

## Quad HOTLink II™ Transceiver

### Features

- Second-generation HOTLink® technology
- Compliant to multiple standards
  - ESCON, DVB-ASI, Fibre Channel and Gigabit Ethernet (IEEE802.3z)
  - CPRI™ compliant
  - CYW15G0401DXB compliant to OBSAI-RP3
  - CYV15G0401DXB compliant to SMPTE 259M and SMPTE 292M
  - 8B/10B encoded or 10-bit unencoded data
- Quad channel transceiver operates from 195 to 1500 MBaud serial data rate
  - CYW15G0401DXB operates from 195 to 1540 MBaud
  - Aggregate throughput of 12 GBits/second
- Selectable parity check/generate
- Selectable multi-channel bonding options
  - Four 8-bit channels
  - Two 16-bit channels
  - One 32-bit channel
  - N x 32-bit channel support (inter-chip)
- Skew alignment support for multiple bytes of offset
- Selectable input/output clocking options
- MultiFrame™ Receive Framer
  - Bit and Byte alignment
  - Comma or full K28.5 detect
  - Single- or multi-byte framer for byte alignment
  - Low-latency option
- Synchronous LVTTTL parallel interface
- Optional Elasticity Buffer in Receive Path
- Optional Phase Align Buffer in Transmit Path
- Internal phase-locked loops (PLLs) with no external PLL components
- Dual differential PECL-compatible serial inputs per channel
  - Internal DC-restoration
- Dual differential PECL-compatible serial outputs per channel
  - Source matched for 50Ω transmission lines
  - No external bias resistors required
  - Signaling-rate controlled edge-rates
- Compatible with
  - fiber-optic modules
  - copper cables
  - circuit board traces
- JTAG boundary scan
- Built-In Self-Test (BIST) for at-speed link testing
- Per-channel Link Quality Indicator
  - Analog signal detect
  - Digital signal detect
- Low power 2.5W @ 3.3V typical
- Single 3.3V supply
- 256-ball thermally enhanced BGA
- Pb-free package option available
- 0.25μ BiCMOS technology

### Functional Description

The CYP(V)15G0401DXB<sup>[1]</sup> Quad HOTLink II™ Transceiver is a point-to-point or point-to-multipoint communications building block allowing the transfer of data over high-speed serial links (optical fiber, balanced, and unbalanced copper transmission lines) at signaling speeds ranging from 195-to-1500 MBaud per serial link.

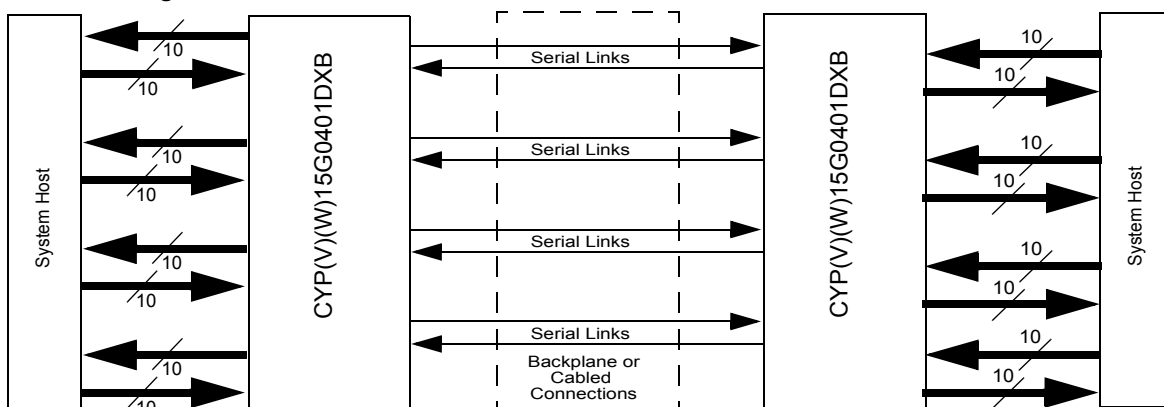


Figure 1. HOTLink II System Connections

#### Note:

1. CYV15G0401DXB refers to SMPTE 259M and SMPTE 292M compliant devices. CYW15G0401DXB refers to OBSAI RP3 compliant devices (maximum operating data rate is 1540 MBaud). CYP15G0401DXB refers to devices not compliant to SMPTE 259M and SMPTE 292M pathological test requirements and also OBSAI RP3 operating data rate of 1536 MBaud. CYP(V)(W)15G0401DXB refers to all three devices.



The CYW15G0401DXB<sup>[1]</sup> operates from 195 to 1540 MBaud, which includes operation at the OBSAI RP3 datarate of both 1536 MBaud and 768 MBaud.

The CYV15G0401DXB satisfies the SMPTE 259M and SMPTE 292M compliance as per the EG34-1999 Pathological Test Requirements.

The multiple channels in each device may be combined to allow transport of wide buses across significant distances with minimal concern for offsets in clock phase or link delay. Each transmit channel accepts parallel characters in an Input Register, encodes each character for transport, and converts it to serial data. Each receive channel accepts serial data and converts it to parallel data, decodes the data into characters, and presents these characters to an Output Register. *Figure 1* illustrates typical connections between independent host systems and corresponding CYP15G0401DXB parts.

As a second-generation HOTLink device, the CYP(V)(W)15G0401DXB extends the HOTLink family with enhanced levels of integration and faster data rates, while maintaining serial-link compatibility (data, command, and BIST) with other HOTLink devices. The transmit (TX) section of the CYP(V)(W)15G0401DXB Quad HOTLink II consists of four byte-wide channels that can be operated independently or bonded to form wider buses. Each channel can accept either eight-bit data characters or pre-encoded 10-bit transmission characters. Data characters are passed from the Transmit Input Register to an embedded 8B/10B Encoder to improve their serial transmission characteristics. These encoded characters are then serialized and output from dual Positive ECL (PECL)-compatible differential transmission-line drivers at a bit-rate of either 10- or 20-times the input reference clock.

The receive (RX) section of the CYP(V)(W)15G0401DXB Quad HOTLink II consists of four byte-wide channels that can be operated independently or synchronously bonded for greater bandwidth. Each channel accepts a serial bit-stream from one of two PECL-compatible differential line receivers and, using a completely integrated PLL Clock Synchronizer, recovers the timing information necessary for data recon-

struction. Each recovered serial stream is deserialized and framed into characters, 8B/10B decoded, and checked for transmission errors. Recovered decoded characters are then written to an internal Elasticity Buffer, and presented to the destination host system. The integrated 8B/10B Encoder/Decoder may be bypassed for systems that present externally encoded or scrambled data at the parallel interface.

For those systems using buses wider than a single byte, the four independent receive paths can be bonded together to allow synchronous delivery of data across a two-byte-wide (16-bit) path, or across all four bytes (32-bit). Multiple CYP(V)(W)15G0401DXB devices may be bonded together to provide synchronous transport of buses wider than 32 bits.

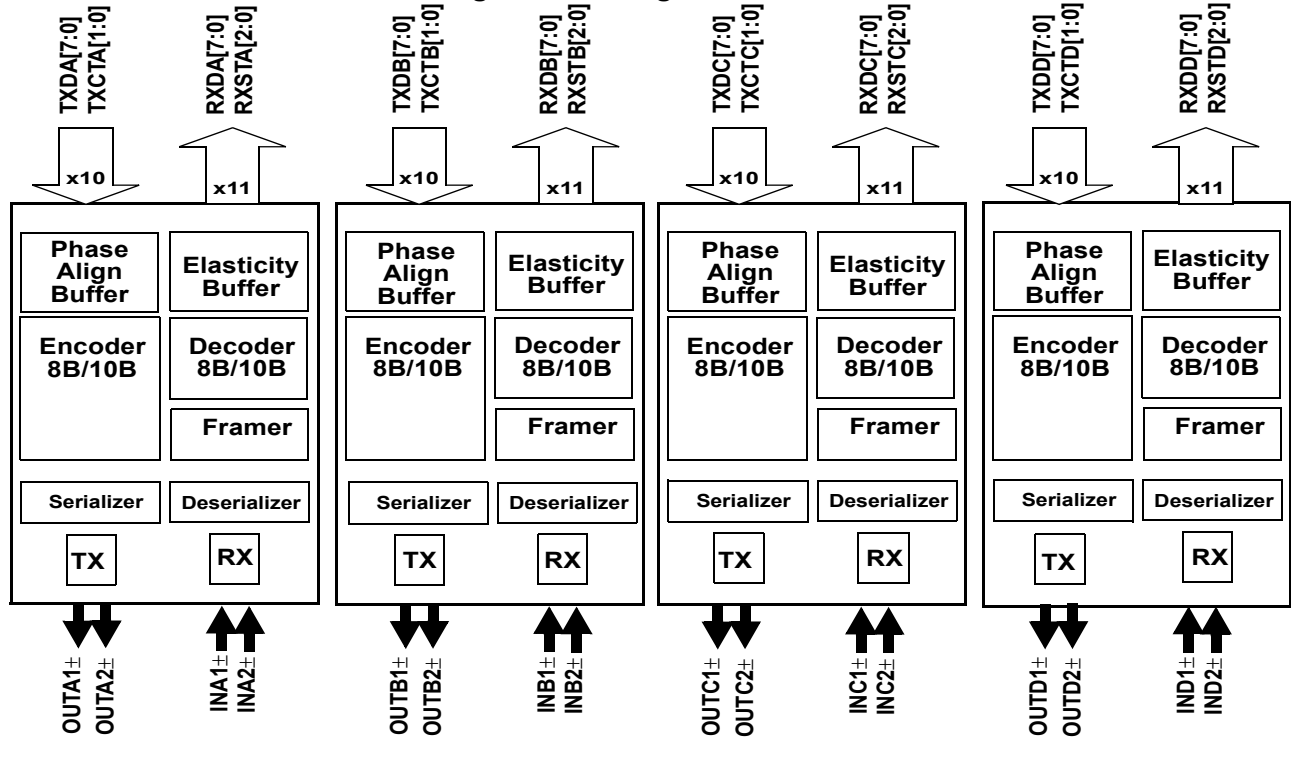
The parallel I/O interface may be configured for numerous forms of clocking to provide the highest flexibility in system architecture. In addition to clocking the transmit path, the receive interface may be configured to present data relative to a recovered clock or to a local reference clock.

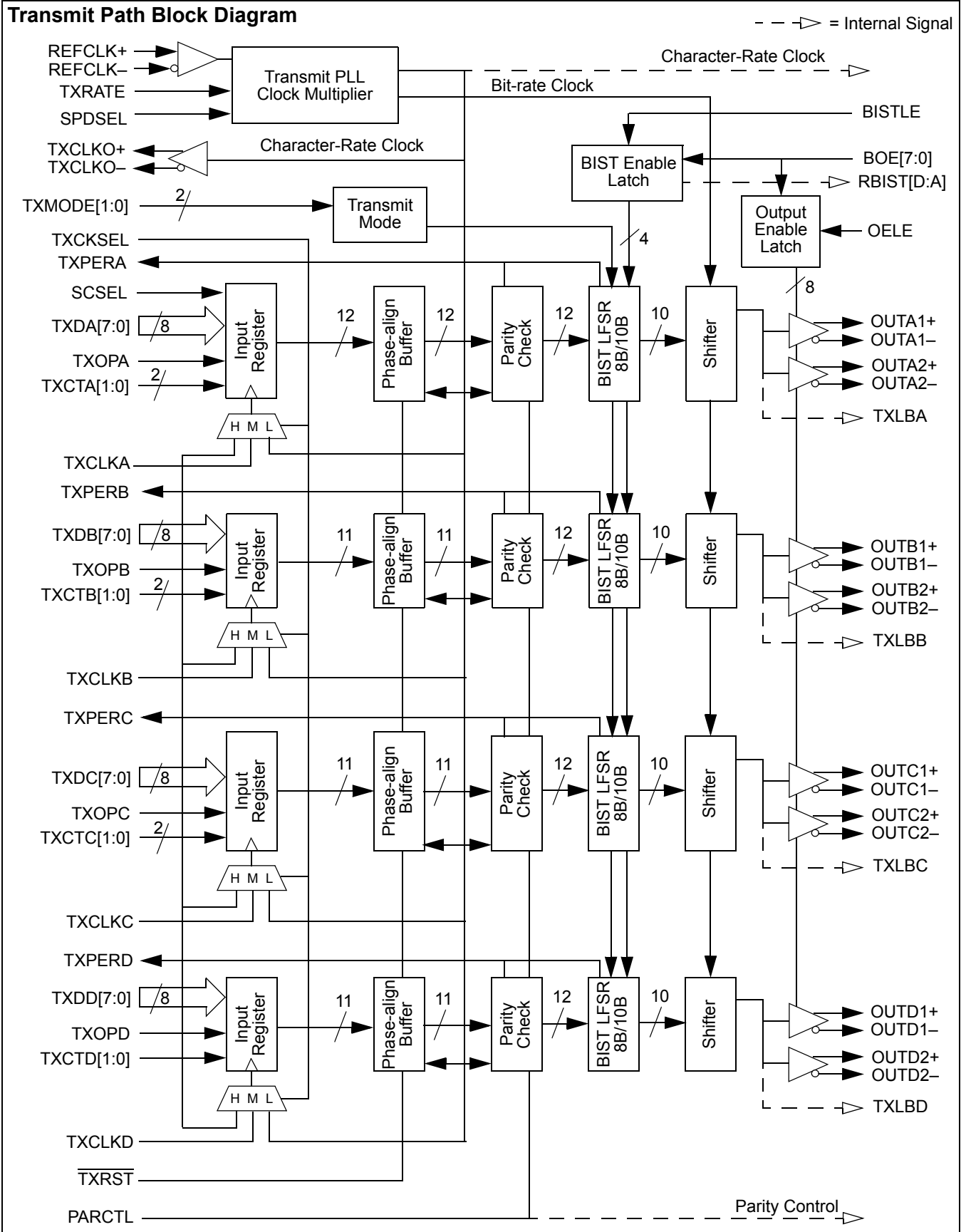
Each transmit and receive channel contains an independent BIST pattern generator and checker. This BIST hardware allows at-speed testing of the high-speed serial data paths in each transmit and receive section, and across the interconnecting links.

HOTLink II devices are ideal for a variety of applications where parallel interfaces can be replaced with high-speed, point-to-point serial links. Some applications include interconnecting backplanes on switches, routers, servers and video transmission systems.

The CYV15G0401DXB is verified by testing to be compliant to all the pathological test patterns documented in SMPTE EG34-1999, for both the SMPTE 259M and 292M signaling rates. The tests ensure that the receiver recovers data with no errors for the following patterns:

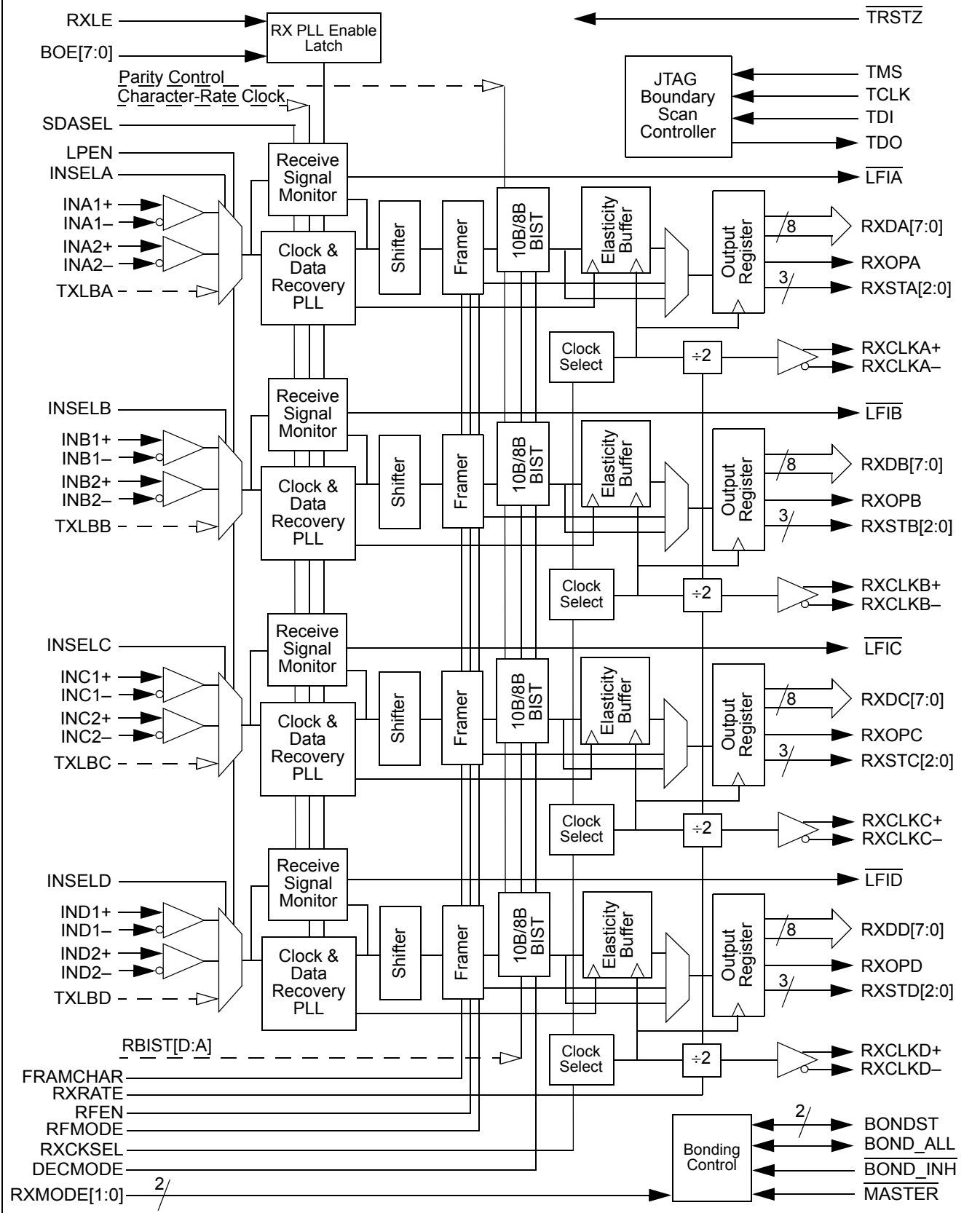
1. Repetitions of 20 ones and 20 zeros.
2. Single burst of 44 ones or 44 zeros.
3. Repetitions of 19 ones followed by 1 zero or 19 zeros followed by 1 one.

**CYP(V)(W)15G0401DXB Transceiver Logic Block Diagram**


**Transmit Path Block Diagram**


**Receive Path Block Diagram**

--- ▷ = Internal Signal





**Pin Configuration (Top View)<sup>[2]</sup>**

|          | 1               | 2               | 3               | 4               | 5               | 6        | 7         | 8   | 9         | 10         | 11       | 12         | 13  | 14          | 15          | 16              | 17              | 18              | 19              | 20              |
|----------|-----------------|-----------------|-----------------|-----------------|-----------------|----------|-----------|-----|-----------|------------|----------|------------|-----|-------------|-------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| <b>A</b> | INC1-           | OUT C1-         | INC2-           | OUT C2-         | V <sub>CC</sub> | IND1-    | OUT D1-   | GND | IND2-     | OUT D2-    | INA1-    | OUT A1-    | GND | INA2-       | OUT A2-     | V <sub>CC</sub> | INB1-           | OUT B1-         | INB2-           | OUT B2-         |
| <b>B</b> | INC1+           | OUT C1+         | INC2+           | OUT C2+         | V <sub>CC</sub> | IND1+    | OUT D1+   | GND | IND2+     | OUT D2+    | INA1+    | OUT A1+    | GND | INA2+       | OUT A2+     | V <sub>CC</sub> | INB1+           | OUT B1+         | INB2+           | OUT B2+         |
| <b>C</b> | TDI             | TMS             | INSEL C         | INSEL B         | V <sub>CC</sub> | PAR CTL  | SDA SEL   | GND | BOE[7]    | BOE[5]     | BOE[3]   | BOE[1]     | GND | TX MODE [0] | RX MODE [0] | V <sub>CC</sub> | TX RATE         | RX RATE         | LPEN            | TDO             |
| <b>D</b> | TCLK            | TRSTZ           | INSEL D         | INSEL A         | V <sub>CC</sub> | RF MODE  | SPD SEL   | GND | BOE[6]    | BOE[4]     | BOE[2]   | BOE[0]     | GND | TX MODE [1] | RX MODE [1] | V <sub>CC</sub> | BOND INH        | RXLE            | RFEN            | MAS TER         |
| <b>E</b> | V <sub>CC</sub> | V <sub>CC</sub> | V <sub>CC</sub> | V <sub>CC</sub> |                 |          |           |     |           |            |          |            |     |             |             |                 | V <sub>CC</sub> | V <sub>CC</sub> | V <sub>CC</sub> | V <sub>CC</sub> |
| <b>F</b> | TXPER C         | TXOP C          | TXDC [0]        | RXCK SEL        |                 |          |           |     |           |            |          |            |     |             |             |                 | BISTLE          | RXSTB [1]       | RXOPB           | RXSTB [0]       |
| <b>G</b> | TXDC [7]        | TXCK SEL        | TXDC [4]        | TXDC [1]        |                 |          |           |     |           |            |          |            |     |             |             |                 | DEC MODE        | OELE            | FRAM CHAR       | RXDB [1]        |
| <b>H</b> | GND             | GND             | GND             | GND             |                 |          |           |     |           |            |          |            |     |             |             |                 | GND             | GND             | GND             | GND             |
| <b>J</b> | TXCTC [1]       | TXDC [5]        | TXDC [2]        | TXDC [3]        |                 |          |           |     |           |            |          |            |     |             |             |                 | RXSTB [2]       | RXDB [0]        | RXDB [5]        | RXDB [2]        |
| <b>K</b> | RXDC [2]        | RXCLK C-        | TXCTC [0]       | LFIC            |                 |          |           |     |           |            |          |            |     |             |             |                 | RXDB [3]        | RXDB [4]        | RXDB [7]        | RXCLK B+        |
| <b>L</b> | RXDC [3]        | RXCLK C+        | TXCLK C         | TXDC [6]        |                 |          |           |     |           |            |          |            |     |             |             |                 | RXDB [6]        | LFIB            | RXCLK B-        | TXDB [6]        |
| <b>M</b> | RXDC [4]        | RXDC [5]        | RXDC [7]        | RXDC [6]        |                 |          |           |     |           |            |          |            |     |             |             |                 | TXCTB [1]       | TXCTB [0]       | TXDB [7]        | TXCLK B         |
| <b>N</b> | GND             | GND             | GND             | GND             |                 |          |           |     |           |            |          |            |     |             |             |                 | GND             | GND             | GND             | GND             |
| <b>P</b> | RXDC [1]        | RXDC [0]        | RXSTC [0]       | RXSTC [1]       |                 |          |           |     |           |            |          |            |     |             |             |                 | TXDB [5]        | TXDB [4]        | TXDB [3]        | TXDB [2]        |
| <b>R</b> | RXSTC [2]       | RXOP C          | TXPER D         | TXOP D          |                 |          |           |     |           |            |          |            |     |             |             |                 | TXDB [1]        | TXDB [0]        | TXOP B          | TXPER B         |
| <b>T</b> | V <sub>CC</sub> | V <sub>CC</sub> | V <sub>CC</sub> | V <sub>CC</sub> |                 |          |           |     |           |            |          |            |     |             |             |                 | V <sub>CC</sub> | V <sub>CC</sub> | V <sub>CC</sub> | V <sub>CC</sub> |
| <b>U</b> | TXDD [0]        | TXDD [1]        | TXDD [2]        | TXCTD [1]       | V <sub>CC</sub> | RXDD [2] | RXDD [1]  | GND | RX OPD    | BOND _ALL  | REF CLK- | TXDA [1]   | GND | TXDA [4]    | TXCTA [0]   | V <sub>CC</sub> | RXDA [2]        | RXOPA           | RXSTA [2]       | RXSTA [1]       |
| <b>V</b> | TXDD [3]        | TXDD [4]        | TXCTD [0]       | RXDD [6]        | V <sub>CC</sub> | RXDD [3] | RXSTD [0] | GND | RXSTD [2] | BOND ST[0] | REF CLK+ | BOND ST[1] | GND | TXDA [3]    | TXDA [7]    | V <sub>CC</sub> | RXDA [7]        | RXDA [3]        | RXDA [0]        | RXSTA [0]       |
| <b>W</b> | TXDD [5]        | TXDD [7]        | LFID            | RXCLK D-        | V <sub>CC</sub> | RXDD [4] | RXSTD [1] | GND | TXCLK O-  | TXRST      | TXOPA    | SCSEL      | GND | TXDA [2]    | TXDA [6]    | V <sub>CC</sub> | LFIA            | RXCLK A-        | RXDA [4]        | RXDA [1]        |
| <b>Y</b> | TXDD [6]        | TXCLK D         | RXDD [7]        | RXCLK D+        | V <sub>CC</sub> | RXDD [5] | RXDD [0]  | GND | TXCLK O+  | N/C        | TXCLK A  | TXPER A    | GND | TXDA [0]    | TXDA [5]    | V <sub>CC</sub> | TXCTA [1]       | RXCLK A+        | RXDA [6]        | RXDA [5]        |

