

# ***TSB12C01A*** ***Data Manual***

***IEEE 1394-1995***  
***High-Speed Serial-Bus***  
***Link-Layer Controller***

SLLS219B  
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# 1 Overview

## 1.1 Description

The TSB12C01A is an IEEE 1394-1995 standard (from now on referred to only as 1394) high-speed serial-bus link-layer controller that allows for easy integration into an I/O subsystem. The TSB12C01A transmits and receives correctly formatted 1394 packets and generates and inspects the 32-bit cyclic redundancy check (CRC). The TSB12C01A is capable of being a cycle master and supports reception of isochronous data on two channels. It interfaces directly to the TSB11C01, TSB11LV01, and TSB21LV03 physical-layer chips and can support bus speeds of 100, 200, and 400 Mb/s. The TSB12C01A has a generic 32-bit host bus interface, which makes connection to most 32-bit host buses very simple. The TSB12C01A has software-adjustable FIFOs for optimal FIFO size and performance characterization and allows for variable-size asynchronous-transmit FIFO (ATF), isochronous-transmit FIFO (ITF), and general-receive FIFO (GRF).

This document is not intended to serve as a tutorial on 1394; users should refer to the IEEE 1394-1995 serial bus for detailed information regarding the 1394 high-speed serial bus.

## 1.2 Features

The following are features of the TSB12C01A.

### 1.2.1 Link

- Complies With IEEE-1394-1995 Standard
- Transmits and Receives Correctly Formatted 1394 Packets
- Supports Isochronous Data Transfer
- Performs Function of Cycle Master
- Generates and Checks 32-Bit CRC
- Detects Lost Cycle-Start Messages
- Contains Asynchronous, Isochronous, and General-Receive FIFOs

### 1.2.2 Physical-Link Interface

- Interfaces Directly to the TSB11C01, TSB11LV01, TSB14C01, and TSB21LV03 Phy Chips
- Supports Speeds of 100, 200, and 400 Mb/s
- Implements the Physical-Link Interface Described in Annex J of the IEEE 1394-1995 Standard
- Supports TI Bus Holder Isolation External Implementation

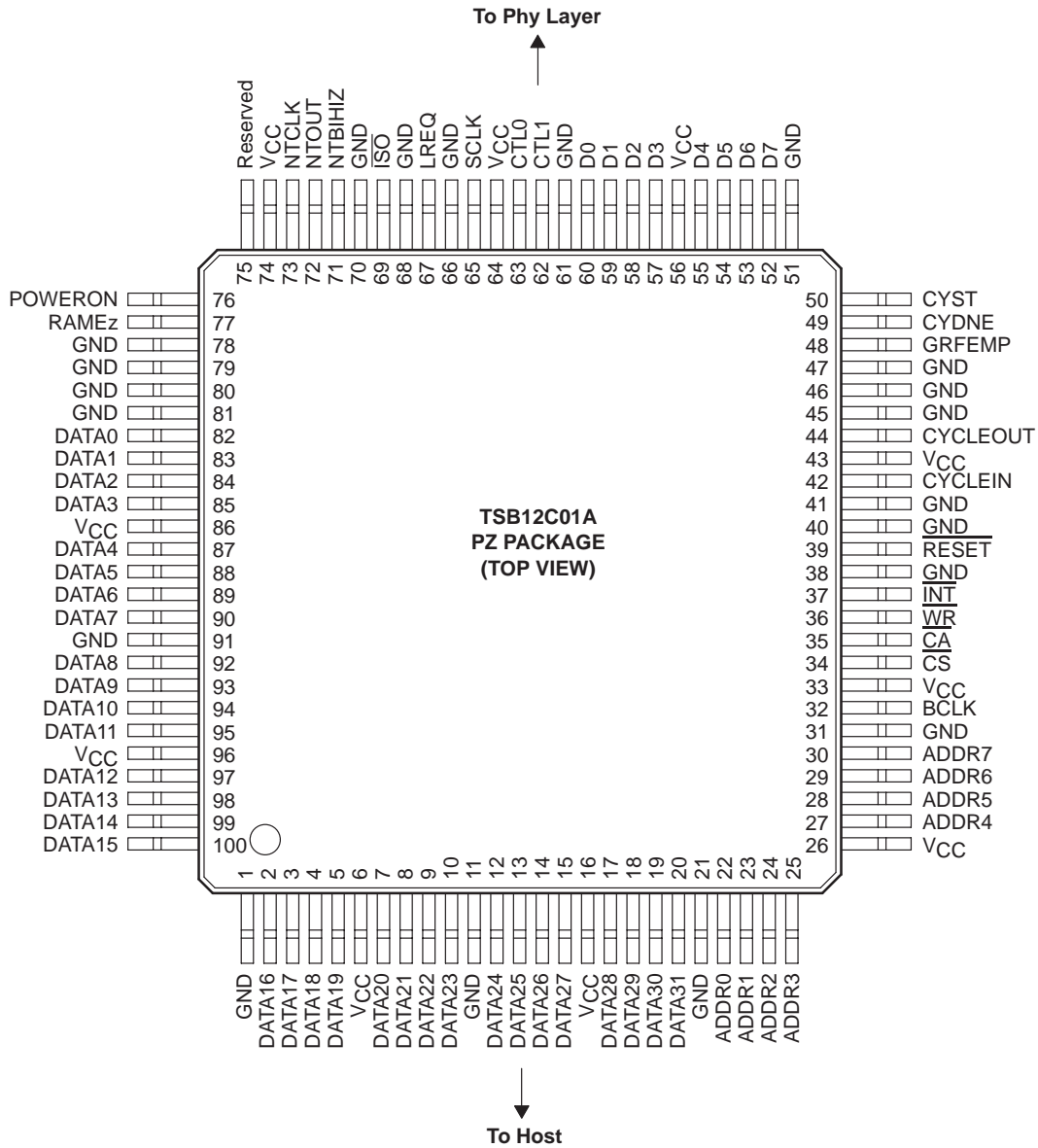
### 1.2.3 Host Bus Interface

- Provides Chip Control With Directly Addressable Registers
- Is Interrupt Driven to Minimize Host Polling
- Has a Generic 32-Bit Host Bus Interface

### 1.2.4 General

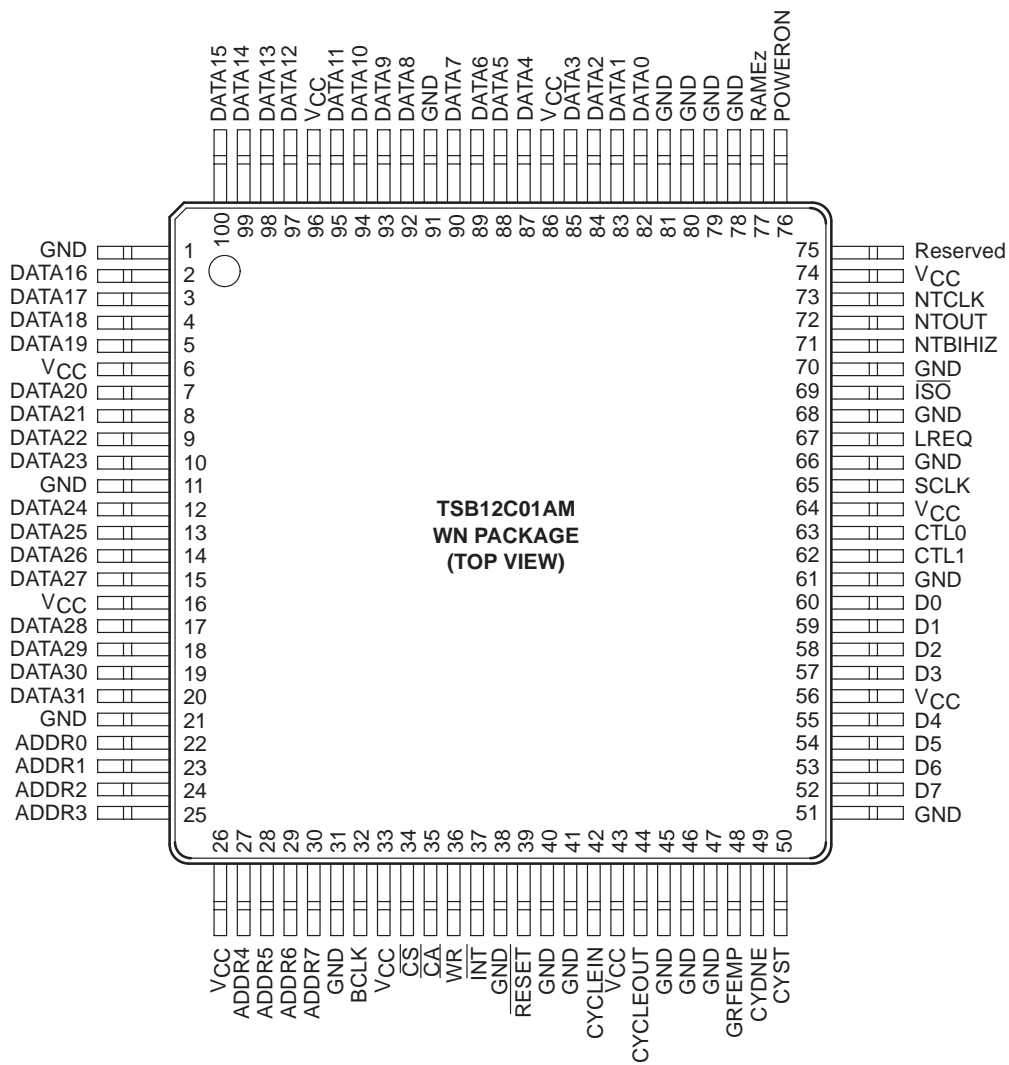
- Requires a Single 5-V  $\pm 5\%$  Power Supply
- Manufactured with Low-Power CMOS Technology
- Packaged in a 100-Pin Thin Quad Flat Package (TQFP) (PZ Package) for 0°C to 70°C and –40°C to 85°C Operation
- Packaged in a 100-Pin Ceramic Quad Flat Package (WN Package) for –55°C to 125°C Operation

### 1.3 Terminal Assignments



- NOTES: A. Tie reserved terminals to GND.  
 B. Bit 0 is the most significant bit (MSB).





- NOTES: A. Tie reserved terminals to GND.  
 B. Bit 0 is the most significant bit (MSB).

## 1.4 Terminal Functions

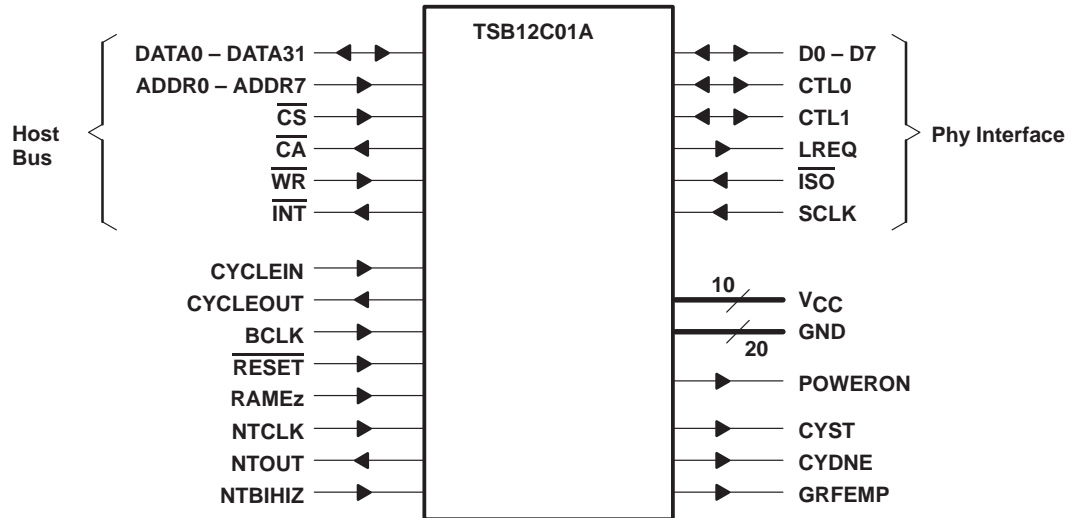


Figure 1–1. TSB12C01A Terminal Functions

Table 1–1. Terminal Functions

TERMINAL NAME	NO.	I/O	DESCRIPTION
<b>Host Bus Interface</b>			
ADDR0 – ADDR7	22–25 27–30	I	Address 0 through address 7. Host bus address bus bits 0 through 7 that address the quadlet-aligned FIFOs and configuration registers. The two least significant address lines, 6 and 7, must be grounded.
$\overline{\text{CA}}$	35	O	Cycle acknowledge (active low). $\overline{\text{CA}}$ is a TSB12C01A control signal to the host bus. When asserted (low), access to the configuration registers or FIFO is complete.
$\overline{\text{CS}}$	34	I	Cycle start (active low). $\overline{\text{CS}}$ is a host bus control signal to enable access to the configuration registers or FIFO.
DATA0 – DATA31	2–5 7–10 12–15 17–20 82–85 87–90 92–95 97–100	I/O	Data 0 through 31. DATA is a host bus data bus bits 0 through 31.
$\overline{\text{INT}}$	37	O	Interrupt (active low). When $\overline{\text{INT}}$ is asserted (low), the TSB12C01A notifies the host bus that an interrupt has occurred.
$\overline{\text{WR}}$	36	I	Read/write enable. When $\overline{\text{WR}}$ is deasserted (high) in conjunction with $\overline{\text{CS}}$ , a read from the TSB12C01A is requested. When $\overline{\text{WR}}$ is asserted (low) in conjunction with $\overline{\text{CS}}$ , a write to the TSB12C01A is requested.

**Table 1–1. Terminal Functions (Continued)**

TERMINAL NAME	NO.	I/O	DESCRIPTION
<b>Phy Interface</b>			
CTL1, CTL0	62, 63	I/O	Control 1 and control 0 of the phy-link control bus. CTL1 and CTL0 indicate the four operations that can occur in this interface (see Section 7 of this document or Annex J of the IEEE 1394-1995 standard for more information about the four operations).
D0 – D7	52–55 57–60	I/O	Data 0 through data 7 of the phy-link data bus. Data is expected on D0 – D1 for 100 Mb/s packets, D0 – D3 for 200 Mb/s, and D0 – D7 for 400 Mb/s.
$\overline{\text{ISO}}$	69	I	Isolation barrier (active low). This $\overline{\text{ISO}}$ is asserted (low) when an isolation barrier is present.
LREQ	67	O	Link request. LREQ is a TSB12C01A output that makes bus requests and accesses the phy layer.
POWERON	76	O	Power on indicator to phy interface. When active, POWERON has a clock output with 1/32 of the BCLK frequency and indicates to the phy interface that the TSB12C01A is powered. This terminal can be connected to the link power status (LPS) terminal on the TI phy devices to provide an indication of the LLC power condition.
SCLK	65	I	System clock. SCLK is a 49.152-MHz clock from the phy, that generates the 24.576-MHz clock.
<b>Miscellaneous Signals</b>			
BCLK	32	I	Bus clock. BCLK is the host bus clock used in the host-interface module of the TSB12C01A. It is asynchronous to SCLK.
CYCLEIN	42	I	Cycle in. CYCLEIN is an optional external 8,000-Hz clock used as the cycle clock, and it should only be used when attached to the cycle-master node. It is enabled by the cycle source bit and should be tied high when not used.
CYCLEOUT	44	O	Cycle out. CYCLEOUT is the TSB12C01A version of the cycle clock. It is based on the timer controls and received cycle-start messages.
CYDNE	49	O	Status of CyDne bit. When the RevAEn bit of the control register is set, CYDNE indicates the value of the CyDne bit of the interrupt register. When RevAEn is cleared, CYDNE is a 3-state output.
CYST	50	O	Status of CySt bit. When the RevAEn bit of the control register is set, CYST indicates the value of the CySt bit of the interrupt register. When RevAEn is cleared, CYST is a 3-state output.
GND	1, 11, 21, 31, 38, 40, 41, 45–47, 51, 61, 66, 68, 70, 78–81, 91		Ground reference
GRFEMP	48	O	Status of Empty bit. When the RevAEn bit of the control register is set, GRFEMP indicates the value of the Empty bit of the GRF status register. When RevAEn is cleared, GRFEMP is a 3-state output.
RAMEz	77	I	RAM 3-state enable. When RAMEz is deasserted (low), FIFOs are enabled. When RAMEz is asserted, the FIFOs are 3-state outputs. (This is a manufacturing test-mode condition and should be grounded under normal operating conditions.)

**Table 1–1. Terminal Functions (Continued)**

<b>TERMINAL NAME</b>	<b>NO.</b>	<b>I/O</b>	<b>DESCRIPTION</b>
NTBIHIZ	71	I	NAND-tree bidirectional 3-state output. When NTBIHIZ is deasserted (low), the bidirectional I/Os operate in a normal state. When NTBIHIZ is asserted (high), the bidirectional I/Os are in the 3-state output mode. (This is a manufacturing test-mode condition and should be grounded under normal operating conditions.)
NTCLK	73	I	NAND clock input. The NAND-tree clock is used for $V_{IH}$ and $V_{IL}$ manufacturing tests. (This input should be grounded under normal operating conditions.)
NTOUT	72	O	NAND-tree output. This output should remain open under normal operating conditions.
$\overline{\text{RESET}}$	39	I	Reset (active low). $\overline{\text{RESET}}$ is the asynchronous reset to the TSB12C01A.
$V_{CC}$	6, 16, 26, 33, 43, 56, 64, 74, 86, 96		5-V $\pm$ 5% power supplies

## 2 Architecture

### 2.1 Functional Block Diagram

The functional block architecture of the TSB12C01A is shown in Figure 2–1.

