map Descriptions

Bit/Register Name(S)	Bit/Register Location (Hex)	Register Type	Reset Value (Hex)	Description												
fixed rev [7:0] fixed id lsb [7:0] fixed id msb [7:0]	00 [7:0] 01 [7:0] 02 [7:0]	sreg	01 01 A0	N.A.												
scratch pad [7:0]	03 [7:0]	creg	00	The scratch pad has no function and is not used anywhere in the ORT4622 core. However, this register can be written to and read from.												
lockreg msb [7:0] lockreg lsb [7:0]	04 [7:0] 05 [7:0]	creg	00 00	In order to write to registers in memory locations 06~7F, lockreg msb and lockreg lsb must be respectively set to the values of A0 and 01. If the msb and lsb lockreg values are not set to {A0, 01}, then any values written to the registers in memory locations 06~7F will be ignored. After reset (both hard and soft) the ORT4622 core is in a write locked mode. The ORT4622 core needs to be unlocked before it can be written to. Also note that the scratch pad register (03) can always be written to as it is unaffected by write lock mode.												
global reset command	06 [0]	preg	N.A.	The global reset command is accessed via the pulse register in memory address 06. The global reset command is a soft (software initiated) reset. Nevertheless, the global reset command will have the exact reset effect as a hard (RST_N pin) reset.												
<b>Device Register Blocks</b>																
lvds lpbk control	08 [0]	creg	0	<table border="1"> <tr> <td>0</td> <td>no loop back</td> </tr> <tr> <td>1</td> <td>lvds loop back, transmit to receive on</td> </tr> </table>	0	no loop back	1	lvds loop back, transmit to receive on								
0	no loop back															
1	lvds loop back, transmit to receive on															
sts 48 sts12 sel	08 [1]	creg	0	This control signal is unused in the ORT4622 core. It is a scratch bit, and it's value has no effect on the ORT4622 core.												
ext prot sw en ext prot sw func	08 [3:2]	creg	0	<table border="1"> <thead> <tr> <th>ext port sw en</th> <th>ext prot sw func</th> <th>switching control master</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>-</td> <td>- MUX is controlled by software (1 control bit per mux) reg 09. - Output buffers' enables are controlled by software (1 control bit per channel) reg 20, 38, 50, 68.</td> </tr> <tr> <td>1</td> <td>0</td> <td>- MUX on parallel output bus of Channel #1 is controlled by 'Prot_Switch A/B' pin (0-&gt; Channel #1, 1-&gt; Channel #2). - MUX on parallel output bus of Channel #3 is controlled by 'Prot_Switch C/D' pin (0-&gt; Channel #3, 1-&gt; Channel #4). - Output buffers' enables are controlled by software (1 control bit per channel) reg 20, 38, 50, 68.</td> </tr> <tr> <td>1</td> <td>1</td> <td>- MUX is controlled by software (1 control bit per mux) reg 09. - Parallel output enable DOUTA_EN of Channels #1 and DOUTB_EN of channel #2 are controlled by 'Prot_Switch A/B' pin (0-&gt; EN=1, 1-&gt; EN=0). - Parallel output enable DOUTC_EN of Channels #3 and DOUTD_EN of channel #4 are controlled by 'Prot_Switch C/D' pin (0-&gt; EN=1, 1-&gt; EN=0).</td> </tr> </tbody> </table> <p>Note: ext prot sw func =0 in OC12 mode</p>	ext port sw en	ext prot sw func	switching control master	0	-	- MUX is controlled by software (1 control bit per mux) reg 09. - Output buffers' enables are controlled by software (1 control bit per channel) reg 20, 38, 50, 68.	1	0	- MUX on parallel output bus of Channel #1 is controlled by 'Prot_Switch A/B' pin (0-> Channel #1, 1-> Channel #2). - MUX on parallel output bus of Channel #3 is controlled by 'Prot_Switch C/D' pin (0-> Channel #3, 1-> Channel #4). - Output buffers' enables are controlled by software (1 control bit per channel) reg 20, 38, 50, 68.	1	1	- MUX is controlled by software (1 control bit per mux) reg 09. - Parallel output enable DOUTA_EN of Channels #1 and DOUTB_EN of channel #2 are controlled by 'Prot_Switch A/B' pin (0-> EN=1, 1-> EN=0). - Parallel output enable DOUTC_EN of Channels #3 and DOUTD_EN of channel #4 are controlled by 'Prot_Switch C/D' pin (0-> EN=1, 1-> EN=0).
ext port sw en	ext prot sw func	switching control master														
0	-	- MUX is controlled by software (1 control bit per mux) reg 09. - Output buffers' enables are controlled by software (1 control bit per channel) reg 20, 38, 50, 68.														
1	0	- MUX on parallel output bus of Channel #1 is controlled by 'Prot_Switch A/B' pin (0-> Channel #1, 1-> Channel #2). - MUX on parallel output bus of Channel #3 is controlled by 'Prot_Switch C/D' pin (0-> Channel #3, 1-> Channel #4). - Output buffers' enables are controlled by software (1 control bit per channel) reg 20, 38, 50, 68.														
1	1	- MUX is controlled by software (1 control bit per mux) reg 09. - Parallel output enable DOUTA_EN of Channels #1 and DOUTB_EN of channel #2 are controlled by 'Prot_Switch A/B' pin (0-> EN=1, 1-> EN=0). - Parallel output enable DOUTC_EN of Channels #3 and DOUTD_EN of channel #4 are controlled by 'Prot_Switch C/D' pin (0-> EN=1, 1-> EN=0).														
"rx toh frame" and "rx toh clk enable" hiz control	08 [4]	creg	0	<table border="1"> <tr> <td>0</td> <td>TOH_CK_FP_EN=0, can be used to tri-state RX_TOH_CK_EN and RX_TOH_FP signals.</td> </tr> <tr> <td>1</td> <td>Function mode.</td> </tr> </table>	0	TOH_CK_FP_EN=0, can be used to tri-state RX_TOH_CK_EN and RX_TOH_FP signals.	1	Function mode.								
0	TOH_CK_FP_EN=0, can be used to tri-state RX_TOH_CK_EN and RX_TOH_FP signals.															
1	Function mode.															

Memory Map (continued)

Table 11. Memory Map Descriptions (continued)

Bit/Register Name(S)	Bit/Register Location (Hex)	Register Type	Reset Value (Hex)	Description																								
serial port output mux select for ch#1 serial port output mux select for ch#3 parallel port output mux select for ch#1 parallel port output mux select for ch#3	09 [0] 09 [1] 09 [2] 09 [3]	creg	1 1 1 1	<table border="1"> <tr> <td>serial port output mux select for ch #1</td> <td></td> </tr> <tr> <td>0</td> <td>TOH output #1 is multiplexed to channel 2</td> </tr> <tr> <td>1</td> <td>TOH output #1 is multiplexed to channel 1</td> </tr> </table> <table border="1"> <tr> <td>serial port output mux select for ch #3</td> <td></td> </tr> <tr> <td>0</td> <td>TOH output #3 is multiplexed to channel 4</td> </tr> <tr> <td>1</td> <td>TOH output #3 is multiplexed to channel 3</td> </tr> </table> <table border="1"> <tr> <td>parallel port output mux select for ch #1</td> <td></td> </tr> <tr> <td>0</td> <td>parallel output data bus #1 is multiplexed to channel 2</td> </tr> <tr> <td>1</td> <td>parallel output data bus #1 is multiplexed to channel 1</td> </tr> </table> <table border="1"> <tr> <td>parallel port output mux select for ch #3</td> <td></td> </tr> <tr> <td>0</td> <td>parallel output data bus #3 is multiplexed to channel 4</td> </tr> <tr> <td>1</td> <td>parallel output data bus #3 is multiplexed to channel 3</td> </tr> </table>	serial port output mux select for ch #1		0	TOH output #1 is multiplexed to channel 2	1	TOH output #1 is multiplexed to channel 1	serial port output mux select for ch #3		0	TOH output #3 is multiplexed to channel 4	1	TOH output #3 is multiplexed to channel 3	parallel port output mux select for ch #1		0	parallel output data bus #1 is multiplexed to channel 2	1	parallel output data bus #1 is multiplexed to channel 1	parallel port output mux select for ch #3		0	parallel output data bus #3 is multiplexed to channel 4	1	parallel output data bus #3 is multiplexed to channel 3
serial port output mux select for ch #1																												
0	TOH output #1 is multiplexed to channel 2																											
1	TOH output #1 is multiplexed to channel 1																											
serial port output mux select for ch #3																												
0	TOH output #3 is multiplexed to channel 4																											
1	TOH output #3 is multiplexed to channel 3																											
parallel port output mux select for ch #1																												
0	parallel output data bus #1 is multiplexed to channel 2																											
1	parallel output data bus #1 is multiplexed to channel 1																											
parallel port output mux select for ch #3																												
0	parallel output data bus #3 is multiplexed to channel 4																											
1	parallel output data bus #3 is multiplexed to channel 3																											
fifo aligner threshold value (min) [4:0] fifo aligner threshold value (max) [4:0]	0A [4:0] 0B [4:0]	creg	02 15	<p>These are the minimum and maximum thresholds values for the per channel receive direction alignment fifos. If and when the minimum or maximum threshold value is violated by a particular channel, then the interrupt event "fifo aligner threshold error" will be generated for that channel and latched as a "fifo aligner threshold error flag" in the respective per sts-12 interrupt alarm register.</p> <p>The allowable range for minimum threshold values is 1 to 23 The allowable range for maximum threshold values is 0 to 22</p> <p>Note that the minimum and maximum fifo aligner threshold values apply to all 4 channels.</p>																								
number of consecutive A1 A2 errors to generate [3:0] A1 error insert value [7:0] A2 error insert value [7:0]	0C [3:0] 0D [7:0] 0E [7:0]	creg	00 00 00	<p>These 3 per device control signals are used in conjunction with the per channel "a1 a2 error insert command" control bits to force A1 A2 errors in the transmit direction.</p> <p>If a particular channel's "a1 a2 error insert command" control bit is set to the value 1 then the "A1 and A2 error insert values" will be inserted into that channels respective A1 and A2 bytes. The number of consecutive frames to be corrupted is determined by the "number of consecutive A1 A2 errors to generate[3:0]" control bits.</p> <p>The error insertion is based on a rising edge detector. As such the control must be set to value 0 before trying to initiate a second a1 a2 corruption.</p>																								
line lpbk control	0C [4]	creg	0	<table border="1"> <tr> <td>0</td> <td>no loop back</td> </tr> <tr> <td>1</td> <td>rx to tx loopback on line side</td> </tr> </table>	0	no loop back	1	rx to tx loopback on line side																				
0	no loop back																											
1	rx to tx loopback on line side																											
input/output parallel bus parity control	0C [5]	creg	1	<table border="1"> <tr> <td>0</td> <td>even parity</td> </tr> <tr> <td>1</td> <td>odd parity</td> </tr> </table>	0	even parity	1	odd parity																				
0	even parity																											
1	odd parity																											
scrambler/ descrambler control	0C [6]	creg	1	<table border="1"> <tr> <td>0</td> <td>no rx direction descramble / tx direction scramble</td> </tr> <tr> <td>1</td> <td>In rx direction descramble channel after sonet frame recovery. In tx direction scramble data just before parallel to serial conversion.</td> </tr> </table>	0	no rx direction descramble / tx direction scramble	1	In rx direction descramble channel after sonet frame recovery. In tx direction scramble data just before parallel to serial conversion.																				
0	no rx direction descramble / tx direction scramble																											
1	In rx direction descramble channel after sonet frame recovery. In tx direction scramble data just before parallel to serial conversion.																											
transmit B1 error insert mask [7:0]	0F [7:0]	creg	00	<table border="1"> <tr> <td>0</td> <td>no Error insertion</td> </tr> <tr> <td>1</td> <td>Invert corresponding bit in B1 byte</td> </tr> </table>	0	no Error insertion	1	Invert corresponding bit in B1 byte																				
0	no Error insertion																											
1	Invert corresponding bit in B1 byte																											
ch 1 int ch 2 int ch 3 int ch 4 int per device int enable/mask register for ch 1-4 + device[4:0] ch 5 int ch 6 int ch 7 int ch 8 int enable/mask register for ch5-8 [3:0]	10 [0] 10 [1] 10 [2] 10 [3] 10 [4] 11 [4:0] 14 [0] 14 [1] 14 [2] 14 [3] 15 [3:0]	isreg isreg isreg isreg isreg iereg isreg isreg isreg isreg iereg	0 0 0 0 0 0 0 0 0 0 0	Consolidation interrupts. 1 = interrupt, 0 = no interrupt.																								

Memory Map (continued)

Table 11. Memory Map Descriptions (continued)

Bit/Register Name(S)	Bit/Register Location (Hex)	Register Type	Reset Value (Hex)	Description																		
frame offset error flag write to locked register error flag enable/mask register [1:0]	12 [0] 12 [1] 13 [1:0]	iareg iareg iereg	0 0 0	If in the receive direction the phase offset between any 2 channels exceeds 17 bytes, then a frame offset error event will be issued. This condition is continuously monitored.  If the ORT4622 core memory map has not been unlocked (by writing a 001 to the lock registers), and any address other than the lockreg registers or scratch pad register is written to, then a "write to locked register" event will be generated																		
STM A mode control	16[3:2]	creg	0	<b>00 - Quad STS-12 or STS-48</b> <b>01 - Quad STS-3</b> <b>10 - Quad STS-1</b> <b>00 - Quad STS-12 or STS-48</b> <b>01 - Quad STS-3</b> <b>10 - Quad STS-1</b>																		
STM B mode control	16[1:0]	creg	0																			
Individual alignment resync register	17[7:0]	creg	0	Write 1 to resync																		
Group alignment resync register	18[7:0]	creg	0	Write 1 to resync																		
<b>Channel Register Blocks</b>																						
rx behavior in lof  force ais-l control	20, 38, 50, 68, 80, 98, b0, c8 [0]  20, 38, 50, 68, 80, 98, b0, c8 [1]		1  0	<table border="1" style="width: 100%;"> <tr> <td colspan="2" style="text-align: center;">rx behavior in log</td> </tr> <tr> <td style="text-align: center;">0</td> <td>When Rx direction OOF occurs, do not insert AIS-L</td> </tr> <tr> <td style="text-align: center;">1</td> <td>When Rx direction OOF occurs, insert AIS-L</td> </tr> <tr> <td colspan="2" style="text-align: center;">force ais-l control</td> </tr> <tr> <td style="text-align: center;">0</td> <td>Do not force AIS-L</td> </tr> <tr> <td style="text-align: center;">1</td> <td>Force AIS-L</td> </tr> </table>	rx behavior in log		0	When Rx direction OOF occurs, do not insert AIS-L	1	When Rx direction OOF occurs, insert AIS-L	force ais-l control		0	Do not force AIS-L	1	Force AIS-L						
rx behavior in log																						
0	When Rx direction OOF occurs, do not insert AIS-L																					
1	When Rx direction OOF occurs, insert AIS-L																					
force ais-l control																						
0	Do not force AIS-L																					
1	Force AIS-L																					
TOH serial output port par err ins cmd	20, 38, 50, 68, 80, 98, b0, c8 [2]		0	<table border="1" style="width: 100%;"> <tr> <td style="text-align: center;">0</td> <td>Do not insert a parity error</td> </tr> <tr> <td style="text-align: center;">1</td> <td>Insert parity error in parity bit of receive TOH serial output for as long as this bit is set</td> </tr> </table>	0	Do not insert a parity error	1	Insert parity error in parity bit of receive TOH serial output for as long as this bit is set														
0	Do not insert a parity error																					
1	Insert parity error in parity bit of receive TOH serial output for as long as this bit is set																					
rx k1/k2 source select	20, 38, 50, 68, 80, 98, b0, c8 [3]		0	<table border="1" style="width: 100%;"> <tr> <td style="text-align: center;">0</td> <td>Set receive direction K2 K2 bytes to 0</td> </tr> <tr> <td style="text-align: center;">1</td> <td>Pass receive direction K1 K2 though pointer mover</td> </tr> </table>	0	Set receive direction K2 K2 bytes to 0	1	Pass receive direction K1 K2 though pointer mover														
0	Set receive direction K2 K2 bytes to 0																					
1	Pass receive direction K1 K2 though pointer mover																					
parallel output bus parity err ins cmd	20, 38, 50, 68, 80, 98, b0, c8 [4]		0	<table border="1" style="width: 100%;"> <tr> <td style="text-align: center;">0</td> <td>Do not insert parity error</td> </tr> <tr> <td style="text-align: center;">1</td> <td>Insert parity error in the parity bit of receive direction parallel output bus for as long as this bit is set</td> </tr> </table>	0	Do not insert parity error	1	Insert parity error in the parity bit of receive direction parallel output bus for as long as this bit is set														
0	Do not insert parity error																					
1	Insert parity error in the parity bit of receive direction parallel output bus for as long as this bit is set																					
channel enable / disable control  hi-z control of parallel output bus  hi-z control of TOH data output	20,,38,,50,,68, 80, 98, b0, c8 [5]  20, 38, 50, 68, 80, 98, b0, c8 [6]  20, 38, 50, 68, 80, 98, b0, c8 [7]	creg  creg  creg	0  0  0	<table border="1" style="width: 100%;"> <tr> <td colspan="2" style="text-align: center;">channel enable / disable control</td> </tr> <tr> <td style="text-align: center;">0</td> <td>Power down CDR channels (PWR_DN_A/B/C/D_N=0), TOH_EN_A(or B, C, D)=0, and DOUTA(or B, C, D)=0, can be used to tristate output busses</td> </tr> <tr> <td style="text-align: center;">1</td> <td>Functional mode</td> </tr> <tr> <td colspan="2" style="text-align: center;">hi-z control of parallel output bus</td> </tr> <tr> <td style="text-align: center;">0</td> <td>DOUTA(or B, C, D) _EN=0, can be used to tristate output bus</td> </tr> <tr> <td style="text-align: center;">1</td> <td>Functional Mode</td> </tr> <tr> <td colspan="2" style="text-align: center;">hi-z control of TOH data output</td> </tr> <tr> <td style="text-align: center;">0</td> <td>TOH_EN_A(or B, C, D)=0, can be used to tristate TOH output lines</td> </tr> <tr> <td style="text-align: center;">1</td> <td>Functional mode</td> </tr> </table>	channel enable / disable control		0	Power down CDR channels (PWR_DN_A/B/C/D_N=0), TOH_EN_A(or B, C, D)=0, and DOUTA(or B, C, D)=0, can be used to tristate output busses	1	Functional mode	hi-z control of parallel output bus		0	DOUTA(or B, C, D) _EN=0, can be used to tristate output bus	1	Functional Mode	hi-z control of TOH data output		0	TOH_EN_A(or B, C, D)=0, can be used to tristate TOH output lines	1	Functional mode
channel enable / disable control																						
0	Power down CDR channels (PWR_DN_A/B/C/D_N=0), TOH_EN_A(or B, C, D)=0, and DOUTA(or B, C, D)=0, can be used to tristate output busses																					
1	Functional mode																					
hi-z control of parallel output bus																						
0	DOUTA(or B, C, D) _EN=0, can be used to tristate output bus																					
1	Functional Mode																					
hi-z control of TOH data output																						
0	TOH_EN_A(or B, C, D)=0, can be used to tristate TOH output lines																					
1	Functional mode																					



Memory Map (continued)

Table 11. Memory Map Descriptions (continued)