**Note:**

- N/C = Do Not Connect



**Pin Configuration (Bottom View)<sup>[3]</sup>**

| 20                         | 19              | 18                       | 17                           | 16              | 15          | 14          | 13  | 12         | 11       | 10                        | 9         | 8   | 7         | 6        | 5               | 4                        | 3                        | 2                         | 1               |   |
|----------------------------|-----------------|--------------------------|------------------------------|-----------------|-------------|-------------|-----|------------|----------|---------------------------|-----------|-----|-----------|----------|-----------------|--------------------------|--------------------------|---------------------------|-----------------|---|
| OUT B2-                    | INB2-           | OUT B1-                  | INB1-                        | V <sub>CC</sub> | OUT A2-     | INA2-       | GND | OUT A1-    | INA1-    | OUT D2-                   | IND2-     | GND | OUT D1-   | IND1-    | V <sub>CC</sub> | OUT C2-                  | INC2-                    | OUT C1-                   | INC1-           | A |
| OUT B2+                    | INB2+           | OUT B1+                  | INB1+                        | V <sub>CC</sub> | OUT A2+     | INA2+       | GND | OUT A1+    | INA1+    | OUT D2+                   | IND2+     | GND | OUT D1+   | IND1+    | V <sub>CC</sub> | OUT C2+                  | INC2+                    | OUT C1+                   | INC1+           | B |
| TDO                        | LPEN            | RX RATE                  | TX RATE                      | V <sub>CC</sub> | RX MODE [0] | TX MODE [0] | GND | BOE[1]     | BOE[3]   | BOE[5]                    | BOE[7]    | GND | SDA SEL   | PAR CTL  | V <sub>CC</sub> | INSELB                   | INSELC                   | TMS                       | TDI             | C |
| $\overline{\text{MASTER}}$ | RFEN            | RXLE                     | $\overline{\text{BOND INH}}$ | V <sub>CC</sub> | RX MODE [1] | TX MODE [1] | GND | BOE[0]     | BOE[2]   | BOE[4]                    | BOE[6]    | GND | SPD SEL   | RF MODE  | V <sub>CC</sub> | INSELA                   | INSELD                   | $\overline{\text{TRSTZ}}$ | TCLK            | D |
| V <sub>CC</sub>            | V <sub>CC</sub> | V <sub>CC</sub>          | V <sub>CC</sub>              |                 |             |             |     |            |          |                           |           |     |           |          |                 | V <sub>CC</sub>          | V <sub>CC</sub>          | V <sub>CC</sub>           | V <sub>CC</sub> | E |
| RXSTB [0]                  | RXOP B          | RXSTB [1]                | BISTLE                       |                 |             |             |     |            |          |                           |           |     |           |          |                 | RXCK SEL                 | TXDC [0]                 | TXOP C                    | TXPER C         | F |
| RXDB [1]                   | FRAM CHAR       | OELE                     | DEC MODE                     |                 |             |             |     |            |          |                           |           |     |           |          |                 | TXDC [1]                 | TXDC [4]                 | TXCK SEL                  | TXDC [7]        | G |
| GND                        | GND             | GND                      | GND                          |                 |             |             |     |            |          |                           |           |     |           |          |                 | GND                      | GND                      | GND                       | GND             | H |
| RXDB [2]                   | RXDB [5]        | RXDB [0]                 | RXSTB [2]                    |                 |             |             |     |            |          |                           |           |     |           |          |                 | TXDC [3]                 | TXDC [2]                 | TXDC [5]                  | TXCTC [1]       | J |
| RXCLK B+                   | RXDB [7]        | RXDB [4]                 | RXDB [3]                     |                 |             |             |     |            |          |                           |           |     |           |          |                 | $\overline{\text{LFIC}}$ | TXCTC [0]                | RXCLK C-                  | RXDC [2]        | K |
| TXDB [6]                   | RXCLK B-        | $\overline{\text{LFIB}}$ | RXDB [6]                     |                 |             |             |     |            |          |                           |           |     |           |          |                 | TXDC [6]                 | TXCLK C                  | RXCLK C+                  | RXDC [3]        | L |
| TXCLK B                    | TXDB [7]        | TXCTB [0]                | TXCTB [1]                    |                 |             |             |     |            |          |                           |           |     |           |          |                 | RXDC [6]                 | RXDC [7]                 | RXDC [5]                  | RXDC [4]        | M |
| GND                        | GND             | GND                      | GND                          |                 |             |             |     |            |          |                           |           |     |           |          |                 | GND                      | GND                      | GND                       | GND             | N |
| TXDB [2]                   | TXDB [3]        | TXDB [4]                 | TXDB [5]                     |                 |             |             |     |            |          |                           |           |     |           |          |                 | RXSTC [1]                | RXSTC [0]                | RXDC [0]                  | RXDC [1]        | P |
| TXPER B                    | TXOP B          | TXDB [0]                 | TXDB [1]                     |                 |             |             |     |            |          |                           |           |     |           |          |                 | TXOP D                   | TXPER D                  | RXOP C                    | RXSTC [2]       | R |
| V <sub>CC</sub>            | V <sub>CC</sub> | V <sub>CC</sub>          | V <sub>CC</sub>              |                 |             |             |     |            |          |                           |           |     |           |          |                 | V <sub>CC</sub>          | V <sub>CC</sub>          | V <sub>CC</sub>           | V <sub>CC</sub> | T |
| RXSTA [1]                  | RXSTA [2]       | RXOPA                    | RXDA [2]                     | V <sub>CC</sub> | TXCTA [0]   | TXDA [4]    | GND | TXDA [1]   | REF CLK- | BOND _ALL                 | RXOP D    | GND | RXDD [1]  | RXDD [2] | V <sub>CC</sub> | TXCTD [1]                | TXDD [2]                 | TXDD [1]                  | TXDD [0]        | U |
| RXSTA [0]                  | RXDA [0]        | RXDA [3]                 | RXDA [7]                     | V <sub>CC</sub> | TXDA [7]    | TXDA [3]    | GND | BOND ST[1] | REF CLK+ | BOND ST[0]                | RXSTD [2] | GND | RXSTD [0] | RXDD [3] | V <sub>CC</sub> | RXDD [6]                 | TXCTD [0]                | TXDD [4]                  | TXDD [3]        | V |
| RXDA [1]                   | RXDA [4]        | RXCLK A-                 | $\overline{\text{LFIA}}$     | V <sub>CC</sub> | TXDA [6]    | TXDA [2]    | GND | SCSEL      | TXOP A   | $\overline{\text{TXRST}}$ | TXCLK O-  | GND | RXSTD [1] | RXDD [4] | V <sub>CC</sub> | RXCLK D-                 | $\overline{\text{LFID}}$ | TXDD [7]                  | TXDD [5]        | W |
| RXDA [5]                   | RXDA [6]        | RXCLK A+                 | TXCTA [1]                    | V <sub>CC</sub> | TXDA [5]    | TXDA [0]    | GND | TXPER A    | TXCLK A  | N/C                       | TXCLK O+  | GND | RXDD [0]  | RXDD [5] | V <sub>CC</sub> | RXCLK D+                 | RXDD [7]                 | TXCLK D                   | TXDD [6]        | Y |

**Note:**  
 3. N/C = Do Not Connect

## Pin Descriptions

### CYP(V)(W)15G0401DXB Quad HOTLink II Transceiver

| Pin Name   | I/O Characteristics   | Signal Description  |
|--|---|---|
| <b>Transmit Path Data Signals</b>                    |   |   |
| TXPERA<br>TXPERB<br>TXPERC<br>TXPERD                 | LVTTTL Output, changes relative to REFCLK <sup>↑</sup> [4]  | <p><b>Transmit Path Parity Error.</b> Active HIGH. Asserted (HIGH) if parity checking is enabled and a parity error is detected at the Encoder. This output is HIGH for one transmit character clock period to indicate detection of a parity error in the character presented to the Encoder.</p> <p>If a parity error is detected, the character in error is replaced with a C0.7 character to force a corresponding bad-character detection at the remote end of the link. This replacement takes place regardless of the encoded/non-encoded state of the interface.</p> <p>When BIST is enabled for the specific transmit channel, BIST progress is presented on these outputs. Once every 511 character times (plus a 16-character Word Sync Sequence when the receive channels are clocked by a common clock, i.e., RXCKSEL = LOW or HIGH), the associated TXPERx signal will pulse HIGH for one transmit-character clock period (if RXCKSEL= MID) or seventeen transmit-character clock periods (if RXCKSEL = LOW or HIGH and Encoder is enabled) to indicate a complete pass through the BIST sequence. Therefore, in this case TXPERx signal will pulse HIGH for one transmit-character clock period.</p> <p>These outputs also provide indication of a transmit Phase-align Buffer underflow or overflow. When the transmit Phase-align Buffers are enabled (TXCKSEL ≠ LOW, or TXCKSEL = LOW and TXRATE = HIGH), if an underflow or overflow condition is detected, TXPERx for the channel in error is asserted <u>and</u> remains asserted until either an atomic Word Sync Sequence is transmitted or <math>\overline{\text{TXRST}}</math> is sampled LOW to re-center the transmit Phase-align Buffers.</p> |
| TXCTA[1:0]<br>TXCTB[1:0]<br>TXCTC[1:0]<br>TXCTD[1:0] | LVTTTL Input, synchronous, sampled by the selected TXCLKx <sup>↑</sup> or REFCLK <sup>↑</sup> [4]                     | <p><b>Transmit Control.</b> These inputs are captured on the rising edge of the transmit interface clock as selected by TXCKSEL, and are passed to the Encoder or Transmit Shifter. They identify how the associated TXDx[7:0] characters are interpreted. When the Encoder is bypassed, these inputs are interpreted as data bits of 10-bit input character. When the Encoder is enabled, these inputs determine if the TXDx[7:0] character is encoded as Data, a Special Character code, a K28.5 fill character or a Word Sync Sequence. See <i>Table 1</i> for details.</p>  |
| TXDA[7:0]<br>TXDB[7:0]<br>TXDC[7:0]<br>TXDD[7:0]     | LVTTTL Input, synchronous, sampled by the selected TXCLKx <sup>↑</sup> or REFCLK <sup>↑</sup> [4]                     | <p><b>Transmit Data Inputs.</b> These inputs are captured on the rising edge of the transmit interface clock as selected by TXCKSEL and passed to the Encoder or Transmit Shifter.</p> <p>When the Encoder is enabled (TXMODE[1:0] ≠ LOW), TXDx[7:0] specify the specific data or command character to be sent. When the Encoder is bypassed, these inputs are interpreted as data bits of the 10-bit input character. See <i>Table 1</i> for details.</p>  |
| TXOPA<br>TXOPB<br>TXOPC<br>TXOPD                     | LVTTTL Input, synchronous, internal pull-up, sampled by the respective TXCLKx <sup>↑</sup> or REFCLK <sup>↑</sup> [4] | <p><b>Transmit Path Odd Parity.</b> When parity checking is enabled (PARCTL ≠ LOW), the parity captured at these inputs is XORed with the data on the associated TXDx bus (and sometimes TXCT[1:0]) to verify the integrity of the captured character. See <i>Table 2</i> for details.</p>  |
| SCSEL  | LVTTTL Input, synchronous, internal pull-down, sampled by TXCLKA <sup>↑</sup> or REFCLK <sup>↑</sup> [4]              | <p><b>Special Character Select.</b> Used in some transmit modes along with TXCTx[1:0] to encode special characters or to initiate a Word Sync Sequence. When the transmit paths are configured for independent input clocks (TXCKSEL = MID), SCSEL is captured relative to TXCLKA<sup>↑</sup>.</p>  |

**Note:**

- When REFCLK is configured for half-rate operation (TXRATE = HIGH), these inputs are sampled (or the outputs change) relative to both the rising and falling edges of REFCLK.



**Pin Descriptions** (continued)

**CYP(V)(W)15G0401DXB Quad HOTLink II Transceiver**

| Pin Name                                     | I/O Characteristics  | Signal Description  |
|--|--|---|
| TXRST  | LVTTTL Input, asynchronous, internal pull-up, sampled by REFCLK <sup>↑</sup> [4] | <p><b>Transmit Clock Phase Reset.</b> Active LOW. When sampled LOW, the transmit Phase-align Buffers are allowed to adjust their data-transfer timing (relative to the selected input clock) to allow clean transfer of data from the Input Register to the Encoder or Transmit Shifter. When TXRST is sampled HIGH, the internal phase relationship between the associated TXCLKx and the internal character-rate clock is fixed and the device operates normally.</p> <p>When configured for half-rate REFCLK sampling of the transmit character stream (TXCKSEL = LOW and TXRATE = HIGH), assertion of TXRST is only used to clear Phase-align buffer faults caused by highly asymmetric REFCLK periods or REFCLKs with excessive cycle-to-cycle jitter. During this alignment period, one or more characters may be added to or lost from all the associated transmit paths as the transmit Phase-align Buffers are adjusted. TXRST must be sampled LOW by a minimum of two consecutive rising edges REFCLK to ensure the reset operation is initiated correctly on all channels. This input is ignored when both TXCKSEL and TXRATE are LOW, since the phase align buffer is bypassed. In all other configurations, TXRST should be asserted during device initialization to ensure proper operation of the Phase-align buffer. TXRST should be asserted after the presence of a valid TXCLKx and after allowing enough time for the TXPLL to lock to the reference clock (as specified by parameter <math>t_{TXLOCK}</math>).</p> |
| <b>Transmit Path Clock and Clock Control</b> |  |   |
| TXCKSEL                                      | Three-level Select [5], static control input                                     | <p><b>Transmit Clock Select.</b> Selects the clock source, used to write data into the transmit Input Register of the transmit channel(s). When LOW, REFCLK<sup>↑</sup> [4] is used as the Input Register clock for TXDx[7:0] and TXCTx[1:0] of all channels. When MID, TXCLKx<sup>↑</sup> is used as the Input Register clock for TXDx[7:0] and TXCTx[1:0]. When HIGH, TXCLKA<sup>↑</sup> is used as the Input Register clock for TXDx[7:0] and TXCTx[1:0] of all channels.</p>  |
| TXCLKO <sub>±</sub>                          | LVTTTL Output  | <p><b>Transmit Clock Output.</b> This true and complement output clock is synthesized by the transmit PLL and is synchronous to the internal transmit character clock. It has the same frequency as REFCLK (when TXRATE = LOW), or twice the frequency of REFCLK (when TXRATE = HIGH). This output clock has no direct phase relationship to REFCLK.</p>  |
| TXRATE                                       | LVTTTL Input, static control input, internal pull-down                           | <p><b>Transmit PLL Clock Rate Select.</b> When TXRATE = HIGH, the Transmit PLL multiplies REFCLK by 20 to generate the serial bit-rate clock. When TXRATE = LOW, the transmit PLL multiplies REFCLK by 10 to generate the serial bit-rate clock. See <i>Table 11</i> for a list of operating serial rates.</p> <p>When REFCLK is selected to clock the receive parallel interfaces (RXCKSEL = LOW), the TXRATE input also determines if the clocks on the RXCLKA<sub>±</sub> and RXCLKC<sub>±</sub> outputs are full or half-rate. When TXRATE = HIGH (REFCLK is half-rate), the RXCLKA<sub>±</sub> and RXCLKC<sub>±</sub> output clocks are also half-rate clocks and follow the frequency and duty cycle of the REFCLK input. When TXRATE = LOW (REFCLK is full-rate), the RXCLKA<sub>±</sub> and RXCLKC<sub>±</sub> output clocks are full-rate clocks and follow the frequency and duty cycle of the REFCLK input.</p> <p>When TXCKSEL = MID or HIGH (TXCLKx or TXCLKA selected to clock input register), configuring TXRATE = HIGH (Half-rate REFCLK) is an invalid mode of operation.</p>   |
| TXCLKA<br>TXCLKB<br>TXCLKC<br>TXCLKD         | LVTTTL Clock Input, internal pull-down   | <p><b>Transmit Path Input Clocks.</b> These clocks must be frequency-coherent to TXCLKO<sub>±</sub>, but may be offset in phase. The internal operating phase of each input clock (relative to REFCLK or TXCLKO<sub>±</sub>) is adjusted when TXRST = LOW and locked when TXRST = HIGH.</p>   |

**Note:**

- Three-level select inputs are used for static configuration. They are ternary (not binary) inputs that make use of non-standard logic levels of LOW, MID, and HIGH. The LOW level is usually implemented by direct connection to V<sub>SS</sub> (ground). The HIGH level is usually implemented by direct connection to V<sub>CC</sub>. When not connected or allowed to float, a Three-level select input will self-bias to the MID level.

**Pin Descriptions** (continued)

**CYP(V)(W)15G0401DXB Quad HOTLink II Transceiver**

| Pin Name   | I/O Characteristics  | Signal Description   |
|--|--|--|
| <b>Transmit Path Mode Control</b>                    |  |  |
| TXMODE[1:0]  | Three-level Select <sup>[5]</sup><br>static control inputs   | <b>Transmit Operating Mode.</b> These inputs are interpreted to select one of nine operating modes of the transmit path. See <i>Table 3</i> for a list of operating modes.   |
| <b>Receive Path Data Signals</b>                     |  |  |
| RXDA[7:0]<br>RXDB[7:0]<br>RXDC[7:0]<br>RXDD[7:0]     | LVTTTL Output,<br>synchronous to the<br>selected RXCLKx <sup>↑</sup> output<br>(or REFCLK <sup>↑</sup> input <sup>[4]</sup><br>when RXCKSEL = LOW)                 | <b>Parallel Data Output.</b> These outputs change following the rising edge of the selected receive interface clock.<br><br>When the Decoder is enabled (DECMODE = HIGH or MID), these outputs represent either received data or special characters. The status of the received data is represented by the values of RXSTx[2:0].<br><br>When the Decoder is bypassed (DECMODE = LOW), RXDx[7:0] become the higher order bits of the 10-bit received character. See <i>Table 18</i> for details.  |
| RXSTA[2:0]<br>RXSTB[2:0]<br>RXSTC[2:0]<br>RXSTD[2:0] | LVTTTL Output,<br>synchronous to the<br>selected RXCLKx <sup>↑</sup> output<br>(or REFCLK <sup>↑</sup> input <sup>[4]</sup><br>when RXCKSEL = LOW)                 | <b>Parallel Status Output.</b> These outputs change following the rising edge of the selected receive interface clock.<br><br>When the Decoder is bypassed (DECMODE = LOW), RXSTx[1:0] become the two low-order bits of the 10-bit received character, while RXSTx[2] = HIGH indicates the presence of a Comma character in the Output Register. See <i>Table 18</i> for details.<br><br>When the Decoder is enabled (DECMODE = HIGH or MID), RXSTx[2:0] provide status of the received signal. See <i>Table 20, 23 and 24</i> for a list of Receive Character status.   |
| RXOPA<br>RXOPB<br>RXOPC<br>RXOPD                     | three-state, LVTTTL<br>Output, synchronous to<br>the selected<br>RXCLKx <sup>↑</sup> output<br>(or REFCLK <sup>↑</sup> input <sup>[4]</sup><br>when RXCKSEL = LOW) | <b>Receive Path Odd Parity.</b> When parity generation is enabled (PARCTL ≠ LOW), the parity output at these pins is valid for the data on the associated RXDx bus bits. When parity generation is disabled (PARCTL = LOW) these output drivers are disabled (High-Z).   |
| <b>Receive Path Clock and Clock Control</b>          |  |  |
| RXRATE   | LVTTTL Input, static control<br>input, internal pull-down  | <b>Receive Clock Rate Select.</b> When LOW, the RXCLKx± recovered clock outputs are complementary clocks operating at the recovered character rate. Data for the associated receive channels should be latched on the rising edge of RXCLKx+ or falling edge of RXCLKx-.<br><br>When HIGH, the RXCLKx± recovered clock outputs are complementary clocks operating at half the character rate. Data for the associated receive channels should be latched alternately on the rising edge of RXCLKx+ and RXCLKx-.<br><br>When REFCLK± is selected to clock the output registers (RXCKSELx = LOW), RXRATE <sub>x</sub> is not interpreted. The RXCLKA± and RXCLKC± output clocks will follow the frequency and duty cycle of REFCLK±. |
| FRAMCHAR   | Three-level Select <sup>[5]</sup> ,<br>static control input  | <b>Framing Character Select.</b> Used to select the character or portion of a character used for character framing of the received data streams. When MID, the Framer looks for both positive and negative disparity versions of the eight-bit Comma character. When HIGH, the Framer looks for both positive and negative disparity versions of the K28.5 character. Configuring FRAMCHAR to LOW is reserved for component test.  |
| RFEN   | LVTTTL Input,<br>asynchronous,<br>internal pull-down   | <b>Reframe Enable for All Channels.</b> Active HIGH. When HIGH, the framers in all four channels are enabled to frame per the presently enabled framing mode as selected by RFMODE and selected framing character as selected by FRAMCHAR.   |
| RXMODE[1:0]  | Three-level Select <sup>[5]</sup> ,<br>static control inputs   | <b>Receive Operating Mode.</b> These inputs are interpreted to select one of nine operating modes of the receive path. See <i>Table 14</i> for details.  |



