

**PM5350**



**S/UNI-155-ULTRA**

**SATURN USER NETWORK INTERFACE  
155.52 & 51.84 MBIT/S**

**DATA SHEET**

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## **1 FEATURES**

- Single chip ATM User-Network Interface operating at 155.52 and 51.84 Mbit/s.
- Provides an Analog Edge Interface that can be selected to interface directly with Category-5 Unshielded Twisted Pair (UTP-5) or Shielded Twisted Pair cables, or to interface with Pseudo-ECL (PECL) optical data links (ODLs), using a minimum of passive components.
- Implements the ATM Forum User Network Interface Specification and the ATM physical layer for Broadband ISDN according to CCITT Recommendation I.432.
- Processes duplex 155.52 Mbit/s STS-3c/STM-1 (direct interface to a twisted pair cable or PECL interface to a PMD device) or 51.84 Mbit/s STS-1 (PECL interface to a PMD device only) data streams with on-chip clock and data recovery and clock synthesis.
- Performs clock recovery and clock synthesis using on-chip loop filters.
- Provides Saturn Compliant Interface - PHYsical layer (SCI-PHY™) FIFO buffers in both transmit and receive paths with parity support. Compatible with ATM Forum Utopia Level 1 specification.
- Inserts and extracts the generic flow control (GFC) bits via a simple serial interface and provides a transmit XOFF function to allow for local flow control.
- Provides a generic 8-bit microprocessor bus interface for configuration, control, and status monitoring.
- Low power, +5 Volt, CMOS technology.
- 128 pin high performance plastic quad flat pack (PQFP) 14 mm x 20 mm package.

### **The receiver section:**

- Provides a serial interface at 155.52 or 51.84 Mbit/s.
- Adaptively equalizes the received differential signal.

- Recovers the clock and data; frames to the recovered data stream; descrambles the received data; interprets the received payload pointer (H1, H2); and extracts the STS-3c or STS-1 synchronous payload envelope (VC4) and path overhead.
- Extracts ATM cells from the synchronous payload envelope using ATM cell delineation and provides optional ATM cell payload descrambling, header check sequence (HCS) error detection and error correction, and idle/unassigned cell filtering.
- Provides a synchronous 8-bit wide, four cell FIFO buffer.
- Detects loss of signal (LOS), out of frame (OOF), loss of frame (LOF), line alarm indication signal (LAIS), line remote defect indication (RDI), loss of pointer (LOP), path alarm indication signal (PAIS), loss of cell delineation and path remote defect indication (PRDI).
- Counts received section BIP-8 (B1) errors, received line BIP-8/24 (B2) errors, line far end block errors (line FEBE), received path BIP-8 (B3) errors and path far end block errors (path FEBE).
- Counts received HCS errored cells that are discarded, received HCS errored cells that are corrected and passed on, and the total received cells passed on.

**The transmitter section:**

- Provides a serial interface at 155.52 or 51.84 Mbit/s.
- Provides a serial interface at 155.52 or 51.84 Mbit/s. Generates data of the correct amplitude and shape to directly interface with a signal transformer and transmit over a UTP-5 cable.
- Provides a synchronous 8-bit wide, four cell FIFO buffer.
- Provides idle/unassigned cell insertion, HCS generation/insertion, and ATM cell payload scrambling; Inserts ATM cells into the transmitted STS-3c (STM-1) or STS-1 synchronous payload envelope using H4 framing
- Generates the transmit payload pointer (H1, H2) and inserts the path overhead; scrambles the transmitted STS-3c (STM-1) or STS-1 stream and inserts framing bytes (A1, A2) and the identity byte (C1).

- Synthesizes the 155.52 MHz, 51.84 MHz transmit clock from a one-eighth frequency reference.
- Inserts path alarm indication signal (PAIS), path remote defect indication (RDI), line alarm indication signal (LAIS) and line RDI.
- Inserts path BIP-8 codes (B3), path far end block error (path FEBE) indications, line BIP-8/24 codes (B2), line far end block error (line FEBE) indications, section BIP-8 codes (B1) to allow performance monitoring at the far end.
- Allows forced insertion of all zeros data (after scrambling) or corruption of framing byte or section, line, or path BIP-8 codes for diagnostic purposes.

## **2 APPLICATIONS**

- ATM LANs over twisted pair cables (UTP-5) at 155.52 Mbit/s
- ATM LANs over optical fibers (using PECL ODLs) at either 155 Mbit/s or 51.84 Mbit/s
- Workstations and Personal Computer NIC Cards
- LAN switches and hubs
- SONET or SDH compliant ATM User-Network Interfaces



### **3 REFERENCES**

1. CCITT Recommendation G.709 - "Synchronous Multiplexing Structure", 1990.
2. CCITT Recommendation I.432, "B-ISDN User Network Interface - Physical Interface Specification", June 1990.
3. Bell Communications Research - SONET Transport Systems: Common Generic Criteria, GR-253-CORE, Issue 1, December 1994.
4. ATM Forum - ATM User-Network Interface Specification, V3.1, September 1994
5. ATM Forum - ATM Physical Medium Dependent Interface Specification for 155 Mbit/s over Twister Pair Cable, V1.0, September 1994
6. T1.105, American National Standard for Telecommunications - Digital Hierarchy - Optical Interface Rates and Formats Specifications (SONET), 1991.
7. Telecommunications Industry Association (TIA), Commercial Building Telecommunications Wiring Standard, EIA/TIA-568.

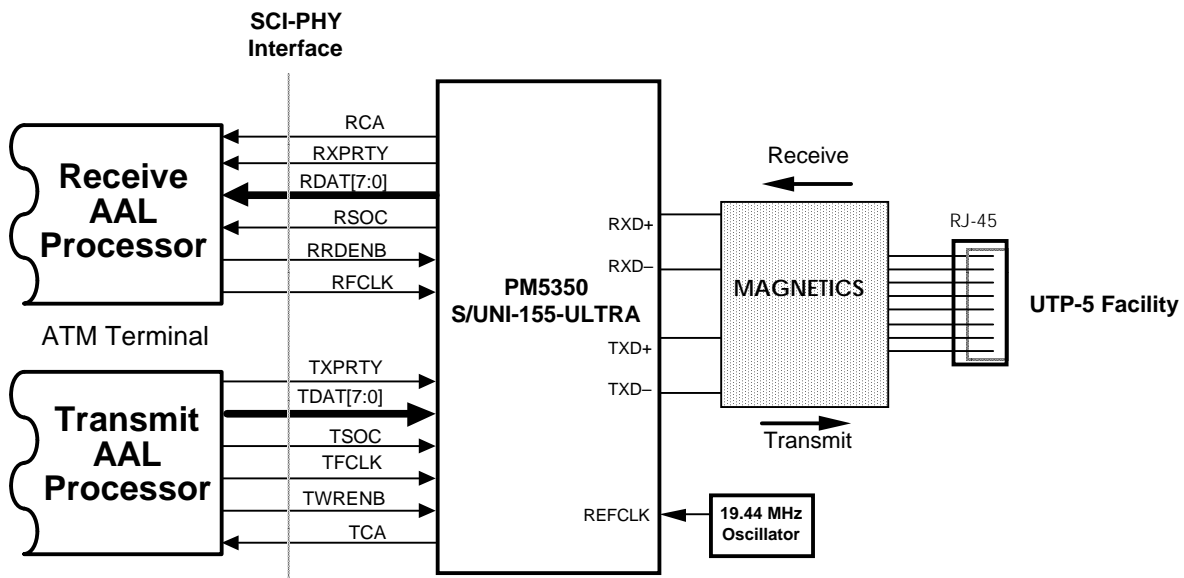
## 4 APPLICATION EXAMPLES

The PM5350 S/UNI-ULTRA is typically used to implement the core of an ATM User Network Interface by which an ATM terminal is linked to an ATM switching system using SONET/SDH compatible transport.

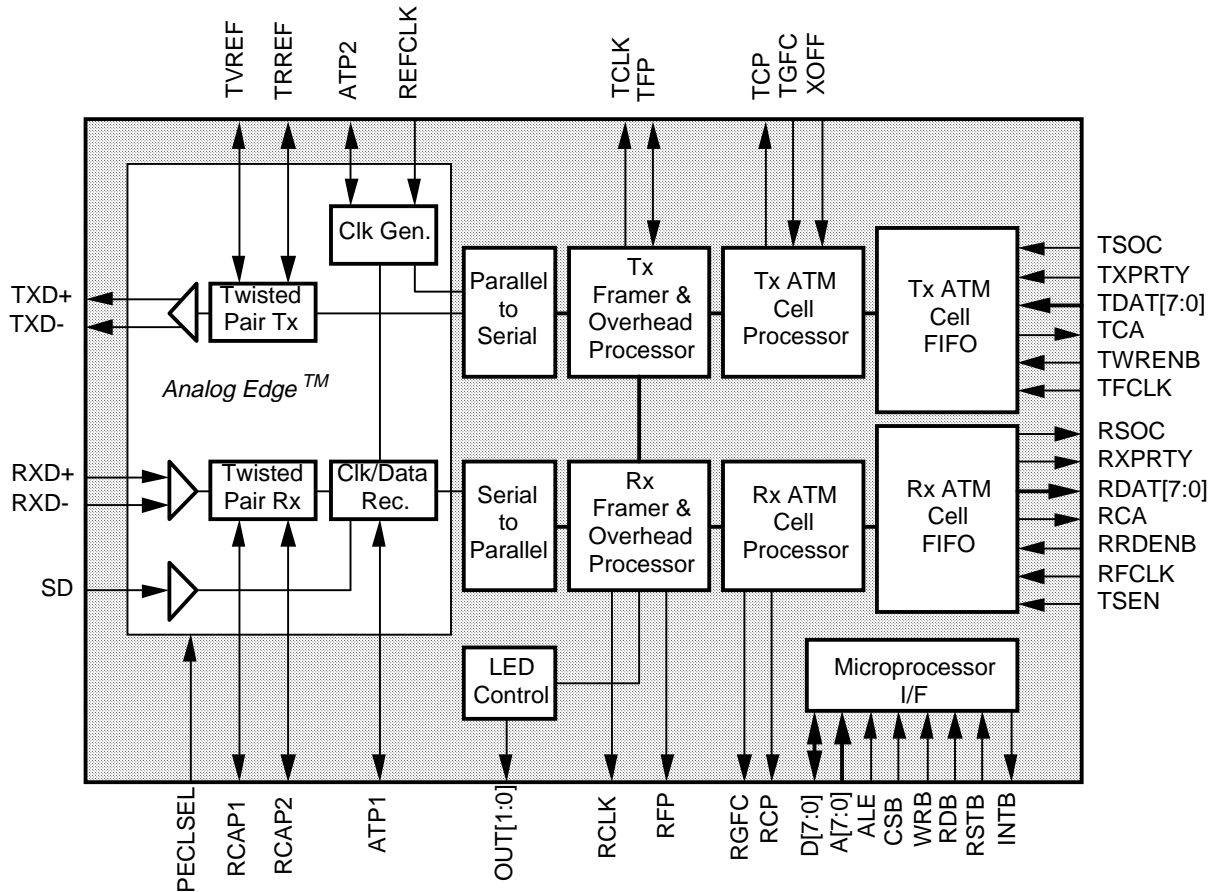
The S/UNI-ULTRA finds application at either end of terminal to switch links or switch to switch links, typically in private network (LAN) applications. In this application, the S/UNI-ULTRA typically interfaces on its line side with line coupling transformers and baluns.

The S/UNI-ULTRA may be loop timed internally (the recovered clock is used in the transmit direction) or source timed (separate transmit and receive clocks). The drop side interfaces directly with ATM adaptation layer or ATM layer processors. The initial configuration and ongoing control and monitoring of the S/UNI-ULTRA is provided via a generic microprocessor interface. The S/UNI-ULTRA also supports a "hardware-only" operating mode where an external microprocessor is not required. This application is shown in Figure 1.

**Figure 1 - Typical ATM Adapter UTP-5 Interface**



## 5 BLOCK DIAGRAM



### Description

The PM5350 S/UNI-ULTRA Saturn User Network Interface is a monolithic integrated circuit that implements the SONET/SDH processing and ATM mapping functions of a 155 Mbit/s or 51Mbit/s ATM User Network Interface. It is fully compliant with both SONET and SDH requirements and ATM Forum UNI specifications.

The S/UNI-ULTRA is capable of directly interfacing with UTP-5 cable. At the receiver end, it performs adaptive equalization. It is fully compliant with the ATM Forum PMD Interface specifications for 155 Mb/s over twisted pair cable.

The S/UNI-ULTRA receives SONET/SDH frames via a bit serial interface, recovers clock and data, and processes section, line, and path overhead. It

performs framing (A1, A2), descrambling, detects alarm conditions, and monitors section, line, and path bit interleaved parity (B1, B2, B3), accumulating error counts at each level for performance monitoring purposes. Line and path far end block error indications (M0 or M1, G1) are also accumulated. The S/UNI-ULTRA interprets the received payload pointers (H1, H2) and extracts the synchronous payload envelope which carries the received ATM cell payload.

The S/UNI-ULTRA frames to the ATM payload using cell delineation. HCS error correction is provided. Idle/unassigned cells may be dropped according to a programmable filter. Cells are also dropped upon detection of an uncorrectable header check sequence error. The ATM cell payloads are descrambled. Generic flow control (GFC) bits from error free cells are extracted and presented on a serial link for external processing.

Legitimate ATM cells are written to a four cell FIFO buffer. These cells are read from the FIFO using a synchronous 8 bit wide datapath interface with cell-based handshake. Counts of received ATM cell headers that are errored and uncorrectable, those that are errored and correctable and all passed cells are accumulated independently for performance monitoring purposes.

The S/UNI-ULTRA transmits SONET/SDH frames via a bit serial interface and formats section, line, and path overhead appropriately. It performs framing pattern insertion (A1, A2), scrambling, alarm signal insertion, and creates section, line, and path bit interleaved parity (B1, B2, B3) as required to allow performance monitoring at the far end. Line and path far end block error indications (M0 or M1, G1) are also inserted.

The S/UNI-ULTRA generates the payload pointer (H1, H2) and inserts the synchronous payload envelope which carries the ATM cell payload. It supports the insertion of a variety of errors into the transmit stream, such as framing pattern errors, bit interleaved parity errors, and illegal pointers, which are useful for system diagnostics.

ATM cells are written to an internal programmable-length 4-cell FIFO using a synchronous 8 bit wide datapath interface. Idle/unassigned cells are automatically inserted when the internal FIFO contains less than one cell or the XOFF input is asserted. Generic flow control (GFC) bits may be inserted downstream of the FIFO via a serial link so that all FIFO latency may be bypassed. A transmission off (XOFF) input is provided to allow the suspension of active ATM cell transmission independent of the FIFO fill state.

The S/UNI-ULTRA generates the header check sequence and scrambles the payload of the ATM cells. Payload scrambling can be disabled.

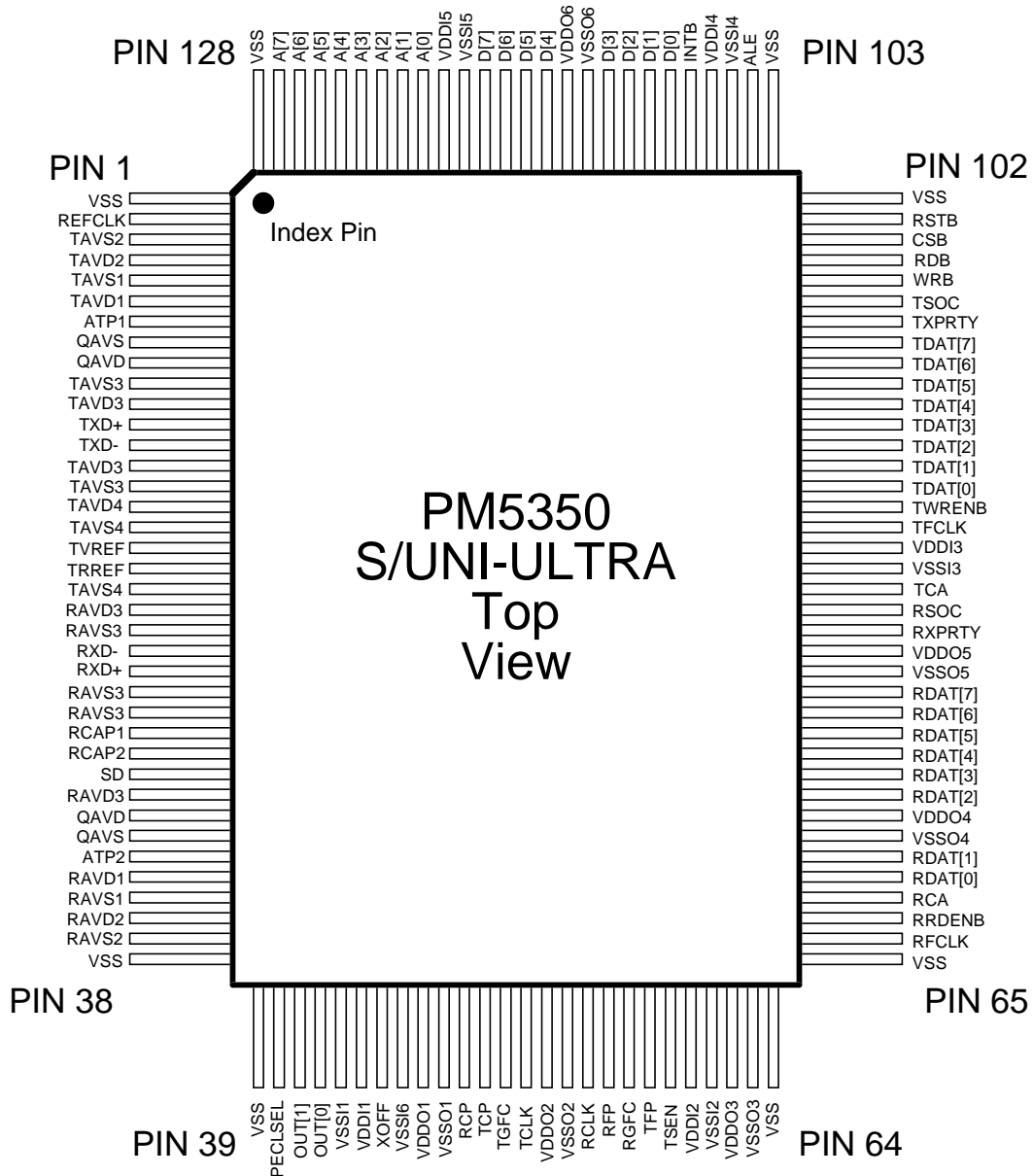
No line rate clocks are required directly by the S/UNI-ULTRA as it synthesizes the transmit clock and recovers the receive clock using a 19.44 MHz reference clock.

The S/UNI-ULTRA provides output control signals that can be used to command an LED display, making it easy to visually monitor either alarms, or the transmit and receive activity.

The S/UNI-ULTRA is configured, controlled and monitored via a generic 8-bit microprocessor bus interface. It is implemented in low power, +5 Volt CMOS technology. It has TTL and pseudo-ECL (PECL) compatible inputs and outputs and is packaged in a 128 pin PQFP package.

## 6 PIN DIAGRAM

The S/UNI-ULTRA is packaged in an 128 pin PQFP package having a body size of 14 mm by 20 mm and a pin pitch of 0.50 mm.



**7 PIN DESCRIPTION**

Pin Name	Type	Pin No.	Function
PECLSEL	TTL Input	40	<p>The PECL mode select (PECLSEL) is used to configure the Analog Edge PMD interface for either PECL or Twisted-pair. A TTL low configures the interface for while a TTL high configures the interface for PECL, enabling direct interfacing with optical transceivers.</p> <p>Refer to the OPERATION section for a detailed description of Twisted-Pair mode and PECL mode configurations. Different termination at TXD+/- and RXD+/- are required depending on the selected mode.</p>
RXD+ RXD-	Diff. Analog Input	24 23	<p>The differential receiver inputs (RXD+/-) NRZ data, from the balun/transformer module interface to these pins when operating in Twisted-pair mode (as configured via the PECLSEL pin tied low), or from an optical data link (ODL) when in PECL mode (as configured via the PECLSEL pin tied high).</p> <p>RXD+/- are truly differential inputs offering superior common-mode noise rejection. Refer to the APPLICATIONS section of this document for a description of the required termination network.</p>
REFCLK	TTL Input	2	<p>The reference clock input (REFCLK) must provide a jitter-free 19.44 MHz reference clock. It is used as the reference clock by both clock recovery and clock synthesis circuits.</p>

Pin Name	Type	Pin No.	Function
SD	Single-Ended PECL Input	29	<p>The Signal Detect pin (SD) indicates the presence of valid receive signal power from the Optical Physical Medium Dependent Device when operating in PECL mode (as configured via the PECLSEL pin tied high). A PECL high indicates the presence of valid data and a PECL low indicates a loss of signal. It is mandatory that SD be terminated into the equivalent network that RXD+/- is terminated into.</p> <p>When operated in Twisted-pair mode (as configured via the PECLSEL pin tied low), SD has no function and should be connected to the analog ground common to RAVS3.</p>
RCLK	Output	55	<p>The receive clock (RCLK) output provides a timing reference for the S/UNI-ULTRA receive outputs. RCLK is a divide by eight of the recovered line rate clock. RGFC, RCP, RFP and OUT[1] (when configured for alarm monitoring) are updated on the rising edge of RCLK.</p>



Pin Name	Type	Pin No.	Function
OUT[1] OUT[0]	Output	41 42	<p>The alarm/output port pins has three functions as selected by POPC control register bits.</p> <p>When configured to output alarms, the OUT[1] output indicates a receive alarm (RALM function) based on the state of the receive framer. OUT[1] is low if no receive alarms are active. OUT[1] is high if an alarm condition is detected. OUT[1] is updated on the rising edge of RCLK. In this operation mode OUT[0] is used as a single bit parallel output port, as described below.</p> <p>When configured as a parallel output port, OUT[1] and OUT[0] can be used to control the operation of external devices. The signal levels on the output port are determined by register bits.</p> <p>When configured as a traffic indicator port, OUT[1] indicates the receive traffic activity and OUT[0] indicates the transmit traffic activity. In this operation mode OUT[1] and OUT[0] pulses high for 100ms on cell receive and transmit events and can be used to control an LED display.</p>
RFP	Output	56	<p>The receive frame pulse (RFP) output, when the framing alignment has been found (the OOF register bit is logic 0), is an 8 kHz signal derived from the receive line clock. RFP pulses high for one RCLK cycle every 2430 RCLK cycles for STS-3c (STM-1) rate or every 810 RCLK cycles for STS-1 rate. RFP is updated on the rising edge of RCLK.</p>

Pin Name	Type	Pin No.	Function
TXD+ TXD-	Diff. Analog Output	12 13	<p>The transmit differential data/positive pulse outputs (TXD+, TXD-) contain NRZ encoded data. These outputs are open drain current sinks which interface directly with the Twisted-pair network or with an Optical Interface Module requiring PECL levels.</p> <p>Refer to the APPLICATIONS section of this document for a description of the required termination network.</p>
TFP	I/O	58	<p>The active high framing position (TFP) signal is an 8 kHz timing marker for the transmitter. TFP defaults to being an input and is used to align the SONET/SDH transport frame generated by the S/UNI-ULTRA device to a system reference. TFP should be brought high for a single TCLK period every 810 (STS-1) or 2430 (STS-3/STM-1) TCLK cycles, or a multiple thereof. TFP may be tied low if such synchronization is not required. TFP is sampled on the rising edge of TCLK. TFP must not be used as an input when loop-timed.</p> <p>When selected as an output through the interface configuration register, TFP pulses high for one TCLK cycle every 2430 TCLK cycles for STS-3c (STM-1) rate or every 810 TCLK cycles for STS-1 rate. TFP is updated on the rising edge of TCLK.</p>

Pin Name	Type	Pin No.	Function
TSEN	Input	59	The tristate enable (TSEN) input selects the configuration of the receive datapath (RDAT[7:0], RXPRTY and RSOC). When TSEN is tied high, RDAT[7:0] operates as a tristate bus controlled by RRDENB. When RRDENB is high upon RFCLK rising, RDAT[7:0], RXPRTY and RSOC are tristated. When RRDENB is low upon RFCLK rising, RDAT[7:0], RXPRTY and RSOC are enabled. When TSEN is tied low, RDAT[7:0], RXPRTY and RSOC are always enabled, regardless of the state of RRDENB.
RFCLK	Input	66	The receive read clock (RFCLK) is used to read ATM cells from the receive FIFO. RFCLK must cycle at a high enough rate to avoid FIFO overflow. RRDENB is sampled using the rising edge of RFCLK. RSOC, RDAT[7:0], RXPRTY and RCA are updated on the rising edge of RFCLK
RRDENB	Input	67	The active low receive read enable input (RRDENB) is used to initiate reads from the receive FIFO. When sampled low using the rising edge of RFCLK, a byte is read from the internal synchronous FIFO and output on bus RDAT[7:0] if one is available. When sampled high using the rising edge of RFCLK, no read is performed and RDAT[7:0] and RSOC are tristated if the TSEN input is high. RRDENB must operate in conjunction with RFCLK to access the FIFO at a high enough instantaneous rate as to avoid FIFO overflows. The ATM layer device may deassert RRDENB at anytime it is unable to accept another byte.  When the RCA signal is configured to be deasserted with zero octets (as opposed to four) in the FIFO, the RCA signal identifies the valid octets.

Pin Name	Type	Pin No.	Function
RDAT[0] RDAT[1] RDAT[2] RDAT[3] RDAT[4] RDAT[5] RDAT[6] RDAT[7]	Tristate Output	69 70 73 74 75 76 77 78	The receive cell data (RDAT[7:0]) bus carries the ATM cell octets that are read from the receive FIFO. RDAT[7:0] is updated on the rising edge of RFCLK and is tristated when not valid if the TSEN input is high. The RDAT[7:0] bus is always driven when TSEN is low, regardless of the level of RRDENB.
RXPRTY	Tristate Output	81	The receive parity (RXPRTY) signal indicates the parity of the RDAT[7:0] bus. Odd or even parity selection can be made using a register. RXPRTY is updated on the rising edge of RFCLK and is tristated when not valid if the TSEN input is high. RXPRTY is always driven when TSEN is low, regardless of the level of RRDENB.
RSOC	Tristate Output	82	The receive start of cell (RSOC) signal marks the start of cell on the RDAT[7:0] bus. When RSOC is high, the first octet of the cell is present on the RDAT[7:0] stream. RSOC is updated on the rising edge of RFCLK and is tristated when not valid if the TSEN input is high. RSOC is always driven when TSEN is low, regardless of the level of RRDENB.
RCA	Output	68	The receive cell available (RCA) signal indicates when a cell is available in the receive FIFO. RCA can be configured to be deasserted when either zero or four bytes remain in the FIFO. RCA is updated on the rising edge of RFCLK. The active polarity of this signal is programmable and defaults to active high.

Pin Name	Type	Pin No.	Function
RGFC	Output	57	The receive generic flow control (RGFC) output presents the extracted GFC bits in a serial stream. The four GFC bits are presented for each received cell, with the RCP output indicating the position of the most significant bit. The updating of RGFC by particular GFC bits may be disabled through the RACP Configuration register. The serial link is forced low if cell delineation is lost. RGFC is updated on the rising edge of RCLK.
RCP	Output	49	The receive cell pulse (RCP) indicates the location of the four GFC bits in the RGFC serial stream. RCP is coincident with the most significant GFC bit. RCP is updated on the rising edge of RCLK.
TCLK	Output	52	The transmit byte clock (TCLK) output provides a timing reference for S/UNI-ULTRA transmit outputs. TCLK is a divide by eight of the synthesized line rate clock. TGFC, TCP and TFP are sampled on the rising edge of TCLK.
TFCLK	Input	86	The transmit write clock (TFCLK) is used to write ATM cells to the four cell transmit FIFO. A complete 53 octet cell must be written to the FIFO before being inserted in the synchronous payload envelope (SPE). Idle/unassigned cells are inserted when a complete cell is not available. TDAT[7:0], TXPRTY, TWRENB and TSOC are sampled on the rising edge of TFCLK. TCA is updated on the rising edge of TFCLK.

Pin Name	Type	Pin No.	Function
TDAT[0] TDAT[1] TDAT[2] TDAT[3] TDAT[4] TDAT[5] TDAT[6] TDAT[7]	Input	88 89 90 91 92 93 94 95	The transmit cell data (TDAT[7:0]) bus carries the ATM cell octets that are written to the transmit FIFO. TDAT[7:0] is sampled on the rising edge of TFCLK and is considered valid only when TWRENB is simultaneously asserted.
TXPRTY	Input	96	The transmit parity (TXPRTY) signal indicates the parity of the TDAT[7:0] bus. Odd or even parity selection can be made using a register bit. TXPRTY is sampled on the rising edge of TFCLK and is considered valid only when TWRENB is simultaneously asserted.  A parity error is indicated by a status bit and a maskable interrupt. Cells with parity errors are not filtered, so the TXPRTY input may be unused.
TWRENB	Input	87	The active low transmit write enable input (TWRENB) is used to initiate writes to the transmit FIFO. When sampled low using the rising edge of TFCLK, the byte on TDAT[7:0] is written into the transmit FIFO. When sampled high using the rising edge of TFCLK, no write is performed. A complete 53 octet cell must be written to the transmit FIFO before it is inserted into the SPE. Idle/unassigned cells are inserted when a complete cell is not available.

Pin Name	Type	Pin No.	Function
TSOC	Input	97	The transmit start of cell (TSOC) signal marks the start of cell on the TDAT[7:0] bus. When TSOC is high, the first octet of the cell is present on the TDAT[7:0] stream. It is not necessary for TSOC to be present at each cell. An interrupt may be generated if TSOC is high during any byte other than the first byte. TSOC is sampled on the rising edge of TFCLK
TCA	Output	83	The transmit cell available (TCA) signal indicates when a cell is available in the transmit FIFO. When high, TCA indicates that the transmit FIFO is not full and a complete cell may be written in. When TCA goes low, it indicates either that the transmit FIFO is near full and can accept no more than four writes or that the transmit FIFO is full. Selection is made using a register bit in the TACP FIFO Control register. To reduce FIFO latency, the FIFO depth at which TCA indicates "full" can be set to one, two, three or four cells by the TACP FIFO Control register. If the programmed depth is less than four, additional cells may be written after TCA is deasserted. TCA is updated on the rising edge of TFCLK. The active polarity of this signal is programmable and defaults to active high.
XOFF	Input	45	The transmit off (XOFF) input prevents the insertion of cells from the transmit FIFO. If XOFF is asserted high, the next cell transmitted is an idle/unassigned cell regardless of the number of cells in the FIFO. Idle/unassigned cells are transmitted until XOFF is deasserted. XOFF may be treated as an asynchronous signal.  When the device is set in production test mode (Master Test Register PMCTST bit set to logic 1) XOFF is used as the test vector clock (VCLK) signal.

Pin Name	Type	Pin No.	Function
TGFC	Input	51	The transmit generic flow control (TGFC) input provides the ability to insert the GFC value. The four TCLK periods following the TCP output pulse contain the GFC value to be inserted into the current cell. The GFC enable bits of the TACP Configuration register enable the insertion of each serial bit. By default, the GFC values are the contents of the TACP Idle/Unassigned Cell Header Control register for idle/unassigned cells and the value received from TDAT[7:0] for assigned cells. TGFC is sampled on the rising edge of TCLK.
TCP	Output	50	The transmit cell pulse (TCP) indicates where the valid TGFC serial bits are expected. If TCP is asserted high, the most significant GFC bit is expected in the subsequent TCLK period. TCP pulses high for one TCLK for every transmitted cell six payload octets before the first octet of the cell read from the transmit FIFO, or the idle cell if the FIFO is empty. TCP is updated on the rising edge of TCLK.
TRREF	Analog	19	The reference resistor (TRREF) input is connected to an off-chip precision resistor RREF to produce calibrated currents for the TXD+/- outputs. The resistor should be connected between TRREF and TAVS4.  Please refer to the APPLICATIONS and the EXTERNAL COMPONENTS sections of this document for a detailed RREF specification.



Pin Name	Type	Pin No.	Function
TVREF	Analog	18	The reference voltage (TVREF) is optionally used to produce calibrated currents for the TXD +/- outputs. In order to meet tight amplitude tolerances over process, temperature and supply, a precise reference voltage generator VREF is required. The other terminal of the reference generator should be connected to TAVS4. If this pin is unused, this input should be connected to analog TAVS4.  Please refer to the APPLICATIONS and the EXTERNAL COMPONENTS sections of this document for a detailed VREF specification.
RCAP1 RCAP2	Analog	27 28	The RCAP1 and RCAP2 pins should be connected to the RAVS3 analog ground.
ATP1 ATP2	Analog	7 33	Two analog test points (ATP1, ATP2) are provided for production test purposes. These pins must be connected to analog ground during normal operation.
CSB	Input	100	The active low chip select (CSB) signal is low during S/UNI-ULTRA register accesses. If CSB is used, it must be held high while RSTB is low to properly initialize the device. If CSB is not required (i.e. register accesses are controlled using the RDB and WRB signals only), CSB must be connected to an inverted version of the RSTB input to ensure proper device initialization. CSB is a Schmitt triggered input with an integral pull up resistor.
RDB	Input	99	The active low read enable (RDB) signal is low during S/UNI-ULTRA register read accesses. The S/UNI-ULTRA drives the D[7:0] bus with the contents of the addressed register while RDB and CSB are low.