Bit/Register Name(S)	Bit/Register Location (Hex)	Register Type	Reset Value (Hex)	Description								
tx mode of operation	21,39,51,69, 81,99,b1,c9 [7]	creg	0	<p>Tx Mode of operation:</p> <table border="1"> <tr> <td>0</td> <td>Insert TOH from Serial Ports</td> </tr> <tr> <td>1</td> <td>Pass through all TOH</td> </tr> </table> <p>Other registers:</p> <table border="1"> <tr> <td>0</td> <td>Insert TOH from Serial Ports</td> </tr> <tr> <td>1</td> <td>Pass through that particular TOH Byte</td> </tr> </table>	0	Insert TOH from Serial Ports	1	Pass through all TOH	0	Insert TOH from Serial Ports	1	Pass through that particular TOH Byte
0	Insert TOH from Serial Ports											
1	Pass through all TOH											
0	Insert TOH from Serial Ports											
1	Pass through that particular TOH Byte											
tx e1 f2 e2 source select	21,39,51,69, 81,99,b1,c9 [6]	creg	0									
tx s1 m0 source select	21,39,51,69, 81,99,b1,c9 [5]	creg	0									
tx k1 k2 source select	21,39,51,69, 81,99,b1,c9 [4]	creg	0									
tx d12~d9 source select	21,39,51,69, 81,99,b1,c9 [3:0]	creg	4'h0									
tx d8~d1 source select	22, 3a, 52, 6a, 82, 9a, b2, ca [7:0]	creg	8'h00									
a1 a2 error insert command	23, 3b, 53, 6b, 83, 9b, b3, cb [0]	creg	0	<table border="1"> <tr> <td>0</td> <td>Do not insert error</td> </tr> <tr> <td>1</td> <td>Insert error for number of frames in register hex 0C</td> </tr> </table> <p>The error insertion is based on a rising edge detector. As such the control must be set to value 0 before trying to initiate a second a1 a2 corruption.</p> <table border="1"> <tr> <td>0</td> <td>Do not insert error</td> </tr> <tr> <td>1</td> <td>Insert error for 1 frame in B1 bits defined by register hex 0F</td> </tr> </table> <p>The error insertion is based on a rising edge detector. As such the control must be set to value 0 before trying to initiate a second B1 corruption.</p>	0	Do not insert error	1	Insert error for number of frames in register hex 0C	0	Do not insert error	1	Insert error for 1 frame in B1 bits defined by register hex 0F
0	Do not insert error											
1	Insert error for number of frames in register hex 0C											
0	Do not insert error											
1	Insert error for 1 frame in B1 bits defined by register hex 0F											
b1 error insert command	23, 3b, 53, 6b, 83, 9b, b3, cb [1]	creg	0									
disable b1 insert	23, 3b, 53, 6b, 83, 9b, b3, cb[2]											
disable a1 insert	23, 3b, 53, 6b, 83, 9b, b3, cb[3]											
concat indication 12, 9, 6, 3	24, 3c, 54, 6c, 84, 9c, b4, cc [3:0]	sreg	0	The value "1" in any bit location indicates that STS# is in CONCAT mode. A "0" indicates that the STS is not in CONCAT mode, or is the head of a concat group.								
concat indication 11, 8, 5, 2, 10, 7, 4, 1	25, 3d, 55, 6d, 85, 9d, b5, cd [7:0]	sreg	0									
per sts-12 alarm flag	26,3e,56,6e, 86,9e,b6,ce[0]	isreg	0	These flag register bits "per sts-12 alarm flag, ais-p flag, and elastic store overflow flag" are the per channel interrupt status (consolidation) register.								
ais-p flag	26, 3e, 56, 6e, 86,9e,b6,ce [1]	isreg	0									
elastic store overflow flag	26,3e,56,6e, 86,9e,b6,ce [2]	isreg	0									
enable/mask register [2:0]	27, 3f, 57, 6f, 87,9f, b7, cf [2:0]	iereg	3'b000									
fifo aligner threshold error flag	28, 40, 58, 70, 88, a0, b8, d0 [0]	iareg	0	These are the "per sts-12" alarm flags.								
receiver internal path parity error flag	28, 40, 58, 70, 88, a0, b8, d0 [1]	iareg	0									
LOF flag	28, 40, 58, 70, 88, a0, b8, d0 [2]	iareg	0									
LVDS link B1 parity error flag	28, 40, 58, 70, 88, a0, b8, d0 [3]	iareg	0									
input parallel bus parity error flag	28, 40, 58, 70, 88, a0, b8, d0 [4]	iareg	0									
TOH serial input port parity error flag	28, 40, 58, 70, 88, a0, b8, d0 [5]	iareg	0									
Fifo OOS error flag	28, 40, 58, 70, 88, a0, b8, d0 [6]	iareg	0									
enable/mask register [5:0]	29, 41, 59, 71, 89, a1, b9, d1 [5:0]	iereg	7'h00									

Memory Map (continued)

Table 11. Memory Map Descriptions (continued)

Bit/Register Name(S)	Bit/Register Location (Hex)	Register Type	Reset Value (Hex)	Description
ais interrupt flags 12, 9, 6, 3	2a,42,5a,72, 8a, a2, ba, d2 [3:0]	iareg	4'h0	These are the "AIS-P" alarm flags.
ais interrupt flags 11, 8, 5, 2, 10, 7, 4, 1	2b,43,5b,73, 8b, a3, bb, d3 [7:0]	iareg	8'h00	
enable/mask register 12, 9, 6, 3	2c,44,5c,74, 8c, a4, bc, d4 [3:0]	iereg	4'h0	
enable/mask register 11, 8, 5, 2, 10, 7, 4, 1	2d,45,5d,75, 8d, a5, bd, d5 [7:0]	iereg	8'h00	
ES overflow flags 12, 9, 6, 3	2e,46,5e,76, 8e, a6, be, d6 [3:0]	iareg	4'h0	These are the "Elastic Store Overflow" alarm flags.
ES overflow flags 11, 8, 5, 2, 10, 7, 4, 1	2f,47,5f,77, 8f, a7, bf, d7 [7:0]	iareg	8'h00	
enable/mask register 12, 9, 6, 3	30,48,60,78, 90, a8, b0, d8 [3:0]	iereg	4'h0	
enable/mask register 11, 8, 5, 2, 10, 7, 4, 1	31,49,61,79, 91, a9, b1, d9 [7:0]	iereg	8'h00	
lvds link b1 parity error counter	32,4a,62,7a, 92, aa, b2, da [7:0]	counter	8'h00	7 bit count + overflow - reset on read
lof counter	33,4b,63,7b, 93, ab, b3, db [7:0]	counter	8'h00	7 bit count + overflow - reset on read
A1 A2 frame error counter	34,4c,64,7c, 94, ac, b4, dc [7:0]	counter	8'h00	7 bit count + overflow - reset on read
FIFO depth register	35, 4d, 65, 7d, 95, ad, c5, dd [4:0]	sreg	0x0c	0x0c indicates FIFO is half full.
Sampler phase error counter	36, 4e, 66, 7e, 96, ae, c6, de [7:0]	counter	0x00	Write 1 to clear
Bypass register	37,4f,67,7f,97,af ,c7,df[0]	creg	0x0	1 - Bypass Pointer Mover
Bypass register	37,4f,67,7f,97,af ,c7,df[1]	creg	0x0	1 - Bypass only Alignment fifo + Pointer Mover
Enable work/protect channels	37,4f,67,7f,97,af ,c7,df[2]	creg	0x0	Bit to control the LVDS drivers/receivers to/from CDR 0 - Use LVDS drivers and receivers to/from Pi-sched I/F block B (Work channels) 1 - Use LVDS drivers and receivers to/from Pi-sched I/F block C (Protect channels)
Sync Control register	37,4f,67,7f,97,af ,c7,df[4:3]	creg	2'b00	00 - No alignment 01 - Align with twin (i.e. STM B stream A) 10 - Align with all 4 (i.e. STM A all streams) 11 - Align with all 8 (i.e. STM A and B all streams)
Disable Framer	37,4f,67,7f,97,af ,c7,df[5]	creg	0x0	0 - Enable framer 1 - Disable STS-12 framing
CDR control register 1	0xe[6]	creg	0x0	Enables CDR test mode. Initiates CDR's built-in self test 0 - Regular mode 1 - Test mode
	0xe[5]	creg	0x0	Enables bypassing of the 622 Mhz clock synthesis with TSTCLK 0 - use PLL 1 - Bypass PLL
	0xe[4]	creg	0x0	Enables LVDS loopback. 0 - No loopback 1 - Loopback
	0xe[3]	creg	0x0	When set to '1', controls bypass of 16 PLL generated phases with 16 low-speed phases.
	0xe[2]	creg	0x0	Sets low speed internal interface frequency between macrocell and asics 1 = 212 MHz 0 = 106 Mhz

Memory Map (continued)

Table 11. Memory Map Descriptions (continued)

Bit/Register Name(S)	Bit/Register Location (Hex)	Register Type	Reset Value (Hex)	Description
	0xe0[1]	creg	0x0	EN10BIT. Sets 10 to 1 mux/demux 1 = 10:1 mux/demux 0 = 8:1 mux/demux
	0xe0[0]	creg	0x0	0 = Long-haul I/F Mode (Enables CDR + STM operation) 1 = Short-haul I/F Mode (Disables CDR, Enables Pi-sched interfaces)
CDR control register 2	0xe1[7:0]	creg	0x0	Sets input bit rate per channel 1 = 424 Mbits/s 0 = 848 Mbits/s
CDR control register 3	0xe2[7:0]	creg	0x0	Sets input bit rate per channel (QUARTRATE) 1 = 212 Mbits/s 0 = 848 Mbits/s
CDR control register 4	0xe3[7:0]	creg	0x0	Enables 10 bit Ethernet word alignment per channel
Pi-Sched I/F Ctl register	0xf0[1]	creg		Used during internal built-in-self-test mode. 0 - No loopback 1 - Loopback
	0xf0[2]	creg	0x0	Reserved bit. (read-only) 0 - Shuts down Bidi logic and ignores auxiliary bypass signals. Always set to '0'
	0xf0[7:3]	creg		Indicates minimum cell size and will be used to detect cell underrun errors.
Pi-Sched I/F status register	0xf1[6]	sreg		Indicates completion of the internal test. Only valid when OTESTENB (0xf2[7] is high). 0 - Test running 1 - Test Complete
	0xf1[7]	sreg		Indicates success of the internal test. Valid only when ITESTDONE is high 0 - Test Failed 1 - Test Passed
Pi-Sched I/F Ctl register	0xf2[6]	creg	0x0	Enables bypass of the PLL circuit. TSTCLK is used in this mode.
	0xf2[7]	creg	0x0	1 - Enables internal self test of the SHIM block. Both internal and external loopback paths exist during this test.
PLL ctl register	0xf3[0]	creg	0x0	PLL testing control signal (See description on Pg 88)
	0xf3[1]	creg	0x0	
	0xf3[7:2]	creg	0x0	

## Absolute Maximum Ratings

Stresses in excess of the absolute maximum ratings can cause permanent damage to the device. These are absolute stress ratings only. Functional operation of the device is not implied at these or any other conditions in excess of those given in the operations sections of this data sheet. Exposure to absolute maximum ratings for extended periods can adversely affect device reliability.

The ORCA Series 3+ FPSCs include circuitry designed to protect the chips from damaging substrate injection currents and to prevent accumulations of static charge. Nevertheless, conventional precautions should be observed during storage, handling, and use to avoid exposure to excessive electrical stress.

**Table 12. Absolute Maximum Ratings**

Parameter	Symbol	Min	Max	Unit
Storage Temperature	T <sub>stg</sub>	-65	150	°C
Power Supply Voltage with Respect to Ground	V <sub>DD3</sub>	—	≤4.2	V
	V <sub>DD15</sub>	—	2	V
Input Signal with Respect to Ground	—	V <sub>SS</sub> - 0.3	V <sub>DDIO</sub> + 0.3	V
Signal Applied to High-impedance Output	—	V <sub>SS</sub> - 0.3	V <sub>DDIO</sub> + 0.3	V
Maximum Package Body Temperature	—	—	220	°C

## Recommend Operating Conditions

**Table 13. Recommend Operating Conditions**

Parameter	Symbol	Min	Max	Unit
Power Supply Voltage with Respect to Ground	V <sub>DD3</sub>	2.7	3.6	V
	V <sub>DD15</sub>	1.4	1.6	V
Input Voltages	V <sub>IN</sub>	V <sub>SS</sub> - 0.3	V <sub>DDIO</sub> + 0.3	V
Junction Temperature	T <sub>J</sub>	-40	125	°C

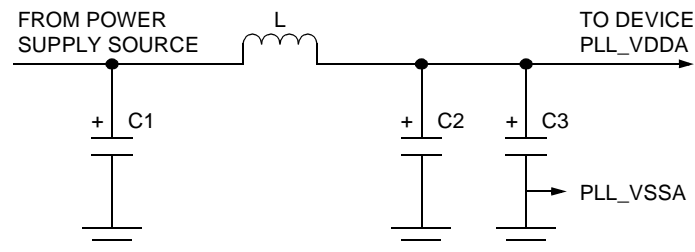
## HSI Circuit Specifications

### Power Supply Decoupling LC Circuit

The 850 MHz HSI macro contains both analog and digital circuitry. The data recovery function, for example, is implemented as primarily a digital function, but it relies on a conventional analog phase-locked loop to provide its 850 MHz reference frequency. The internal analog phase-locked loop contains a voltage-controlled oscillator. This circuit will be sensitive to digital noise generated from the rapid switching transients associated with internal logic gates and parasitic inductive elements. Generated noise that contains frequency components beyond the bandwidth of the internal phase-locked loop (about 3 MHz) will not be attenuated by the phase-locked loop and will impact bit error rate directly. Thus, separate power supply pins are provided for these critical analog circuit elements.

Additional power supply filtering in the form of a LC pi filter section will be used between the power supply source and these device pins as shown in Figure 15. The corner frequency of the LC filter is chosen based on the power supply switching frequency, which is between 100 kHz and 300 kHz in most applications.

Capacitors C1 and C2 are large electrolytic capacitors to provide the basic cutoff frequency of the LC filter. For example, the cutoff frequency of the combination of these elements might fall between 5 kHz and 50 kHz. Capacitor C3 is a smaller ceramic capacitor designed to provide a low-impedance path for a wide range of high-frequency signals at the analog power supply pins of the device. The physical location of capacitor C3 must be as close to the device lead as possible. Multiple instances of capacitors C3 can be used if necessary. The recommended filter for the HSI macro is shown below:  $L = 4.7 \mu\text{H}$ ,  $R_L = 1 \Omega$ ,  $C1 = 0.01 \mu\text{F}$ ,  $C2 = 0.01 \mu\text{F}$ ,  $C3 = 4.7 \mu\text{F}$ .



5-9344(F)

Figure 15. Sample Power Supply Filter Network for Analog HSI Power Supply Pins

## HSI Electrical and Timing Characteristics

Table 14. Absolute Maximum Ratings

Parameter	Conditions	Min	Typ	Max	Unti
Power Dissipation	8 Channels	—	—	300	mW

Table 15. Recommended Operating Conditions

Parameter	Conditions	Min	Typ	Max	Unti
V <sub>DD15</sub> Supply Voltage	—	1.4	—	1.6	V

Table 16. Receiver Specifications

Parameter	Conditions	Min	Typ	Max	Unti
<b>Input Data*</b>					
Stream of Nontransitions <sup>†</sup>	—	—	—	60	bits
Phase change, Input Signal	Over a 200 ns time interval <sup>‡</sup>	—	—	100	ps
<b>Eye Opening<sup>§</sup></b>	—	0.4	—	—	UIP-P
<b>Jitter Tolerance</b>					
Jitter Tolerance:	—	—	—	—	—
250 kHz	—	—	—	0.6	UIP-P
25 kHz	—	—	—	6	UIP-P
2 kHz	—	—	—	60	UIP-P

\* Scrambled data stream conforming to SONET STS-12 and SDH STM-4 data format using either a PN7 or PN9 sequence.

■ PN7 characteristic is  $1 + X^6 + X^7$

■ PN9 characteristic is  $1 + X^4 + X^9$

<sup>†</sup> This sequence should not occur more than once per minute.

<sup>‡</sup> Translates to a frequency change of 500 ppm.

<sup>§</sup> A unit interval for 622.08 Mbits/s data is 1.6075 ns.

Table 17. Transmitter Specifications

Parameter	Conditions	Min	Typ	Max	Unti
Output Jitter, Generated	250 kHz to 5 MHz (measured with a spectrum analyzer)	—	—	0.15	UIP-P
Output Jitter, generated (including I/O buffers)	250 kHz to 5 MHz	—	—	0.25	UIP-P

Table 18. Synthesizer Specifications

Parameter	Conditions	Min	Typ	Max	Unti
<b>PLL*</b>					
Loop Bandwidth	—	—	—	6	MHz
Jitter Peaking	—	—	—	2	dB
Powerup Reset Time	—	10	—	—	s
Lock Acquisition Time	—	—	—	1	ms
<b>Input Reference Clock</b>					
Frequency	—	62.5	—	212.50	MHz
Frequency Deviation	—	—	—	20	ppm
Phase Change	Over a 200 ns time interval <sup>†</sup>	—	—	100	ps

\* (TBD) External 10 kΩ resistor to analog ground required.

<sup>†</sup> Translates to a frequency change of 500 ppm.

## Embedded Core LVDS I/O

Table 19. Driver dc Data\*

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
Output Voltage High, $V_{OA}$ or $V_{OB}$	$V_{OH}$	$R_{LOAD} = 100 \Omega \pm 1\%$	—	—	1.475 <sup>†</sup>	V
Output Voltage Low, $V_{OA}$ or $V_{OB}$	$V_{OL}$	$R_{LOAD} = 100 \Omega \pm 1\%$	0.925 <sup>†</sup>	—	—	V
Output Differential Voltage	$ V_{OD} $	$R_{LOAD} = 100 \Omega \pm 1\%$	0.25	—	0.45 <sup>†</sup>	V
Output Offset Voltage	$V_{OS}$	$R_{LOAD} = 100 \Omega \pm 1\%$	1.125*	—	1.275 <sup>†</sup>	V
Output Impedance, Differential	$R_o$	$V_{CM} = 1.0 \text{ V and } 1.4 \text{ V}$	80	100	120	$\Omega$
$R_o$ Mismatch Between A and B	$\Delta R_o$	$V_{CM} = 1.0 \text{ V and } 1.4 \text{ V}$	—	—	10	%
Change in Differential Voltage between Complimentary States	$ \Delta V_{OD} $	$R_{LOAD} = 100 \Omega \pm 1\%$	—	—	25	mV
Change in Output Offset Voltage between Complimentary States	$\Delta V_{OS}$	$R_{LOAD} = 100 \Omega \pm 1\%$	—	—	25	mV
Output Current	$I_{SA}, I_{SB}$	Driver shorted to GND	—	—	24	mA
Output Current	$I_{SAB}$	Drivers shorted together	—	—	12	mA
Power-off Output Leakage	$ I_{xa} ,  I_{xb} $	$V_{DD} = 0 \text{ V}$ $V_{PAD}, V_{PADN} = 0 \text{ V} - 2.5 \text{ V}$	—	—	10	mA

\*  $V_{DD33} = 3.1 \text{ V} - 3.5 \text{ V}$ ,  $V_{DD15} = 1.4 \text{ V} - 1.6 \text{ V}$ ,  $-40 \text{ }^\circ\text{C}$ , and Slow—Fast Process.

<sup>†</sup> External reference,  $REF10 = 1.0 \text{ V} \pm 3\%$ ,  $REF14 = 1.4 \text{ V} \pm 3\%$

Table 20. Driver ac Data\*

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
$V_{OD}$ Fall Time, 80% to 20%	$t_f$	$Z_L = 100 \Omega \pm 1\%$ $C_{PAD} = 3.0 \text{ pF}, C_{PADN} = 3.0 \text{ pF}$	100	—	210	ps
$V_{OD}$ Rise Time, 20% to 80%	$t_r$	$Z_L = 100 \Omega \pm 1\%$ $C_{PAD} = 3.0 \text{ pF}, C_{PADN} = 3.0 \text{ pF}$	100	—	210	ps
Differential Skew $ t_{PHLA} - t_{PLHB} $ or $ t_{PHLB} - t_{PLHA} $	$t_{SKEW1}$	Any differential pair on package at 50% point of the transition	—	—	50	ps
Channel-to-channel Skew $ t_{pDIFFm} - t_{pDIFFn} $ ,	$t_{SKEW2}$	Any two signals on package at 0 V differential	—	—	—	ps
Propagation Delay Time	$t_{PLH}$ $t_{PHL}$	$Z_L = 100 \Omega \pm 1\%$ $C_{PAD} = 3.0 \text{ pF}, C_{PADN} = 3.0 \text{ pF}$	0.54 0.55	0.77 0.76	1.10 1.09	ns ns

\*  $V_{DD33} = 3.1 \text{ V} - 3.5 \text{ V}$ ,  $V_{DD15} = 1.4 \text{ V} - 1.6 \text{ V}$ ,  $-40 \text{ }^\circ\text{C}$ , and Slow—Fast Process.

Table 21. Driver Power Consumption\*

Parameter	Symbol	Test Conditions	Min	Max	Unit
Driver dc Power	$PD_{dc}$	$Z_L = 100 \Omega \pm 1\%$	—	26.0	mW
Driver ac Power	$PD_{ac}$	$Z_L = 100 \Omega \pm 1\%$ $C_{PAD} = 3.0 \text{ pF}, C_{PADN} = 3.0 \text{ pF}$	—	64	$\mu\text{W}/\text{MHz}$

\*  $V_{DD33} = 3.1 \text{ V} - 3.5 \text{ V}$ ,  $V_{DD15} = 1.4 \text{ V} - 1.6 \text{ V}$ ,  $-40 \text{ }^\circ\text{C}$ , and Slow—Fast Process.