**Pin Descriptions** (continued)

CYP(V)(W)15G0401DXB Quad HOTLink II Transceiver

| Pin Name                                 | I/O Characteristics  | Signal Description  |
|--|--|---|
| RXCLKA±<br>RXCLKB±<br>RXCLKC±<br>RXCLKD± | Three-state, LVTTL<br>Output clock or static control input | <p><b>Receive Character Clock Output or Clock Select Input.</b> When configured such that all output data paths are clocked by the recovered clock (RXCKSEL = MID), these true and complement clocks are the receive interface clocks which are used to control timing of output data (RXDx[7:0], RXSTx[2:0] and RXOPx). These clocks are output continuously at either the dual-character rate (1/20<sup>th</sup> the serial bit-rate) or character rate (1/10<sup>th</sup> the serial bit-rate) of the data being received, as selected by RXRATE.</p> <p>When configured such that all output data paths are clocked by REFCLK instead of a recovered clock (RXCKSEL = LOW), the RXCLKA± and RXCLKC± output drivers present a buffered and delayed form of REFCLK. RXCLKA± and RXCLKC± are buffered forms of REFCLK that are slightly different in phase. This phase difference allows the user to select the optimal setup/hold timing for their specific interface.</p> <p>When RXCKSEL = LOW and quad channel bonding is enabled, RXCLKB+ and RXCLKD+ are static control inputs used to select the master channel for bonding and status control.</p> <p>When RXCKSEL = HIGH and quad-channel bonding is enabled, one of the recovered clocks from channels A, B, C or D can be selected to clock the bonded output data. The selection of the recovered clock is made by RXCLKB+ and RXCLKD+ which act as static control inputs in this mode. Both RXCLKA± and RXCLKC± output buffered forms of the recovered clock selected from receive channel A, B, C, or D. See <i>Table 15</i> for details.</p> <p>When RXCKSEL = HIGH and dual-channel bonding is enabled, one of the recovered clocks from channels A or B is selected to present bonded data from channels A and B, and one of the recovered clocks from channels C or D is selected to present bonded data from channels C and D. RXCLKA± output the recovered clock from either receive channel A or receive channel B as selected by RXCLKB+ to clock the bonded output data from channels A and B, and RXCLKC± output the recovered clock from either receive channel C or receive channel D as selected by RXCLKD+ to the clock the bonded output data from channels C and D. See <i>Table 16</i> for details.</p> |
| RXCKSEL                                  | Three-level Select <sup>[5]</sup> , static control input   | <p><b>Receive Clock Mode.</b> Selects the receive clock source used to transfer data to the Output Registers.</p> <p>When LOW, all four Output Registers are clocked by REFCLK. RXCLKB± and RXCLKD± outputs are disabled (High-Z), and RXCLKA± and RXCLKC± present buffered and delayed forms of REFCLK. This clocking mode is required for channel bonding across multiple devices.</p> <p>When MID, each RXCLKx± output follows the recovered clock for the respective channel, as selected by RXRATE. When the 10B/8B Decoder and Elasticity Buffer are bypassed (DECMODE = LOW), RXCKSEL must be MID.</p> <p>When HIGH and channel bonding is enabled in dual-channel mode (RX modes 3 and 5), RXCLKA± outputs the recovered clock from either receive channel A or B as selected by RXCLKB+, and RXCLKC± outputs the recovered clock from either receive channel C or D as selected by RXCLKD+. These output clocks may operate at the character-rate or half the character-rate as selected by RXRATE.</p> <p>When HIGH and channel bonding is enabled in quad channel mode (RX modes 6 and 8), or if the receive channels are operated in independent mode (RX modes 0 and 2), RXCLKA± and RXCLKC± output the recovered clock from receive channel A, B, C, or D, as selected by RXCLKB+ and RXCLKD+. This output clock may operate at the character-rate or half the character-rate as selected by RXRATE.</p>  |



**Pin Descriptions** (continued)

CYP(V)(W)15G0401DXB Quad HOTLink II Transceiver

| Pin Name                      | I/O Characteristics                                      | Signal Description  |
|-------------------------------|--|---|
| DECMODE                       | Three-level Select <sup>[5]</sup> , static control input | <p><b>Decoder Mode Select.</b> This input selects the behavior of the Decoder block. When LOW, the Decoder is bypassed and raw 10-bit characters are passed to the Output Register. When the Decoder is bypassed, RXCKSEL must be MID.</p> <p>When MID, the Decoder is enabled and the Cypress decoder table for Special Code characters is used.</p> <p>When HIGH, the Decoder is enabled and the alternate decoder table for Special Code characters is used. See <i>Table 29</i> for a list of the Special Codes supported in both encoded modes.</p>  |
| RFMODE                        | Three-level Select <sup>[5]</sup> , static control input | <p><b>Reframe Mode Select.</b> Used to select the type of character framing used to adjust the character boundaries (based on detection of one or more framing characters in the received serial bit stream). This signal operates in conjunction with the presently enabled channel bonding mode, and the type of framing character selected.</p> <p>When LOW, the Low-Latency Framer is selected. This will frame on each occurrence of the selected framing character(s) in the received data stream. This mode of framing stretches the recovered character-rate clock for one or multiple cycles to align that clock with the recovered data.</p> <p>When MID, the Cypress-mode Multi-Byte parallel Framer is selected. This requires a pair of the selected framing character(s), on identical 10-bit boundaries, within a span of 50 bits, before the character boundaries are adjusted. The recovered character clock remains in the same phase regardless of character offset.</p> <p>When HIGH, the alternate mode Multi-Byte parallel Framer is selected. This requires detection of the selected framing character(s) of the allowed disparities in the received serial bit stream, on identical 10-bit boundaries, on four directly adjacent characters. The recovered character clock remains in the same phase regardless of character offset.</p> |
| <b>Device Control Signals</b> |  |   |
| PARCTL                        | Three-level Select <sup>[5]</sup> , static control input | <p><b>Parity Check/Generate Control.</b> Used to control the different parity check and generate functions. When LOW, parity checking is disabled, and the RXOPx outputs are all disabled (High-Z). When MID, and the 8B/10B Encoder and Decoder are enabled (TXMODE[1] ≠ LOW, DECMODE ≠ LOW), TXDx[7:0] inputs are checked (along with TXOPx) for valid ODD parity, and ODD parity is generated for the RXDx[7:0] outputs and presented on RXOPx. When the Encoder and Decoder are disabled (TXMODE[1] = LOW, DECMODE = LOW), the TXDx[7:0] and TXCTx[1:0] inputs are checked (along with TXOPx) for valid ODD parity, and ODD parity is generated for the RXDx[7:0] and RXSTx[1:0] outputs and presented on RXOPx. When HIGH, parity checking and generation are enabled. The TXDx[7:0] and TXCTx[1:0] inputs are checked (along with TXOPx) for valid ODD parity, and ODD parity is generated for the RXDx[7:0] and RXSTx[2:0] outputs and presented on RXOPx. See <i>Table 2</i> and <i>19</i> for details.</p>   |
| SPDSEL                        | Three-level Select <sup>[5]</sup> static control input   | <p><b>Serial Rate Select.</b> This input specifies the operating bit-rate range of both transmit and receive PLLs. LOW = 195–400 MBaud, MID = 400–800 MBaud, HIGH = 800–1500 MBaud (800–1540 MBaud for CYW15G0401DXB). When SPDSEL is LOW, setting TXRATE = HIGH (Half-rate Reference Clock) is invalid.</p>  |
| TRSTZ                         | LVTTL Input, internal pull-up                            | <p><b>Device Reset.</b> Active LOW. Initializes all state machines and counters in the device. When sampled LOW by the rising edge of REFCLK<sup>↑</sup>, this input resets the internal state machines and sets the Elasticity Buffer pointers to a nominal offset. When the reset is removed (TRSTZ sampled HIGH by REFCLK<sup>↑</sup>), the status and data outputs will become deterministic in less than 16 REFCLK cycles. The BISTLE, OELE, and RXLE latches are reset by TRSTZ. If the Elasticity Buffer or the Phase-align Buffer are used, TRSTZ should be applied after power up to initialize the internal pointers into these memory arrays.</p>  |

**Pin Descriptions** (continued)

**CYP(V)(W)15G0401DXB Quad HOTLink II Transceiver**

| Pin Name                             | I/O Characteristics  | Signal Description  |
|--------------------------------------|--|---|
| REFCLK±                              | Differential LVPECL or single-ended LVTTTL Input Clock       | <p><b>Reference Clock.</b> This clock input is used as the timing reference for the transmit PLL. It is also used as the centering frequency of the Range Controller block of the Receive CDR PLLs. This input clock may also be selected to clock the transmit and receive parallel interfaces. When driven by a single-ended LVCMOS or LVTTTL clock source, connect the clock source to either the true or complement REFCLK input, and leave the alternate REFCLK input open (floating). When driven by an LVPECL clock source, the clock must be a differential clock, using both inputs. When TXCKSEL = LOW, REFCLK is also used as the clock for the parallel transmit data (input) interface. When RXCKSEL = LOW, the Elasticity Buffer is enabled and REFCLK is used as the clock for the parallel receive data (output) interface.</p> <p>If the Elasticity Buffer is used, framing characters will be inserted or deleted to/from the data stream to compensate for frequency differences between the reference clock and recovered clock. When an addition happens, a K28.5 will be appended immediately after a framing is detected in the Elasticity Buffer. When deletion happens, a framing character will be removed from the data stream when detected in the Elasticity Buffer.</p> |
| <b>Analog I/O and Control</b>        |  |   |
| OUTA1±<br>OUTB1±<br>OUTC1±<br>OUTD1± | CML Differential Output                                      | <b>Primary Differential Serial Data Outputs.</b> These PECL-compatible CML outputs (+3.3V referenced) are capable of driving terminated transmission lines or standard fiber-optic transmitter modules.   |
| OUTA2±<br>OUTB2±<br>OUTC2±<br>OUTD2± | CML Differential Output                                      | <b>Secondary Differential Serial Data Outputs.</b> These PECL-compatible CML outputs (+3.3V referenced) are capable of driving terminated transmission lines or standard fiber-optic transmitter modules.   |
| INA1±<br>INB1±<br>INC1±<br>IND1±     | LVPECL Differential Input                                    | <b>Primary Differential Serial Data Inputs.</b> These inputs accept the serial data stream for deserialization and decoding. The INx1± serial streams are passed to the receiver Clock and Data Recovery (CDR) circuits to extract the data content when INSELx = HIGH.   |
| INA2±<br>INB2±<br>INC2±<br>IND2±     | LVPECL Differential Input                                    | <b>Secondary Differential Serial Data Inputs.</b> These inputs accept the serial data stream for deserialization and decoding. The INx2± serial streams are passed to the receiver Clock and Data Recovery (CDR) circuits to extract the data content when INSELx = LOW.  |
| INSELA<br>INSELB<br>INSELC<br>INSELD | LVTTTL Input, asynchronous                                   | <b>Receive Input Selector.</b> Determines which external serial bit stream is passed to the receiver Clock and Data Recovery circuit. When HIGH, the INx1± input is selected. When LOW, the INx2± input is selected.  |
| SDASEL                               | Three-level Select <sup>[5]</sup> static configuration input | <b>Signal Detect Amplitude Level Select.</b> Allows selection of one of three predefined amplitude trip points for a valid signal indication, as listed in <i>Table 12</i> .  |
| LPEN                                 | LVTTTL Input, asynchronous, internal pull-down               | <b>All-Port Loop-Back Enable.</b> Active HIGH. When asserted (HIGH), the transmit serial data from each channel is internally routed to the associated receiver Clock and Data Recovery (CAR) circuit. All enabled serial drivers are forced to differential logic "1." All serial data inputs are ignored.   |
| OELE                                 | LVTTTL Input, asynchronous, internal pull-up                 | <b>Serial Driver Output Enable Latch Enable.</b> Active HIGH. When OELE = HIGH, the signals on the BOE[7:0] inputs directly control the OUTxy± differential drivers. When the BOE[x] input is HIGH, the associated OUTxy± differential driver is enabled. When the BOE[x] input is LOW, the associated OUTxy± differential driver is powered down. The specific mapping of BOE[7:0] signals to transmit output enables is listed in <i>Table 10</i> . When OELE returns LOW, the last values present on BOE[7:0] are captured in the internal Output Enable Latch. If the device is reset (TRSTZ is sampled LOW), the latch is reset to disable all outputs.  |



Pin Descriptions (continued)

CYP(V)(W)15G0401DXB Quad HOTLink II Transceiver

| Pin Name                     | I/O Characteristics                          | Signal Description   |
|------------------------------|--|--|
| BISTLE                       | LVTTTL Input, asynchronous, internal pull-up | <b>Transmit and Receive BIST Latch Enable.</b> Active HIGH. When BISTLE = HIGH, the signals on the BOE[7:0] inputs directly control the transmit and receive BIST enables. When the BOE[x] input is LOW, the associated transmit or receive channel is configured to generate or compare the BIST sequence respectively. When the BOE[x] input is HIGH, the associated transmit or receive channel is configured for normal data transmission or reception. The specific mapping of BOE[7:0] signals to transmit and receive BIST enables is listed in <i>Table 10</i> . When BISTLE returns LOW, the last values present on BOE[7:0] are captured in the internal BIST Enable Latch. When the latch is closed, if the device is reset (TRSTZ is sampled LOW), the latch is reset to disable BIST on all transmit and receive channels.  |
| RXLE                         | LVTTTL Input, asynchronous, internal pull-up | <b>Receive Channel Power-control Latch Enable.</b> Active HIGH. When RXLE = HIGH, the signals on the BOE[7:0] inputs directly control the power enables for the receive PLLs and analog circuitry. When the BOE[7:0] input is HIGH, the associated receive channel A through D PLL and analog circuitry are active. When the BOE[7:0] input is LOW, the associated receive channel A through D PLL and analog circuitry are powered down. The specific mapping of BOE[7:0] signals to the associated receive channel enables is listed in <i>Table 10</i> . When RXLE returns LOW, the last values present on BOE[7:0] are captured in the internal RX PLL Enable Latch. When the device is reset (TRSTZ = LOW), the latch is reset to disable all receive channels.   |
| BOE[7:0]                     | LVTTTL Input, asynchronous, internal pull-up | <b>BIST, Serial Output, and Receive Channel Enables.</b> These inputs are passed to and through the Output Enable Latch when OELE is HIGH, and captured in this latch when OELE returns LOW. These inputs are passed to and through the BIST Enable Latch when BISTLE is HIGH, and captured in this latch when BISTLE returns LOW. These inputs are passed to and through the Receive Channel Enable Latch when RXLE is HIGH, and captured in this latch when RXLE returns LOW.  |
| LFIA<br>LFIB<br>LFIC<br>LFID | LVTTTL Output, Asynchronous                  | <b>Link Fault Indication Output.</b> Active LOW. $\overline{LFix}$ is the logical OR of four internal conditions: <ol style="list-style-type: none"> <li>1. Received serial data frequency outside expected range</li> <li>2. Analog amplitude below expected levels</li> <li>3. Transition density lower than expected</li> <li>4. Receive Channel disabled.</li> </ol>   |
| <b>Bonding Control</b>       |  |  |
| BONDST[1:0]                  | Bidirectional Open Drain, internal pull-up   | <b>Bonding Status.</b> These signals are only used when multiple devices are bonded together. They communicate the status of Elasticity Buffer management events from master device of the bonding domain to the slave devices of the same bonding domain. These outputs change at the same character rate as the receive output data buses, <u>but are</u> connected only to all the slave CYP(V)(W)15G0401DXB devices. When MASTER = LOW, these are output signals and present the Elasticity Buffer status from the selected master receive channel of the device configured as the master. Receive master channel selection is performed using the RXCLKB+ and RXCLKD+ inputs. The BONDST[1:0] Outputs of the master device must be connected to BONDST[1:0] Inputs of all the slave devices in the bonding domain. These status outputs indicate one of four possible conditions, on a synchronous basis, to the slave devices. These conditions are: <ul style="list-style-type: none"> <li>00—Reserved</li> <li>01—Add one K28.5 immediately following the next framing character received</li> <li>10—Delete next framing character received</li> <li>11—Normal data.</li> </ul> These outputs are driven only when the device is configured as a master, all four channels are bonded together, and the receive parallel interface is clocked by REFCLK↑. |

**Pin Descriptions** (continued)

**CYP(V)(W)15G0401DXB Quad HOTLink II Transceiver**

| Pin Name              | I/O Characteristics  | Signal Description   |
|-----------------------|--|--|
| MASTER                | LVTTTL Input, static configuration input, internal pull-down | <b>Master Device Select.</b> When LOW, the present device is configured as the master, and BONDST[1:0] outputs are driven. When HIGH, the present device is configured as a slave, and BONDST[1:0] are inputs. MASTER is only interpreted when configured for quad channel bonding, and the receive parallel interface is clocked by REFCLK↑.  |
| BOND_ALL              | Bidirectional Open Drain, Internal pull-up                   | <b>All Channels Bonded Indicator.</b> Active HIGH, wired AND. BOND_ALL pins from all CYP(V)15G0401DXB devices in the same bonding domain must be wired together. After bonding resolution is completed and when HIGH, all receive channels have detected valid framing. This output is LOW during the bonding resolution process. This output is driven only when configured for four channel bonding, and the receive parallel interface is clocked by REFCLK↑.   |
| BOND_INH              | LVTTTL Input, static configuration input, Internal pull-up   | <b>Parallel Bond Inhibit.</b> Active LOW. When asserted (LOW), this signal inhibits the adjustment of character offsets in all receive channels if the Bonding Sequence has <i>not</i> been detected in all bonded channels. When HIGH, all channels that have detected the Bonding Sequence are allowed to align their Receive Elasticity Buffer pipelines. For any channels to bond, the selected master channel <b>must</b> be a member of the group. When multiple devices are used together, the BOND_INH input on all parts must be configured the same. |
| <b>JTAG Interface</b> |  |  |
| TMS                   | LVTTTL Input, internal pull-up                               | <b>Test Mode Select.</b> Used to control access to the JTAG Test Modes. If maintained high for ≥5 TCLK cycles, the JTAG test controller is reset. The TAP controller is also reset automatically upon application of power to the device.  |
| TCLK                  | LVTTTL Input, internal pull-down                             | <b>JTAG Test Clock</b>   |
| TDO                   | Three-state LVTTTL Output                                    | <b>Test Data Out.</b> JTAG data output buffer which is High-Z while JTAG test mode is not selected.  |
| TDI                   | LVTTTL Input, internal pull-up                               | <b>Test Data In.</b> JTAG data input port.   |
| <b>Power</b>          |  |  |
| V <sub>CC</sub>       |  | <b>+3.3V Power</b>   |
| GND                   |  | <b>Signal and power ground for all internal circuits.</b>  |

**CYP(V)(W)15G0401DXB HOTLink II Operation**

The CYP(V)(W)15G0401DXB is a highly configurable device designed to support reliable transfer of large quantities of data, using high-speed serial links, from one or multiple sources to one or multiple destinations. This device supports four single-byte or single-character channels that may be combined to support transfer of wider buses.

**CYP(V)(W)15G0401DXB Transmit Data Path**
*Operating Modes*

The transmit path of the CYP(V)(W)15G0401DXB supports four character-wide data paths. These data paths are used in multiple operating modes as controlled by the TXMODE[1:0] inputs.

*Input Register*

The bits in the Input Register for each channel support different assignments, based on if the character is unencoded, encoded with two control bits, or encoded with three control bits. These assignments are shown in *Table 1*. Each Input

Register captures a minimum of eight data bits and two control bits on each input clock cycle. When the Encoder is bypassed, the TXCTx[1:0] control bits, are part of the preencoded 10-bit character.

When the Encoder is enabled (TXMODE[1] ≠ LOW), the TXCTx[1:0] bits are interpreted along with the associated TXDx[7:0] character to generate the specific 10-bit transmission character. When TXMODE[0] ≠ HIGH, an additional special character select (SCSEL) input is also captured and interpreted. This SCSEL input is used to modify the encoding of the associated characters. When the transmit Input Registers are clocked by a common clock (TXCLKA↑ or REFCLK↑), this SCSEL input can be changed on a clock-by-clock basis and affects all four channels.

When operated with a separate input clock on each transmit channel, this SCSEL input is sampled synchronous to TXCLKA↑. While the value on SCSEL still affects all channels, it is interpreted when the character containing it is read from the transmit Phase-align Buffer (where all four paths are internally clocked synchronously).

**Table 1. Input Register Bit Assignments** <sup>[6]</sup>

| Signal Name    | Unencoded | Encoded       |               |
|----------------|-----------|---------------|---------------|
|                |           | 2-bit Control | 3-bit Control |
| TXDx[0] (LSB)  | DINx[0]   | TXDx[0]       | TXDx[0]       |
| TXDx[1]        | DINx[1]   | TXDx[1]       | TXDx[1]       |
| TXDx[2]        | DINx[2]   | TXDx[2]       | TXDx[2]       |
| TXDx[3]        | DINx[3]   | TXDx[3]       | TXDx[3]       |
| TXDx[4]        | DINx[4]   | TXDx[4]       | TXDx[4]       |
| TXDx[5]        | DINx[5]   | TXDx[5]       | TXDx[5]       |
| TXDx[6]        | DINx[6]   | TXDx[6]       | TXDx[6]       |
| TXDx[7]        | DINx[7]   | TXDx[7]       | TXDx[7]       |
| TXCTx[0]       | DINx[8]   | TXCTx[0]      | TXCTx[0]      |
| TXCTx[1] (MSB) | DINx[9]   | TXCTx[1]      | TXCTx[1]      |
| SCSEL          | N/A       | N/A           | SCSEL         |

#### Phase-align Buffer

Data from the Input Registers are passed either to the Encoder or to the associated Phase-align Buffer. When the transmit paths are operated synchronous to REFCLK $\uparrow$  (TXCKSEL = LOW and TXRATE = LOW), the Phase-align Buffers are bypassed and data is passed directly to the Parity Check and Encoder blocks to reduce latency.