Pin Name	Type	Pin No.	Function
WRB	Input	98	The active low write strobe (WRB) signal is low during a S/UNI-ULTRA register write accesses. The D[7:0] bus contents are clocked into the addressed register on the rising WRB edge while CSB is low.
D[0] D[1] D[2] D[3] D[4] D[5] D[6] D[7]	I/O	108 109 110 111 114 115 116 117	The bidirectional data bus D[7:0] is used during S/UNI-ULTRA register read and write accesses.
A[0] A[1] A[2] A[3] A[4] A[5] A[6] A[7]/TRS	Input	120 121 122 123 124 125 126 127	The address bus A[7:0] selects specific registers during S/UNI-ULTRA register accesses.  The test register select (TRS) signal selects between normal and test mode register accesses. TRS is high during test mode register accesses, and is low during normal mode register accesses.
RSTB	Input	101	The active low reset (RSTB) signal provides an asynchronous S/UNI-ULTRA reset. RSTB is a Schmitt triggered input with an integral pull up resistor.

Pin Name	Type	Pin No.	Function
ALE	Input	104	The address latch enable (ALE) is active high and latches the address bus A[7:0] when low. When ALE is high, the internal address latches are transparent. It allows the S/UNI-ULTRA to interface to a multiplexed address/data bus.
INTB	Open-Drain Output	107	The active low interrupt (INTB) signal goes low when a S/UNI-ULTRA interrupt source is active, and that source is unmasked. The S/UNI-ULTRA may be enabled to report many alarms or events via interrupts. INTB returns high when the interrupt is acknowledged via an appropriate register access. INTB is an open drain output and must have an external pull-up resistor.
VDDI1 VDDI2 VDDI3 VDDI4 VDDI5	Power	44 60 85 106 119	The core power (VDDI1 - VDDI5) pins should be connected to a well decoupled +5 V DC in common with VDDO.
VSSI1 VSSI2 VSSI3 VSSI4 VSSI5 VSSI6	Ground	43 61 84 105 118 46	The core ground (VSSI1 - VSSI6) pins should be connected to GND in common with VSSO.
VDDO1 VDDO2 VDDO3 VDDO4 VDDO5 VDDO6	Power	47 53 62 72 80 113	The pad ring power (VDDO1 - VDDO6) pins should be connected to a well decoupled +5 V DC in common with VDDI.

Pin Name	Type	Pin No.	Function
VSSO1 VSSO2 VSSO3 VSSO4 VSSO5 VSSO6	Ground	48 54 63 71 79 112	The pad ring ground (VSSO1 - VSSO6) pins should be connected to GND in common with VSSI.
VSS	Thermal Ground	1 38 39 64 65 102 103 128	The thermal grounds (VSS) provide a low thermal resistance for the dissipated heat. These pins are shorted internally and must be connected to VSSI ground for correct operation.
TAVD1	Analog Power	6	The power (TAVD1) pin for the transmit clock synthesizer reference circuitry. TAVD1 should be connected to analog +5V.
TAVD2	Analog Power	4	The power (TAVD2) pin for the transmit clock synthesizer oscillator. TAVD2 should be connected to analog +5V.
TAVD3	Analog Power	11 14	The power (TAVD3) pins for the twisted pair and PECL transmitter output driver. TAVD3 should be connected to analog +5V.
TAVD4	Analog Power	16	The power (TAVD4) pin for the twisted pair and PECL transmitter block reference circuitry. TAVD4 should be connected to analog +5V.
TAVS1	Analog Ground	5	The ground (TAVS1) pin for the transmit clock synthesizer reference circuitry. TAVS1 should be connected to analog GND.

Pin Name	Type	Pin No.	Function
TAVS2	Analog Ground	3	The ground (TAVS2) pin for the transmit clock synthesizer oscillator. TAVS2 should be connected to analog GND.
TAVS3	Analog Ground	10 15	The ground (TAVS3) pins for the twisted pair and PECL transmitter output driver. TAVS3 should be connected to analog GND.
TAVS4	Analog Ground	17 20	The ground (TAVS4) pins for the twisted pair and PECL transmitter block reference circuitry. TAVS4 should be connected to analog GND.
RAVD1	Analog Power	34	The power (RAVD1) pin for receive clock and data recovery block reference circuitry. RAVD1 should be connected to analog +5V.
RAVD2	Analog Power	36	The power (RAVD2) pin for receive clock and data recovery block active loop filter and oscillator. RAVD2 should be connected to analog +5V.
RAVD3	Analog Power	21 30	The power (RAVD3) pins for the twisted pair and PECL receiver block. RAVD3 should be connected to analog +5V.
RAVS1	Analog Ground	35	The ground (RAVS1) pin for receive clock and data recovery block reference circuitry. RAVS1 should be connected to analog GND.
RAVS2	Analog Ground	37	The ground (RAVS2) pin for receive clock and data recovery block active loop filter and oscillator. RAVS2 should be connected to analog GND.
RAVS3	Analog Ground	22 25 26	The ground (RAVS3) pins for the twisted pair and PECL receiver block. RAVS3 should be connected to analog GND.
QAVD	Analog Power	9 31	The power (QAVD) pins for the analog core. QAVD should be connected to analog +5V.
QAVS	Analog Ground	8 32	The ground (QAVS) pins for the analog core. QAVS should be connected to analog GND.

**Notes on Pin Description:**

1. All S/UNI-ULTRA inputs and bidirectionals present minimum capacitive loading and operate at TTL logic levels except: the SD input operates at pseudo-ECL (PECL) logic levels; the RXD+ and RXD- inputs can be configured to operate at either PECL levels or UTP-5 cable interface levels, respectively.
2. The RDAT[7:0], RXPRTY, RCP, RGFC, RSOC, RCA, TCA, TCP, TCLK and RCLK outputs have a 4 mA drive capability. All other S/UNI-ULTRA digital outputs and bidirectionals have 2 mA drive capability. All 4 mA and 2 mA outputs are slew rate limited. The TXD+ and TXD- outputs have either a 16mA or 20mA capability, depending if they are configure to operate at PECL or UTP-5 levels.
3. The VSSO and VSSI ground pins are not internally connected together. Failure to connect these pins externally may cause malfunction or damage the device.
4. The VDDO and VDDI power pins are not internally connected together. Failure to connect these pins externally may cause malfunction or damage the device.
5. All analog power and ground pins are sensitive to noise. They must be isolated from the digital power and ground. The TAVD2 and RAVD2 pins power oscillators; therefore, they generate significant switching noise. Care must be taken to decouple these pins from each other and all other analog power and ground pins.
6. The OUT[1] and OUT[0] outputs can control an LED display but must be buffered to provide a sufficient drive.
7. Due to ESD protection structures in the pads it is necessary to exercise caution when powering a device up or down. ESD protection devices behave as diodes between power supply pins and from I/O pins to power supply pins. Under extreme conditions it is possible to blow these ESD protection devices or trigger latch up. **Please adhere to the recommended power supply sequencing as described in the OPERATION section of this document.**

## FunctionAL Description

### 7.1 UTP-5 and PECL Receiver

The line receiver (RUTP-5) can be configured to interface with a UTP-5 twisted pair cable, or to interface with an optical interface module. In the former case it performs adaptive equalization on the received signal. It is fully compliant to the ATM Forum PMD Interface specification for 155 Mbit/s over twisted pair cable. In the latter case, it provides a PECL line interface.

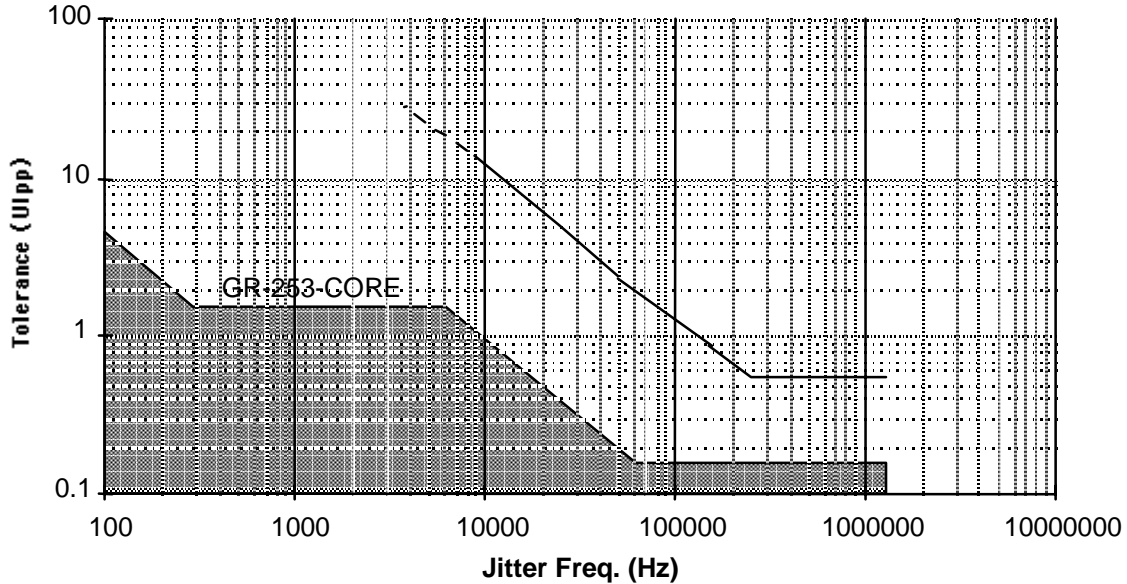
### 7.2 Clock Recovery

The clock recovery unit recovers the clock from the incoming bit serial data stream. The clock recovery unit is fully compliant with SONET and SDH jitter tolerance requirements. The clock recovery unit utilizes a low frequency reference clock to train and monitor its clock recovery PLL. Under loss of signal conditions, the clock recovery unit will continue to output a line rate clock that is locked to this reference for "keep alive" purposes. The clock recovery unit utilizes a 19.44 MHz reference clock. The clock recovery unit provides status bits that indicate whether it is locked to data or the reference. The clock recovery unit also supports diagnostic loopback and a loss of signal input that squelches normal input data.

Initially, the PLL locks to the reference clock, REFCLK. When the frequency of the recovered clock is within 488 ppm of the reference clock, the PLL attempts to lock to the data. Once in data lock, the PLL reverts to the reference clock if no data transitions occur in 80 bit periods or if the recovered clock drifts beyond 488 ppm of the reference clock.

The internal loop filter transfer function is optimized to enable the PLL to track the jitter, yet tolerate the minimum transition density expected in a received SONET data signal. The total loop dynamics of the clock recovery PLL yield a jitter tolerance which exceeds the minimum tolerance required for SONET equipment by GR-253-CORE (Figure 2).

**Figure 2 - STS-3c/STM-1 Jitter Tolerance**



Note that for frequencies below 300 Hz the jitter tolerance is greater than 15 UIpp; 15 UIpp is the maximum jitter tolerance of the test equipment. If the recovered clock drifts beyond 488 ppm of the reference, the PLL locks to the reference clock.

**7.3 Serial to Parallel Converter**

The Serial to Parallel Converter (SIPO) converts the received bit serial SONET stream to a byte serial stream. The SIPO searches for the SONET/SDH framing pattern (A1, A2 ) in the incoming stream, and performs serial to parallel conversion on octet boundaries.

**7.4 Receive Section Overhead Processor**

The Receive Section Overhead Processor (RSOP) provides frame synchronization, descrambling, section level alarm and performance monitoring.

**7.4.1 Framer**

The Framer Block determines the in-frame/out-of-frame status of the STS-3c or STS-1 data stream. The loss of frame condition asserts the OUT[1] output with timing aligned to RCLK (provided POPC receive alarm monitor mode is selected).



While in-frame, the framing bytes (A1, A2) in each frame are compared against the expected pattern. Out-of-frame is declared when four consecutive frames containing one or more framing pattern errors have been received.

While out-of-frame, the SIPO block monitors the bit serial data stream for an occurrence of the framing pattern. When a framing pattern has been recognized, the Framing Block verifies that an error free framing pattern is present in the next frame before declaring in-frame.

#### **7.4.2 Descramble**

The Descramble Block utilizes a frame synchronous descrambler to process the received byte serial stream. The generating polynomial is  $1+x^6+x^7$  and the sequence length is 127. Details of the descrambling operation are provided in the references. Note that the framing bytes (A1 and A2) and the section trace/section growth bytes (J0/Z0) are not descrambled. A register bit is provided to disable the descrambling operation.

#### **7.4.3 Error Monitor**

The Error Monitor Block calculates the received section BIP-8 error detection code (B1) based on the scrambled data of the complete STS-3c or STS-1 frame. The section BIP-8 code is based on a bit interleaved parity calculation using even parity. Details are provided in the references. The calculated BIP-8 code is compared with the BIP-8 code extracted from the B1 byte of the following frame. Differences indicate that a section level bit error has occurred. Up to 64000 (8x8000) bit errors can be detected per second. The Error Monitor Block accumulates these section level bit errors in a 16 bit saturating counter that can be read via the microprocessor interface. Circuitry is provided to latch this counter so that its value can be read while simultaneously resetting the internal counter to 0 or 1, if appropriate, so that a new period of accumulation can begin without loss of any events. It is intended that this counter be polled at least once per second so as not to miss bit error events.

#### **7.4.4 Loss of Signal**

The Loss of Signal Block monitors the scrambled data of the complete STS-3c or STS-1 stream for the absence of 1's. When  $20 \pm 3 \mu\text{s}$  of all zeros patterns is detected, a loss of signal (LOS) is declared. Loss of signal is cleared when two valid framing words are detected and during the intervening time, no loss of signal condition is detected. The loss of signal condition asserts the RALM output with timing aligned to RCLK.

### **7.4.5 Loss of Frame**

The Loss of Frame Block monitors the in-frame / out-of-frame status of the Framer Block. A loss of frame (LOF) is declared when an out-of-frame (OOF) condition persists for 3 ms. To provide for intermittent out-of-frame conditions, the 3 ms timer is not reset to zero until an in-frame condition persists for 3 ms. The loss of frame is cleared when an in frame condition persists for a period of 3 ms. The loss of frame condition asserts the RALM output with timing aligned to RCLK.

## **7.5 Receive Line Overhead Processor**

The Receive Line Overhead Processor (RLOP) provides line level alarm and performance monitoring.

### **7.5.1 Line Remote Defect Indication Detect**

The Line RDI Detect Block detects the presence of Line remote defect indication (RDI) in the data stream. Line RDI is declared when a 110 binary pattern is detected in bits 6, 7, and 8 of the K2 byte, for five consecutive frames. Line RDI is removed when any pattern other than 110 is detected in bits 6, 7, and 8 of the K2 byte for five consecutive frames. The line RDI status is available through a maskable interrupt and register bits.

### **7.5.2 Line AIS Detect**

The Line AIS Block detects the presence of a Line Alarm Indication Signal (AIS) in the data stream. Line AIS is declared when a 111 binary pattern is detected in bits 6,7,8 of the K2 byte, for five consecutive frames. LAIS is removed when any pattern other than 111 is detected in bits 6, 7, and 8 of the K2 byte for five consecutive frames. Line AIS detection asserts the RALM output with timing aligned to RCLK.

### **7.5.3 Error Monitor**

The Error Monitor Block calculates the received line BIP-8/24 error detection code (B2) based on the line overhead and synchronous payload envelope of the data stream. The line BIP-8/24 code is a bit interleaved parity calculation using even parity. Details are provided in the references. The calculated BIP code is compared with the BIP-8/24 code extracted from the B3 byte(s) of the following frame. Any differences indicate that a line layer bit error has occurred. Up to 192000 (24 x 8000) bit errors can be detected per second.

The Error Monitor Block accumulates these line layer bit errors in a 20 bit saturating counter that can be read via the microprocessor interface. During a read, the counter value is latched and the counter is reset to 0 (or 1, if there is an outstanding event). Note, this counter should be polled at least once per second to avoid saturation which in turn may result in missed bit error events.

The Error Monitor Block also accumulates line far end block error indications (contained in the M0/M1 byte) in a similar manner.

## **7.6 Receive Path Overhead Processor**

The Receive Path Overhead Processor (RPOP) provides pointer interpretation, extraction of path overhead, extraction of the synchronous payload envelope, and path level alarm and performance monitoring.

### **7.6.1 Pointer Interpreter**

The Pointer Interpreter interprets the incoming pointer (H1, H2) as specified in the references. The pointer value is used to determine the location of the path overhead (the J1 byte) in the incoming STS-3c (AU4) or STS-1 (AU3) stream.

The Pointer Interpreter Block detects loss of pointer (LOP) in the incoming STS-1 or STS-3c. LOP is declared as a result of eight consecutive invalid pointers or eight consecutive NDF enabled indications. LOP is removed when the same valid pointer with normal NDF is detected for three consecutive frames.

The Pointer Interpreter Block detects path AIS in the incoming STS-1 or STS-3c stream. PAIS is declared on entry to the AIS\_state after three consecutive AIS indications. PAIS is removed when the same valid pointer with normal NDF is detected for three consecutive frames or when a valid with NDF enabled is detected.

The pointer value is used to extract the path overhead from the incoming stream.

Note that due to anomalies in the standard pointer interpretation rules, certain illegal pointers may not cause the device to declare a loss of pointer (LOP) state. In this situation, however, the device will declare a loss of cell delineation state and return to normal operation when presented with legal pointer values. Such illegal pointers typically can only be generated continuously by test equipment and will not normally occur during live-traffic operation.

## **7.6.2 Error Monitor**

The Error Monitor Block contains two 16-bit counters that are used to accumulate path BIP-8 errors (B3), and far end block errors (FEBE). The contents of the two counters may be transferred to holding registers, and the counters reset under microprocessor control.

Path BIP-8 errors are detected by comparing the path BIP-8 byte (B3) extracted from the current frame, to the path BIP-8 computed for the previous frame.

FEBEs are detected by extracting the 4-bit FEBE field from the path status byte (G1). The legal range for the 4-bit field is between 0000 and 1000, representing zero to eight errors. Any other value is interpreted as zero errors.

Path remote defect indication (RDI) is detected by extracting bit 5 of the path status byte. Path RDI is declared when bit 5 is set high for five consecutive frames and is cleared when bit 5 is low for five consecutive frames.

## **7.7 Receive ATM Cell Processor**

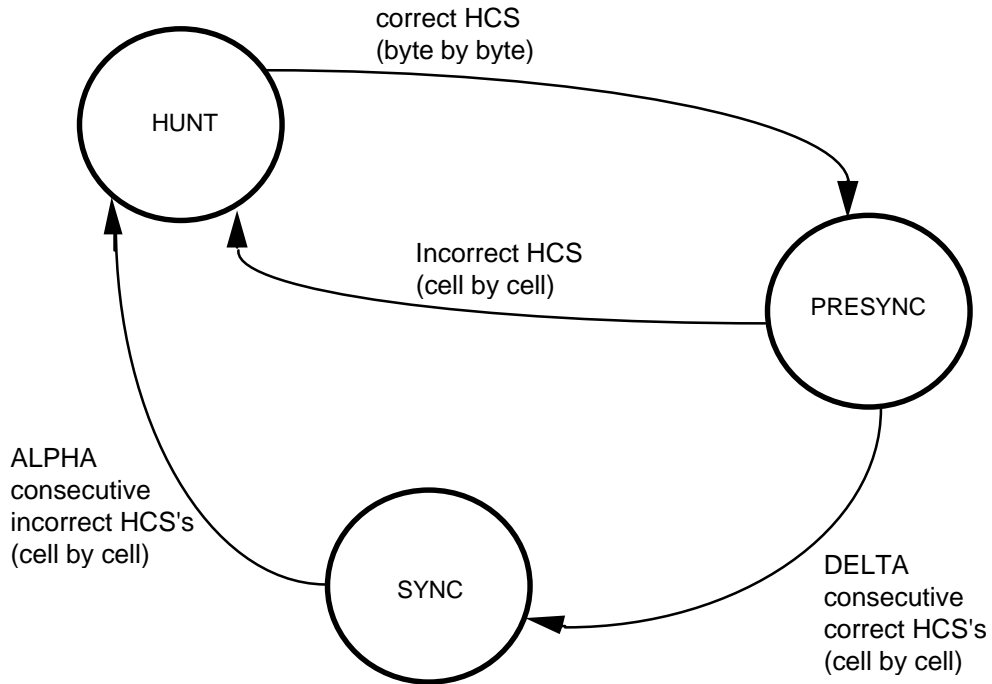
The Receive ATM Cell Processor (RACP) performs ATM cell delineation, provides cell filtering based on idle/unassigned cell detection and HCS error detection, and performs ATM cell payload descrambling. The RACP also provides a four cell deep receive FIFO. This FIFO passes a 53 byte data structure and is used to separate the line timing from the higher layer ATM system timing.

### **7.7.1 Cell Delineation**

Cell Delineation is the process of framing to ATM cell boundaries using the header check sequence (HCS) field found in the cell header. The HCS is a CRC-8 calculation over the first 4 octets of the ATM cell header. When performing delineation, correct HCS calculations are assumed to indicate cell boundaries. Cells must be byte aligned before insertion in the synchronous payload envelope. The cell delineation algorithm searches the 53 possible cell boundary candidates one at a time to determine the valid cell boundary location. While searching for the cell boundary location, the cell delineation circuit is in the HUNT state. When a correct HCS is found, the cell delineation state machine locks on the particular cell boundary and enters the PRESYNC state. This state validates the cell boundary location. If the cell boundary is invalid then an incorrect HCS will be received within the next DELTA cells, at which point a transition back to the HUNT state is executed. If no HCS errors are detected in this PRESYNC period then the SYNC state is entered. While in the SYNC state,

synchronization is maintained until ALPHA consecutive incorrect HCS patterns are detected. In such an event a transition is made back to the HUNT state. The state diagram of the delineation process is shown in Figure 3.

**Figure 3 - Cell Delineation State Diagram**



The values of ALPHA and DELTA determine the robustness of the delineation method. ALPHA determines the robustness against false misalignments due to bit errors. DELTA determines the robustness against false delineation in the synchronization process. ALPHA is chosen to be 7 and DELTA is chosen to be 6. These values result in a maximum average time to delineate of 31  $\mu$ s for STS-3c and 93  $\mu$ s for STS-1.

**7.7.2 Descrambler**

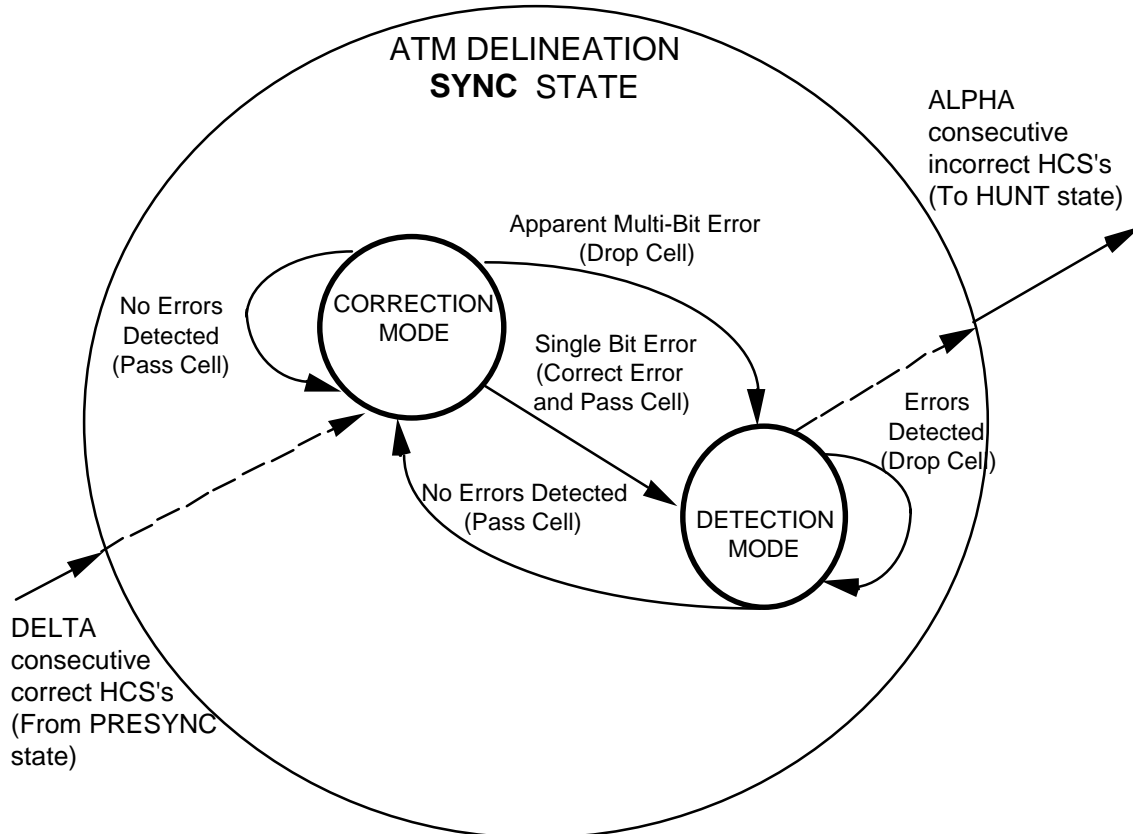
The self synchronous descrambler operates on the 48 byte cell payload only. The circuitry descrambles the information field using the ' $x^{43}+1$ ' polynomial. The descrambler is disabled for the duration of the header and HCS fields, and may optionally be disabled.

### 7.7.3 Cell Filter and HCS Verification

Cells are filtered (or dropped) based on HCS errors and/or a cell header pattern. Cell filtering is optional and is enabled through the RACP registers. Cells are passed to the receive FIFO while the cell delineation state machine is in the SYNC state as described above. When both filtering and HCS checking are enabled, cells are dropped if uncorrectable HCS errors are detected, or if the corrected header contents match the pattern contained in the 'Match Header Pattern' and 'Match Header Mask' registers. Idle or unassigned cell filtering is accomplished by writing the appropriate cell header pattern into the 'Match Header Pattern' and 'Match Header Mask' registers. Idle/Unassigned cells are assumed to contain the all zeros pattern in the VCI and VPI fields. The 'Match Header Pattern' and 'Match Header Mask' registers allow filtering control over the contents of the GFC, PTI, and CLP fields of the header.

The HCS is a CRC-8 calculation over the first 4 octets of the ATM cell header. The RACP block verifies the received HCS using the polynomial,  $x^8+x^2+x+1$ . The coset polynomial,  $x^6+x^4+x^2+1$  is added (modulo 2) to the received HCS octet before comparison with the calculated result. While the cell delineation state machine (described above) is in the SYNC state, the HCS verification circuit implements the state machine shown in Figure 4:

**Figure 4 - HCS Verification State Diagram**



In normal operation, the HCS verification state machine remains in the 'Correction Mode' state. Incoming cells containing no HCS errors are passed to the receive FIFO. Incoming single bit errors are corrected, and the resulting cell is passed to the FIFO. Upon detection of a single bit error or a multi bit error, the state machine transitions to the 'Detection Mode' state. In this state, the detection of any HCS error causes the corresponding cell to be dropped. Cells containing an error-free HCS are passed, and the state machine transitions back to the 'Correction Mode' state.

**7.7.4 Performance Monitor**

The Performance Monitor consists of two 8-bit saturating HCS error event counters and a 19-bit cell counter. One of the counters accumulates correctable HCS errors (i.e. single HCS bit errors detected while the HCS Verification state machine is in the 'Correction Mode' state described above). The second counter accumulates uncorrectable HCS errors (i.e. HCS bit errors detected while the

HCS Verification state machine is in the 'Detection Mode' state or multiple HCS bit errors detected while the state machine is in the 'Correction Mode' state as described above). The cell counter accumulates the number of received assigned cells. All counters are enabled only when the RACP is in the SYNC state.

Each counter may be read through the microprocessor interface. Circuitry is provided to latch these counters so that their values can be read while simultaneously resetting the internal counters to 0 or 1, if appropriate, so that a new period of accumulation can begin without loss of any events. It is intended that the counters be polled at least once per second so HCS error events or cell counts will not be missed.

### **7.7.5 GFC Extraction Port**

The GFC Extraction Port outputs the received GFC bits in a serial stream. The four GFC bits are presented for each received cell, with the RCP output indicating the position of the most significant bit. The updating of RGFC by particular GFC bits may be disabled through an internal register. The serial link is forced low if cell delineation is lost.

### **7.7.6 Receive FIFO**

The Receive FIFO provides FIFO management and a synchronous interface between the S/UNI-ULTRA device and the external environment. The receive FIFO can accommodate four cells. The receive FIFO provides for the separation of the STS-1 or STS-3c line or physical layer timing from the ATM layer timing.

Management functions include filling the receive FIFO, indicating when cells are available to be read from the receive FIFO, maintaining the receive FIFO read and write pointers, and detecting FIFO overrun and underrun conditions. Upon detection of an overrun condition, the FIFO will drop all incoming cells until at least one cell has been read from the FIFO. At least one cell will be lost during the FIFO drop operation. Upon detection of an underrun, the offending read is ignored. FIFO overruns are indicated through a maskable interrupt and register bit. The interface provided indicates the start of a cell (RSOC) when data is read from the receive FIFO (using RFCLK) and indicates the cell available status (RCA). The cell available status may be configured to change from available to unavailable on read cell boundaries or four reads before the cell boundary.

When the RCA signal is configured to be deasserted with zero octets (as opposed to four) in the FIFO, it is not an error condition to hold the read enable (RRDENB) active. In this situation, the RCA signal identifies the valid octets.



## **7.8 UTP-5 and PECL Transmitter**

The line transmitter (TUTP-5) provides the accurate logic levels required to interface with a UTP-5 twisted pair, or PECL levels to interface with an optical interface module. It is fully compliant to the ATM Forum PMD Interface specification for 155 Mb/s over twisted pair.

## **7.9 Clock Synthesis**

The transmit clock is synthesized from a 19.44 MHz reference. The intrinsic jitter is minimized when the reference frequency is 19.44 MHz. With a jitter free 19.44 MHz reference input and a low noise board layout, the intrinsic jitter is typically less than 0.01 UI RMS and 0.10 UI peak-to-peak when measured using a band pass filter with 12 kHz and 1.3 MHz cutoff frequencies.

## **7.10 Parallel to Serial Converter**

The Parallel to Serial Converter (PISO) converts the internal byte serial stream to a bit serial stream.

## **7.11 Transmit Section Overhead Processor**

The Transmit Section Overhead Processor (TSOP) provides frame pattern insertion (A1, A2), scrambling, section level alarm signal insertion, and section BIP-8 (B1) insertion.

### **7.11.1 Line AIS Insert**

Line AIS insertion results in all bits of the SONET/SDH frame being set to 1 before scrambling except for the section overhead. The Line AIS Insert Block substitutes all ones as described when enabled through an internal register accessed through the microprocessor interface. Activation or deactivation of line AIS insertion is synchronized to frame boundaries.

### **7.11.2 BIP-8 Insert**

The BIP-8 Insert Block calculates and inserts the BIP-8 error detection code (B1) into the unscrambled data stream.

The BIP-8 calculation is based on the scrambled data of the complete STS-3c or STS-1 frame. The section BIP-8 code is based on a bit interleaved parity calculation using even parity. Details are provided in the references. The

calculated BIP-8 code is then inserted into the B1 byte of the following frame before scrambling. BIP-8 errors may be continuously inserted under register control for diagnostic purposes.

### **7.11.3 Framing and Identity Insert**

The Framing and Identity Insert Block inserts the framing bytes (A1, A2) and identity bytes (C1) into the STS-3c or STS-1 frame. Framing bit errors may be continuously inserted under register control for diagnostic purposes.

### **7.11.4 Scrambler**

The Scrambler Block utilizes a frame synchronous scrambler to process the transmit serial stream when enabled through an internal register accessed via the microprocessor interface. The generating polynomial is  $1+x^6+x^7$ . Precise details of the scrambling operation are provided in the references. Note that the framing bytes and the identity bytes are not scrambled. All zeros may be continuously inserted (after scrambling) under register control for diagnostic purposes.

## **7.12 Transmit Line Overhead Processor**

The Transmit Line Overhead Processor (TLOP) provides line level alarm signal insertion and line BIP-8/24 insertion (B2).

### **7.12.1 BIP Calculate**

The BIP Calculate Block calculates the line BIP error detection code (B2) based on the line overhead and synchronous payload envelope of the STS-3c or STS-1 stream. The line BIP code is a bit interleaved parity calculation using even parity. Details are provided in the references. The calculated BIP code is inserted into the B2 byte positions of the following frame. BIP errors may be continuously inserted under register control for diagnostic purposes.

### **7.12.2 Line Remote Defect Indication Insert**

The Line RDI Insert Block multiplexes the line overhead bytes into the output stream and optionally inserts line RDI. Line RDI is inserted by this block when enabled via register control. Line RDI is inserted by transmitting the code 110 (binary) in bit positions 6, 7, and 8 of the K2 byte contained in the STS-3c or STS-1 stream.

### 7.12.3 Line FEBE Insert

The Line FEBE Insert Block accumulates line BIP errors (B2) detected by the Receive Line Overhead Processor and encodes far end block error indications in the transmit M0/M1 byte.