Embedded Core LVDS I/O (continued)

LVDS Receiver Buffer Requirements

Table 22. Receiver ac Data\*

Parameter	Symbol	Test Conditions	Min	Max	Unit
Pulse Width Distortion	tpwd	WIDTH = 100 mV, 450 MHz	—	160	ps
Propagation Delay Time	tPLH	CL = 0.5 pF	0.60	1.41	ns
	tPHL		0.60	1.47	ns
With Common-mode Variation (0 V to 2.4 V)	$ \Delta tPD $	CL = 0.5 pF	—	50	ps
Output Rise Time, 20% to 80%	tR	CL = 0.5 pF	150	350	ps
Output Fall Time, 80% to 20%	tF	CL = 0.5 pF	150	350	ps

\* V<sub>DD</sub> = 3.1 V—3.5 V, 0 °C—125 °C, slow-fast process.

Table 23. Receiver Power Consumption\*

Parameter	Symbol	Test Conditions	Min	Max	Unit
Receiver dc Power	PR <sub>dc</sub>	dc	—	20.4	mW
Receiver ac Power	PR <sub>ac</sub>	ac CL = 0.5 pF	—	4.5	μW/ MHz

\* V<sub>DD</sub> = 3.1 V—3.5 V, 0 °C—125 °C, slow-fast process.

Table 24. Receiver dc Data\*

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
Input Voltage Range, V <sub>IA</sub> or V <sub>IB</sub>	V <sub>I</sub>	$ VGPD  < 925$ mV dc – 1 MHz	0.0	1.2	2.4	V
Input Differential Threshold	WIDTH	$ VGPD  < 925$ mV 450 MHz	–100	—	100	mV
Input Differential Hysteresis	V <sub>HYST</sub>	(+WIDTH <sub>H</sub> ) – (–WIDTH <sub>L</sub> )	—	—	— <sup>†</sup>	mV
Receiver Differential Input Impedance	R <sub>IN</sub>	With build-in termination, center-tapped	80	100	120	Ω

\* V<sub>DD</sub> = 3.1 V—3.5 V, 0 °C—125 °C, slow-fast process.

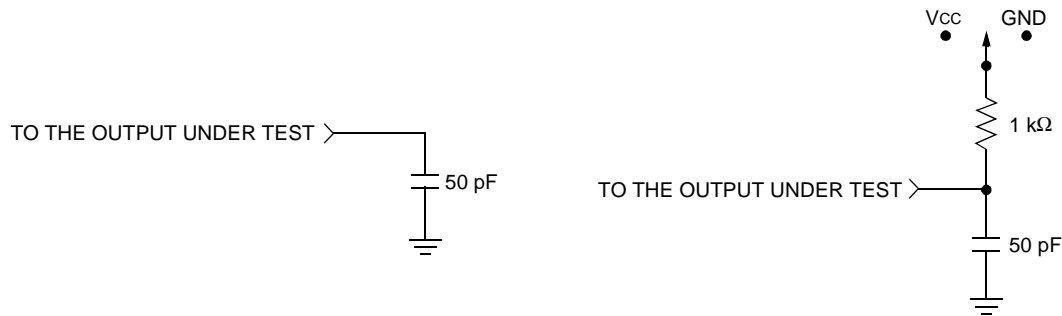
Table 25. LVDS Operating Parameters

Parameter	Test Conditions	Min	Normal	Max	Unit
Transmit Termination Resistor	—	80	100	120	Ω
Receiver Termination Resistor	—	80	100	120	Ω
Temperature Range	—	–40	—	125	°C
Power Supply V <sub>DD33</sub>	—	3.1	—	3.5	V
Power Supply V <sub>DD15</sub>	—	1.4	—	1.6	V
Power Supply V <sub>SS</sub>	—	—	0	—	V

Note: Under worst-case operating condition, the LVDS driver will withstand a disabled or unpowered receiver for an unlimited period of time without being damaged. Similarly, when outputs are short-circuited to each other or to ground, the LVDS will not suffer permanent damage. The LVDS driver supports hot-insertion. Under a well-controlled environment, the LVDS I/O can drive backplane as well as cable.



### Input/Output Buffer Measurement Conditions (on-LVDS Buffer)



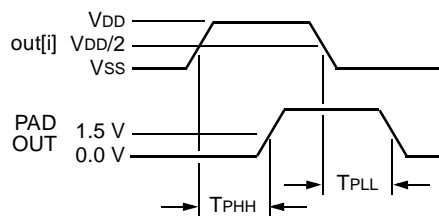
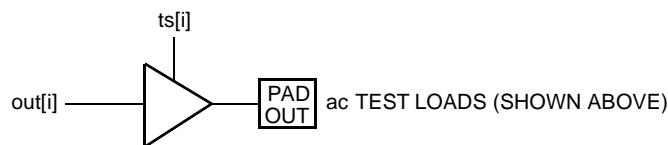
**A. Load Used to Measure Propagation Delay**

**B. Load Used to Measure Rising/Falling Edges**

Note: Switch to VDD for TPLZ/TPZL; switch to GND for TPHZ/TPZH.

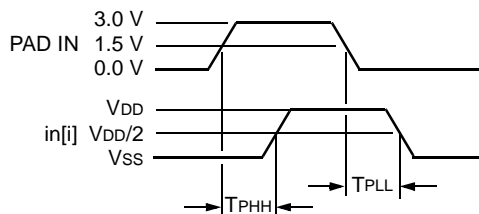
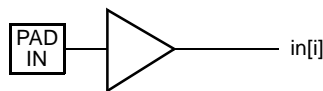
5-3234(F)

**Figure 16. ac Test Loads**



5-3233.a(F)

**Figure 17. Output Buffer Delays**



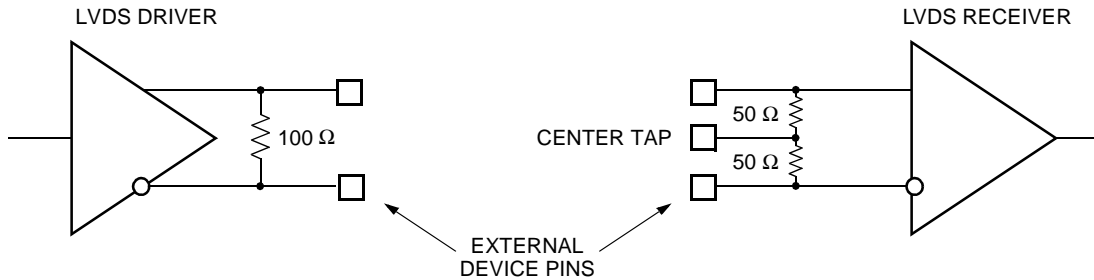
5-3235(F)

**Figure 18. Input Buffer Delays**

## LVDS Buffer Characteristics

### Termination Resistor

The LVDS drivers and receivers operate on a 100 Ω differential impedance, as shown below. External resistors are not required. The differential driver and receiver buffers include termination resistors inside the device package as shown in Figure 19 below.

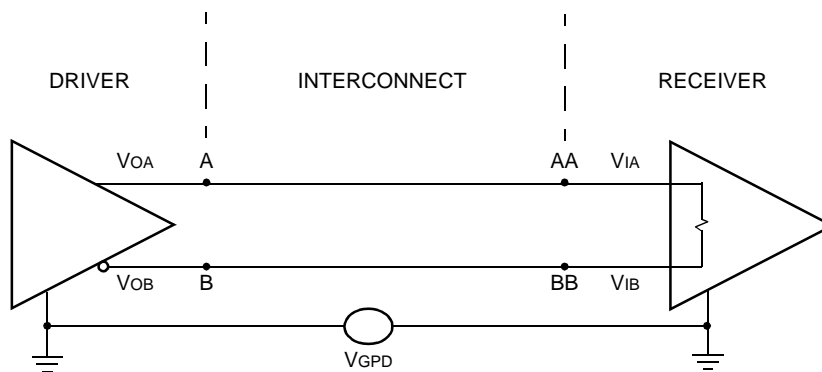


5-8703(F)

Figure 19. LVDS Driver and Receiver and Associated Internal Components

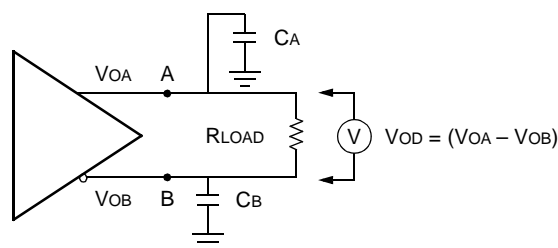
### LVDS Driver Buffer Capabilities

Under worst-case operating condition, the LVDS driver must withstand a disabled or unpowered receiver for an unlimited period of time without being damaged. Similarly, when its outputs are short-circuited to each other or to ground, the LVDS driver will not suffer permanent damage. Figure 20 illustrates the terms associated with LVDS driver and receiver pairs.



5-8704(F)

Figure 20. LVDS Driver and Receiver



5-8705(F)

Figure 21. LVDS Driver

## Pin Information

This section describes the pins and signals that perform FPGA-related functions. During configuration, the user-programmable I/Os are 3-stated and pulled-up with an internal resistor. If any FPGA function pin is not used (or not bonded to package pin), it is also 3-stated and pulled-up after configuration.

**Table 26. FPGA Common-Function Pin Description**

Symbol	I/O	Description
<b>Dedicated Pins</b>		
VDD33	—	3 V positive power supply.
VDD15	—	1.5 V positive power supply for internal logic.
VDDIO	—	Positive power supply used by I/O banks.
GND	—	Ground supply.
PLL_VF	—	Dedicated pins for PLL filtering.
PTEMP	I	Temperature sensing diode pin. Dedicated input.
$\overline{\text{RESET}}$	I	During configuration, $\overline{\text{RESET}}$ forces the restart of configuration and a pull-up is enabled. After configuration, RESET can be used as a general FPGA input or as a direct input, which causes all PLC latches/FFs to be asynchronously set/reset.
CCLK	I O	In the master and asynchronous peripheral modes, CCLK is an output which strobes configuration data in. In the slave or readback after configuration, CCLK is input synchronous with the data on DIN or D[7:0]. CCLK is an output for daisy-chain operation when the lead device is in master, peripheral, or system bus modes.
DONE	I	As an input, a low level on DONE delays FPGA start-up after configuration.*
	O	As an active-high, open-drain output, a high level on this signal indicates that configuration is complete. DONE has an optional pull-up resistor.
$\overline{\text{PRGM}}$	I	$\overline{\text{PRGM}}$ is an active-low input that forces the restart of configuration and resets the boundary-scan circuitry. This pin always has an active pull-up.
$\overline{\text{RD\_CFG}}$	I	This pin must be held high during device initialization until the $\overline{\text{INIT}}$ pin goes high. This pin always has an active pull-up.  During configuration, $\overline{\text{RD\_CFG}}$ is an active-low input that activates the TS_ALL function and 3-states all of the I/O.  After configuration, $\overline{\text{RD\_CFG}}$ can be selected (via a bit stream option) to activate the TS_ALL function as described above, or, if readback is enabled via a bit stream option, a high-to-low transition on $\overline{\text{RD\_CFG}}$ will initiate readback of the configuration data, including PFU output states, starting with frame address 0.
RD_DATA/TDO	O	RD_DATA/TDO is a dual-function pin. If used for readback, RD_DATA provides configuration data out. If used in boundary-scan, TDO is test data out.
$\overline{\text{CFG\_IRQ}}/\overline{\text{MPI\_IRQ}}$	O	During JTAG, slave, master, and asynchronous peripheral configuration assertion on this $\overline{\text{CFG\_IRQ}}$ (active-low) indicates an error or errors for block RAM or FPSC initialization. MPI active-low interrupt request output.

\* The FPGA States of Operation section contains more information on how to control these signals during start-up. The timing of DONE release is controlled by one set of bit stream options, and the timing of the simultaneous release of all other configuration pins (and the activation of all user I/Os) is controlled by a second set of options.

Pin Information (continued)

Table 26. FPGA Common-Function Pin Description (continued)

Symbol	I/O	Description
<b>Special-Purpose Pins</b> (Can also be used as a general I/O.)		
M[3:0]	I	During powerup and initialization, M0—M3 are used to select the configuration mode with their values latched on the rising edge of $\overline{\text{INIT}}$ . During configuration, a pull-up is enabled.
	I/O	After configuration, these pins are user-programmable I/O.*
PLL_CK[0:7]	I/O	Dedicated PCM clock pins. These pins are a user-programmable I/O pins if not used by PLLs.
P[ $\overline{\text{TBTR}}$ ]CLK[1:0][TC]	I/O	Pins dedicated for the primary clock. Input pins on the middle of each side with differential pairing. They may be used as general I/O pins if not needed for clocking purposes.
TDI, TCK, TMS	I	If boundary-scan is used, these pins are test data in, test clock, and test mode select inputs. If boundary-scan is not selected, all boundary-scan functions are inhibited once configuration is complete. Even if boundary-scan is not used, either TCK or TMS must be held at logic 1 during configuration. Each pin has a pull-up enabled during configuration.
	I/O	After configuration, these pins are user-programmable I/O.*
RDY/BUSY/RCLK	O	During configuration in peripheral mode, RDY/RCLK indicates another byte can be written to the FPGA. If a read operation is done when the device is selected, the same status is also available on D7 in asynchronous peripheral mode. After configuration, if the MPI is not used, this pin is a user-programmable I/O pin.*
	I/O	During the master parallel configuration mode, RCLK is a read output signal to an external memory. This output is not normally used.
HDC	O	High during configuration is output high until configuration is complete. It is used as a control output, indicating that configuration is not complete.
	I/O	After configuration, this pin is a user-programmable I/O pin.*
$\overline{\text{LDC}}$	O	Low during configuration is output low until configuration is complete. It is used as a control output, indicating that configuration is not complete.
	I/O	After configuration, this pin is a user-programmable I/O pin.*
$\overline{\text{INIT}}$	I/O	$\overline{\text{INIT}}$ is a bidirectional signal before and during configuration. During configuration, a pull-up is enabled, but an external pull-up resistor is recommended. As an active-low open-drain output, $\overline{\text{INIT}}$ is held low during power stabilization and internal clearing of memory. As an active-low input, $\overline{\text{INIT}}$ holds the FPGA in the wait-state before the start of configuration. After configuration, this pin is a user-programmable I/O pin.*
$\overline{\text{CS0}}$ , CS1	I	$\overline{\text{CS0}}$ and CS1 are used in the asynchronous peripheral, slave parallel, and microprocessor configuration modes. The FPGA is selected when $\overline{\text{CS0}}$ is low and CS1 is high. During configuration, a pull-up is enabled.
	I/O	After configuration, these pins are user-programmable I/O pins.*
RD/MPI_STRB	I	$\overline{\text{RD}}$ is used in the asynchronous peripheral configuration mode. A low on $\overline{\text{RD}}$ changes D7 into a status output. As a status indication, a high indicates ready, and a low indicates busy. $\overline{\text{WR}}$ and $\overline{\text{RD}}$ should not be used simultaneously. If they are, the write strobe overrides. This pin is also used as the MPI data transfer strobe.
	I/O	After configuration, if the MPI is not used, this pin is a user-programmable I/O pin.*

\* The FPGA States of Operation section contains more information on how to control these signals during start-up. The timing of DONE release is controlled by one set of bit stream options, and the timing of the simultaneous release of all other configuration pins (and the activation of all user I/Os) is controlled by a second set of options.

Pin Information (continued)

Table 26. FPGA Common-Function Pin Description (continued)

Symbol	I/O	Description
A[17:0]	I	During MPI mode, the A[17:0] are used as the address bus driven by the <i>PowerPC</i> bus master utilizing the least significant bits of the <i>PowerPC</i> 32-bit address.
$\overline{\text{MPI\_BURST}}$	O	During master parallel configuration mode, A[17:0] address the configuration EPROM. In MPI mode, many of the A[n] pins have alternate uses as described below. See the special function blocks section for more MPI information. During configuration, if not in master parallel or an MPI configuration mode, these pins are 3-stated with a pull-up enabled. A[21] is used as the $\overline{\text{MPI\_BURST}}$ . It is driven low to indicate a burst transfer is in progress. Driven high indicates that the current transfer is not a burst.
$\overline{\text{MPI\_BDIP}}$	O	A[22] is used as the $\overline{\text{MPI\_BDIP}}$ . It is driven by the <i>PowerPC</i> processor assertion of this pin indicates that the second beat in front of the current one is requested by the master. Negated before the burst transfer ends to abort the burst data phase.
MPI_TSZ[1:0]	O	A[19:18] are used as the MPI_TSZ[1:0] signals and are driven by the bus master to indicate the data transfer size for the transaction. Set 01 for byte, 10 for half-word, and 00 for word.
A[21:0]	O	During master parallel mode A[21:0], address the configuration EPROMs up to 4M bytes. If not used for MPI, these pins are user-programmable I/O pins.*
$\overline{\text{MPI\_ACK}}$	O	In <i>PowerPC</i> mode MPI operation, this is driven low indicating the MPI received the data on the write cycle or returned data on a read cycle.
$\overline{\text{MPI\_CLK}}$	I	This is the <i>PowerPC</i> synchronous, positive-edge bus clock used for the MPI interface. It can be a source of the clock for the embedded system bus. If MPI is used, this can be the <i>AMBA</i> bus clock.
$\overline{\text{MPI\_TEA}}$	O	A low on the MPI transfer error acknowledge indicates that the MPI detects a bus error on the internal system bus for the current transaction.
$\overline{\text{MPI\_RTRY}}$	O	This pin requests the MPC860 to relinquish the bus and retry the cycle.
D[31:0]	I/O	Selectable data bus width from 8-, 16-, 32-bit. Driven by the bus master in a write transaction. Driven by MPI in a read transaction.
	I	D[7:0] receive configuration data during master parallel, peripheral, and slave parallel configuration modes and each pin has a pull-up enabled. During serial configuration modes, D0 is the DIN input. D[7:3] output internal status for asynchronous peripheral mode when RD is low. After configuration, the pins are user-programmable I/O pins.*
DP[3:0]	I/O	Selectable parity bus width from 1, 2, 4-bit, DP[0] for D[7:0], DP[1] for D[15:8], DP[2] for D[23:16], and DP[3] for D[32:24]. After configuration, this pin is a user-programmable I/O pin.*
DIN	I	During slave serial or master serial configuration modes, DIN accepts serial configuration data synchronous with CCLK. During parallel configuration modes, DIN is the D0 input. During configuration, a pull-up is enabled.
	I/O	After configuration, this pin is a user-programmable I/O pin.*
DOUT	O	During configuration, DOUT is the serial data output that can drive the DIN of daisy-chained slave devices. Data out on DOUT changes on the rising edge of CCLK.
	I/O	After configuration, DOUT is a user-programmable I/O pin.*

\* The FPGA States of Operation section contains more information on how to control these signals during start-up. The timing of DONE release is controlled by one set of bit stream options, and the timing of the simultaneous release of all other configuration pins (and the activation of all user I/Os) is controlled by a second set of options.

**Pin Information** (continued)

This section describes device I/O signals to/from the embedded core excluding the signals at the CIC boundary.