When an Input-Register clock with an uncontrolled phase relationship to REFCLK is selected (TXCKSEL  $\neq$  LOW) or if data is captured on both edges of REFCLK (TXRATE = HIGH), the Phase-align Buffers are enabled. These buffers are used to absorb clock phase differences between the presently selected input clock and the internal character clock.

Initialization of the Phase-align Buffers takes place when the TXRST input is sampled LOW by two consecutive rising edges of REFCLK. When TXRST is returned HIGH, the present input clock phase relative to REFCLK is set. TXRST is an asynchronous input, but is sampled internally to synchronize it to the internal transmit path state machines.

Once set, the input clocks are allowed to skew in time up to half a character period in either direction relative to REFCLK; i.e.,  $\pm 180^\circ$ . This time shift allows the delay paths of the character clocks (relative to REFCLK) to change due to operating voltage and temperature, while not affecting the design operation.

If the phase offset, between the initialized location of the input clock and REFCLK $\uparrow$ , exceeds the skew handling capabilities of the Phase-align Buffer, an error is reported on the associated TXPERx output. This output indicates a continuous error until the Phase-align Buffer is reset. While the error remains active, the transmitter for the associated channel will

#### Notes:

- The TXOPx inputs are also captured in the associated Input Register, but their interpretation is under the separate control of PARCTL.
- One or more K28.5 characters may be added or lost from the data stream during this reset operation. When used with non-Cypress devices that require a complete 16-character Word Sync Sequence for proper Receive Elasticity Buffer alignment, it is recommended that the sequence be followed by a second Word Sync Sequence to ensure proper operation.
- Transmit path parity errors are reported on the associated TXPERx output.
- Bits marked as X are XORed together. Result must be a logic-1 for parity to be valid.

output a continuous C0.7 character to indicate to the remote receiver that an error condition is present in the link.

In specific transmit modes, it is also possible to reset the Phase-align Buffers individually and with minimal disruption of the serial data stream. When the transmit interface is configured for generation of atomic Word Sync Sequences (TXMODE[1] = MID) and a Phase-align Buffer error is present, the transmission of a Word Sync Sequence will re-center the Phase-align Buffer and clear the error condition.<sup>[7]</sup>

#### Parity Support

In addition to the ten data and control bits that are captured at each transmit Input Register, a TXOPx input is also available on each channel. This allows the CYP(V)(W)15G0401DXB to support ODD parity checking for each channel. Parity checking is available for all operating modes (including Encoder Bypass). The specific mode of parity checking is controlled by the PARCTL input, and operates per Table 2.

**Table 2. Input Register Bits Checked for Parity** <sup>[8]</sup>

| Signal Name | Transmit Parity Check Mode (PARCTL) |                  |                      |      |
|-------------|-------------------------------------|------------------|----------------------|------|
|             | LOW                                 | MID              |                      | HIGH |
|             |                                     | TXMODE[1] = LOW  | TXMODE[1] $\neq$ LOW |      |
| TXDx[0]     |                                     | X <sup>[9]</sup> | X                    | X    |
| TXDx[1]     |                                     | X                | X                    | X    |
| TXDx[2]     |                                     | X                | X                    | X    |
| TXDx[3]     |                                     | X                | X                    | X    |
| TXDx[4]     |                                     | X                | X                    | X    |
| TXDx[5]     |                                     | X                | X                    | X    |
| TXDx[6]     |                                     | X                | X                    | X    |
| TXDx[7]     |                                     | X                | X                    | X    |
| TXCTx[0]    |                                     | X                |                      | X    |
| TXCTx[1]    |                                     | X                |                      | X    |
| TXOPx       |                                     | X                | X                    | X    |

When PARCTL is MID (open) and the Encoders are enabled (TXMODE[1]  $\neq$  LOW), only the TXDx[7:0] data bits are checked for ODD parity along with the associated TXOPx bit. When PARCTL = HIGH with the Encoder enabled (or MID with the Encoder bypassed), the TXDx[7:0] and TXCTx[1:0] inputs are checked for ODD parity along with the associated TXOPx bit. When PARCTL = LOW, parity checking is disabled.

When parity checking and the Encoder are both enabled (TXMODE[1]  $\neq$  LOW), the detection of a parity error causes a C0.7 character of proper disparity to be passed to the Transmit Shifter. When the Encoder is bypassed (TXMODE[1] = LOW, LOW), detection of a parity error causes a positive disparity version of a C0.7 transmission character to be passed to the Transmit Shifter.



### Encoder

The character, received from the Input Register or Phase-align Buffer and Parity Check Logic, is then passed to the Encoder logic. This block interprets each character and any associated control bits, and outputs a 10-bit transmission character.

Depending on the configured operating mode, the generated transmission character may be

- the 10-bit pre-encoded character accepted in the Input Register
- the 10-bit equivalent of the eight-bit Data character accepted in the Input Register
- the 10-bit equivalent of the eight-bit Special Character code accepted in the Input Register
- the 10-bit equivalent of the C0.7 SVS character if parity checking was enabled and a parity error was detected
- the 10-bit equivalent of the C0.7 SVS character if a Phase-align Buffer overflow or underflow error is present
- a character that is part of the 511-character BIST sequence
- a K28.5 character generated as an individual character or as part of the 16-character Word Sync Sequence.

The selection of the specific characters generated are controlled by the TXMODE[1:0], SCSEL, TXCTx[1:0], and TXDx[7:0] inputs for each character.

### Data Encoding

Raw data, as received directly from the Transmit Input Register, is seldom in a form suitable for transmission across a serial link. The characters must usually be processed or transformed to guarantee

- a minimum transition density (to allow the serial receive PLL to extract a clock from the data stream).
- a DC-balance in the signaling (to prevent baseline wander).
- run-length limits in the serial data (to limit the bandwidth requirements of the serial link).
- the remote receiver a way of determining the correct character boundaries (framing).

When the Encoder is enabled (TXMODE[1]  $\neq$  LOW), the characters to be transmitted are converted from Data or Special Character codes to 10-bit transmission characters (as selected by their respective TXCTx[1:0] and SCSEL inputs), using an integrated 8B/10B Encoder. When directed to encode the character as a Special Character code, it is encoded using the Special Character encoding rules listed in *Table 29*. When directed to encode the character as a Data character, it is encoded using the Data Character encoding rules in *Table 28*.

The 8B/10B Encoder is standards compliant with ANSI/NCITS ASC X3.230-1994 (Fibre Channel), IEEE 802.3z (Gigabit Ethernet), the IBM<sup>®</sup> ESCON<sup>®</sup> and FICON<sup>™</sup> channels, Digital Video Broadcast (DVB-ASI), and ATM Forum standards for data transport.

Many of the Special Character codes listed in *Table 29* may be generated by more than one input character. The CYP(V)(W)15G0401DXB is designed to support two independent (but non-overlapping) Special Character code tables. This allows the CYP(V)(W)15G0401DXB to operate in mixed environments with other Cypress HOTLink devices using the enhanced Cypress command code set, and the reduced command sets of other non-Cypress devices. Even when used in an environment that normally uses non-Cypress Special Character codes, the selective use of Cypress

command codes can permit operation where running disparity and error handling must be managed.

Following conversion of each input character from eight bits to a 10-bit transmission character, it is passed to the Transmit Shifter and is shifted out LSB first, as required by ANSI and IEEE standards for 8B/10B coded serial data streams.

### Transmit Modes

The operating mode of the transmit path is set through the TXMODE[1:0] inputs. These static three-level select inputs allow one of nine transmit modes to be selected. The transmit modes are listed in *Table 3*

**Table 3. Transmit Operating Modes**

| TX Mode     |              | Operating Mode             |                   |                   |
|-------------|--------------|----------------------------|-------------------|-------------------|
| Mode Number | TXMODE [1:0] | Word Sync Sequence Support | SCSEL Control     | TXCTx Function    |
| 0           | LL           | None                       | None              | Encoder Bypass    |
| 1           | LM           | None                       | None              | Reserved for test |
| 2           | LH           | None                       | None              | Reserved for test |
| 3           | ML           | Atomic                     | Special Character | Encoder Control   |
| 4           | MM           | Atomic                     | Word Sync         | Encoder Control   |
| 5           | MH           | Atomic                     | None              | Encoder Control   |
| 6           | HL           | Interruptible              | Special Character | Encoder Control   |
| 7           | HM           | Interruptible              | Word Sync         | Encoder Control   |
| 8           | HH           | Interruptible              | None              | Encoder Control   |

The encoded modes (TX Modes 3 through 8) support multiple encoding tables. These encoding tables vary by the specific combinations of SCSEL, TXCTx[1], and TXCTx[0] that are used to control the generation of data and control characters. These multiple encoding forms allow maximum flexibility in interfacing to legacy applications, while also supporting numerous extensions in capabilities.

#### TX Mode 0—Encoder Bypass

When the Encoder is bypassed, the character captured from the TXDx[7:0] and TXCTx[1:0] inputs is passed directly to the Transmit Shifter without modification. If parity checking is enabled (PARCTL  $\neq$  LOW) and a parity error is detected, the 10-bit character is replaced with the 1001111000 pattern (+C0.7 character).

With the Encoder bypassed, the TXCTx[1:0] inputs are considered part of the data character and do not perform a control function that would otherwise modify the interpretation of the TXDx[7:0] bits. The bit usage and mapping of these control bits when the Encoder is bypassed is shown in *Table 4*.

In Encoder Bypass mode, the SCSEL input is ignored. All clocking modes interpret the data the same, with no internal linking between channels.

#### TX Modes 1 and 2—Factory Test Modes

These modes enable specific factory test configurations. They are not considered normal operating modes of the device.



When TXCKSEL = MID, all transmit channels operate independently. In this mode, the SCSEL input is sampled only by TXCLKA↑. When the character accepted in the Channel-A Input Register has passed any selected validation and is ready to be passed to the Encoder, the level captured on SCSEL is passed to the Encoders of the remaining channels during this same cycle.

**Table 6. TX Modes 4 and 7 Encoding**

| SCSEL | TXCTx[1] | TXCTx[0] | Characters Generated            |
|-------|----------|----------|---------------------------------|
| X     | X        | 0        | Encoded data character          |
| 0     | 0        | 1        | K28.5 fill character            |
| 0     | 1        | 1        | Special character code          |
| 1     | X        | 1        | 16-character Word Sync Sequence |

Changing the state of SCSEL will change the relationship of the characters to other channels. SCSEL should either be used as a static configuration input, or changed only when the state of TXCTx[1:0] on the alternate channels are such that SCSEL is ignored during the change.

TX Mode 4 also supports an Word Sync Sequence. Unlike TX Mode 3, this sequence starts when SCSEL and TXCTx[0] are both high. With the exception of the combination of control bits used to initiate the sequence, the generation and operation of this Word Sync Sequence is the same as for TX Mode 3.

**TX Mode 5—Atomic Word Sync generation without SCSEL.**

When configured in TX Mode 5, the SCSEL signal is not used. In addition to the standard character encodings, two additional encoding mappings are controlled by the Channel Bonding selection made through the RXMODE[1:0] inputs. For non-bonded operation, the TXCTx[1:0] inputs for each channel control the characters generated by that channel. The specific characters generated by these bits are listed in Table 7.

**Table 7. TX Modes 5 and 8 Encoding, Non-bonded (RX-MODE[1] = LOW)**

| SCSEL | TXCTx[1] | TXCTx[0] | Characters Generated            |
|-------|----------|----------|---------------------------------|
| X     | 0        | 0        | Encoded data character          |
| X     | 0        | 1        | K28.5 fill character            |
| X     | 1        | 0        | Special character code          |
| X     | 1        | 1        | 16-character Word Sync Sequence |

TX Mode 5 also has the capability of generating an atomic Word Sync Sequence. For the sequence to be started, the TXCTx[1:0] inputs must both be sampled HIGH. The generation and operation of this Word Sync Sequence is the same as TX Mode 3. Two additional encoding maps are provided for use when receive channel bonding is enabled. When

dual-channel bonding is enabled (RXMODE[1] = MID), the CYP(V)(W)15G0401DXB is configured such that channels A and B are bonded together to form a two-character-wide path, and channels C and D are bonded together to form a second two-character-wide path.

When operated in this two-channel bonded mode, the TXCTA[0] and TXCTB[0] inputs control the interpretation of the data on both the A and B channels, while the TXCTC[0] and TXCTD[0] inputs control the interpretation of the data on both the C and D channels. The characters on each half of these bonded channels are controlled by the associated TXCTx[1] bit. The specific characters generated by these control bit combinations are listed in Table 8.

Note especially that any time TXCTB[0] is sampled HIGH, both channels A and B start generating an atomic Word Sync Sequence, regardless of the state of any of the other bits in the A or B Input Registers. In a similar fashion, anytime TXCTD[0] is sampled HIGH, both the C and D channels start generation of an atomic Word Sync Sequence.

When RXMODE[1] = HIGH, the CYP(V)(W)15G0401DXB is configured for quad-channel bonding, such that channels A, B, C, and D are bonded together to form a four-character-wide path. When operated in this mode, the TXCTA[0] and TXCTB[0] inputs control the interpretation of the data on all four channels. The characters generated on these bonded channels are controlled by the associated TXCTx[1] bit. The specific characters generated by these bits are listed in Table 9.

Unlike dual-channel bonded modes, when all four channels are bonded together, the TXCTC[0] and TXCTD[0] inputs are ignored.

**Transmit BIST**

Each transmit channel contains an internal pattern generator that can be used to validate both device and link operation. These generators are enabled by the associated BOE[x] signals listed in Table 10 (when the BISTLE latch enable input is HIGH). When enabled, a register in the associated transmit channel becomes a signature pattern generator by logically converting to a Linear Feedback Shift Register (LFSR). This LFSR generates a 511-character sequence that includes all Data and Special Character codes, including the explicit violation symbols. This provides a predictable yet pseudo-random sequence that can be matched to identical LFSR in the attached Receiver(s). If the receive channels are configured for common clock operation (RXCKSEL ≠ MID) and Encoder is enabled (TXMODE[1] ≠ LOW) each pass is preceded by a 16-character Word Sync Sequence to allow Elasticity Buffer alignment and management of clock-frequency variations.

When the BISTLE signal is HIGH, any BOE[x] input that is LOW enables the BIST generator in the associated transmit channel (or the BIST checker in the associated receive channel). When BISTLE returns LOW, the values of all BOE[x] signals are captured in the BIST Enable Latch. These values remain in the BIST Enable Latch until BISTLE is returned HIGH to open the latch. A device reset (TRSTZ sampled LOW), presets the BIST Enable Latch to disable BIST on all channels.

All data and data-control information present at the associated TXDx[7:0] and TXCTx[1:0] inputs are ignored when BIST is active on that channel.

**Table 8. TX Modes 5 and 8, Dual-channel Bonded (RXMODE[1] = MID)**

| SCSEL | TXCTA[1] | TXCTA[0] | TXCTB[1] | TXCTB[0] | TXCTC[1] | TXCTC[0] | TXCTD[1] | TXCTD[0] | Characters Generated                       |
|-------|----------|----------|----------|----------|----------|----------|----------|----------|--|
| X     | 0        | 0        | X        | 0        | X        | X        | X        | X        | Encoded data character on channel A        |
| X     | 0        | 1        | X        | 0        | X        | X        | X        | X        | K28.5 fill character on channel A          |
| X     | 1        | 0        | X        | 0        | X        | X        | X        | X        | Special character code on channel A        |
| X     | 1        | 1        | X        | 0        | X        | X        | X        | X        | 16-character word sync on channel A        |
| X     | X        | 0        | 0        | 0        | X        | X        | X        | X        | Encoded data character on channel B        |
| X     | X        | 1        | 0        | 0        | X        | X        | X        | X        | K28.5 fill character on channel B          |
| X     | X        | 0        | 1        | 0        | X        | X        | X        | X        | Special character code on channel B        |
| X     | X        | 1        | 1        | 0        | X        | X        | X        | X        | 16-character word sync on channel B        |
| X     | X        | X        | X        | 1        | X        | X        | X        | X        | 16-character word sync on channels A and B |
| X     | X        | X        | X        | X        | 0        | 0        | X        | 0        | Encoded data character on channel C        |
| X     | X        | X        | X        | X        | 0        | 1        | X        | 0        | K28.5 fill character on channel C          |
| X     | X        | X        | X        | X        | 1        | 0        | X        | 0        | Special character code on channel C        |
| X     | X        | X        | X        | X        | 1        | 1        | X        | 0        | 16-character word sync on channel C        |
| X     | X        | X        | X        | X        | X        | 0        | 0        | 0        | Encoded data character on channel D        |
| X     | X        | X        | X        | X        | X        | 1        | 0        | 0        | K28.5 fill character on channel D          |
| X     | X        | X        | X        | X        | X        | 0        | 1        | 0        | Special character code on channel D        |
| X     | X        | X        | X        | X        | X        | 1        | 1        | 0        | 16-character word sync on channel D        |
| X     | X        | X        | X        | X        | X        | X        | X        | 1        | 16-character word sync on channels C and D |

**Table 9. TX Modes 5 and 8, Quad-Channel Bonded (RXMODE[1] = HIGH)**

| SCSEL | TXCTA[1] | TXCTA[0] | TXCTB[1] | TXCTB[0] | TXCTC[1] | TXCTC[0] | TXCTD[1] | TXCTD[0] | Characters Generated                              |
|-------|----------|----------|----------|----------|----------|----------|----------|----------|---|
| X     | 0        | 0        | X        | 0        | X        | X        | X        | X        | Encoded data character on channel A               |
| X     | 0        | 1        | X        | 0        | X        | X        | X        | X        | K28.5 fill character on channel A                 |
| X     | 1        | 0        | X        | 0        | X        | X        | X        | X        | Special character code on channel A               |
| X     | 1        | 1        | X        | 0        | X        | X        | X        | X        | 16-character word sync on channel A               |
| X     | X        | 0        | 0        | 0        | X        | X        | X        | X        | Encoded data character on channel B               |
| X     | X        | 1        | 0        | 0        | X        | X        | X        | X        | K28.5 fill character on channel B                 |
| X     | X        | 0        | 1        | 0        | X        | X        | X        | X        | Special character code on channel B               |
| X     | X        | 1        | 1        | 0        | X        | X        | X        | X        | 16-character word sync on channel B               |
| X     | X        | 0        | X        | 0        | 0        | X        | X        | X        | Encoded data character on channel C               |
| X     | X        | 1        | X        | 0        | 0        | X        | X        | X        | K28.5 fill character on channel C                 |
| X     | X        | 0        | X        | 0        | 1        | X        | X        | X        | Special character code on channel C               |
| X     | X        | 1        | X        | 0        | 1        | X        | X        | X        | 16-character word sync on channel C               |
| X     | X        | 0        | X        | 0        | X        | X        | 0        | X        | Encoded data character on channel D               |
| X     | X        | 1        | X        | 0        | X        | X        | 0        | X        | K28.5 fill character on channel D                 |
| X     | X        | 0        | X        | 0        | X        | X        | 1        | X        | Special character code on channel D               |
| X     | X        | 1        | X        | 0        | X        | X        | 1        | X        | 16-character word sync on channel D               |
| X     | X        | X        | X        | 1        | X        | X        | X        | X        | 16-character word sync on channels A, B, C, and D |

### Serial Output Drivers

The serial interface Output Drivers use high-performance differential CML (Current Mode Logic) to provide source-matched drivers for the transmission lines. These Serial Drivers accept data from the Transmit Shifters. These outputs have signal swings equivalent to that of standard PECL drivers, and are capable of driving AC-coupled optical modules or transmission lines. To achieve OBSAI RP3 compliancy, the serial output drivers must be AC-coupled to the transmission medium.

When configured for local loopback (LPEN = HIGH), all enabled Serial Drivers are configured to drive a static differential logic-1.

Each Serial Driver can be enabled or disabled separately through the BOE[7:0] inputs, as controlled by the OELE latch-enable signal. When OELE is HIGH, the signals present on the BOE[7:0] inputs are passed through the Serial Output Enable Latch to control the Serial Driver. The BOE[7:0] input associated with a specific OUTxy± driver is listed in *Table 10*. When OELE is HIGH and BOE[x] is HIGH, the associated Serial Driver is enabled. When OELE is HIGH and BOE[x] is LOW, the associated Serial Driver is disabled and internally powered down. If both Serial Drivers for a channel are in this disabled state, the associated internal logic for that channel is also powered down. When OELE returns LOW, the values present on the BOE[7:0] inputs are latched in the Output Enable Latch, and remain there until OELE returns HIGH to enable the latch. A device reset (TRSTZ sampled LOW) clears this latch and disables all Serial Drivers.

**Table 10. Output Enable, BIST, and Receive Channel Enable Signal Map**

| BOE Input | Output Controlled (OELE) | BIST Channel Enable (BISTLE) | Receive PLL Channel Enable (RXLE) |
|-----------|--------------------------|------------------------------|-----------------------------------|
| BOE[7]    | OUTD2±                   | Transmit D                   | X                                 |
| BOE[6]    | OUTD1±                   | Receive D                    | Receive D                         |
| BOE[5]    | OUTC2±                   | Transmit C                   | X                                 |
| BOE[4]    | OUTC1±                   | Receive C                    | Receive C                         |
| BOE[3]    | OUTB2±                   | Transmit B                   | X                                 |
| BOE[2]    | OUTB1±                   | Receive B                    | Receive B                         |
| BOE[1]    | OUTA2±                   | Transmit A                   | X                                 |
| BOE[0]    | OUTA1±                   | Receive A                    | Receive A                         |

**NOTE:** When all transmit channels are disabled (i.e., both outputs disabled in all channels) and a channel is re-enabled, the data on the Serial Drivers may not meet all timing specifications for up to 200 μs.

### Transmit PLL Clock Multiplier

The Transmit PLL Clock Multiplier accepts a character-rate or half-character-rate external clock at the REFCLK input, and multiplies that clock by 10 or 20 (as selected by TXRATE) to generate a bit-rate clock for use by the Transmit Shifter. It also provides a character-rate clock used by the transmit paths.

This clock multiplier PLL can accept a REFCLK input between 20 MHz and 150 MHz (19.5 MHz and 154 MHz for CYW15G0401DXB), however, this clock range is limited by the operating mode of the CYP(V)(W)15G0401DXB clock

multiplier (controlled by TXRATE) and by the level on the SPDSEL input.

When TXRATE = HIGH (Half-rate REFCLK), TXCKSEL = HIGH or MID (TXCLKx or TXCLKA selected to clock input register) is an invalid mode of operation.