**Figure 5 - STS-3c/STM-1 Default Transport Overhead Values**

<b>A1</b> (0xF6)	<b>A1</b> (0xF6)	<b>A1</b> (0xF6)	<b>A2</b> (0x28)	<b>A2</b> (0x28)	<b>A2</b> (0x28)	<b>J0</b> (0x01)	<b>Z0</b> (0x02)	<b>Z0</b> (0x03)
<b>B1</b> (*)	(0x00)	(0x00)	<b>E1</b> (0x00)	(0x00)	(0x00)	<b>F1</b> (0x00)	(0x00)	(0x00)
<b>D1</b> (0x00)	(0x00)	(0x00)	<b>D2</b> (0x00)	(0x00)	(0x00)	<b>D3</b> (0x00)	(0x00)	(0x00)
<b>H1</b> (0x62)	<b>H1</b> (0x93)	<b>H1</b> (0x93)	<b>H2</b> (0x0A)	<b>H2</b> (0xFF)	<b>H2</b> (0xFF)	<b>H3</b> (0x00)	<b>H3</b> (0x00)	<b>H3</b> (0x00)
<b>B2</b> (*)	<b>B2</b> (*)	<b>B2</b> (*)	<b>K1</b> (0x00)	(0x00)	(0x00)	<b>K2</b> (0x00)	(0x00)	(0x00)
<b>D4</b> (0x00)	(0x00)	(0x00)	<b>D5</b> (0x00)	(0x00)	(0x00)	<b>D6</b> (0x00)	(0x00)	(0x00)
<b>D7</b> (0x00)	(0x00)	(0x00)	<b>D8</b> (0x00)	(0x00)	(0x00)	<b>D9</b> (0x00)	(0x00)	(0x00)
<b>D10</b> (0x00)	(0x00)	(0x00)	<b>D11</b> (0x00)	(0x00)	(0x00)	<b>D12</b> (0x00)	(0x00)	(0x00)
<b>Z1</b> (0x00)	<b>Z1</b> (0x00)	<b>Z1</b> (0x00)	<b>Z2</b> (0x00)	<b>Z2</b> (0x00)	<b>M1</b> (*)	<b>E2</b> (0x00)	(0x00)	(0x00)

\* : B1, B2 values depend on payload contents  
M1 value depends on incoming line bit errors

**Figure 6 - STS-1 Default Transport Overhead Values**

<b>A1</b> <b>(0xF6)</b>	<b>A2</b> <b>(0x28)</b>	<b>J0</b> <b>(0x01)</b>
<b>B1</b> <b>(*)</b>	<b>E1</b> <b>(0x00)</b>	<b>F1</b> <b>(0x00)</b>
<b>D1</b> <b>(0x00)</b>	<b>D2</b> <b>(0x00)</b>	<b>D3</b> <b>(0x00)</b>
<b>H1</b> <b>(0x62)</b>	<b>H2</b> <b>(0x0A)</b>	<b>H3</b> <b>(0x00)</b>
<b>B2</b> <b>(*)</b>	<b>K1</b> <b>(0x00)</b>	<b>K2</b> <b>(0x00)</b>
<b>D4</b> <b>(0x00)</b>	<b>D5</b> <b>(0x00)</b>	<b>D6</b> <b>(0x00)</b>
<b>D7</b> <b>(0x00)</b>	<b>D8</b> <b>(0x00)</b>	<b>D9</b> <b>(0x00)</b>
<b>D10</b> <b>(0x00)</b>	<b>D11</b> <b>(0x00)</b>	<b>D12</b> <b>(0x00)</b>
<b>Z1</b> <b>(0x00)</b>	<b>M0</b> <b>(*)</b>	<b>E2</b> <b>(0x00)</b>

**\* : B1, B2 values depend on payload contents  
M0 value depends on incoming line bit errors**

### **7.13 Transmit Path Overhead Processor**

The Transmit Path Overhead Processor (TPOP) provides transport frame alignment generation, pointer generation (H1, H2), path overhead insertion, insertion of the synchronous payload envelope, insertion of path level alarm signals and path BIP-8 (B3) insertion.

#### **7.13.1 Pointer Generator**

The Pointer Generator Block generates the outgoing payload pointer (H1, H2). The block contains a free running time slot counter that locates the start of the

synchronous payload envelope based on the generated pointer value and the SONET/SDH frame alignment.

The Pointer Generator Block generates the outgoing pointer as specified in the references. The concatenation indication (the NDF field set to 1001, I-bits and D-bits set to all ones, and unused bits set to all zeros) is inserted in the second and third pointer bytes.

### **7.13.2 BIP-8 Calculate**

The BIP-8 Calculate Block performs a path bit interleaved parity calculation on the SPE of the outgoing stream. The resulting parity byte is inserted in the path BIP-8 (B3) byte position of the subsequent frame. BIP-8 errors may be continuously inserted under register control for diagnostic purposes.

### **7.13.3 FEBE Calculate**

The FEBE Calculate Block accumulates far end block errors on a per frame basis, and inserts the accumulated value (up to maximum value of eight) in the FEBE bit positions of the path status (G1) byte. The FEBE information is derived from path BIP-8 errors detected by the receive path overhead processor, RPOP. The asynchronous nature of these signals implies that more than eight FEBE events may be accumulated between transmit G1 bytes. If more than eight receive Path BIP-8 errors are accumulated between transmit G1 bytes, the accumulation counter is decremented by eight, and the remaining FEBEs are transmitted at the next opportunity. Far end block errors may be inserted under register control for diagnostic purposes.

### **7.13.4 SPE Multiplexer**

The SPE Multiplexer Block multiplexes the payload pointer bytes, the SPE stream, and the path overhead bytes into the STS-3c or STS-1 stream.

**Figure 7 - Default Path Overhead Values**

<b>J1 (0x00)</b>
<b>B3 (*)</b>
<b>C2 (0x13)</b>
<b>G1 (*)</b>
<b>F2 (0x00)</b>
<b>H4 (*)</b>
<b>Z3 (0x00)</b>
<b>Z4 (0x00)</b>
<b>Z5 (0x00)</b>

- \* : B3 value depend on payload contents**
- G1 value depends on incoming path bit errors**
- H4 value depends on cell boundary offset**

#### **7.14 Transmit ATM Cell Processor**

The Transmit ATM Cell Processor (TACP) inserts H4 framing, provides rate adaptation via idle/unassigned cell insertion, provides HCS generation and insertion, and performs ATM cell scrambling. The TACP contains a four cell transmit FIFO. An idle or unassigned cell is transmitted if a complete ATM cell has not been written into the FIFO.

### 7.14.1 Idle/Unassigned Cell Generator

The Idle/Unassigned Cell Generator inserts idle or unassigned cells into the cell stream when enabled. Registers are provided to program the GFC, PTI, and CLP fields of the idle cell header and the idle cell payload. An all zeros pattern is inserted into the VCI/VPI bit locations. The idle cell HCS is automatically calculated and inserted.

### 7.14.2 Scrambler

The Scrambler scrambles the 48 octet information field. Scrambling is performed using a parallel implementation of the self synchronous scrambler described in the references. The cell headers are transmitted unscrambled, and the scrambler may optionally be completely disabled.

### 7.14.3 HCS Generator

The HCS Generator performs a CRC-8 calculation over the first four header octets. A parallel implementation of the polynomial,  $x^8+x^2+x+1$  is used. The coset polynomial,  $x^6+x^4+x^2+1$  is added (modulo 2) to the residue. The HCS Generator inserts the result into the fifth octet of the header.

### 7.14.4 GFC Insertion Port

The GFC Insertion Port provides the ability to insert the GFC value downstream of the FIFO. The four GFC bits are received on a serial stream that is synchronized to the transmit cell by a framing pulse. The GFC enable register bits control the insertion of each serial bit. If the enable is cleared, the default GFC value is inserted. For idle/unassigned cells, the default is the contents of the TACP Idle/Unassigned Cell Header Control register. For assigned cells, the default is the value received from TDAT[7:0].

### 7.14.5 Transmit FIFO

The Transmit FIFO provides FIFO management and a synchronous interface between the S/UNI-ULTRA device and the external environment. The transmit FIFO can accommodate four cells. It provides for the separation of the physical layer timing from the ATM layer timing.

Management functions include filling the transmit FIFO, indicating when cells are available to be written to the transmit FIFO, maintaining the transmit FIFO read and write pointers, and detecting a FIFO overrun condition. The synchronous

interface provided to an external device expects the start of a cell (TSOC) when the first byte of the cell is written to the FIFO (using TFCLK in conjunction with TWRENB) and indicates the cell available status (TCA). The FIFO status changes from cell unavailable to cell available on read cell boundaries. The FIFO status can be configured to change from cell available to cell unavailable on write cell boundaries or four octets before the end of the cell.

The latency through the transmit FIFO can be controlled by setting the fill level at which the cell available (TCA) signal is deasserted. Although all four cell buffers are always accessible, TCA may be programmed to indicate when the FIFO contains one, two, three or four cells. (The current cell being read out of the FIFO is included in the count. Be aware that setting a depth of one may limit throughput.) If a cell write is started immediately after TCA is asserted, the latency through the device for STS-3c/STM-1 is

$$\begin{aligned} \text{latency} &= \text{depth} * (53 \text{ line byte periods}) + 16 \text{ line byte periods (min.)} \\ &= \text{depth} * (53 \text{ line byte periods}) + 26 \text{ line byte periods (max.).} \end{aligned}$$

The latency for STS-1 is

$$\begin{aligned} \text{latency} &= \text{depth} * (53 \text{ line byte periods}) + 10 \text{ line byte periods (min.)} \\ &= \text{depth} * (53 \text{ line byte periods}) + 14 \text{ line byte periods (max.).} \end{aligned}$$

The presence of the SONET/SDH overhead accounts for the difference between the minimum and maximum latencies.

When the FIFO contains four cells and the upstream device writes into the FIFO, the TACP indicates a FIFO overrun condition using a maskable interrupt and register bits. The offending write and all subsequent writes are ignored until there is room in the FIFO.

## **7.15 Drop Side Interface**

### **7.15.1 Receive Interface**

The drop side receive interface can be accessed through a generic 8-bit wide interface.

External circuitry is notified, using the RCA signal, when a cell is available in the receive FIFO. External circuitry may then read the cell from the buffer as a byte wide stream (along with a bit marking the first byte of the cell).



### **7.15.2 Transmit Interface**

The drop side transmit interface can be accessed through a generic 8-bit wide interface.

External circuitry is notified, using the TCA signal, when a cell may be written to the transmit FIFO. The cell is written to the FIFO as a byte wide stream (along with a bit marking the first byte of the cell).

### **7.16 Parallel output port and LED display controller**

The parallel output port (OUT[1:0]) and LED display controller (POPC) has three modes of operation: parallel output port, alarm monitor and traffic monitor. The output port mode provides direct output control, while register bits set the OUT[1:0] outputs. The output port is either set to a fixed logic value and used to command an external device, or it toggles at a programmable rate and is used to command an LED display. The alarm monitor mode allows external monitoring of alarm conditions through the OUT[1] output (used as RALM). The OUT[1] output is either set to a static logic value and used to command an external device, or it toggles at a programmable rate and is used to command an LED display. The traffic monitor mode provides traffic activity indication and is only intended to command an external LED display. The controller produces a separate fixed length 100 ms pulse on OUT[1] when a cell transmit event occurs or on OUT[0] when a cell receive event occurs.

### **7.17 Microprocessor Interface**

The microprocessor interface block provides normal and test mode registers, and the logic required to connect to the microprocessor interface. The normal mode registers are required for normal operation, and test mode registers are used to enhance the testability of the S/UNI-ULTRA.

The microprocessor interface consist of a bidirectional 8 bit data bus and a separate 8 bit address bus, which allows both separate address/data bus and multiplexed address/data bus operations. The interface uses separate read (RDB) and write (WRB) signals, an address latch enable (ALE), a chip select (CSB), a master chip reset (RSTB) and the active low interrupt output (INTB).

The register set is accessed as follows:

## **8 REGISTER MEMORY MAP**

For all register accesses, CSB must be low.

<b>Address</b>	<b>Register</b>
0x00	S/UNI-ULTRA Master Reset and Identity / Load Meters
0x01	S/UNI-ULTRA Master Configuration
0x02	S/UNI-ULTRA Master Interrupt Status
0x03	S/UNI-ULTRA Master Mode Control
0x04	S/UNI-ULTRA Master Clock Monitor
0x05	S/UNI-ULTRA Master Control
0x06	S/UNI-ULTRA Clock Synthesis Control and Status
0x07	Reserved
0x08	S/UNI-ULTRA Clock Recovery Control and Status
0x09	S/UNI-ULTRA Clock Recovery Configuration
0x0A	S/UNI-ULTRA Transmit Interface Configuration
0x0B	Reserved
0x0C	S/UNI-ULTRA Receive Interface Configuration
0x0D-0x0F	Reserved
0x10	RSOP Control/Interrupt Enable
0x11	RSOP Status/Interrupt Status
0x12	RSOP Section BIP-8 LSB
0x13	RSOP Section BIP-8 MSB
0x14	TSOP Control
0x15	TSOP Diagnostic
0x16-0x17	TSOP Reserved
0x18	RLOP Control/Status
0x19	RLOP Interrupt Enable/Status
0x1A	RLOP Line BIP-8/24 LSB

<b>Address</b>	<b>Register</b>
0x1B	RLOP Line BIP-8/24
0x1C	RLOP Line BIP-8/24 MSB
0x1D	RLOP Line FEBE LSB
0x1E	RLOP Line FEBE
0x1F	RLOP Line FEBE MSB
0x20	TLOP Control
0x21	TLOP Diagnostic
0x22-0x23	TLOP Reserved
0x24-0x2F	Reserved
0x30	RPOP Status/Control
0x31	RPOP Interrupt Status
0x32	RPOP Reserved
0x33	RPOP Interrupt Enable
0x34	RPOP Reserved
0x35	RPOP Reserved
0x36	RPOP Reserved
0x37	RPOP Path Signal Label
0x38	RPOP Path BIP-8 LSB
0x39	RPOP Path BIP-8 MSB
0x3A	RPOP Path FEBE LSB
0x3B	RPOP Path FEBE MSB
0x3C	RPOP Reserved
0x3D	RPOP Path BIP-8 Configuration
0x3E-0x3F	RPOP Reserved
0x40	TPOP Control/Diagnostic
0x41	TPOP Pointer Control
0x42	TPOP Reserved
0x43	TPOP Reserved

<b>Address</b>	<b>Register</b>
0x44	TPOP Reserved
0x45	TPOP Arbitrary Pointer LSB
0x46	TPOP Arbitrary Pointer MSB
0x47	TPOP Reserved
0x48	TPOP Path Signal Label
0x49	TPOP Path Status
0x4A	TPOP Reserved
0x4B-0x4F	TPOP Reserved
0x50	RACP Control/Status
0x51	RACP Interrupt Enable/Status
0x52	RACP Match Header Pattern
0x53	RACP Match Header Mask
0x54	RACP Correctable HCS Error Count
0x55	RACP Uncorrectable HCS Error Count
0x56	RACP Receive Cell Counter (LSB)
0x57	RACP Receive Cell Counter
0x58	RACP Receive Cell Counter (MSB)
0x59	RACP Configuration
0x5A-0x5F	RACP Reserved
0x60	TACP Control/Status
0x61	TACP Idle/Unassigned Cell Header Pattern
0x62	TACP Idle/Unassigned Cell Payload Octet Pattern
0x63	TACP FIFO Configuration
0x64	TACP Transmit Cell Counter (LSB)
0x65	TACP Transmit Cell Counter
0x66	TACP Transmit Cell Counter (MSB)
0x67	TACP Configuration
0x68	POPC Control

Address	Register
0x69	POPC Rate 0
0x6A	POPC Rate 1
0x6B	POPC Reserved
0x6C-0x7F	Reserved
0x80	S/UNI-ULTRA Master Test
0x81-0xFF	Reserved for Test

### **NORMAL MODE REGISTER Description**

Normal mode registers are used to configure and monitor the operation of the S/UNI-ULTRA. Normal mode registers (as opposed to test mode registers) are selected when TRS (A[7]) is low.

#### **Notes on Normal Mode Register Bits:**

1. Writing values into unused register bits has no effect. However, to ensure software compatibility with future, feature-enhanced versions of the product, unused register bits must be written with logic zero. Reading back unused bits can produce either a logic one or a logic zero; hence unused register bits should be masked off by software when read.
2. All configuration bits that can be written into can also be read back. This allows the processor controlling the S/UNI-ULTRA to determine the programming state of the block.
3. Writable normal mode register bits are cleared to logic zero upon reset unless otherwise noted.
4. Writing into read-only normal mode register bit locations does not affect S/UNI-ULTRA operation unless otherwise noted.
5. Certain register bits are reserved. These bits are associated with megacell functions that are unused in this application. To ensure that the S/UNI-ULTRA operates as intended, reserved register bits must only be written with either logic zero or logic one, as indicated. Similarly, writing to reserved registers should be avoided.

**Register 0x00: S/UNI-ULTRA Master Reset and Identity / Load Meters**

Bit	Type	Function	Default
Bit 7	R/W	RESET	0
Bit 6	R	TYPE[2]	1
Bit 5	R	TYPE[1]	1
Bit 4	R	TYPE[0]	1
Bit 3	R	TIP	0
Bit 2	R	ID[2]	0
Bit 1	R	ID[1]	0
Bit 0	R	ID[0]	0

This register allows the revision of the S/UNI-ULTRA to be read by software permitting graceful migration to support for newer, feature enhanced versions of the S/UNI-ULTRA. It also provides software reset capability.

Writing to this register (without setting the RESET bit) loads all the error counters in the RSOP, RLOP, RPOP, RACP and TACP blocks.

ID[2:0]:

The ID bits can be read to provide a binary S/UNI-ULTRA revision number.

TIP:

The TIP bit is set to a logic one when any value with the RESET bit set to logic 0 is written to this register. Such a write initiates an accumulation interval transfer and loads all the performance meter registers in the RSOP, RLOP, RPOP, RACP, and TACP blocks. TIP remains high while the transfer is in progress, and is set to a logic zero when the transfer is complete. TIP can be polled by a microprocessor to determine when the accumulation interval transfer is complete.

TYPE[2:0]:

The TYPE bits distinguish the S/UNI-ULTRA from the other members of the S/UNI family of devices.

**RESET:**

The RESET bit allows the S/UNI-ULTRA to be reset under software control. If the RESET bit is a logic one, the entire S/UNI-ULTRA is held in reset. This bit is not self-clearing. Therefore, a logic zero must be written to bring the S/UNI-ULTRA out of reset. Holding the S/UNI-ULTRA in a reset state places it into a low power, stand-by mode. A hardware reset clears the RESET bit, thus negating the software reset. Otherwise the effect of a software reset is equivalent to that of a hardware reset.

**Register 0x01: S/UNI-ULTRA Master Configuration**

Bit	Type	Function	Default
Bit 7		Unused	
Bit 6	R/W	AUTOFEBE	1
Bit 5	R/W	AUTOLRDI	1
Bit 4	R/W	AUTOPRDI	1
Bit 3	R/W	TCAINV	0
Bit 2	R/W	RCAINV	0
Bit 1	R/W	Reserved	0
Bit 0	R/W	TFP_IN	1

TFP\_IN:

The transmit frame pulse interface (TFP\_IN) bit determines whether the TFP pin is used as input or output. If TFP\_IN is a logic 0, TFP outputs the transmit overhead frame pulse for external use. If TFP\_IN is a logic 1, TFP is used to align the SONET/SDH transport frame generated by the S/UNI-ULTRA device to a system reference.

RCAINV:

The RCAINV bit selects the active polarity of the RCA signal. The default configuration selects RCA to be active high, indicating that a received cell is available when high. When RCAINV is set to logic one, the RCA signal becomes active low.

TCAINV:

The TCAINV bit selects the active polarity of the TCA signal. The default configuration selects TCA to be active high, indicating that a cell is available in the transmit FIFO when high. When TCAINV is set to logic one, the TCA signal becomes active low.

AUTOPRDI

The AUTOPRDI bit determines whether STS path remote defect indication (RDI) is sent immediately upon detection of an incoming alarm. When AUTOPRDI is set to logic one, STS path RDI is inserted immediately upon declaration of loss of signal (LOS), loss of frame (LOF), line AIS, loss of pointer (LOP) or STS path AIS.



### AUTOLRDI

The AUTOLRDI bit determines whether line remote defect indication (RDI) is sent immediately upon detection of an incoming alarm. When AUTOLRDI is set to logic one, line RDI is inserted immediately upon declaration of loss of signal (LOS), loss of frame (LOF) or line AIS.

### AUTOFEBE

The AUTOFEBE bit determines whether line and path far end block errors are sent upon detection of an incoming line and path BIP error events. When AUTOFEBE is set to logic one, one line or path FEBE is inserted for each line or path BIP error event, respectively. When AUTOFEBE is set to logic zero, incoming line or path BIP error events do not generate FEBE events.

### Reserved:

The reserved bits must be programmed to logic zero for proper operation.

**Register 0x02: S/UNI-ULTRA Master Interrupt Status**

Bit	Type	Function	Default
Bit 7	R	CSUI	X
Bit 6	R	LCDI	X
Bit 5	R	CRUI	X
Bit 4	R	TACPI	X
Bit 3	R	RACPI	X
Bit 2	R	RPOPI	X
Bit 1	R	RLOPI	X
Bit 0	R	RSOPI	X

When the interrupt output INTB goes low, this register allows the source of an active interrupt to be identified down to the block level. Further register accesses are required for the block in question to determine the cause of an active interrupt and to acknowledge the interrupt source.

RSOPI:

The RSOPI bit is high when an interrupt request is active from the RSOP block. The RSOP interrupt sources are enabled in the RSOP Control/Interrupt Enable Register.

RLOPI:

The RLOPI bit is high when an interrupt request is active from the RLOP block. The RLOP interrupt sources are enabled in the RLOP Interrupt Enable/Status Register.

RPOPI:

The RPOPI bit is high when an interrupt request is active from the RPOP block. The RPOP interrupt sources are enabled in the RPOP Interrupt Enable Register.

RACPI:

The RACPI bit is high when an interrupt request is active from the RACP block. The RACP interrupt sources are enabled in the RACP Interrupt Enable/Status Register.

**TACPI:**

The TACPI bit is high when an interrupt request is active from the TACP block. The TACP interrupt sources are enabled in the TACP Interrupt Control/Status Register.

**CSUI:**

The CSUI bit is high when an interrupt request is active from the Clock Synthesis Unit. The CSU interrupt sources are enabled in the Clock Synthesis Interrupt Control/Status Register.

**LCDI:**

The LCDI interrupt bit is set high when entering and exiting loss of cell delineation. This bit is reset immediately after a read to this register. The LCD interrupt is enabled in the S/UNI-ULTRA Master Control Register.

**CRUI:**

The CRUI bit is high when an interrupt request is active from the Clock Recovery Unit. The CRU interrupt sources are enabled in the Clock Recovery Interrupt Control/Status Register.

**Register 0x03: S/UNI-ULTRA Master Mode Control**

Bit	Type	Function	Default
Bit 7		Unused	X
Bit 6		Unused	X
Bit 5		Unused	X
Bit 4		Unused	X
Bit 3		Unused	X
Bit 2		Unused	X
Bit 1	R/W	RATE[1]	1
Bit 0	R/W	RATE[0]	1

RATE[1:0]:

The RATE[1:0] bits select the operation rate of the S/UNI-ULTRA. The default configuration selects STS-3c rate operation. The S/UNI-ULTRA will not operate correctly if a Reserved mode is selected.

RATE[1:0]	MODE
00	Reserved
01	Reserved
10	51.84 Mbit/s, STS-1
11	155.52 Mbit/s, STS-3c/STM-1

**Register 0x04: S/UNI-ULTRA Master Clock Monitor**

Bit	Type	Function	Default
Bit 7		Unused	X
Bit 6		Unused	X
Bit 5		Unused	X
Bit 4	R	RFCLKA	X
Bit 3	R	TFCLKA	X
Bit 2	R	REFCLKA	X
Bit 1	R	RCLKA	X
Bit 0	R	TCLKA	X

This register provides activity monitoring on S/UNI-ULTRA clocks. When a monitored clock signal makes a low to high transition, the corresponding register bit is set high. The bit will remain high until this register is read, at which point, all the bits in this register are cleared. A lack of transitions is indicated by the corresponding register bit reading low. This register should be read at periodic intervals to detect clock failures.

TCLKA:

The TCLK active (TCLKA) bit monitors for low to high transitions on the TCLK output. TCLKA is set high on a rising edge of TCLK, and is set low when this register is read.

RCLKA:

The RCLK active (RCLKA) bit monitors for low to high transitions on the RCLK output. RCLKA is set high on a rising edge of RCLK, and is set low when this register is read.

REFCLKA:

The REFCLK active (REFCLKA) bit monitors for low to high transitions on the REFCLK reference clock input. REFCLKA is set high on a rising edge of REFCLK, and is set low when this register is read.

**TFCLKA:**

The TFCLK active (TFCLKA) bit monitors for low to high transitions on the TFCLK transmit FIFO clock input. TFCLKA is set high on a rising edge of TFCLK, and is set low when this register is read.

**RFCLKA:**

The RFCLK active (RFCLKA) bit monitors for low to high transitions on the RFCLK receive FIFO clock input. RFCLKA is set high on a rising edge of RFCLK, and is set low when this register is read.

**Register 0x05: S/UNI-ULTRA Master Control**

Bit	Type	Function	Default
Bit 7	R/W	LCDE	0
Bit 6	R	LCDV	X
Bit 5	R/W	FIXPTR	1
Bit 4	R/W	TPLE	0
Bit 3	R/W	PDLE	0
Bit 2	R/W	LLE	0
Bit 1	R/W	SDLE	0
Bit 0	R/W	LOOPT	0

This register controls the timing and high speed loopback features of the S/UNI-ULTRA.

LOOPT:

The LOOPT bit selects the source of timing for the transmit section of the S/UNI-ULTRA. When LOOPT is a logic zero, the transmitter timing is derived from input REFCLK. **Only one of the LOOPT, SDLE and LLE bits can be set to logic one at any time.**

When LOOPT is a logic one, the transmitter timing is derived from the receiver inputs RXD+ and RXD- when the CRU is locked on data (RDOOL is low) and from REFCLK when the CRU is out of data lock (RDOOL is high).

SDLE:

The SDLE bit enables the S/UNI-ULTRA serial diagnostic loopback. When SDLE is a logic one, the transmit stream is connected to the receive stream. **Only one of the LOOPT, SDLE and LLE bits can be set to logic one at any time.**

LLE:

The LLE bit enables the S/UNI-ULTRA line loopback. When LLE is a logic one, the receive serial data stream is looped back into the transmit serial stream. This loopback mode includes the RUTP-5, CRU, CSU and TUTP-5 blocks. **Only one of the LOOPT, SDLE and LLE bits can be set to logic one at any time.**

**PDLE:**

The PDLE bit enables the S/UNI-ULTRA parallel diagnostic loopback. When PDLE is a logic one, the transmit parallel stream is connected to the receive stream. The loopback point is between the TPOP and the RPOP blocks. Blocks upstream of the loopback point continue to operate normally. For example, line AIS may still be inserted in the transmit stream using TSOP.

**TPLE:**

The TPLE bit enables the S/UNI-ULTRA twisted pair diagnostic loopback. When TPLE is a logic one, the receive serial data stream is looped back into the transmit serial stream. This loopback mode includes only the RUTP-5 and TUTP-5 blocks.

**FIXPTR:**

The FIXPTR bit disables transmit payload pointer adjustments. If the FIXPTR bit is a logic 1, the transmit payload pointer is set at 522. If FIXPTR is a logic zero, the payload pointer is controlled by the contents of the TPOP Pointer Control register.

**LCDV:**

The LCDV bit reflects the current loss of cell delineation state. LCDV becomes a logic 1 when an out of cell delineation state has persisted for 4ms without any lower level alarms (LOS, LOP, Path AIS, Line AIS) occurring. LCDV becomes logic 0 when the SYNC state has been maintained for 4ms.

**LCDE:**

The LCDE bit enables the loss of cell delineation (LCD) interrupt. When logic one, the S/UNI-ULTRA INTB output is asserted when there is a change in the LCD state. When logic zero, the S/UNI-ULTRA INTB output is not affected by the change in LCD state.



**Register 0x06: S/UNI-ULTRA Clock Synthesis Control and Status**

Bit	Type	Function	Default
Bit 7	R/W	Reserved	0
Bit 6		Unused	X
Bit 5	R	TROOLI	X
Bit 4		Unused	X
Bit 3	R	TROOLV	X
Bit 2		Unused	X
Bit 1	R/W	TROOLE	0
Bit 0	R/W	Reserved	0

This register controls the clock synthesis and reports the state of the transmit phase locked loop.

TROOLE:

The TROOLE bit is an interrupt enable for the transmit reference out of lock status. When TROOLE is set to logic one, an interrupt is generated when the TROOLV bit changes state.

TROOLV:

The transmit reference out of lock status indicates the clock synthesis phase locked loop is unable to lock to the reference on REFCLK. TROOLV is a logic one if the divided down synthesized clock frequency not within 488 ppm of the REFCLK frequency.

TROOLI:

The TROOLI bit is the transmit reference out of lock interrupt status bit. TROOLI is set high when the TROOLV bit of the S/UNI-ULTRA Clock Synthesis Control and Status register changes state. TROOLV indicates the clock synthesis phase locked loop is unable to lock to the reference on REFCLK and is a logic one if the divided down synthesized clock frequency not within 488 ppm of the REFCLK frequency. TROOLI is cleared when this register is read.

Reserved:

The reserved bits must be programmed to logic zero for proper operation.

**Register 0x08: S/UNI-ULTRA Clock Recovery Control and Status**

Bit	Type	Function	Default
Bit 7	R/W	Reserved	0
Bit 6	R	RROOLI	X
Bit 5	R	RDOOLI	X
Bit 4	R	RROOLV	X
Bit 3	R	RDOOLV	X
Bit 2	R/W	RROOLE	0
Bit 1	R/W	RDOOLE	0
Bit 0	R/W	Reserved	0

This register controls the clock recovery and reports the state of the receive phase locked loop.

**RDOOLE:**

The RDOOLE bit is an interrupt enable for the receive data out of lock status. When RDOOLE is set to logic one, an interrupt is generated when the RDOOLV bit changes state.

**RROOLE:**

The RROOLE bit is an interrupt enable for the reference out of lock status. When RROOLE is set to logic one, an interrupt is generated when the RROOLV bit changes state.

**RDOOLV:**

The receive data out of lock status indicates the clock recovery phase locked loop is unable to lock to the incoming data stream. RDOOLV is a logic one if the divided down recovered clock frequency is not within 488 ppm of the REFCLK frequency or if no transitions have occurred on the RXD+/- inputs for more than 80 bit periods.

**RROOLV:**

The receive reference out of lock status indicates the clock recovery phase locked loop is unable to lock to the receive reference (REFCLK). RROOLV should be polled after a power up reset to determine when the CRU PLL is operational. When RROOLV is a logic 1, the CRU is unable to lock to the

receive reference. When RROOLV is a logic 0, the CRU is locked to the receive reference. The RROOLV bit may remain set at logic 1 for several hundred milliseconds after the removal of the power on reset as the CRU PLL locks to the receive reference clock.

**RDOOLI:**

The RDOOLI bit is the receive data out of lock interrupt status bit. RDOOLI is set high when the RDOOLV bit of the S/UNI-ULTRA Clock Recovery Control and Status register changes state. RDOOLI is cleared when this register is read.

**RROOLI:**

The RROOLI bit is the receive reference out of lock interrupt status bit. RROOLI is set high when the RROOLV bit of the Clock Synthesis Control and Status register changes state. RROOLI is cleared when this register is read.

**Reserved:**

The reserved bits must be programmed to logic zero for proper operation.

**Register 0x09: S/UNI-ULTRA Clock Recovery Configuration**

Bit	Type	Function	Default
Bit 7		Unused	X
Bit 6		Unused	X
Bit 5		Unused	X
Bit 4		Unused	X
Bit 3		Unused	X
Bit 2	R/W	Reserved	1
Bit 1	R/W	Reserved	1
Bit 0	R/W	Reserved	1

Reserved:

The reserved bits must be programmed to logic one for proper operation.

**Register 0x0A: S/UNI-ULTRA Line Transmitter Configuration 1**

Bit	Type	Function	Default
Bit 7	R/W	VREFSEL	0
Bit 6		Unused	X
Bit 5	R/W	OEN	1
Bit 4	R/W	OTQ	0
Bit 3	R/W	Reserved	1
Bit 2	R/W	Reserved	1
Bit 1	R/W	Reserved	0
Bit 0	R/W	Reserved	0

This register controls the S/UNI-ULTRA PECL/Twisted-pair transmitter.

OTQ:

The Output True Quiet (OTQ) bit, when set to logic 1, puts the TXD+/- outputs into a "True Quiet" mode, where the output current is split equally between the two outputs. When OTQ is set to logic 0 the TXD+/- outputs operate normally.

OEN:

The output enable (OEN) bit enables the TXD+ and TXD- outputs. When this signal is set to logic 0, TXD+ and TXD- are high-impedance. When this signal is set to logic 1, TXD+ and TXD- operate in their normal mode.

VREFSEL:

The voltage reference select (VREFSEL) bit selects which reference voltage will be used. When VREFSEL is set to logic 0, the internal reference voltage is selected. When VREFSEL is set to logic 1, the external reference (VREF) is selected.

Reserved:

The reserved bits must be programmed to logic 0 or logic 1 for proper operation, as indicated by their default value.