**Table 27. FPSC Function Pin Description**

Symbol	I/O	Description
<b>HSI LVDS Pins</b>		
rxd_b_p0	I	LVDS work link—Channel AA (Shared with <i>RapidIO</i> ports B and C).
rxd_b_n0	I	LVDS work link—Channel AA (Shared with <i>RapidIO</i> ports B and C).
rxd_c_p0	I	LVDS protect link—Channel AA (Shared with <i>RapidIO</i> ports B and C).
rxd_c_n0	I	LVDS protect link—Channel AA (Shared with <i>RapidIO</i> ports B and C).
rxd_b_p1	I	LVDS work link—Channel AB (Shared with <i>RapidIO</i> ports B and C).
rxd_b_n1	I	LVDS work link—Channel AB (Shared with <i>RapidIO</i> ports B and C).
rxd_c_p1	I	LVDS protect link—Channel AB (Shared with <i>RapidIO</i> ports B and C).
rxd_c_n1	I	LVDS protect link—Channel AB (Shared with <i>RapidIO</i> ports B and C).
rxd_b_p2	I	LVDS work link—Channel AC (Shared with <i>RapidIO</i> ports B and C).
rxd_b_n2	I	LVDS work link—Channel AC (Shared with <i>RapidIO</i> ports B and C).
rxd_c_p2	I	LVDS protect link—Channel AC (Shared with <i>RapidIO</i> ports B and C).
rxd_c_n2	I	LVDS protect link—Channel AC (Shared with <i>RapidIO</i> ports B and C).
rxd_b_p3	I	LVDS work link—Channel AD (Shared with <i>RapidIO</i> ports B and C).
rxd_b_n3	I	LVDS work link—Channel AD (Shared with <i>RapidIO</i> ports B and C).
rxd_c_p3	I	LVDS protect link—Channel AD (Shared with <i>RapidIO</i> ports B and C).
rxd_c_n3	I	LVDS protect link—Channel AD (Shared with <i>RapidIO</i> ports B and C).
rxd_b_p4	I	LVDS work link—Channel BA (Shared with <i>RapidIO</i> ports B and C).
rxd_b_n4	I	LVDS work link—Channel BA (Shared with <i>RapidIO</i> ports B and C).
rxd_c_p4	I	LVDS protect link—Channel BA (Shared with <i>RapidIO</i> ports B and C).
rxd_c_n4	I	LVDS protect link—Channel BA (Shared with <i>RapidIO</i> ports B and C).
rxd_b_p5	I	LVDS work link—Channel BB (Shared with <i>RapidIO</i> ports B and C).
rxd_b_n5	I	LVDS work link—Channel BB (Shared with <i>RapidIO</i> ports B and C).
rxd_c_p5	I	LVDS protect link—Channel BB (Shared with <i>RapidIO</i> ports B and C).
rxd_c_n5	I	LVDS protect link—Channel BB (Shared with <i>RapidIO</i> ports B and C).
rxd_b_p6	I	LVDS work link—Channel BC (Shared with <i>RapidIO</i> ports B and C).
rxd_b_n6	I	LVDS work link—Channel BC (Shared with <i>RapidIO</i> ports B and C).
rxd_c_p6	I	LVDS protect link—Channel BC (Shared with <i>RapidIO</i> ports B and C).
rxd_c_n6	I	LVDS protect link—Channel BC (Shared with <i>RapidIO</i> ports B and C).
rxd_b_p7	I	LVDS work link—Channel BD (Shared with <i>RapidIO</i> ports B and C).
rxd_b_n7	I	LVDS work link—Channel BD (Shared with <i>RapidIO</i> ports B and C).
rxd_c_p7	I	LVDS protect link—Channel BD (Shared with <i>RapidIO</i> ports B and C).
rxd_c_n7	I	LVDS protect link—Channel BD (Shared with <i>RapidIO</i> ports B and C).
pll_VDDA	—	PLL analog VDD (3.3 V ± 5% (Shared with <i>RapidIO</i> ports B and C)).
pll_VSSA	—	PLL analog VSS (GND) (Shared with <i>RapidIO</i> ports B and C).

Pin Information (continued)

Table 27. FPSC Function Pin Description (continued)

Symbol	I/O	Description
<b>HSI Test Signals</b>		
tstclk	I	Test clock for emulation of 622 MHz clock during PLL bypass. Internal pull-down.
mreset	I	Test mode reset. Internal pull-down.
testrst	I	Resets receiver clock division counter. Internal pull-up.
resetx	I	Resets transmitter clock division counter. Internal pull-up.
tstmux[9:0]s	O	Test mode output port.
<b>RapidIO LVDS Interface Pins (Receiver)</b>		
rxd_a_p<7:0>	I	LVDS data for <i>RapidIO</i> , receiver port A.
rxd_a_n<7:0>	I	LVDS data for <i>RapidIO</i> , receiver port A.
rxsoc_a_p	I	LVDS start-of-cell for <i>RapidIO</i> , receiver port A.
rxsoc_a_n	I	LVDS start-of-cell for <i>RapidIO</i> , receiver port A.
rxclk_a_p	I	LVDS receive clock for <i>RapidIO</i> , receiver port A.
rxclk_a_n	I	LVDS receive clock for <i>RapidIO</i> , receiver port A.
lvctap_a<1:0>	—	LVDS input center tap (use 0.01 uF to GND).
lvref10_a	—	LVDS reference voltage: 1.0 V ± 3%.
lvref14_a	—	LVDS reference voltage: 1.4 V ± 3%.
lvresh_a	—	LVDS resistor high pin (Use 100 Ω to lvresl_a pin).
lvresl_a	—	LVDS resistor low pin (Use 100 Ω to lvresh_a pin).
rxd_b_p<7:0>	I	LVDS data for <i>RapidIO</i> , receiver port B.
rxd_b_n<7:0>	I	LVDS data for <i>RapidIO</i> , receiver port B.
rxsoc_b_p	I	LVDS Start-of-Cell for <i>RapidIO</i> , receiver port B.
rxsoc_b_n	I	LVDS Start-of-Cell for <i>RapidIO</i> , receiver port B.
rxclk_b_p	I	LVDS receive clock for <i>RapidIO</i> , receiver port B.
rxclk_b_n	I	LVDS receive clock for <i>RapidIO</i> , receiver port B.
lvctap_b<4:0>	—	LVDS input center tap (use 0.01 uF to GND).
lvref10_b	—	LVDS reference voltage: 1.0 V ± 3%.
lvref14_b	—	LVDS reference voltage: 1.4 V ± 3%.
lvresh_b	—	LVDS resistor high pin (Use 100 Ω to lvresl_b pin).
lvresl_b	—	LVDS resistor low pin (Use 100 Ω to lvresh_b pin).
rxd_c_p<7:0>	I	LVDS data for <i>RapidIO</i> , receiver port C.
rxd_c_n<7:0>	I	LVDS data for <i>RapidIO</i> , receiver port C.
rxsoc_c_p	I	LVDS Start-of-Cell for <i>RapidIO</i> , receiver port C.
rxsoc_c_n	I	LVDS Start-of-Cell for <i>RapidIO</i> , receiver port C.
rxclk_c_p	I	LVDS receive clock for <i>RapidIO</i> , receiver port C.
rxclk_c_n	I	LVDS receive clock for <i>RapidIO</i> , receiver port C.
lvctap_c<4:0>	—	LVDS input center tap (use 0.01 uF to GND).
lvref10_c	—	LVDS reference voltage: 1.0 V ± 3%.
lvref14_c	—	LVDS reference voltage: 1.4 V ± 3%.
lvresh_c	—	LVDS resistor high pin (Use 100 Ω to lvresl_c pin).
lvresl_c	—	LVDS resistor low pin (Use 100 Ω to lvresh_c pin).

\* BSCAN pins-TDI, TDO, TCK, and TMS are on FPGA side.

Pin Information (continued)

Table 27. FPSC Function Pin Description (continued)

Symbol	I/O	Description
<b>RapidIO LVDS Interface Pins (Transmitter)</b>		
txd_a_p<7:0>	O	LVDS data for <i>RapidIO</i> , transmitter port A.
txd_a_n<7:0>	O	LVDS data for <i>RapidIO</i> , transmitter port A.
txsoc_a_p	O	LVDS start-of-cell for <i>RapidIO</i> , transmitter port A.
txsoc_a_n	O	LVDS start-of-cell for <i>RapidIO</i> , transmitter port A.
txclk_a_p	O	LVDS receive clock for <i>RapidIO</i> , transmitter port A.
txclk_a_n	O	LVDS receive clock for <i>RapidIO</i> , transmitter port A.
txd_b_p<7:0>	O	LVDS data for <i>RapidIO</i> , transmitter port B.
txd_b_n<7:0>	O	LVDS data for <i>RapidIO</i> , transmitter port B.
txsoc_b_p	O	LVDS start-of-cell for <i>RapidIO</i> , transmitter port B.
txsoc_b_n	O	LVDS start-of-cell for <i>RapidIO</i> , transmitter port B.
txclk_b_p	O	LVDS receive clock for <i>RapidIO</i> , transmitter port B.
txclk_b_n	O	LVDS receive clock for <i>RapidIO</i> , transmitter port B.
txd_c_p<7:0>	O	LVDS data for <i>RapidIO</i> , transmitter port C.
txd_c_n<7:0>	O	LVDS data for <i>RapidIO</i> , transmitter port C.
txsoc_c_p	O	LVDS start-of-cell for <i>RapidIO</i> , transmitter port C.
txsoc_c_n	O	LVDS start-of-cell for <i>RapidIO</i> , transmitter port C.
txclk_c_p	O	LVDS receive clock for <i>RapidIO</i> , transmitter port C.
txclk_c_n	O	LVDS receive clock for <i>RapidIO</i> , transmitter port C.
<b>MISC System Signals</b>		
rst_n	I	Reset the core only. The FPGA logic is not reset by rst_n. Internal pull-down allows chip to stay in reset state when external driver loses power.
sys_clk_p	I	LVDS system clock (77.76 MHz), 50% duty cycle, also the reference clock of PLL.
sys_clk_n	I	LVDS system clock (77.76 MHz), 50% duty cycle, also the reference clock of PLL.
gclk_p	I	LVDS clock for <i>RapidIO</i> PLL.
gclk_n	I	LVDS clock for <i>RapidIO</i> PLL.
dxp	—	Temperature sensing diode (anode +).
dxn	—	Temperature sensing diode (cathode –).



**Pin Information** (continued)

In Table 28, an input refers to a signal flowing into the FPGA logic (out of the embedded core) and an output refers to a signal flowing out of the FPGA logic (into the embedded core).

**Table 28. Embedded Core/FPGA Interface Signal Description**

Pin Name	I/O	Description
<b>STM Signals</b>		
dinaa<7:0>	O	Parallel bus of STM slice A, transmitter A. MSB is bit 7.
dinaa_par	O	Parity for STM slice A, transmitter A.
dinaa_fp	O	Frame pulse for STM slice A, transmitter A.
dinab<7:0>	O	Parallel bus of STM slice A, transmitter B. MSB is bit 7.
dinab_par	O	Parity for STM slice A, transmitter B.
dinab_fp	O	Frame pulse for STM slice A, transmitter B.
dinac<7:0>	O	Parallel bus of STM slice A, transmitter C. MSB is bit 7.
dinac_par	O	Parity for STM slice A, transmitter C.
dinac_fp	O	Frame pulse for STM slice A, transmitter C.
dinad<7:0>	O	Parallel bus of STM slice A, transmitter D. MSB is bit 7.
dinad_par	O	Parity for STM slice A, transmitter D.
dinad_fp	O	Frame pulse for STM slice A, transmitter D.
dinba<7:0>	O	Parallel bus of STM slice B, transmitter A. MSB is bit 7.
dinba_par	O	Parity for STM slice B, transmitter A.
dinba_fp	O	Frame pulse for STM slice B, transmitter A.
dinbb<7:0>	O	Parallel bus of STM slice B, transmitter B. MSB is bit 7.
dinbb_par	O	Parity for STM slice B, transmitter B.
dinbb_fp	O	Frame pulse for STM slice B, transmitter B.
dinbc<7:0>	O	Parallel bus of STM slice B, transmitter C. MSB is bit 7.
dinbc_par	O	Parity for STM slice B, transmitter C.
dinbc_fp	O	Frame pulse for STM slice B, transmitter C.
dinbd<7:0>	O	Parallel bus of STM slice B, transmitter D. MSB is bit 7.
dinbd_par	O	Parity for STM slice B, transmitter D.
dinbd_fp	O	Frame pulse for STM slice B, transmitter D.
doutaa<7:0>	I	Parallel bus of STM slice A, receiver A. MSB is bit 7.
doutaa_par	I	Parity for parallel bus of STM slice A, receiver A.
doutaa_spe	I	SPE signal for parallel bus of STM slice A, receiver A.
doutaa_c1j1	I	C1J1 signal for parallel bus of STM slice A, receiver A.
doutaa_en	I	Enable for parallel bus of STM slice A, receiver A.
doutaa_fp	I	Frame pulse for parallel bus of STM slice A, receiver A.
doutab<7:0>	I	Parallel bus of STM slice B, receiver A. MSB is bit 7.
doutab_par	I	Parity for parallel bus of STM slice A, receiver B.
doutab_spe	I	SPE signal for parallel bus of STM slice A, receiver B.
doutab_c1j1	I	C1J1 signal for parallel bus of STM slice A, receiver B.
doutab_en	I	Enable for parallel bus of STM slice A, receiver B.
doutab_fp	I	Frame pulse for parallel bus of STM slice A, receiver B.

Pin Information (continued)

Table 28. Embedded Core/FPGA Interface Signal Description (continued)

Pin Name	I/O	Description
<b>STM signals (continued)</b>		
doutac<7:0>	I	Parallel bus of STM slice A, receiver C. MSB is bit 7.
doutac_par	I	Parity for parallel bus of STM slice A, receiver C.
doutac_spe	I	SPE signal for parallel bus of STM slice A, receiver C.
doutac_c1j1	I	C1J1 signal for parallel bus of STM slice A, receiver C.
doutac_en	I	Enable for parallel bus of STM slice A, receiver C.
doutac_fp	I	Frame pulse for parallel bus of STM slice A, receiver C.
doutad<7:0>	I	Parallel bus of STM slice A, receiver D. MSB is bit 7.
doutad_par	I	Parity for parallel bus of STM slice A, receiver D.
doutad_spe	I	SPE signal for parallel bus of STM slice A, receiver D.
doutad_c1j1	I	C1J1 signal for parallel bus of STM slice A, receiver D.
doutad_en	I	Enable for parallel bus of STM slice A, receiver D.
doutad_fp	I	Frame pulse for parallel bus of STM slice A, receiver D.
doutba<7:0>	I	Parallel bus of STM slice B, receiver A. MSB is bit 7.
doutba_par	I	Parity for parallel bus of STM slice B, receiver A.
doutba_spe	I	SPE signal for parallel bus of STM slice B, receiver A.
doutba_c1j1	I	C1J1 signal for parallel bus of STM slice B, receiver A.
doutba_en	I	Enable for parallel bus of STM slice B, receiver A.
doutba_fp	I	Frame pulse for parallel bus of STM slice B, receiver A.
doutbb<7:0>	I	Parallel bus of STM slice B, receiver B. MSB is bit 7.
doutbb_par	I	Parity for parallel bus of STM slice B, receiver B.
doutbb_spe	I	SPE signal for parallel bus of STM slice B, receiver B.
doutbb_c1j1	I	C1J1 signal for parallel bus of STM slice B, receiver B.
doutbb_en	I	Enable for parallel bus of STM slice B, receiver B.
doutbb_fp	I	Frame pulse for parallel bus of STM slice B, receiver A.
doutbc<7:0>	I	Parallel bus of STM slice B, receiver C. MSB is bit 7.
doutbc_par	I	Parity for parallel bus of STM slice B, receiver C.
doutbc_spe	I	SPE signal for parallel bus of STM slice B, receiver C.
doutbc_c1j1	I	C1J1 signal for parallel bus of STM slice B, receiver C.
doutbc_en	I	Enable for parallel bus of STM slice B, receiver C.
doutbc_fp	I	Frame pulse for parallel bus of STM slice B, receiver C.
doutbd<7:0>	I	Parallel bus of STM slice B, receiver D. MSB is bit 7.
doutbd_par	I	Parity for parallel bus of STM slice B, receiver D.
doutbd_spe	I	SPE signal for parallel bus of STM slice B, receiver D.
doutbd_c1j1	I	C1J1 signal for parallel bus of STM slice B, receiver D.
doutbd_en	I	Enable for parallel bus of STM slice B, receiver D.
doutbd_fp	I	Frame pulse for parallel bus of STM slice B, receiver D.

Pin Information (continued)

Table 28. Embedded Core/FPGA Interface Signal Description (continued)

Pin Name	I/O	Description
<b>TOH signals</b>		
toh_clk	O	TX and RX TOH serial links clock (25 MHz to 77.76 MHz).
toh_inaa	O	TOH serial link for STM slice A, transmitter A.
toh_inab	O	TOH serial link for STM slice A, transmitter B.
toh_inac	O	TOH serial link for STM slice A, transmitter C.
toh_inad	O	TOH serial link for STM slice A, transmitter D.
toh_inba	O	TOH serial link for STM slice B, transmitter A.
toh_inbb	O	TOH serial link for STM slice B, transmitter B.
toh_inbc	O	TOH serial link for STM slice B, transmitter C.
toh_inbd	O	TOH serial link for STM slice B, transmitter D.
tx_toh_ck_en	O	TX TOH serial link clock enable.
toh_outaa	I	TOH serial link for STM slice A, receiver A.
toh_outab	I	TOH serial link for STM slice A, receiver B.
toh_outac	I	TOH serial link for STM slice A, receiver C.
toh_outad	I	TOH serial link for STM slice A, receiver D.
toh_outba	I	TOH serial link for STM slice B, receiver A.
toh_outbb	I	TOH serial link for STM slice B, receiver B.
toh_outbc	I	TOH serial link for STM slice B, receiver C.
toh_outbd	I	TOH serial link for STM slice B, receiver D.
rx_toh_ck_en	I	RX TOH serial link clock enable.
rx_toh_fp	I	RX TOH serial link frame pulse.
toh_ck_fp_en	I	A soft register bit available to enable RX TOH clock and frame pulse.
toh_aa_en	I	RX TOH enable, soft register. AND output of resistor channel AA enable and hi-z control of TOH data output AA.
toh_ab_en	I	RX TOH enable, soft register. AND output of resistor channel AB enable and hi-z control of TOH data output AB.
toh_ac_en	I	RX TOH enable, soft register. AND output of resistor channel AC enable and hi-z control of TOH data output AC.
toh_ad_en	I	RX TOH enable, soft register. AND output of resistor channel AD enable and hi-z control of TOH data output AD.
toh_ba_en	I	RX TOH enable, soft register. AND output of resistor channel BA enable and hi-z control of TOH data output BA.
toh_bb_en	I	RX TOH enable, soft register. AND output of resistor channel BB enable and hi-z control of TOH data output BB.
toh_bc_en	I	RX TOH enable, soft register. AND output of resistor channel BC enable and hi-z control of TOH data output BC.
toh_bd_en	I	RX TOH enable, soft register. AND output of resistor channel BD enable and hi-z control of TOH data output BD.

Pin Information (continued)

Table 28. Embedded Core/FPGA Interface Signal Description (continued)

Pin Name	I/O	Description
<b>STM clock and control</b>		
sys_fp	O	System frame pulse for transmitter section.
line_fp	O	Line frame pulse for receiver section.
fpga_sysclk	I	System clock (77.76 MHz).
prot_switch_aa	O	Protection switching control signal.
prot_switch_ac	O	Protection switching control signal.
prot_switch_ba	O	Protection switching control signal.
prot_switch_bc	O	Protection switching control signal.
lvds_prot_aa	O	Protection switching control signal.
lvds_prot_ab	O	Protection switching control signal.
lvds_prot_ac	O	Protection switching control signal.
lvds_prot_ad	O	Protection switching control signal.
lvds_prot_ba	O	Protection switching control signal.
lvds_prot_bb	O	Protection switching control signal.
lvds_prot_bc	O	Protection switching control signal.
lvds_prot_bd	O	Protection switching control signal.
core_ready	I	During powerup and FPGA configuration sequence, the core_ready is held low. At the end of FPGA configuration, the core_ready will be held low for six clock (sys_clk) cycles and then go active-high. Flag indicates that the embedded core is out of its reset state.
cdr_clk_aa	I	77.76 MHz recovered clock for STM slice A, channel A.
cdr_clk_ab	I	77.76 MHz recovered clock for STM slice A, channel B.
cdr_clk_ac	I	77.76 MHz recovered clock for STM slice A, channel C.
cdr_clk_ad	I	77.76 MHz recovered clock for STM slice A, channel D.
cdr_clk_ba	I	77.76 MHz recovered clock for STM slice B, channel A.
cdr_clk_bb	I	77.76 MHz recovered clock for STM slice B, channel B.
cdr_clk_bc	I	77.76 MHz recovered clock for STM slice B, channel C.
cdr_clk_bd	I	77.76 MHz recovered clock for STM slice B, channel D.
<b>8B/10B Mode signals</b>		
tx_k_ctrl_aa	O	K control bit for STM slice A, channel A.
tx_k_ctrl_ab	O	K control bit for STM slice A, channel B.
tx_k_ctrl_ac	O	K control bit for STM slice A, channel C.
tx_k_ctrl_ad	O	K control bit for STM slice A, channel D.
tx_k_ctrl_ba	O	K control bit for STM slice B, channel A.
tx_k_ctrl_bb	O	K control bit for STM slice B, channel B.
tx_k_ctrl_bc	O	K control bit for STM slice B, channel C.
tx_k_ctrl_bd	O	K control bit for STM slice B, channel D.