SPDSEL is a static three-level select<sup>[5]</sup> (ternary) input that selects one of three operating ranges for the serial data outputs and inputs. The operating serial signaling-rate and allowable range of REFCLK frequencies are listed in *Table 11*.

**Table 11. Operating Speed Settings**

| SPDSEL     | TXRATE | REFCLK Frequency (MHz) | Signaling Rate (Mbaud)                          |
|------------|--------|------------------------|---|
| LOW        | 1      | reserved               | 195–400   |
|            | 0      | 19.5–40                |   |
| MID (Open) | 1      | 20–40                  | 400–800   |
|            | 0      | 40–80                  |   |
| HIGH       | 1      | 40–75                  | 800–1500<br>(800–1540 for<br>CYW15G0401<br>DXB) |
|            | 0      | 80–150                 |   |

The REFCLK± input is a differential input with each input internally biased to 1.4V. If the REFCLK+ input is connected to a TTL, LVTTTL, or LVCMOS clock source, REFCLK– can be left floating and the input signal is recognized when it passes through the internally biased reference point.

When both the REFCLK+ and REFCLK– inputs are connected, the clock source must be a differential clock. This can be either a differential LVPECL clock that is DC- or AC-coupled, or a differential LVTTTL or LVCMOS clock.

By connecting the REFCLK– input to an external voltage source or resistive voltage divider, it is possible to adjust the reference point of the REFCLK+ input for alternate logic levels. When doing so, it is necessary to ensure that the input differential crossing point remains within the parametric range supported by the input.

### CYP(V)(W)15G0401DXB Receive Data Path

#### Serial Line Receivers

Two differential Line Receivers, INx1± and INx2±, are available on each channel for accepting serial data streams. The active Serial Line Receiver on a channel is selected using the associated INSELx input. The Serial Line Receiver inputs are differential, and can accommodate wire interconnect and filtering losses or transmission line attenuation greater than 16 dB. For normal operation, these inputs should receive a signal of at least  $V_{DIFF} > 100$  mV, or 200 mV peak-to-peak differential. Each Line Receiver can be DC- or AC-coupled to +3.3V powered fiber-optic interface modules (any ECL/PECL family, not limited to 100K PECL) or AC-coupled to +5V powered optical modules. The common-mode tolerance of these line receivers accommodates a wide range of signal termination voltages. Each receiver provides internal DC-restoration, to the center of the receiver's common mode range, for AC-coupled signals.

The local loopback input (LPEN) allows the serial transmit data to be routed internally back to the Clock and Data Recovery circuit associated with each channel. When configured for

local loopback, all transmit Serial Driver outputs are forced to output a differential logic-1. This prevents local diagnostic patterns from being broadcast to attached remote receivers.

### Signal Detect/Link Fault

Each selected Line Receiver (i.e., that routed to the clock and data recovery PLL) is simultaneously monitored for

- analog amplitude above limit specified by SDASEL
- transition density greater than specified limit
- range controller reports the received data stream within normal frequency range ( $\pm 1500$  ppm)<sup>[12]</sup>
- receive channel enabled

All of these conditions must be valid for the Signal Detect block to indicate a valid signal is present. This status is presented on the LFix (Link Fault Indicator) output associated with each receive channel.

**Table 12. Analog Amplitude Detect Valid Signal Levels<sup>[13]</sup>**

| SDASEL     | Typical signal with peak amplitudes above |
|------------|---|
| LOW        | 140 mV p-p differential                   |
| MID (Open) | 280 mV p-p differential                   |
| HIGH       | 420 mV p-p differential                   |

#### Analog Amplitude

While most signal monitors are based on fixed constants, the analog amplitude level detection is adjustable. This allows operation with highly attenuated signals, or in high-noise environments. This adjustment is made through the SDASEL signal, a three-level select<sup>[5]</sup> input, which sets the trip point for the detection of a valid signal at one of three levels, as listed in *Table 12*. This control input affects the analog monitors for all receive channels.

The Analog Signal Detect Monitors are active for the Line Receiver selected by the associated INSELx input. When the channel is configured for local loopback ( $\underline{LPEN} = \text{HIGH}$ ), no line receivers are selected, and the LFix output for each channel reports only the receive VCO frequency out-of-range and transition density status of the associated transmit signal. When local loopback is active, the Analog Signal Detect Monitors are disabled.

#### Transition Density

The Transition Detection logic checks for the absence of any transitions spanning greater than six transmission characters (60 bits). If no transitions are present in the data received on a channel, the Transition Detection logic for that channel will assert LFix. The LFix output remains asserted until at least one transition is detected in each of three adjacent received characters.

#### Range Controls

The Clock/Data Recovery (CDR) circuit includes logic to monitor the frequency of the Phase Locked Loop (PLL)

#### Notes:

- REFCLK has no phase or frequency relationship with the recovered clock(s) and only acts as a centering reference to reduce clock synchronization time. REFCLK must be within  $\pm 1500$  PPM ( $\pm 0.15\%$ ) of the remote transmitter's PLL reference (REFCLK) frequency. Although transmitting to a HOTLink II receiver necessitates the frequency difference between the transmitter and receiver reference clocks to be within  $\pm 1500$ -PPM, the stability of the crystal needs to be within the limits specified by the appropriate standard when transmitting to a remote receiver that is compliant to that standard. For example, to be IEEE 802.3z Gigabit Ethernet compliant, the frequency stability of the crystal needs to be within  $\pm 100$  PPM.
- The peak amplitudes listed in this table are for typical waveforms that have generally 3 – 4 transitions for every ten bits. In a worse case environment the signals may have a sign-wave appearance (highest transition density with repeating 0101...). Signal peak amplitudes levels within this environment type could increase the values in the table above by approximately 100 mV.
- When a disabled receive channel is re-enabled, the status of the associated LFix output and data on the parallel outputs for the associated channel may be indeterminate for up to 2 ms.

Voltage Controlled Oscillator (VCO) used to sample the incoming data stream. This logic ensures that the VCO operates at, or near the rate of the incoming data stream for two primary cases:

- when the incoming data stream resumes after a time in which it has been "missing"
- when the incoming data stream is outside the acceptable frequency range

To perform this function, the frequency of the VCO is periodically sampled and compared to the frequency of the REFCLK input. If the VCO is running at a frequency beyond  $\pm 1500$  ppm<sup>[12]</sup> as defined by the reference clock frequency, it is periodically forced to the correct frequency (as defined by REFCLK, SPDSEL, and TXRATE) and then released in an attempt to lock to the input data stream. The sampling and relock period of the Range Control is calculated as follows: RANGE CONTROL SAMPLING PERIOD = (REFCLKPERIOD) \* (16000).

During the time that the Range Control forces the PLL VCO to run at REFCLK\*10 (or REFCLK\*20 when TXRATE = HIGH) rate, the LFix output will be asserted LOW. While the PLL is attempting to re-lock to the incoming data stream, LFix may be either HIGH or LOW (depending on other factors such as transition density and amplitude detection) and the recovered byte clock (RXCLKx) may run at an incorrect rate (depending on the quality or existence of the input serial data stream). After a valid serial data stream is applied, it may take up to one RANGE CONTROL SAMPLING PERIOD before the PLL locks to the input data stream, after which LFix should be HIGH.

#### Receive Channel Enabled

The CYP(V)(W)15G0401DXB contains four receive channels that can be independently enabled and disabled. Each channel can be enabled or disabled separately through the BOE[7:0] inputs, as controlled by the RXLE latch-enable signal. When RXLE is HIGH, the signals present on the BOE[7:0] inputs are passed through the Receive Channel Enable Latch to control the PLLs and logic of the associated receive channel. The BOE[7:0] input associated with a specific receive channel is listed in *Table 10*.

When RXLE is HIGH and BOE[x] is HIGH, the associated receive channel is enabled to receive and recover a serial stream. When RXLE is HIGH and BOE[x] is LOW, the associated receive channel is disabled and powered down. If a single channel of a bonded-pair or bonded-quad is disabled, the other receive channels may not bond correctly. If the disabled channel is selected as the master channel for insert/delete or recovered clock select, these functions will not work correctly. Any disabled channel indicates an asserted LFix output. When RXLE returns LOW, the values present on the BOE[7:0] inputs are latched in the Receive Channel Enable Latch, and remain there until RXLE returns HIGH to open the latch again.<sup>[14]</sup>

### Clock/Data Recovery

The extraction of a bit-rate clock and recovery of bits from each received serial stream is performed by a separate Clock/Data Recovery (CDR) block within each receive channel. The clock extraction function is performed by embedded phase-locked loops (PLLs) that track the frequency of the transitions in the incoming bit streams and align the phase of their internal bit-rate clocks to the transitions in the selected serial data streams.

Each CDR accepts a character-rate (bit-rate ÷ 10) or half-character-rate (bit-rate ÷ 20) reference clock from the REFCLK input. This REFCLK input is used to

- ensure that the VCO (within the CDR) is operating at the correct frequency.
- to reduce PLL acquisition time
- and to limit unlocked frequency excursions of the CDR VCO when there is no input data present at the selected Serial Line Receiver.

Regardless of the type of signal present, the CDR will attempt to recover a data stream from it. If the frequency of the recovered data stream is outside the limits of the range control monitor, the CDR will switch to track REFCLK instead of the data stream. Once the CDR output (RXCLKx) frequency returns back close to REFCLK frequency, the CDR input will be switched back to track the input data stream. In case no data is present at the input this switching behavior may result in brief RXCLKx frequency excursions from REFCLK. However, the validity of the input data stream is indicated by the LFIx output. The frequency of REFCLK is required to be within ±1500 ppm<sup>[12]</sup> of the frequency of the clock that drives the REFCLK input of the remote transmitter to ensure a lock to the incoming data stream.

For systems using multiple or redundant connections, the LFIx output can be used to select an alternate data stream. When an LFIx indication is detected, external logic can toggle selection of the associated INx1± and INx2± inputs through the associated INSELx input. When a port switch takes place, it is necessary for the receive PLL for that channel to reacquire the new serial stream and frame to the incoming character boundaries. If channel bonding is also enabled, a channel alignment event is also required before the output data may be considered usable.

### Deserializer/Framer

Each CDR circuit extracts bits from the associated serial data stream and clocks these bits into the Shifter/Framer at the bit-clock rate. When enabled, the Framer examines the data stream, looking for one or more Comma or K28.5 characters at all possible bit positions. The location of this character in the data stream is used to determine the character boundaries of all following characters.

#### Framing Character

The CYP(V)(W)15G0401DXB allows selection of two combinations of framing characters to support requirements of different interfaces. The selection of the framing character is made through the FRAMCHAR input.

#### Notes:

15. The standard definition of a Comma contains only seven bits. However, since all valid Comma characters within the 8B/10B character set also have the eighth bit as an inversion of the seventh bit, the compare pattern is extended to a full eight bits to reduce the possibility of a framing error.
16. When Receive BIST is enabled on a channel, the Low-Latency Framer must not be enabled. The BIST sequence contains an aliased K28.5 framing character, which would cause the Receiver to update its character boundaries incorrectly.

The specific bit combinations of these framing characters are listed in *Table 13*. When the specific bit combination of the selected framing character is detected by the Framer, the boundaries of the characters present in the received data stream are known.

**Table 13. Framing Character Selector**

| FRAMCHAR   | Bits Detected in Framer |   |
|------------|-------------------------|---|
|            | Character Name          | Bits Detected                               |
| LOW        | Reserved for test       |   |
| MID (Open) | Comma+<br>or Comma-     | 00111110XX <sup>[15]</sup><br>or 11000001XX |
| HIGH       | -K28.5<br>or +K28.5     | 0011111010 or<br>1100000101                 |

#### Framer

The Framer on each channel operates in one of three different modes, as selected by the RFMODE input. In addition, the Framer itself may be enabled or disabled through the RFEN input. When RFEN = LOW, the framers in all four receive paths are disabled, and no combination of bits in a received data stream will alter the character boundaries. When RFEN = HIGH, the Framer selected by RFMODE is enabled on all four channels.

When RFMODE = LOW, the Low-Latency Framer is selected<sup>[16]</sup>. This Framer operates by stretching the recovered character clock until it aligns with the received character boundaries. In this mode, the Framer starts its alignment process on the first detection of the selected framing character. To reduce the impact on external circuits that make use of a recovered clock, the clock period is not stretched by more than two bit-periods in any one clock cycle. When operated with a character-rate output clock (RXRATE = LOW), the output of properly framed characters may be delayed by up to nine character-clock cycles from the detection of the selected framing character. When operated with a half-character-rate output clock (RXRATE = HIGH), the output of properly framed characters may be delayed by up to fourteen character-clock cycles from the detection of the selected framing character.

When RFMODE = MID (open), the Cypress-mode Multi-Byte Framer is selected. The required detection of multiple framing characters makes the associated link much more robust to incorrect framing due to aliased framing characters in the data stream. In this mode, the Framer does not adjust the character clock boundary, but instead aligns the character to the already recovered character clock. This ensures that the recovered clock does not contain any significant phase changes or hops during normal operation or framing, and allows the recovered clock to be replicated and distributed to other external circuits or components using PLL-based clock distribution elements. In this framing mode, the character boundaries are only adjusted if the selected framing character is detected at least twice within a span of 50 bits, with both instances on identical 10-bit character boundaries.

When RFMODE = HIGH, the Alternate-mode Multi-Byte Framer is enabled. Like the Cypress-mode Multi-Byte Framer, multiple framing characters must be detected before the character boundary is adjusted. In this mode, the Framer does not adjust the character clock boundary, but instead aligns the character to the already recovered character clock. In this mode, the data stream must contain a minimum of four of the selected framing characters, received as consecutive characters, on identical 10-bit boundaries, before character framing is adjusted.

Framing for all channels is enabled when RFEN = HIGH. If RFEN = LOW, the Framer for each channel is disabled. When the framers are disabled, no changes are made to the recovered character boundaries on any channel, regardless of the presence of framing characters in the data stream.

#### 10B/8B Decoder Block

The Decoder logic block performs three primary functions:

- decoding the received transmission characters back into Data and Special Character codes
- comparing generated BIST patterns with received characters to permit at-speed link and device testing
- generation of ODD parity on the decoded characters.

#### 10B/8B Decoder

The framed parallel output of each Deserializer Shifter is passed to the 10B/8B Decoder where, if the Decoder is enabled (DECMODE  $\neq$  LOW), it is transformed from a 10-bit transmission character back to the original Data and Special Character codes. This block uses the 10B/8B Decoder patterns in *Table 28* and *Table 29* of this data sheet. Valid data characters are indicated by a 000b bit-combination on the associated RXSTx[2:0] status bits, and Special Character codes are indicated by a 001b bit-combination on these same status outputs. Framing characters, invalid patterns, disparity errors, and synchronization status are presented as alternate combinations of these status bits.

The 10B/8B Decoder operates in two normal modes, and can also be bypassed. The operating mode for the Decoder is controlled by the DECMODE input.

When DECMODE = LOW, the Decoder is bypassed and raw 10-bit characters are passed to the Output Register. In this mode, channel bonding is not possible, the Receive Elasticity Buffers are bypassed, and RXCKSEL must be MID. This clock mode generates separate RXCLKx $\pm$  outputs for each receive channel.

When DECMODE = MID (or open), the 10-bit transmission characters are decoded using *Table 28* and *Table 29*. Received Special Code characters are decoded using the Cypress column of *Table 29*.

When DECMODE = HIGH, the 10-bit transmission characters are decoded using *Table 28* and *Table 29*. Received Special Code characters are decoded using the Alternate column of *Table 29*.

In all settings where the Decoder is enabled, the receive paths may be operated as separate channels or bonded to form various multi-channel buses.

#### Receive BIST Operation

The Receiver interfaces contain internal pattern generators that can be used to validate both device and link operation.

These generators are enabled by the associated BOE[x] signals listed in *Table 10* (when the BISTLE latch enable input is HIGH). When enabled, a register in the associated receive channel becomes a pattern generator and checker by logically converting to a Linear Feedback Shift Register (LFSR). This LFSR generates a 511-character sequence that includes all Data and Special Character codes, including the explicit violation symbols. This provides a predictable yet pseudo-random sequence that can be matched to an identical LFSR in the attached Transmitter(s). If the receive channels are configured for common clock operation (RXCKSEL  $\neq$  MID) each pass is preceded by a 16-character Word Sync Sequence. When synchronized with the received data stream, the associated Receiver checks each character in the Decoder with each character generated by the LFSR and indicates compare errors and BIST status at the RXSTx[2:0] bits of the Output Register. See *Table 24* for details.

When the BISTLE signal is HIGH, any BOE[x] input that is LOW enables the BIST generator/checker in the associated Receive channel (or the BIST generator in the associated Transmit channel). When BISTLE returns LOW, the values of all BOE[x] signals are captured in the BIST Enable Latch. These values remain in the BIST Enable Latch until BISTLE is returned HIGH. All captured signals in the BIST Enable Latch are set HIGH (i.e., BIST is disabled) following a device reset (TRSTZ is sampled LOW).

When BIST is first recognized as being enabled in the Receiver, the LFSR is preset to the BIST-loop start-code of D0.0. This D0.0 character is sent only once per BIST loop. The status of the BIST progress and any character mismatches is presented on the RXSTx[2:0] status outputs.

Code rule violations or running disparity errors that occur as part of the BIST loop do not cause an error indication. RXSTx[2:0] indicates 010b or 100b for one character period per BIST loop to indicate loop completion. This status can be used to check test pattern progress. These same status values are presented when the Decoder is bypassed and BIST is enabled on a receive channel.

The status reported on RXSTx[2:0] by the BIST state machine are listed in *Table 24*. When Receive BIST is enabled, the same status is reported on the receive status outputs regardless of the state of DECMODE.

The specific patterns checked by each receiver are described in detail in the Cypress application note "HOTLink Built-In Self-Test." The sequence compared by the CYP(V)(W)15G0401DXB when RXCKSEL = MID is identical to that in the CY7B933 and CY7C924DX, allowing interoperable systems to be built when used at compatible serial signaling rates.

If the number of invalid characters received ever exceeds the number of valid characters by sixteen, the receive BIST state machine aborts the compare operations and resets the LFSR to the D0.0 state to look for the start of the BIST sequence again.

When the receive paths are configured for common clock operation (RXCKSEL  $\neq$  MID), each pass must be preceded by a 16-character Word Sync Sequence to allow output buffer alignment and management of clock frequency variations. This is automatically generated by the transmitter when its local RXCKSEL  $\neq$  MID and Encoder is enabled (TXMODE[1]  $\neq$  LOW).



The BIST state machine requires the characters to be correctly framed for it to detect the BIST sequence. If the Low Latency Framer is enabled (RFMODE = LOW), the Framer will misalign to an aliased framing character within the BIST sequence. If the Alternate Multi-Byte Framer is enabled (RFMODE = HIGH) and the Receiver outputs are clocked relative to a recovered clock, it is necessary to frame the Receiver before BIST is enabled.

### Receive Elasticity Buffer

Each receive channel contains an Elasticity Buffer that is designed to support multiple clocking modes. These buffers allow data to be read using an Elasticity Buffer read-clock that is asynchronous in both frequency and phase from the Elasticity Buffer write clock, or to use a read clock that is frequency coherent but with uncontrolled phase relative to the Elasticity Buffer write clock.

Each Elasticity Buffer is 10-characters deep, and supports a twelve-bit wide data path. It is capable of supporting a decoded character, three status bits, and a parity bit for each character present in the buffer. The write clock for these buffers is always the recovered clock for the associated read channel.

The read clock for the Elasticity Buffers may come from one of three selectable sources. It may be a

- character-rate REFCLK (RXCKSEL = LOW and DECMODE ≠ LOW)
- recovered clock from an alternate receive channel (RXCKSEL = HIGH and DECMODE ≠ LOW).

These Elasticity Buffers are also used to align the output data streams when multiple channels are bonded together. More details on how the Elasticity Buffer is used for Independent Channel Modes and Channel Bonded Modes is discussed in the next section. The Elasticity Buffers are bypassed whenever the Decoders are bypassed (DECMODE = LOW). When the Decoders and Elasticity Buffers are bypassed, RXCKSELx must be set to MID.

### Receive Modes

The operating mode of the receive path is set through the RXMODE[1:0] inputs. The 'Reserved for test' settings (RXMODE0 = M) is not allowed, even if the receiver is not being used, as it will stop normal function of the device. When the decoder is disabled, the RXMODE[1:0] settings are ignored as long as they are not test modes. These modes determine the type (if any) of channel bonding and status reporting. The different receive modes are listed in *Table 14*.

#### Independent Channel Modes

In independent channel modes (RX Modes 0 and 2, where RXMODE[1] = LOW), all four receive paths may be clocked in any clock mode selected by RXCKSEL.

When RXCKSEL = LOW, all four receive channels are clocked by REFCLK. RXCLKB± and RXCLKD± outputs are disabled (High-Z), and the RXCLKA± and RXCLKC± outputs present a buffered and delayed form of REFCLK. In this mode, the Receive Elasticity Buffers are enabled. For REFCLK clocking, the Elasticity Buffers must be able to insert K28.5 characters and delete framing characters as appropriate.

The insertion of a K28.5 or deletion of a framing character can occur at any time on any channel, however, the actual timing on these insertions and deletions is controlled in part by the

how the transmitter sends its data. Insertion of a K28.5 character can only occur when the receiver has a framing character in the Elasticity Buffer. Likewise, to delete a framing character, one must also be present in the Elasticity Buffer. To prevent a receive buffer overflow or underflow on a receive channel, a minimum density of framing characters must be present in the received data streams.

**Table 14. Receive Operating Modes**

| RX Mode     |              | Operating Mode  |                        |
|-------------|--------------|-----------------|------------------------|
| Mode Number | RXMODE [1:0] | Channel Bonding | RXSTx Status Reporting |
| 0           | LL           | Independent     | Status A               |
| 1           | LM           |                 | Reserved for test      |
| 2           | LH           | Independent     | Status B               |
| 3           | ML           | Dual            | Status A               |
| 4           | MM           |                 | Reserved for test      |
| 5           | MH           | Dual            | Status B               |
| 6           | HL           | Quad            | Status A               |
| 7           | HM           |                 | Reserved for test      |
| 8           | HH           | Quad            | Status B               |

When RXCKSEL = MID (or open), each received channel Output Register is clocked by the recovered clock for that channel. Since no characters may be added or deleted, the receiver Elasticity Buffer is bypassed.

When RXCKSEL = HIGH in independent channel mode, all channels are clocked by the selected recovered clock. This selection is made using the RXCLKB+ and RXCLKD+ signals as inputs per *Table 15*. This selected clock is always output on RXCLKA± and RXCLKC±. In this mode the Receive Elasticity Buffers are enabled. When data is output using a recovered clock (RXCKSEL = HIGH), the receive channels are not allowed to insert and delete characters, except as necessary for Elasticity Buffer alignment.