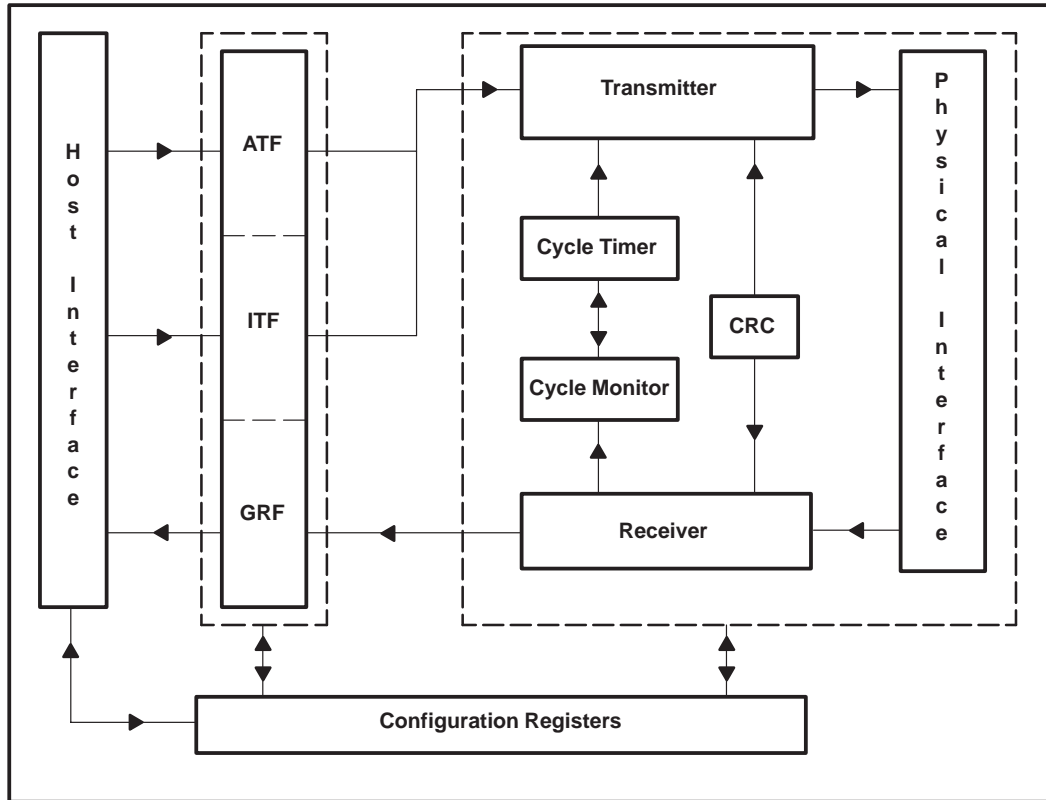


Figure 2–1. TSB12C01A Block Diagram

#### 2.1.1 Physical Interface

The physical (phy) interface provides phy-level services to the transmitter and receiver. This includes gaining access to the serial bus, sending packets, receiving packets, and sending and receiving acknowledge packets.

The phy interface module also interfaces to the phy chip and conforms to the phy-link interface specification described in Annex J of the IEEE 1394-1995 standard (refer to Section 7 of this document for more information).

#### 2.1.2 Transmitter

The transmitter retrieves data from either the ATF or the ITF and creates correctly formatted serial-bus packets to be transmitted through the phy interface. When data is present at the ATF interface to the transmitter, the TSB12C01A phy interface arbitrates for the serial bus and sends a packet. When data is present at the ITF interface to the transmitter, the TSB12C01A arbitrates for the serial bus during the next isochronous cycle. The transmitter autonomously sends the cycle-start packets when the chip is a cycle master.

### 2.1.3 Receiver

The receiver takes incoming data from the phy interface and determines if the incoming data is addressed to this node. If the incoming packet is addressed to this node, the CRC of the packet is checked. If the header CRC is good, the header is confirmed in the GRF. For block and isochronous packets, the remainder of the packet is confirmed one quadlet at a time. The receiver places a status quadlet in the GRF after the last quadlet of the packet is confirmed in the GRF. The status quadlet contains the error code for the packet. The error code is the acknowledge code that is sent for that packet. For broadcast packets that do not need acknowledge packets, the error code is the acknowledge code that would have been sent. This acknowledge code tells the transaction layer whether or not the data CRC is good or bad. When the header CRC is bad, the header is flushed and the rest of the packet is ignored.

When a cycle-start message is received, it is detected and the cycle-start message data is sent to the cycle timer. The cycle-start messages are not placed in the GRF like other quadlet packets. At the end of an isochronous cycle and if the cycle mark enable (CyMrkEn) bit of the control register is set, the receiver inserts a cycle-mark packet in the GRF to indicate the end of the isochronous cycle.

### 2.1.4 Transmit and Receive FIFOs

The TSB12C01A contains two transmit FIFOs (asynchronous and isochronous) and one receive FIFO (general receive). Each of these FIFOs is one quadlet wide and their length is software adjustable. These software-adjustable FIFOs allow customization of the size of each FIFO for individual applications. The sum of all FIFOs cannot be larger than 509 quadlets. To understand how to set the size of the FIFOs, see subsections 3.2.11 through 3.2.13. The transmit FIFOs are write only from the host bus interface, and the receive FIFO is read only from the host bus interface.

An example of how to use software-adjustable FIFOs follows:

In applications where isochronous packets are large and asynchronous packets are small, the implementer can set the ITF and GRF to a large size (200 quadlets each) and set the ATF to a smaller size (100 quadlets). Notice that the sum of all FIFOs is less than or equal to 509 quadlets.

### 2.1.5 Cycle Timer

The cycle timer is used by nodes that support isochronous data transfer. The cycle timer is a 32-bit cycle-timer register. Each node with isochronous data-transfer capability has a cycle-timer register as defined in the IEEE 1394-1995 standard. In the TSB12C01A, the cycle-timer register is implemented in the cycle timer and is located in IEEE-1212 initial register space at location 200h and can also be accessed through the local bus at address 14h. The low-order 12 bits of the timer are a modulo 3072 counter, which increments once every 24.576-MHz clock periods (or 40.69 ns). The next 13 higher-order bits are a count of 8, 000-Hz (or 125  $\mu$ s) cycles, and the highest 7 bits count seconds.

The cycle timer contains the cycle-timer register. The cycle-timer register consists of three fields: cycle offset, cycle count, and seconds count. The cycle timer has two possible sources. First, if the cycle source (CySrc) bit in the configuration register is set, then the CYCLEIN input causes the cycle count field to increment for each positive transition of the CYCLEIN input (8 kHz) and the cycle offset resets to all zeros. CYCLEIN should only be the source when the node is cycle master. When the cycle-count field increments, CYCLEOUT is generated. The timer can also be disabled using the cycle-timer-enable bit in the control register. See subsection 3.2.5 for more information.

The second cycle-source option is when the CySrc bit is cleared. In this state, the cycle-offset field of the cycle-timer register is incremented by the internal 24.576-MHz clock. The cycle timer is updated by the reception of the cycle-start packet for the noncycle master nodes. Each time the cycle-offset field rolls over, the cycle-count field is incremented and the CYCLEOUT signal is generated. The cycle-offset field in the cycle-start packet is used by the cycle-master node to keep all nodes in phase and running with a nominal isochronous cycle of 125  $\mu$ s.

CYCLEOUT indicates to the cyclemaster node that it is time to send a cycle-start packet. And, on noncyclemaster nodes, CYCLEOUT indicates that it is time to expect a cycle-start packet. The cycle-start bit is set when the cycle-start packet is sent from the cyclemaster node or received by a noncyclemaster node.

### **2.1.6 Cycle Monitor**

The cycle monitor is only used by nodes that support isochronous data transfer. The cycle monitor observes chip activity and handles scheduling of isochronous activity. When a cycle-start message is received or sent, the cycle monitor sets the cycle-started interrupt bit. It also detects missing cycle-start packets and sets the cycle-lost interrupt bit when this occurs. When the isochronous cycle is complete, the cycle monitor sets the cycle-done-interrupt bit. The cycle monitor instructs the transmitter to send a cycle-start message when the cycle-master bit is set in the control register.

### **2.1.7 Cyclic Redundancy Check (CRC)**

The CRC module generates a 32-bit CRC for error detection. This is done for both the header and data. The CRC module generates the header and data CRC for transmitting packets and checks the header and data CRC for received packets. See the IEEE 1394-1995 standard for details on the generation of the CRC<sup>†</sup>.

### **2.1.8 Internal Registers**

The internal registers control the operation of the TSB12C01A. The register definitions are specified in Section 3.

### **2.1.9 Host Bus Interface**

The host bus interface allows the TSB12C01A to be easily connected to most host processors. This host bus interface consists of a 32-bit data bus and an 8-bit address bus. The TSB12C01A utilizes cycle-start and cycle-acknowledge handshake signals to allow the local bus clock and the 1394 clock to be asynchronous to one another. The TSB12C01A is interrupt driven to reduce polling.

<sup>†</sup> This is the same CRC used by the IEEE802 LANs and the X3T9.5 FDDI.





## **3 Internal Registers**

### **3.1 General**

The host-bus processor directs the operation of the TSB12C01A through a set of registers internal to the TSB12C01A itself. These registers are read or written by asserting  $\overline{CS}$  with the proper address on ADDR0 – ADDR7 and asserting or deasserting  $\overline{WR}$  depending on whether a read or write is needed. Figure 3–1 lists the register addresses; subsequent sections describe the function of the various registers.

### **3.2 Internal Register Definitions**

The TSB12C01A internal registers control the operation of the TSB12C01A. The bit definitions of the internal registers are shown in Figure 3–1 and are described in subsections 3.2.1 through 3.2.13.

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31																
00h	Version																Revision										Version																					
04h	Bus Number								Node Number								ATAck								Node Address																							
08h	IdVal	RxSlid	BsyCtrl			TxEn	RxEn	PSBz	PSOn	PSRO	RstTx	RstRx	BlkBusDep					ATRC						CyMas	CySrc	CyTEn	CyMrkEn							RevAEn	Control													
0Ch	Int	PhInt	PhRRx	PhRst	TxRdy	RxDia	RxDia	CmdRst				ITStk	ATStk			SntRj	HdrEr	TCErr				CySec	CySt	CyDne	CyPnd	CyLst	CArbFI						IARbFI	Interrupt														
10h	Int	PhInt	PhRRx	PhRst	TxRdy	RxDia	RxDia	CmdRst				ITStk	ATStk			SntRj	HdrEr	TCErr				CySec	CySt	CyDne	CyPnd	CyLst	CArbFI						IARbFI	Interrupt Mask														
14h	7 Bits							Rollover @ 8000										13 Bits													Rollover @ 3072			12 Bits												Cycle Timer		
	Seconds Count							Cycle Count										Cycle Offset																														
18h	TAG		IR Port1					TAG		IR Port2																											Isoch Port Number											
1Ch																																					Reserved											
20h	ENSP	BsyFI	ArbGp	FrGp	regRW	Adr_clr	Control_bit1	Control_bit_err	RAM Test																											Diagnostics												
24h	RdPhy	WrPhy		PhyRgAd				PhyRgData												PhyRxAd				PhyRxData				Phy Chip Access																				
28h																																					Reserved											
2Ch																																					Reserved											
30h	Full	AIF			4AV																															Size	ATF Status											
34h	Full	AIF			4AV																															Size	ITF Status											
38h																																					Reserved											
3Ch	Full	AIF											4Th			AIE	Empty	cd																	Size	GRF Status												
40h																																					Reserved											

NOTE A: All gray areas (bits) are reserved bits.

Figure 3–1. Internal Register Map

### 3.2.1 Version/Revision Register

The version/revision register allows software to be written that supports multiple versions of the high-speed serial-bus link-layer controllers. This register is at address 00h and is read only. The initial value is 3031\_3041h.

**Table 3–1. Version/Revision Register Field Descriptions**

BITS	ACRONYM	FUNCTION NAME	DESCRIPTION
0–15	Version	Version	Version of the TSB12C01A
16–31	Revision	Revision	Revision of the TSB12C01A

### 3.2.2 Node-Address/Transmitter Acknowledge Register

The node-address/transmitter acknowledge register controls which packets are accepted/rejected, and it presents the last acknowledge received for packets sent from the ATF. This register is at offset 04h. The bus number and node number fields are read/write. The AT acknowledge (ATAck) received is normally read only. Setting the regRW bit in the diagnostic register makes these fields read/write. The initial value is FFFF\_0000h.

**Table 3–2. Node-Address/Transmitter Acknowledge Register Field Descriptions**

BITS	ACRONYM	FUNCTION NAME	DESCRIPTION
0–9	BusNumber	Bus number	BusNumber is the 10-bit IEEE 1212 bus number that the TSB12C01A uses with the node number in the SOURCE address for outgoing packets and to accept or reject incoming packets. The TSB12C01A always accepts packets with a bus number equal to 3FFh.
10–15	NodeNumber	Node number	NodeNumber is the 6-bit node number that the TSB12C01A uses with the bus number in the source address for outgoing packets and to accept or reject incoming packets. The TSB12C01A always accepts packets with the node address equal to 3Fh. See BlkBusDep bits in Table 3–3 for exceptions.
16–23	Reserved	Reserved	Reserved
24–27	ATAck	Address transmitter acknowledge received	ATAck is the last acknowledge received by the transmitting node in response to a packet sent from the asynchronous transmit-FIFO. When an acknowledge time out occurs, the value written to ATAck is 0h. See Table 6–13 in IEEE 1394-1995 standard for acknowledge codes.
28–31	Reserved	Reserved	Reserved

### 3.2.3 Control Register

The control register dictates the basic operation of the TSB12C01A. This register is at address 08h and is read/write. The initial value is 0000\_0000h.

**Table 3–3. Control-Register Field Descriptions**

BITS	ACRONYM	FUNCTION NAME	DESCRIPTION
0	IdVal	ID Valid	When IdVal is set, the TSB12C01A accepts packets addressed to the IEEE 1212 address set (Node Number) in the node-address register. When IdVal is cleared, the TSB12C01A accepts only broadcast packets.
1	RxSId	Received self-ID packets	When RxSId is set, the self-identification packets generated by phy chips during bus initialization are received and placed into the GRF as a single packet. Each self-identification packet is composed of two quadlets, where the second quadlet is the logical inverse of the first. If ACK (4 bits) equals 1h, then the data is good. If ACK equals Dh, then the data is wrong.

**Table 3–3. Control-Register Field Descriptions (Continued)**

<b>BITS</b>	<b>ACRONYM</b>	<b>FUNCTION NAME</b>	<b>DESCRIPTION</b>								
2–4	BsyCtrl	Busy control	<p>These bits control which busy status (as described in IEEE 1394-1995 standard, the chip returns to incoming packets. The field is defined as follows:</p> <p>000 = follow normal busy/retry protocol, only send busy when necessary.</p> <p>001 = send busyA when it is necessary to send a busy acknowledge.</p> <p>010 = send busyB when it is necessary to send a busy acknowledge.</p> <p>011 = reserved</p> <p>100 = send a busy acknowledge to all incoming packets following the normal busy/retry protocol.</p> <p>101 = send a busy acknowledge to all incoming packets by sending a busyA acknowledge.</p> <p>110 = send a busy acknowledge to all incoming packets by sending a busyB acknowledge.</p> <p>111 = reserved</p> <p>When retry_X is received and the receiving node needs to send a busy acknowledge signal, it sends an ack_busy_X signal.</p>								
5	TxEEn	Transmitter enable	When TxEn is cleared, the transmitter does not arbitrate or send packets.								
6	RxEEn	Receiver enable	When RXEn is cleared, the receiver does not receive any packets.								
7	PSBz	Physical DMA busy	<p>When:</p> <ol style="list-style-type: none"> <li>1) PSON is set,</li> <li>2) PSRO is cleared or the incoming packet is a read,</li> <li>3) destination offset is in the lower 4 Gbytes, and</li> <li>4) PSBz is set,</li> </ol> <p>the TSB12C01A sends a busy acknowledge to the incoming packet.</p>								
8	PSON	Physical DMA on	When PSON is set, the TSB12C01A uses PSRO and PSBz to determine acceptance of incoming request packets addressed to the lower 4 Gbytes of initial memory space.								
9	PSRO	Physical DMA read only	When PSON is set, the TSB12C01A uses PSRO to determine the acceptance of incoming write request packets addressed to the lower 4 Gbytes of initial memory space.								
10	RstTx	Reset transmitter	When RstTx is set, the entire transmitter resets synchronously. This bit clears itself.								
11	RstRx	Reset receiver	When RstRx is set, the entire receiver resets synchronously. This bit clears itself.								
12–15	BlkBusDep	Block bus-dependent address	This field is used by the receiver to filter out broadcast packets to the bus-dependent area of CSR space. Setting the LSB of this field disables the reception of broadcast packets to the lowest 128 bytes of bus-dependent CSR space. Setting the MSB of this field disables the reception of broadcast packets to the highest 128 bytes of bus-dependent CSR space.								
16–17	ATRC	AT retry code	<p>This field contains the last retry code received. This code is logically ORed with the retry code field (00) in the transmit packet, and the packet is resent. This alleviates the need to change the retry code in the transmit packet. The retry encoding follows the IEEE 1394-1995 standard. The retry code is as follows:</p> <table style="width: 100%; border: none;"> <tr> <td style="width: 20%;">00</td> <td style="width: 40%;">retry_o (new)</td> <td style="width: 20%;">01</td> <td style="width: 20%;">retry_X</td> </tr> <tr> <td>10</td> <td>retry_A</td> <td>11</td> <td>retry_B</td> </tr> </table>	00	retry_o (new)	01	retry_X	10	retry_A	11	retry_B
00	retry_o (new)	01	retry_X								
10	retry_A	11	retry_B								

**Table 3–3. Control-Register Field Descriptions (Continued)**

<b>BITS</b>	<b>ACRONYM</b>	<b>FUNCTION NAME</b>	<b>DESCRIPTION</b>
18–19	Reserved	Reserved	Reserved
20	CyMas	Cycle master	When CyMas is set and the TSB12C01A is attached to the root phy, the cyclemaster function is enabled. When the cycle_count field of the cycle timer register increments, the transmitter sends a cycle-start packet. This bit is not cleared upon bus reset. When another node is selected as root during a bus reset, the transaction layer in the now nonroot TSB12C01A node must clear this bit and the transaction layer in the TSB12C01a node selected as root must set this bit.
21	CySrc	Cycle source	When CySrc is set, the cycle_count field increments and the cycle_offset field resets for each positive transition of CYCLEIN. When CySrc is cleared, the cycle_count field increments when the cycle_offset field rolls over.
22	CyTEn	Cycle-timer enable	When CyTEn is set, the cycle_offset field increments.
23	CyMrkEn	Cycle mark enable	When CyMrkEn is set, cycle marks are inserted into GRF at the end of each isochronous cycle (TSB12C01A compatible). When CyMrkEn is cleared, no cycle marks are generated.
24	IRP1En	IR port 1 enable	When IRP1En is set, the receiver accepts isochronous packets when the channel number matches the value in the IR Port1 field.
25	IRP2En	IR port 2 enable	When IRP2En is set, the receiver accepts isochronous packets when the channel number matches the value in the IR Port2 field.
26–30	Reserved	Reserved	Reserved
31	RevAEn	Rev A enable	When set, RevAEn enables the output of GRFEMP, CYDNE, and CYST. When not set, these outputs are in a high-impedance state, which makes TSB12C01A pin-compatible with the TSB12C01. This bit is 0 on power up.