Pin Information (continued)

Table 28. Embedded Core/FPGA Interface Signal Description (continued)

Pin Name	I/O	Description
<b>RapidIO signals (Channel A)</b>		
csysenb_a	O	System cell processing enable. After reset is released, drive this signal high when <i>RapidIO</i> is ready to transmit cells. This signal should be active after all control signals into the <i>RapidIO</i> are stable.
rstn_rx_a	O	Synchronous reset for all memory elements clocked by WRXCLK_A_FPGA (derived from PLL).
utxd_a<31:0>	O	Transmit data bus containing 4 octets synchronized with the rising edge of the 60-146 MHz WUTXCLK_FPGA (derived from PLL) is clocked into the transmit FIFO within the <i>RapidIO</i> .
utxsoc_a	O	Start of cell originating with the core and synchronized with the rising edge of WUTXCLK_FPGA into the transmit FIFO. Indicates the first data word on TXD_A bus includes the first octet of a new cell in bit positions <31:24>.
rstn_utx_a	O	Synchronous reset for all memory elements in the WUTXCLK_FPGA domain.
utxtristn_a	O	Output 3-state enable (active-low). When active, the TXD_A, TXSOC_A, and TXCLK_A LVDS drivers are tri-stated.
ytristn_a	O	3-state override for transmit outputs (active-low). This signal is ignored during reset, but takes priority over all tri-state control signals otherwise.
zrxld_a<31:0>	I	32-bit data from the receive module. The bus contains 4 octets and reflects data received via the high speed RXD_A data bus.
zrxsoc_a	I	Indicates the presence of the 1st octet of a new cell within the 1st 32-bit data word on the RXD_A bus in bit positions <31:24>.
zrxsocviol_a	I	Indicates a minimum cell violation within the receive module. This signal will transition active high coincident with RXSOC. This indicates that the new cell overran the previous cell and that the previous cell is in violation of the minimum cell size.
zrxalnvio_a	I	Indicates an alignment error. An active state signals RXSOC was captured on a negative RXCLK edge. This signal will stay high for a single WRXCLK_A_FPGA cycle coincident with RXSOC.
zclkstat_a	I	Indicates the loss or absence of a clock on the LVDS clock (RXCLK). After the validation of the absence of the clock, this signal will stay high for the duration of the absence of the clock.
wrxclk_a_fpga	I	Derived from high-speed LVDS clock RXCLK (= RXCLK/2).
<b>RapidIO signals (Channel B)</b>		
csysenb_b	O	System cell processing enable. After reset is released, drive this signal high when <i>RapidIO</i> is ready to transmit cells. This signal should be active after all control signals into the <i>RapidIO</i> are stable.

Pin Information (continued)

Table 28. Embedded Core/FPGA Interface Signal Description (continued)

Pin Name	I/O	Description
<b>RapidIO signals (Channel B) continued</b>		
rstn_rx_b	O	Synchronous reset for all memory elements clocked by WRXCLK_B_FPGA (derived from PLL).
utxd_b<31:0>	O	Transmit data bus containing 4 octets synchronized with the rising edge of the 60—146 MHz WUTXCLK_FPGA (derived from PLL) is clocked into the transmit FIFO within the <i>RapidIO</i> .
utxsoc_b	O	Start of cell originating with the core and synchronized with the rising edge of WUTXCLK_FPGA into the transmit FIFO. Indicates the first data word on TXD_B bus includes the first octet of a new cell in bit positions <31:24>.
rstn_utx_b	O	Synchronous reset for all memory elements in the WUTXCLK_FPGA domain.
utxtristn_b	O	Output 3-state enable (active-low). When active, the TXD_B, TXSOC_B, and TXCLK_B LVDS drivers are tri-stated.
ytristn_b	O	3-state override for transmit outputs (active-low). This signal is ignored during reset, but takes priority over all tri-state control signals otherwise.
zrx_d_b<31:0>	I	32-bit data from the receive module. The bus contains 4 octets and reflects data received via the high speed RXD_B data bus.
zrxsoc_b	I	Indicates the presence of the 1st octet of a new cell within the 1st 32-bit data word on the RXD_B bus in bit positions <31:24>.
zrxsocviol_b	I	Indicates a minimum cell violation within the receive module. This signal will transition active high coincident with RXSOC. This indicates that the new cell overran the previous cell and that the previous cell is in violation of the minimum cell size.
zrxalnviol_b	I	Indicates an alignment error. An active state signals RXSOC was captured on a negative RXCLK edge. This signal will stay high for a single WRXCLK_B_FPGA cycle coincident with RXSOC.
zclkstat_b	I	Indicates the loss or absence of a clock on the LVDS clock (RXCLK). After the validation of the absence of the clock, this signal will stay high for the duration of the absence of the clock.
wrxclk_b_fpga	I	Derived from high-speed LVDS clock RXCLK (= RXCLK/2).
<b>RapidIO signals (Channel C)</b>		
csysenb_c	O	System cell processing enable. After reset is released, drive this signal high when <i>RapidIO</i> is ready to transmit cells. This signal should be active after all control signals into the <i>RapidIO</i> are stable.
rstn_rx_c	O	Synchronous reset for all memory elements clocked by WRXCLK_C_FPGA (derived from PLL).

Pin Information (continued)

Table 28. Embedded Core/FPGA Interface Signal Description (continued)

Pin Name	I/O	Description
<b>RapidIO signals (Channel C) continued</b>		
utxd_c<31:0>	O	Transmit data bus containing 4 octets synchronized with the rising edge of the 60-146 MHz WUTXCLK_FPGA (derived from PLL) is clocked into the transmit FIFO within the <i>RapidIO</i> .
utxsoc_c	O	Start of cell originating with the core and synchronized with the rising edge of WUTXCLK_FPGA into the transmit FIFO. Indicates the first data word on TXD_C bus includes the first octet of a new cell in bit positions <31:24>.
rstn_utx_c	O	Synchronous reset for all memory elements in the WUTXCLK_FPGA domain.
utxtristn_c	O	Output 3-state enable (active-low). When active, the TXD_C, TXSOC_C, and TXCLK_C LVDS drivers are tri-stated.
ytristn_c	O	3-state override for transmit outputs (active-low). This signal is ignored during reset, but takes priority over all tri-state control signals otherwise.
zrxd_c<31:0>	I	32-bit data from the receive module. The bus contains 4 octets and reflects data received via the high speed RXD_C data bus.
zrxsoc_c	I	Indicates the presence of the 1st octet of a new cell within the first 32-bit data word on the RXD_C bus in bit positions <31:24>.
zrxsocviol_c	I	Indicates a minimum cell violation within the receive module. This signal will transition active high coincident with RXSOC. This indicates that the new cell overran the previous cell and that the previous cell is in violation of the minimum cell size.
zrxalnvio_c	I	Indicates an alignment error. An active state signals RXSOC was captured on a negative RXCLK edge. This signal will stay high for a single WRXCLK_C_FPGA cycle coincident with RXSOC.
zclkstat_c	I	Indicates the loss or absence of a clock on the LVDS clock (RXCLK). After the validation of the absence of the clock, this signal will stay high for the duration of the absence of the clock.
wrxclk_c_fpga	I	Derived from high-speed LVDS clock RXCLK (= RXCLK/2).
<b>RapidIO signals</b>		
wutxclk_fpga	I	One X core clock (60-146 MHz) generated from an internal PLL circuit. Input data on UTXD<31:0> and UTXSCO are synchronous to this clock. The Transmit FIFO inputs are clocked by this clock. The test interface module also runs off this clock. This clock is sent to the FPGA logic.
halfclk_fpga	I	1/2 X main PLL output clock. Phase aligned with PFCLK. Nominal frequency range is 30 MHz to 73 MHz. Duty cycle spec is 47%/53%.

## **Pin Information** (continued)

### **Package Pinouts**

Table 29 provides the package pin and pin function for the ORT8850H FPSC and packages. The bond pad name is identified in the PIO nomenclature used in the *ORCA* Foundry design editor. The Bank Column provides information as to which output voltage level bank the given pin is in. The group column provides information as to the group of pins the given pin is in. This is used to show which VREF pin is used to provide the reference voltage for single-ended limited-swing I/Os. If none of these buffer types (such as SSTL, GTL, HSTL) are used in a given group, then the VREF pin is available as an I/O pin.

When the number of FPGA bond pads exceeds the number of package pins, bond pads are unused. when the number of package pins exceeds the number of bond pads, package pins are left unconnected (no connects). When a package pin is to be left as a no connect for a specific die, it is indicated as a note in the device column for the FPGA. The tables provide no information on unused pads.



Pin Information (continued)

Table 29. ORT8850H 680-Pin PBGAM Pinout

BALL	BANK	GROUP	ORT8850-PAD	FUNCTION	Pair*	Differential
E4	TL	—	VDD33	—	—	—
F5	TL	—	PRD_DATA	RD_DATA/TDO	—	—
D2	TL	—	PRESET	RESET	—	—
E3	TL	—	PRD_CFG	RD_CFG	—	—
G5	TL	—	PPRGRM	PRGRM	—	—
F4	TL	7	PL2D	PLL_CK0C	L21C_D2	COMPLEMENT
D1	TL	7	PL2C	PLL_CK0T	L21T_D2	TRUE
E2	TL	7	PL3D	—	L22C_D0	COMPLEMENT
F3	TL	7	PL3C	VREF	L22T_D0	TRUE
G4	TL	7	PL4D	D5	L23C_D0	COMPLEMENT
H5	TL	7	PL4C	D6	L23T_D0	TRUE
E1	TL	8	PL5D	—	L24C_D0	COMPLEMENT
F2	TL	8	PL5C	VREF	L24T_D0	TRUE
J5	TL	8	PL6D	HDC	L25C_D1	COMPLEMENT
G3	TL	8	PL6C	LDC	L25T_D1	TRUE
H4	TL	8	PL7D	—	L26C_D2	COMPLEMENT
F1	TL	8	PL7C	—	L26T_D2	TRUE
G2	TL	9	PL8D	—	L27C_D0	COMPLEMENT
H3	TL	9	PL8C	D7	L27T_D0	TRUE
K5	TL	9	PL9D	VREF	L28C_D0	COMPLEMENT
J4	TL	9	PL9C	A17	L28T_D0	TRUE
G1	TL	9	PL10D	CS0	L29C_D3	COMPLEMENT
L5	TL	9	PL10C	CS1	L29T_D3	TRUE
H2	TL	10	PL11D	—	L30C_D0	COMPLEMENT
J3	TL	10	PL11C	—	L30T_D0	TRUE
K4	TL	10	PL11A	—	—	TRUE
H1	TL	10	PL12D	INIT	L31C_D0	COMPLEMENT
J2	TL	10	PL12C	DOUT	L31T_D0	TRUE
K3	TL	10	PL13D	VREF	L32C_D0	COMPLEMENT
L4	TL	10	PL13C	A16	L32T_D0	TRUE
M5	TL	10	PL13A	—	—	TRUE
J1	CL	1	PL14D	A15	L1C_D0	COMPLEMENT
K2	CL	1	PL14C	A14	L1T_D0	TRUE
M4	CL	1	PL15D	—	L2C_D0	COMPLEMENT
L3	CL	1	PL15C	—	L2T_D0	TRUE

\* Differential pairs and physical locations are numbered within each bank (e.g., L19C\_A0 is nineteenth pair in an associated bank). The C indicates complementary differential whereas a T indicates true differential. The \_A0 indicates the physical location is adjacent balls in either horizontal/vertical direction. Other physical indicators are as follows:

\_A1 indicates one ball between pairs.

\_A2 indicates two balls between pairs.

\_D0 indicates balls are diagonally adjacent.

\_D1 indicates diagonally adjacent separated by one physical ball.

Pin Information (continued)

Table 29. ORT8850H 680-Pin PBGAM Pinout (continued)

BALL	BANK	GROUP	ORT8850-PAD	FUNCTION	Pair*	Differential
K1	CL	1	PL16D	VREF	L3C_D3	COMPLEMENT
N5	CL	1	PL16C	D4	L3T_D3	TRUE
L2	CL	2	PL17D	—	L4C_D1	COMPLEMENT
N4	CL	2	PL17C	—	L4T_D1	TRUE
P5	CL	2	PL18D	RDY/BUSY/RCLK	L5C_D2	COMPLEMENT
M2	CL	2	PL18C	VREF	L5T_D2	TRUE
M1	CL	2	PL19D	A13	L6C_D2	COMPLEMENT
P4	CL	2	PL19C	A12	L6T_D2	TRUE
N2	CL	3	PL20D	—	L7C_D0	COMPLEMENT
P3	CL	3	PL20C	—	L7T_D0	TRUE
R5	CL	3	PL20A	—	—	TRUE
R4	CL	3	PL21D	A11	L8C_D2	COMPLEMENT
N1	CL	3	PL21C	VREF	L8T_D2	TRUE
T5	CL	3	PL21A	—	—	TRUE
P2	CL	3	PL22D	—	L9C_A0	COMPLEMENT
P1	CL	3	PL22C	—	L9T_A0	TRUE
R2	CL	3	PL22A	—	L10T_D1	TRUE
T4	CL	3	PL22B	—	L10C_D1	COMPLEMENT
U5	CL	4	PL23D	RD/MPI_STRB	L11C_D3	COMPLEMENT
R1	CL	4	PL23C	VREF	L11T_D3	TRUE
T3	CL	4	PL23A	—	L12T_D1	TRUE
V5	CL	4	PL23B	—	L12C_D1	COMPLEMENT
T2	CL	4	PL24D	PLCK0C	L13C_A0	COMPLEMENT
T1	CL	4	PL24C	PLCK0T	L13T_A0	TRUE
U4	CL	4	PL24B	—	L14C_A0	COMPLEMENT
U3	CL	4	PL24A	—	L14T_A0	TRUE
U2	CL	5	PL25D	A10	L15C_A0	COMPLEMENT
V2	CL	5	PL25C	A9	L15T_A0	TRUE
V3	CL	5	PL25B	—	L16C_A0	COMPLEMENT
V4	CL	5	PL25A	—	L16T_A0	TRUE
W5	CL	5	PL26D	A8	L17C_A2	COMPLEMENT
W2	CL	5	PL26C	VREF	L17T_A2	TRUE
W3	CL	5	PL27D	—	L18C_D1	COMPLEMENT
Y1	CL	5	PL27C	—	L18T_D1	TRUE
W4	CL	5	PL27A	—	—	TRUE

\* Differential pairs and physical locations are numbered within each bank (e.g., L19C\_A0 is nineteenth pair in an associated bank). The C indicates complementary differential whereas a T indicates true differential. The \_A0 indicates the physical location is adjacent balls in either horizontal/vertical direction. Other physical indicators are as follows:

\_A1 indicates one ball between pairs.

\_A2 indicates two balls between pairs.

\_D0 indicates balls are diagonally adjacent.

\_D1 indicates diagonally adjacent separated by one physical ball.

Pin Information (continued)

Table 29. ORT8850H 680-Pin PBGAM Pinout (continued)

BALL	BANK	GROUP	ORT8850-PAD	FUNCTION	Pair*	Differential
Y2	CL	6	PL28D	PLCK1C	L19C_D0	COMPLEMENT
AA1	CL	6	PL28C	PLCK1T	L19T_D0	TRUE
AA2	CL	6	PL28A	—	—	TRUE
Y5	CL	6	PL29D	VREF	L20C_D3	COMPLEMENT
AB1	CL	6	PL29C	A7	L20T_D3	TRUE
Y4	CL	6	PL29A	—		TRUE
AA5	CL	6	PL30D	A6	L21C_A1	COMPLEMENT
AA3	CL	6	PL30C	A5	L21T_A1	TRUE
AB2	CL	7	PL31D	—	—	COMPLEMENT
AA4	CL	7	PL32D	WR/MPI_RW	L22C_D2	COMPLEMENT
AC1	CL	7	PL32C	VREF	L22T_D2	TRUE
AB5	CL	7	PL33D	—	L23C_D2	COMPLEMENT
AC2	CL	7	PL33C	—	L23T_D2	TRUE
AB4	CL	8	PL34D	A4	L23C_D0	COMPLEMENT
AC5	CL	8	PL34C	VREF	L23T_D0	TRUE
AD2	CL	8	PL35D	A3	L23C_D0	COMPLEMENT
AE1	CL	8	PL35C	A2	L23T_D0	TRUE
AC4	CL	8	PL35A	—	—	TRUE
AD3	CL	8	PL36D	A1	L24C_D0	COMPLEMENT
AE2	CL	8	PL36C	A0	L24T_D0	TRUE
AF1	CL	8	PL37D	DP0	L25C_D2	COMPLEMENT
AD4	CL	8	PL37C	DP1	L25T_D2	TRUE
AD5	CL	8	PL37A	—	—	TRUE
AE3	BL	1	PL38D	D8	L1C_D0	COMPLEMENT
AF2	BL	1	PL38C	VREF	L1T_D0	TRUE
AG1	BL	1	PL38A	—	—	TRUE
AE4	BL	1	PL39D	D9	L2C_D0	COMPLEMENT
AF3	BL	1	PL39C	D10	L2T_D0	TRUE
AE5	BL	2	PL40D	—	L3C_D1	COMPLEMENT
AG2	BL	2	PL40C	VREF	L3T_D1	TRUE
AH1	BL	2	PL41D	—	L4C_D3	COMPLEMENT
AF5	BL	2	PL41C	—	L4T_D3	TRUE
AF4	BL	3	PL42D	D11	L5C_D0	COMPLEMENT
AG3	BL	3	PL42C	D12	L5T_D0	TRUE
AH2	BL	3	PL43D	—	L6C_D0	COMPLEMENT

\* Differential pairs and physical locations are numbered within each bank (e.g., L19C\_A0 is nineteenth pair in an associated bank). The C indicates complementary differential whereas a T indicates true differential. The \_A0 indicates the physical location is adjacent balls in either horizontal/vertical direction. Other physical indicators are as follows:

- \_A1 indicates one ball between pairs.
- \_A2 indicates two balls between pairs.
- \_D0 indicates balls are diagonally adjacent.
- \_D1 indicates diagonally adjacent separated by one physical ball.

Pin Information (continued)

Table 29. ORT8850H 680-Pin PBGAM Pinout (continued)

BALL	BANK	GROUP	ORT8850-PAD	FUNCTION	Pair*	Differential
AJ1	BL	3	PL43C	—	L6T_D0	TRUE
AG4	BL	3	PL44D	VREF	L7C_A0	COMPLEMENT
AG5	BL	3	PL44C	D13	L7T_A0	TRUE
AH3	BL	4	PL44B	—	—	COMPLEMENT
AJ2	BL	4	PL45D	—	L8C_D2	COMPLEMENT
AH5	BL	4	PL45C	VREF	L8T_D2	TRUE
AK1	BL	4	PL45A	—	—	TRUE
AH4	BL	4	PL46D	—	—	COMPLEMENT
AJ3	BL	4	PL46A	—	—	TRUE
AK2	BL	4	PL47D	PLL_CK7C	L9C_D0	COMPLEMENT
AL1	BL	4	PL47C	PLL_CK7T	L9T_D0	TRUE
AJ5	BL	4	PL47B	—	L10C_A0	COMPLEMENT
AJ4	BL	4	PL47A	—	L10T_A0	TRUE
AK3	BL	—	PTEMP	PTEMP	—	—
AL2	BL	—	LVDS_R	LVDS_R	—	—
AK4	BL	—	VDD33	—	—	—
AK6	BL	—	VDD33	—	—	—
AL5	BL	5	PB2A	DP2	L11T_D1	TRUE
AN4	BL	5	PB2B	—	L11C_D1	COMPLEMENT
AM5	BL	5	PB2C	PLL_CK6T	L12T_D1	TRUE
AK7	BL	5	PB2D	PLL_CK6C	L12C_D1	COMPLEMENT
AP4	BL	5	PB3A	—	—	TRUE
AL6	BL	5	PB3C	—	L13T_D1	TRUE
AN5	BL	5	PB3D	—	L13C_D1	COMPLEMENT
AM6	BL	5	PB4C	VREF	L14T_D0	TRUE
AL7	BL	5	PB4D	DP3	L14C_D0	COMPLEMENT
AK8	BL	6	PB5C	—	L15T_D3	TRUE
AP5	BL	6	PB5D	—	L15C_D3	COMPLEMENT
AK9	BL	6	PB6C	VREF	L16T_D2	TRUE
AN6	BL	6	PB6D	D14	L16C_D2	COMPLEMENT
AM7	BL	6	PB7C	—	L17T_D1	TRUE
AP6	BL	6	PB7D	—	L17C_D1	COMPLEMENT
AL8	BL	7	PB8C	D15	L18T_D1	TRUE
AN7	BL	7	PB8D	D16	L18C_D1	COMPLEMENT
AK10	BL	7	PB9A	—	—	TRUE

\* Differential pairs and physical locations are numbered within each bank (e.g., L19C\_A0 is nineteenth pair in an associated bank). The C indicates complementary differential whereas a T indicates true differential. The \_A0 indicates the physical location is adjacent balls in either horizontal/vertical direction. Other physical indicators are as follows:

\_A1 indicates one ball between pairs.