When the Elasticity Buffer is used, prior to reception of valid data, a Word Sync Sequence (or at least four framing characters) must be received to center the Elasticity Buffers. The Elasticity Buffer may also be centered by a device reset operation initiated by TRSTZ input. However, following such an event, the CYP(V)(W)15G0401DXB also requires a framing event before it will correctly decode characters. When RXCKSEL = HIGH, since the Elasticity Buffer is not allowed to insert or delete framing characters, the transmit clocks on all received channels must all be from a common source.

**Table 15. Independent and Quad Channel Bonded Recovered Clock or Master Channel Select**

| RXCLKB+ | RXCLKD+ | RXCLKA±/RXCLKC± Clock Source |
|---------|---------|------------------------------|
| 0       | 0       | RXCLKA                       |
| 0       | 1       | RXCLKB                       |
| 1       | 0       | RXCLKC                       |
| 1       | 1       | RXCLKD                       |

### Dual-Channel Bonded Modes

In dual-channel bonded modes (RX Modes 3 and 5, where RXMODE[1] = MID or open), the associated receive channel pair Output Registers must be clocked by a common clock. This mode does not operate when RXCKSEL = MID.

Proper operation in this mode requires that the associated transmit data streams are clocked from a common reference with no long-term character slippage between the bonded channels. In dual-channel mode this means that channels A and B must be clocked from a common reference, and channels C and D must be clocked from a common reference.

Prior to the reception of valid data, a Word Sync Sequence (or that portion necessary to align the receive buffers) must be received on the bonded channels (within the allowable inter-channel skew window) to allow the Receive Elasticity Buffers to be centered. While normal characters may be output prior to this alignment event, they are not necessarily aligned to the same word boundaries as when they were transmitted.

When RXCKSEL = LOW, all four receive channels are clocked by REFCLK. RXCLKB± and RXCLKD± outputs are disabled (High-Z), and RXCLKA± and RXCLKC± present a buffered and delayed form of REFCLK. In this mode, the Receive Elasticity Buffers are enabled. For REFCLK clocking, the Elasticity Buffers must be able to insert K28.5 characters and delete framing characters as appropriate. While these insertions and deletions can take place at any time, they must occur at the same time on both channels that are bonded together. This is necessary to keep the data in the bonded channel-pairs properly aligned. This insert and delete process is controlled by the channel selected using the RXCLKB+ and RXCLKD+ inputs as listed in *Table 16*.

When RXCKSEL = HIGH, the A and B channels are clocked by the selected recovered clock, and the C and D channels are clocked by the selected recovered clock, as shown in *Table 16*. The output clock for the channel A/B bonded-pair is output continuously on RXCLKA±. The clock source for this output is selected from the recovered clock for channel A or channel B using the RXCLKB+ input. The output clock for the channel C/D bonded-pair is output continuously on RXCLKC±. The clock source for this output is selected from the recovered clock for channel C or channel D using the RXCLKD+ input.

**Table 16. Dual-Channel Bonded Recovered Clock Select**

| RXCLKB+ | RXCLKD+ | Clock Source |         |
|---------|---------|--------------|---------|
|         |         | RXCLKA±      | RXCLKC± |
| 0       | X       | RXCLKA       |         |
| 1       | X       | RXCLKB       |         |
| X       | 0       |              | RXCLKC  |
| X       | 1       |              | RXCLKD  |

When data is output using a recovered clock (RXCKSEL = HIGH), receive channels are not allowed to insert and delete characters, except as necessary for Elasticity Buffer alignment.

### Quad Channel Modes

In quad-channel modes (RX modes 6 and 7, where RXMODE[1] = HIGH), all four receive channel Output

Registers must be clocked by a common clock. This mode does not operate when RXCKSEL = MID.

Proper operation in this mode requires that the four transmit data streams are clocked from a common reference with no long-term character slippage between the bonded channels. In quad-channel modes this means that the transmit channels A, B, C, and D must all be clocked from a common reference.

Prior to the delivery of valid data, at least one Word Sync Sequence (or that portion necessary to align the receive buffers) must be received on all four bonded channels (within the allowable inter-channel skew window) to allow the Receive Elasticity Buffers to be centered and aligned.

When RXCKSEL = LOW, all four receive channels are clocked by the internal derivative of REFCLK. RXCLKB± and RXCLKD± outputs are disabled (High-Z), and RXCLKA± and RXCLKC± present a buffered and delayed form of REFCLK. In this mode the Receive Elasticity Buffers are enabled. For REFCLK clocking, the Elasticity Buffers must be able to insert K28.5 characters and delete framing characters as appropriate. While these insertions and deletions can take place at any time, they must occur at the same time on all four channels. This is necessary to keep the data in the four bonded channels properly aligned. This insert and delete process is controlled by the master channel selected using the RXCLKB+ and RXCLKD+ inputs as listed in *Table 15*.

When RXCKSEL = HIGH, all four receive-channel Output Registers are clocked by the selected recovered clock. The clock select for quad channel mode is the same as that for independent channel operation. This selection is made using the RXCLKB+ and RXCLKD+ inputs, as shown in *Table 15*. The output clock for the four bonded channels is output continuously on RXCLKA± and RXCLKC±.

When data is output using a recovered clock (RXCKSEL = HIGH), receive channels are not allowed to insert and delete characters, except as necessary for Elasticity Buffer alignment.

### Multi-device Bonding

When configured for quad-channel bonding (RXMODE[1] = HIGH) it is also possible to bond channels across multiple devices. This form of channel bonding is only possible when RXCKSEL = LOW, selecting REFCLK as the output clock for all channels on all devices.

In this mode, the BONDST[1:0] signals of all bonding devices must be connected together to pass Elasticity buffer management events between the devices. This is necessary to keep the data on all bonded devices in common alignment. One device must be selected as the controlling device by driving the MASTER pin on that device LOW. All other devices must have their MASTER pin HIGH to prevent having multiple active drivers on the BONDST bus. Within the master device, a single receive channel is selected as the master channel for generation of the different BONDST[1:0] status. This selection is made using the RXCLKB+ and RXCLKD+ inputs, as shown in *Table 15*. This allows the master channel selection to be changed through external control of the MASTER, RXCLKB+, and RXCLKD+ inputs.<sup>[17]</sup>

**Note:**

17. Any change in the master device or channel must be followed by assertion of  $\overline{\text{TRSTZ}}$  to properly initialize the device.



In this mode, the BOND\_ALL signal of all bonding devices must be connected together. The BOND\_ALL signal is a wired AND and the signal is LOW during the bonding resolution process. After the completion of bonding resolution it returns HIGH.

**Power Control**

The CYP(V)(W)15G0401DXB supports user control of the powered up or down state of each transmit and receive channel. The receive channels are controlled by the RXLE signal and the values present on the BOE[7:0] bus. The transmit channels are controlled by the OELE signal and the values present on the BOE[7:0] bus. Powering down unused channels will save power and reduce system heat generation. Controlling system power dissipation will improve the system performance.

*Receive Channels*

When RXLE is HIGH, the signals on the BOE[7:0] inputs directly control the power enables for the receive PLLs and analog circuits. When a BOE[7:0] input is HIGH, the associated receive channel [A through D] PLL and analog logic are active. When a BOE[7:0] input is LOW, the associated receive channel [A through D] PLL and analog circuits are powered down. When RXLE returns LOW, the last values present on the BOE[7:0] inputs are captured in the Receive Channel Enable Latch. The specific BOE[7:0] input signal associated with a receive channel is listed in *Table 10*.

If a single channel of a bonded-pair or quad is disabled, this may prevent the other receive channels from bonding. If the disabled channel has been selected as the master channel for insert/delete functions, or for recovered clock select, these functions will not operate. Any disabled receive channel will indicate a constant LFIx output.

When a disabled receive channel is re-enabled, the status of the associated LFIx output and data on the parallel outputs for the associated channel may be indeterminate for up to 2 ms.

*Transmit Channels*

When OELE is HIGH, the signals on the BOE[7:0] inputs directly control the power enables for the Serial Drivers. When a BOE[x] input is HIGH, the associated Serial Driver is enabled. When a BOE[x] input is LOW, the associated Serial Driver is disabled and powered down. If both Serial Drivers of a channel are disabled, the internal logic for that transmit channel is powered down. When OELE returns LOW, the values present on the BOE[7:0] inputs are latched in the Output Enable Latch.

*Device Reset State*

When the CYP(V)(W)15G0401DXB is reset by assertion of TRSTZ, the Transmit Enable and Receive Enable Latches are both cleared, and the BIST Enable Latch is preset. In this state, all transmit and receive channels are disabled, and BIST is disabled on all channels.

Following a device reset, it is necessary to enable the transmit and receive channels used for normal operation. This can be done by sequencing the appropriate values on the BOE[7:0]

**Notes:**

18. The RXOPx outputs are also driven from the associated Output Register, but their interpretation is under the separate control of PARCTL.

inputs while the OELE and RXLE signals are raised and lowered. For systems that do not require dynamic control of power, or want the device to power up in a fixed configuration, it is also possible to strap the RXLE and OELE control signals HIGH to permanently enable their associated latches. Connection of the associated BOE[7:0] signals to a stable HIGH will then enable the respective transmit and receive channels as soon as the TRSTZ signal is deasserted.

**Output Bus**

Each receive channel presents a 12-signal output bus consisting of

- an eight-bit data bus
- a three-bit status bus
- a parity bit.

The bit assignments of the Data and Status are dependent on the setting of DECMODE. The bits are assigned as per *Table 17*.

**Table 17. Output Register Bit Assignments** <sup>[18]</sup>

| Signal Name                | DECMODE = LOW       | DECMODE = MID or HIGH |
|----------------------------|---------------------|-----------------------|
| RXSTx[2] (LSB)             | COMDET <sub>x</sub> | RXSTx[2]              |
| RXSTx[1]                   | DOUTx[0]            | RXSTx[1]              |
| RXSTx[0]                   | DOUTx[1]            | RXSTx[0]              |
| RXD <sub>x</sub> [0]       | DOUTx[2]            | RXD <sub>x</sub> [0]  |
| RXD <sub>x</sub> [1]       | DOUTx[3]            | RXD <sub>x</sub> [1]  |
| RXD <sub>x</sub> [2]       | DOUTx[4]            | RXD <sub>x</sub> [2]  |
| RXD <sub>x</sub> [3]       | DOUTx[5]            | RXD <sub>x</sub> [3]  |
| RXD <sub>x</sub> [4]       | DOUTx[6]            | RXD <sub>x</sub> [4]  |
| RXD <sub>x</sub> [5]       | DOUTx[7]            | RXD <sub>x</sub> [5]  |
| RXD <sub>x</sub> [6]       | DOUTx[8]            | RXD <sub>x</sub> [6]  |
| RXD <sub>x</sub> [7] (MSB) | DOUTx[9]            | RXD <sub>x</sub> [7]  |

When the 10B/8B Decoder is bypassed (DECMODE = LOW), the framed 10-bit character and a single status bit (COMDET) are presented at the receiver Output Register. The status output indicates if the character in the Output Register is one of the selected framing characters. The bit usage and mapping of the external signals to the raw 10B transmission character is shown in *Table 18*.

The COMDET<sub>x</sub> outputs are HIGH when the character in the Output Register for the associated channel contains the selected framing character at the proper character boundary, and LOW for all other bit combinations.

When the Low-Latency Framer and half-rate receive port clocking are also enabled (RFMODE = LOW, RXRATE = HIGH, and RXCKSEL ≠ LOW), the Framer will stretch the recovered clock to the nearest 20-bit boundary such that the rising edge of RXCLK<sub>x</sub>+ occurs when COMDET<sub>x</sub> is present on the associated output bus.

**Table 18. Decoder Bypass Mode (DECMODE = LOW)**

| Signal Name                | Bus Weight          | 10Bit Name |
|----------------------------|---------------------|------------|
| RXSTx[2] (LSB)             | COMDET <sub>x</sub> |            |
| RXSTx[1]                   | 2 <sup>0</sup>      | a          |
| RXSTx[0]                   | 2 <sup>1</sup>      | b          |
| RXD <sub>x</sub> [0]       | 2 <sup>2</sup>      | c          |
| RXD <sub>x</sub> [1]       | 2 <sup>3</sup>      | d          |
| RXD <sub>x</sub> [2]       | 2 <sup>4</sup>      | e          |
| RXD <sub>x</sub> [3]       | 2 <sup>5</sup>      | i          |
| RXD <sub>x</sub> [4]       | 2 <sup>6</sup>      | f          |
| RXD <sub>x</sub> [5]       | 2 <sup>7</sup>      | g          |
| RXD <sub>x</sub> [6]       | 2 <sup>8</sup>      | h          |
| RXD <sub>x</sub> [7] (MSB) | 2 <sup>9</sup>      | j          |

When the Cypress or Alternate Mode Framer is enabled and half-rate receive port clocking is also enabled (RFMODE ≠ LOW and RXRATE = HIGH), the output clock is not modified when framing is detected, but a single pipeline stage may be added or subtracted from the data stream by the Framer logic such that the rising edge of RXCLK<sub>x</sub>+ occurs when COMDET<sub>x</sub> is present on the associated output bus.

This adjustment only occurs when the Framer is enabled (RFEN = HIGH). When the Framer is disabled, the clock boundaries are not adjusted, and COMDET<sub>x</sub> may be asserted during the rising edge of RXCLK<sub>x</sub>- (if an odd number of characters were received following the initial framing).

### Parity Generation

In addition to the eleven data and status bits that are presented by each channel, an RXOP<sub>x</sub> parity output is also available on each channel. This allows the CYP(V)(W)15G0401DXB to support ODD parity generation for each channel. To handle a wide range of system environments, the CYP(V)(W)15G0401DXB supports different forms of parity generation, including no parity.

When the decoders are enabled (DECMODE ≠ LOW), parity can be generated on

- the RXD<sub>x</sub>[7:0] character
- the RXD<sub>x</sub>[7:0] character and RXST<sub>x</sub>[2:0] status.

When the decoders are bypassed (DECMODE = LOW), parity can be generated on

- the RXD<sub>x</sub>[7:0] and RXST<sub>x</sub>[1:0] bits
- the RXD<sub>x</sub>[7:0] and RXST<sub>x</sub>[2:0] bits.

These modes differ in the number of bits which are included in the parity calculation. Only ODD parity is provided which ensures that at least one bit of the data bus is always a logic-1. Those bits covered by parity generation are listed in *Table 19*.

Parity generation is enabled through the three-level select PARCTL input. When PARCTL = LOW, parity checking is disabled, and the RXOP<sub>x</sub> outputs are all disabled (High-Z).

When PARCTL = MID (open) and the decoders are enabled (DECMODE ≠ LOW), ODD parity is generated for the received

#### Notes:

19. Receive path parity output drivers (RXOP<sub>x</sub>) are disabled (High-Z) when PARCTL = LOW.
20. When the Decoder is bypassed (DECMODE = LOW) and BIST is not enabled (Receive BIST Latch output is HIGH), RXST<sub>x</sub>[2] is driven to a logic-0, except when the character in the output buffer is a framing character.

**Table 19. Output Register Parity Generation**

| Signal Name           | Receive Parity Generate Mode (PARCTL) |               |               |                   |
|-----------------------|---------------------------------------|---------------|---------------|-------------------|
|                       | LOW <sub>[19]</sub>                   | MID           |               | HIGH              |
|                       |                                       | DECMODE = LOW | DECMODE ≠ LOW |                   |
| RXST <sub>x</sub> [2] |                                       |               |               | X <sup>[20]</sup> |
| RXST <sub>x</sub> [1] |                                       | X             |               | X                 |
| RXST <sub>x</sub> [0] |                                       | X             |               | X                 |
| RXD <sub>x</sub> [0]  |                                       | X             | X             | X                 |
| RXD <sub>x</sub> [1]  |                                       | X             | X             | X                 |
| RXD <sub>x</sub> [2]  |                                       | X             | X             | X                 |
| RXD <sub>x</sub> [3]  |                                       | X             | X             | X                 |
| RXD <sub>x</sub> [4]  |                                       | X             | X             | X                 |
| RXD <sub>x</sub> [5]  |                                       | X             | X             | X                 |
| RXD <sub>x</sub> [6]  |                                       | X             | X             | X                 |
| RXD <sub>x</sub> [7]  |                                       | X             | X             | X                 |

and decoded character in the RXD<sub>x</sub>[7:0] signals and is presented on the associated RXOP<sub>x</sub> output. When PARCTL = MID and the decoders are bypassed (DECMODE = LOW), ODD parity is generated for the received and decoded character in the RXD<sub>x</sub>[7:0] and RXST<sub>x</sub>[1:0] bit positions. When PARCTL = HIGH, ODD parity is generated for the RXD<sub>x</sub>[7:0] and the associated RXST<sub>x</sub>[2:0] status bits.

### Receive Status Bits

When the 10B/8B Decoder is enabled (DECMODE ≠ LOW), each character presented at the Output Register includes three associated status bits. These bits are used to identify:

- if the contents of the data bus are valid
- the type of character present
- the state of receive BIST operations (regardless of the state of DECMODE)
- character violations
- channel bonding status.

These conditions normally overlap; e.g., a valid data character received with incorrect running disparity is not reported as a valid data character. It is instead reported as a Decoder violation of some specific type. This implies a hierarchy or priority level to the various status bit combinations. The hierarchy and value of each status is listed in *Table 20* when channel bonding enabled and in *Table 23* when channel bonding is disabled.

Within these status codes, there are three modes of status reporting. The two data status reporting modes (Type A and Type B) are selectable through the RXMODE[0] input. These status types allow compatibility with legacy systems, while allowing full reporting in new systems. These status values are generated in part by the Receive Synchronization State Machine, and are listed in *Table 20*. The receive status when the channels are operated independently with channel bonding disabled is shown in *Table 23*. The receive status when Receive BIST is enabled is shown in *Table 24*.

**Receive Synchronization State Machine when Channel Bonding is enabled**

Each receive channel contains a Receive Synchronization State Machine that is enabled whenever the receive channels are configured for channel bonding (RXMODE[1] ≠ LOW). This machine handles loss and recovery of bit, channel, and word framing, and part of the control for channel bonding. Separate forms of the state machine exist for the two different types of status reporting. When operated without channel bonding (RXMODE[1] = LOW, RX Modes 0 and 2), these state machines are disabled and characters are decoded directly as shown in *Table 23*.

*Status Type-A Receive State Machine*

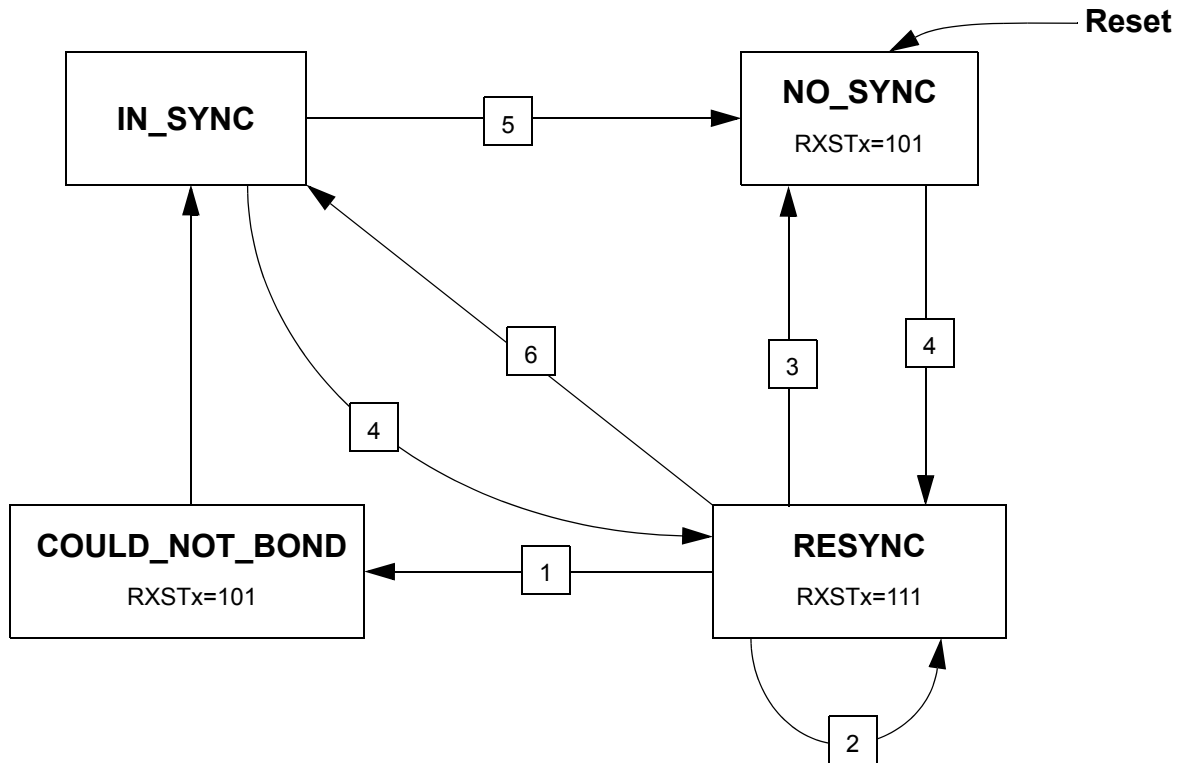
This machine has four primary states: NO\_SYNC, RESYNC, COULD\_NOT\_BOND, and IN\_SYNC, as shown in *Figure 2*. The IN\_SYNC state can respond with multiple status types, while others can respond with only one type.

*Status Type-B Receive State Machine*

This machine has four primary states: NO\_SYNC, RESYNC, IN\_SYNC, and COULD\_NOT\_BOND, as shown in *Figure 3*. Some of these states can respond with only one status value, while others can respond with multiple status types.