### 3.2.4 Interrupt and Interrupt-Mask Registers

The interrupt and interrupt-mask registers work in tandem to inform the host bus interface when the state of the TSB12C01A changes. The interrupt register is at address 0Ch. The interrupt mask register is at address 10h. The interrupt mask register is read/write. Its initial value is 0000\_0000h. When regRW is cleared to 0, the interrupt register (except for the Int bit) is write to clear. When regRW (in diagnostics register at 20h) is set to 1, the interrupt register (including the Int bit) is read/write. Its initial value is 1000\_0000h.

The interrupt bits all work the same. For example, when a phy interrupt occurs, the PhInt bit is set. When the PhIntMask bit is set, the Int bit is set. When the IntMask is set, the INT signal is asserted. The logic for the interrupt bits is shown in Figure 3–2. Table 3–4 defines the interrupt and interrupt-mask register field descriptions. As shown in Figure 3–2, the INT bit is the OR of interrupt bits 1 – 31. When all the interrupt bits are cleared, INT equals 0. When any of the interrupt bits are set, INT equals 1, even when the INT bit was just cleared.

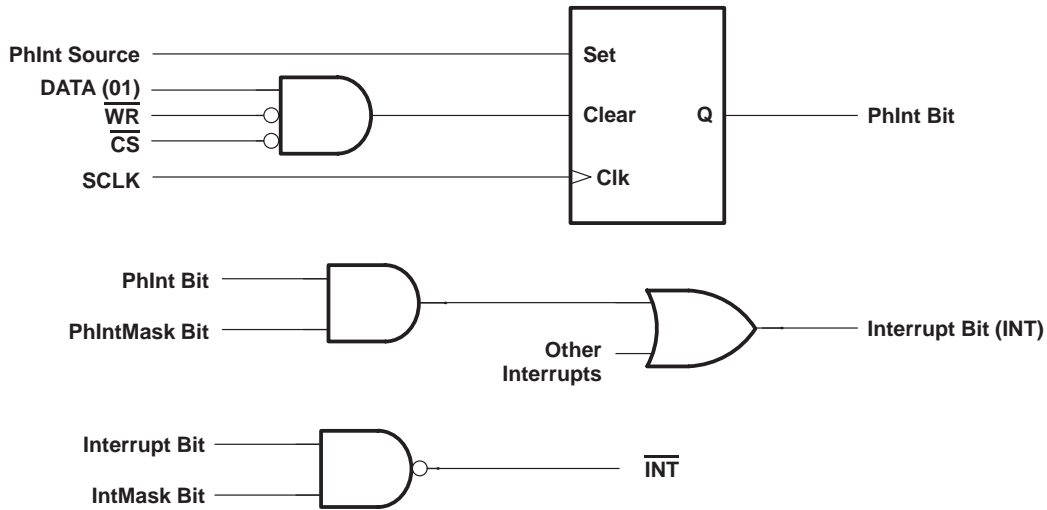


Figure 3-2. Interrupt Logic Diagram Example

Table 3-4. Interrupt- and Mask-Register Field Descriptions

BITS	ACRONYM	FUNCTION NAME	DESCRIPTION
0	Int	Interrupt	Int contains the value of all interrupt and interrupt mask bits ORed together.
1	PhInt	Phy chip interrupt	When PhInt is set, the phy chip has signaled an interrupt through the Phy interface.
2	PhyRRx	Phy register information received	When PhyRRx is set, a register value has been transferred to the phy chip access register (offset 24h) from the phy interface.
3	PhRst	Phy reset started	When PhRst is set, a phy-layer reconfiguration has started (1394 bus reset).
4	Reserved	Reserved	Reserved
5	TxDta	Transmitter ready	When TxDta is set, the transmitter is idle and ready.
6	RxDta	Receiver has data	In normal mode and when set, RxDta indicates that the receiver has accepted a quadlet of data into the GRF interface. This bit is set each time a quadlet of data is accepted. However, during the self-ID portion of a bus reset, this bit is set after each complete self-ID packet is received into the GRF.
7	CmdRst	Command reset received	When CmdRst is set, the receiver has been sent a quadlet write request addressed to the RESET_START CSR register.
8-10	Reserved	Reserved	Reserved
11	ITStk	Transmitter is stuck (IT)	When ITStk is set, the transmitter has detected invalid data at the isochronous transmit-FIFO interface.
12	ATStk	Transmitter is stuck (AT)	When ATStk is set, the transmitter has detected invalid data at the asynchronous transmit-FIFO interface. If the first quadlet of a packet is not written to the ATF_First or ATF_First&Update, the transmitter enters a state denoted by an ATStuck interrupt. An underflow of the ATF also causes an ATStuck interrupt. If this state is entered, no asynchronous packets can be sent until the ATF is cleared by way of the CLR ATF control bit. Isochronous packets can be sent while in this state.

**Table 3–4. Interrupt- and Mask-Register Field Descriptions (Continued)**

<b>BITS</b>	<b>ACRONYM</b>	<b>FUNCTION NAME</b>	<b>DESCRIPTION</b>
13	Reserved	Reserved	Reserved
14	SntRj	Busy acknowledge sent by receiver	When SntRj is set, the receiver is forced to send a busy acknowledge to a packet addressed to this node because the GRF overflowed.
15	HdrEr	Header error	When HdrEr is set, the receiver detected a header CRC error on an incoming packet that may have been addressed to this node.
16	TCErr	Transaction code error	When TCErr is set, the transmitter detected an invalid transaction code in the data at the transmit FIFO interface.
17–19	Reserved	Reserved	Reserved
20	CySec	Cycle second incremented	When CySec is set, the cycle-second field in the cycle-timer register is incremented. This occurs approximately every second when the cycle timer is enabled.
21	CySt	Cycle started	When CySt is set, the transmitter has sent or the receiver has received a cycle-start packet.
22	CyDne	Cycle done	When CyDne is set, an arbitration gap has been detected on the bus after the transmission or reception of a cycle-start packet. This indicates that the isochronous cycle is over.
23	CyPnd	Cycle pending	When CyPnd is set, the cycle-timer offset is set to 0 (rolled over or reset) and remains set until the isochronous cycle ends.
24	CyLst	Cycle lost	When CyLst is set, the cycle timer has rolled over twice without the reception of a cycle-start packet. This occurs only when this node is not the cycle master.
25	CArbFI	Cycle arbitration failed	When CArbFI is set, the arbitration to send the cycle-start packet failed.
26–30	Reserved	Reserved	Reserved
31	IArbFI	Isochronous arbitration failed	When IArbFI is set, the arbitration to send an isochronous packet failed.

### 3.2.5 Cycle-Timer Register

The cycle-timer register contains the `seconds_count`, `cycle_count` and `cycle_offset` fields of the cycle timer. The register is at address 14h and is read/write. This field is controlled by the cycle master, cycle source, and cycle timer enable bits of the control register. Its initial value is 0000\_0000h.

**Table 3–5. Cycle-Timer Register Field Descriptions**

<b>BITS</b>	<b>ACRONYM</b>	<b>FUNCTION NAME</b>	<b>DESCRIPTION</b>
0–6	<code>seconds_count</code>	Seconds count	1-Hz cycle-timer counter
7–19	<code>cycle_count</code>	Cycle count	8,000-Hz cycle-timer counter
20–31	<code>cycle_offset</code>	Cycle offset	24.576-MHz cycle-timer counter

### 3.2.6 Isochronous Receive-Port Number Register

The isochronous receive-port number register controls which isochronous channels are received by this node. This register is at address 18h. The register is read/write, and its initial value is 0000\_0000h.

**Table 3–6. Isochronous Receive-Port Number Register Field Descriptions**

BITS	ACRONYM	FUNCTION NAME	DESCRIPTION
0–7	IRPort1	Isochronous receive TAG bits and port 1 channel number	IRPort1 contains the channel number of the isochronous packets the receiver accepts when IRP1En is set (bits 0 and 1 are reserved as TAG bits). See Table 4–5 and Table 4–6 for more information.
8–15	IRPort2	Isochronous receive TAG bits and port 2 channel number	IRPort2 contains the channel number of the isochronous packets the receiver accepts when IRP2En is set (bits 8 and 9 are reserved as TAG bits). See Table 4–5 and Table 4–6 for more information.
16–31	Reserved	Reserved	Reserved

### 3.2.7 Diagnostic Control and Status Register

The diagnostic control and status register allows for the monitoring and control of the diagnostic features of the TSB12C01A. The register is at address 20h. The regRW and enable snoop bits are read/write. When regRW is cleared, all other bits are read only. When regRW is set, all bits are read/write. Its initial value is 0000\_0000h. For a RAM test read/write, enable RAM test mode and set Adr\_clr to clear the RAM internal address counter. Do the host bus read/write to location 80h; this accesses RAM starting at location 00h. With each read/write the RAM internal address counter increments by one.

**Table 3–7. Diagnostic Control and Status-Register Field Descriptions**

BITS	ACRONYM	FUNCTION NAME	DESCRIPTION
0	ENSp	Enable Snoop	When ENSp is set, the receiver accepts all packets on the bus regardless of address or format. The receiver uses the snoop data format defined in Section 4.4.
1	BsyFl	Busy flag	When BsyFl is set, the receiver sends an ack_busyB the next time the receiver must busy a packet. When cleared, the receiver sends an ack_busyA the next time the receiver must busy a packet.
2	ArbGp	Arbitration reset gap	When ArbGp is set, the serial bus has been idle for an arbitration reset gap.
3	FrGp	Fair gap	When FrGp is set, the serial bus has been idle for a fair-gap time (Sub-Action Gap).
4	regR/W	Register read/write access	When regR/W is set, most registers are fully read/write.
5	Adr_clr	Address clear	When Adr_clr is set, the internal RAM address counter and the Control_bit_err flag are cleared.
6	Control_bit1	Control bit for RAM test write	During RAM test mode, Control_bit1 is written into the control bit of RAM (bit 33) for RAM write transaction.
7	Control_bit_err	Control bit error flag	When Control_bit_err is set, the control bit of the RAM does not match Control_bit1 during RAM test mode.
8	RAMTest	RAM test mode	When RAMTest and regRW are set, RAM test mode is enabled.
9–31	Reserved	Reserved	Reserved

### 3.2.8 Phy-Chip Access Register

The phy-chip access register allows access to the registers in the attached phy chip. The most significant 16 bits send read and write requests to the phy-chip registers. The least significant 16 bits are for the phy chip to respond to a read request sent by the TSB12C01A. The phy-chip access register also allows the phy interface to send important information back to the TSB12C01A. When the phy interface sends new



information to the TSB12C01A, the phy register-information-receive (PhyRRx) interrupt is set. The register is at address 24h and is read/write. Its initial value is 0000\_0000h. All gap counts (set in the phy device registers) on all nodes of a 1394 bus must be identical. This can be accomplished by using the phy configuration packets to set a specific gap count or by using two bus resets, which resets the gap counts to the default 3Fh. See Section 4.6 for the format of the phy configuration packets.

**Table 3–8. Phy-Chip Access Register**

<b>BITS</b>	<b>ACRONYM</b>	<b>FUNCTION NAME</b>	<b>DESCRIPTION</b>
0	RdPhy	Read phy-chip register	When RdPhy is set, the TSB12C01A sends a read register request with address equal to phyRgAd to the phy interface. This bit is cleared when the request is sent.
1	WrPhy	Write phy-chip register	When WrPhy is set, the TSB12C01A sends a write register request with an address equal to phyRgAd on to the phy interface. This bit is cleared when the request is sent.
2–3	Reserved	Reserved	Reserved
4–7	PhyRgAd	Phy-chip-register address	PhyRgAd is the address of the phy-chip register that is to be accessed.
8–15	PhyRgData	Phy-chip-register data	PhyRgData is the data to be written to the phy-chip register indicated in PhyRgAd.
16–19	Reserved	Reserved	Reserved
20–23	PhyRxAd	Phy-chip-register-received address	PhyRxAd is the address of the register from which PhyRxData came.
24–31	PhyRxData	Phy-chip-register-received data	PhyRxData contains the data from register addressed by PhyRxAd.

### 3.2.9 Asynchronous Transmit-FIFO (ATF) Status Register

The ATF status register allows access to the registers that control or monitor the ATF. The register is at address 30h. All the FIFO flag bits are read only, and the FIFO control bits are read/write. Its initial value is 0000\_0000h.

**Table 3–9. ATF Status Register**

<b>BITS</b>	<b>ACRONYM</b>	<b>FUNCTION NAME</b>	<b>DESCRIPTION</b>
0	Full	ATF full flag	When Full is set, the FIFO is full. Write operations are ignored.
1	AIF	ATF almost-full flag	When AIF is set, the FIFO can accept one more write.
2–3	Reserved	Reserved	Reserved
4	4AV	ATF-4-available flag	When 4AV is set, the FIFO has space available for at least four quadlets.
5–13	Reserved	Reserved	Reserved
14	AIE	ATF-almost-empty flag	When AIE is set, the FIFO has only one quadlet in it.
15	Empty	ATF-empty flag	When Empty is set, the FIFO is empty.
16–18	Reserved	Reserved	Reserved
19	Clr	ATF-clear control bit	When Clr is set by software/firmware, the FIFO is cleared of all entries.
20–22	Reserved	Reserved	Reserved
23–31	Size	ATF-size control bits	Size is equal to the ATF size number in quadlets.

### 3.2.10 ITF Status Register

The ITF status register allows access to the registers that control or monitor the ITF. The register is at address 34h. All the FIFO flag bits are read only, and the FIFO control bits are read/write. Its initial value is 0000\_0000h.

**Table 3–10. ITF Status Register**

BITS	ACRONYM	FUNCTION NAME	DESCRIPTION
0	Full	ITF full flag	When Full is set, the FIFO is full and all writes are ignored.
1	AIF	ITF almost-full flag	When AIF is set, the FIFO can accept only one more write.
2–3	Reserved	Reserved	Reserved
4	4AV	ITF-4-available flag	When 4AV is set, the FIFO has space for at least four more quadlets.
5–13	Reserved	Reserved	Reserved
14	AIE	ITF-almost-empty flag	When AIE is set, the FIFO has only one quadlet in it.
15	Empty	ITF-empty flag	When Empty is set, the FIFO is empty.
16–18	Reserved	Reserved	Reserved
19	Clr	ITF-clear control bit	When Clr is set by software/firmware, the FIFO is cleared of all entries.
20–22	Reserved	Reserved	Reserved
23–31	Size	ITF-size control bits	The size is equal to the ITF size number in quadlets.

### 3.2.11 GRF Status Register

The GRF status register allows access to the registers that control or monitor the GRF. The register is at address 3Ch. All the FIFO flag bits are read only, and the FIFO control bits are read/write. Its initial value is 0000\_0000h.