**Register 0x0B: S/UNI-ULTRA Line Transmitter Configuration 2**

<b>Bit</b>	<b>Type</b>	<b>Function</b>	<b>Default</b>
Bit 7	R/W	Reserved	1
Bit 6	R/W	Reserved	1
Bit 5	R/W	Reserved	1
Bit 4	R/W	Reserved	1
Bit 3	R/W	Reserved	1
Bit 2	R/W	Reserved	1
Bit 1	R/W	Reserved	1
Bit 0	R/W	Reserved	1

This register controls the S/UNI-ULTRA PECL/Twisted-pair transmitter.

**Reserved:**

The reserved bits must be programmed to logic one for proper operation.

**Register 0x0C: S/UNI-ULTRA Line Receiver Configuration**

Bit	Type	Function	Default
Bit 7		Unused	X
Bit 6	R/W	Reserved	0
Bit 5	R/W	Reserved	0
Bit 4	R/W	Reserved	0
Bit 3	R/W	Reserved	0
Bit 2	R/W	Reserved	0
Bit 1	R/W	Reserved	0
Bit 0	R/W	Reserved	1

This register controls the S/UNI-ULTRA PECL/Twisted-pair receiver.

**Reserved:**

The reserved bits must be programmed to logic 0 or logic 1 for proper operation, as indicated by their default value.

**Register 0x10: RSOP Control/Interrupt Enable**

Bit	Type	Function	Default
Bit 7	R/W	Reserved	0
Bit 6	R/W	DDS	0
Bit 5	W	FOOF	X
Bit 4	R/W	Reserved	0
Bit 3	R/W	BIPEE	0
Bit 2	R/W	LOSE	0
Bit 1	R/W	LOFE	0
Bit 0	R/W	OOFE	0

OOFE:

The OOFE bit is an interrupt enable for the out of frame alarm. When OOFE is set to logic one, an interrupt is generated when the out of frame alarm changes state.

LOFE:

The LOFE bit is an interrupt enable for the loss of frame alarm. When LOFE is set to logic one, an interrupt is generated when the loss of frame alarm changes state.

LOSE:

The LOSE bit is an interrupt enable for the loss of signal alarm. When LOSE is set to logic one, an interrupt is generated when the loss of signal alarm changes state.

BIPEE:

The BIPEE bit is an interrupt enable for the section BIP-8 errors. When BIPEE is set to logic one, an interrupt is generated when a section BIP-8 error (B1) is detected.

FOOF:

The FOOF bit controls the framing of the RSOP. When a logic one is written to FOOF, the RSOP is forced out of frame at the next frame boundary. The FOOF bit is a write only bit, register reads may yield a logic one or a logic zero.



DDS:

The DDS bit is set to logic one to disable the descrambling of the STS-3c (STM-1) or STS-1 stream. When DDS is a logic zero, descrambling is enabled.

Reserved:

The reserved bits must be programmed to logic zero for proper operation.

**Register 0x11: RSOP Status/Interrupt Status**

Bit	Type	Function	Default
Bit 7		Unused	X
Bit 6	R	BIPEI	X
Bit 5	R	LOSI	X
Bit 4	R	LOFI	X
Bit 3	R	OOFI	X
Bit 2	R	LOSV	X
Bit 1	R	LOFV	X
Bit 0	R	OOFV	X

**OOFV:**

The OOFV bit is read to determine the out of frame state of the RSOP. When OOFV is high, the RSOP is out of frame. When OOFV is low, the RSOP is in-frame.

**LOFV:**

The LOFV bit is read to determine the loss of frame state of the RSOP. When LOFV is high, the RSOP has declared loss of frame.

**LOSV:**

The LOSV bit is read to determine the loss of signal state of the RSOP. When LOSV is high, the RSOP has declared loss of signal.

**OOFI:**

The OOFI bit is the out of frame interrupt status bit. OOFI is set high when a change in the out of frame state occurs. This bit is cleared when this register is read.

**LOFI:**

The LOFI bit is the loss of frame interrupt status bit. LOFI is set high when a change in the loss of frame state occurs. This bit is cleared when this register is read.

**LOSI:**

The LOSI bit is the loss of signal interrupt status bit. LOSI is set high when a change in the loss of signal state occurs. This bit is cleared when this register is read.

**BIPEI:**

The BIPEI bit is the section BIP-8 interrupt status bit. BIPEI is set high when a section layer (B1) bit error is detected. This bit is cleared when this register is read.

**Register 0x12: RSOP Section BIP-8 LSB**

Bit	Type	Function	Default
Bit 7	R	SBE[7]	X
Bit 6	R	SBE[6]	X
Bit 5	R	SBE[5]	X
Bit 4	R	SBE[4]	X
Bit 3	R	SBE[3]	X
Bit 2	R	SBE[2]	X
Bit 1	R	SBE[1]	X
Bit 0	R	SBE[0]	X

**Register 0x13: RSOP Section BIP-8 MSB**

Bit	Type	Function	Default
Bit 7	R	SBE[15]	X
Bit 6	R	SBE[14]	X
Bit 5	R	SBE[13]	X
Bit 4	R	SBE[12]	X
Bit 3	R	SBE[11]	X
Bit 2	R	SBE[10]	X
Bit 1	R	SBE[9]	X
Bit 0	R	SBE[8]	X

SBE[15:0]:

Bits SBE[15:0] represent the number of section BIP-8 errors (B1) that have been detected since the last time the error count was polled. The error count is polled by writing to either of the RSOP Section BIP-8 Register addresses. Such a write transfers the internally accumulated error count to the Section BIP-8 registers within approximately 7  $\mu$ s and simultaneously resets the internal counter to begin a new cycle of error accumulation. This transfer and reset is carried out in a manner that ensures that coincident events are not lost.

The error count can also be polled by writing to the S/UNI-ULTRA Master Reset and Identity / Load Meters register (0x00). Writing to register address 0x00 loads all the error counter registers in the RSOP, RLOP, RPOP and RACP blocks.

**Register 0x14: TSOP Control**

Bit	Type	Function	Default
Bit 7		Unused	X
Bit 6	R/W	DS	0
Bit 5	R/W	Reserved	0
Bit 4	R/W	Reserved	0
Bit 3	R/W	Reserved	0
Bit 2	R/W	Reserved	0
Bit 1	R/W	Reserved	0
Bit 0	R/W	LAIS	0

LAIS:

The LAIS bit controls the insertion of line alarm indication signal (AIS). When LAIS is set to logic one, the TSOP inserts AIS into the transmit SONET stream. Activation or deactivation of line AIS insertion is synchronized to frame boundaries. Line AIS insertion results in all bits of the SONET frame being set to 1 prior to scrambling except for the section overhead.

The DC1 bit controls the overwriting of the identity byte(s) in the STS-3c stream. When DC1 is set low, the identity bytes of the constituent STS-1s in the STS-3c stream are programmed as specified in the references: STS-1 #1 C1 = 01 hexadecimal, STS-1 #2 C1 = 02 hexadecimal,..., STS-1 #N C1 = N hexadecimal. When DC1 is set high the PIN[7:0] identity byte positions in each of the constituent STS-1s are not overwritten.

DS:

The DS bit is set to logic one to disable the scrambling of the STS-3c (STM-1) or STS-1 stream. When DS is a logic zero, scrambling is enabled.

Reserved:

The reserved bits must be programmed to logic zero for proper operation.

**Register 0x15: TSOP Diagnostic**

Bit	Type	Function	Default
Bit 7		Unused	X
Bit 6		Unused	X
Bit 5		Unused	X
Bit 4		Unused	X
Bit 3		Unused	X
Bit 2	R/W	DLOS	0
Bit 1	R/W	DBIP8	0
Bit 0	R/W	DFP	0

**DFP:**

The DFP bit controls the insertion of a single bit error continuously in the most significant bit (bit 1) of the A1 section overhead framing byte. When DFP is set to logic one, the A1 bytes are set to 0x76 instead of 0xF6.

**DBIP8:**

The DBIP8 bit controls the insertion of bit errors continuously in the section BIP-8 byte (B1). When DBIP8 is set to logic one, the B1 byte is inverted.

**DLOS:**

The DLOS bit controls the insertion of all zeros in the transmit stream. When DLOS is set to logic one, the transmit stream is forced to 0x00.

**Register 0x18: RLOP Control/Status**

Bit	Type	Function	Default
Bit 7	R/W	BIPWORD	0
Bit 6	R/W	Reserved	0
Bit 5	R/W	Reserved	0
Bit 4	R/W	Reserved	0
Bit 3	R/W	Reserved	0
Bit 2		Unused	X
Bit 1	R	LAISV	0
Bit 0	R	RDIV	0

**RDIV:**

The RDIV bit is read to determine the remote defect indication state of the RLOP. When RDIV is high, the RLOP has declared line RDI.

**LAISV:**

The LAISV bit is read to determine the line AIS state of the RLOP. When LAISV is high, the RLOP has declared line AIS.

**BIPWORD:**

The BIPWORD bit controls the accumulation of B2 errors. When BIPWORD is logic one, the B2 error event counter is incremented only once per frame whenever one or more B2 bit errors occur during that frame. When BIPWORD is logic zero, the B2 error event counter is incremented for each B2 bit error that occurs during that frame (the counter can be incremented up to 8 times per frame for STS-1 and 24 times per frame for STS-3c).

**Reserved:**

The reserved bits must be programmed to logic zero for proper operation.



**Register 0x19: RLOP Interrupt Enable/Interrupt Status**

Bit	Type	Function	Default
Bit 7	R/W	FEBEE	0
Bit 6	R/W	BIPEE	0
Bit 5	R/W	LAISE	0
Bit 4	R/W	RDIE	0
Bit 3	R	FEBEI	X
Bit 2	R	BIPEI	X
Bit 1	R	LAISI	X
Bit 0	R	RDII	X

**RDII:**

The RDII bit is the far end receive failure interrupt status bit. RDII is set high when a change in the line RDI state occurs. This bit is cleared when this register is read.

**LAISI:**

The LAISI bit is the line AIS interrupt status bit. LAISI is set high when a change in the line AIS state occurs. This bit is cleared when this register is read.

**BIPEI:**

The BIPEI bit is the line BIP interrupt status bit. BIPEI is set high when a line layer (B2) bit error is detected. This bit is cleared when this register is read.

**FEBEI:**

The FEBEI bit is the line far end block error interrupt status bit. FEBEI is set high when a line layer FEBE (M0/M1) is detected. This bit is cleared when this register is read.

**RDIE:**

The RDIE bit is an interrupt enable for the far end receive failure alarm. When RDIE is set to logic one, an interrupt is generated when RDI changes state.

**LAISE:**

The LAISE bit is an interrupt enable for line AIS. When LAISE is set to logic one, an interrupt is generated when line AIS changes state.

**BIPEE:**

The BIPEE bit is an interrupt enable for the line BIP-24 errors. When BIPEE is set to logic one, an interrupt is generated when a line BIP-24 error (B2) is detected.

**FEBEE:**

The FEBEE bit is an interrupt enable for the line far end block errors. When FEBE (M0/M1) is detected.

**Register 0x1A: RLOP Line BIP-8/24 LSB**

<b>Bit</b>	<b>Type</b>	<b>Function</b>	<b>Default</b>
Bit 7	R	LBE[7]	X
Bit 6	R	LBE[6]	X
Bit 5	R	LBE[5]	X
Bit 4	R	LBE[4]	X
Bit 3	R	LBE[3]	X
Bit 2	R	LBE[2]	X
Bit 1	R	LBE[1]	X
Bit 0	R	LBE[0]	X

**Register 0x1B: RLOP Line BIP-8/24**

<b>Bit</b>	<b>Type</b>	<b>Function</b>	<b>Default</b>
Bit 7	R	LBE[15]	X
Bit 6	R	LBE[14]	X
Bit 5	R	LBE[13]	X
Bit 4	R	LBE[12]	X
Bit 3	R	LBE[11]	X
Bit 2	R	LBE[10]	X
Bit 1	R	LBE[9]	X
Bit 0	R	LBE[8]	X

**Register 0x1C: RLOP Line BIP-8/24 MSB**

Bit	Type	Function	Default
Bit 7		Unused	X
Bit 6		Unused	X
Bit 5		Unused	X
Bit 4		Unused	X
Bit 3	R	LBE[19]	X
Bit 2	R	LBE[18]	X
Bit 1	R	LBE[17]	X
Bit 0	R	LBE[16]	X

LBE[19:0]

Bits LBE[19:0] represent the number of line BIP-8/24 errors (B2) that have been detected since the last time the error count was polled. The error count is polled by writing to any of the RLOP Line BIP Register or Line FEBE Register addresses. Such a write transfers the internally accumulated error count to the Line BIP Registers within approximately 7  $\mu$ s and simultaneously resets the internal counter to begin a new cycle of error accumulation.

The error count can also be polled by writing to the S/UNI-ULTRA Master Reset and Identity / Load Meters register (0x00). Writing to register address 0x00 loads all the error counter registers in the RSOP, RLOP, RPOP, RACP and TACP blocks.

**Register 0x1D: RLOP Line FEBE LSB**

<b>Bit</b>	<b>Type</b>	<b>Function</b>	<b>Default</b>
Bit 7	R	LFE[7]	X
Bit 6	R	LFE[6]	X
Bit 5	R	LFE[5]	X
Bit 4	R	LFE[4]	X
Bit 3	R	LFE[3]	X
Bit 2	R	LFE[2]	X
Bit 1	R	LFE[1]	X
Bit 0	R	LFE[0]	X

**Register 0x1E: RLOP Line FEBE**

<b>Bit</b>	<b>Type</b>	<b>Function</b>	<b>Default</b>
Bit 7	R	LFE[15]	X
Bit 6	R	LFE[14]	X
Bit 5	R	LFE[13]	X
Bit 4	R	LFE[12]	X
Bit 3	R	LFE[11]	X
Bit 2	R	LFE[10]	X
Bit 1	R	LFE[9]	X
Bit 0	R	LFE[8]	X

**Register 0x1F: RLOP Line FEBE MSB**

Bit	Type	Function	Default
Bit 7		Unused	X
Bit 6		Unused	X
Bit 5		Unused	X
Bit 4		Unused	X
Bit 3	R	LFE[19]	X
Bit 2	R	LFE[18]	X
Bit 1	R	LFE[17]	X
Bit 0	R	LFE[16]	X

LFE[19:0]

Bits LFE[19:0] represent the number of line FEBE errors (M0/M1) that have been detected since the last time the error count was polled. The error count is polled by writing to any of the RLOP Line BIP Register or Line FEBE Register addresses. Such a write transfers the internally accumulated error count to the Line FEBE Registers within approximately 7  $\mu$ s and simultaneously resets the internal counter to begin a new cycle of error accumulation.

The error count can also be polled by writing to the S/UNI-ULTRA Master Reset and Identity / Load Meters register (0x00). Writing to register address 0x00 loads all the error counter registers in the RSOP, RLOP, RPOP, RACP and TACP blocks.



**Register 0x20: TLOP Control**

Bit	Type	Function	Default
Bit 7		Unused	X
Bit 6	R/W	Reserved	0
Bit 5	R/W	Reserved	0
Bit 4	R/W	Reserved	0
Bit 3	R/W	Reserved	0
Bit 2	R/W	Reserved	0
Bit 1	R/W	Reserved	0
Bit 0	R/W	RDI	0

**RDI:**

The RDI bit controls the insertion of line far end receive failure (RDI). When RDI is set to logic one, the TLOP inserts line RDI into the transmit SONET stream. Line RDI is inserted by transmitting the code 110 in bit positions 6, 7, and 8 of the K2 byte of the transmit stream.

**Reserved:**

The reserved bits must be programmed to logic zero for proper operation.

**Register 0x21: TLOP Diagnostic**

Bit	Type	Function	Default
Bit 7		Unused	X
Bit 6		Unused	X
Bit 5		Unused	X
Bit 4		Unused	X
Bit 3		Unused	X
Bit 2		Unused	X
Bit 1		Unused	X
Bit 0	R/W	DBIP	0

**DBIP:**

The DBIP bit controls the insertion of bit errors continuously in the line BIP byte(s) (B2). When DBIP is set to logic one, the B2 byte(s) are inverted.

**Register 0x30: RPOP Status/Control**

Bit	Type	Function	Default
Bit 7	R/W	Reserved	0
Bit 6		Unused	X
Bit 5	R	LOP	X
Bit 4		Unused	X
Bit 3	R	PAIS	X
Bit 2	R	PRDI	X
Bit 1		Unused	X
Bit 0	R/W	Reserved	0

This register allows the status of path level alarms to be monitored.

**PRDI, PAIS, LOP:**

The PRDI, PAIS, and LOP bits reflect the current state of the corresponding path level alarms.

**Reserved:**

The reserved bits must be programmed to logic zero for proper operation.

**Register 0x31: RPOP Interrupt Status**

Bit	Type	Function	Default
Bit 7	R	PSLI	X
Bit 6		Unused	X
Bit 5	R	LOPI	X
Bit 4		Unused	X
Bit 3	R	PAISI	X
Bit 2	R	PRDII	X
Bit 1	R	BIPEI	X
Bit 0	R	FEBEI	X

This register allows identification and acknowledgment of path level alarm and error event interrupts.

**FEBEI, BIPEI:**

The BIPEI and FEBEI bits are set to logic one when the corresponding event, a path BIP-8 error or path FEBE is detected.

**PRDII, PAISI, LOPI:**

The PRDII, PAISI, and LOPI bits are set to logic one when a transition occurs in the corresponding alarm state.

**PSLI:**

The PSLI bit is set to logic one when a change is detected in the path signal label register. The current path signal label can be read from the RPOP Path Signal Label register.

These bits (and the interrupt) are cleared when this register is read.

**Register 0x33: RPOP Interrupt Enable**

Bit	Type	Function	Default
Bit 7	R/W	PSLE	0
Bit 6	R/W	Reserved	0
Bit 5	R/W	LOPE	0
Bit 4	R/W	Reserved	0
Bit 3	R/W	PAISE	0
Bit 2	R/W	PRDIE	0
Bit 1	R/W	BIPEE	0
Bit 0	R/W	FEBEE	0

This register allows interrupt generation to be enabled for path level alarm and error events.

**FEBEE:**

When a 1 is written to the FEBEE interrupt enable bit position, the reception of one or more FEBEs will activate the interrupt output.

**BIPEE:**

When a 1 is written to the BIPEE interrupt enable bit position, the detection of one or more path BIP-8 errors will activate the interrupt output.

**PRDIE, PAISE:**

When a 1 is written to the PRDIE interrupt enable bit position, a change in the path remote defect indication state will activate the interrupt output. When a 1 is written to the PAISE interrupt enable bit position, a change in the path AIS state will activate the interrupt output.

**LOPE:**

When a 1 is written to the LOPE interrupt enable bit position, a change in the loss of pointer state will activate the interrupt output.

**PSLE:**

When a 1 is written to the PSLE interrupt enable bit position, a change in the path signal label will activate the interrupt output.

Reserved:

The reserved bits must be programmed to logic zero for proper operation.

**Register 0x37: RPOP Path Signal Label**

Bit	Type	Function	Default
Bit 7	R	PSL[7]	X
Bit 6	R	PSL[6]	X
Bit 5	R	PSL[5]	X
Bit 4	R	PSL[4]	X
Bit 3	R	PSL[3]	X
Bit 2	R	PSL[2]	X
Bit 1	R	PSL[1]	X
Bit 0	R	PSL[0]	X

This register allows the received path signal label byte to be read.

**PSL[7:0]:**

The PSL7 - PSL0 bits contain the path signal label byte (C2). The value in this register is updated to a new path signal label value if the same new value is observed for three consecutive frames.

**Register 0x38: RPOP Path BIP-8 LSB**

<b>Bit</b>	<b>Type</b>	<b>Function</b>	<b>Default</b>
Bit 7	R	PBE[7]	X
Bit 6	R	PBE[6]	X
Bit 5	R	PBE[5]	X
Bit 4	R	PBE[4]	X
Bit 3	R	PBE[3]	X
Bit 2	R	PBE[2]	X
Bit 1	R	PBE[1]	X
Bit 0	R	PBE[0]	X



**Register 0x39: RPOP Path BIP-8 MSB**

Bit	Type	Function	Default
Bit 7	R	PBE[15]	X
Bit 6	R	PBE[14]	X
Bit 5	R	PBE[13]	X
Bit 4	R	PBE[12]	X
Bit 3	R	PBE[11]	X
Bit 2	R	PBE[10]	X
Bit 1	R	PBE[9]	X
Bit 0	R	PBE[8]	X

These registers allow path BIP-8 errors to be accumulated.

PBE[15:0]:

Bits PBE[15:0] represent the number of path BIP-8 errors (B3) that have been detected since the last time the error count was polled. The error count is polled by writing to either of the RPOP Path BIP-8 Register addresses or to either of the RPOP Path FEBE Register addresses. Such a write transfers the internally accumulated error count to the Path BIP-8 Registers within approximately 7  $\mu$ s and simultaneously resets the internal counter to begin a new cycle of error accumulation. This transfer and reset is carried out in a manner that ensures that coincident events are not lost.

The error count can also be polled by writing to the S/UNI-ULTRA Master Reset and Identity / Load Meters register (0x00). Writing to register address 0x00 loads all the error counter registers in the RSOP, RLOP, RPOP, RACP and TACP blocks.

**Register 0x3A: RPOP Path FEBE LSB**

<b>Bit</b>	<b>Type</b>	<b>Function</b>	<b>Default</b>
Bit 7	R	PFE7	X
Bit 6	R	PFE6	X
Bit 5	R	PFE5	X
Bit 4	R	PFE4	X
Bit 3	R	PFE3	X
Bit 2	R	PFE2	X
Bit 1	R	PFE1	X
Bit 0	R	PFE0	X

**Register 0x3B: RPOP Path FEBE MSB**

Bit	Type	Function	Default
Bit 7	R	PFE15	X
Bit 6	R	PFE14	X
Bit 5	R	PFE13	X
Bit 4	R	PFE12	X
Bit 3	R	PFE11	X
Bit 2	R	PFE10	X
Bit 1	R	PFE9	X
Bit 0	R	PFE8	X

These registers allow path FEBEs to be accumulated.

PFE[15:0]:

Bits PFE[15:0] represent the number of path FEBE errors (G1) that have been detected since the last time the error count was polled. The error count is polled by writing to either of the RPOP Path BIP-8 Register addresses or to either of the RPOP Path FEBE Register addresses. Such a write transfers the internally accumulated error count to the Path FEBE Registers within approximately 7  $\mu$ s and simultaneously resets the internal counter to begin a new cycle of error accumulation. This transfer and reset is carried out in a manner that ensures that coincident events are not lost.

The error count can also be polled by writing to the S/UNI-ULTRA Master Reset and Identity / Load Meters register (0x00). Writing to register address 0x00 loads all the error counter registers in the RSOP, RLOP, RPOP, RACP and TACP blocks.

**Register 0x3D: RPOP Path BIP-8 Configuration**

Bit	Type	Function	Default
Bit 7	R/W	Reserved	0
Bit 6	R/W	Reserved	0
Bit 5	R/W	BLKBIP	0
Bit 4	R/W	Reserved	0
Bit 3		Unused	X
Bit 2	R/W	Reserved	0
Bit 1	R/W	Reserved	0
Bit 0	R/W	Reserved	0

BLKBIP:

When set high, the block BIP-8 bit (BLKBIP) indicates that path BIP-8 errors are to be reported and accumulated on a block basis. A single BIP error is accumulated and reported to the return transmit path overhead processor if one or more of the BIP-8 results indicates a mismatch. When BLKBIP is set low, BIP-8 errors are accumulated and reported on a bit basis.

Reserved:

The reserved bits must be programmed to logic zero for proper operation.

**Register 0x40: TPOP Control/Diagnostic**

Bit	Type	Function	Default
Bit 7		Unused	X
Bit 6		Unused	X
Bit 5		Unused	X
Bit 4		Unused	X
Bit 3		Unused	X
Bit 2	R/W	Reserved	0
Bit 1	R/W	DB3	0
Bit 0	R/W	PAIS	0

This register allows insertion of path level alarms and diagnostic signals.

PAIS:

The PAIS bit controls the insertion of STS path alarm indication signal. When a logic one is written to this bit position, the complete SPE, and the pointer bytes (H1, H2, and H3) are overwritten with the all ones pattern. When a logic zero is written to this bit position, the pointer bytes and the SPE are processed normally.

DB3:

The DB3 bit controls the inversion of the B3 byte value. When a logic one is written to this bit position, the B3 byte is inverted, causing the insertion of eight path BIP-8 errors per frame. When a logic zero is written to this bit position, the B3 byte is transmitted uncorrupted.

Reserved:

The reserved bits must be programmed to logic zero for proper operation.

**Register 0x41: TPOP Pointer Control**

Bit	Type	Function	Default
Bit 7		Unused	X
Bit 6	R/W	FTPTR	0
Bit 5	R/W	SOS	0
Bit 4	R/W	PLD	0
Bit 3	R/W	NDF	0
Bit 2	R/W	NSE	0
Bit 1	R/W	PSE	0
Bit 0	R/W	Reserved	0

This register allows control over the transmitted payload pointer for diagnostic purposes.

**PSE:**

The PSE bit controls the insertion of positive pointer movements. A zero to one transition on this bit enables the insertion of a single positive pointer justification in the outgoing stream. This register bit is automatically cleared when the pointer movement is inserted. This bit has no effect if the FIXPTR bit of the Master Control register is a logic 1.

**NSE:**

The NSE bit controls the insertion of negative pointer movements. A zero to one transition on this bit enables the insertion of a single negative pointer justification in the outgoing stream. This register bit is automatically cleared when the pointer movement is inserted. This bit has no effect if the FIXPTR bit of the Master Control register is a logic 1.

**NDF:**

The NDF bit controls the insertion of new data flags in the inserted payload pointer. When a logic one is written to this bit position, the pattern contained in the NDF[3:0] bit positions in the Arbitrary Pointer MSB Register is inserted continuously in the payload pointer. When a logic zero is written to this bit position, the normal pattern (0110) is inserted in the payload pointer.

**PLD:**

The PLD bit controls the loading of the pointer value contained in the Arbitrary Pointer Registers. Normally, the Arbitrary Pointer Registers are written to set up the arbitrary new pointer value and a logic one is then written to this bit position to load the new pointer value.

If a legal value (i.e. 0 • pointer value • 782) is transferred from the Arbitrary Pointer Registers, the transmit payload pointer will immediately change to the corresponding byte position. If a value greater than 782 is transferred, the payload pointer remains unchanged.

This bit is automatically cleared after the new payload pointer has been loaded. This bit has no effect if the FIXPTR bit of the Master Control register is a logic 1.

**SOS:**

The SOS bit controls the stuff opportunity spacing between consecutive SPE positive or negative stuff events. When SOS is a logic zero, stuff events may be generated every frame as controlled by the PSE and NSE register bits described above. When SOS is a logic one, stuff events may be generated at a maximum rate of once every four frames.

**FTPTR:**

The force transmit pointer bit (FTPTR) enables the insertion of the pointer value contained in the Arbitrary Pointer Registers into the transmit stream for diagnostic purposes. This allows upstream payload mapping circuitry to continue functioning normally and a valid SPE to continue to be generated, although it is unlikely to be extracted by far end circuitry. If FTPTR is set to logic 1, the APTR[9:0] bits of the Arbitrary Pointer Registers are inserted into the H1 and H2 bytes of the transmit stream. At least one corrupted pointer is guaranteed to be sent. If FTPTR is a logic 0, a valid pointer is inserted. This bit has no effect if the FIXPTR bit of the Master Control register is a logic 1.

**Reserved:**

The reserved bits must be programmed to logic zero for proper operation.

**Register 0x45: TPOP Arbitrary Pointer LSB**

Bit	Type	Function	Default
Bit 7	R/W	APTR[7]	0
Bit 6	R/W	APTR[6]	0
Bit 5	R/W	APTR[5]	0
Bit 4	R/W	APTR[4]	0
Bit 3	R/W	APTR[3]	0
Bit 2	R/W	APTR[2]	0
Bit 1	R/W	APTR[1]	0
Bit 0	R/W	APTR[0]	0

This register allows an arbitrary pointer to be inserted for diagnostic purposes.

APTR[7], APTR[6], APTR[5], APTR[4], APTR[3], APTR[2], APTR[1], APTR[0]:

The APTR[7:0] bits, along with the APTR[9:8] bits in the Arbitrary Pointer MSB Register are used to set an arbitrary payload pointer value. The arbitrary pointer value is transferred by writing a logic one to the PLD bit in the Pointer Control Register. A legal value (i.e. 0 • pointer value • 782) results in the transmit payload pointer immediately changing to the corresponding byte position. If a value greater than 782 is transferred, the payload pointer remains unchanged.

If the FTPTR bit in the Pointer Control register is a logic 1, the current APTR[9:0] value is inserted into the payload pointer bytes (H1 and H2) in the transmit stream.



**Register 0x46: TPOP Arbitrary Pointer MSB**

Bit	Type	Function	Default
Bit 7	R/W	NDF[3]	1
Bit 6	R/W	NDF[2]	0
Bit 5	R/W	NDF[1]	0
Bit 4	R/W	NDF[0]	1
Bit 3	R/W	S[1]	0
Bit 2	R/W	S[0]	0
Bit 1	R/W	APTR[9]	0
Bit 0	R/W	APTR[8]	0

This register allows an arbitrary pointer to be inserted for diagnostic purposes.

**APTR[9], APTR[8]:**

The APTR[9:8] bits, along with the APTR[7:0] bits in the TPOP Arbitrary Pointer LSB Register are used to set an arbitrary payload pointer value. The arbitrary pointer value is inserted in the outgoing stream by writing a logic one to the PLD bit in the TPOP Pointer Control Register.

**S[1], S[0]:**

The S[1:0] bits contain the value inserted in the S[1:0] bit positions (also referred to as the unused bits) in the payload pointer.

**NDF[3], NDF[2], NDF[1], NDF[0]:**

The NDF[3:0] bits contain the value inserted in the NDF bit positions when an arbitrary new payload pointer value is inserted (using the PLD bit in the Pointer Control Register) or when new data flag generation is enabled using the NDF bit in the TPOP Pointer Control Register.

**Register 0x48: TPOP Path Signal Label**

Bit	Type	Function	Default
Bit 7	R/W	C2[7]	0
Bit 6	R/W	C2[6]	0
Bit 5	R/W	C2[5]	0
Bit 4	R/W	C2[4]	1
Bit 3	R/W	C2[3]	0
Bit 2	R/W	C2[2]	0
Bit 1	R/W	C2[1]	1
Bit 0	R/W	C2[0]	1

This register allows control over the path signal label.

C2[7], C2[6], C2[5], C2[4], C2[3], C2[2], C2[1], C2[0]:

The C2[7:0] bits are inserted in the C2 byte position in the transmit stream.

**Register 0x49: TPOP Path Status**

Bit	Type	Function	Default
Bit 7	R/W	FEBE[3]	0
Bit 6	R/W	FEBE[2]	0
Bit 5	R/W	FEBE[1]	0
Bit 4	R/W	FEBE[0]	0
Bit 3	R/W	PRDI	0
Bit 2	R/W	G1[2]	0
Bit 1	R/W	G1[1]	0
Bit 0	R/W	G1[0]	0

This register allows control over the path status byte.

FEBE[3], FEBE[2], FEBE[1], FEBE[0]:

The FEBE[3:0] bits are inserted in the FEBE bit positions in the path status byte. The value contained in FEBE[3:0] is cleared after being inserted in the path status byte. Any non-zero FEBE[3:0] value overwrites the value that would normally have been inserted based on the number of FEBEs accumulated during the last frame. When reading this register, a non-zero value in these bit positions indicates that the insertion of this value is still pending.

PRDI:

The PRDI bit controls the insertion of the path remote defect indication (RDI). When a logic one is written to this bit position, the PRDI bit position in the path status byte (G1) is set high. If the AUTORDI bit is a logic one, an alarm state also sets the PRDI bit high. When a logic zero is written to this bit position, the PRDI bit position in the path status byte is set low provided AUTORDI is low or no alarms are currently active.

G1[2], G1[1], G1[0]:

The G1[2:0] bits are inserted in the unused bit positions in the path status byte.

**Register 0x50: RACP Control/Status**

Bit	Type	Function	Default
Bit 7	R	OOC DV	X
Bit 6	R/W	RXPTYP	0
Bit 5	R/W	PASS	0
Bit 4	R/W	DISCOR	0
Bit 3	R/W	HCSPASS	0
Bit 2	R/W	HCSADD	1
Bit 1	R/W	DDSCR	0
Bit 0	R/W	FIFORST	0

**FIFORST:**

The FIFORST bit is used to reset the four cell receive FIFO. When FIFORST is set to logic zero, the FIFO operates normally. When FIFORST is set to logic one, the FIFO is immediately emptied and ignores writes. The FIFO remains empty and continues to ignore writes until a logic zero is written to FIFORST.

**DDSCR:**

The DDSCR bit controls the descrambling of the cell payload. When DDSCR is a logic one, cell payload descrambling is disabled. When DDSCR is a logic zero, payload descrambling is enabled.

**HCSADD:**

The HCSADD bit controls the addition of the coset polynomial,  $x^6+x^4+x^2+1$ , to the HCS octet prior to comparison. When HCSADD is a logic one, the polynomial is added, and the resulting HCS is compared. When HCSADD is a logic zero, the polynomial is not added, and the unmodified HCS is compared.

**HCSPASS:**

The HCSPASS bit controls the dropping of cells based on the detection of an uncorrectable HCS error. When HCSPASS is a logic zero, cells containing an uncorrectable HCS error are dropped. When HCSPASS is a logic one, cells are passed to the receive FIFO regardless of errors detected in the HCS. In addition, the HCS verification finite state machine never exits the correction

mode. Regardless of the programming of this bit, cells are always dropped while the cell delineation state machine is in the 'HUNT' or 'PRESYNC' states.