\_A2 indicates two balls between pairs.

\_D0 indicates balls are diagonally adjacent.

\_D1 indicates diagonally adjacent separated by one physical ball.

Pin Information (continued)

Table 29. ORT8850H 680-Pin PBGAM Pinout (continued)

BALL	BANK	GROUP	ORT8850-PAD	FUNCTION	Pair*	Differential
AM8	BL	7	PB9C	D17	L19T_D0	TRUE
AL9	BL	7	PB9D	D18	L19C_D0	COMPLEMENT
AK11	BL	7	PB10A	—	—	TRUE
AP7	BL	7	PB10C	VREF	L20T_D0	TRUE
AN8	BL	7	PB10D	D19	L20C_D0	COMPLEMENT
AM9	BL	8	PB11A	—	—	TRUE
AL10	BL	8	PB11C	D20	L21T_D2	TRUE
AP8	BL	8	PB11D	D21	L21C_D2	COMPLEMENT
AN9	BL	8	PB12A	—	—	TRUE
AL11	BL	8	PB12C	VREF	L22T_D0	TRUE
AM10	BL	8	PB12D	D22	L22C_D0	COMPLEMENT
AK12	BL	9	PB13A	—	L23T_D3	TRUE
AP9	BL	9	PB13B	—	L23C_D3	COMPLEMENT
AN10	BL	9	PB13C	D23	L24T_D1	TRUE
AL12	BL	9	PB13D	D24	L24C_D1	COMPLEMENT
AM11	BL	9	PB14A	—	L25T_D1	TRUE
AP10	BL	9	PB14B	—	L25C_D1	COMPLEMENT
AK13	BL	9	PB14C	VREF	L26T_D2	TRUE
AN11	BL	9	PB14D	D25	L26C_D2	COMPLEMENT
AL13	BL	9	PB15C	—	L27T_D0	TRUE
AK14	BL	9	PB15D	—	L27C_D0	COMPLEMENT
AN12	BL	10	PB16C	D26	L28T_D1	TRUE
AL14	BL	10	PB16D	D27	L28C_D1	COMPLEMENT
AP12	BL	10	PB17C	—	L29T_D0	TRUE
AN13	BL	10	PB17D	—	L29C_D0	COMPLEMENT
AP13	BL	10	PB18C	VREF	L30T_D3	TRUE
AK15	BL	10	PB18D	D28	L30C_D3	COMPLEMENT
AM14	BL	11	PB19A	—	—	TRUE
AL15	BL	11	PB19C	D29	L31T_D0	TRUE
AK16	BL	11	PB19D	D30	L31C_D0	COMPLEMENT
AN14	BL	11	PB20A	—	—	TRUE
AP14	BL	11	PB20C	VREF	L32T_D2	TRUE
AL16	BL	11	PB20D	D31	L32C_D2	COMPLEMENT
AN15	BC	1	PB21A	—	—	TRUE
AP15	BC	1	PB21C	—	L1T_D3	TRUE

\* Differential pairs and physical locations are numbered within each bank (e.g., L19C\_A0 is nineteenth pair in an associated bank). The C indicates complementary differential whereas a T indicates true differential. The \_A0 indicates the physical location is adjacent balls in either horizontal/vertical direction. Other physical indicators are as follows:

- \_A1 indicates one ball between pairs.
- \_A2 indicates two balls between pairs.
- \_D0 indicates balls are diagonally adjacent.
- \_D1 indicates diagonally adjacent separated by one physical ball.

Pin Information (continued)

Table 29. ORT8850H 680-Pin PBGAM Pinout (continued)

BALL	BANK	GROUP	ORT8850-PAD	FUNCTION	Pair*	Differential
AK17	BC	1	PB21D	—	L1C_D3	COMPLEMENT
AM16	BC	1	PB22A	—	—	TRUE
AN16	BC	1	PB22C	VREF	L2T_D1	TRUE
AL17	BC	1	PB22D	—	L2C_D1	COMPLEMENT
AP16	BC	2	PB23A	—	L3T_D1	TRUE
AM17	BC	2	PB23B	—	L3C_D1	COMPLEMENT
AN17	BC	2	PB23C	PBCK0T	L4T_D1	TRUE
AL18	BC	2	PB23D	PBCK0C	L4C_D1	COMPLEMENT
AM18	BC	2	PB24B	—	L5C_A0	COMPLEMENT
AN18	BC	2	PB24A	—	L5T_A0	TRUE
AN19	BC	2	PB24C	VREF	L6T_D2	TRUE
AK18	BC	2	PB24D	—	L6C_D2	COMPLEMENT
AM19	BC	2	PB25C	—	L7T_A0	TRUE
AL19	BC	2	PB25D	—	L7C_A0	COMPLEMENT
AP20	BC	3	PB26C	—	L8T_D3	TRUE
AK19	BC	3	PB26D	VREF	L8C_D3	COMPLEMENT
AN20	BC	3	PB27A	—	—	TRUE
AP21	BC	3	PB27C	—	L9T_D2	TRUE
AL20	BC	3	PB27D	—	L9C_D2	COMPLEMENT
AK20	BC	3	PB28A	—	—	TRUE
AN21	BC	3	PB28C	PBCK1T	L10T_A0	TRUE
AM21	BC	3	PB28D	PBCK1C	L10C_A0	COMPLEMENT
AK21	BC	3	PB29A	—	—	TRUE
AP22	BC	4	PB29C	—	L11T_D2	TRUE
AL21	BC	4	PB29D	—	L11C_D2	COMPLEMENT
AN22	BC	4	PB30A	—	—	TRUE
AP23	BC	4	PB30C	—	L12T_A0	TRUE
AN23	BC	4	PB30D	VREF	L12C_A0	COMPLEMENT
AK22	BC	4	PB31C	—	L13T_A0	TRUE
AL22	BC	4	PB31D	—	L13C_A0	COMPLEMENT
AN24	BC	5	PB32C	—	L14T_D2	TRUE
AK23	BC	5	PB32D	VREF	L14C_D2	COMPLEMENT
AL23	BC	5	PB33C	—	L15T_D0	TRUE
AM24	BC	5	PB33D	—	L15C_D0	COMPLEMENT
AP25	BC	5	PB34C	—	L16T_A0	TRUE

\* Differential pairs and physical locations are numbered within each bank (e.g., L19C\_A0 is nineteenth pair in an associated bank). The C indicates complementary differential whereas a T indicates true differential. The \_A0 indicates the physical location is adjacent balls in either horizontal/vertical direction. Other physical indicators are as follows:

\_A1 indicates one ball between pairs.

\_A2 indicates two balls between pairs.

\_D0 indicates balls are diagonally adjacent.

\_D1 indicates diagonally adjacent separated by one physical ball.

Pin Information (continued)

Table 29. ORT8850H 680-Pin PBGAM Pinout (continued)

BALL	BANK	GROUP	ORT8850-PAD	FUNCTION	Pair*	Differential
AN25	BC	5	PB34D	—	L16T_A0	COMPLEMENT
AP26	BC	6	PB35A	—	—	TRUE
AK25	BC	6	PB35C	—	L17T_A0	TRUE
AN26	BC	6	PB35D	VREF	L17C_A0	COMPLEMENT
AP27	BC	6	PB36A	—	—	TRUE
AM25	BC	6	PB36C	—	L18T_D3	TRUE
AK26	BC	6	PB36D	—	L18C_D3	COMPLEMENT
AL24	CR	—	TXD_C0_N	—	L1N_A0	COMPLEMENT
AK24	CR	—	TXD_C0_P	—	L1P_A0	TRUE
AN27	CR	—	TXD_C1_N	—	L2N_D0	COMPLEMENT
AP28	CR	—	TXD_C1_P	—	L2P_D0	TRUE
AL25	CR	—	TXD_C2_N	—	L3N_A0	COMPLEMENT
AL26	CR	—	TXD_C2_P	—	L3P_A0	TRUE
AM26	CR	—	TXD_C3_N	—	L4N_A0	COMPLEMENT
AM27	CR	—	TXD_C3_P	—	L4P_A0	TRUE
AN28	CR	—	TXSOC_C_N	—	L5N_D0	COMPLEMENT
AP29	CR	—	TXSOC_C_P	—	L5P_D0	TRUE
AL27	CR	—	TXCLK_C_N	—	L6N_A0	COMPLEMENT
AK27	CR	—	TXCLK_C_P	—	L6P_A0	TRUE
AL28	CR	—	TXD_C4_N	—	L7N_A0	COMPLEMENT
AK28	CR	—	TXD_C4_P	—	L7P_A0	TRUE
AM28	CR	—	TXD_C5_N	—	L8N_D0	COMPLEMENT
AN29	CR	—	TXD_C5_P	—	L8P_D0	TRUE
AK29	CR	—	TXD_C6_P	—	L9P_A0	TRUE
AL29	CR	—	TXD_C6_N	—	L9N_A0	COMPLEMENT
AP30	CR	—	TXD_C7_N	—	L10N_D0	COMPLEMENT
AN30	CR	—	TXD_C7_P	—	L10P_D0	TRUE
AM29	CR	—	DAUTREC	—	—	—
AP31	CR	—	TSTCLK	—	—	—
AM30	CR	—	TESTRST	—	—	—
AN31	CR	—	TSTSHFTLD	—	—	—
AL30	CR	—	RESETTX	—	—	—
AH30	CR	—	ETOGGLE	—	—	—
AJ30	CR	—	ECSEL	—	—	—
AL33	CR	—	EXDNUP	—	—	—

\* Differential pairs and physical locations are numbered within each bank (e.g., L19C\_A0 is nineteenth pair in an associated bank). The C indicates complementary differential whereas a T indicates true differential. The \_A0 indicates the physical location is adjacent balls in either horizontal/vertical direction. Other physical indicators are as follows:

- \_A1 indicates one ball between pairs.
- \_A2 indicates two balls between pairs.
- \_D0 indicates balls are diagonally adjacent.
- \_D1 indicates diagonally adjacent separated by one physical ball.

Pin Information (continued)

Table 29. ORT8850H 680-Pin PBGAM Pinout (continued)

BALL	BANK	GROUP	ORT8850-PAD	FUNCTION	Pair*	Differential
AH31	CR	—	MRESET	—	—	—
AK32	CR	—	RXD_C0_N	—	L11N_D0	COMPLEMENT
AJ31	CR	—	RXD_C0_P	—	L11P_D0	TRUE
AL34	CR	—	RXD_C1_N	—	L12N_D0	COMPLEMENT
AK33	CR	—	RXD_C1_P	—	L12P_D0	TRUE
AJ32	CR	—	LVCTAP_C_0	—	—	—
AF30	CR	—	RXD_C2_N	—	L13N_A0	COMPLEMENT
AG30	CR	—	RXD_C2_P	—	L13P_A0	TRUE
AG31	CR	—	RXD_C3_N	—	L14N_A0	COMPLEMENT
AF31	CR	—	RXD_C3_P	—	L14P_A0	TRUE
AK34	CR	—	LVCTAP_C_1	—	—	—
AJ33	CR	—	RXSOC_C_N	—	L15N_A0	COMPLEMENT
AH32	CR	—	RXSOC_C_P	—	L15P_A0	TRUE
AJ34	CR	—	RXCLK_C_N	—	L16N_D0	COMPLEMENT
AH33	CR	—	RXCLK_C_P	—	L16P_D0	TRUE
AD30	CR	—	LVCTAP_C_2	—	—	—
AG32	CR	—	RXD_C4_N	—	L17N_A0	COMPLEMENT
AG33	CR	—	RXD_C4_P	—	L17P_A0	TRUE
AH34	CR	—	LVCTAP_C_3	—	—	—
AE30	CR	—	RXD_C5_N	—	L18N_A0	COMPLEMENT
AE31	CR	—	RXD_C5_P	—	L18P_A0	TRUE
AF32	CR	—	RXD_C6_N	—	L19N_A0	COMPLEMENT
AF33	CR	—	RXD_C6_P	—	L19P_A0	TRUE
AC30	CR	—	LVCTAP_C_4	—	—	—
AG34	CR	—	RXD_C7_N	—	L20N_A0	COMPLEMENT
AF34	CR	—	RXD_C7_P	—	L20P_A0	TRUE
AB30	CR	—	VDDA_STM	—	—	—
AD31	CR	—	VSSA_STM	—	—	—
AE32	CR	—	SYS_CLK_N	—	L21N_D0	COMPLEMENT
AE33	CR	—	SYS_CLK_P	—	L21P_D0	TRUE
AE34	CR	—	LVCTAP_SK	—	—	—
AC31	CR	—	RXD_B0_N	—	L22N_A0	COMPLEMENT
AB31	CR	—	RXD_B0_P	—	L22P_A0	TRUE
AD32	CR	—	RXD_B1_N	—	L23N_A0	COMPLEMENT
AD33	CR	—	RXD_B1_P	—	L23P_A0	TRUE

\* Differential pairs and physical locations are numbered within each bank (e.g., L19C\_A0 is nineteenth pair in an associated bank). The C indicates complementary differential whereas a T indicates true differential. The \_A0 indicates the physical location is adjacent balls in either horizontal/vertical direction. Other physical indicators are as follows:

\_A1 indicates one ball between pairs.

\_A2 indicates two balls between pairs.

\_D0 indicates balls are diagonally adjacent.

\_D1 indicates diagonally adjacent separated by one physical ball.



Pin Information (continued)

Table 29. ORT8850H 680-Pin PBGAM Pinout (continued)

BALL	BANK	GROUP	ORT8850-PAD	FUNCTION	Pair*	Differential
AA30	CR	—	LVCTAP_B_0	—	—	—
AC33	CR	—	RXD_B2_N	—	L24N_A0	COMPLEMENT
AC34	CR	—	RXD_B2_P	—	L24P_A0	TRUE
AB33	CR	—	RXD_B3_N	—	L25N_A0	COMPLEMENT
AB34	CR	—	RXD_B3_P	—	L25P_A0	TRUE
Y30	CR	—	LVCTAP_B_1	—	—	—
AA31	CR	—	RXSOC_B_N	—	L26N_A0	COMPLEMENT
AA32	CR	—	RXSOC_B_P	—	L26P_A0	TRUE
W30	CR	—	RXCLK_B_N	—	L27N_D0	COMPLEMENT
Y31	CR	—	RXCLK_B_P	—	L27P_D0	TRUE
AA33	CR	—	LVCTAP_B_2	—	—	—
AA34	CR	—	RXD_B4_N	—	L28N_A0	COMPLEMENT
Y34	CR	—	RXD_B4_P	—	L28P_A0	TRUE
Y33	CR	—	LVCTAP_B_3	—	—	—
W31	CR	—	RXD_B5_N	—	L29N_A0	COMPLEMENT
W32	CR	—	RXD_B5_P	—	L29P_A0	TRUE
V30	CR	—	RXD_B6_N	—	L30N_A0	COMPLEMENT
V31	CR	—	RXD_B6_P	—	L30P_A0	TRUE
W33	CR	—	LVCTAP_B_4	—	—	—
V32	CR	—	RXD_B7_N	—	L31N_A0	COMPLEMENT
V33	CR	—	RXD_B7_P	—	L31P_A0	TRUE
U33	CR	—	RESLO	—	—	—
U32	CR	—	RESHI	—	—	—
U31	CR	—	REF14	—	—	—
T33	CR	—	REF10	—	—	—
T32	CR	—	TXD_B0_N	—	L32N_D1	COMPLEMENT
R34	CR	—	TXD_B0_P	—	L32P_D1	TRUE
U30	CR	—	TXD_B1_N	—	L33N_D0	COMPLEMENT
T31	CR	—	TXD_B1_P	—	L33P_D0	TRUE
R33	CR	—	TXD_B2_N	—	L34N_D0	COMPLEMENT
P34	CR	—	TXD_B2_P	—	L34P_D0	TRUE
P33	CR	—	TXD_B3_N	—	L35N_D0	COMPLEMENT
N34	CR	—	TXD_B3_P	—	L35P_D0	TRUE
T30	CR	—	TXSOC_B_N	—	L36N_D0	COMPLEMENT
R31	CR	—	TXSOC_B_P	—	L36P_D0	TRUE

\* Differential pairs and physical locations are numbered within each bank (e.g., L19C\_A0 is nineteenth pair in an associated bank). The C indicates complementary differential whereas a T indicates true differential. The \_A0 indicates the physical location is adjacent balls in either horizontal/vertical direction. Other physical indicators are as follows:

- \_A1 indicates one ball between pairs.
- \_A2 indicates two balls between pairs.
- \_D0 indicates balls are diagonally adjacent.
- \_D1 indicates diagonally adjacent separated by one physical ball.

Pin Information (continued)

Table 29. ORT8850H 680-Pin PBGAM Pinout (continued)

BALL	BANK	GROUP	ORT8850-PAD	FUNCTION	Pair*	Differential
P32	CR	—	TXCLK_B_N	—	L37N_D1	COMPLEMENT
R30	CR	—	TXCLK_B_P	—	L37P_D1	TRUE
N33	CR	—	TXD_B4_N	—	L38N_D0	COMPLEMENT
M34	CR	—	TXD_B4_P	—	L38P_D0	TRUE
P31	CR	—	TXD_B5_N	—	L39N_D1	COMPLEMENT
M33	CR	—	TXD_B5_P	—	L39P_D1	TRUE
N31	CR	—	TXD_B6_N	—	L40N_D0	COMPLEMENT
P30	CR	—	TXD_B6_P	—	L40P_D0	TRUE
L33	CR	—	TXD_B7_N	—	L41N_D0	COMPLEMENT
K34	CR	—	TXD_B7_P	—	L41P_D0	TRUE
M31	CR	—	GCLK_N	—	L42N_D0	COMPLEMENT
L32	CR	—	GCLK_P	—	L42P_D0	TRUE
K33	CR	—	LVCTAP_GK	—	—	—
N30	CR	—	VDDA_SHIM	—	—	—
L30	CR	—	VSSA_SHIM	—	—	—
M30	CR	—	RXD_A0_N	—	L43N_D0	COMPLEMENT
L31	CR	—	RXD_A0_P	—	L43P_D0	TRUE
J34	CR	—	RXD_A1_N	—	L44N_D1	COMPLEMENT
K32	CR	—	RXD_A1_P	—	L44P_D1	TRUE
H34	CR	—	RXD_A2_N	—	L45N_D1	COMPLEMENT
J33	CR	—	LVCTAP_A_0	—	—	—
J32	CR	—	RXD_A2_P	—	L45P_D1	TRUE
K30	CR	—	RXD_A3_P	—	L46P_A0	TRUE
K31	CR	—	RXD_A3_N	—	L46N_A0	COMPLEMENT
H33	CR	—	LVCTAP_A_1	—	—	—
J30	CR	—	RXSOC_A_P	—	L47P_A0	TRUE
J31	CR	—	RXSOC_A_N	—	L47N_A0	COMPLEMENT
G34	CR	—	RXCLK_A_N	—	L48N_D1	COMPLEMENT
H32	CR	—	RXCLK_A_P	—	L48P_D1	TRUE
H31	CR	—	LVCTAP_A_2	—	—	—
G33	CR	—	RXD_A4_N	—	L49N_D0	COMPLEMENT
F34	CR	—	RXD_A4_P	—	L49P_D0	TRUE
H30	CR	—	LVCTAP_A_3	—	—	—
G32	CR	—	RXD_A5_N	—	L50N_D0	COMPLEMENT
F33	CR	—	RXD_A5_P	—	L50P_D0	TRUE

\* Differential pairs and physical locations are numbered within each bank (e.g., L19C\_A0 is nineteenth pair in an associated bank). The C indicates complementary differential whereas a T indicates true differential. The \_A0 indicates the physical location is adjacent balls in either horizontal/vertical direction. Other physical indicators are as follows:

\_A1 indicates one ball between pairs.

\_A2 indicates two balls between pairs.

\_D0 indicates balls are diagonally adjacent.

\_D1 indicates diagonally adjacent separated by one physical ball.