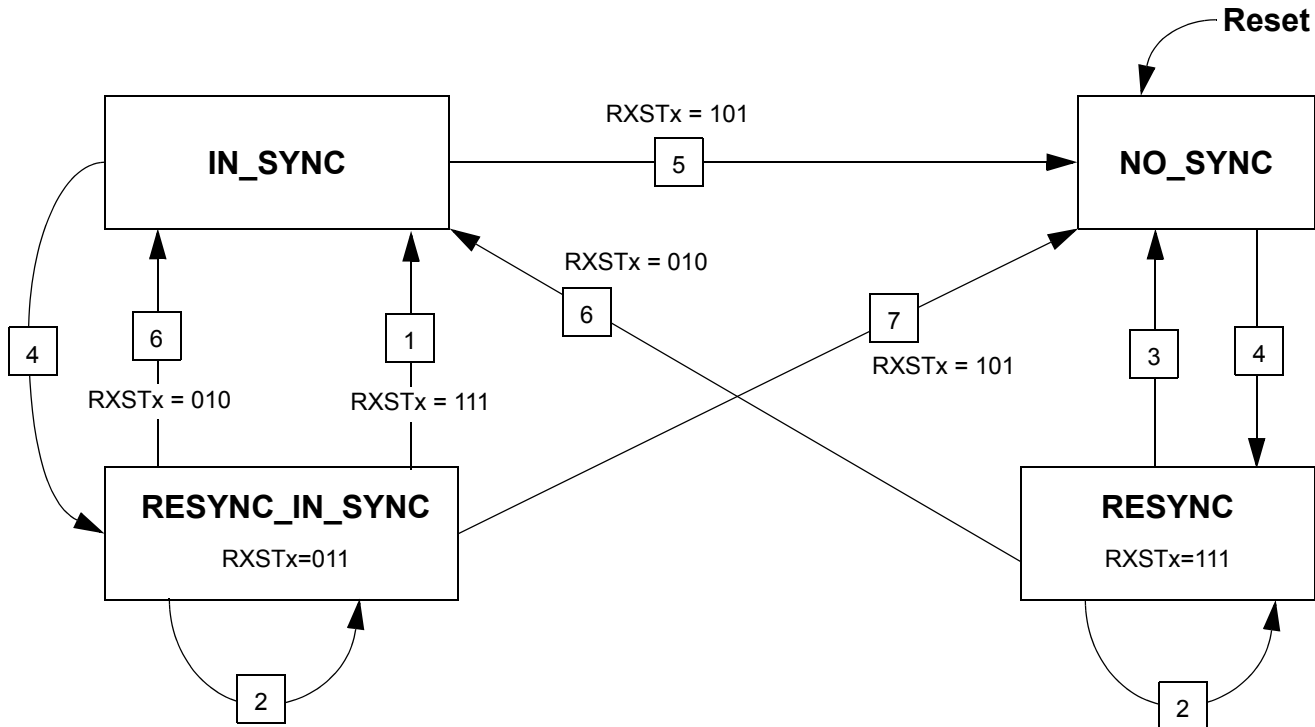
**Table 20. Receive Character Status Bits when Channel Bonding is enabled**

| RXSTx<br>[2:0] | Priority | Description   |  |
|----------------|----------|---|--|
|                |          | RX Status A   | RX Status B  |
| 000            | 7        | <b>Normal Character Received.</b> The valid Data character on the output bus meets all the formatting requirements of Data characters listed in <i>Table 28</i> .   |  |
| 001            | 7        | <b>Special Code Detected.</b> The valid special character on the output bus meets all the formatting requirements of the Special Code characters listed in <i>Table 29</i> , but is not the presently selected framing character or a decoder violation indication.   |  |
| 010            | 2        | <b>Receive Elasticity Buffer Underrun/Overrun Error.</b> The receive buffer was not able to add/drop a K28.5 or framing character.  | <b>Channel Lock Detected.</b> Asserts when the bonded channels have detected RESYNC within the allotted window. Presented only on the last cycle before aligned data is presented.   |
| 011            | 5        | <b>Framing Character Detected.</b> This indicates that a character matching the patterns identified as a framing character (as selected by FRAMCHAR) was detected. The decoded value of this character is present to the associated output bus.   |  |
| 100            | 4        | <b>Codeword Violation.</b> The character on the output bus is a C0.7. This indicates that the received character cannot be decoded into any valid character.  |  |
| 101            | 1        | <b>Loss of Sync.</b> The character on the bus is invalid, due to an event that has caused the receive channels to lose synchronization. When channel bonding is enabled, this indicates that one or more channels have either lost bit synchronization (loss of character framing), or that the bonded channels are no longer in proper character alignment. When the channels are operated independently (with the decoder enabled), this indicates a PLL Out of Lock condition. | <b>Loss of Sync.</b> The character on the bus is invalid, due to an event that has caused the receive channels to lose synchronization. When channel bonding is enabled, this indicates that one or more channels have either lost bit synchronization (loss of character framing), or that the bonded channels are no longer in proper character alignment. When the channels are operated independently (with the decoder enabled), this indicates a PLL Out of Lock condition. Also used to indicate Receive Elasticity Buffer underflow/overflow errors. |
| 110            | 6        | <b>Running Disparity Error.</b> The character on the output bus is a C4.7, C1.7, or C2.7.   |  |
| 111            | 3        | <b>Resync.</b> The receiver state machine is in the Resynchronization state. In this state the data on the output bus reflects the presently decoded FRAMCHAR.  |  |


**Table 21.**

| # | State Transition Conditions  |
|---|--|
| 1 | (BOND_INH = LOW) AND (Deskew Window Expired)   |
| 2 | FRAMCHAR Detected  |
| 3 | (Elasticity Buffer Under/Overrun) OR (RX PLL Loss of Lock) OR (Any Decoder Error)  |
| 4 | Four Consecutive FRAMCHAR Detected   |
| 5 | (Elasticity Buffer Under/Overrun) OR (RX PLL Loss of Lock) OR (Four Consecutive Decoder Errors) OR (Invalid Minus Valid = 4) |
| 6 | Valid Character other than a FRAMCHAR  |

**Figure 2. Status Type-A Receive State Machine for Channel Bonding**


**Table 22.**

| # | Condition   |
|---|---|
| 1 | (BOND_INH = LOW OR Master Channel Did Not Bond) AND (Deskew Window Expired) OR (Decoder Error)  |
| 2 | FRAMCHAR Detected   |
| 3 | (Elasticity Buffer Under/Overrun) OR (RX PLL Loss of Lock) OR (Any Decoder Error) OR (BOND_INH = LOW) OR (Master Channel Did Not Bond) AND (Deskew Window Expired)) |
| 4 | Four Consecutive FRAMCHAR Detected  |
| 5 | (Elasticity Buffer Under/Overrun) OR (RX PLL Loss of Lock) OR (Four Consecutive Decoder Errors) OR (Invalid Minus Valid = 4)  |
| 6 | (Last FRAMCHAR Before a Valid Character) AND (Bonded to MASTER Channel)   |
| 7 | (Elasticity Buffer Under/Overrun) OR (RX PLL Loss of Lock)  |

**Figure 3. Status Type-B Receive State Machine for Channel Bonding**

**Table 23. Receive character status when channels are operated in independent mode (RXMODE[1:0] = LL or LH)**

| RXSTx[2:0] | Priority | Type-A Status   | Type-B status  |
|------------|----------|---|----------------|
| 000        | 7        | <b>Normal Character Received.</b> The valid data character with the correct running disparity received  |                |
| 001        | 7        | <b>Special Code Detected.</b> Special code other than the selected framing character or decoder violation received  |                |
| 010        | 2        | <b>Receive Elasticity Buffer underrun/overflow error.</b> The receive elasticity buffer was not able to add/drop a K28.5 or framing character.  | <b>INVALID</b> |
| 011        | 5        | <b>Framing Character Detected.</b> This indicates that a character matching the patterns identified as a framing character was detected. The decoded value of this character is present on the associated output bus. |                |
| 100        | 4        | <b>Codeword Violation.</b> The character on the output bus is a C0.7. This indicates that the received character cannot be decoded into any valid character.  |                |
| 101        | 1        | <b>PLL Out Of Lock Indication</b>   |                |
| 110        | 6        | <b>Running Disparity Error.</b> The character on the output bus is a C4.7, C1.7 or C2.7   |                |
| 111        | 3        | <b>INVALID</b>  |                |

**Table 24. Receive character status when channels are operated to receive BIST Data**

| RXSTx[2:0] | Priority | Receive BIST Status<br>(Receive BIST = Enabled)  |
|------------|----------|--|
| 000        | 7        | <b>BIST Data Compare.</b> Character compared correctly   |
| 001        | 7        | <b>BIST Command Compare.</b> Character compared correctly  |
| 010        | 2        | <b>BIST Last Good.</b> Last Character of BIST sequence detected and valid.   |
| 011        | 5        | <b>RESERVED for TEST</b>   |
| 100        | 4        | <b>BIST Last Bad.</b> Last Character of BIST sequence detected invalid.  |
| 101        | 1        | <b>BIST Start.</b> Receive BIST is enabled on this channel, but character compares have not yet commenced. This also indicates a PLL Out of Lock condition, and Elasticity Buffer overflow/underflow conditions. |
| 110        | 6        | <b>BIST Error.</b> While comparing characters, a mismatch was found in one or more of the decoded character bits.  |
| 111        | 3        | <b>BIST Wait.</b> The receiver is comparing characters. but has not yet found the start of BIST character to enable the LFSR.  |



### *BIST Status State Machine*

When a receive path is enabled to look for and compare the received data stream with the BIST pattern, the RXSTx[2:0] bits identify the present state of the BIST compare operation.

The BIST state machine has multiple states, as shown in *Figure 2* and *Table 24*. When the receive PLL detects an out-of-lock condition, the BIST state is forced to the Start-of-BIST state, regardless of the present state of the BIST state machine. If the number of detected errors ever exceeds the number of valid matches by greater than sixteen, the state machine is forced to the WAIT\_FOR\_BIST state where it monitors the interface for the first character (D0.0) of the next BIST sequence. Also, if the Elasticity Buffer ever hits an overflow/underflow condition, the status is forced to the BIST\_START until the buffer is recentered (approximately nine character periods).

To ensure compatibility between the source and destination systems when operating in BIST modes, the sending and

receiving ends of the link must use the same receive clock setup. (RXCKSEL = MID or RXCKSEL  $\neq$  MID).

### **JTAG Support**

The CYP(V)(W)15G0401DXB contains a JTAG port to allow system level diagnosis of device interconnect. Of the available JTAG modes, only boundary scan is supported. This capability is present only on the LVTTTL inputs, LVTTTL outputs and the REFCLK $\pm$  clock input. The high-speed serial inputs and outputs are not part of the JTAG test chain.

### *JTAG ID*

The JTAG device ID for the CYP(V)(W)15G0401DXB is '1C800069'x.

### *Three-level Select Inputs*

Each Three-level select input reports as two bits in the scan register. These bits report the LOW, MID, and HIGH state of the associated input as 00, 10, and 11, respectively.

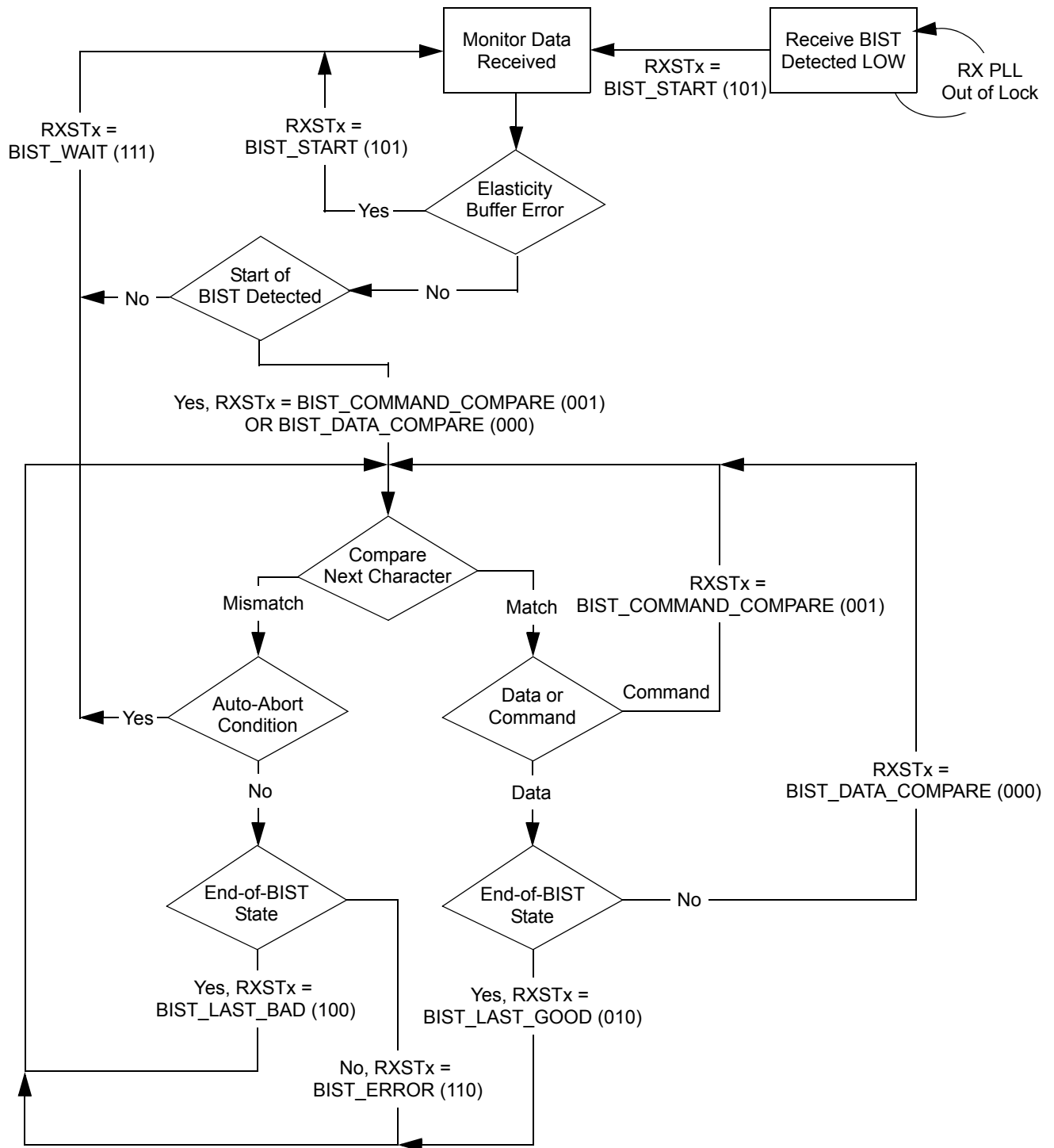


Figure 2. Receive BIST State Machine



**Maximum Ratings**

(Above which the useful life may be impaired. User guidelines only, not tested.)

Storage Temperature .....-65°C to +150°C  
 Ambient Temperature with Power Applied....-55°C to +125°C  
 Supply Voltage to Ground Potential ..... -0.5V to +3.8V  
 DC Voltage Applied to LVTTTL Outputs  
 in High-Z State .....-0.5V to  $V_{CC} + 0.5V$   
 Output Current into LVTTTL Outputs (LOW).....60 mA  
 DC Input Voltage.....-0.5V to  $V_{CC} + 0.5V$

Static Discharge Voltage..... > 2000 V  
 (per MIL-STD-883, Method 3015)

Latch-up Current..... > 200 mA

**Power-up Requirements**

The CYP(V)15G0401DXB requires one power-supply. The Voltage on any input or I/O pin cannot exceed the power pin during power-up

**Operating Range**

| Range      | Ambient Temperature | $V_{CC}$  |
|------------|---------------------|-----------|
| Commercial | 0°C to +70°C        | +3.3V ±5% |
| Industrial | -40°C to +85°C      | +3.3V ±5% |

**CYP(V)(W)15G0401DXB DC Electrical Characteristics** Over the Operating Range

| Parameter  | Description                                   | Test Conditions                                | Min.            | Max.            | Unit |
|--|---|--|-----------------|-----------------|------|
| <b>LVTTTL-compatible Outputs</b>   |   |  |                 |                 |      |
| $V_{OHT}$  | Output HIGH Voltage                           | $I_{OH} = -4 \text{ mA}, V_{CC} = \text{Min.}$ | 2.4             | $V_{CC}$        | V    |
| $V_{OLT}$  | Output LOW Voltage                            | $I_{OL} = 4 \text{ mA}, V_{CC} = \text{Min.}$  | 0               | 0.4             | V    |
| $I_{OST}$  | Output Short Circuit Current                  | $V_{OUT} = 0V^{[21]}$                          | -20             | -100            | mA   |
| $I_{OZL}$  | High-Z Output Leakage Current                 |  | -20             | 20              | µA   |
| <b>LVTTTL-compatible Inputs</b>  |   |  |                 |                 |      |
| $V_{IHT}$  | Input HIGH Voltage                            |  | 2.0             | $V_{CC} + 0.3$  | V    |
| $V_{ILT}$  | Input LOW Voltage                             |  | -0.5            | 0.8             | V    |
| $I_{IHT}$  | Input HIGH Current                            | REFCLK Input, $V_{IN} = V_{CC}$                |                 | 1.5             | mA   |
|  |   | Other Inputs, $V_{IN} = V_{CC}$                |                 | +40             | µA   |
| $I_{ILT}$  | Input LOW Current                             | REFCLK Input, $V_{IN} = 0.0V$                  |                 | -1.5            | mA   |
|  |   | Other Inputs, $V_{IN} = 0.0V$                  |                 | -40             | µA   |
| $I_{IHPDT}$  | Input HIGH Current with internal pull-down    | $V_{IN} = V_{CC}$                              |                 | +200            | µA   |
| $I_{ILPUT}$  | Input LOW Current with internal pull-up       | $V_{IN} = 0.0V$                                |                 | -200            | µA   |
| <b>LVDIFF Inputs: REFCLK±</b>  |   |  |                 |                 |      |
| $V_{DIFF}^{[22]}$  | Input Differential Voltage                    |  | 400             | $V_{CC}$        | mV   |
| $V_{IHHP}$   | Highest Input HIGH Voltage                    |  | 1.2             | $V_{CC}$        | V    |
| $V_{ILLP}$   | Lowest Input LOW voltage                      |  | 0.0             | $V_{CC}/2$      | V    |
| $V_{COMREF}^{[23]}$  | Common Mode Range                             |  | 1.0             | $V_{CC} - 1.2V$ | V    |
| <b>Three-level Inputs</b>  |   |  |                 |                 |      |
| $V_{IHH}$  | Three-level Input HIGH Voltage                | $\text{Min.} \leq V_{CC} \leq \text{Max.}$     | $0.87 * V_{CC}$ | $V_{CC}$        | V    |
| $V_{IMM}$  | Three-level Input MID Voltage                 | $\text{Min.} \leq V_{CC} \leq \text{Max.}$     | $0.47 * V_{CC}$ | $0.53 * V_{CC}$ | V    |
| $V_{ILL}$  | Three-level Input LOW Voltage                 | $\text{Min.} \leq V_{CC} \leq \text{Max.}$     | 0.0             | $0.13 * V_{CC}$ | V    |
| $I_{IHH}$  | Input HIGH Current                            | $V_{IN} = V_{CC}$                              |                 | 200             | µA   |
| $I_{IMM}$  | Input MID current                             | $V_{IN} = V_{CC}/2$                            | -50             | 50              | µA   |
| $I_{ILL}$  | Input LOW current                             | $V_{IN} = \text{GND}$                          |                 | -200            | µA   |
| <b>Differential CML Serial Outputs: OUTA1±, OUTA2±, OUTB1±, OUTB2±, OUTC1±, OUTC2±, OUTD1±, OUTD2±</b> |   |  |                 |                 |      |
| $V_{OHC}$  | Output HIGH Voltage<br>( $V_{CC}$ referenced) | 100Ω differential load                         | $V_{CC} - 0.5$  | $V_{CC} - 0.2$  | V    |
|  |   | 150Ω differential load                         | $V_{CC} - 0.5$  | $V_{CC} - 0.2$  | V    |

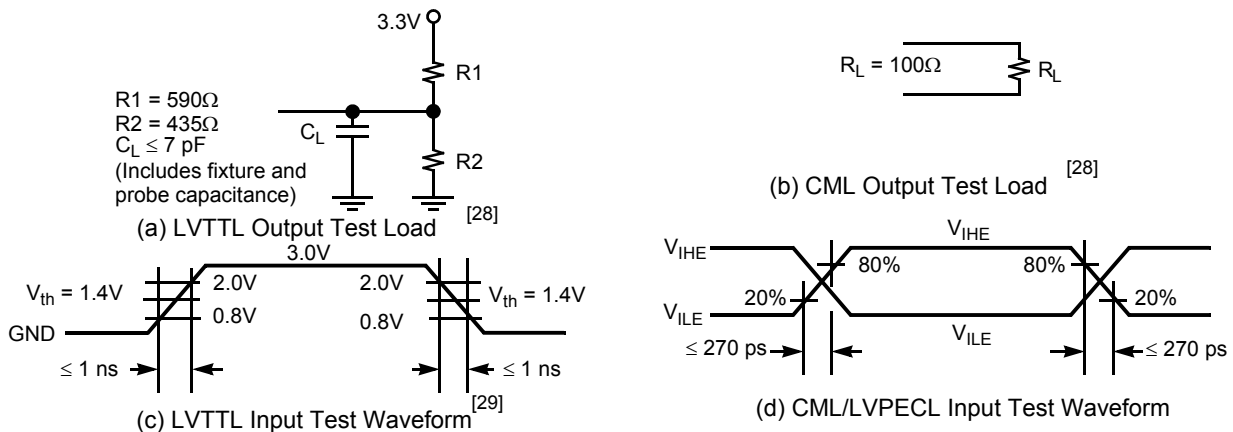
**Notes:**

21. Tested one output at a time, output shorted for less than one second, less than 10% duty cycle.
22. This is the minimum difference in voltage between the true and complement inputs required to ensure detection of a logic-1 or logic-0. A logic-1 exists when the true (+) input is more positive than the complement (-) input. A logic-0 exists when the complement (-) input is more positive than true (+) input.
23. The common mode range defines the allowable range of REFCLK+ and REFCLK- when REFCLK+ = REFCLK-. This marks the zero-crossing between the true and complement inputs as the signal switches between a logic-1 and a logic-0.