**Table 3–11. GRF Status Register**

BITS	ACRONYM	FUNCTION NAME	DESCRIPTION
0	Full	GRF full flag	When Full is set, the FIFO is full.
1	AIF	GRF-almost-full flag	When AIF is set, the FIFO can accept only one more write.
2–11	Reserved	Reserved	Reserved
12	4Th	GRF four there	When 4Th is set, the FIFO has at least four quadlets in it.
13	Reserved	Reserved	Reserved
14	AIE	GRF-almost-empty flag	When AIE is set, the FIFO has one quadlet in it.
15	Empty	GRF-empty flag	When Empty is set, the FIFO is empty and reads are ignored.
16	cd	GRF control bit	This is the control bit for the GRF. When cd is set, either the first quadlet of a packet is being read from the GRF_Data address, or the final quadlet (trailer quadlet) of a packet is being read from the GRF data address. See Section 4 for descriptions of received packet formats.
17–18	Reserved	Reserved	Reserved
19	Clr	GRF-clear control bit	When Clr is set by software/firmware, the FIFO is cleared of all entries.
20–22	Reserved	Reserved	Reserved
23–31	Size	GRF-size control bits	The size is equal to the GRF size number in quadlets.

### 3.3 FIFO Access

Access to all the transmit FIFOs is fundamentally the same; only the address to where the write is made changes.

#### 3.3.1 General

The TSB12C01A controller FIFO-access address map shown in Figure 3–3 illustrates how the FIFOs are mapped. The suffix `_First` denotes a write to the FIFO location where the first quadlet of a packet should be written when the writer wants the packet to be held in the FIFO until a quadlet is written to an update location.

The suffix `_Continue` denotes a write to the FIFO location where the second through  $n-1$  quadlets of a packet could be written.

The suffix `_First&Update` denotes a write to the FIFO location where the first quadlet of a packet should be written when the writer wants the packet to be transmitted as soon as possible.

The suffix `_Continue&Update` denotes a write to the FIFO location where the second through  $n$  quadlets of a packet could be written when the writer wants the packet to be transmitted as soon as possible. The last quadlet of a multiple quadlet packet should be written to the FIFO location with the notation `_Continue&Update`.

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
80h	ATF_First																															
84h	ATF_Continue																															
88h	Reserved																															
8Ch	ATF_Continue & Update																															
90h	ITF_First																															
94h	ITF_Continue																															
98h	Reserved																															
9Ch	ITF_Continue & Update																															
A0h	Reserved																															
A4h	Reserved																															
A8h	Reserved																															
ACh	Reserved																															
B0h	Reserved																															
B4h	Reserved																															
B8h	Reserved																															
BCh	Reserved																															
C0h	GRF Data																															
C4h	Reserved																															
C8h	Reserved																															
CCh	Reserved																															

Figure 3–3. TSB12C01A Controller-FIFO-Access Address Map

### 3.3.2 ATF Access

The procedure to access to the ATF is as follows:

1. Write the first quadlet of the packet to ATF location 80h: the data is not confirmed for transmission.
2. Write the second n–1 quadlets of the packet to ATF location 84h: the data is not confirmed for transmission.
3. Write the final quadlet of the packet to ATF location 8Ch: the data is confirmed for transmission.

If the first quadlet of a packet is not written to the ATF\_First address, the transmitter enters a state denoted by an ATStuck interrupt. An underflow of the ATF also causes an ATStuck interrupt. When this state is entered, no asynchronous packets can be sent until the ATF is cleared via the CLR ATF control bit. Isochronous packets can be sent while in this state.

Ack code = 0000b is reserved, however, the TSB12C01A uses ATAck code = 0000b to indicate that no acknowledgement was received. For example, if an asynchronous write is addressed to a nonexistent address, the TSB12C01 waits until a time out occurs and then sets ATAck (in the node address register) to 0000b. After the asynchronous command is sent, the sender reads ATAck. If ATAck = 0000b, then a time out has occurred (i.e., no response from any node was received).

ATF access example:

The first quadlet of n quadlets is written to ATF location 80h. Quadlets (2 to n-1) are written to ATF location 84h. The last quadlet (nth) is written to ATF location 8Ch. If the ATFEmpty bit is true, it is set to false and the TSB12C01A requests the phy layer to arbitrate for the bus. To ensure that an ATF underflow condition does not occur, loading of the ATF in this manner is suggested.

After loading the ATF with an asynchronous packet and sending it, the software driver needs to wait until the TxRdy bit (bit 5) of the Interrupt register is set to 1 before reading ATAck. When TxRdy is set to 1, this indicates that the transmitter has received an ACK or time out. So the correct ATAck can then be read from the node address register. In order to receive the next Ack code, the TxRdy bit needs to be cleared to 0.

### 3.3.3 ITF Access

The procedure to access to the ITF is as follows:

1. Write to ITF location 90h: the data is not confirmed for transmission (first quadlet of the packet).
2. Write to ITF location 94h: the data is not confirmed for transmission (second n–1 quadlets of the packet).
3. Write to ITF location 98h: the data is confirmed for transmission (first quadlet of the packet). The read logic sees all data written to the FIFO since the last confirm (update).
4. Write to ITF location 9Ch: the data is confirmed for transmission (second n quadlet of the packet).

If the first quadlet of a packet is not written to the ITF\_First or ITF\_First&Update, the transmitter enters a state denoted by an ITStuck interrupt. An underflow of the ITF also causes an ITStuck interrupt. When this state is entered, no isochronous packets can be sent until the ITF is cleared by the CLR ITF control bit. Asynchronous packets can be sent while in this state.

ITF access example:

The first quadlet of n quadlets is written to ITF location 90h. Quadlets (2 to n-1) are written to ITF location 94h. The last quadlet (nth) is written to ITF location 9Ch. If the ITFEmpty is true, it is set to false and the TSB12C01A requests the phy layer to arbitrate for the bus. To ensure that an ITF underflow condition does not occur, loading of the ITF in this manner is suggested.

### 3.3.4 General-Receive-FIFO (GRF)

Access to the GRF is done with a read from the GRF, which requires a read from address C0h.

### 3.3.5 RAM Test Mode

The purpose of RAM test mode is to test the RAM with writes and reads. During RAM test mode, RAM, which makes up the ATF, ITF, and GRF, is accessed directly from the host bus. Different data is written to and read back from the RAM and compared with what was expected to be read back. ATF status, ITF status, and GRF status are not changed during RAM test mode, but the stored data in RAM is changed by any write transaction. To enable RAM test mode, set regRW bit and RAMTest bit of the diagnostics register. Before beginning any read or write to the RAM, the Adr\_clr bit of the diagnostics register should be set to clear the internal RAM address counter. This action also clears the Adr\_clr bit.

During RAM test mode, the host bus address should be 80h. The first host bus transaction (either read or write) accesses location 0 of the RAM. The second host bus transaction accesses location 1 of the RAM. The nth host bus transaction accesses location n-1 of the RAM. After each transaction, the internal RAM address counter is incremented by one.

The RAM has 512 locations with each location containing 33 bits. The most significant bit is the control bit. When the control bit is set, that indicates the quadlet is the start of the packet. In order to set the control bit, Control\_bit1 of the diagnostics register has to be set. In order to clear the control bit, Control\_bit1 of the diagnostics register has to be cleared. When a write occurs, the 32 bits of data from the host bus is written to the low order 32 bits of the RAM and the value in Control\_bit1 is written to the control bit. When a read occurs, the low order 32 bits of RAM are sent to the host data bus and the control bit is compared to Control\_bit1. If the control bit and Control\_bit1 do not match, Control\_bit\_err of the diagnostics register is set. This does not stop operation and another read or write can immediately be transmitted. To clear Control\_bit\_err, set Adr\_clr of the diagnostics register, or transact another write.



## 4 TSB12C01A Data Formats

The data formats for transmission and reception of data are shown in the following sections. The transmit format describes the expected organization of data presented to the TSB12C01A at the host-bus interface. The receive formats describe the data format that the TSB12C01A presents to the host-bus interface.

### 4.1 Asynchronous Transmit (Host Bus to TSB12C01A)

Asynchronous transmit refers to the use of the asynchronous-transmit FIFO (ATF) interface. The general-receive FIFO (GRF) is shared by asynchronous data and isochronous data. There are two basic formats for data to be transmitted and received. The first is for quadlet packets, and the second is for block packets. For transmits, the FIFO address indicates the beginning, middle, and end of a packet. For receives, the data length, which is found in the header of the packet, determines the number of bytes in a block packet.

#### 4.1.1 Quadlet Transmit

The quadlet-transmit format is shown in Figure 4–1. The first quadlet contains packet control information. The second and third quadlets contain the 64-bit, quadlet-aligned address. The fourth quadlet is data used only for write requests and read responses. For read requests and write responses, the quadlet data field is omitted.

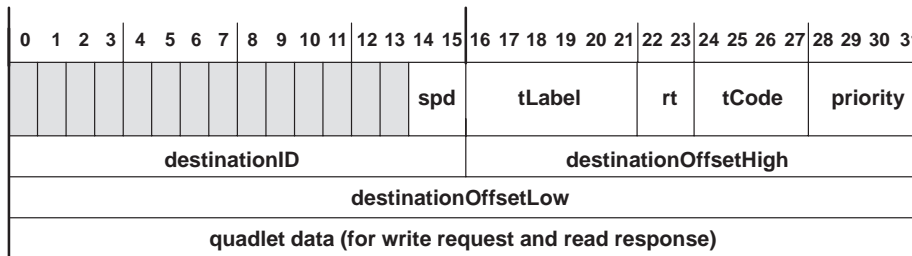


Figure 4–1. Quadlet-Transmit Format

Table 4–1. Quadlet-Transmit Format

FIELD NAME	DESCRIPTION
spd	This field indicates the speed at which this packet is to be sent. 00 = 100 Mb/s, 01 = 200 Mb/s, and 10 = 400 Mb/s, and 11 is undefined for this implementation.
tLabel	This field is the transaction label, which is a unique tag for each outstanding transaction between two nodes. This is used to pair up a response packet with its corresponding request packet.
rt	The retry code for this packet is: 00 = new, 01 = retry_X, 10 = retryA, and 11 = retryB.
tCode	tCode is the transaction code for this packet (see Table 6–10 of IEEE 1394-1995 standard).
priority	The priority level for this packet. For cable implementation, the value of the bits must be 0. For backplane implementation, see clause 5.4.1.3 and 5.4.2.1 of the IEEE 1394-1995 standard.
destinationID	This is the concatenation of the 10-bit bus number and the 6-bit node number that forms the destination node address of this packet.
destination OffsetHigh, destination OffsetLow	The concatenation of these two fields addresses a quadlet in the destination nodes address space. This address must be quadlet aligned (modulo 4).
quadlet data	For write requests and read responses, this field holds the data to be transferred. For write responses and read requests, this field is not used and should not be written into the FIFO.

#### 4.1.2 Block Transmit

The block-transmit format is shown in Figure 4–2. The first quadlet contains packet-control information. The second and third quadlets contain the 64-bit address. The first 16 bits of the fourth quadlet contains the dataLength field. This is the number of bytes of data in the packet. The remaining 16 bits represent the extended\_tCode field. (See Table 6–11 of the IEEE 1394-1995 standard for more information on extended\_tCodes.) The block data, if any, follows the extended\_tCode. Block write responses are identical to the quadlet write response and use the format described in subsection 4.1.3.

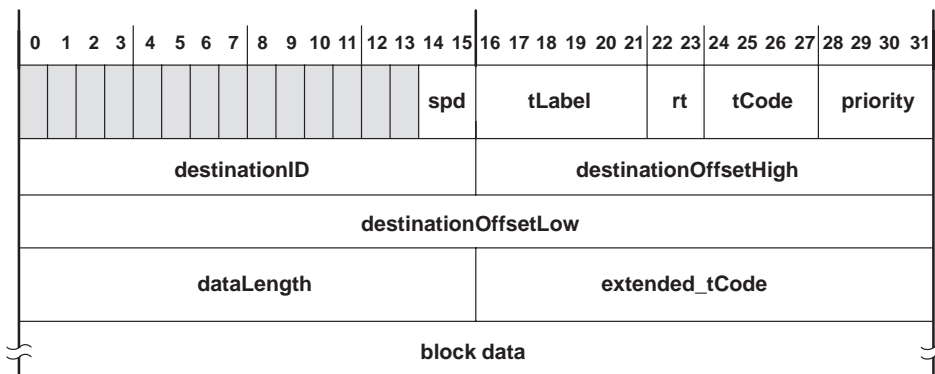


Figure 4–2. Block-Transmit Format

Table 4–2. Block-Transmit Format Functions

FIELD NAME	DESCRIPTION
spd	This field indicates the speed at which this packet is to be sent. 00 = 100 Mb/s, 01 = 200 Mb/s, and 10 = 400 Mb/s, and 11 is undefined for this implementation.
tLabel	This field is the transaction label, which is a unique tag for each outstanding transaction between two nodes. This is used to pair up a response packet with its corresponding request packet.
rt	The retry code for this packet is 00 = new, 01 = retry_X, 10 = retryA, and 11 = retryB.
tCode	tCode is the transaction code for this packet (see Table 6–10 of IEEE 1394-1995 standard).
priority	The priority level for this packet. For cable implementation, the value of the bits must be 0. For backplane implementation, see clause 5.4.1.3 and 5.4.2.1 of the IEEE 1394-1995 standard.
destinationID	This is the concatenation of the 10-bit bus number and the 6-bit node number that forms the node address to which this packet is being sent.
destination OffsetHigh, destination OffsetLow	The concatenation of these two fields addresses a quadlet in the destination node's address space. This address must be quadlet aligned (modulo 4). The upper four bits of the destination OffsetHigh field are used as the response code for lock-response packets and the remaining bits are reserved.
dataLength	The number of bytes of data to be transmitted in the packet.
extended_tCode	This field is the block extended_tCode to be performed on the data in this packet. See Table 6–11 of the IEEE 1394-1995 standard.
block data	The data to be sent. If dataLength is 0, no data should be written into the FIFO for this field. Regardless of the destination or source alignment of the data, the first byte of the block must appear in byte 0 of the first quadlet.

#### 4.1.3 Quadlet Receive

The quadlet-receive format is shown in Figure 4–3. The first 16 bits of the first quadlet contain the destination node and bus id, and the remaining 16 bits contain packet-control information. The first 16 bits of the second



quadlet contain the node and bus ID of the source, and the remaining 16 bits of the second and third quadlets contain the 48-bit, quadlet-aligned destination offset address. The fourth quadlet contains data that was used by write requests and read responses. For read requests and write responses, the quadlet data field is omitted. The last quadlet contains packet-reception status, added by the TSB12C01A.

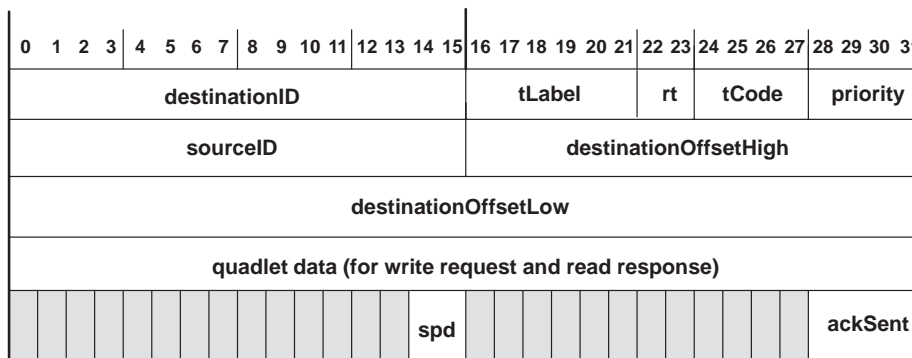


Figure 4–3. Quadlet-Receive Format

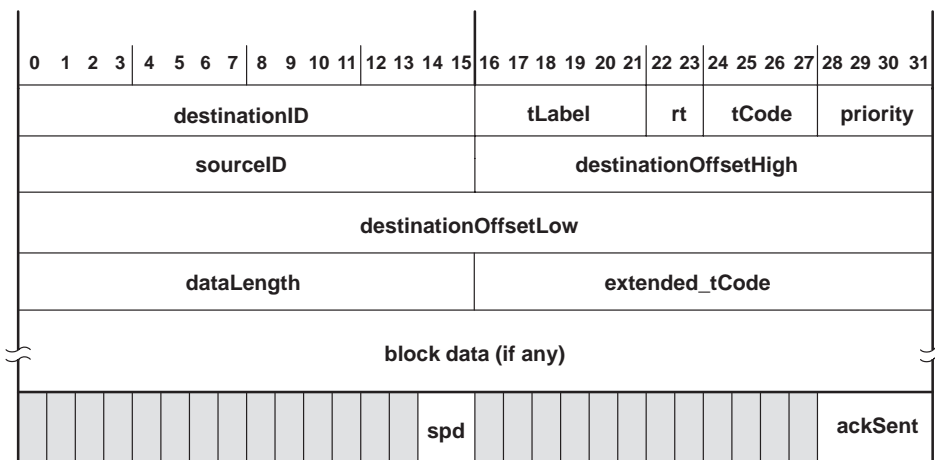
Table 4–3. Quadlet-Receive Format Functions

FIELD NAME	DESCRIPTION
destinationID	This is the concatenation of the 10-bit bus number and the 6-bit node number that forms the node address to which this packet is being sent.
tLabel	This field is the transaction label, which is a unique tag for each outstanding transaction between two nodes. This is used to pair up a response packet with its corresponding request packet.
rt	The retry code for this packet is 00 = new, 01 = retry_X, 10 = retryA, and 11 = retryB.
tCode	tCode is the transaction code for this packet. (See Table 6–10 of the IEEE 1394-1995 standard).
priority	The priority level for this packet. For cable implementation, the value of the bits must be zero. For backplane implementation, see clause 5.4.1.3 and 5.4.2.1 of the IEEE 1394-1995 standard.
sourceID	This is the node ID of the sender of this packet.
destination OffsetHigh, destination OffsetLow	The concatenation of these two fields addresses a quadlet in the destination node's address space. This address must be quadlet aligned (modulo 4). (The upper four bits of the destination OffsetHigh field are used as the response code for lock-response packets, and the remaining bits are reserved.)
quadlet data	For write requests and read responses, this field holds the transferred data. For write responses and read requests, this field is not present.
spd	This field indicates the speed at which this packet was sent. 00 = 100 Mb/s, 01 = 200 Mb/s, 10 = 400 Mb/s, and 11 is undefined for this implementation.
ackSent	This field holds the acknowledge sent by the receiver for this packet. (See Table 6–13 in the draft standard.)