Pin Information (continued)

Table 29. ORT8850H 680-Pin PBGAM Pinout (continued)

BALL	BANK	GROUP	ORT8850-PAD	FUNCTION	Pair*	Differential
G30	CR	—	RXD_A6_N	—	L51N_A0	COMPLEMENT
G31	CR	—	RXD_A6_P	—	L51P_A0	TRUE
E34	CR	—	LVCTAP_A_4	—	—	—
F32	CR	—	RXD_A7_N	—	L52N_A0	COMPLEMENT
E33	CR	—	RXD_A7_P	—	L52P_A0	TRUE
F31	CR	—	TSTMUX0S	—	—	—
E32	CR	—	TSTMUX1S	—	—	—
D34	CR	—	TSTMUX2S	—	—	—
D33	CR	—	TSTMUX3S	—	—	—
F30	CR	—	TSTMUX4S	—	—	—
D30	CR	—	TSTMUX5S	—	—	—
E29	CR	—	TSTMUX6S	—	—	—
C30	CR	—	TSTMUX7S	—	—	—
B31	CR	—	TSTMUX8S	—	—	—
D29	CR	—	TSTMUX9S	—	—	—
A31	CR	—	SCAN_TSTMD	—	—	—
B30	CR	—	SCANEN	—	—	—
B29	CR	—	RST	—	—	—
E28	CR	—	TXD_A0_N	—	L53N_D1	COMPLEMENT
C29	CR	—	TXD_A0_P	—	L53P_D1	TRUE
D28	CR	—	TXD_A1_N	—	L54N_D0	COMPLEMENT
E27	CR	—	TXD_A1_P	—	L54P_D0	TRUE
A30	CR	—	TXD_A2_N	—	L55N_D1	COMPLEMENT
C28	CR	—	TXD_A2_P	—	L55P_D1	TRUE
B28	CR	—	TXD_A3_N	—	L56N_D0	COMPLEMENT
A29	CR	—	TXD_A3_P	—	L56P_D0	TRUE
D27	CR	—	TXSOC_A_N	—	L57N_D0	COMPLEMENT
E26	CR	—	TXSOC_A_P	—	L57P_D0	TRUE
C27	CR	—	TXCLK_A_N	—	L58N_D0	COMPLEMENT
D26	CR	—	TXCLK_A_P	—	L58P_D0	TRUE
A28	CR	—	TXD_A4_N	—	L59N_D0	COMPLEMENT
B27	CR	—	TXD_A4_P	—	L59P_D0	TRUE
C26	CR	—	TXD_A5_N	—	L60N_D0	COMPLEMENT
D25	CR	—	TXD_A5_P	—	L60P_D0	TRUE
A27	CR	—	TXD_A6_N	—	L61N_D0	COMPLEMENT

\* Differential pairs and physical locations are numbered within each bank (e.g., L19C\_A0 is nineteenth pair in an associated bank). The C indicates complementary differential whereas a T indicates true differential. The \_A0 indicates the physical location is adjacent balls in either horizontal/vertical direction. Other physical indicators are as follows:

- \_A1 indicates one ball between pairs.
- \_A2 indicates two balls between pairs.
- \_D0 indicates balls are diagonally adjacent.
- \_D1 indicates diagonally adjacent separated by one physical ball.

Pin Information (continued)

Table 29. ORT8850H 680-Pin PBGAM Pinout (continued)

BALL	BANK	GROUP	ORT8850-PAD	FUNCTION	Pair*	Differential
B26	CR	—	TXD_A6_P	—	L61P_D0	TRUE
D24	CR	—	TXD_A7_N	—	L62N_D0	COMPLEMENT
C25	CR	—	TXD_A7_P	—	L62P_D0	TRUE
A26	TC	1	PT35D	—	L1C_D3	COMPLEMENT
E25	TC	1	PT35C	—	L1T_D3	TRUE
B25	TC	1	PT35A	—	L2T_A0	TRUE
A25	TC	1	PT35B	—	L2C_A0	COMPLEMENT
C24	TC	1	PT34D	VREF	L3C_D0	COMPLEMENT
D23	TC	1	PT34C	—	L3T_D0	TRUE
B24	TC	1	PT33D	—	L4C_A2	COMPLEMENT
E24	TC	1	PT33C	—	L4T_A2	TRUE
D22	TC	2	PT32D	—	L5C_D1	COMPLEMENT
B23	TC	2	PT32C	VREF	L5T_D1	TRUE
E23	TC	2	PT31D	—	L6C_A3	COMPLEMENT
A23	TC	2	PT31C	—	L6T_A3	TRUE
D21	TC	2	PT30D	—	L7C_D1	COMPLEMENT
B22	TC	2	PT30C	—	L7T_D1	TRUE
A22	TC	3	PT29D	—	L8C_D1	COMPLEMENT
C21	TC	3	PT29C	VREF	L8T_D1	TRUE
E22	TC	3	PT29A	—	—	TRUE
D20	TC	3	PT28D	—	L9C_D1	COMPLEMENT
B21	TC	3	PT28C	—	L9T_D1	TRUE
E21	TC	3	PT28A	—	—	TRUE
A21	TC	3	PT27D	—	L10C_D0	COMPLEMENT
B20	TC	3	PT27C	—	L10T_D0	TRUE
A20	TC	3	PT27A	—	—	TRUE
E20	TC	4	PT26D	—	L11C_D0	COMPLEMENT
D19	TC	4	PT26C	—	L11T_D0	TRUE
C19	TC	4	PT25D	—	L12C_A0	COMPLEMENT
B19	TC	4	PT25C	—	L12T_A0	TRUE
E19	TC	4	PT24D	—	L13C_D0	COMPLEMENT
D18	TC	4	PT24C	VREF	L13T_D0	TRUE
C18	TC	4	PT24A	—	L14T_A0	TRUE
B18	TC	4	PT24B	—	L14C_A0	COMPLEMENT
B17	TC	5	PT23D	PTCK1C	L15C_A0	COMPLEMENT

\* Differential pairs and physical locations are numbered within each bank (e.g., L19C\_A0 is nineteenth pair in an associated bank). The C indicates complementary differential whereas a T indicates true differential. The \_A0 indicates the physical location is adjacent balls in either horizontal/vertical direction. Other physical indicators are as follows:

\_A1 indicates one ball between pairs.

\_A2 indicates two balls between pairs.

\_D0 indicates balls are diagonally adjacent.

\_D1 indicates diagonally adjacent separated by one physical ball.

Pin Information (continued)

Table 29. ORT8850H 680-Pin PBGAM Pinout (continued)

BALL	BANK	GROUP	ORT8850-PAD	FUNCTION	Pair*	Differential
C17	TC	5	PT23C	PTCK1T	L15T_A0	TRUE
D17	TC	5	PT23A	—	L16T_D2	TRUE
A16	TC	5	PT23B	—	L16C_D2	COMPLEMENT
B16	TC	5	PT22D	PTCK0C	L17C_A0	COMPLEMENT
C16	TC	5	PT22C	PTCK0T	L17T_A0	TRUE
D16	TC	5	PT22A	—	—	TRUE
E18	TC	5	PT21D	VREF	L18C_D3	COMPLEMENT
A15	TC	5	PT21C	—	L18T_D3	TRUE
B15	TC	5	PT21A	—	—	TRUE
D15	TC	6	PT20D	—	L19C_D2	COMPLEMENT
A14	TC	6	PT20C	—	L19T_D2	TRUE
B14	TC	6	PT20A	—	—	TRUE
E17	TC	6	PT19D	—	L20C_D2	COMPLEMENT
C14	TC	6	PT19C	VREF	L20T_D2	TRUE
D14	TC	6	PT19A	—	—	TRUE
E16	TL	1	PT18D	MPI_RTRY	L1C_D3	COMPLEMENT
A13	TL	1	PT18C	MPI_ACK	L1T_D3	TRUE
B13	TL	1	PT17D	—	L2C_D0	COMPLEMENT
A12	TL	1	PT17C	VREF	L2T_D0	TRUE
B12	TL	1	PT16D	M0	L3C_D1	COMPLEMENT
D13	TL	1	PT16C	M1	L3T_D1	TRUE
E15	TL	2	PT15D	MPI_CLK	L4C_D3	COMPLEMENT
B11	TL	2	PT15C	A21/MPI_BURST	L4T_D3	TRUE
A10	TL	2	PT14D	M2	L5C_D3	COMPLEMENT
E14	TL	2	PT14C	M3	L5T_D3	TRUE
D12	TL	2	PT13D	VREF	L6C_D0	COMPLEMENT
C11	TL	2	PT13C	MPI_TEA	L6T_D0	TRUE
B10	TL	3	PT12D	—	L7C_D0	COMPLEMENT
A9	TL	3	PT12C	—	L7T_D0	TRUE
D11	TL	3	PT12A	—	—	TRUE
C10	TL	3	PT11D	VREF	L8C_D0	COMPLEMENT
B9	TL	3	PT11C	—	L8T_D0	TRUE
E13	TL	3	PT11A	—	—	TRUE
A8	TL	3	PT10D	D0	L9C_D2	COMPLEMENT
D10	TL	3	PT10C	TMS	L9T_D2	TRUE

\* Differential pairs and physical locations are numbered within each bank (e.g., L19C\_A0 is nineteenth pair in an associated bank). The C indicates complementary differential whereas a T indicates true differential. The \_A0 indicates the physical location is adjacent balls in either horizontal/vertical direction. Other physical indicators are as follows:

- \_A1 indicates one ball between pairs.
- \_A2 indicates two balls between pairs.
- \_D0 indicates balls are diagonally adjacent.
- \_D1 indicates diagonally adjacent separated by one physical ball.

Pin Information (continued)

Table 29. ORT8850H 680-Pin PBGAM Pinout (continued)

BALL	BANK	GROUP	ORT8850-PAD	FUNCTION	Pair*	Differential
C9	TL	4	PT9D	A20/MPI_BDIP	L10C_D0	COMPLEMENT
B8	TL	4	PT9C	A19/MPI_TSZ1	L10T_D0	TRUE
A7	TL	4	PT8D	A18/MPI_TSZ0	L11C_D4	COMPLEMENT
E12	TL	4	PT8C	D3	L11T_D4	TRUE
D9	TL	4	PT7D	VREF	L12C_D0	COMPLEMENT
C8	TL	4	PT7C	—	L12T_D0	TRUE
E11	TL	5	PT6D	D1	L13C_D3	COMPLEMENT
B7	TL	5	PT6C	D2	L13T_D3	TRUE
A6	TL	5	PT5D	—	L14C_D2	COMPLEMENT
D8	TL	5	PT5C	VREF	L14T_D2	TRUE
C7	TL	5	PT4D	TDI	L15C_D1	COMPLEMENT
A5	TL	5	PT4C	TCK	L15T_D1	TRUE
E10	TL	5	PT4B	—	L16C_D2	COMPLEMENT
D7	TL	5	PT4A	—	L16T_D2	TRUE
A4	TL	6	PT3D	—	L17C_D4	COMPLEMENT
E9	TL	6	PT3C	VREF	L17T_D4	TRUE
B6	TL	6	PT3B	—	L18C_A0	COMPLEMENT
C6	TL	6	PT3A	—	L18T_A0	TRUE
B5	TL	6	PT2D	PLL_CK1C	L19C_D1	COMPLEMENT
D6	TL	6	PT2C	PLL_CK1T	L19T_D1	TRUE
C5	TL	6	PT2B	—	L20C_D0	COMPLEMENT
E8	TL	--	PCFG_MPI_IRQ	CFG_IRQ/MPI_IRQ	—	—
B4	TL	6	PT2A	—	L20T_D0	TRUE
E7	TL	--	PCCLK	CCLK	—	—
D5	TL	--	PDONE	DONE	—	—
E6	TL	--	VDD33	—	—	—
A1	TL	--	Vss	—	—	—
A2	TL	—	Vss	—	—	—
A18	TL	—	Vss	—	—	—
A33	TL	—	Vss	—	—	—
A34	TL	—	Vss	—	—	—
B1	TL	—	Vss	—	—	—
B2	TL	—	Vss	—	—	—
B33	TL	—	Vss	—	—	—
B34	TL	—	Vss	—	—	—

\* Differential pairs and physical locations are numbered within each bank (e.g., L19C\_A0 is nineteenth pair in an associated bank). The C indicates complementary differential whereas a T indicates true differential. The \_A0 indicates the physical location is adjacent balls in either horizontal/vertical direction. Other physical indicators are as follows:

\_A1 indicates one ball between pairs.

\_A2 indicates two balls between pairs.

\_D0 indicates balls are diagonally adjacent.

\_D1 indicates diagonally adjacent separated by one physical ball.

**Pin Information** (continued)

**Table 29. ORT8850H 680-Pin PBGAM Pinout** (continued)

BALL	BANK	GROUP	ORT8850-PAD	FUNCTION	Pair*	Differential
C3	TL	—	Vss	—	—	—
C13	TL	—	Vss	—	—	—
C22	TC	—	Vss	—	—	—
C32	TC	—	Vss	—	—	—
D4	TC	—	Vss	—	—	—
D31	TC	—	Vss	—	—	—
N3	TC	—	Vss	—	—	—
N13	TC	—	Vss	—	—	—
N14	TC	—	Vss	—	—	—
N15	TC	—	Vss	—	—	—
N20	TC	—	Vss	—	—	—
N21	TC	—	Vss	—	—	—
N22	TC	—	Vss	—	—	—
N32	CR	—	Vss	—	—	—
P13	CR	—	Vss	—	—	—
P14	CR	—	Vss	—	—	—
P15	CR	—	Vss	—	—	—
P20	CR	—	Vss	—	—	—
P21	CR	—	Vss	—	—	—
P22	CR	—	Vss	—	—	—
R13	CR	—	Vss	—	—	—
R14	CR	—	Vss	—	—	—
R15	CR	—	Vss	—	—	—
R20	CR	—	Vss	—	—	—
R21	CR	—	Vss	—	—	—
R22	CR	—	Vss	—	—	—
T16	CR	—	Vss	—	—	—
T17	CR	—	Vss	—	—	—
T18	CR	—	Vss	—	—	—
T19	CR	—	Vss	—	—	—
T34	CR	—	Vss	—	—	—
U16	CR	—	Vss	—	—	—
U17	CR	—	Vss	—	—	—
U18	CR	—	Vss	—	—	—
U19	CR	—	Vss	—	—	—

\* Differential pairs and physical locations are numbered within each bank (e.g., L19C\_A0 is nineteenth pair in an associated bank). The C indicates complementary differential whereas a T indicates true differential. The \_A0 indicates the physical location is adjacent balls in either horizontal/vertical direction. Other physical indicators are as follows:

\_A1 indicates one ball between pairs.

\_A2 indicates two balls between pairs.

\_D0 indicates balls are diagonally adjacent.

\_D1 indicates diagonally adjacent separated by one physical ball.

Pin Information (continued)

Table 29. ORT8850H 680-Pin PBGAM Pinout (continued)

BALL	BANK	GROUP	ORT8850-PAD	FUNCTION	Pair*	Differential
V1	CR	—	Vss	—	—	—
V16	CR	—	Vss	—	—	—
V17	CR	—	Vss	—	—	—
V18	CR	—	Vss	—	—	—
V19	CR	—	Vss	—	—	—
V34	CR	—	Vss	—	—	—
W16	CR	—	Vss	—	—	—
W17	CR	—	Vss	—	—	—
W18	CR	—	Vss	—	—	—
W19	CR	—	Vss	—	—	—
Y13	CR	—	Vss	—	—	—
Y14	CR	—	Vss	—	—	—
Y15	BC	—	Vss	—	—	—
Y20	BC	—	Vss	—	—	—
Y21	BC	—	Vss	—	—	—
Y22	BC	—	Vss	—	—	—
AA13	BC	—	Vss	—	—	—
AA14	BC	—	Vss	—	—	—
AA15	BC	—	Vss	—	—	—
AA20	BC	—	Vss	—	—	—
AA21	BC	—	Vss	—	—	—
AA22	BC	—	Vss	—	—	—
AB3	BC	—	Vss	—	—	—
AB13	BL	—	Vss	—	—	—
AB14	BL	—	Vss	—	—	—
AB15	BL	—	Vss	—	—	—
AB20	BL	—	Vss	—	—	—
AB21	BL	—	Vss	—	—	—
AB22	BL	—	Vss	—	—	—
AB32	BL	—	Vss	—	—	—
AL4	BL	—	Vss	—	—	—
AL31	BL	—	Vss	—	—	—
AM3	BL	—	Vss	—	—	—
AM13	BL	—	Vss	—	—	—
AM22	CL	—	Vss	—	—	—

\* Differential pairs and physical locations are numbered within each bank (e.g., L19C\_A0 is nineteenth pair in an associated bank). The C indicates complementary differential whereas a T indicates true differential. The \_A0 indicates the physical location is adjacent balls in either horizontal/vertical direction. Other physical indicators are as follows:

\_A1 indicates one ball between pairs.

\_A2 indicates two balls between pairs.

\_D0 indicates balls are diagonally adjacent.

\_D1 indicates diagonally adjacent separated by one physical ball.



Pin Information (continued)

Table 29. ORT8850H 680-Pin PBGAM Pinout (continued)

BALL	BANK	GROUP	ORT8850-PAD	FUNCTION	Pair*	Differential
AM32	CL	—	Vss	—	—	—
AN1	CL	—	Vss	—	—	—
AN2	CL	—	Vss	—	—	—
AN33	CL	—	Vss	—	—	—
AN34	CL	—	Vss	—	—	—
AP1	CL	—	Vss	—	—	—
AP2	CL	—	Vss	—	—	—
AP18	CL	—	Vss	—	—	—
AP33	CL	—	Vss	—	—	—
AP34	CL	—	Vss	—	—	—
N16	TL	—	VDD15	—	—	—
N17	TL	—	VDD15	—	—	—
N18	TL	—	VDD15	—	—	—
N19	TL	—	VDD15	—	—	—
P16	TL	—	VDD15	—	—	—
P17	TC	—	VDD15	—	—	—
P18	TC	—	VDD15	—	—	—
P19	TC	—	VDD15	—	—	—
R16	TC	—	VDD15	—	—	—
R17	TC	—	VDD15	—	—	—
R18	CR	—	VDD15	—	—	—
R19	CR	—	VDD15	—	—	—
T13	CR	—	VDD15	—	—	—
T14	CR	—	VDD15	—	—	—
T15	CR	—	VDD15	—	—	—
T20	CR	—	VDD15	—	—	—
T21	CR	—	VDD15	—	—	—
T22	CR	—	VDD15	—	—	—
U13	CR	—	VDD15	—	—	—
U14	CR	—	VDD15	—	—	—
U15	CR	—	VDD15	—	—	—
U20	CR	—	VDD15	—	—	—
U21	CR	—	VDD15	—	—	—
U22	CR	—	VDD15	—	—	—
V13	CR	—	VDD15	—	—	—

\* Differential pairs and physical locations are numbered within each bank (e.g., L19C\_A0 is nineteenth pair in an associated bank). The C indicates complementary differential whereas a T indicates true differential. The \_A0 indicates the physical location is adjacent balls in either horizontal/vertical direction. Other physical indicators are as follows:

- \_A1 indicates one ball between pairs.
- \_A2 indicates two balls between pairs.
- \_D0 indicates balls are diagonally adjacent.
- \_D1 indicates diagonally adjacent separated by one physical ball.

Pin Information (continued)

Table 29. ORT8850H 680-Pin PBGAM Pinout (continued)

BALL	BANK	GROUP	ORT8850-PAD	FUNCTION	Pair*	Differential
V14	CR	—	VDD15	—	—	—
V15	CR	—	VDD15	—	—	—
V20	CR	—	VDD15	—	—	—
V21	CR	—	VDD15	—	—	—
V22	CR	—	VDD15	—	—	—
W13	CR	—	VDD15	—	—	—
W14	CR	—	VDD15	—	—	—
W15	CR	—	VDD15	—	—	—
W20	BC	—	VDD15	—	—	—
W21	BC	—	VDD15	—	—	—
W22	BC	—	VDD15	—	—	—
Y16	BC	—	VDD15	—	—	—
Y17	BC	—	VDD15	—	—	—
Y18	BL	—	VDD15	—	—	—
Y19	BL	—	VDD15	—	—	—
AA16	BL	—	VDD15	—	—	—
AA17	BL	—	VDD15	—	—	—
AA18	BL	—	VDD15	—	—	—
AA19	CL	—	VDD15	—	—	—
AB16	CL	—	VDD15	—	—	—
AB17	CL	—	VDD15	—	—	—
AB18	CL	—	VDD15	—	—	—
AB19	CL	—	VDD15	—	—	—
A3	TL	—	VDDIO_TL	—	—	—
B3	TL	—	VDDIO_TL	—	—	—
C1	TL	—	VDDIO_TL	—	—	—
C2	TL	—	VDDIO_TL	—	—	—
C4	TL	—	VDDIO_TL	—	—	—
D3	TL	—	VDDIO_TL	—	—	—
E5	TL	—	VDDIO_TL	—	—	—
A11	TC	—	VDDIO_TC	—	—	—
A17	TC	—	VDDIO_TC	—	—	—
A19	TC	—	VDDIO_TC	—	—	—
A24	TC	—	VDDIO_TC	—	—	—
C12	TC	—	VDDIO_TC	—	—	—

\* Differential pairs and physical locations are numbered within each bank (e.g., L19C\_A0 is nineteenth pair in an associated bank). The C indicates complementary differential whereas a T indicates true differential. The \_A0 indicates the physical location is adjacent balls in either horizontal/vertical direction. Other physical indicators are as follows:

\_A1 indicates one ball between pairs.