**DISCOR:**

The DISCOR bit disables the HCS error correction algorithm. When DISCOR is a logic zero, the error correction algorithm is enabled, and single bit errors detected in the cell header are corrected. When DISCOR is a logic one, the error correction algorithm is disabled, and any error detected in the cell header is treated as an uncorrectable HCS error.

**PASS:**

The PASS bit controls the function of the cell filter. When PASS is written with a logic zero, all cells matching the cell filter are dropped. When PASS is a logic one, the match header pattern registers are ignored and filtering of cells with VPI and VCI fields set to 0 is not performed. The default state of this bit together with the default states of the bits in the Match Mask and Match Pattern Registers enable the dropping of cells containing all zero VCI and VPI fields.

**RXPTYP:**

The RXPTYP bit selects even or odd parity for outputs RXPRTY. When it is set to logic one, output RXPRTY is the even parity bit for outputs RDAT[7:0]. When it is set to logic zero, RXPRTY is the odd parity bits for outputs RDAT[7:0].

**OOCDV:**

The OOCDV bit indicates the cell delineation state. When OOCDV is set high, the cell delineation state machine is in the 'HUNT' or 'PRESYNC' states, and is hunting for the cell boundaries in the synchronous payload envelope. When OOCDV is set low, the cell delineation state machine is in the 'SYNC' state and cells are passed through the receive FIFO.

**Register 0x51: RACP Interrupt Enable/Status**

Bit	Type	Function	Default
Bit 7	R/W	OOCDE	0
Bit 6	R/W	HCSE	0
Bit 5	R/W	FIFOE	0
Bit 4	R	OOCDI	X
Bit 3	R	CHCSI	X
Bit 2	R	UHCSI	X
Bit 1	R	FOVRI	X
Bit 0		Unused	X

FOVRI:

The FOVRI bit is set high when a FIFO overrun occurs. This bit is reset immediately after a read to this register.

UHCSI:

The UHCSI bit is set high when an uncorrectable HCS error is detected. This bit is reset immediately after a read to this register.

CHCSI:

The CHCSI bit is set high when a correctable HCS error is detected. This bit is reset immediately after a read to this register.

OOCDI:

The OOCDI bit is set high when a change of cell delineation state has occurred. The OOCDI bit is set high when the RACP block transitions from the PRESYNC state to the SYNC state and from the SYNC state to the HUNT state. This bit is reset immediately after a read to this register.

FIFOE:

The FIFOE bit enables the generation of an interrupt due to a FIFO overrun error condition. When FIFOE is set to logic one, the interrupt is enabled.

**HCSE:**

The HCSE bit enables the generation of an interrupt due to the detection of a correctable or an uncorrectable HCS error. When HCSE is set to logic one, the interrupt is enabled.

**OOCDE:**

The OOCDE bit enables the generation of an interrupt due to a change of cell delineation state. When OOCDE is set to logic one, the interrupt is enabled.

**Register 0x52: RACP Match Header Pattern**

Bit	Type	Function	Default
Bit 7	R/W	GFC[3]	0
Bit 6	R/W	GFC[2]	0
Bit 5	R/W	GFC[1]	0
Bit 4	R/W	GFC[0]	0
Bit 3	R/W	PTI[2]	0
Bit 2	R/W	PTI[1]	0
Bit 1	R/W	PTI[0]	0
Bit 0	R/W	CLP	0

This register extends the cell filtering criteria beyond the all zeros pattern that must be present in the VPI and VCI fields of the idle or unassigned cell. The PASS bit in the RACP Control/Status Register must be set to logic zero to enable dropping of idle/unassigned cells matching the pattern defined by the contents of this register and the RACP Match Header Mask Register.

GFC[3:0]:

The GFC[3:0] bits contain the pattern to match in the first, second, third and fourth bits of the first octet of the 53 octet cell, in conjunction with the RACP Match Header Mask Register.

PTI[2:0]:

The PTI[2:0] bits contain the pattern to match in the fifth, sixth and seventh bits of the fourth octet of the 53 octet cell, in conjunction with the RACP Match Header Mask Register.

CLP:

The CLP bit contains the pattern to match in the eighth bit of the fourth octet of the 53 octet cell, in conjunction with the RACP Match Header Mask Register.



**Register 0x53: RACP Match Header Mask**

Bit	Type	Function	Default
Bit 7	R/W	MGFC[3]	0
Bit 6	R/W	MGFC[2]	0
Bit 5	R/W	MGFC[1]	0
Bit 4	R/W	MGFC[0]	0
Bit 3	R/W	MPTI[2]	0
Bit 2	R/W	MPTI[1]	0
Bit 1	R/W	MPTI[0]	0
Bit 0	R/W	MCLP	0

The mask contained in this register is applied to the RACP Match Header Pattern Register to select the bits included in the cell filter. A logic one in any bit position enables the corresponding bit in the pattern register to be compared. A logic zero causes the masking of the corresponding bit.

**MGFC[3:0]:**

The MGFC[3:0] bits contain the mask pattern for the first, second, third and fourth bits of the first octet of the 53 octet cell.

**MPTI[3:0]:**

The MPTI[3:0] bits contain the mask pattern for the fifth, sixth and seventh bits of the fourth octet of the 53 octet cell.

**MCLP:**

The MCLP bit contains the mask pattern for the eighth bit of the fourth octet of the 53 octet cell.

**Register 0x54: RACP Correctable HCS Error Count**

Bit	Type	Function	Default
Bit 7	R	CHCS[7]	X
Bit 6	R	CHCS[6]	X
Bit 5	R	CHCS[5]	X
Bit 4	R	CHCS[4]	X
Bit 3	R	CHCS[3]	X
Bit 2	R	CHCS[2]	X
Bit 1	R	CHCS[1]	X
Bit 0	R	CHCS[0]	X

CHCS[7:0]:

The CHCS[7:0] bits indicate the number of correctable HCS error events that occurred during the last accumulation interval. The contents of these registers are valid 200 ns after a transfer is triggered by a write to the correctable HCS error count register address, or to the uncorrectable HCS error count register address.

The error count can also be polled by writing to the S/UNI-ULTRA Master Reset and Identity / Load Meters register (0x00). Writing to register address 0x00 loads all the error counter registers in the RSOP, RLOP, RPOP, RACP and TACP blocks.

**Register 0x55: RACP Uncorrectable HCS Error Count**

Bit	Type	Function	Default
Bit 7	R	UHCS[7]	X
Bit 6	R	UHCS[6]	X
Bit 5	R	UHCS[5]	X
Bit 4	R	UHCS[4]	X
Bit 3	R	UHCS[3]	X
Bit 2	R	UHCS[2]	X
Bit 1	R	UHCS[1]	X
Bit 0	R	UHCS[0]	X

UHCS[7:0]:

The UHCS[7:0] bits indicate the number of uncorrectable HCS error events that occurred during the last accumulation interval. The contents of these registers are valid 200 ns after a transfer is triggered by a write to the correctable HCS error count register address, or to the uncorrectable HCS error count register address.

The error count can also be polled by writing to the S/UNI-ULTRA Master Reset and Identity / Load Meters register (0x00). Writing to register address 0x00 loads all the error counter registers in the RSOP, RLOP, RPOP, RACP and TACP blocks.

**Register 0x56: RACP Receive Cell Counter (LSB)**

<b>Bit</b>	<b>Type</b>	<b>Function</b>	<b>Default</b>
Bit 7	R	RCELL[7]	X
Bit 6	R	RCELL[6]	X
Bit 5	R	RCELL[5]	X
Bit 4	R	RCELL[4]	X
Bit 3	R	RCELL[3]	X
Bit 2	R	RCELL[2]	X
Bit 1	R	RCELL[1]	X
Bit 0	R	RCELL[0]	X

**Register 0x57: RACP Receive Cell Counter**

<b>Bit</b>	<b>Type</b>	<b>Function</b>	<b>Default</b>
Bit 7	R	RCELL[15]	X
Bit 6	R	RCELL[14]	X
Bit 5	R	RCELL[13]	X
Bit 4	R	RCELL[12]	X
Bit 3	R	RCELL[11]	X
Bit 2	R	RCELL[10]	X
Bit 1	R	RCELL[9]	X
Bit 0	R	RCELL[8]	X

**Register 0x58: RACP Receive Cell Counter (MSB)**

Bit	Type	Function	Default
Bit 7		Unused	X
Bit 6		Unused	X
Bit 5		Unused	X
Bit 4		Unused	X
Bit 3		Unused	X
Bit 2	R	RCELL[18]	X
Bit 1	R	RCELL[17]	X
Bit 0	R	RCELL[16]	X

**RCELL[18:0]:**

The RCELL[18:0] bits indicate the number of cells received and written into the receive FIFO during the last accumulation interval. Cells received and filtered due to HCS errors or Idle/Unassigned cell matches are not counted. The counter should be polled every second to avoid saturating. The contents of these registers are valid 200 ns after a transfer is triggered by a write to the correctable HCS error count register addresses, the uncorrectable HCS error count register addresses or the receive cell counter register addresses.

The cell count can also be polled by writing to the S/UNI-ULTRA Master Reset and Identity / Load Meters register (0x00). Writing to register address 0x00 loads all the error counter registers in the RSOP, RLOP, RPOP, RACP and TACP blocks.

**Register 0x59: RACP Configuration**

Bit	Type	Function	Default
Bit 7	R/W	RGFCE[3]	1
Bit 6	R/W	RGFCE[2]	1
Bit 5	R/W	RGFCE[1]	1
Bit 4	R/W	RGFCE[0]	1
Bit 3	R/W	FSEN	1
Bit 2	R/W	RCALEVEL0	1
Bit 1	R/W	Reserved	0
Bit 0	R/W	Reserved	0

The Configuration Register is provided at RACP read/write address 9.

HCSFTR[1:0]	Correction Mode Reversion Cell Threshold
00	One ATM cell with correct HCS. This error free cell is accepted.
01	Two ATM cells with correct HCS. Error free cells are accepted.
10	Four ATM cells with correct HCS. Error free cells are accepted.
11	Eight ATM cells with correct HCS. Error free cells are accepted.

RCALEVEL0:

The RCA level 0 bit, RCALEVEL0, determines what output RCA indicates when it transitions low. When RCALEVEL0 is set to logic one, a high to low transition on output RCA indicates that the receive FIFO is empty. When RCALEVEL0 is set to logic zero, a high to low transition on output RCA indicates that the receive FIFO is near empty and contains four only bytes.

FSEN:

The active high fix stuff control enable bit FSEN selects the expected payload mapping of ATM cells when STS-1 mapping is selected. When FSEN is set to logic one, it is assumed columns 30 and 59 of the Synchronous Payload

Envelope (SPE) contain fixed stuff bytes. When FSEN is set to logic zero, it is assumed ATM payload fills the entire SPE except the path overhead column.

RGFCE[3:0]:

The receive GFC enable bits, RGFCE[3:0], determine which generic flow control bits are presented on the RGFC output. RGFCE[3] corresponds to the most significant GFC bit (first bit in the cell). If a RGFCE bit is a logic 1, the RGFC output presents in the appropriate bit location the state of the associated GFC bit in the current cell; otherwise, RFGC is deasserted low.

Reserved:

The reserved bits must be programmed to logic zero for proper operation.



**Register 0x60: TACP Control/Status**

Bit	Type	Function	Default
Bit 7	R/W	FIFOE	0
Bit 6	R	TSOCI	X
Bit 5	R	FOVRI	X
Bit 4	R/W	DHCS	0
Bit 3	R/W	HCSB	0
Bit 2	R/W	HCSADD	1
Bit 1	R/W	DSCR	0
Bit 0	R/W	FIFORST	0

FIFORST:

The FIFORST bit is used to reset the four cell transmit FIFO. When FIFORST is set to logic zero, the FIFO operates normally. When FIFORST is set to logic one, the FIFO is immediately emptied and ignores writes. The FIFO remains empty and continues to ignore writes until a logic zero is written to FIFORST.

DSCR:

The DSCR bit controls the scrambling of the cell payload. When DSCR is a logic one, cell payload scrambling is disabled. When DSCR is a logic zero, payload scrambling is enabled.

HCSADD:

The HCSADD bit controls the addition of the coset polynomial,  $x^6+x^4+x^2+1$ , to the HCS octet prior to insertion in the synchronous payload envelope. When HCSADD is a logic one, the polynomial is added, and the resulting HCS is inserted. When HCSADD is a logic zero, the polynomial is not added, and the unmodified HCS is inserted.

HCSB:

The active low HCS bit enables the internal generation and insertion of the HCS octet into the transmit cell stream. When HCSB is a logic zero, the HCS is generated and inserted internally. When HCSB is a logic one, the HCS octet read from the FIFO is inserted transparently into the transmit cell stream.

**DHCS:**

The DHCS bit controls the insertion of HCS errors for diagnostic purposes. When DHCS is set to logic one, the HCS octet is inverted prior to insertion in the synchronous payload envelope.

**FOVRI:**

The FOVRI bit is set high when a FIFO overrun occurs. This bit is reset immediately after a read to this register

**TSOCI:**

The TSOCI bit is set high when the TSOC input is sampled high during any position other than the first byte. The write address counter is reset to the first byte of the cell when TSOC is sampled high. This bit is reset immediately after a read to this register.

**FIFOE:**

The FIFOE bit enables the generation of an interrupt due to a FIFO overrun error condition, or when the TSOC input is sampled high during any position other than the first byte. When FIFOE is set to logic one, the interrupt is enabled.

**Register 0x61: TACP Idle/Unassigned Cell Header Pattern**

Bit	Type	Function	Default
Bit 7	R/W	GFC[3]	0
Bit 6	R/W	GFC[2]	0
Bit 5	R/W	GFC[1]	0
Bit 4	R/W	GFC[0]	0
Bit 3	R/W	PTI[2]	0
Bit 2	R/W	PTI[1]	0
Bit 1	R/W	PTI[0]	0
Bit 0	R/W	CLP	0

GFC[3:0]:

The GFC[3:0] bits contain the first, second, third, and fourth bit positions of the first octet of the idle/unassigned cell pattern. Cell rate decoupling is accomplished by transmitting idle/unassigned cells when the TACP detects that no outstanding cells exist in the transmit FIFO. The all zeros pattern is transmitted in the VCI and VPI fields of the idle cell.

PTI[3:0]:

The PTI[3:0] bits contain the fifth, sixth, and seventh bit positions of the fourth octet of the idle/unassigned cell pattern. Idle cells are transmitted when the TACP detects that no outstanding cells exist in the transmit FIFO.

CLP:

The CLP bit contains the eighth bit position of the fourth octet of the idle/unassigned cell pattern. Idle cells are transmitted when the TACP detects that no outstanding cells exist in the transmit FIFO.

**Register 0x62: TACP Idle/Unassigned Cell Payload Octet Pattern**

<b>Bit</b>	<b>Type</b>	<b>Function</b>	<b>Default</b>
Bit 7	R/W	ICP[7]	0
Bit 6	R/W	ICP[6]	1
Bit 5	R/W	ICP[5]	1
Bit 4	R/W	ICP[4]	0
Bit 3	R/W	ICP[3]	1
Bit 2	R/W	ICP[2]	0
Bit 1	R/W	ICP[1]	1
Bit 0	R/W	ICP[0]	0

**ICP[7:0]:**

The ICP[7:0] bits contain the pattern inserted in the payload octets of the idle or unassigned cell. Cell rate decoupling is accomplished by transmitting idle/unassigned cells when the TACP detects that no outstanding cells exist in the transmit FIFO. Bit ICP[7] corresponds to the most significant bit of the octet, the first bit transmitted.

**Register 0x63: TACP FIFO Control**

Bit	Type	Function	Default
Bit 7	R/W	TXPTYP	0
Bit 6	R/W	TXPRTYE	0
Bit 5		Reserved	X
Bit 4	R	TXPRTYI	X
Bit 3	R/W	FIFODP[1]	0
Bit 2	R/W	FIFODP[0]	0
Bit 1	R/W	TCALEVEL0	0
Bit 0		Reserved	0

TCALEVEL0:

The active high TCA level 0 bit, TCALEVEL0 determines what output TCA indicates when it transitions low. When TCALEVEL0 is set to logic one, output TCA indicates that the transmit FIFO is full and can accept no more writes. When TCALEVEL0 is set to logic zero, output TCA indicates that the transmit FIFO is near full and can accept no more than four additional writes.

FIFODP[1:0]:

The FIFODP[1:0] bits determine the transmit FIFO cell depth. FIFO depth control may be important in systems where the cell latency through the TACP must be minimized. When the FIFO is filled to the specified depth, the transmit cell available signal, TCA is deasserted. TCA is asserted only after a complete cell has been read out; therefore, the current cell being read is included in the count. The selectable FIFO cell depths are shown below:

FIFODP[1]	FIFODP[0]	FIFO DEPTH
0	0	4 cells
0	1	3 cells
1	0	2 cells
1	1	1 cell

Note that FIFODP[1:0] only affects when TCA is asserted. All four cells of the FIFO may be filled before an over flow is declared.

It is not recommended that the FIFO depth be set to 1 cell. If a cell write is initiated only when TCA is asserted, half the bandwidth is lost to idle/unassigned cells. For minimum latency and maximum throughput, set the FIFO depth to 2 cells.

**Reserved:**

The reserved bits must be programmed to logic zero for proper operation.

**TXPRTYI:**

The TXPRTYI bit indicates if a parity error was detected on the TDAT[7:0] bus. This bit is cleared when this register is read. Odd or even parity is selected using the TXPTYP bit.

**TXPRTYE:**

The TXPRTYE bit enables transmit parity interrupts. When set to logic one, parity errors on inputs TDAT[7:0] are indicated by the TXPRTYI bit and the INTB output. When set to logic zero, parity errors are indicated by the TXPRTYI bit but are not indicated on the INTB output.

**TXPTYP:**

The TXPTYP bit selects even or odd parity for input TXPRTY. When set to logic one input TXPRTY is the even parity bit for inputs TDAT[7:0]. When set to logic zero, inputs TXPRTY is the odd parity bit for inputs TDAT[7:0].

**Register 0x64: TACP Transmit Cell Counter (LSB)**

<b>Bit</b>	<b>Type</b>	<b>Function</b>	<b>Default</b>
Bit 7	R	TCELL[7]	X
Bit 6	R	TCELL[6]	X
Bit 5	R	TCELL[5]	X
Bit 4	R	TCELL[4]	X
Bit 3	R	TCELL[3]	X
Bit 2	R	TCELL[2]	X
Bit 1	R	TCELL[1]	X
Bit 0	R	TCELL[0]	X

**Register 0x65: TACP Transmit Cell Counter**

<b>Bit</b>	<b>Type</b>	<b>Function</b>	<b>Default</b>
Bit 7	R	TCELL[15]	X
Bit 6	R	TCELL[14]	X
Bit 5	R	TCELL[13]	X
Bit 4	R	TCELL[12]	X
Bit 3	R	TCELL[11]	X
Bit 2	R	TCELL[10]	X
Bit 1	R	TCELL[9]	X
Bit 0	R	TCELL[8]	X



**Register 0x66: TACP Transmit Cell Counter (MSB)**

Bit	Type	Function	Default
Bit 7		Unused	X
Bit 6		Unused	X
Bit 5		Unused	X
Bit 4		Unused	X
Bit 3		Unused	X
Bit 2	R	TCELL[18]	X
Bit 1	R	TCELL[17]	X
Bit 0	R	TCELL[16]	X

TCELL[15:0]:

The TCELL[18:0] bits indicate the number of cells read from the transmit FIFO and inserted into the SPE during the last accumulation interval. Idle/Unassigned cells inserted into the SPE are not counted.

A write to any one of the Transmit Cell Counter registers loads the registers with the current counter value and resets the internal 19 bit counter to 1 or 0. The counter reset value is dependent on if there was a count event during the transfer of the count to the Transmit Cell Counter registers. The counter should be polled every second to avoid saturating. The contents of these registers are valid 200 ns after a transfer is triggered by a write to the transmit cell count register space.

The cell count can also be polled by writing to the S/UNI-ULTRA Master Reset and Identity / Load Meters register (0x00). Writing to register address 0x00 loads all the error counter registers in the RSOP, RLOP, RPOP, RACP and TACP blocks.

**Register 0x67: TACP Configuration**

Bit	Type	Function	Default
Bit 7	R/W	TGFCE[3]	0
Bit 6	R/W	TGFCE[2]	0
Bit 5	R/W	TGFCE[1]	0
Bit 4	R/W	TGFCE[0]	0
Bit 3	R/W	FSEN	1
Bit 2	R/W	H4INSB	0
Bit 1	R/W	FIXBYTE[1]	0
Bit 0	R/W	FIXBYTE[0]	0

FIXBYTE[1:0]:

The FIXBYTE[1:0] bits identify the byte pattern inserted into fixed byte columns of the synchronous payload envelope.

FIXBYTE[1]	FIXBYTE[0]	BYTE
0	0	00H
0	1	55H
1	0	AAH
1	1	FFH

H4INSB:

The active low H4 insert enable, H4INSB bit determines the contents of the H4 byte in the outgoing SPE. If H4INSB is set to logic one, the H4 byte is set to the value of 00 hexadecimal. If H4INSB is set to logic zero, the H4 byte is set to the cell indicator offset value.

FSEN:

The active high fix stuff control enable, FSEN bit determines the payload mapping of ATM cells for STS-1 mapping. When FSEN is set to logic one, a fixed pattern is inserted into columns 30 and 59 of the Synchronous Payload Envelope (SPE). When FSEN is set to logic zero, ATM payload fills the entire SPE except the path overhead column.

**TGFCE[3:0]:**

The GFC enable bits, TGFCE[3:0], enable the insertion of the associated GFC bit by the TGFC serial input. If MFC[3] is a logic 1, first bit of the 4 bit serial sequence is inserted into the most significant GFC bit transmitted. Likewise, if MFC[0] is a logic 1, last bit of the sequence is inserted into the least significant GFC bit transmitted. If a bit is logic 0, the associated GFC bit value is derived from TDAT[7:0] in the case of an assigned cell, or from the Idle/Unassigned Cell Header Control register in the case of unassigned cells.

**Register 0x68: S/UNI-ULTRA POPC Control**

Bit	Type	Function	Default
Bit 7	R/W	PDAT[1]	0
Bit 6	R/W	PDAT[0]	0
Bit 5	R/W	TOGGLE[1]	0
Bit 4	R/W	TOGGLE[0]	0
Bit 3		Unused	X
Bit 2		Unused	X
Bit 1	R/W	TRAFFIC	0
Bit 0	R/W	ALARM	1

ALARM:

The receive alarm interface (ALARM) bit determines whether the OUT[1] output is used as receive alarm (RALM) or as an extension to the parallel output port (OUT[1:0] output). If ALARM is a logic 0, OUT[1] is an output port bit. If ALARM is a logic 1, RALM is used as the receive alarm (RALM).

TRAFFIC:

The traffic monitoring enable (TRAFFIC) allows to select between the traffic pulse generation when set high and a programmable rate toggling signal when set low.

TOGGLE[1:0]:

The output port toggle (TOGGLE[1:0]) bits determine whether the corresponding output port is held at a constant value or toggles at a register defined rate. If TOGGLE is a logic 0, the corresponding PDAT value is driven onto its corresponding output, as selected by the ALARM bit. If TOGGLE is a logic 1, a logic one in the corresponding PDAT enables the toggle rate register for the corresponding output, as selected by the ALARM bit.

PDAT[1:0]:

The values written to the PDAT[1:0] bits in the S/UNI-ULTRA Output Port Control register either directly correspond to the states set on the OUT[1:0] output pins or enable the corresponding pin to strobe at a selectable rate. PDAT[1] corresponds to output OUT[1]; PDAT[0] corresponds to output

OUT[0]. This provides a generic port useful for controlling an external PMD device or supplying external LED drivers.

Refer to the OPERATION section for more details on how to use the Parallel Output Port and LED Display Controller.

**Register 0x69: S/UNI-ULTRA POPC Strobe Rate 0**

Bit	Type	Function	Default
Bit 7	R/W	RATE0[7]	0
Bit 6	R/W	RATE0[6]	0
Bit 5	R/W	RATE0[5]	1
Bit 4	R/W	RATE0[4]	1
Bit 3	R/W	RATE0[3]	1
Bit 2	R/W	RATE0[2]	1
Bit 1	R/W	RATE0[1]	1
Bit 0	R/W	RATE0[0]	0

**RATE0[7:0]:**

The output strobe rate 0 (RATE0[7:0]) bits determine the period (in milliseconds increasing in 8 ms increments) of the OUT[0] output pin. The default setting is for a strobe period of 496 ms, resulting in a 2.0 Hz strobe. Note that a register value of 0x00 results in a steady logic 0 value.

**Register 0x6A: S/UNI-ULTRA POPC Strobe Rate 1**

Bit	Type	Function	Default
Bit 7	R/W	RATE1[7]	0
Bit 6	R/W	RATE1[6]	0
Bit 5	R/W	RATE1[5]	0
Bit 4	R/W	RATE1[4]	0
Bit 3	R/W	RATE1[3]	0
Bit 2	R/W	RATE1[2]	1
Bit 1	R/W	RATE1[1]	1
Bit 0	R/W	RATE1[0]	0

RATE1[7:0]:

The output strobe rate 1 (RATE1[7:0]) bits determine the period (in milliseconds increasing in 8 ms increments) of the RALM/OUT[1] output pin. The default setting is for a strobe period of 48 ms, resulting in a 20.8 Hz strobe. Note that a register value of 0x00 results in a steady logic 0 value.

**TEST FEATURES Description**

Simultaneously asserting (low) the CSB, RDB and WRB inputs causes all digital output pins and the data bus to be held in a high-impedance state. This test feature may be used for board testing.

Test mode registers are used to apply test vectors during production testing of the S/UNI-ULTRA. Test mode registers (as opposed to normal mode registers) are selected when TRS (A[7]) is high.

Test mode registers may also be used for board testing. When all of the TSBs within the S/UNI-ULTRA are placed in test mode 0, device inputs may be read and device outputs may be forced via the microprocessor interface (refer to the section "Test Mode 0" for details).

**8.1 Test Mode Register Memory Map**

Address	Register
0x00-0x7F	Normal Mode Registers
0x80	Master Test
0x81-0xFF	Reserved For Test

**Notes on Test Mode Register Bits:**

1. Writing values into unused register bits has no effect. However, to ensure software compatibility with future, feature-enhanced versions of the product, unused register bits must be written with logic zero. Reading back unused bits can produce either a logic one or a logic zero; hence unused register bits should be masked off by software when read.
2. Writable test mode register bits are not initialized upon reset unless otherwise noted.



**Register 0x80: Master Test**

Bit	Type	Function	Default
Bit 7		Unused	X
Bit 6	W	BYPASS	X
Bit 5	W	PMCATST	X
Bit 4	W	PMCTST	X
Bit 3	W	DBCTRL	X
Bit 2	R/W	IOTST	0
Bit 1	W	HIZDATA	X
Bit 0	R/W	HIZIO	0

This register is used to enable S/UNI-ULTRA test features. All bits, except PMCTST, PMCATST and BYPASS are reset to zero by a reset of the S/UNI-ULTRA using either the RSTB input or the Master Reset register. PMCTST and BYPASS are reset when CSB is logic 1. PMCATST is reset when both CSB is high and RSTB is low. PMCTST, PMCATST and BYPASS can also be reset by writing a logic 0 to the corresponding register bit.

HIZIO, HIZDATA:

The HIZIO and HIZDATA bits control the tristate modes of the S/UNI-ULTRA . While the HIZIO bit is a logic one, all output pins of the S/UNI-ULTRA except the data bus are held in a high-impedance state. The microprocessor interface is still active. While the HIZDATA bit is a logic one, the data bus is also held in a high-impedance state which inhibits microprocessor read cycles.

IOTST:

The IOTST bit is used to allow normal microprocessor access to the test registers and control the test mode in each TSB block in the S/UNI-ULTRA for board level testing. When IOTST is a logic one, all blocks are held in test mode and the microprocessor may write to a block's test mode 0 registers to manipulate the outputs of the block and consequentially the device outputs (refer to the "Test Mode 0 Details" in the "Test Features" section).

**DBCTRL:**

The DBCTRL bit is used to pass control of the data bus drivers to the CSB pin. When the DBCTRL bit is set to logic one, the CSB pin controls the output enable for the data bus. While the DBCTRL bit is set, holding the CSB pin high causes the S/UNI-ULTRA to drive the data bus and holding the CSB pin low tristates the data bus. The DBCTRL bit only has effect if the IOTST bit is a logic one. The DBCTRL bit overrides the HIZDATA bit. The DBCTRL bit is used to measure the drive capability of the data bus driver pads.

**PMCTST:**

The PMCTST bit is used to configure the S/UNI-ULTRA for PMC's manufacturing tests. When PMCTST is set to logic one, the S/UNI-ULTRA microprocessor port becomes the test access port used to run the PMC "canned" manufacturing test vectors. The PMCTST bit is logically "ORed" with the IOTST bit.

**PMCATST:**

The PMCATST bit is used to configure the analog portion of the S/UNI-ULTRA for PMC's manufacturing tests.

**BYPASS**

The BYPASS bit forces the clock recovery and clock synthesis units into a reset, and permits the input data and clock to feed directly into the serial-to-parallel converter. BYPASS is available for PMC manufacturing test purposes only.

**8.2 Test Mode 0 Details**

In test mode 0, the S/UNI-ULTRA allows the logic levels on the device inputs to be read through the microprocessor interface, and allows the device outputs to be forced to either logic level through the microprocessor interface. The IOTST bit in the Master Test register should be set to logic one.

To enable test mode 0, the IOTST bit in the Master Test register is set to logic one and the following addresses must be written with 00H: 91H, 95H, 99H, A1H, B1H, D1H and E1H. Reading the following address locations returns the values for the indicated inputs :

Addr	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
82H	TDAT[7]	TDAT[6]	TDAT[5]	TDAT[4]	TDAT[3]	TDAT[2]	TDAT[1]	TDAT[0]
83H		TFP <sup>3</sup>	TGFC	XOFF	TSOC	TXPRTY	TWRENB	TFCLK
84H	RFCLK	RRDENB	TSEN					

The following inputs can not be read using the IOTST feature: REFCLK, RXD+/-, SD, D[7:0], A[7:0], ALE, CSB, WRB, RDB and RSTB.

Writing the following address locations forces the outputs to the value in the corresponding bit position:

Addr	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
90H						RFP <sup>2</sup>		
96H								TFP <sup>3</sup>
D0H	RSOC <sup>4</sup>		RCA <sup>4</sup>	RCP	RGFC		RXPRTY <sup>4</sup>	INT <sup>1</sup>
D2H	RDAT[7] <sup>4</sup>	RDAT[6] <sup>4</sup>	RDAT[5] <sup>4</sup>	RDAT[4] <sup>4</sup>	RDAT[3] <sup>4</sup>	RDAT[2] <sup>4</sup>	RDAT[1] <sup>4</sup>	RDAT[0] <sup>4</sup>
E0H							TCP	
EAH							OUT[1]	OUT[0]

**Notes:**

1. Bit INT corresponds to output INTB. INTB is an open drain output and should be pulled high for proper operation. Writing a logic one to the INT bit allows the S/UNI-ULTRA to drive INTB low. Writing a logic zero to the INT bit tristates the INTB output.
2. RFP must be clocked by VCLK at least twice to become valid.
3. TFP is bidirectional and must be configured appropriately using the TFP\_IN register bit.
4. The corresponding device output is assigned the programmed register value only on a rising edge of RFCLK.

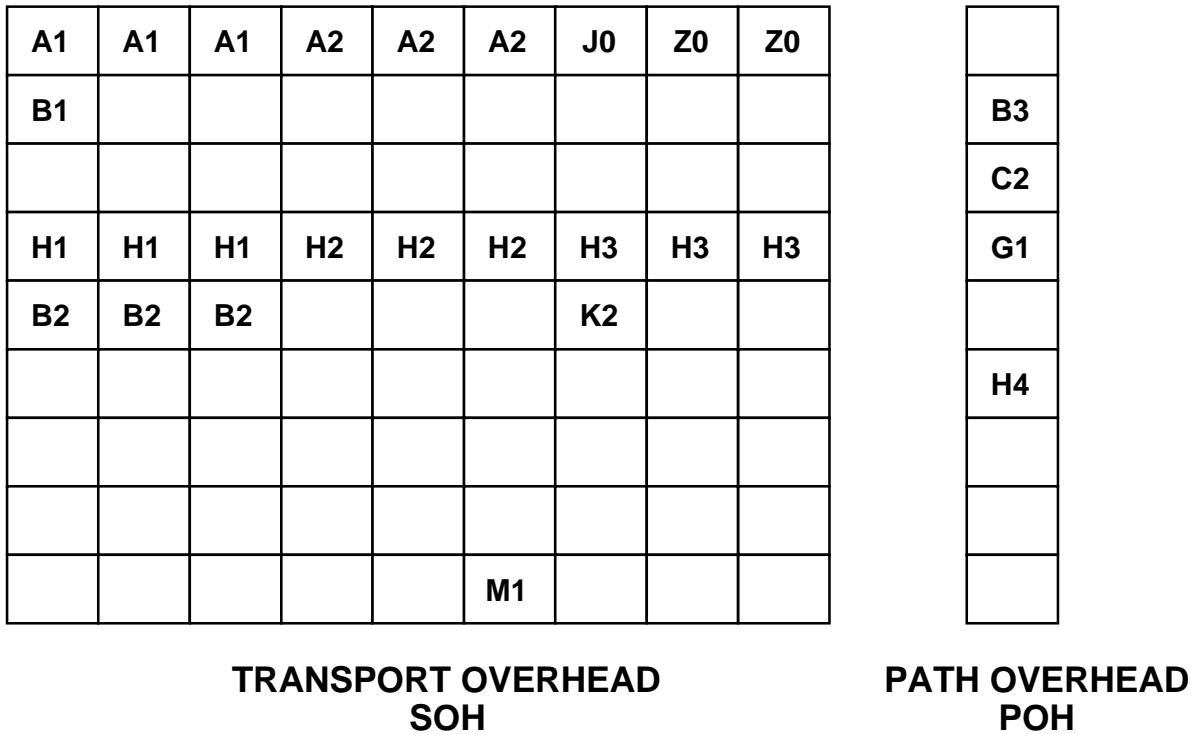
The following outputs can not be controlled using the IOTST feature: TXD+/-, TCLK, RCLK, D[7:0] and TCA.