#### 4.1.4 Block Receive

The block-receive format is shown in Figure 4–4. The first 16 bits of the first quadlet contain the node and bus ID of the destination node, and the last 16 bits contain packet-control information. The first 16 bits of the second quadlet contain the node and bus ID of the source node, and the last 16 bits of the second quadlet and all of the third quadlet contain the 48-bit, quadlet-aligned destination offset address. All remaining quadlets, except for the last one, contain data that is used only for write requests and read

responses. For block read requests and block write responses, the data field is omitted. The last quadlet contains packet-reception status.



**Figure 4-4. Block-Receive Format**

**Table 4-4. Block-Receive Format Functions**

FIELD NAME	DESCRIPTION
destinationID	This is the concatenation of the 10-bit bus number and the 6-bit node number that forms the node address to which this packet is being sent.
tLabel	This field is the transaction label, which is a unique tag for each outstanding transaction between two nodes. This is used to pair up a response packet with its corresponding request packet.
rt	The retry code for this packet is 00 = new, 01 = retry_X, 10 = retryA, and 11 = retryB.
tCode	tCode is the transaction code for this packet. (See Table 6-10 of the IEEE 1394-1995 standard).
priority	This field contains the priority level for this packet. For cable implementation, the value of the bits must be zero. For backplane implementation, see clause 5.4.1.3 and 5.4.2.1 of the IEEE 1394-1995 standard.
sourceID	This is the node ID of the sender of this packet.
destination OffsetHigh, destination OffsetLow	The concatenation of these two fields addresses a quadlet in the destination node's address space. This address must be quadlet aligned (modulo 4). The upper four bits of the destination OffsetHigh field are used as the response code for lock-response packets and the remaining bits are reserved.
dataLength	For write request, read responses, and locks, this field indicates the number of bytes being transferred. For read requests, this field indicates the number of bytes of data to be read. A write-response packet does not use this field. Note that the number of bytes does not include the head, only the bytes of block data.
extended_tCode	The block extended_tCode to be performed on the data in this packet. See Table 6-11 of the IEEE 1394-1995 standard.
block data	This field contains any data being transferred for this packet. Regardless of the destination address or memory alignment, the first byte of the data appears in byte 0 of the first quadlet of this field. The last quadlet of this field is padded with zeros out to four bytes, if necessary.
spd	This field indicates the speed at which this packet was sent. 00 = 100 Mb/s, 01 = 200 Mb/s, 10 = 400 Mb/s, and 11 is undefined for this implementation.
ackSent	This field holds the acknowledge sent by the receiver for this packet.

## 4.2 Isochronous Transmit (Host Bus to TSB12C01A)

The format of the isochronous-transmit packet is shown in Figure 4–5. The data for each channel must be presented to the isochronous-transmit FIFO interface in this format in the order that packets are to be sent. The transmitter sends any packets available at the isochronous-transmit interface immediately following reception or transmission of the cycle-start message.

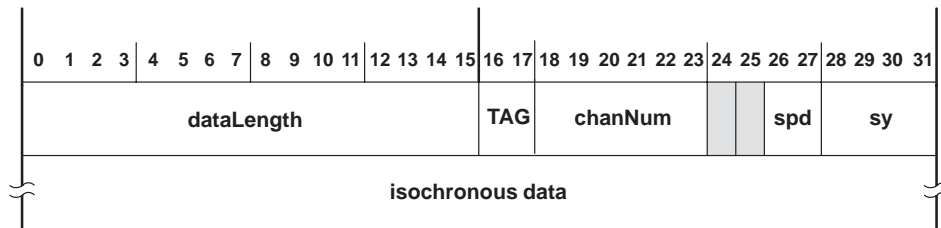


Figure 4–5. Isochronous-Transmit Format

Table 4–5. Isochronous-Transmit Functions

FIELD NAME	DESCRIPTION
dataLength	This field indicates the number of bytes in this packet
TAG	This field indicates the format of data carried by the isochronous packet (00 = formatted, 01 – 11 are reserved).
chanNum	This field carries the channel number with which this data is associated.
spd	This field contains the speed at which to send this packet.
sy	This field carries the transaction layer-specific synchronization bits.
isochronous data	This field contains the data to be sent with this packet. The first byte of data must appear in byte 0 of the first quadlet of this field. If the last quadlet does not contain four bytes of data, the unused bytes should be padded with zeros.

## 4.3 Isochronous Receive (TSB12C01A to Host Bus)

The format of the isochronous-receive data is shown in Figure 4–6. The data length, which is found in the header of the packet, determines the number of bytes in an isochronous packet.

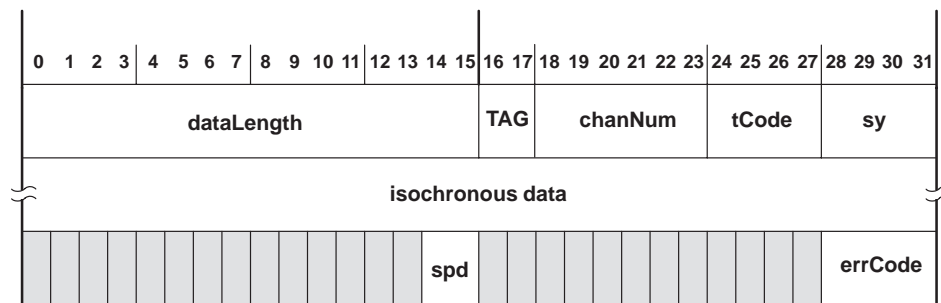


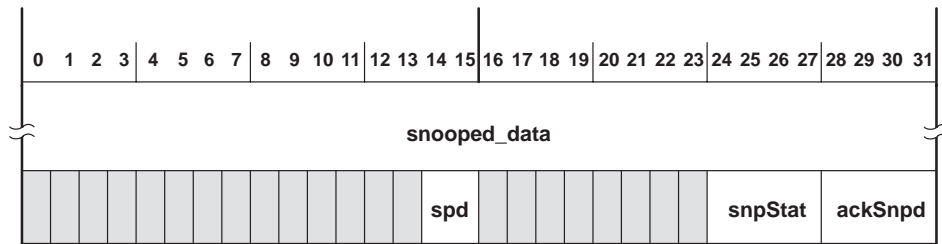
Figure 4–6. Isochronous-Receive Format

**Table 4–6. Isochronous-Receive Functions**

FIELD NAME	DESCRIPTION
dataLength	This field indicates the number of bytes in this packet
TAG	This field indicates the format of data carried by isochronous packet (00 = formatted, 01 – 11 are reserved).
chanNum	This field contains the channel number with which this data is associated
tCode	This field carries the transaction code for this packet (tCode = Ah).
sy	This field carries the transaction layer-specific synchronization bits.
isochronous data	This field has the data to be sent with this packet. The first byte of data must appear in byte 0 of the first quadlet of this field. The last quadlet should be padded with zeros.
spd	This field indicates the speed at which this packet was sent.
errCode	This field indicates whether this packet was received correctly. The possibilities are Complete, DataErr, or CRCErr and have the same encoding as the corresponding acknowledge codes.

#### 4.4 Snoop

The format of the snoop data is shown in Figure 4–7. The receiver module can be directed to receive any and all packets that pass by on the serial bus. In this mode, the receiver presents the data received to the receive-FIFO interface.



**Figure 4–7. Snoop Format**

**Table 4–7. Snoop Functions**

FIELD NAME	DESCRIPTION
snooped_data	This field contains the entire packet received or as much as could be received.
spd	This field carries the speed at which this packet was sent.
snpStat	This field indicates whether the entire packet snooped was received correctly. A value equal to the complete acknowledge code indicates complete reception. A busyA or busyB acknowledge code indicates incomplete reception.
ackSnpd	This field indicates the acknowledge seen on the bus after the packet is received.

## 4.5 CycleMark

The format of the CycleMark data is shown in Figure 4–8. The receiver module inserts a single quadlet to mark the end of an isochronous cycle. The quadlet is inserted into the receive-FIFO.

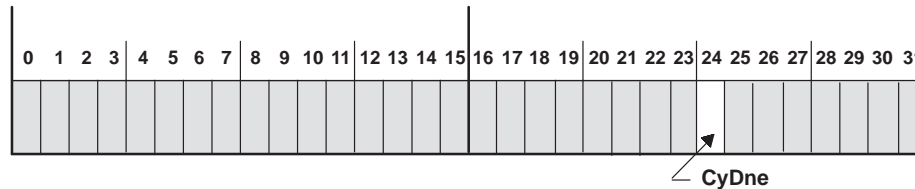


Figure 4–8. CycleMark Format

Table 4–8. CycleMark Functions

FIELD NAME	DESCRIPTION
CyDne	This field indicates the end of an isochronous cycle.

## 4.6 Phy Configuration

The format of the phy configuration packet is shown in Figure 4–9. The phy configuration packet transmit contains two quadlets, which are loaded into the ATF. The first quadlet is written to address 80h. The second quadlet is written to address 8Ch. The 00E0h in the first quadlet tells the TSB12C01A that this is the phy configuration packet. The Eh is then replaced with 0h before the packet is transmitted to the phy interface.

There is a possibility of a false header error on receipt of a phy configuration packet. If the first 16 bits of a phy configuration packet (see Figure 4–9) happen to match the destination identifier of a node (bus number and node number), the TSB12C01A on that node issues a header error since the node misinterprets the phy configuration packet as a data packet addressed to the node. The suggested solution to this potential problem is to assign bus numbers that all have the MS bit set to 1. Since the all-ones case is reserved for addressing the local bus, this leaves only 511 available unique bus identifiers. This is an artifact of the IEEE 1394-1995 standard.

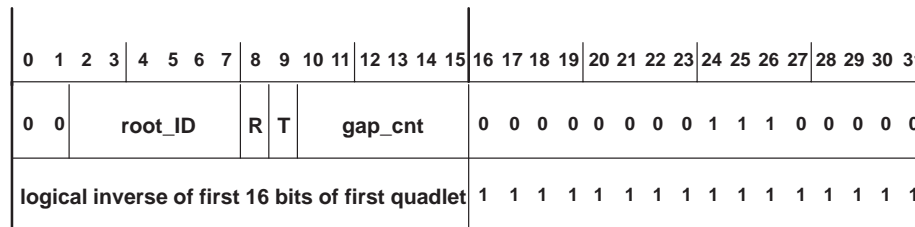


Figure 4–9. Phy Configuration Format

**Table 4–9. Phy Configuration Functions**

FIELD NAME	DESCRIPTION
00	This field is the phy configuration packet identifier.
root_ID	This field is the physical_ID of the node to have its force_root bit set (only meaningful when R is set).
R†	When R is set, the force-root bit of the node identified in root_ID is set and the force_root bit of all other nodes are cleared. When R is cleared, root_ID is ignored.
T†	When T is set, the PHY_CONFIGURATION.gap_count field of all the nodes is set to the value in the gap_cnt field.
gap_cnt	This field contains the new value for PHY_CONFIGURATION.gap_count for all nodes. This value goes into effect immediately upon receipt and remains valid after the next bus reset. After the second reset, gap_cnt is set to 63h unless a new phy configuration packet is received.

† A phy configuration packet with R = 0, and T = 0 is reserved and is ignored when received.

### 4.7 Link-On

The format of the link-on packet is shown in Figure 4–10. The link-on packet transmit contains two quadlets, which are loaded into the ATF. The first quadlet is written to address 80h. The second quadlet is written to address 8Ch. The 00E0h in the first quadlet tells the TSB12C01A that this is the link-on packet. The Eh is then replaced with 0h before the packet is transmitted to the phy interface.

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31														
0	1	root_ID						0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0													
logical inverse of first 16 bits of first quadlet																1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

**Figure 4–10. Link-On Format**

**Table 4–10. Link-On Functions**

FIELD NAME	DESCRIPTION
01	This field is the link-on packet identifier.
root_ID	This field is the physical_ID of the node to have its force_root bit set.

## 4.8 Receive Self-ID

The format of the receive self-ID packet is shown in Figure 4–11. The first quadlet is the packet header with the special tCode of Eh. The quadlets that follow are a concatenation of all received self-ID packets. The last quadlet contains the final packet status. See IEEE 1394-1995 standard, paragraph 4.3.4.1, for additional information about self-ID packets.

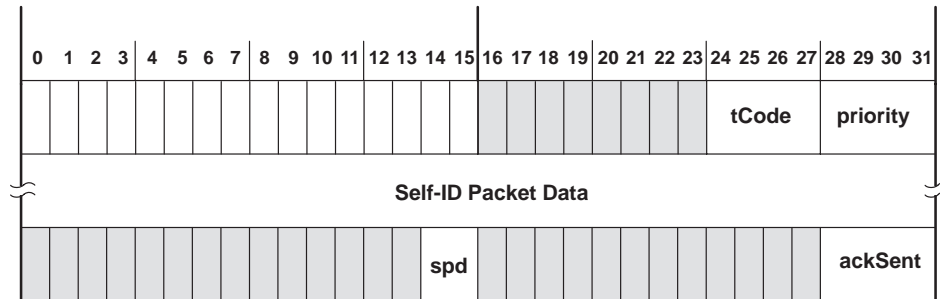


Figure 4–11. Receive Self-ID Format

Table 4–11. Isochronous-Receive Functions

FIELD NAME	DESCRIPTION
tCode	This field carries the transaction code for this packet (tCode = Eh).
priority	This field carries the priority level for this packet.
Self-ID packet data	This field contains a concatenation of all the Self-ID packets received.
spd	This field indicates the speed at which this packet was sent (00 = 100 Mbits/s, 01 = 200 Mbits/s, 10 = 400 Mbits/s, and 11 is undefined).
ackSent	This field holds the acknowledge sent by the receiver for this packet.





## 5 Electrical Characteristics

### 5.1 Absolute Maximum Ratings Over Free-Air Temperature Range (Unless Otherwise Noted)<sup>†</sup>

Supply voltage range, $V_{CC}$ (see Note 1)	−0.5 V to 6 V
Input voltage range, at any input, $V_I$	−0.5 V to $V_{CC} + 0.5$ V
Output voltage range, $V_O$	−0.5 V to $V_{CC} + 0.5$ V
Input clamp current, $I_{IK}$ ( $V_I < 0$ or $V_I > V_{CC}$ ) (see Note 2)	±20 mA
Continuous total power dissipation	See Maximum Dissipation Rating Table
Output clamp current, $I_{OK}$ ( $V_O < 0$ or $V_O > V_{CC}$ ) (see Note 3)	±20 mA
Operating free-air temperature range, $T_A$ : A suffix	0°C to 70°C
AI suffix	−40°C to 85°C
AM suffix	−55°C to 125°C
Storage temperature range, $T_{stg}$	−65°C to 150°C
Case temperature for 10 seconds, $T_C$	260°C

<sup>†</sup> Stresses beyond those listed under “absolute maximum ratings” may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under “recommended operating conditions” is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

- NOTES:
1. All voltage values are with respect to GND.
  2. This applies to all inputs.
  3. This applies to all outputs.

MAXIMUM DISSIPATION RATING TABLE<sup>‡</sup>

PACKAGE	$T_A \leq 25^\circ\text{C}$ POWER RATING	DERATING FACTOR ABOVE $T_A = 25^\circ\text{C}$	$T_A = 70^\circ\text{C}$ POWER RATING	$T_A = 85^\circ\text{C}$ POWER RATING	$T_A = 125^\circ\text{C}$ POWER RATING
PZ	2119 mW	16.9 mW/°C	1356 mW	1102 mW	—
WN	2404 mW	19.2 mW/°C	1538 mW	1250 mW	481 mW

<sup>‡</sup> Power dissipation of package based on an absolute maximum junction temperature of 150°C.

PACKAGE THERMAL CHARACTERISTICS<sup>§</sup>

PARAMETER	TEST CONDITIONS	PZ PACKAGE			WN PACKAGE			UNIT
		MIN	NOM	MAX	MIN	NOM	MAX	
$R_{\theta JA}$	Junction-to-ambient thermal impedance	Board mounted, No air flow			59			°C/W
$R_{\theta JC}$	Junction-to-case thermal impedance	13			8			°C/W

<sup>§</sup> Thermal characteristics vary depending on die and leadframe pad size as well as mold compound. These values represent typical die and pad sizes for the respective packages. The R value decreases as the die or pad sizes increases. Thermal values represent PWB bands with minimal amounts of metal.