\_A2 indicates two balls between pairs.

\_D0 indicates balls are diagonally adjacent.

\_D1 indicates diagonally adjacent separated by one physical ball.

Pin Information (continued)

Table 29. ORT8850H 680-Pin PBGAM Pinout (continued)

BALL	BANK	GROUP	ORT8850-PAD	FUNCTION	Pair*	Differential
C15	TC	—	VDDIO_TC	—	—	—
C20	TC	—	VDDIO_TC	—	—	—
C23	TC	—	VDDIO_TC	—	—	—
A32	CR	—	VDD33	—	—	—
B32	CR	—	VDD33	—	—	—
C31	CR	—	VDD33	—	—	—
C33	CR	—	VDD33	—	—	—
C34	CR	—	VDD33	—	—	—
D32	CR	—	VDD33	—	—	—
E30	CR	—	VDD33	—	—	—
E31	CR	—	VDD33	—	—	—
L34	CR	—	VDD33	—	—	—
M32	CR	—	VDD33	—	—	—
R32	CR	—	VDD33	—	—	—
U34	CR	—	VDD33	—	—	—
W34	CR	—	VDD33	—	—	—
Y32	CR	—	VDD33	—	—	—
AC32	CR	—	VDD33	—	—	—
AD34	CR	—	VDD33	—	—	—
AK30	CR	—	VDD33	—	—	—
AK31	CR	—	VDD33	—	—	—
AL32	CR	—	VDD33	—	—	—
AM31	CR	—	VDD33	—	—	—
AM33	CR	—	VDD33	—	—	—
AM34	CR	—	VDD33	—	—	—
AN32	CR	—	VDD33	—	—	—
AP32	CR	—	VDD33	—	—	—
AM12	BC	—	VDDIO_BC	—	—	—
AM15	BC	—	VDDIO_BC	—	—	—
AM20	BC	—	VDDIO_BC	—	—	—
AM23	BC	—	VDDIO_BC	—	—	—
AP11	BC	—	VDDIO_BC	—	—	—
AP17	BC	—	VDDIO_BC	—	—	—
AP19	BC	—	VDDIO_BC	—	—	—
AP24	BC	—	VDDIO_BC	—	—	—

\* Differential pairs and physical locations are numbered within each bank (e.g., L19C\_A0 is nineteenth pair in an associated bank). The C indicates complementary differential whereas a T indicates true differential. The \_A0 indicates the physical location is adjacent balls in either horizontal/vertical direction. Other physical indicators are as follows:

- \_A1 indicates one ball between pairs.
- \_A2 indicates two balls between pairs.
- \_D0 indicates balls are diagonally adjacent.
- \_D1 indicates diagonally adjacent separated by one physical ball.

Pin Information (continued)

Table 29. ORT8850H 680-Pin PBGAM Pinout (continued)

BALL	BANK	GROUP	ORT8850-PAD	FUNCTION	Pair*	Differential
AK5	BL	—	VDDIO_BL	—	—	—
AL3	BL	—	VDDIO_BL	—	—	—
AM1	BL	—	VDDIO_BL	—	—	—
AM2	BL	—	VDDIO_BL	—	—	—
AM4	BL	—	VDDIO_BL	—	—	—
AN3	BL	—	VDDIO_BL	—	—	—
AP3	BL	—	VDDIO_BL	—	—	—
L1	CL	—	VDDIO_CL	—	—	—
M3	CL	—	VDDIO_CL	—	—	—
R3	CL	—	VDDIO_CL	—	—	—
U1	CL	—	VDDIO_CL	—	—	—
W1	CL	—	VDDIO_CL	—	—	—
Y3	CL	—	VDDIO_CL	—	—	—
AC3	CL	—	VDDIO_CL	—	—	—
AD1	CL	—	VDDIO_CL	—	—	—

\* Differential pairs and physical locations are numbered within each bank (e.g., L19C\_A0 is nineteenth pair in an associated bank). The C indicates complementary differential whereas a T indicates true differential. The \_A0 indicates the physical location is adjacent balls in either horizontal/vertical direction. Other physical indicators are as follows:  
 \_A1 indicates one ball between pairs.  
 \_A2 indicates two balls between pairs.  
 \_D0 indicates balls are diagonally adjacent.  
 \_D1 indicates diagonally adjacent separated by one physical ball.

## Package Thermal Characteristics Summary

There are three thermal parameters that are in common use:  $\Theta_{JA}$ ,  $\psi_{JC}$ , and  $\Theta_{JC}$ . It should be noted that all the parameters are affected, to varying degrees, by package design (including paddle size) and choice of materials, the amount of copper in the test board or system board, and system airflow.

### $\Theta_{JA}$

This is the thermal resistance from junction to ambient (theta-JA, R-theta, etc.).

$$\Theta_{JA} = \frac{T_J - T_A}{Q}$$

where  $T_J$  is the junction temperature,  $T_A$  is the ambient air temperature, and  $Q$  is the chip power.

Experimentally,  $\Theta_{JA}$  is determined when a special thermal test die is assembled into the package of interest, and the part is mounted on the thermal test board. The diodes on the test chip are separately calibrated in an oven. The package/board is placed either in a JEDEC natural convection box or in the wind tunnel, the latter for forced convection measurements. A controlled amount of power ( $Q$ ) is dissipated in the test chip's heater resistor, the chip's temperature ( $T_J$ ) is determined by the forward drop on the diodes, and the ambient temperature ( $T_A$ ) is noted. Note that  $\Theta_{JA}$  is expressed in units of °C/watt.

### $\psi_{JC}$

This JEDEC designated parameter correlates the junction temperature to the case temperature. It is generally used to infer the junction temperature while the device is operating in the system. It is not considered a true thermal resistance, and it is defined by:

$$\psi_{JC} = \frac{T_J - T_C}{Q}$$

where  $T_C$  is the case temperature at top dead center,  $T_J$  is the junction temperature, and  $Q$  is the chip power. During the  $\Theta_{JA}$  measurements described above, besides the other parameters measured, an additional temperature reading,  $T_C$ , is made with a thermocouple attached at top-dead-center of the case.  $\psi_{JC}$  is also expressed in units of °C/W.

### $\Theta_{JC}$

This is the thermal resistance from junction to case. It is most often used when attaching a heat sink to the top of the package. It is defined by:

$$\Theta_{JC} = \frac{T_J - T_C}{Q}$$

The parameters in this equation have been defined above. However, the measurements are performed with the case of the part pressed against a water-cooled heat sink to draw most of the heat generated by the chip out the top of the package. It is this difference in the measurement process that differentiates  $\Theta_{JC}$  from  $\psi_{JC}$ .  $\Theta_{JC}$  is a true thermal resistance and is expressed in units of °C/W.

### $\Theta_{JB}$

This is the thermal resistance from junction to board ( $\Theta_{JB}$ ). It is defined by:

$$\Theta_{JB} = \frac{T_J - T_B}{Q}$$

where  $T_B$  is the temperature of the board adjacent to a lead measured with a thermocouple. The other parameters on the right-hand side have been defined above. This is considered a true thermal resistance, and the measurement is made with a water-cooled heat sink pressed against the board to draw most of the heat out of the leads. Note that  $\Theta_{JB}$  is expressed in units of °C/W, and that this parameter and the way it is measured are still in JEDEC committee.

## FPSC Maximum Junction Temperature

Once the power dissipated by the FPSC has been determined (see the Estimating Power Dissipation section), the maximum junction temperature of the FPSC can be found. This is needed to determine if speed derating of the device from the 85 °C junction temperature used in all of the delay tables is needed. Using the maximum ambient temperature,  $T_{Amax}$ , and the power dissipated by the device,  $Q$  (expressed in °C), the maximum junction temperature is approximated by:

$$T_{Jmax} = T_{Amax} + (Q \cdot \Theta_{JA})$$

Table 30 lists the thermal characteristics for all packages used with the ORCA ORT8850 Series of FPSCs.

## Package Thermal Characteristics

Table 30. ORCA ORT8850 Plastic Package Thermal Guidelines

Package	$\Theta_{JA}$ ( $^{\circ}\text{C}/\text{W}$ )			T = 70 $^{\circ}\text{C}$ Max T <sub>J</sub> = 125 $^{\circ}\text{C}$ Max 0 fpm (W)
	0 fpm	200 fpm	500 fpm	
680-Pin PBGAM	14.5	TBD	TBD	3.8

## Package Coplanarity

The coplanarity limits of the Lucent packages are as follows:

- PBGAM: 8.0 mils

## Package Parasitics

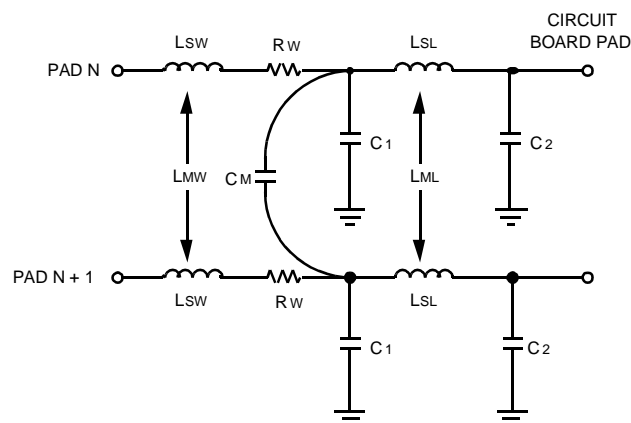
The electrical performance of an IC package, such as signal quality and noise sensitivity, is directly affected by the package parasitics. Table 31 lists eight parasitics associated with the ORCA packages. These parasitics represent the contributions of all components of a package, which include the bond wires, all internal package routing, and the external leads.

Four inductances in nH are listed: L<sub>sw</sub> and L<sub>sl</sub>, the self-inductance of the lead; and L<sub>mw</sub> and L<sub>ml</sub>, the mutual inductance to the nearest neighbor lead. These parameters are important in determining ground bounce noise and inductive crosstalk noise. Three capacitances in pF are listed: C<sub>m</sub>, the mutual capacitance of the lead to the nearest neighbor lead; and C<sub>1</sub> and C<sub>2</sub>, the total capacitance of the lead to all other leads (all other leads are assumed to be grounded). These parameters are important in determining capacitive crosstalk and the capacitive loading effect of the lead. Resistance values are in m $\Omega$ .

The parasitic values in Table 31 are for the circuit model of bond wire and package lead parasitics. If the mutual capacitance value is not used in the designer's model, then the value listed as mutual capacitance should be added to each of the C<sub>1</sub> and C<sub>2</sub> capacitors.

Table 31. ORCA ORT8850 Package Parasitics

Package Type	L <sub>sw</sub>	L <sub>mw</sub>	R <sub>w</sub>	C <sub>1</sub>	C <sub>2</sub>	C <sub>m</sub>	L <sub>sl</sub>	L <sub>ml</sub>
680-Pin PBGAM	3.8	1.3	250	1.0	1.0	0.3	2.8—5	0.5—1



5-3862(C)r2

Figure 22. Package Parasitics

## Package Outline Diagrams

### Terms and Definitions

**Basic Size (BSC):** The basic size of a dimension is the size from which the limits for that dimension are derived by the application of the allowance and the tolerance.

**Design Size:** The design size of a dimension is the actual size of the design, including an allowance for fit and tolerance.

**Typical (TYP):** When specified after a dimension, this indicates the repeated design size if a tolerance is specified or repeated basic size if a tolerance is not specified.

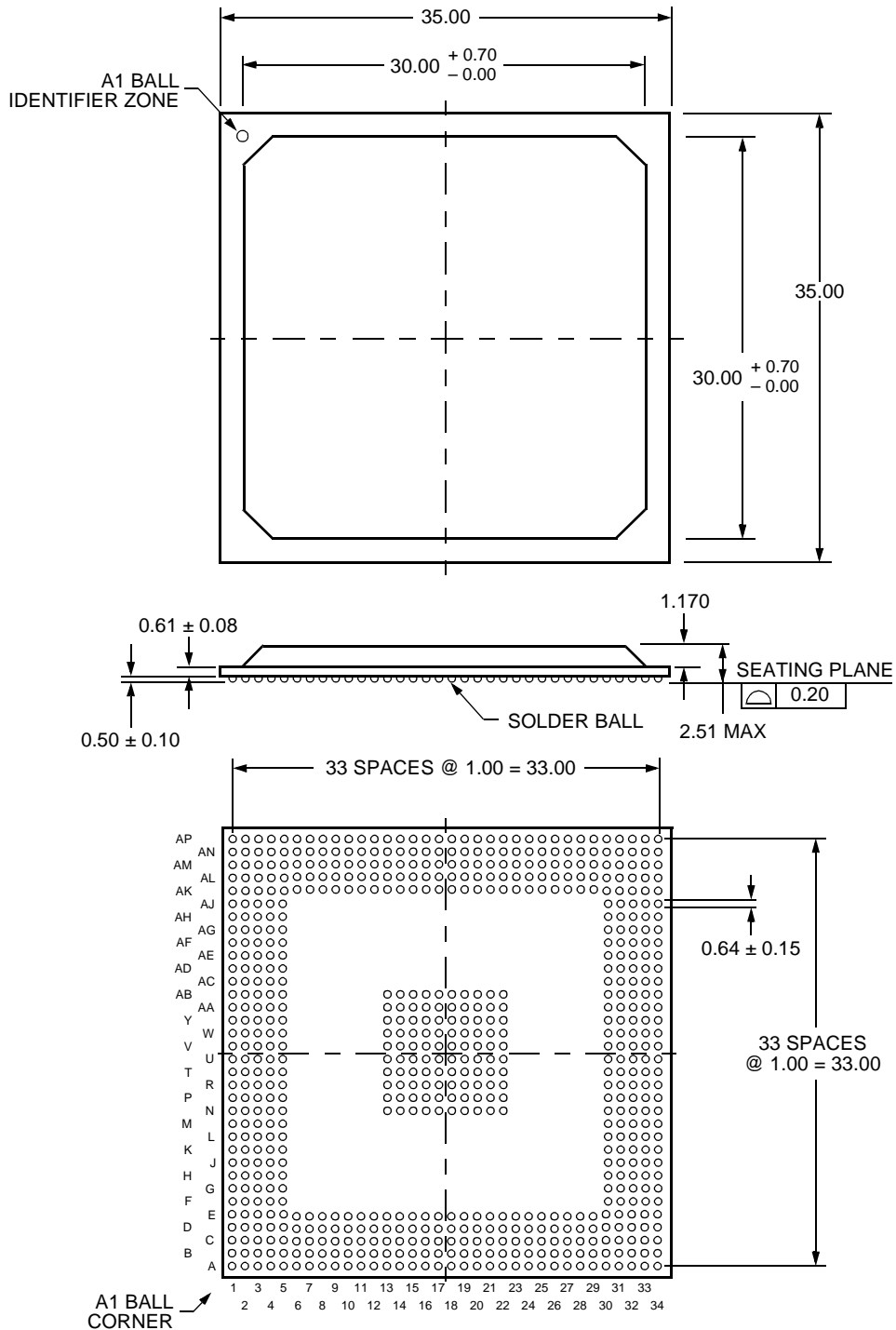
**Reference (REF):** The reference dimension is an untoleranced dimension used for informational purposes only. It is a repeated dimension or one that can be derived from other values in the drawing.

**Minimum (MIN) or Maximum (MAX):** Indicates the minimum or maximum allowable size of a dimension.

Package Outline Diagrams (continued)

680-Pin PBGAM

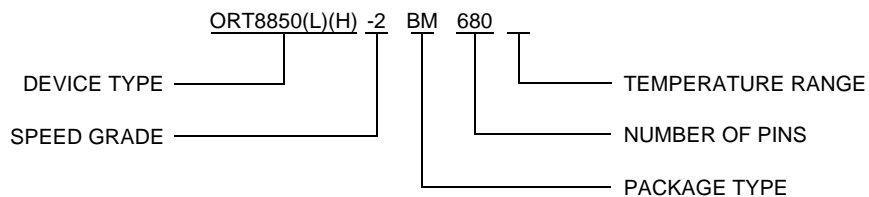
Dimensions are in millimeters.



5-4406(F)



## Hardware Ordering Information



5-6435 (F)

**Table 32. Device Type Options**

Device	Parameter	Value
ORT8850L	Voltage	1.5 V core 3.3 V/2.5 V I/O
	Package	680-pin PBGAM 352-pin PBGA. Two channels with redundancy only
ORT8850H	Voltage	1.5 V core 3.3 V/2.5 V I/O
	Package	680-pin PBGAM

**Table 33. Temperature Options**

Symbol	Description	Temperature
(Blank)	Commercial	0 °C to 70 °C
I	Industrial	-40 °C to +85 °C

**Table 34. Package Type Options**

Symbol	Description
BM	Plastic Ball Grid Array, Multilayer
BA	Plastic Ball Grid Array

**Table 35. ORCA FPSC Package Matrix (Speed Grades)**

Device	Package	
	680-Pin PBGAM	352-Pin PBGA
	BM680	BA352
ORT8850L	-1, -2	-1, -2
ORT8850H	-1, -2	—

## Software Ordering Information

Implementing a design in an ORT8850H/L requires the *ORCA* Foundry Development System and an ORT8850 FPSC Design Kit. For ordering information please visit:

<http://www.lucent.com/micro/netcom/ipkits/ort8850/>

---

For additional information, contact your Microelectronics Group Account Manager or the following:

INTERNET: <http://www.lucent.com/micro>, or for FPGA information, <http://www.lucent.com/orca>

E-MAIL: [docmaster@micro.lucent.com](mailto:docmaster@micro.lucent.com)

N. AMERICA: Microelectronics Group, Lucent Technologies Inc., 555 Union Boulevard, Room 30L-15P-BA, Allentown, PA 18109-3286

**1-800-372-2447**, FAX 610-712-4106 (In CANADA: **1-800-553-2448**, FAX 610-712-4106)

ASIA PACIFIC: Microelectronics Group, Lucent Technologies Singapore Pte. Ltd., 77 Science Park Drive, #03-18 Cintech III, Singapore 118256

**Tel. (65) 778 8833**, FAX (65) 777 7495

CHINA: Microelectronics Group, Lucent Technologies (China) Co., Ltd., A-F2, 23/F, Zao Fong Universe Building, 1800 Zhong Shan Xi Road, Shanghai 200233 P. R. China **Tel. (86) 21 6440 0468, ext. 325**, FAX (86) 21 6440 0652

JAPAN: Microelectronics Group, Lucent Technologies Japan Ltd., 7-18, Higashi-Gotanda 2-chome, Shinagawa-ku, Tokyo 141, Japan

**Tel. (81) 3 5421 1600**, FAX (81) 3 5421 1700

EUROPE: Data Requests: MICROELECTRONICS GROUP DATALINE: **Tel. (44) 7000 582 368**, FAX (44) 1189 328 148

Technical Inquiries: GERMANY: **(49) 89 95086 0** (Munich), UNITED KINGDOM: **(44) 1344 865 900** (Ascot),

FRANCE: **(33) 1 40 83 68 00** (Paris), SWEDEN: **(46) 8 594 607 00** (Stockholm), FINLAND: **(358) 9 3507670** (Helsinki),

ITALY: **(39) 02 6608131** (Milan), SPAIN: **(34) 1 807 1441** (Madrid)

---

Lucent Technologies Inc. reserves the right to make changes to the product(s) or information contained herein without notice. No liability is assumed as a result of their use or application. No rights under any patent accompany the sale of any such product(s) or information. *ORCA* is a registered trademark of Lucent Technologies Inc. *Foundry* is a trademark of Xilinx