## 9 OPERATION

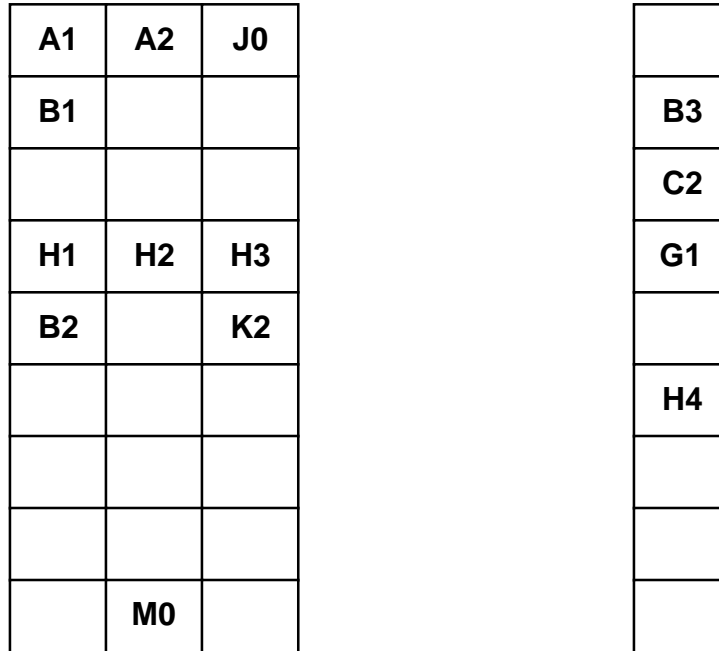
### 9.1 Overhead Byte Usage

Under normal operating conditions, the S/UNI-ULTRA processes a subset of the complete transport overhead present in an STS-3c/STM-1 stream. The byte positions processed by the S/UNI-ULTRA are indicated in figure Figure 8 and Figure 9.

**Figure 8 - STS-3c (STM-1) Overhead**



**Figure 9 - STS-1 Overhead**



**TRANSPORT OVERHEAD  
SOH**

**PATH OVERHEAD  
POH**

- A1, A2: The frame alignment bytes (A1, A2) locate the SONET frame in the 155.52 Mbit/s data stream. The transmitter inserts these bytes in the outgoing stream. The receiver searches for the A1, A2 bit sequence in the incoming stream. A1 and A2 are not scrambled by the frame synchronous SONET scrambler.
- J0, Z0: The section trace and section growth bytes are disabled for this application. The sequence 0x01, 0x02, 0x03 is inserted in the transmit direction (Only 0x01 is transmitted in STS-1 mode). These bytes are ignored in the receive direction. These bytes are not scrambled by the frame synchronous SONET scrambler.
- B1: The section bit interleaved parity byte provides a section error monitoring function. B1 is calculated over all bits of the previous frame after scrambling. B1 is placed in the current

frame before scrambling. Receive B1 errors are accumulated in an error event counter.

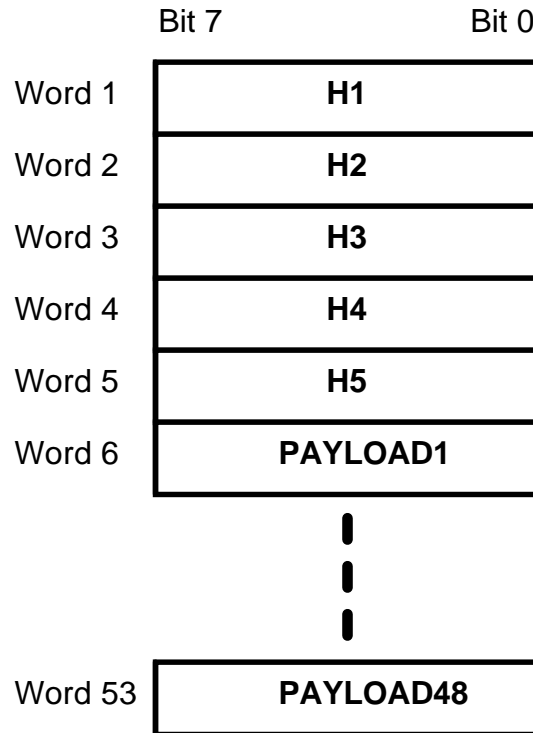
- H1, H2: The pointer value bytes locate the start of the synchronous payload envelope (SPE) in the SONET/SDH frame. In the transmit direction, a fixed pointer value of 522 decimal, with a normal new data flag indication, is inserted in the first H1-H2 pair. The concatenation indication is inserted in the remaining two H1-H2 pairs in STS-3c mode. In the receive direction, the pointer is interpreted to locate the SPE. The loss of pointer state is entered when a valid pointer cannot be found. Path AIS is detected when H1, H2 contain an all ones pattern.
- H3: The pointer action bytes contain synchronous payload envelope data when a negative stuff event occurs. The all zeros pattern is inserted in the transmit direction. This byte is ignored in the receive direction unless a negative stuff event is detected.
- B2: The line bit interleaved parity bytes provide a line error monitoring function. B2 is calculated over all bits of the line overhead, and the SPE capacity of the previous frame before scrambling. B2 is placed in the current frame before scrambling. Receive B2 errors are accumulated in an error event counter.
- K2: The K2 byte is used to identify line layer maintenance signals. In the transmit direction, line RDI is inserted by setting bits 6, 7, and 8 of the K2 byte to the pattern '110'. Line AIS is inserted by overwriting the line overhead (including bits 6, 7, and 8 of the K2 byte), and the SPE with the all ones pattern before scrambling. In the receive direction, bits 6, 7, and 8 of the K2 byte are examined to determine the presence of the line AIS, and the line RDI maintenance signals.
- M0/M1: The growth byte provides a line far end block error function for remote performance monitoring. In the transmit direction, the number of B2 errors detected in the previous interval is inserted. This number has 25 legal values, namely 0 to 24 errors. In the receive direction, a legal M0/M1 byte value is added to the line FEBE event counter.

- B3:** The path bit interleaved parity byte provides a path error monitoring function. B3 is calculated over all bits of the SPE capacity of the previous frame before scrambling. B3 is placed in the current frame before scrambling. Receive B3 errors are accumulated in an error event counter.
- C2:** The path signal label byte indicates the content of the SPE. A hexadecimal value of 13 is transmitted, which indicates "Mapping for ATM."
- G1:** The path status byte provides a path far end block error function, and provides control over the path remote defect indication maintenance signal. In the transmit direction, path remote alarm indication (RDI) and the number of B3 errors detected in the previous interval are inserted. This number has 9 legal values, namely 0 to 8 errors. In the receive direction, a legal G1 byte value is added to the path FEBE event counter. In addition, the path remote defect indication is detected.
- H4:** The cell offset indicator byte indicates the offset in bytes between itself, and the first cell boundary following the H4 byte. This byte is inserted correctly in the transmit direction, and is ignored in the receive direction.

## **9.2 Cell Data Structure**

ATM cells may be passed to/from the S/UNI-ULTRA using a 9 bit data structure, consisting of a start of cell indication and an 8-bit wide word. The data structure is shown in Figure 10.

**Figure 10 - Data Structure**



Fifty-three 8-bit words are contained in this data structure. Bit 7 of each word is the most significant bit (which corresponds to the first bit transmitted or received). The header check sequence octet (HCS) is passed through this structure. The start of cell indication input and output (TSOC and RSOC) are coincident with Word 1 (containing the first cell header octet). Word 5 of this structure contains the HCS octet.

In the receive direction, cells containing uncorrectable header errors are dropped while the HCSPASS bit in the RACP Control/Status Register is set to logic zero. No header status information is passed within this data structure; error free headers, and "corrected" headers are passed while HCSPASS is a logic zero. Error free headers, "corrected" headers, and headers containing uncorrectable errors are passed while HCSPASS is a logic one.

In the transmit direction, the HCS bit in the TACP Control Register determines whether the HCS is calculated internally, or is inserted directly from Word 5.



### **9.3 Parallel Output Port and LED Display Controller Operation**

The Parallel Output Port and LED Display Controller is configured by programming the POPC Block registers, located at addresses 0x68, 0x69 and 0x6A.

#### **9.3.1 Direct Control Parallel Output Port**

The POPC direct control parallel output port mode allows to directly control the two bit output port OUT[1:0]. This mode can be used to control external PMD devices.

The direct control output port mode is activated by setting both TRAFFIC and ALARM POPC Configuration Register bits to logic 0. The value of register bits PDAT[1:0] is directly assigned to outputs OUT[1:0]. The TOGGLE[1:0] register bits are affecting the behavior and OUT[1:0]. When the TOGGLE bit is set to logic 0, the PDAT bit is assigned as is. When the TOGGLE bit is set to logic 1, the OUT output toggles at the programmed rate and PDAT act as an enable.

#### **9.3.2 Alarm Monitor**

The alarm monitoring mode allows to directly command an external alarm display. The LED can be turned on and off, or toggled at a programmable rate. In this mode, the OUT[1] output is used for alarm monitoring and the OUT[0] output remains a direct control output port.

The alarm monitoring mode is activated by setting the TRAFFIC and ALARM POPC Configuration Register bits to logic 0 and logic 1, respectively. OUT[1:0] operates as described above for the Direct Control Parallel Output Port mode, except that OUT[1] is enabled by the internal receive alarm indicator instead of the PDAT[1] register bit.

#### **9.3.3 Traffic Monitor**

The traffic monitoring mode allows to visually monitor ATM cells transmit and receive events. It is intended to be used with an external LED display and provides a quick and easy monitoring capability to a system operator.

The traffic monitoring mode is activated by setting the POPC Configuration Register bits as follows: TRAFFIC to logic 1, ALARM to logic 0 and TOGGLE[1:0] to logic 0b11. PDAT[1:0] is unused. When a successful ATM cell transmit or receive event occurs the OUT[1] or OUT[0] outputs, respectively, produces a fixed length 100 ms pulse, which is long enough to be visible to the human eye.

## **9.4 Loopback Operation**

The S/UNI-ULTRA supports four loopback functions: twisted-pair loopback, line loopback, parallel diagnostic loopback and serial diagnostic loopback. Loopback modes are activated by bits contained in the S/UNI-ULTRA Master Control Register, and are provided to ease system design.

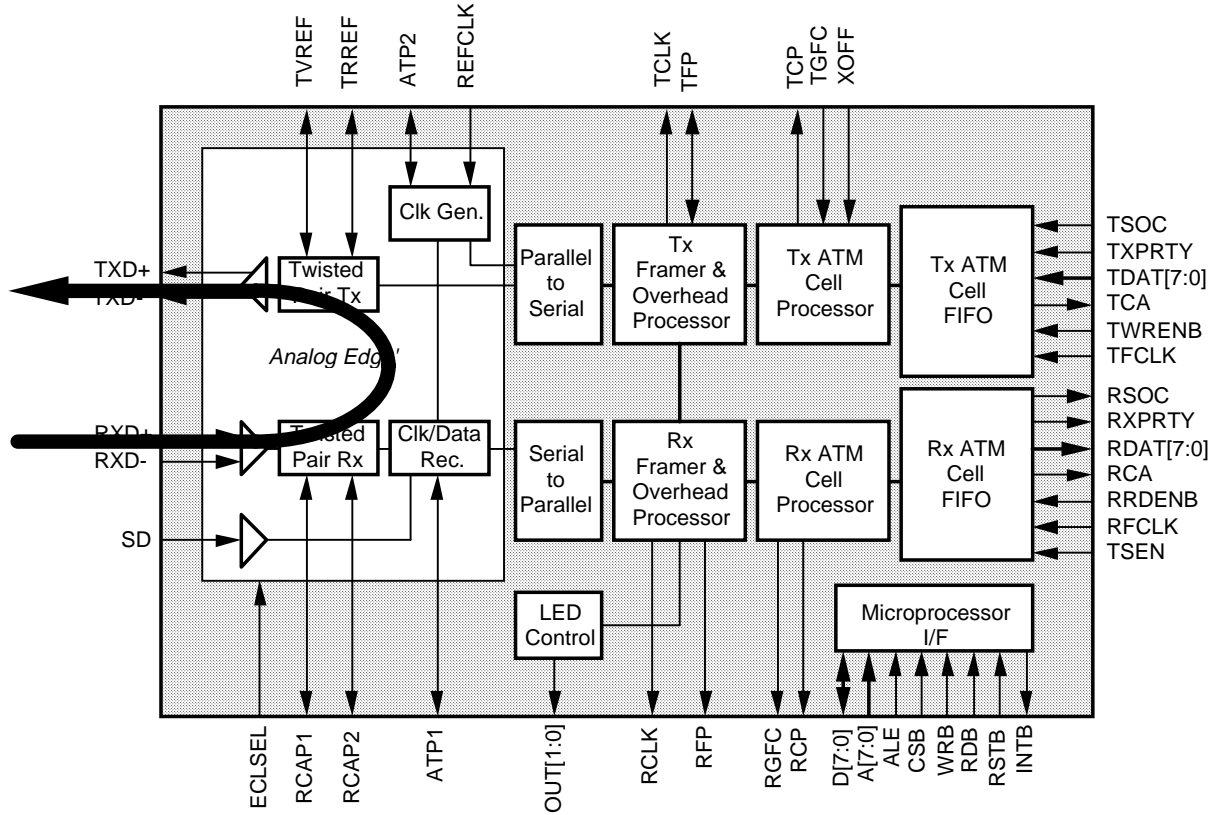
The twisted-pair loopback connects the high speed receive data to the high speed transmit data as shown by the block diagram in Figure 11, and can be used for line side investigations (does not include clock recovery and clock synthesis). While in this mode, the entire receive path is operating normally and cells can be received through the FIFO interface.

The line loopback connects the high speed receive data and clock to the high speed transmit data and clock as shown by the block diagram in Figure 12, and can be used for line side investigations (including clock recovery and clock synthesis). While in this mode, the entire receive path is operating normally and cells can be received through the FIFO interface.

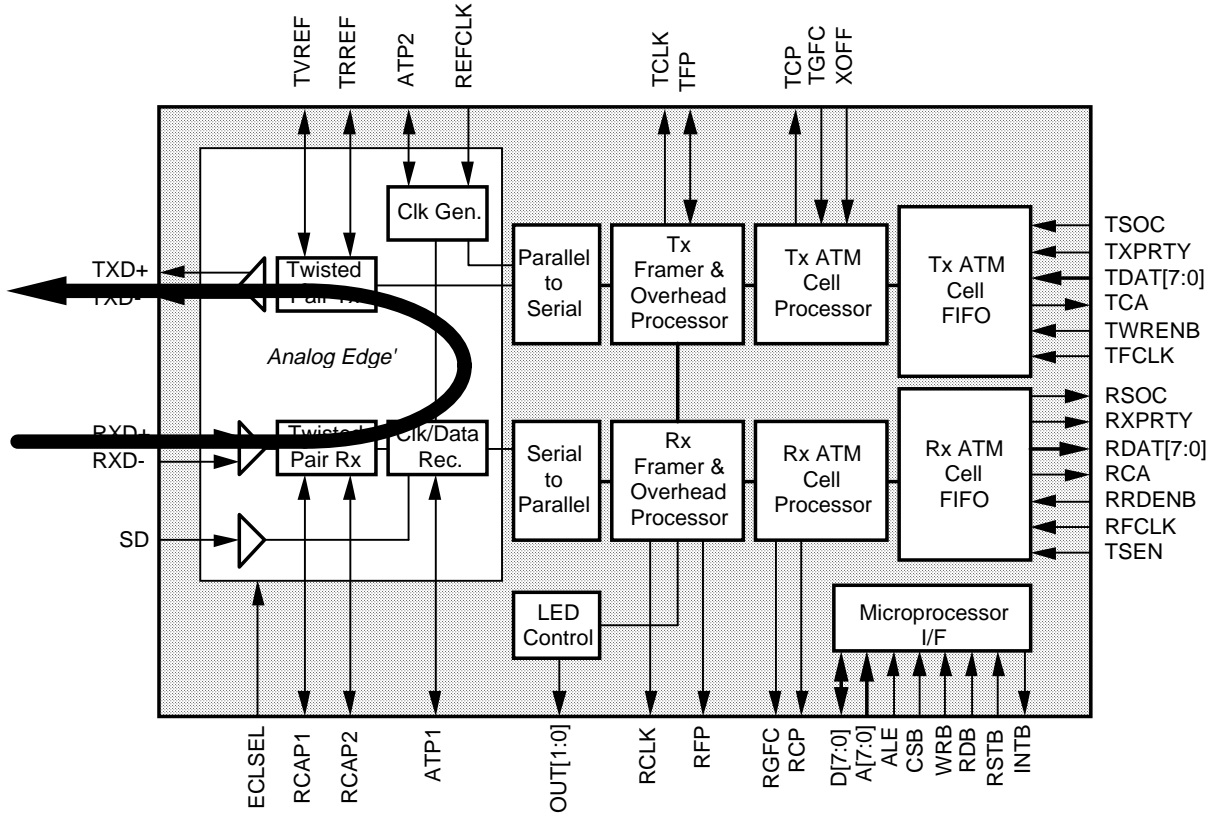
The serial diagnostic loopback connects the high speed transmit data and clock to the high speed receive data and clock as shown by the block diagram in Figure 13. While in this mode, the entire transmit path is operating normally and data is transmitted on the TXD+/- outputs.

The parallel diagnostic loopback connects the byte wide transmit data and clock to the byte wide receive data and clock as also shown by the block diagram in Figure 14. While in this mode, the entire transmit path is operating normally and data is transmitted on the TXD+/- outputs.

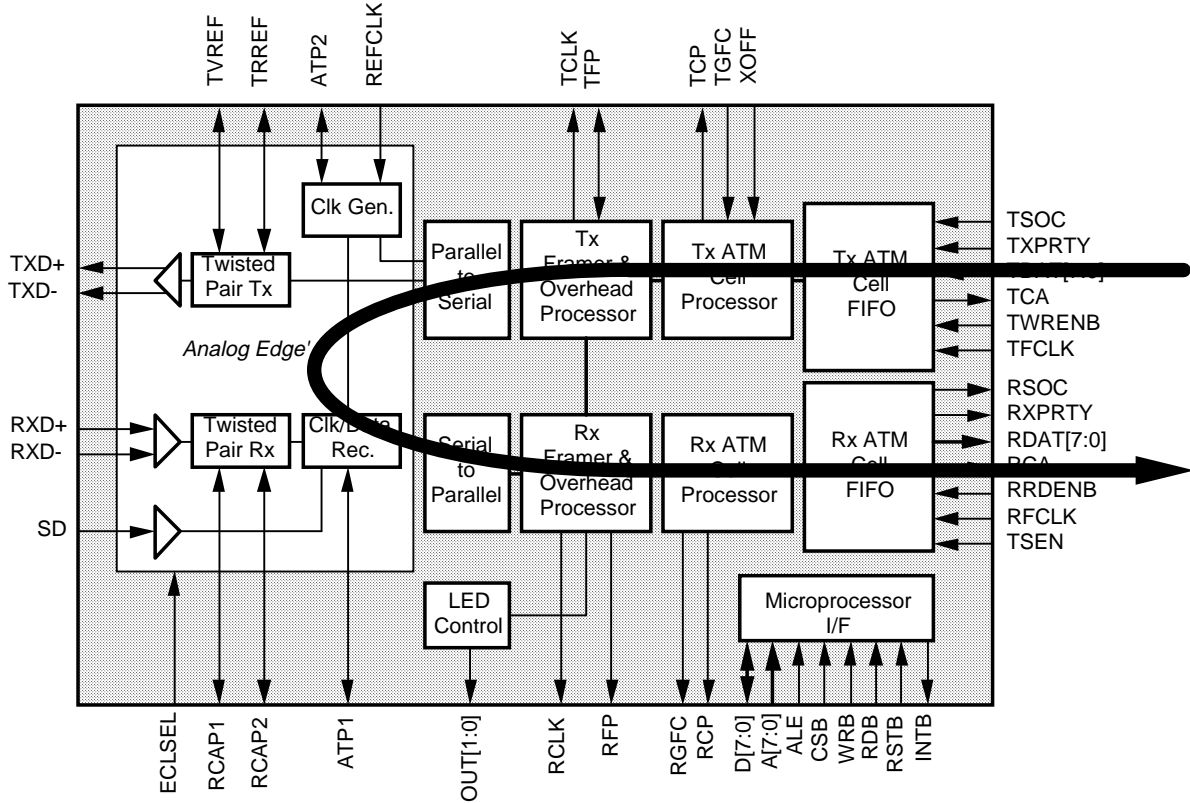
**Figure 11 - Twisted-pair Loopback Operation**



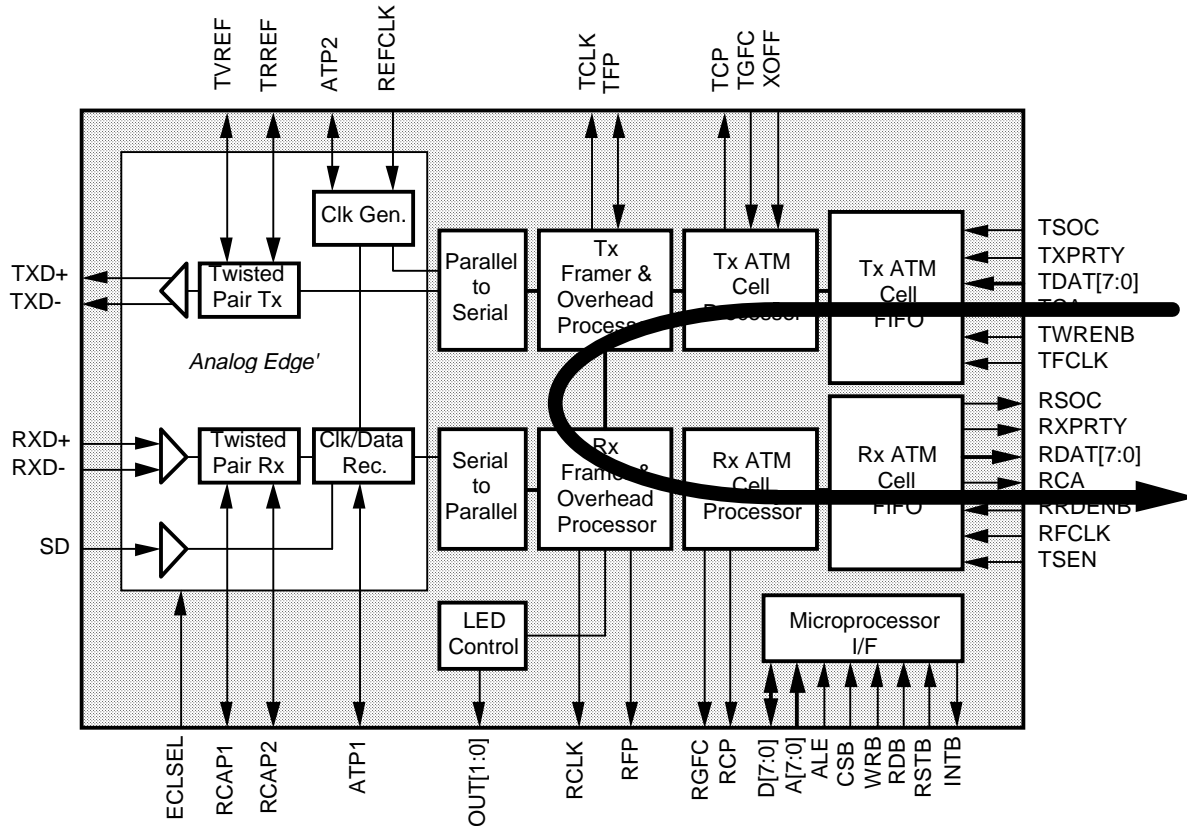
**Figure 12 - Line Loopback Operation**



**Figure 13 - Serial Diagnostic Loopback Operation**



**Figure 14 - Parallel Diagnostic Loopback Operation**



### 9.5 Board Design Recommendations

The noise environment and signal integrity are often the limiting factors in system performance. Therefore, the following board design guidelines *must* be followed in order to ensure proper operation:

1. Use a single plane for both digital and analog grounds.
2. Provide separate +5 volt analog transmit, +5 volt analog receive, and +5 volt digital supplies, but otherwise connect the supply voltages together at one point close to the connector where +5 volts is brought to the card.
3. Ferrite beads are not advisable in digital switching circuits because inductive spiking (di/dt noise) is introduced into the power rail. Simple RC filtering is probably the best approach provided care is taken to ensure the IR drop in the resistance does not lower the supply voltage below the recommended operating voltage.

4. Ferrite beads are recommended for TAVD1, TAVD2, TAVD3, TAVD4, RAVD1, RAVD2, RAVD3 and QAVD.
5. Separate high-frequency decoupling capacitors are recommended for each analog power (TAVD1, TAVD2, TAVD3, TAVD4, RAVD1, RAVD2, RAVD3 and QAVD) pin as close to the package pin as possible. Separate decoupling is required to prevent the transmitter from coupling noise into the receiver and to prevent transients from coupling into some reference circuitry.
6. The high speed serial streams (TXD+/- and RXD+/-) must be routed with controlled impedance circuit board traces and must be terminated with a matched load. Normal TTL-type design rules are not recommended and will reduce the performance of the device.

## **9.6 Power Supplies Sequencing**

Due to ESD protection structures in the pads it is necessary to exercise caution when powering a device up or down. ESD protection devices behave as diodes between power supply pins and from I/O pins to power supply pins. Under extreme conditions it is possible to blow these ESD protection devices or trigger latch up. The recommended power supply sequencing follows:

1. VDDI power must be supplied either before VDDO or simultaneously with VDDO to prevent current flow through the ESD protection devices which exist between VDDI and VDDO power supplies. Connection to a common VDD power plane is the recommended standard practice for customer applications.
2. To prevent damage to the ESD protection on the device inputs the maximum DC input current specification must be respected. This is accomplished by either ensuring that the VDDI power is applied before input pins are driven or by increasing the source impedance of the driver so that the maximum driver short circuit current is less than the maximum DC input current specification. (20 mA)
3. QAVD power must be supplied either after VDDI or simultaneously with VDDI to prevent current flow through the ESD protection devices which exist between QAVD and VDDI power supplies. To prevent forward biasing the ESD protection diode between QAVD supplies and VDDI the differential voltage measured between these power supplies must be less than 0.5 volt. This recommended differential voltage is to include peak to peak noise on the VDDI power supply as digital noise will otherwise be coupled into the analog circuitry. Current limiting can be accomplished by using an off chip three terminal voltage regulator supplied by a quiet high voltage supply.

4. Analog power supplies (AVD, includes RAVDs, TAVDs but not QAVD) must be applied after all QAVD, VDDI and VDDO have been applied or they must be current limited to the maximum latchup current specification. (100 mA). To prevent forward biasing the ESD protection diode between AVD supplies and QAVD the differential voltage measured between these power supplies must be less than 0.5 volt. This recommended differential voltage is to include peak to peak noise on the QAVD and AVD power supplies as digital noise will otherwise be coupled into the analog circuitry. Current limiting can be accomplished by using an off chip three terminal voltage regulator supplied by a quiet high voltage supply. If the VDD power supply is relatively quiet, VDD can be filtered using a ferrite bead and a high frequency decoupling capacitor to supply AVD. The relative power sequencing of the multiple AVD power supplies is not important.
5. Power down the device in the reverse sequence. Use the above current limiting technique for the analog power supplies. Small offsets in VDD / AVD discharge times will not damage the device.

### **9.7 Selecting Between Twisted-Pair and PECL Interfaces**

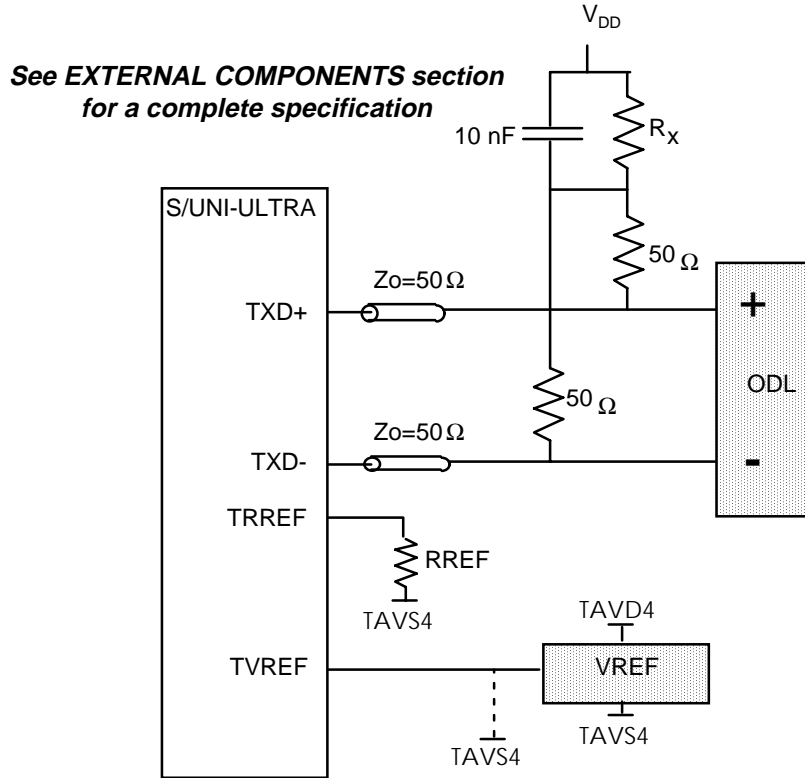
Although intended to be used with UTP-5 cables, the S/UNI-ULTRA can also be configured to interface with PECL devices. When set to logic 0, the PECLSEL input selects the Twisted-Pair mode interface. When set to logic 1, the PECLSEL input selects the PECL mode interface. No special register programming is required.

### **9.8 Interfacing Transmit and Receive Data Lines with PECL Devices**

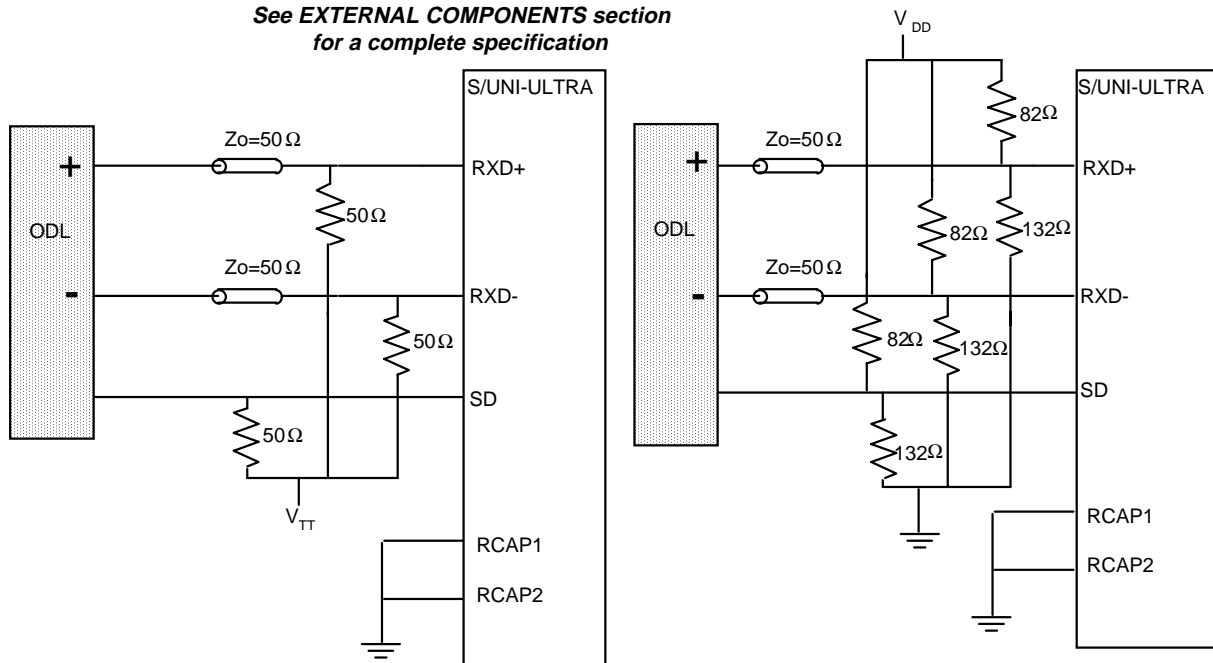
The S/UNI-ULTRA is capable of interfacing with PECL devices. In this type of application some external components are required to ensure proper operation of the device. Figure 15 and Figure 16 illustrate the recommended circuits.