## 5.2 Recommended Operating Conditions

		MIN	NOM	MAX	UNIT
Supply voltage, $V_{CC}$		4.75	5	5.25	V
Input voltage, $V_I$		0	$V_{CC}$		V
High-level input voltage, $V_{IH}$		2	$V_{CC}$		V
Low-level input voltage, $V_{IL}$		0		0.8	V
Clock frequency	BCLK	25			MHz
	SCLK	49.152			
Virtual junction temperature, $T_J^\dagger$	TSB12C01A	115			°C
	TSB12C01AI	125			
	TSB12C01AM	150			
Operating free-air temperature, $T_A$	TSB12C01A	0	70		°C
	TSB12C01AI	-40	85		
	TSB12C01AM	-55	125		

$^\dagger$  Actual junction temperature is a function of ambient temperature, package selection, power dissipation, and air flow. Customer is responsible for maintaining the junction temperature within the recommended operating conditions. Operating device at junction temperatures higher than what is recommended will cause device to operate outside the characterization models established during device simulation and may affect the reliability performance.

## 5.3 Electrical Characteristics Over Recommended Ranges of Supply Voltage and Operating Free-Air Temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP $^\dagger$	MAX	UNIT
$V_{OH}$	High-level output voltage	$I_{OH} = -4$ mA	$V_{CC} - 0.8$			V
$V_{OL}$	Low-level output voltage	$I_{OL} = 4$ mA			0.5	V
$V_{IT+}$	Positive-going input threshold voltage				2	V
$V_{IT-}$	Negative-going input threshold voltage		0.8			V
$I_{IL}$	Low-level input current	$V_I = \text{GND}$			-1	$\mu\text{A}$
$I_{IH}$	High-level input current	$V_I = V_{CC}$			1	$\mu\text{A}$
$I_{OZ}$	High-impedance-state output current	$V_O = V_{CC}$ or GND, See Note 4			$\pm 10$	$\mu\text{A}$
$I_{CC}$	Supply current	No load on outputs, SCLK = 49.152 MHz BCLK = 25 MHz		150		mA
$C_i$	Input capacitance	$V_{CC} = 5$ V, $T_A = 25^\circ\text{C}$	PZ package input terminals	5		pF
			WN package input terminals	6		
			PZ package bidirectional terminals	13		
			WN package bidirectional terminals	7		
$C_o$	Output capacitance		PZ package	8		pF
			WN package	7		

$^\dagger$  All typical values are at  $V_{CC} = 5$  V and  $T_A = 25^\circ\text{C}$ .

NOTE 4: All outputs are in the high-impedance state.

#### 5.4 Host-Interface Timing Requirements, $T_A = 25^\circ\text{C}$ (see Note 5)

PARAMETER		MIN	MAX	UNIT
$t_{c1}$	Cycle time, BCLK (see Figure 6–1)	30	111	ns
$t_{w1(H)}$	Pulse duration, BCLK high (see Figure 6–1)	10		ns
$t_{w1(L)}$	Pulse duration, BCLK low (see Figure 6–1)	10		ns
$t_{su1}$	Setup time, DATA0 – DATA31 valid before BCLK $\uparrow$ (see Figure 6–2)	4		ns
$t_{h1}$	Hold time, DATA0 – DATA31 invalid after BCLK $\uparrow$ (see Figure 6–2)	2		ns
$t_{su2}$	Setup time, ADDR0 – ADDR7 valid before BCLK $\uparrow$ (see Figures 6–2 and 6–3)	12		ns
$t_{h2}$	Hold time, ADDR0 – ADDR7 invalid after BCLK $\uparrow$ (see Figures 6–2 and 6–3)	2		ns
$t_{su3}$	Setup time, $\overline{CS}\downarrow$ before BCLK $\uparrow$ (see Figures 6–2 and 6–3)	12		ns
$t_{h3}$	Hold time, $\overline{CS}\uparrow$ after BCLK $\uparrow$ (see Figures 6–2 and 6–3)	2		ns
$t_{su4}$	Setup time, $\overline{WR}$ valid before BCLK $\uparrow$ (see Figures 6–2 and 6–3)	12		ns
$t_{h4}$	Hold time, $\overline{WR}$ invalid after BCLK $\uparrow$ (see Figures 6–2 and 6–3)	2		ns

NOTE 5: These parameters are not production tested.

#### 5.5 Host-Interface Switching Characteristics Over Operating Free-Air Temperature Range of $0^\circ\text{C}$ to $70^\circ\text{C}$ , $C_L = 45\text{ pF}$ (unless otherwise noted)

PARAMETER		MIN	MAX	UNIT
$t_{d1}$	Delay time, BCLK $\uparrow$ to $\overline{CA}\downarrow$ (see Figure 6–2)	4	16	ns
$t_{d2}$	Delay time, BCLK $\uparrow$ to $\overline{CA}\uparrow$ (see Figure 6–2)	4	16	ns
$t_{d3}$	Delay time, BCLK $\uparrow$ to DATA0 – DATA31 valid (see Figure 6–3 and Note 5)	4	24	ns
$t_{d4}$	Delay time, BCLK $\uparrow$ to DATA0 – DATA31 invalid (see Figure 6–3 and Note 5)	4	24	ns

NOTE 5: These parameters are not production tested.

#### 5.6 Phy-Interface Timing Requirements Over Operating Free-Air Temperature Range of $0^\circ\text{C}$ to $70^\circ\text{C}$ (see Note 5)

PARAMETER		MIN	MAX	UNIT
$t_{c2}$	Cycle time, SCLK (see Figure 6–4)	20.24	20.45	ns
$t_{w2(H)}$	Pulse duration, SCLK high (see Figure 6–4)	9		ns
$t_{w2(L)}$	Pulse duration, SCLK low (see Figure 6–4)	9		ns
$t_{su5}$	Setup time, D0 – D7 valid before SCLK $\uparrow$ (see Figure 6–6)	6		ns
$t_{h5}$	Hold time, D0 – D7 invalid after SCLK $\uparrow$ (see Figure 6–6)	1		ns
$t_{su6}$	Setup time, CTL0 – CTL1 valid before SCLK $\uparrow$ (see Figure 6–6)	6		ns
$t_{h6}$	Hold time, CTL0 – CTL1 invalid after SCLK $\uparrow$ (see Figure 6–6)	1		ns

NOTE 5: These parameters are not production tested.

**5.7 Phy-Interface Switching Characteristics Over Operating Free-Air Temperature Range of 0°C to 70°C, C<sub>L</sub> = 45 pF (unless otherwise noted) (see Note 5)**

PARAMETER		MIN	MAX	UNIT
t <sub>d5</sub>	Delay time, SCLK↑ to D0 – D7 valid (see Figure 6–5)	3	14	ns
t <sub>d6</sub>	Delay time, SCLK↑ to D0 – D7↑↓ (see Figure 6–5)	3	14	ns
t <sub>d7</sub>	Delay time, SCLK↑ to D0 – D7 invalid (see Figure 6–5)	3	14	ns
t <sub>d8</sub>	Delay time, SCLK↑ to CTL0 – CTL1 valid (see Figure 6–5)	3	14	ns
t <sub>d9</sub>	Delay time, SCLK↑ to CTL0 – CTL1↑↓ (see Figure 6–5)	3	14	ns
t <sub>d10</sub>	Delay time, SCLK↑ to CTL0 – CTL1 invalid (see Figure 6–5)	3	14	ns
t <sub>d11</sub>	Delay time, SCLK↑ to LREQ↑↓ (see Figure 6–7)	3	14	ns

NOTE 5: These parameters are not production tested.

**5.8 Miscellaneous Timing Requirements Over Operating Free-Air Temperature Range of 0°C to 70°C (see Figure 6–9 and Note 5)**

PARAMETER		MIN	MAX	UNIT
t <sub>c3</sub>	Cycle time, CYCLEIN	124.99	125.01	μs
t <sub>w3(H)</sub>	Pulse duration, CYCLEIN↑	62		μs
t <sub>w3(L)</sub>	Pulse duration, CYCLEIN↓	62		μs

NOTE 5: These parameters are not production tested.

**5.9 Miscellaneous Signal Switching Characteristics Over Operating Free-Air Temperature Range of 0°C to 70°C (see Note 5)**

PARAMETER		MIN	MAX	UNIT
t <sub>d12</sub>	Delay time, SCLK↑ to $\overline{\text{INT}}\downarrow$ (see Figure 6–8)	4	18	ns
t <sub>d13</sub>	Delay time, SCLK↑ to $\overline{\text{INT}}\uparrow$ (see Figure 6–8)	4	18	ns
t <sub>d14</sub>	Delay time, SCLK↑ to CYCLEOUT↑ (see Figure 6–10)	4	16	ns
t <sub>d15</sub>	Delay time, SCLK↑ to CYCLEOUT↓ (see Figure 6–10)	4	16	ns

NOTE 5: These parameters are not production tested.

## 6 Parameter Measurement Information

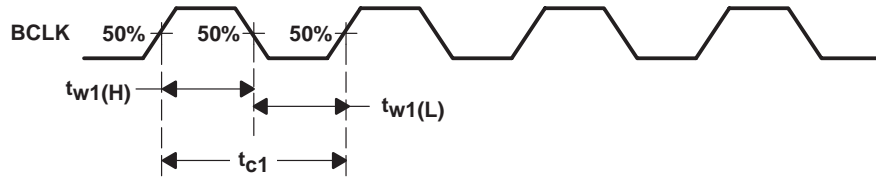
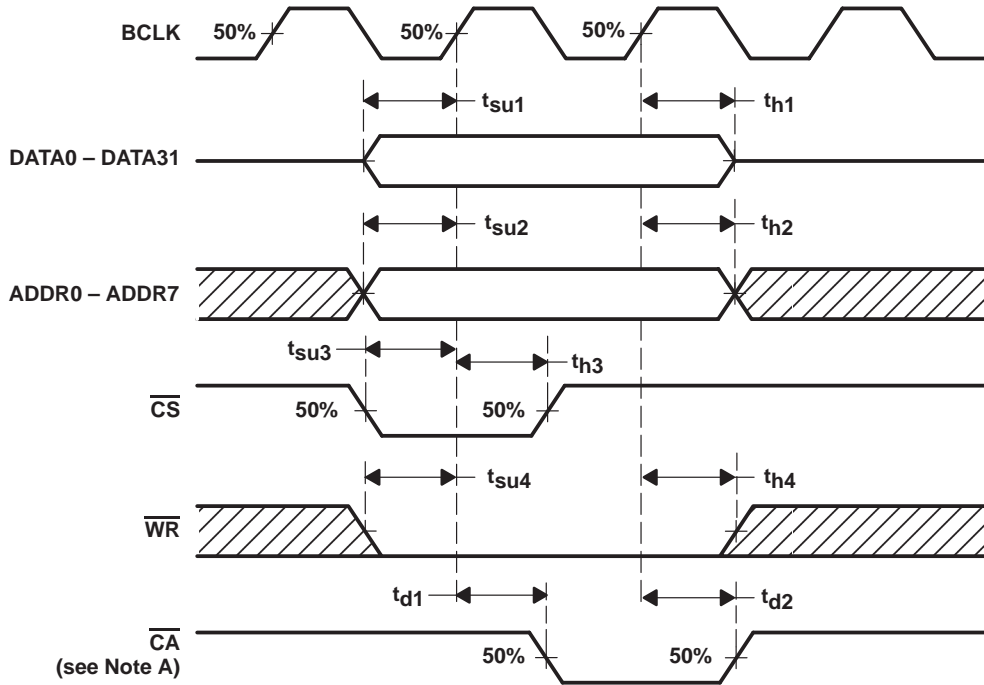
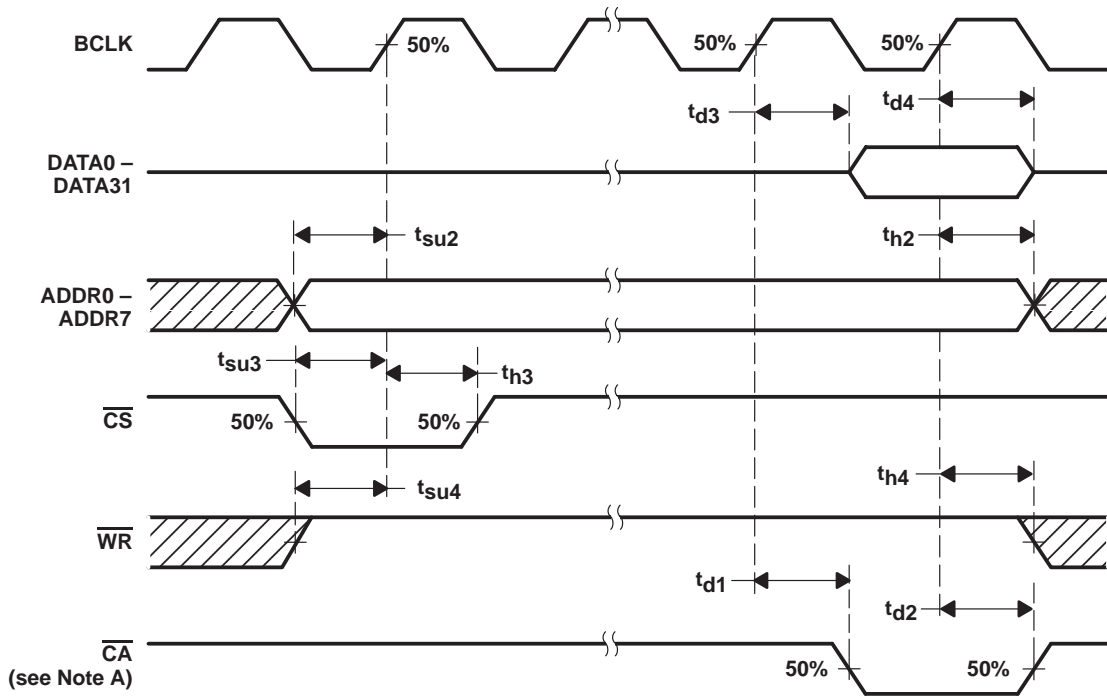


Figure 6-1. BCLK Waveform



NOTE A: When back-to-back write cycles are done, a maximum of 9 BCLK cycles may be required after the falling edge of  $\overline{CS}$  before  $\overline{CA}$  is asserted (low). DATA0 – DATA31, ADDR0 – ADDR7, and  $\overline{WR}$  need to remain valid until  $\overline{CA}$  is asserted (low). These cycles are to synchronize data passing between the BCLK and SCLK clock domains.

Figure 6-2. Host-Interface Write-Cycle Waveforms



NOTE A: When back-to-back read cycles are done, a maximum of 9 BCLK cycles may be required after the falling edge of  $\overline{CS}$  and before  $\overline{CA}$  is asserted (low). ADDR0 – ADDR7 and  $\overline{WR}$  need to remain valid until  $\overline{CA}$  is asserted (low).