**Figure 15 - Interfacing TXD+/- to PECL**



**Figure 16 - Interfacing with RXD+/- using PECL (2 examples)**



The TXD+/- is a true differential PECL output and thus only requires proper line termination. The termination resistor  $R_X$  should have a nominal value of

$$R_X = \frac{(AVD - V_{POH}) \times Z_0}{V_{POH} - V_{POL}} \cong 63.4\ \Omega$$

The reference resistor  $R_{REF}$  should be 1.30K $\Omega$  when either the internal reference voltage is used or when an external bandgap reference voltage is used. The external bandgap reference voltage  $V_{REF}$ , if used, must be 1.23V, and referenced to TAVD4 and TAVS4. If unused, the TVREF pin should be tied to TAVS4. Refer to the EXTERNAL COMPONENTS section for a more detailed PECL mode specification of  $R_X$ ,  $R_{REF}$  and  $V_{REF}$ . The internal reference voltage exceeds  $\pm 3\%$  tolerance over process, temperature and supply, and is more than sufficient to meet the tight amplitude tolerances required.

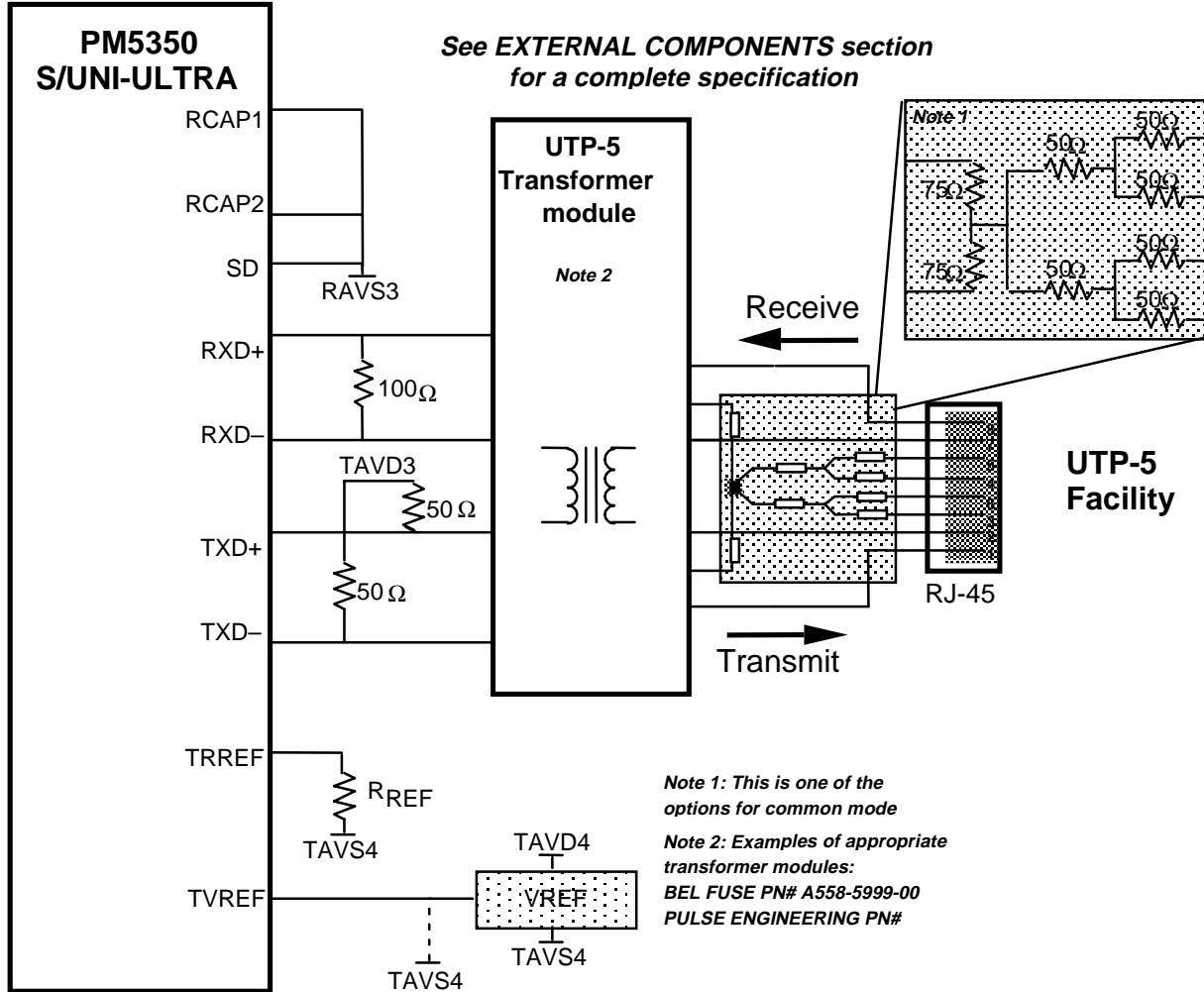
Two methods to terminate the RXD+/- PECL differential inputs are illustrated, one using a bias voltage source  $V_{TT}$  and the other a  $Z_0 = 50\ \Omega$  Thevenin equivalent circuit. The choice of the method to be used will primarily depend on the availability of a bias voltage source  $V_{TT}$ . If used,  $V_{TT}$  must be well decoupled

to the common ground plane. It is important that the SD termination be identical to the RXD+ and RXD- termination.

### **9.9 Interfacing Transmit and Receive Data Lines with UTP-5 Cable**

The S/UNI-ULTRA will directly interface to signal transformers for transmission over UTP Category 5 cable and is designed to meet the ATM Forum 155 Mbit/s Physical Media Dependent (PMD) Twisted Pair Copper Specification. A minimal set of external components is required at both transmit and receive ends. However, many issues must be handled carefully in order to insure proper operation. Figure 17 shows a typical UTP-5 application circuit. An example of common mode termination is provided but other designs may provide improved performance. The reference resistor  $R_{REF}$  should  $1.0K\Omega$  when the internal reference voltage is used and  $976\Omega$  when an external bandgap reference voltage is used, assuming no insertion loss. The external bandgap reference voltage  $V_{REF}$ , if used, must be 1.23V, and referenced to TAVD4 and TAVS4. If unused, the TVREF pin should be tied to TAVS4. Refer to the EXTERNAL COMPONENTS section for a more detailed UTP-5 mode specification of  $R_{REF}$  and  $V_{REF}$ .

**Figure 17 - Interfacing TXD+/- and RXD+/- with UTP-5**

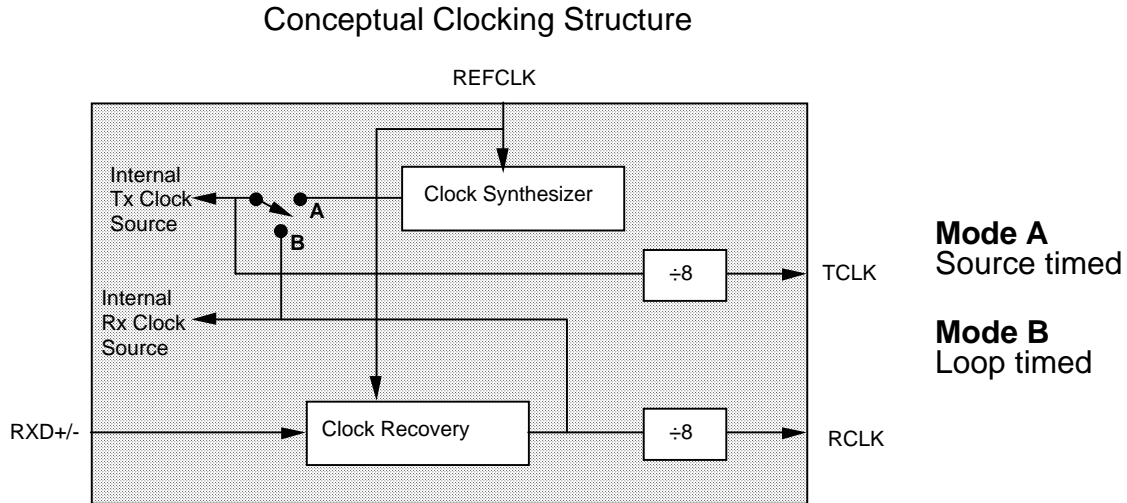


The above is a basic operation description and more details on interfacing the S/UNI-ULTRA with UTP-5 cable will be provided in a dedicated PMC-Sierra application note.

### 9.10 Clocking Options

The S/UNI-ULTRA supports several clocking modes. Figure 18 is an abstraction of the clocking topology.

**Figure 18 - Conceptual Clocking Structure**



Mode A is provided for all public user network interfaces (UNIs) and for private UNIs and private network node interfaces (NNIs) that are not synchronized to the recovered clock.

The transmit clock in a private UNI or a private NNI may be locked to an external reference or may free-run. The simplest implementation requires an oscillator free-running at 19.44 MHz.

Mode A is selected by clearing the LOOPT bit of the Master Control register. REFCLK is multiplied by 8 (STS-3) or 8/3 (STS-1) to become the 155.52 MHz or 51.84 MHz transmit clock. REFCLK must be jitter free. The source REFCLK is also internally used as the clock recovery reference.

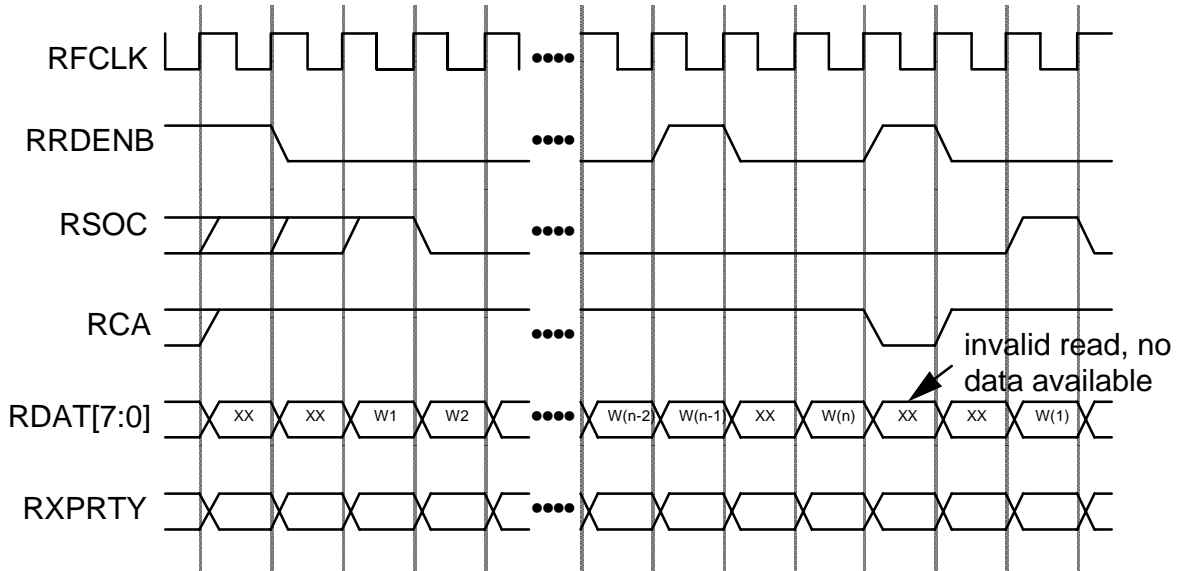
Mode B is provided for private UNIs and private NNIs that require synchronization to the recovered clock.

Mode B is selected by setting the LOOPT bit of the Master Control register. Normally, the transmit clock is locked to the receive data. In the event of a loss of signal condition, the transmit clock is synthesized from REFCLK.

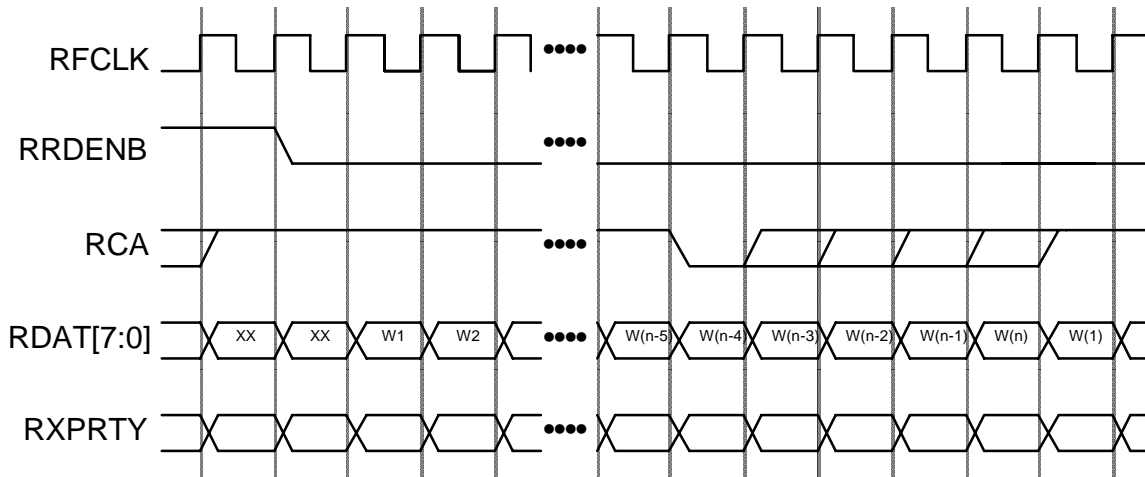
## FunctionAL TIMING

### 9.11 Drop Side Receive Interface

**Figure 19 - Receive FIFO Empty Option (RCALEVEL0=1)**



**Figure 20 - Receive FIFO Near Empty Option (RCALEVEL0=0)**



The S/UNI-ULTRA indicates that a cell is available by asserting the receive cell available signal, RCA. RCA remains high until the internal FIFO is near empty or

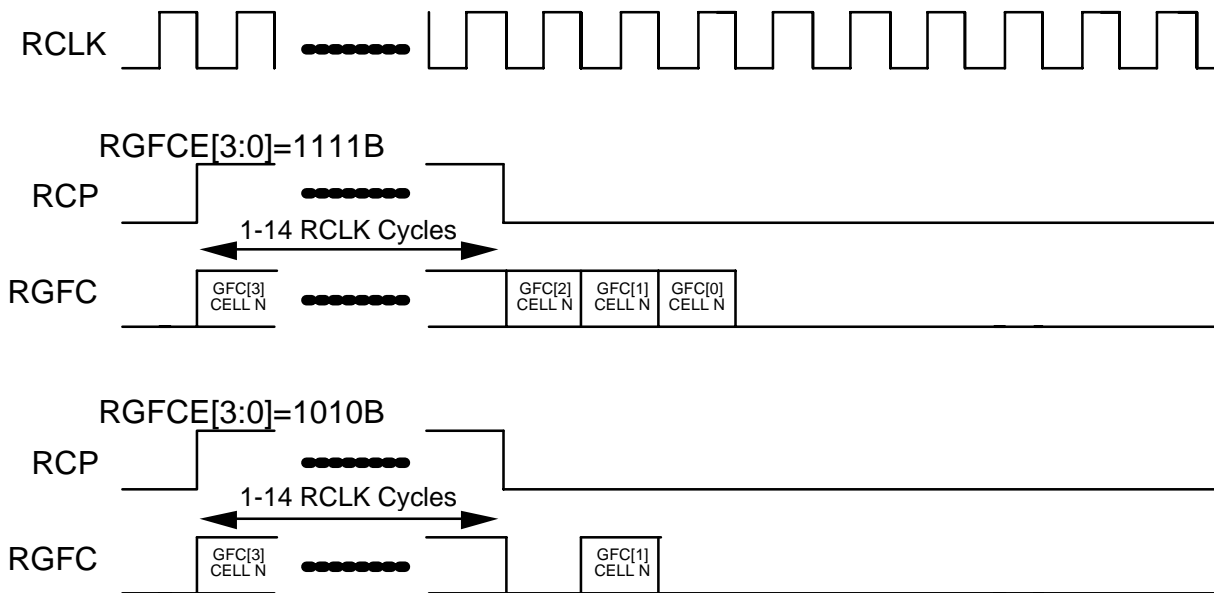
empty. Near empty implies that the ATM Layer device can initiate at most four additional reads. The ATM Layer device indicates, by asserting the RRDENB signal, that the data on the RDAT[7:0] bus during the next RFCLK cycle will be read from the S/UNI-ULTRA.

Figure 19 illustrates the Receive FIFO empty option. RCA transitions low when the last word of the last cell is available on the RDAT[7:0] bus. The RDAT[7:0] bus, RXPRTY and RSOC are valid in cycles for which RCA is high and RRDENB was low in the previous cycle. If the ATM Layer device requests a read while RCA is deasserted, the PHY layer device will ignore the additional reads.

Figure 20 illustrates the Receive FIFO near empty option. RCA transitions low four words before the last word of the last cell is read from the S/UNI-ULTRA. RCA remains low for a minimum of one RFCLK clock cycle and then can transition high to indicate that there are additional cells available from the PHY layer device.

Once RCA is deasserted and has been sampled, the ATM Layer device can issue no more than four reads. If the ATM Layer device issues more reads than the allowable number, and RCA remains deasserted throughout, the PHY layer device will ignore the additional reads.

**Figure 21 - Receive GFC Serial Link**

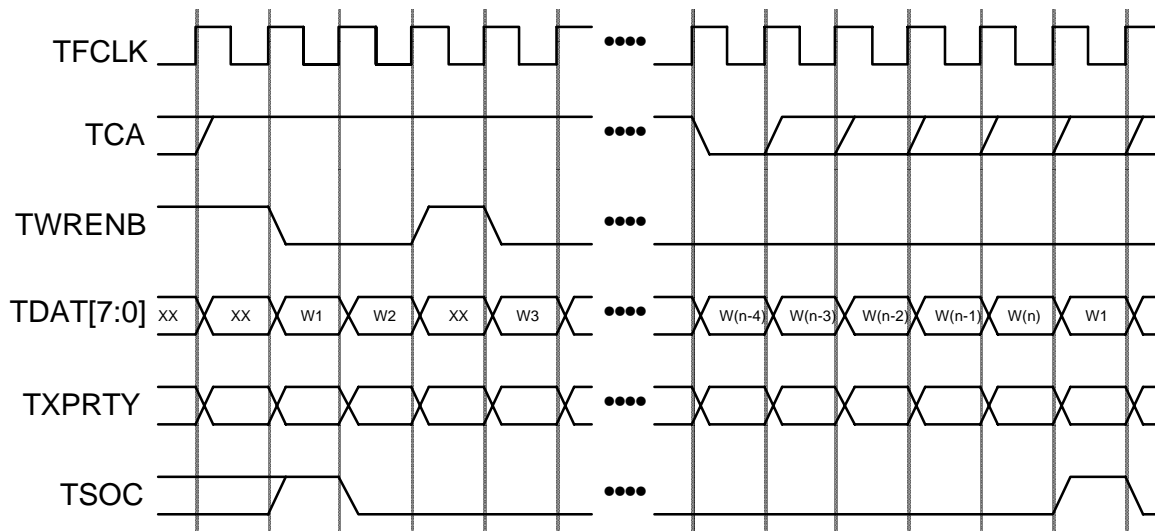


The Receive GFC Serial Link Diagram (Figure 21) illustrates the operation of the receive generic flow control, RGFC, and receive GFC control pulse, RCP,

outputs. The first RGFC bit position, which is coincident with the RCP being high, contains the first GFC bit received and corresponds to the first bit of the cell. The RCP pulse width varies between 1 and 14 RCLK cycles depending on the alignment of the ATM cell and the SONET/SDH transport and path overheads. Extraction of the GFC[3:0] bits is controlled by the four RGFC enable (RGFCE[3:0]) bits in the RACP Configuration register. The output value in each GFC bit position can be forced low by setting the corresponding RGFCE bit to zero. The serial link is inactive (forced low) if the S/UNI-ULTRA is out of cell delineation or if the current cell contains an uncorrectable header.

### 9.12 Drop Side Transmit Interface

**Figure 22 - Transmit FIFO**



As shown in Figure 22, the S/UNI-ULTRA indicates that there is space available for a full cell in its internal FIFO by asserting the transmit cell available signal, TCA. TCA remains asserted until the transmit FIFO is almost full. Almost full implies that the S/UNI-ULTRA can accept at most an additional four writes after the current write.

If TCA is asserted and the ATM Layer device is ready to write a byte, it should assert TWRENB low and present the byte on the TDAT[7:0] bus. If the presented byte is the first byte of a cell, the ATM Layer device should also assert signal TSOC. At any time, if the ATM Layer device does not have a byte to write, it can deassert TWRENB.



When TCA is deasserted and it has been sampled, the ATM Layer device can write no more than four bytes to the PHY layer device. If the ATM Layer writes more than four bytes and TCA remains deasserted throughout, the S/UNI-ULTRA will indicate an error condition and ignore additional writes until it asserts TCA again.

**Figure 23 - Transmit GFC Serial Link**

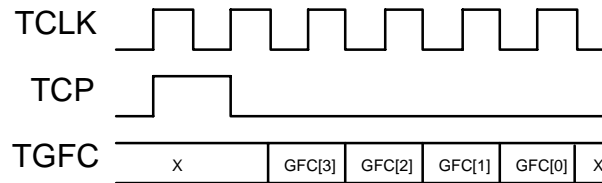


Figure 23 illustrates the transmit GFC serial link which provides the ability to insert flow control information downstream of the transmit FIFO. The TCP output pulses high once per transmitted cell to initiate the transfer on the GFC bits. GFC[3] is the most significant bit and is transmitted first. The TACP Configuration register controls the insertion of each serial bit. If the insertion is disabled, the default GFC value is inserted. For unassigned cells, the default is the contents of the TACP Idle/Unassigned Cell Header Pattern register. For assigned cells, the default is the value received from TDAT[7:0].

## **10 ABSOLUTE MAXIMUM RATINGS**

Maximum ratings are the worst case limits that the device can withstand without sustaining permanent damage. They are not indicative of normal mode operation conditions.

Ambient Temperature under Bias	0°C to +70°C
Storage Temperature	-40°C to +125°C
Supply Voltage	-0.5V to +6.0V
Voltage on Any Pin	-0.5V to $V_{DD}+0.5V$
Static Discharge Voltage	±1000 V
Latch-Up Current	±100 mA
DC Input Current	±20 mA
Lead Temperature	+300°C
Junction Temperature	+150°C

## 11 D.C. CHARACTERISTICS

$T_A = 0^{\circ}\text{C}$  to  $+70^{\circ}\text{C}$ ,  $V_{DD} = 5\text{ V} \pm 10\%$

(Typical Conditions:  $T_A = 25^{\circ}\text{C}$ ,  $V_{DD} = 5\text{ V}$ )

Symbol	Parameter	Min	Typ	Max	Units	Conditions
$V_{IL}$	Input Low Voltage (TTL Only)	-0.5		0.8	Volts	Guaranteed Input LOW Voltage
$V_{IH}$	Input High Voltage (TTL Only)	2.0		$V_{DD} + 0.5$	Volts	Guaranteed Input HIGH Voltage
$V_{PIL}$	Input Low Voltage (RXD+/-, SD PECL mode only)	AVD -1.81		AVD -1.48	Volts	Guaranteed PECL Input LOW Voltage referenced to RAVD3. Note 6.
$V_{PIH}$	Input High Voltage (RXD+/-, SD PECL mode only)	AVD -1.17		AVD -0.88	Volts	Guaranteed PECL Input HIGH Voltage referenced to RAVD3. Note 6.
$V_{POH}$	Output High Voltage (TXD+/-, PECL mode only)	AVD -1.00	AVD -0.95	AVD -0.90	Volts	Output high voltage assuming PECL application as illustrated in figure 15.
$V_{POL}$	Output Low Voltage (TXD+/-, PECL mode only)	AVD -1.80	AVD -1.70	AVD -1.60	Volts	Output swing assuming PECL application as illustrated in figure 15.

Symbol	Parameter	Min	Typ	Max	Units	Conditions
$V_{TPOCM}$	Output Common Mode Voltage (TXD+/-, twisted-pair mode only)		AVD - 0.5	AVD - 0.231	Volts	Output common mode voltage assuming Twisted-Pair application as illustrated in figure 17.
$V_{TPOSWING}$	Output Swing (TXD+/-, twisted-pair mode only)	0.475	0.500	0.525	Volts	Output swing (single-ended) assuming Twisted-Pair application as illustrated in figure 17. Note 7.
$V_{OL}$	Output or Bidirectional Low Voltage		0.1	0.4	Volts	$V_{DD} = \text{min}$ , $I_{OL} = -4$ mA for RDAT[7:0], RXPRTY, RCP, RGFC, RSOC, RCA, TCA, TCP, TCLK, and RCLK, and -2 mA for all others, Note 3
$V_{OH}$	Output or Bidirectional High Voltage	2.4	4.7		Volts	$V_{DD} = \text{min}$ , $I_{OH} = 4$ mA for RDAT[7:0], RXPRTY, RCP, RGFC, RSOC, RCA, TCA, TCP, TCLK, and RCLK, and 2 mA for all others, Note 3
$V_{T+}$	Input High Voltage (TTL Schmitt Trigger inputs only)	3.5			Volts	RSTB and CSB inputs.
$V_{T-}$	Input Low Voltage (TTL Schmitt Trigger inputs only)			0.8	Volts	RSTB and CSB inputs.

Symbol	Parameter	Min	Typ	Max	Units	Conditions
$V_{TH}$	Schmitt Trigger Input Hysteresis Voltage		1.0		Volts	RSTB and CSB inputs.
$I_{ILPU}$	Input Low Current	30		300	$\mu A$	$V_{IL} = GND$ , Notes 1, 3
$I_{IHPU}$	Input High Current	-10		+10	$\mu A$	$V_{IH} = V_{DD}$ , Notes 1, 3
$I_{IL}$	Input Low Current	-10		+10	$\mu A$	$V_{IL} = GND$ , Notes 2, 3
$I_{IH}$	Input High Current	-10		+10	$\mu A$	$V_{IH} = V_{DD}$ , Notes 2, 3
$C_{IN}$	Input Capacitance		5		pF	Excluding Package, Package Typically 2 pF
$C_{OUT}$	Output Capacitance		5		pF	Excluding Package, Package Typically 2 pF
$C_{IO}$	Bidirectional Capacitance		5		pF	Excluding Package, Package Typically 2 pF

Symbol	Parameter	Min	Typ	Max	Units	Conditions
POP	Operating Power Consumption Processing Cells (digital + analog circuitry)		0.92	1.54	W	Outputs Loaded, UTP-5 mode, TXD+/- = RXD+/- =155.52 Mbit/s, PECL mode TXD+/- = RXD+/- =155.52 Mbit/s
			0.74	1.16	W	
			0.80	1.41	W	Outputs Unloaded, UTP-5 mode, TXD+/- = RXD+/- =155.52 Mbit/s, PECL mode TXD+/- = RXD+/- =155.52 Mbit/s
			0.62	1.03	W	
			180	280	mA	Outputs Loaded, UTP-5 mode, TXD+/- = RXD+/- =155.52 Mbit/s, PECL mode TXD+/- = RXD+/- =155.52 Mbit/s
			150	210	mA	
IDDOP	Operating Current Processing Cells (digital + analog circuitry)		160	260	mA	Outputs Unloaded, UTP-5 mode, TXD+/- = RXD+/- =155.52 Mbit/s, PECL mode TXD+/- = RXD+/- =155.52 Mbit/s
			120	190	mA	

**Notes on D.C. Characteristics:**

1. Input pin or bidirectional pin with internal pull-up resistor.
2. Input pin or bidirectional pin without internal pull-up resistor

3. Negative currents flow into the device (sinking), positive currents flow out of the device (sourcing).
4. Input pin or bidirectional pin with internal pull-down resistor.
5. Typical values are not production tested.
6. When operating the device in PECL mode, the  $V_{CM}$  (common-mode voltage) of the SD input must match the  $V_{CM}$  of the RXD+/- differential inputs. The RXD+/- inputs are truly differential. Their common mode voltage is extracted and used as the reference voltage for the SD single ended PECL input.
7. The given value is the single ended output swing. This number must be doubled to obtain the differential output swing.

**12 EXTERNAL COMPONENTS**

Symbol	Parameter	Min	Typ	Max	Units	Specification
VREF	External Reference Voltage (PECL mode only)		1.23		Volts	+/- 3%
RREF	Reference Resistor, using Internal Reference Voltage (PECL mode only)		1.30		KΩ	+/- 1%, 1/8 W
RREF	Reference Resistor, using External Reference Voltage (PECL mode only)		1.30		KΩ	+/- 1%, 1/8 W
VREF	External Reference Voltage (Twisted-Pair mode only)		1.23		Volts	+/- 3%
RREF	Reference Resistor, using Internal Reference Voltage (Twisted-Pair mode only)		100 0 976 953 931		Ω Ω Ω Ω	+/- 1%, 1/8 W , Note 3 Insertion Loss: 0.0 – 0.1 dB 0.2 – 0.3 dB 0.4 – 0.5 dB 0.6 – 0.7 dB
RREF	Reference Resistor, using External Reference Voltage (Twisted-Pair mode only)		976 953 931 909		Ω Ω Ω Ω	+/- 1%, 1/8 W , Note 3 Insertion Loss: 0.0 – 0.1 dB 0.2 – 0.3 dB 0.4 – 0.5 dB 0.6 – 0.7 dB



Symbol	Parameter	Min	Typ	Max	Units	Specification
R <sub>X</sub>	External Receiver Resistor (PECL mode only)		63.4		Ω	+/- 1%, 1/8 W
R <sub>TERM</sub>	Line Termination Resistors				Ω	+/- 1%, 1/8W Values depend on application
T <sub>MOCL</sub>	Transformer Module Open Circuit Inductance	350			μH	at 100 KHz
T <sub>MRT</sub>	Transformer Module Rise Time		2.5		ns	at 10% – 90%
T <sub>MIL</sub>	Transformer Module Insertion Loss		-1.0		dB	at 100 KHz – 155 MHz
T <sub>MIL</sub>	Transformer Module Return Loss	16 Note 2 10			dB	at 2 MHz – 30 MHz at 30 MHz – 60 MHz at 60 MHz – 100 MHz
T <sub>MCDR</sub>	Transformer Module Common Mode to Differential Mode Rejection	-40			dB	at 100KHz – 155 MHz
T <sub>MDCR</sub>	Transformer Module Differential Mode to Common Mode Rejection	-32			dB	at 100KHz – 155 MHz
T <sub>MCCR</sub>	Transformer Module Common Mode to Common Mode Rejection	-30			dB	at 100KHz – 155 MHz
T <sub>M<sub>RATIO</sub></sub>	Transformer Module Ratio (UTP-5)		1:1			+/- 5%

Symbol	Parameter	Min	Typ	Max	Units	Specification
TMCT	Transformer Module Crosstalk	-35			dB	This applies only to integrated Rx and Tx modules

**Notes on External Components:**

1. The above specification applies only to the recommended applications as described in the Operation section and are designed to optimize the typical performance of the system.
2. The following equation must be used:  $16dB - 20 \times \log(f/30MHz)$ .
3. In Twisted Pair mode of operation, the appropriate RREF value is a function of the transformer insertion loss since the required output amplitude is specified at the AOI. The RREF value is chosen to meet the amplitude tolerance.