Figure 6–3. Host-Interface Read-Cycle Waveforms

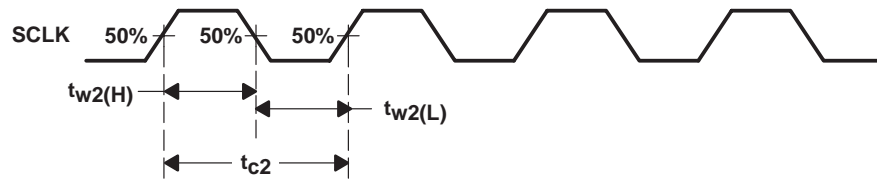


Figure 6–4. SCLK Waveform

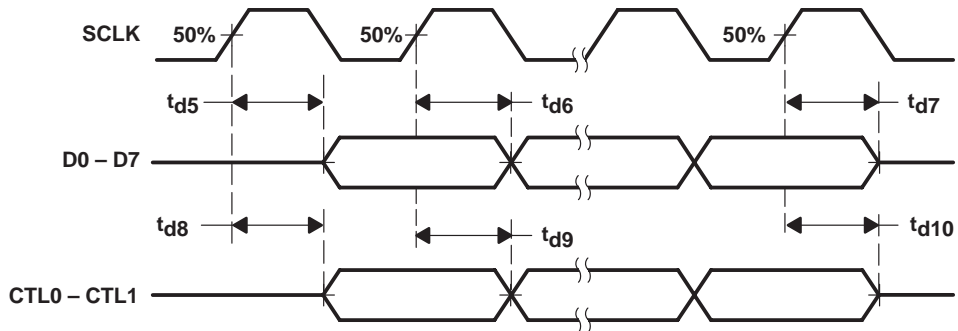


Figure 6–5. TSB12C01A-to-Phy-Layer Transfer Waveforms

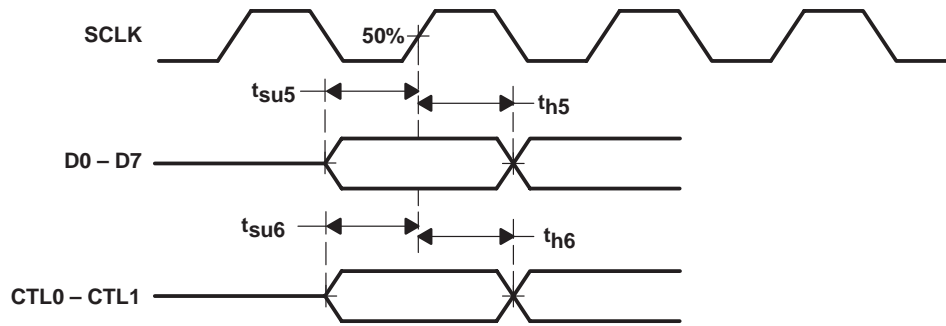


Figure 6-6. Phy Layer-to-TSB12C01A Transfer Waveforms



Figure 6-7. TSB12C01A Link-Request-to-Phy-Layer Waveforms

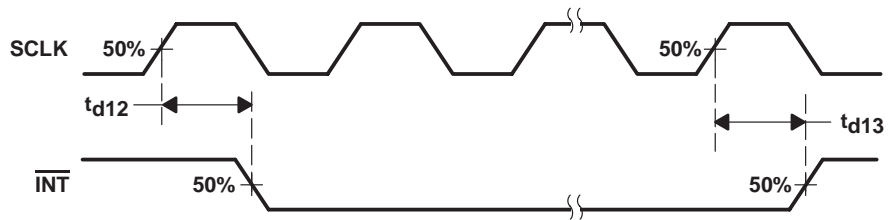


Figure 6-8. Interrupt Waveform

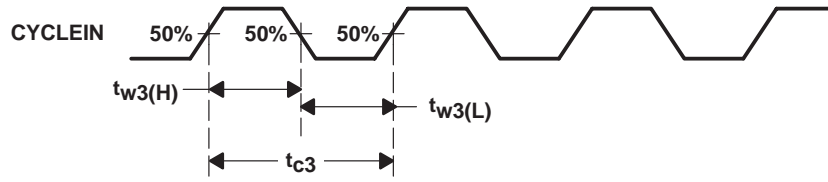


Figure 6–9. CYCLEIN Waveform

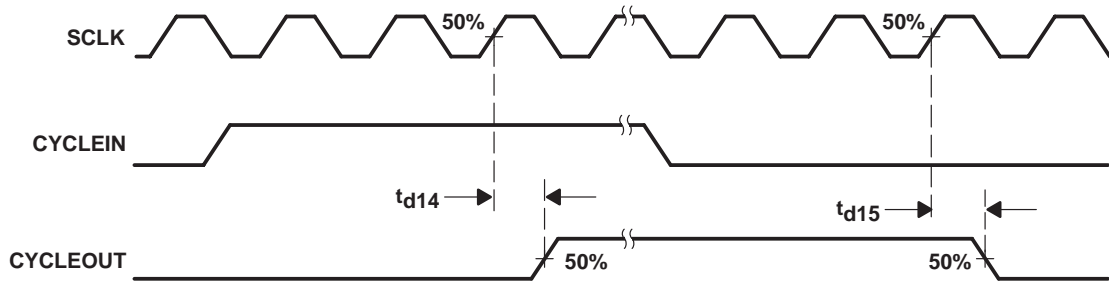


Figure 6–10. CYCLEIN and CYCLEOUT Waveforms



## 7 TSB12C01A to 1394 Phy Interface Specification

### 7.1 Introduction

This chapter provides an overview of a TSB12C01A to the phy interface. The information that follows can be used as a guide through the process of connecting the TSB12C01A to a 1394 physical-layer device. The part numbers referenced, the TSB11C01 and the TSB12C01A, represent the Texas Instruments implementation of the phy (TSB11C01) and link (TSB12C01A) layers of the IEEE 1394-1995 standard.

The specific details of how the TSB11C01 device operates is not discussed in this document. Only those parts that relate to the TSB12C01A phy-link interface are mentioned.

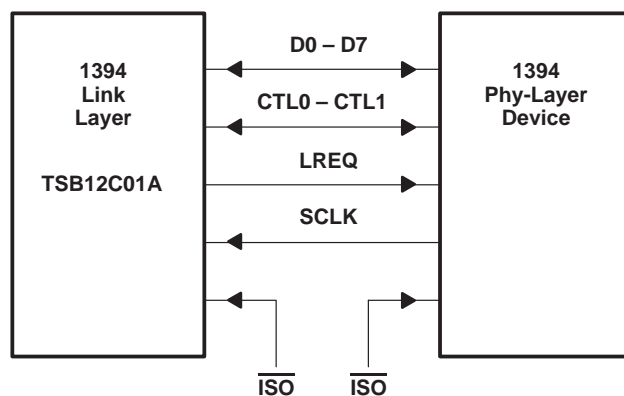
### 7.2 Assumptions

The TSB12C01A is capable of supporting 100 Mb/s, 200 Mb/s and 400 Mb/s phy-layer devices. For that reason, this document describes an interface to a 400-Mb/s (actually 393.216-Mb/s) device. To support lower-speed phy layers, adjust the width of the data bus by two terminals per 100 Mb/s. For example, for 100-, 200- and 400-Mb/s devices, the data bus is 2, 4, and 8 bits wide respectively. The width of the CTL bus and the clock rate between the devices, however, does not change regardless of the transmission speed that is used.

Finally, the 1394 phy layer has control of all bidirectional terminals that run between the phy layer and TSB12C01A. The TSB12C01A can drive these terminals only after it has been given permission by the phy layer. A dedicated request terminal (LREQ) is used by the TSB12C01A for any activity that the designer wishes to initiate.

### 7.3 Block Diagram

The functional block diagram of the TSB12C01A to phy layer is shown in Figure 7–1.



NOTE A: See Table 2–2 for signal definition.

Figure 7–1. Functional Block Diagram of the TSB12C01A to Phy Layer

### 7.4 Operational Overview

The four operations that can occur in the phy-link interface are request, status, transmit, and receive. With the exception of the request operation, all actions are initiated by the phy layer.

The CTL0 – CTL1 bus is encoded as shown in the following sections.

### 7.4.1 Phy Interface Has Control of the Bus

**Table 7–1. Phy Interface Control of Bus Functions**

CTL0,CTL1	NAME	DESCRIPTION OF ACTIVITY
00	Idle	No activity is occurring (this is the default mode).
01	Status	Status information is being sent from the phy layer to the TSB12C01A.
10	Receive	An incoming packet is being sent from the phy layer to the TSB12C01A.
11	Transmit	The TSB12C01A has been given control of the bus to send an outgoing packet.

### 7.4.2 TSB12C01A Has Control of the Bus

The TSB12C01A has control of the bus after receiving permission from the phy layer.

**Table 7–2. TSB12C01A Control of Bus Functions**

CTL0, CTL1	NAME	DESCRIPTION OF ACTIVITY
00	Idle	The TSB12C01A releases the bus (transmission has been completed).
01	Hold	The TSB12C01A is holding the bus while data is being prepared for transmission, or the TSB12C01A wants to send another packet without arbitration.
10	Transmit	An outgoing packet is being sent from the TSB12C01A to phy layer.
11	Reserved	None

## 7.5 Request

A serial stream of information is sent across the LREQ terminal whenever the TSB12C01A needs to request the bus or access a register that is located in the phy layer. The size of the stream varies depending on whether the transfer is a bus request, a read command, or a write command. Regardless of the type of transfer, a start bit of 1 is required at the beginning of the stream and a stop bit of 0 is required at the end of the stream.

**Table 7–3. Request Functions**

NUMBER of BITS	NAME
7	Bus Request
9	Read Register Request
17	Write Register Request

### 7.5.1 LREQ Transfer

The definition of the bits in the three different types of transfers are shown in Table 7–4.

#### 7.5.1.1 TSB12C01A Bus Request

**Table 7–4. Bus-Request Functions (Length of Stream: 7 Bits)**

BIT(S)	NAME	DESCRIPTION
0	Start Bit	Start bit indicates the beginning of the transfer (always set).
1–3	Request Type	Request type indicates the type of bus request (see Table 7–7 for the encoding of this field).
4–5	Request Speed	Request speed indicates the speed at which the phy interface sends the packet for this particular request (see Table 7–8 for the encoding of this field).
6	Stop Bit	Stop bit indicates the end of the transfer (always cleared).

### 7.5.1.2 TSB12C01A Read-Register Request

**Table 7-5. Read-Register Request Functions (Length of Stream: 9 Bits)**

BIT(S)	NAME	DESCRIPTION
0	Start Bit	Start bit indicates the beginning of the transfer (always set).
1-3	Request Type	Request type indicates the type of request function (see Table 7-7 for the encoding of this field).
4-7	Address	These bits contain the address of the phy register to be read.
8	Stop Bit	Stop bit indicates the end of the transfer (always cleared).

### 7.5.1.3 TSB12C01A Write-Register Request

**Table 7-6. Write-Register Request (Length of Stream: 17 Bits)**

BIT(S)	NAME	DESCRIPTION
0	Start Bit	Start bit indicates the beginning of the transfer (always set).
1-3	Request Type	Request type indicates the type of request (see Table 7-7 for the encoding of this field).
4-7	Address	These bits contain the address of the phy register to be written to.
8-15	Data	These bits contain the data that is to be written to the specified register address.
16	Stop Bit	Stop bit indicates the end of the transfer (always cleared).

### 7.5.1.4 Request-Type Field for TSB12C01A Request

**Table 7-7. TSB12C01A Request Functions**

LREQ1 – LREQ3	NAME	DESCRIPTION
000	TakeBus	Immediate request. Upon detection of an idle, take control of the bus immediately (no arbitration) for asynchronous packet ACK response.
001	IsoReq	Isochronous request. IsoReq arbitrates for control of the bus after an isochronous gap.
010	PriReq	Priority request. PriReq arbitrates for control of the bus after a fair gap and ignores fair protocol.
011	FairReq	Fair request. FairReq arbitrates for control of the bus after a fair gap and uses fair protocol.
100	RdReg	Read request. RdReg returns the specified register contents through a status transfer.
101	WrReg	Write request. WrReg writes to the specified register.
110, 111	Reserved	Reserved

### 7.5.1.5 Request-Speed Field for TSB12C01A Request

**Table 7-8. TSB12C01A Request-Speed Functions**

LREQ4, LREQ5	DATA RATE
00	100 Mb/s
01	200 Mb/s
10	400 Mb/s
11	Reserved

### 7.5.2 Bus Request

For fair or priority access, the TSB12C01A requests control of the bus at least one clock after the TSB12C01A phy interface becomes idle  $CTL0 - CTL1 = 00$ , which indicates the physical layer is in an idle state. If the TSB12C01A senses that  $CTL0 - CTL1 = 10$ , then it knows that its request has been lost. This is true any time during or after the TSB12C01A sends the bus request transfer. Additionally, the phy interface ignores any fair or priority requests when it asserts the receive state while the TSB12C01A is requesting the bus. The link then reissues the request one clock after the next interface idle.

The cycle master uses a normal priority request to send a cycle-start message. After receiving a cycle start, the TSB12C01A can issue an isochronous bus request. When arbitration is won, the TSB12C01A proceeds with the isochronous transfer of data. The isochronous request is cleared in the phy interface once the TSB12C01A sends another type of request or when the isochronous transfer has been completed.

The TakeBus request is issued when the TSB12C01A needs to send an acknowledgment after reception of a packet addressed to it. This request must be issued during packet reception. This is done to minimize the delay times that a phy interface would have to wait between the end of a packet reception and the transmittal of an acknowledgment. As soon as the packet ends, the phy interface immediately grants access of the bus to the TSB12C01A. The TSB12C01A sends an acknowledgment to the sender unless the header CRC of the packet turns out to be invalid. In this case, the TSB12C01A releases the bus immediately; it is not allowed to send another type of packet on this grant. To ensure this, the TSB12C01A is forced to wait 160 ns after the end of the packet is received. The phy interface then gains control of the bus and the acknowledge with the CRC error sent. The bus is then released and allowed to proceed with another request.

Although highly improbable, it is conceivable that two separate nodes believe that an incoming packet is intended for them. The nodes then issue a TakeBus request before checking the CRC of the packet. Since both phys seize control of the bus at the same time, a temporary, localized collision of the bus occurs somewhere between the competing nodes. This collision would be interpreted by the other nodes on the network as being a ZZ line state, not a bus reset. As soon as the two nodes check the CRC, the mistaken node drops its request and the false line state is removed. The only side effect is the loss of the intended acknowledgment packet (this is handled by the higher layer protocol).

### 7.5.3 Read/Write Requests

When the TSB12C01A requests to read the specified register contents, the phy interface sends the contents of the register to the TSB12C01A through a status transfer. When an incoming packet is received while the phy interface is transferring status information to the TSB12C01A, the phy interface continues to attempt to transfer the contents of the register until it is successful.

For write requests, the phy interface loads the data field into the appropriately addressed register as soon as the transfer has been completed. The TSB12C01A is allowed to request read or write operations at any time.

See Section 7.6, for a more detailed description of the status transfer.

## 7.6 Status

A status transfer is initiated by the phy interface when it has some status information to transfer to the TSB12C01A. The transfer is initiated by asserting the following:  $CTL0 - CTL1 = 01$  and  $D0 - D1$  are used to transmit the status data; see Table 7-9 for status-request functions.  $D2 - D7$  are not used for status transfers.

The status transfer can be interrupted by an incoming packet from another node. When this occurs, the phy interface attempts to resend the status information after the packet has been acted upon. The phy interface continues to attempt to complete the transfer until the information has been successfully transmitted.

#### NOTE:

There must be at least one idle cycle between consecutive status transfers.

### 7.6.1 Status Request

The definition of the bits in the status transfer is shown in Table 7–9.

**Table 7–9. Status-Request Functions (Length of Stream: 16 Bits)**

BIT(s)	NAME	DESCRIPTION
0	Arbitration Reset Gap	The arbitration-reset gap bit indicates that the phy interface has detected that the bus has been idle for an arbitration reset gap time (this time is defined in the IEEE 1394-1995 standard). This bit is used by the TSB12C01A in its busy/retry state machine.
1	Fair Gap	The fair-gap bit indicates that the phy interface has detected that the bus has been idle for a fair-gap time (this time is defined in the IEEE 1394-1995 standard). This bit is used by the TSB12C01A to detect the completion of an isochronous cycle.
2	Bus Reset	The bus reset bit indicates that the phy interface has entered the bus reset state.
3	phy Interrupt	The phy interrupt bit indicates that the phy interface is requesting an interrupt to the host.
4–7	Address	The address bits hold the address of the phy register whose contents are transferred to the TSB12C01A.
8–15	Data	The data bits hold the data that is to be sent to the TSB12C01A.

Normally, the phy interface sends just the first four bits of data to the TSB12C01A. These bits are used by the TSB12C01A state machine. However, if the TSB12C01A initiates a read request (through a request transfer), then the phy interface sends the entire status packet to the TSB12C01A. Additionally, the phy interface sends the contents of the register to the TSB12C01A when it has some important information to pass on. Currently, the only condition where this occurs is after the self-identification process when the phy interface needs to inform the TSB12C01A of its new node address (physical ID register).

There may be times when the phy interface wants to start a second status transfer. The phy interface first has to wait at least one clock cycle with the CTL lines idle before it can begin a second transfer.

### 7.6.2 Transmit

When the TSB12C01A wants to transmit information, it first requests access to the bus through an LREQ signal. Once the phy interface receives this request, it arbitrates to gain control of the bus. When the phy interface wins ownership of the serial bus, it grants the bus to the TSB12C01A by asserting the transmit state on the CTL terminals for at least one SCLK cycle. The TSB12C01A takes control of the bus by asserting either hold or transmit on the CTL lines. Hold is used by the TSB12C01A to keep control of the bus when it needs some time to prepare the data for transmission. The phy interface keeps control of the bus for the TSB12C01A by asserting a data-on state on the bus. It is not necessary for the TSB12C01A to use hold when it is ready to transmit as soon as bus ownership is granted.

When the TSB12C01A is prepared to send data, it asserts transmit on the CTL lines as well as sends the first bits of the packet on the D0 – D7 lines (assuming 400 Mb/s). The transmit state is held on the CTL terminals until the last bits of data have been sent. The TSB12C01A then asserts idle on the CTL lines for one clock cycle after which it releases control of the interface.

However, there are times when the TSB12C01A needs to send another packet without releasing the bus. For example, the TSB12C01A may want to send consecutive isochronous packets or it may want to attach a response to an acknowledgment. To do this, the TSB12C01A asserts hold instead of idle when the first packet of data has been completely transmitted. Hold, in this case, informs the phy interface that the TSB12C01A needs to send another packet without releasing control of the bus. The phy interface then waits a set amount of time before asserting transmit. The TSB12C01A can then proceed with the transmittal of the second packet. After all data has been transmitted and the TSB12C01A has asserted idle on the CTL terminals, the phy interface asserts its own idle state on the CTL lines. When sending multiple packets in this fashion, it is required that all data be transmitted at the same speed. This is required because the transmission speed is set during arbitration, and since the arbitration step is skipped, there is no way of informing the network of a change in speed.

### 7.6.3 Receive

When data is received by the phy interface from the serial bus, it transfers the data to the TSB12C01A for further processing. The phy interface asserts receive on the CTL lines and is set to 1 on each D terminal. The phy interface indicates the start of the packet by placing the speed code on the data bus (see the following note). The phy interface then proceeds with the transmittal of the packet to the TSB12C01A on the D lines while still keeping the receive status on the CTL terminals. Once the packet has been completely transferred, the phy interface asserts idle on the CTL terminals that completes the receive operation.

**NOTE:**

The speed code sent is a phy-TSB12C01A protocol and not included in the packets CRC calculation.

SPD = Speed code  
D0 => Dn = Packet data

**Table 7–10. Speed Code for Receive**

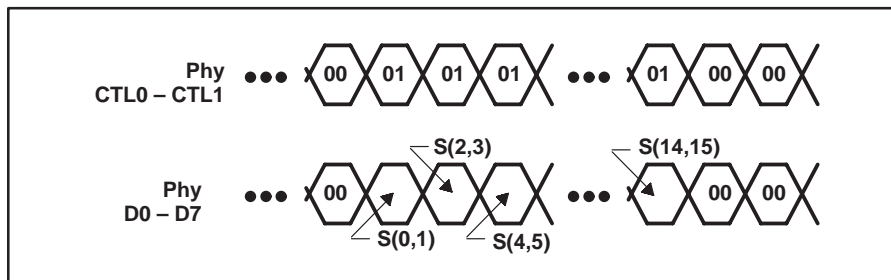
D0 – D7	DATA RATE
00xxxxx†	100 Mb/s
0100xxxx†	200 Mb/s
01010000	400 Mb/s
11111111	Data-on indication

† The x means transmitted as 0 and ignored by phy layer.

### 7.7 TSB12C01A to Phy Bus Timing

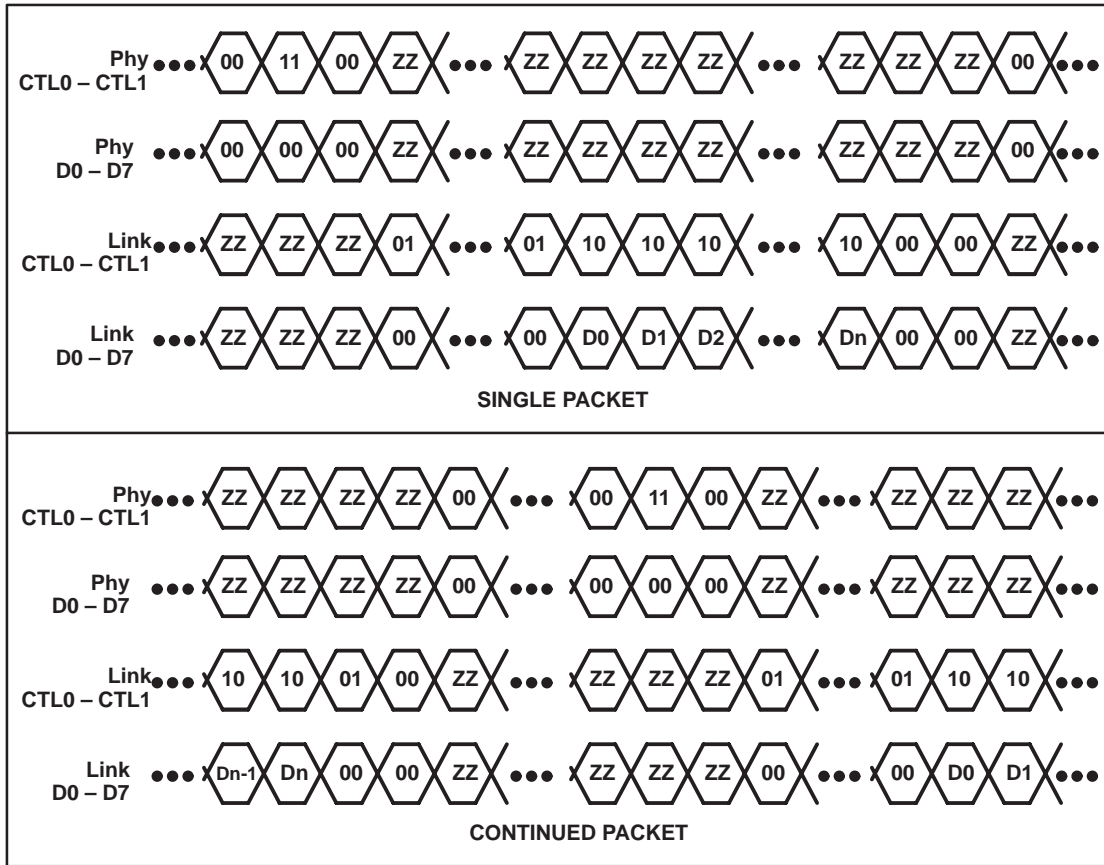


**Figure 7–2. LREQ Timing**



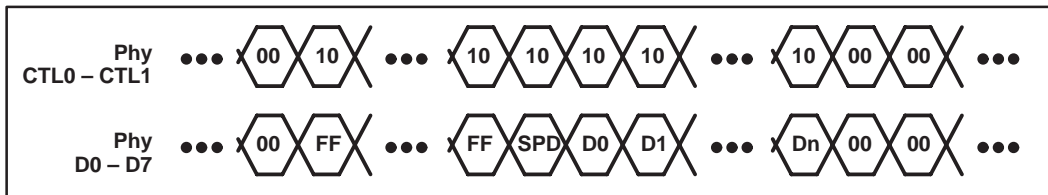
NOTE A: Each cell represents one SCLK sample time.

**Figure 7–3. Status-Transfer Timing**



NOTE A: ZZ = high-impedance state, D0 – Dn = packet data

**Figure 7-4. Transmit Timing**



**Figure 7-5. Receiver Timing**

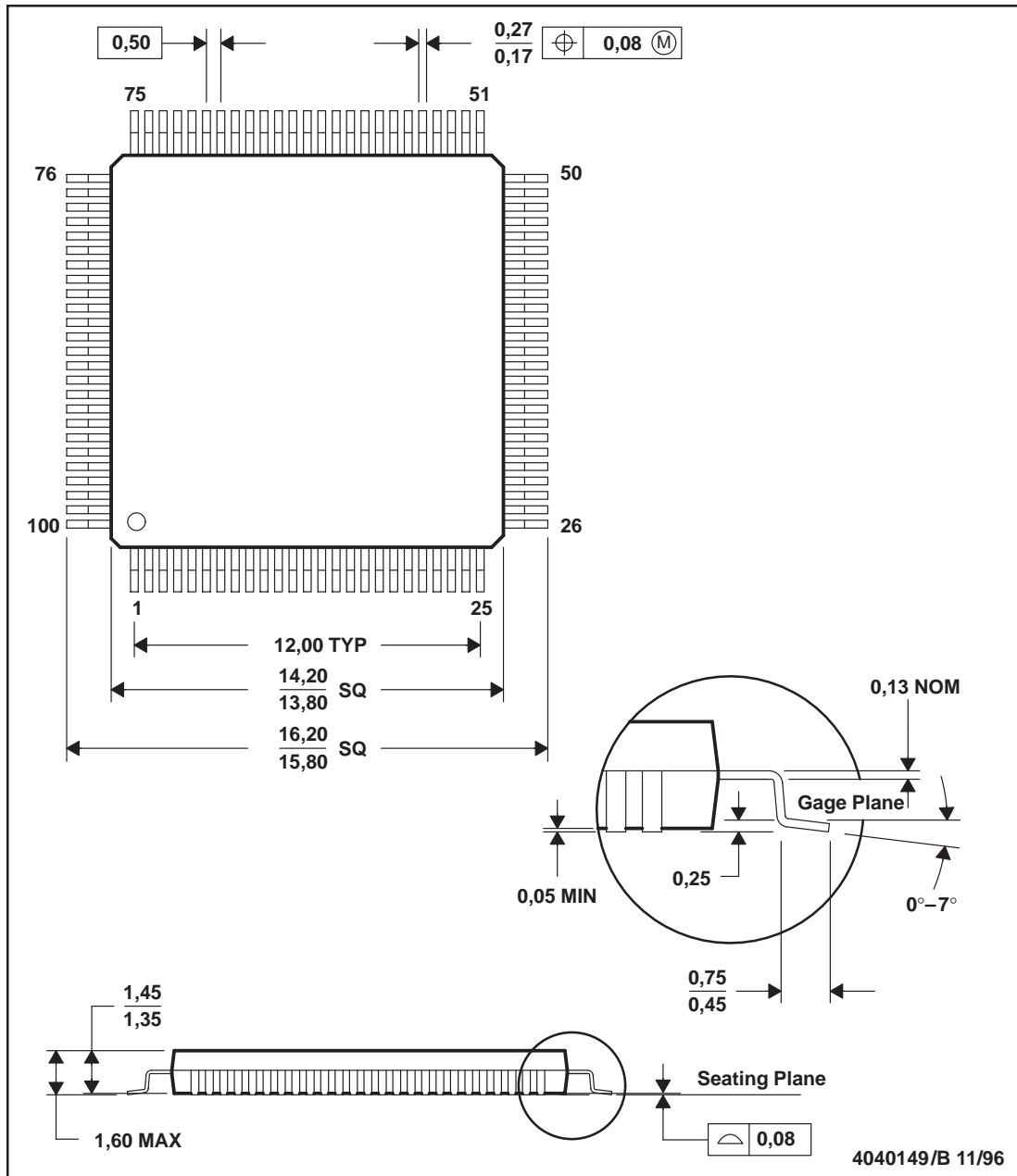




## 8 Mechanical Data

PZ (S-PQFP-G100)

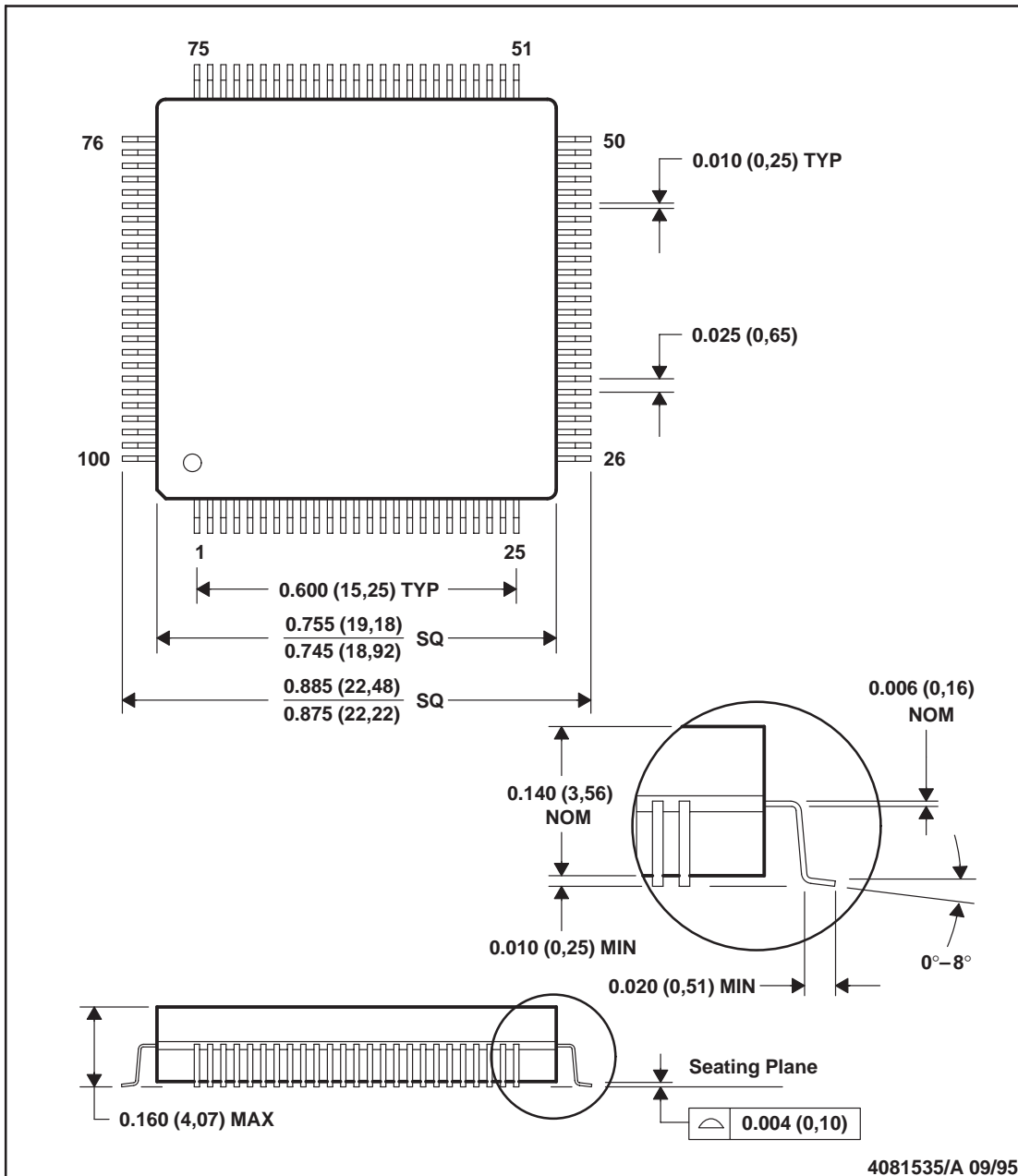
PLASTIC QUAD FLATPACK



- NOTES: A. All linear dimensions are in millimeters.  
 B. This drawing is subject to change without notice.  
 C. Falls within JEDEC MS-026

WN (R-GQFP-G100)

CERAMIC QUAD FLATPACK



NOTES: A. All linear dimensions are in inches (millimeters).  
B. This drawing is subject to change without notice.

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## TSB12C01A, High Performance 5V Link Layer with 32-bit host I/F, 2K FIFOs

Device Status: Active

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Parameter Name	TSB12C01A
Supply Voltage(s) (V)	5
Speed (max) (Mbps)	400
FIFO (kb)	2

### Description

The TSB12C01A is an IEEE 1394-1995 standard (from now on referred to only as 1394) high-speed serial-bus link-layer controller that allows for easy integration into an I/O subsystem. The TSB12C01A transmits and receives correctly formatted 1394 packets and generates and inspects the 32-bit cyclic redundancy check (CRC). The TSB12C01A is capable of being a cycle master and supports reception of isochronous data on two channels. It interfaces directly to the TSB11C01, TSB11LV01, and TSB21LV03 physical-layer chips and can support bus speeds of 100, 200, and 400 Mb/s. The TSB12C01A has a generic 32-bit host bus interface, which makes connection to most 32-bit host buses very simple. The TSB12C01A has software-adjustable FIFOs for optimal FIFO size and performance characterization and allows for variable-size asynchronous-transmit FIFO (ATF), isochronous-transmit FIFO (ITF), and general-receive FIFO (GRF).

This document is not intended to serve as a tutorial on 1394; users should refer to the IEEE 1394-1995 serial bus for detailed information regarding the 1394 high-speed serial bus.

### Features

- 1.2.1 Link
  - Complies With IEEE 1394-1995 Standard
  - Transmits and Receives Correctly Formatted 1394 Packets
  - Supports Isochronous Data Transfer
  - Performs Function of Cycle Master
  - Generates and Checks 32-Bit CRC
  - Detects Lost Cycle-Start Messages
  - Contains Asynchronous, Isochronous, and General-Receive FIFOs
- 1.2.2 Physical-Link Interface
  - Interfaces Directly to the TSB11C01, TSB11LV01, TSB14C01, and TSB21LV03 Phy Chips
  - Supports Speeds of 100, 200, and 400 Mb/s
  - Implements the Physical-Link Interface Described in Annex J of the IEEE 1394-1995 Standard
  - Supports TI Bus Holder Isolation External Implementation
- 1.2.3 Host Bus Interface
  - Provides Chip Control With Directly Addressable Registers
  - Is Interrupt Driven to Minimize Host Polling
  - Has a Generic 32-Bit Host Bus Interface
- 1.2.4 General
  - Requires a Single 5-V  $\pm 5\%$  Power Supply
  - Manufactured with Low-Power CMOS Technology
  - Packaged in a 100-Pin Thin Quad Flat Package (TQFP) (PZ Package) for 0°C to 70°C and -40°C to 85°C Operation
  - Packaged in a 100-Pin Ceramic Quad Flat Package (WN Package) for -55°C to 125°C Operation

To view the following documents, [Acrobat Reader 3.x](#) is required.

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## Datasheets

Full datasheet in Acrobat PDF: [slls219b.pdf](#) (275 KB)

Full datasheet in Zipped PostScript: [slls219b.psz](#) (225 KB)

## Errata:

[Errata To The TSB12C01A 1394 Link Layer Controller Data Sheet](#) (SLLS282, 62 KB - Updated: 09/25/1997)

## Pricing/Samples/Availability

<u>Orderable Device</u>	<u>Package</u>	<u>Pins</u>	<u>Temp (°C)</u>	<u>Status</u>	<u>Price/unit USD (100-999)</u>	<u>Pack Qty</u>	<u>DSCC Number</u>	<u>Availability / Samples</u>
5962-9677001QXA	<u>WN</u>	100	-55 TO 125	ACTIVE	116.46	1		<u>Check stock or order</u>
TSB12C01AIPZ	<u>PZ</u>	100		ACTIVE	19.11	90		<u>Check stock or order</u>
TSB12C01AMWN	<u>WN</u>	100	-55 TO 125	ACTIVE	110.33	1		<u>Check stock or order</u>
TSB12C01AMWNB	<u>WN</u>	100	-55 TO 125	ACTIVE	116.46	1		<u>Check stock or order</u>
TSB12C01APZ	<u>PZ</u>	100		ACTIVE	16.03	90		<u>Check stock or order</u>

## Development Tools

<u>Tool Part Number</u>	<u>Tool Title</u>	<u>Tool Type</u>
<u>TSBKBACKPL</u>	TSBKBACKPL Designer Kit	Designer's Kits

## Application Reports

- [Comparing Bus Solutions \(SLLA067 - Updated: 03/02/2000\)](#)
- [Galvanic Isolation of the IEEE1394-1995 Serial Bus \(SLLA011 - Updated: 10/09/1997\)](#)
- [Jitter Analysis \(SLLA075 - Updated: 03/30/2000\)](#)
- [Recommendations For Phy Layout \(SLLA020A - Updated: 02/05/1999\)](#)

## User Manuals

- [LynxSoft Software Application Programmers User's Guide \(SLLU003 - Updated: 10/31/1996\)](#)

## Table Data Updated on: 9/7/2000