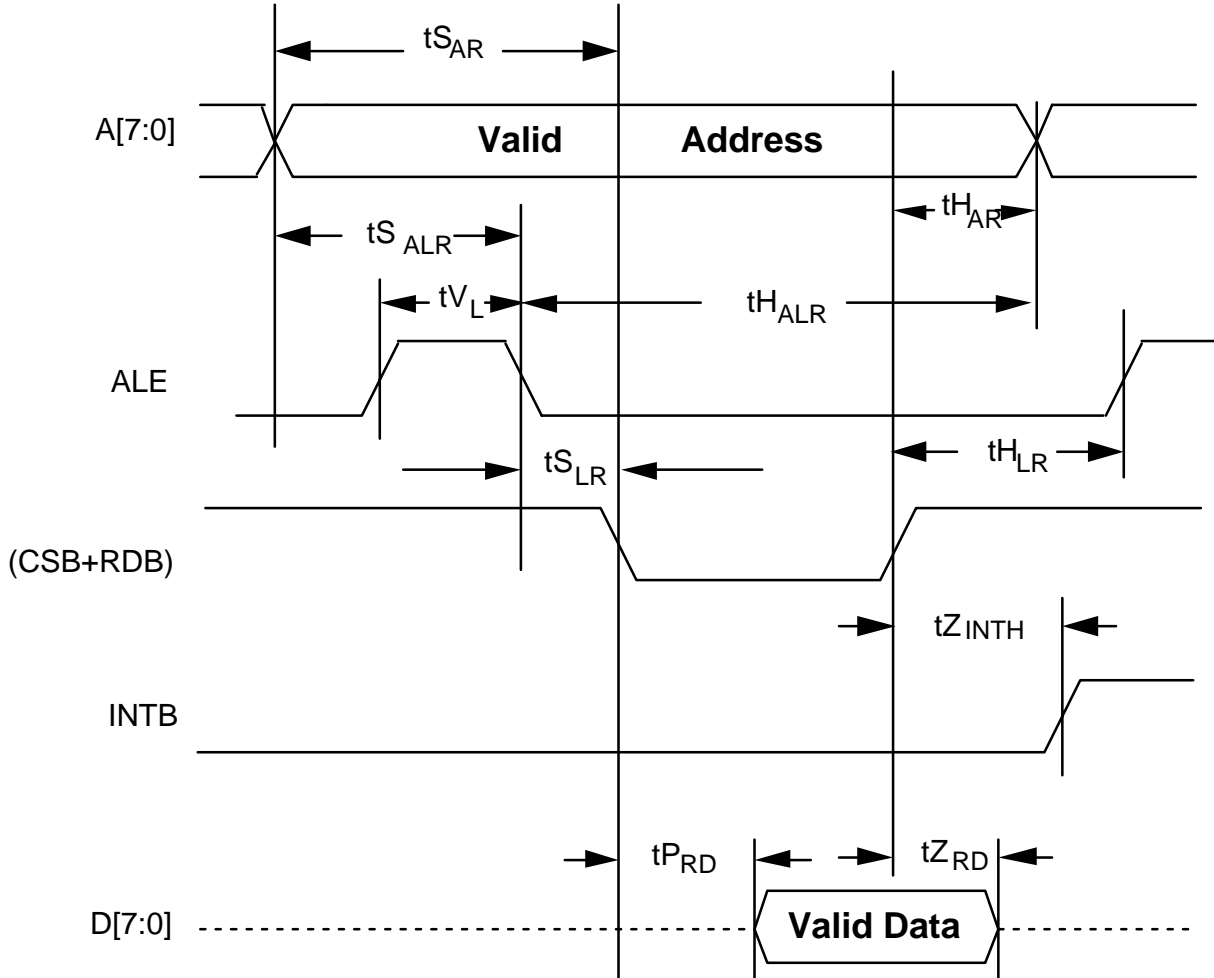
**13 MICROPROCESSOR INTERFACE TIMING CHARACTERISTICS**

( $T_A = 0^\circ\text{C}$  to  $+70^\circ\text{C}$ ,  $V_{DD} = 5\text{ V} \pm 10\%$ )

**Table 1 - Microprocessor Interface Read Access (Figure 24)**

Symbol	Parameter	Min	Max	Units
t <sub>SAR</sub>	Address to Valid Read Set-up Time	25		ns
t <sub>HAR</sub>	Address to Valid Read Hold Time	5		ns
t <sub>SALR</sub>	Address to Latch Set-up Time	20		ns
t <sub>HALR</sub>	Address to Latch Hold Time	10		ns
t <sub>VL</sub>	Valid Latch Pulse Width	20		ns
t <sub>SLR</sub>	Latch to Read Set-up	0		ns
t <sub>HLR</sub>	Latch to Read Hold	5		ns
t <sub>PRD</sub>	Valid Read to Valid Data Propagation Delay		80	ns
t <sub>ZRD</sub>	Valid Read Negated to Data Output Tri-state		20	ns
t <sub>ZINTH</sub>	Valid Read Negated to Interrupt Output Tri-state		50	ns

**Figure 24 - Microprocessor Interface Read Timing**



**Notes on Microprocessor Interface Read Timing:**

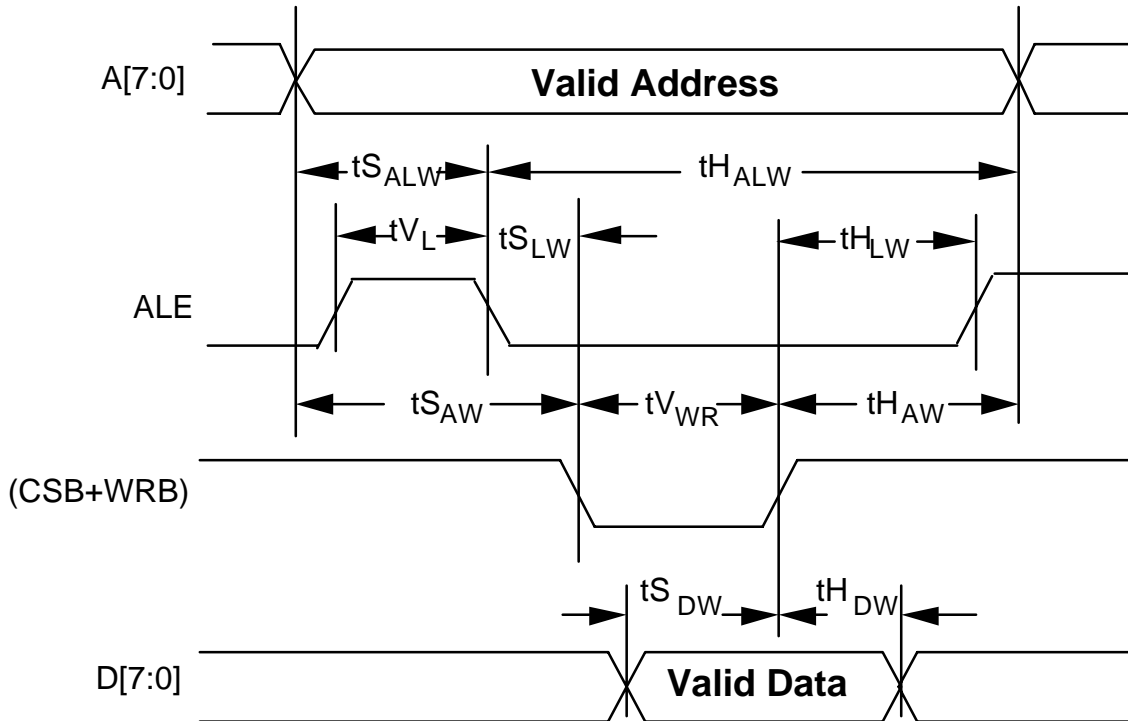
1. Output propagation delay time is the time in nanoseconds from the 1.4 Volt point of the reference signal to the 1.4 Volt point of the output.
2. Maximum output propagation delays are measured with a 100 pF load on the Microprocessor Interface data bus, (D[7:0]).
3. A valid read cycle is defined as a logical OR of the CSB and the RDB signals.
4. Microprocessor Interface timing applies to normal mode register accesses only.

5. In a non-multiplexed address/data bus architecture, ALE should be held high, parameters  $t_{S_{ALR}}$ ,  $t_{H_{ALR}}$ ,  $t_{V_L}$ , and  $t_{S_{LR}}$  are not applicable.
6. Parameters  $t_{H_{AR}}$  and  $t_{S_{AR}}$  are not applicable if address latching is used.
7. When a set-up time is specified between an input and a clock, the set-up time is the time in nanoseconds from the 1.4 Volt point of the input to the 1.4 Volt point of the clock.
8. When a hold time is specified between an input and a clock, the hold time is the time in nanoseconds from the 1.4 Volt point of the input to the 1.4 Volt point of the clock.

**Table 2 - Microprocessor Interface Write Access (Figure 25)**

<b>Symbol</b>	<b>Parameter</b>	<b>Min</b>	<b>Max</b>	<b>Units</b>
$t_{S_{AW}}$	Address to Valid Write Set-up Time	25		ns
$t_{S_{DW}}$	Data to Valid Write Set-up Time	20		ns
$t_{S_{ALW}}$	Address to Latch Set-up Time	20		ns
$t_{H_{ALW}}$	Address to Latch Hold Time	10		ns
$t_{V_L}$	Valid Latch Pulse Width	20		ns
$t_{S_{LW}}$	Latch to Write Set-up	0		ns
$t_{H_{LW}}$	Latch to Write Hold	5		ns
$t_{H_{DW}}$	Data to Valid Write Hold Time	5		ns
$t_{H_{AW}}$	Address to Valid Write Hold Time	5		ns
$t_{V_{WR}}$	Valid Write Pulse Width	40		ns

**Figure 25 - Microprocessor Interface Write Timing**



**Notes on Microprocessor Interface Write Timing:**

1. A valid write cycle is defined as a logical OR of the CSB and the WRB signals.
2. Microprocessor Interface timing applies to normal mode register accesses only.
3. In a non-multiplexed address/data bus architecture, ALE should be held high, parameters  $t_{S_{ALW}}$ ,  $t_{H_{ALW}}$ ,  $t_{V_L}$ , and  $t_{S_{LW}}$  are not applicable.
4. Parameters  $t_{H_{AW}}$  and  $t_{S_{AW}}$  are not applicable if address latching is used.
5. When a set-up time is specified between an input and a clock, the set-up time is the time in nanoseconds from the 1.4 Volt point of the input to the 1.4 Volt point of the clock.
6. When a hold time is specified between an input and a clock, the hold time is the time in nanoseconds from the 1.4 Volt point of the input to the 1.4 Volt point of the clock.

**14 S/UNI-ULTRA TIMING CHARACTERISTICS**

( $T_A = 0^\circ\text{C}$  to  $+70^\circ\text{C}$ ,  $V_{DD} = 5\text{ V} \pm 10\%$ )

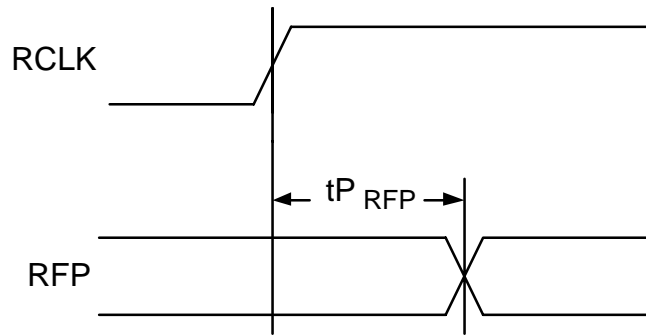
**Table 3 - Line Side Reference Clock**

Symbol	Description	Min	Max	Units
	REFCLK Duty Cycle 19.44	30	70	%
	REFCLK Frequency Tolerance	-50	+50	ppm

**Table 4 - Line Side Receive Interface (Figure 26)**

Symbol	Description	Min	Max	Units
$t_{P_{RFP}}$	RCLK High to RFP Valid	0	10	ns

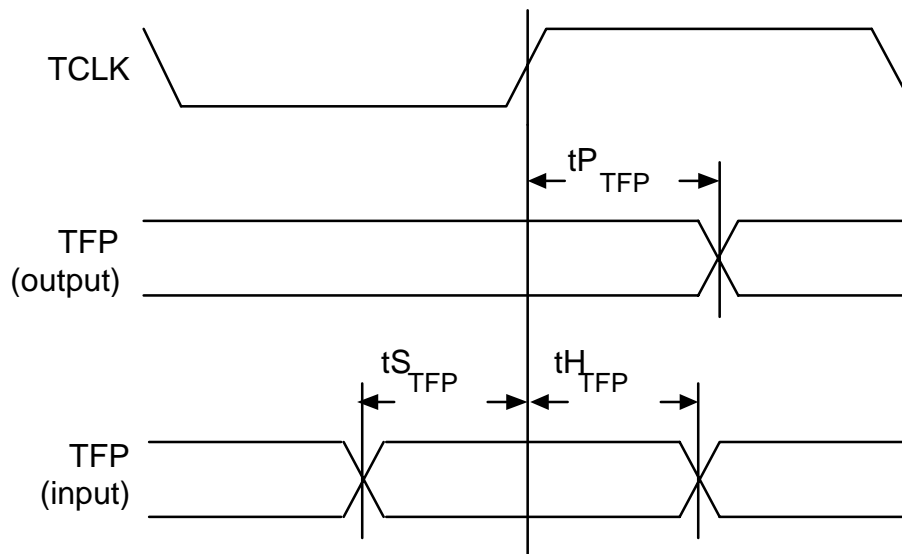
**Figure 26 - Receive Frame Pulse Output Timing**



**Table 5 - Line Side Transmit Interface (Figure 27)**

Symbol	Description	Min	Max	Units
$t_{S_{TFP}}$	TFP to TCLK High Setup (TFP_IN bit is logic 1)	10		ns
$t_{H_{TFP}}$	TCLK High to TFP Hold (TFP_IN bit is logic 1)	10		ns
$t_{P_{TFP}}$	TCLK High to TFP Valid (TFP_IN bit is logic 0)	0	10	ns

**Figure 27 - Line Side Transmit Interface Timing**



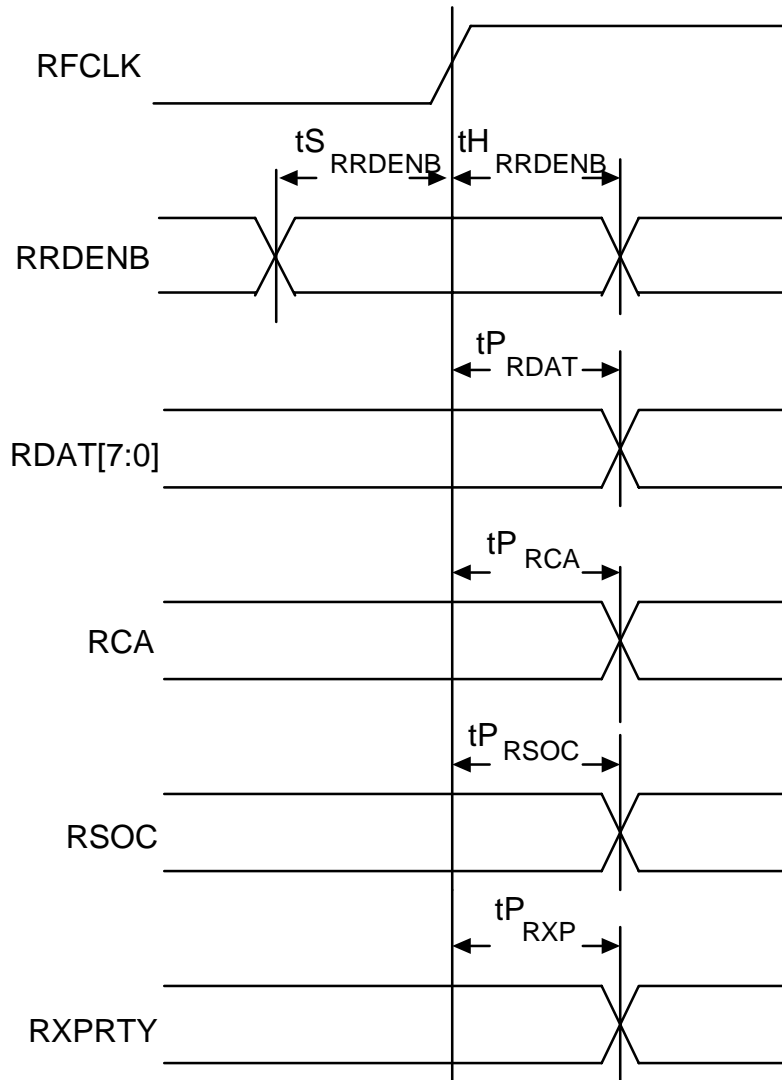
**Table 6 - Drop Side Receive Synchronous Interface (TSEN = 0) (Figure 28)**

Symbol	Description	Min	Max	Units
	RFCLK Frequency		50	MHz
	RFCLK Duty Cycle	40	60	%
$t_{S_{RRDENB}}$	RRDENB to RFCLK High Setup	4		ns
$t_{H_{RRDENB}}$	RFCLK High to RRDENB Hold	1		ns



Symbol	Description	Min	Max	Units
$t_{P_{RDAT}}$	RFCLK High to RDAT[7:0] Valid	2	14	ns
$t_{P_{RXP}}$	RFCLK High to RXPRTY Valid	2	14	ns
$t_{P_{RCA}}$	RFCLK High to RCA Valid	2	14	ns
$t_{P_{RSOC}}$	RFCLK High to RSOC Valid	2	14	ns

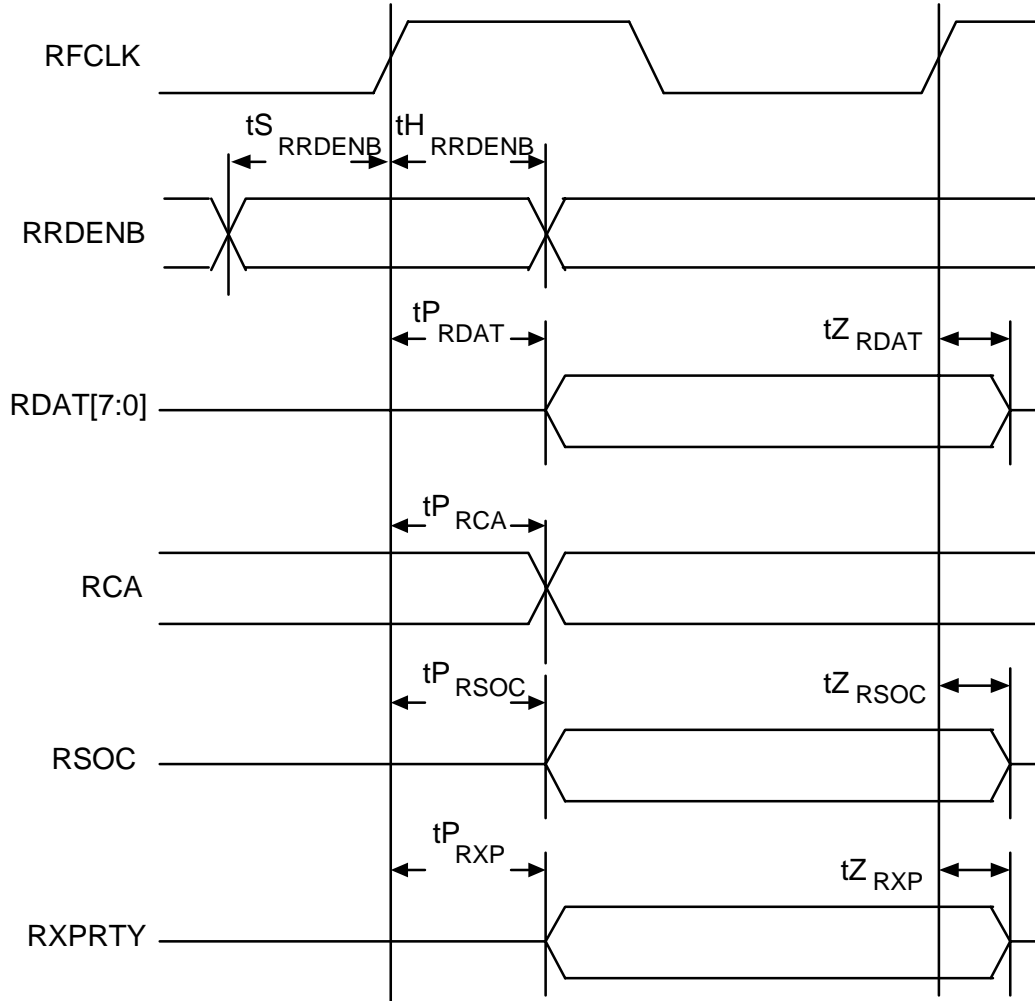
**Figure 28 - Drop Side Receive Synchronous Interface Timing (TSEN = 0)**



**Table 7 - Drop Side Receive Synchronous Interface (TSEN = 1) (Figure 29)**

Symbol	Description	Min	Max	Units
	RFCLK Frequency		50	MHz
	RFCLK Duty Cycle	40	60	%
t <sub>SRDENB</sub>	RRDENB to RFCLK High Setup	4		ns
t <sub>HRRDENB</sub>	RFCLK High to RRDENB Hold	1		ns
t <sub>PRDAT</sub>	RFCLK High to RDAT[7:0] Valid	2	14	ns
t <sub>ZRDAT</sub>	RFCLK High to RDAT[7:0] Tristate	2	14	ns
t <sub>PRXP</sub>	RFCLK High to RXPRTY Valid	2	14	ns
t <sub>ZRXP</sub>	RFCLK High to RXPRTY Tristate	2	14	ns
t <sub>PRCA</sub>	RFCLK High to RCA Valid	2	14	ns
t <sub>PRSOC</sub>	RFCLK High to RSOC Valid	2	14	ns
t <sub>ZRSOC</sub>	RFCLK High to RSOC Tristate	2	14	ns

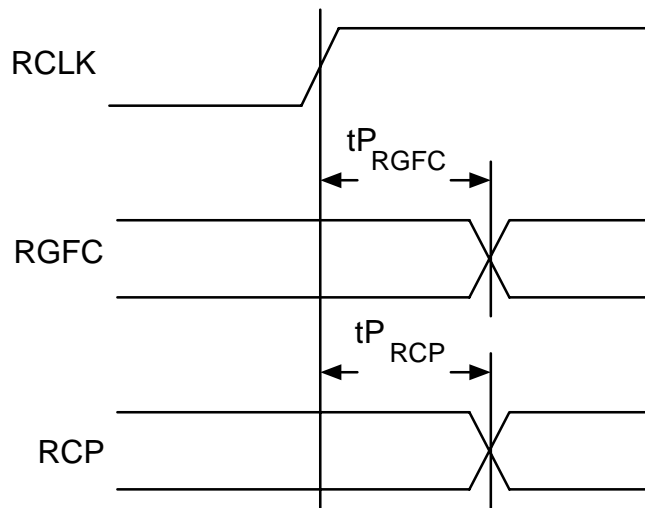
**Figure 29 - Drop Side Receive Synchronous Interface Timing (TSEN = 1)**



**Table 8 - GFC Extract Port (Figure 30)**

Symbol	Description	Min	Max	Units
t <sub>PRGFC</sub>	RCLK High to RGFC Valid	-1	10	ns
t <sub>PRCP</sub>	RCLK High to RCP Valid	-1	10	ns

**Figure 30 - GFC Extract Port Timing**

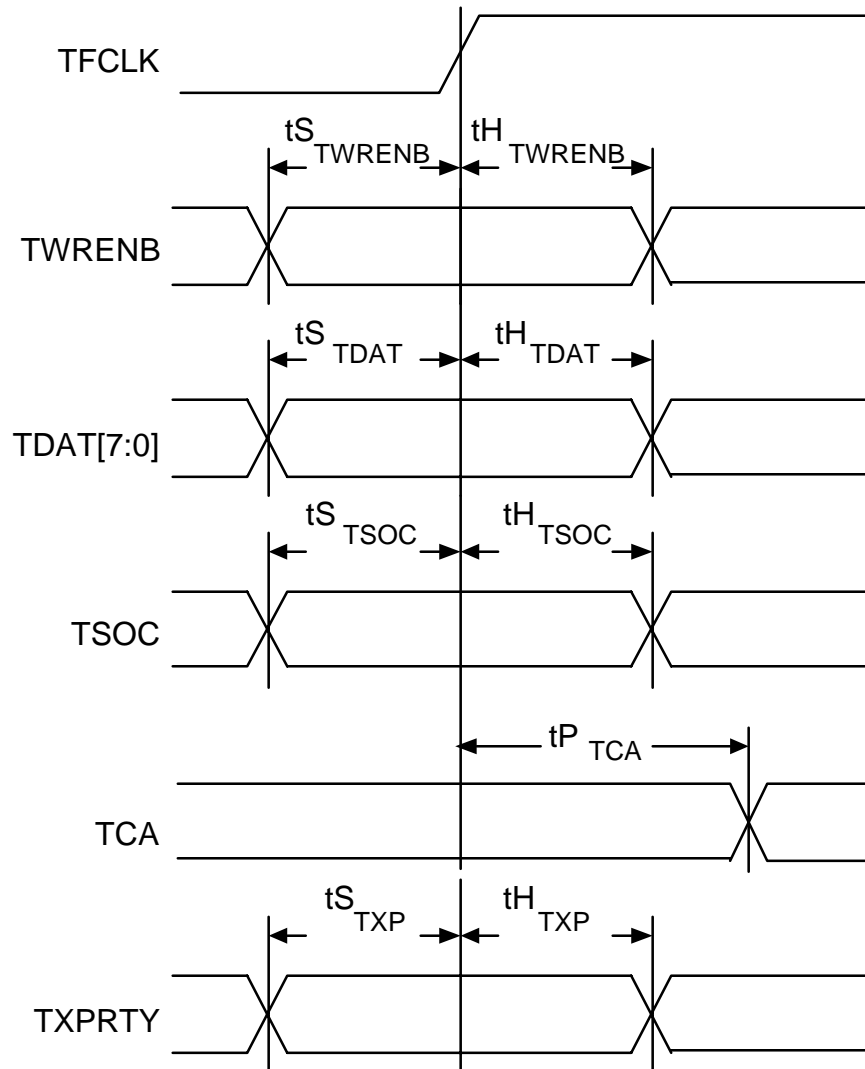


**Table 9 - Drop Side Transmit Synchronous Interface (Figure 31)**

Symbol	Description	Min	Max	Units
	TFCLK Frequency		50	MHz
	TFCLK Duty Cycle	40	60	%
t <sub>S</sub> <sub>TWRENB</sub>	TWRENB Set-up time to TFCLK	4		ns
t <sub>H</sub> <sub>TWRENB</sub>	TWRENB Hold time to TFCLK	1		ns
t <sub>S</sub> <sub>TDAT</sub>	TDAT[7:0] Set-up time to TFCLK	4		ns
t <sub>H</sub> <sub>TDAT</sub>	TDAT[7:0] Hold time to TFCLK	1		ns
t <sub>S</sub> <sub>TXP</sub>	TXPRTY Set-up time to TFCLK	4		ns
t <sub>H</sub> <sub>TXP</sub>	TXPRTY Hold time to TFCLK	1		ns

Symbol	Description	Min	Max	Units
$t_{S_{TSOC}}$	TSOC Set-up time to TFCLK	4		ns
$t_{H_{TSOC}}$	TSOC Hold time to TFCLK	1		ns
$t_{P_{TCA}}$	TFCLK to TCA Valid	2	14	ns

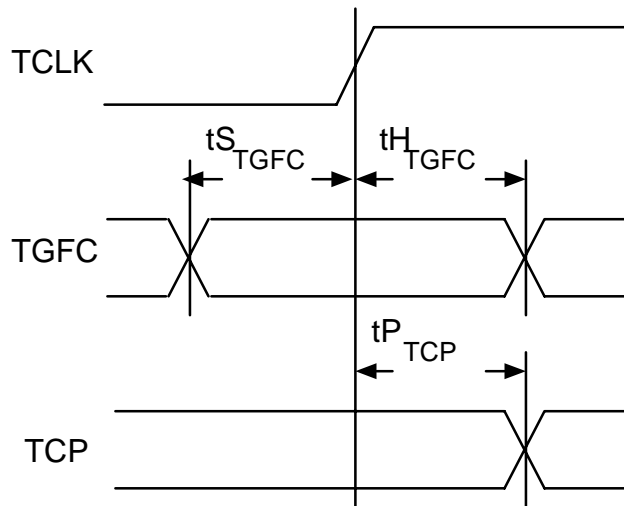
**Figure 31 - Drop Side Transmit Synchronous Interface**



**Table 10 - GFC Insert Port (Figure 32)**

Symbol	Description	Min	Max	Units
$t_{STGFC}$	TGFC Set-up time to TCLK	10		ns
$t_{HTGFC}$	TGFC Hold time to TCLK	1		ns
$t_{PTCP}$	TCLK High to TCP Valid	-1	10	ns

**Figure 32 - GFC Insert Port Timing**



**Notes on Input Timing:**

1. When a set-up time is specified between an input and a clock, the set-up time is the time in nanoseconds from the 1.4 Volt point of the input to the 1.4 Volt point of the clock.
2. When a hold time is specified between an input and a clock, the hold time is the time in nanoseconds from the 1.4 Volt point of the clock to the 1.4 Volt point of the input.

**Notes on Output Timing:**

1. Output propagation delay time is the time in nanoseconds from the 1.4 Volt point of the reference signal to the 1.4 Volt point of the output.

2. Output propagation delays for RCA, TCA, RSOC, RXPRTY and RDAT[7:0] are measured with a 30 pF load on the output. Other output propagation delays are measured with a 50 pF load on the outputs.

**15 ORDERING AND THERMAL INFORMATION**

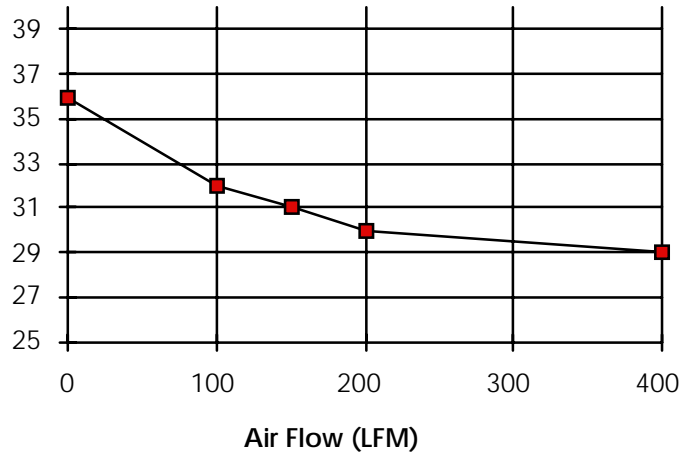
**Table 11 - S/UNI-ULTRA Ordering Information**

PART NO	Description
PM5350-RC	128 Pin Copper Leadframe Plastic Quad Flat Pack (PQFP)

**Table 12 - S/UNI-ULTRA Thermal Information**

PART NO.	AMBIENT TEMPERATURE	Theta Ja	Theta Jc
PM5350-RC	0°C to 70°C	36 °C/W	25 °C/W

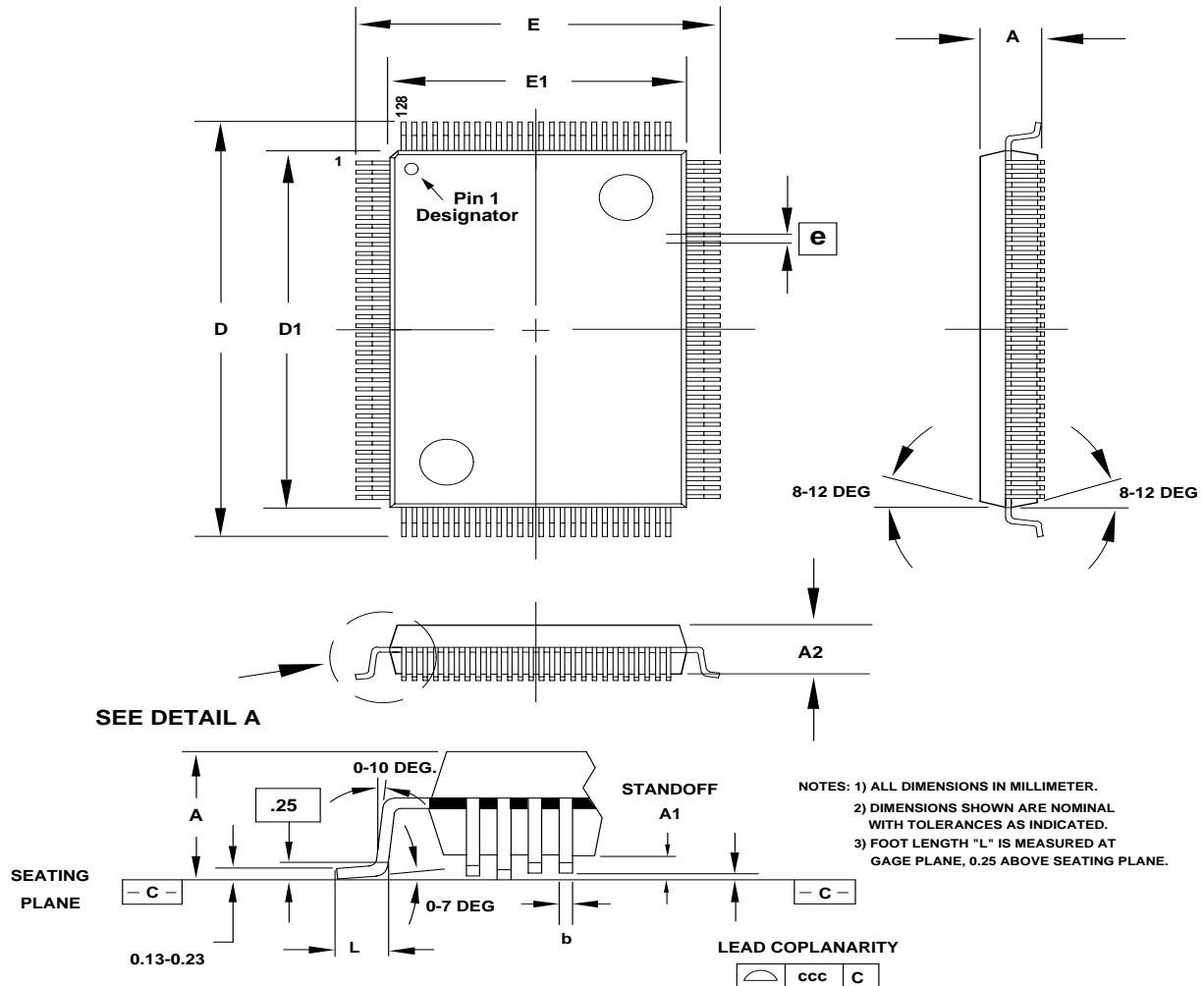
**Figure 33 - Theta JA vs. Air Flow**





**16 MECHANICAL INFORMATION**

**128 Pin Copper Leadframe Rectangular Plastic Quad Flat Pack (R Suffix)**



PACKAGE TYPE: 128 PIN METRIC RECTANGULAR PLASTIC QUAD FLATPACK-MQFP											
BODY SIZE: 14 x 20 x 2.7 MM											
Dim.	A	A1	A2	D	D1	E	E1	L	e	b	ccc
Min.	2.82	0.25	2.57	22.95	19.90	16.95	13.90	0.73		0.17	
Nom.			2.70	23.20	20.00	17.20	14.00	0.88	0.50	0.22	
Max.	3.40	0.53	2.87	23.45	20.10	17.45	14.10	1.03		0.27	0.10

**NOTES**

**NOTES**

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