**CYP(V)(W)15G0401DXB DC Electrical Characteristics** Over the Operating Range (continued)

| Parameter   | Description  | Test Conditions                         | Min.                   | Max.                   | Unit |
|---|--|---|------------------------|------------------------|------|
| V <sub>OLC</sub>  | Output LOW Voltage<br>(V <sub>CC</sub> referenced) | 100Ω differential load                  | V <sub>CC</sub> - 1.4  | V <sub>CC</sub> - 0.7  | V    |
|   |  | 150Ω differential load                  | V <sub>CC</sub> - 1.4  | V <sub>CC</sub> - 0.7  | V    |
| V <sub>ODIF</sub>   | Output Differential Voltage<br> (OUT+) - (OUT-)    | 100Ω differential load                  | 450                    | 900                    | mV   |
|   |  | 150Ω differential load                  | 560                    | 1000                   | mV   |
| <b>Differential Serial Line Receiver Inputs: INA1±, INA2±, INB1±, INB2±, INC1±, INC2±, IND1±, IND2±</b> |  |   |                        |                        |      |
| V <sub>DIFFS</sub> [22]   | Input Differential Voltage  (IN+) - (IN-)          |   | 100                    | 1200                   | mV   |
| V <sub>IHE</sub>  | Highest Input HIGH Voltage                         |   |                        | V <sub>CC</sub>        | V    |
| V <sub>ILE</sub>  | Lowest Input LOW Voltage                           |   | V <sub>CC</sub> - 2.0  |                        | V    |
| I <sub>IHE</sub>  | Input HIGH Current                                 | V <sub>IN</sub> = V <sub>IHE</sub> Max. |                        | 1350                   | μA   |
| I <sub>ILE</sub>  | Input LOW Current                                  | V <sub>IN</sub> = V <sub>ILE</sub> Min. | -700                   |                        | μA   |
| V <sub>COM</sub> [24, 25]   | Common Mode Input Range                            |   | V <sub>CC</sub> - 1.95 | V <sub>CC</sub> - 0.05 | V    |

| Power Supply    |  |            | Typ. [26] | Max. [27] |    |
|-----------------|--|------------|-----------|-----------|----|
| I <sub>CC</sub> | Power Supply Current<br>REFCLK = Max.    | Commercial | 870       | 1060      | mA |
|                 |  | Industrial |           |           |    |
| I <sub>CC</sub> | Power Supply Current<br>REFCLK = 125 MHz | Commercial | 830       | 1060      | mA |
|                 |  | Industrial |           |           |    |

**Test Loads and Waveforms**

**CYP(V)(W)15G0401DXB AC Characteristics** Over the Operating Range

| Parameter  | Description            | Min.                 | Max.                | Unit |
|--|------------------------|----------------------|---------------------|------|
| <b>CYP(V)(W)15G0401DXB Transmitter LVTTTL Switching Characteristics</b> Over the Operating Range |                        |                      |                     |      |
| f <sub>TS</sub>  | TXCLKx Clock Frequency | 19.5                 | 150 <sup>[30]</sup> | MHz  |
| t <sub>TXCLK</sub>   | TXCLKx Period          | 6.66 <sup>[31]</sup> | 51.28               | ns   |
| t <sub>TXCLKH</sub> [32]   | TXCLKx HIGH Time       | 2.2                  |                     | ns   |
| t <sub>TXCLKL</sub> [32]   | TXCLKx LOW Time        | 2.2                  |                     | ns   |

**Notes:**

24. The common mode range defines the allowable range of INPUT+ and INPUT- when INPUT+ = INPUT-. This marks the zero-crossing between the true and complement inputs as the signal switches between a logic-1 and a logic-0.
25. Not applicable for AC-coupled interfaces. For AC-coupled interfaces, V<sub>DIFFS</sub> requirement still needs to be satisfied.
26. Maximum I<sub>CC</sub> is measured with V<sub>CC</sub> = MAX, RXCKSEL = LOW, with all TX and RX channels and Serial Line Drivers enabled, sending a continuous alternating 01 pattern to the associated receive channel, and outputs unloaded.
27. Typical I<sub>CC</sub> is measured under similar conditions except with V<sub>CC</sub> = 3.3V, T<sub>A</sub> = 25°C, RXCKSEL = LOW, with all TX and RX channels enabled and one Serial Line Driver per transmit channel sending a continuous alternating 01 pattern to the associated receive channel. The redundant outputs on each channel are powered down and the parallel outputs are unloaded.
28. Cypress uses constant current (ATE) load configurations and forcing functions. This figure is for reference only. 5-pF differential load reflects tester capacitance, and is recommended at low data rates only.
29. The LVTTTL switching threshold is 1.4V. All timing references are made relative to the point where the signal edges crosses the threshold voltage.
30. This parameter is 154 MHz for CYW15G0401DXB
31. This parameter is 6.49 ns for CYW15G0401DXB
32. Tested initially and after any design or process changes that may affect these parameters, but not 100% tested.

**CYP(V)(W)15G0401DXB AC Characteristics** Over the Operating Range (continued)

| Parameter                            | Description   | Min.                 | Max.                | Unit |
|--------------------------------------|---|----------------------|---------------------|------|
| $t_{TXCLKR}$ <sup>[32, 33, 34]</sup> | TXCLKx Rise Time  | 0.2                  | 1.7                 | ns   |
| $t_{TXCLKF}$ <sup>[32, 33, 34]</sup> | TXCLKx Fall Time  | 0.2                  | 1.7                 | ns   |
| $t_{TXDS}$                           | Transmit Data Set-Up Time to TXCLKx $\uparrow$ (TXCKSEL $\neq$ LOW) | 1.7                  |                     | ns   |
| $t_{TXDH}$                           | Transmit Data Hold Time from TXCLKx $\uparrow$ (TXCKSEL $\neq$ LOW) | 0.8                  |                     | ns   |
| $f_{TOS}$                            | TXCLKO Clock Frequency = 1x or 2x REFCLK Frequency                  | 20                   | 150 <sup>[30]</sup> | MHz  |
| $t_{TXCLKO}$                         | TXCLKO Period   | 6.66 <sup>[31]</sup> | 50                  | ns   |
| $t_{TXCLKOD+}$                       | TXCLKO+ Duty Cycle with 60% HIGH time                               | -1.0                 | +0.5                | ns   |
| $t_{TXCLKOD-}$                       | TXCLKO- Duty Cycle with 40% HIGH time                               | -0.5                 | +1.0                | ns   |

**CYP(V)(W)15G0401DXB Receiver LVTTTL Switching Characteristics** Over the Operating Range

|                              |  |                      |                     |     |
|------------------------------|--|----------------------|---------------------|-----|
| $f_{RS}$                     | RXCLKx Clock Output Frequency                                      | 9.75                 | 150 <sup>[30]</sup> | MHz |
| $t_{RXCLKP}$                 | RXCLKx Period  | 6.66 <sup>[31]</sup> | 102.56              | ns  |
| $t_{RXCLKH}$                 | RXCLKx HIGH Time (RXRATE = LOW)                                    | 2.33 <sup>[32]</sup> | 26.64               | ns  |
|                              | RXCLKx HIGH Time (RXRATE = HIGH)                                   | 5.66                 | 52.28               | ns  |
| $t_{RXCLKL}$                 | RXCLKx LOW Time (RXRATE = LOW)                                     | 2.33 <sup>[32]</sup> | 26.64               | ns  |
|                              | RXCLKx LOW Time (RXRATE = HIGH)                                    | 5.66                 | 52.28               | ns  |
| $t_{RXCLKD}$                 | RXCLKx Duty Cycle centered at 50%                                  | -1.0                 | +1.0                | ns  |
| $t_{RXCLKR}$ <sup>[32]</sup> | RXCLKx Rise Time   | 0.3                  | 1.2                 | ns  |
| $t_{RXCLKF}$ <sup>[32]</sup> | RXCLKx Fall Time   | 0.3                  | 1.2                 | ns  |
| $t_{RXDV-}$ <sup>[35]</sup>  | Status and Data Valid Time to RXCLKx (RXCKSEL HIGH or MID)         | 5UI - 1.5            |                     | ns  |
|                              | Status and Data Valid Time to RXCLKx (HALF RATE RECOVERED CLOCK)   | 5UI - 1.0            |                     | ns  |
| $t_{RXDV+}$ <sup>[35]</sup>  | Status and Data Valid Time From RXCLKx (RXCKSEL HIGH or MID)       | 5UI - 1.8            |                     | ns  |
|                              | Status and Data Valid Time From RXCLKx (HALF RATE RECOVERED CLOCK) | 5UI - 2.3            |                     | ns  |

**CYP(V)(W)15G0401DXB REFCLK Switching Characteristics** Over the Operating Range

|                                    |  |                      |                     |     |
|------------------------------------|--|----------------------|---------------------|-----|
| $f_{REF}$                          | REFCLK Clock Frequency                               | 19.5                 | 150 <sup>[30]</sup> | MHz |
| $t_{REFCLK}$                       | REFCLK Period  | 6.66 <sup>[31]</sup> | 51.28               | ns  |
| $t_{REFH}$                         | REFCLK HIGH Time (TXRATE = HIGH)                     | 5.9                  |                     | ns  |
|                                    | REFCLK HIGH Time (TXRATE = LOW)                      | 2.9 <sup>[32]</sup>  |                     | ns  |
| $t_{REFL}$                         | REFCLK LOW Time (TXRATE = HIGH)                      | 5.9                  |                     | ns  |
|                                    | REFCLK LOW Time (TXRATE = LOW)                       | 2.9 <sup>[32]</sup>  |                     | ns  |
| $t_{REFD}$ <sup>[36]</sup>         | REFCLK Duty Cycle                                    | 30                   | 70                  | %   |
| $t_{REFR}$ <sup>[32, 33, 34]</sup> | REFCLK Rise Time (20% - 80%)                         |                      | 2                   | ns  |
| $t_{REFF}$ <sup>[32, 33, 34]</sup> | REFCLK Fall Time (20% - 80%)                         |                      | 2                   | ns  |
| $t_{TREFDS}$                       | Transmit Data Setup Time to REFCLK (TXCKSEL = LOW)   | 1.7                  |                     | ns  |
| $t_{TREFDH}$                       | Transmit Data Hold Time from REFCLK (TXCKSEL = LOW)  | 0.8                  |                     | ns  |
| $t_{RREFDA}$ <sup>[37]</sup>       | Receive Data Access Time from REFCLK (RXCKSEL = LOW) |                      | 9.5                 | ns  |
| $t_{RREFDV}$                       | Receive Data Valid Time from REFCLK (RXCKSEL = LOW)  | 2.5                  |                     | ns  |

**Notes:**

33. The ratio of rise time to falling time must not vary by greater than 2:1.
34. For a given operating frequency, neither rise or fall specification can be greater than 20% of the clock-cycle period or the data sheet maximum time.
35. Parallel data output specifications are only valid if all inputs or outputs are loaded with similar DC and AC loads.
36. The duty cycle specification is a simultaneous condition with the  $t_{REFH}$  and  $t_{REFL}$  parameters. This means that at faster character rates the REFCLK duty cycle cannot be as large as 30% - 70%.
37. Since this timing parameter is greater than the minimum time period of REFCLK it sets an upper limit to the frequency in which REFCLKx can be used to clock the receive data out of the output register. For predictable timing, users can use this parameter only if REFCLK period is greater than sum of  $t_{RREFDA}$  and set-up time of the upstream device. When this condition is not true, RXCLKC $\pm$  or RXCLKA $\pm$  (a buffered or delayed version of REFCLK when RXCKSELx = LOW) could be used to clock the receive data out of the device.

**CYP(V)(W)15G0401DXB AC Characteristics** Over the Operating Range (continued)

| Parameter          | Description  | Min.       | Max.  | Unit |
|--------------------|--|------------|-------|------|
| $t_{REFADV-}$      | Received Data Valid Time to RXCLKA (RXCKSEL = LOW)   | 10UI – 4.7 |       | ns   |
| $t_{REFADV+}$      | Received Data Valid Time from RXCLKA (RXCKSEL = LOW) | 0.5        |       | ns   |
| $t_{REFCDV-}$      | Received Data Valid Time to RXCLKC (RXCKSEL = LOW)   | 10UI – 4.3 |       | ns   |
| $t_{REFCDV+}$      | Received Data Valid Time from RXCLKC (RXCKSEL = LOW) | –0.2       |       | ns   |
| $t_{REFRX}^{[12]}$ | REFCLK Frequency Referenced to Received Clock Period | –1500      | +1500 | ppm  |

**CYP(V)(W)15G0401DXB Transmit Serial Outputs and TX PLL Characteristics** Over the Operating Range

| Parameter               | Description                                    | Condition                   | Min. | Max.                | Unit |
|-------------------------|--|-----------------------------|------|---------------------|------|
| $t_B$                   | Bit Time                                       |                             | 5100 | 666 <sup>[38]</sup> | ps   |
| $t_{RISE}^{[32]}$       | CML Output Rise Time 20% – 80% (CML Test Load) | SPDSEL = HIGH               | 60   | 270                 | ps   |
|                         |  | SPDSEL = MID                | 100  | 500                 | ps   |
|                         |  | SPDSEL = LOW                | 180  | 1000                | ps   |
| $t_{FALL}^{[32]}$       | CML Output Fall Time 80% – 20% (CML Test Load) | SPDSEL = HIGH               | 50   | 270                 | ps   |
|                         |  | SPDSEL = MID                | 100  | 500                 | ps   |
|                         |  | SPDSEL = LOW                | 180  | 1000                | ps   |
| $t_{DJ}^{[32, 39, 41]}$ | Deterministic Jitter (peak-peak)               | IEEE 802.3z <sup>[42]</sup> |      | 25                  | ps   |
| $t_{RJ}^{[32, 40, 41]}$ | Random Jitter ( $\sigma$ )                     | IEEE 802.3z <sup>[42]</sup> |      | 11                  | ps   |
| $t_{TXLOCK}$            | Transmit PLL lock to REFCLK                    |                             |      | 200                 | us   |

**CYP(V)(W)15G0401DXB Receive Serial Inputs and CDR PLL Characteristics** Over the Operating Range

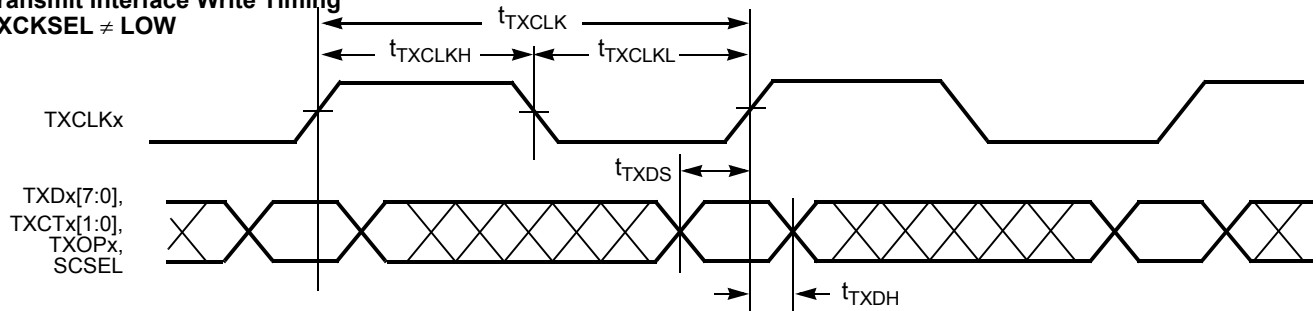
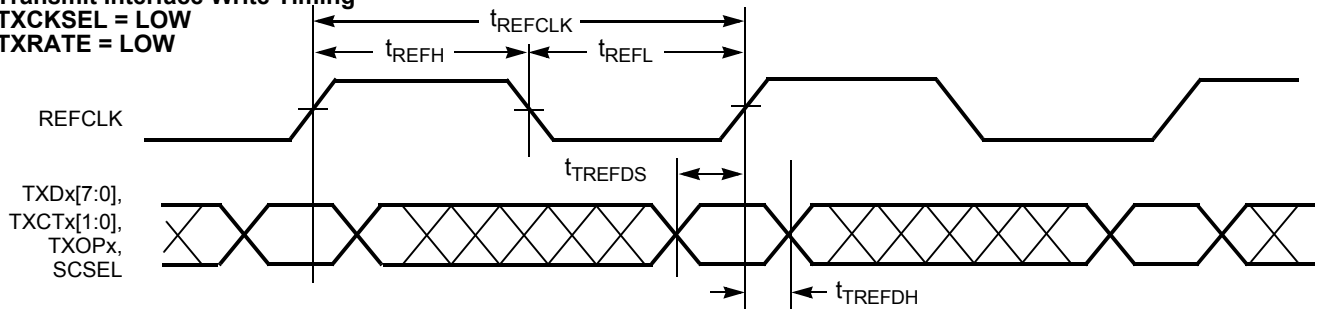
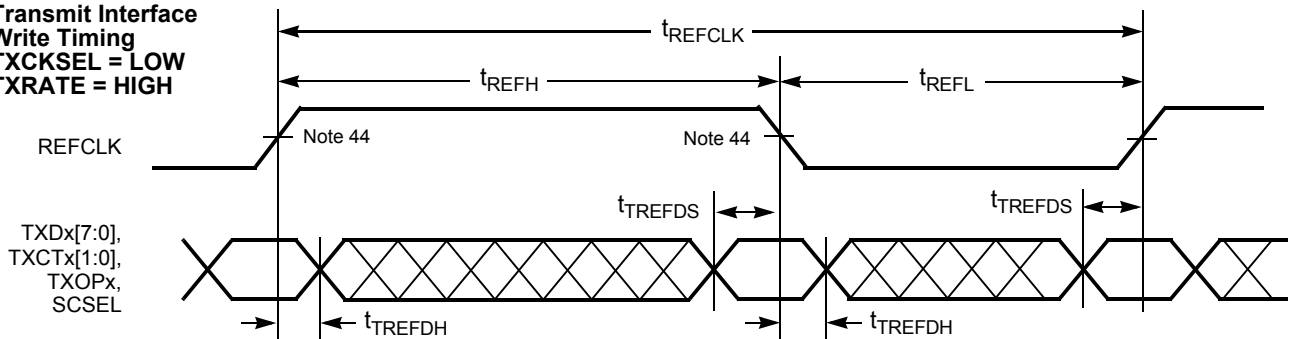
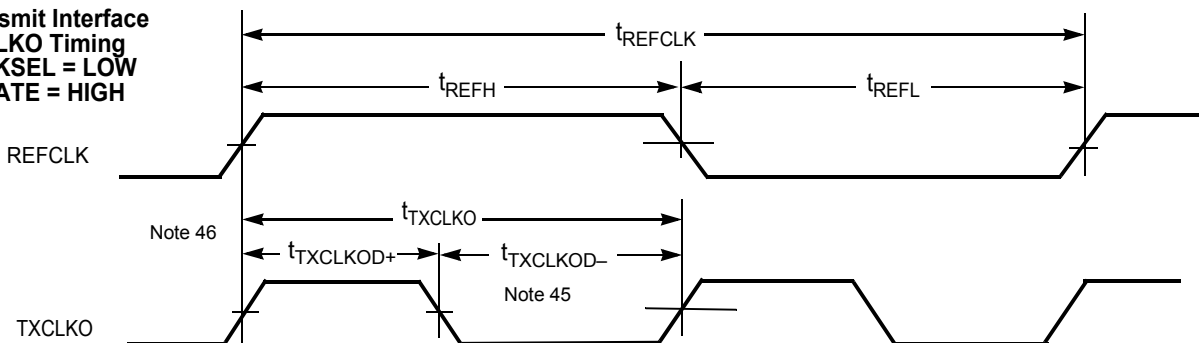
|                    |  |                             |     |      |                    |
|--------------------|--|-----------------------------|-----|------|--------------------|
| $t_{RXLOCK}$       | Receive PLL lock to input data stream (cold start) |                             |     | 376K | UI <sup>[43]</sup> |
|                    | Receive PLL lock to input data stream              |                             |     | 376K | UI                 |
| $t_{RXUNLOCK}$     | Receive PLL Unlock Rate                            |                             |     | 46   | UI                 |
| $t_{JTOL}^{[41]}$  | Total Jitter Tolerance                             | IEEE 802.3z <sup>[42]</sup> | 600 |      | ps                 |
| $t_{DJTOL}^{[41]}$ | Deterministic Jitter Tolerance                     | IEEE 802.3z <sup>[42]</sup> | 370 |      | ps                 |

**Capacitance** <sup>[32]</sup>

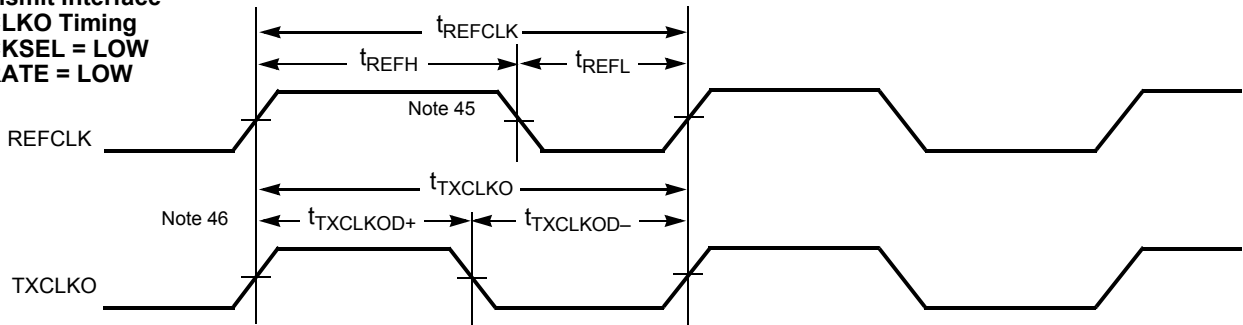
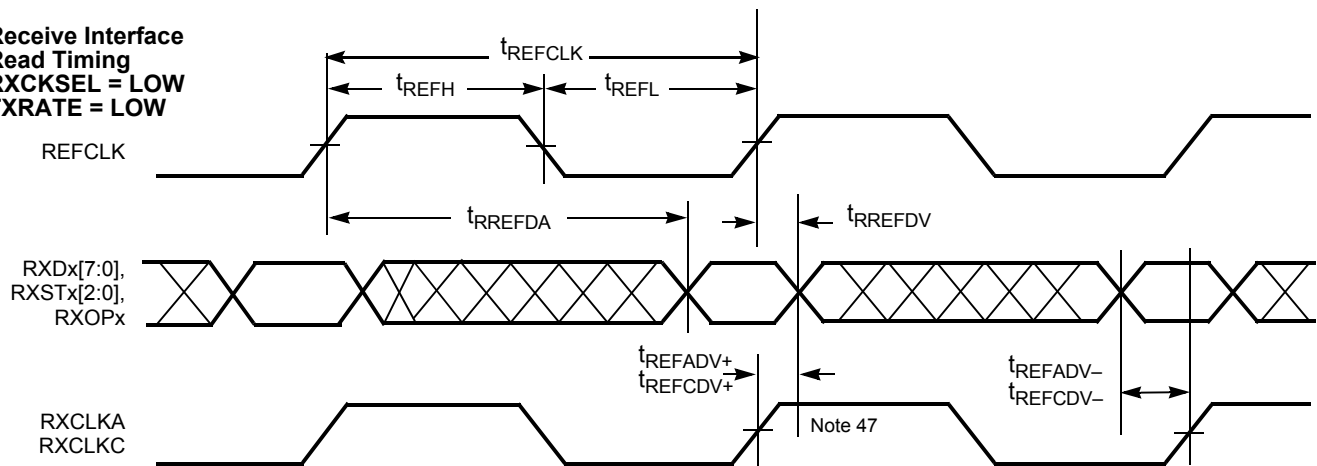
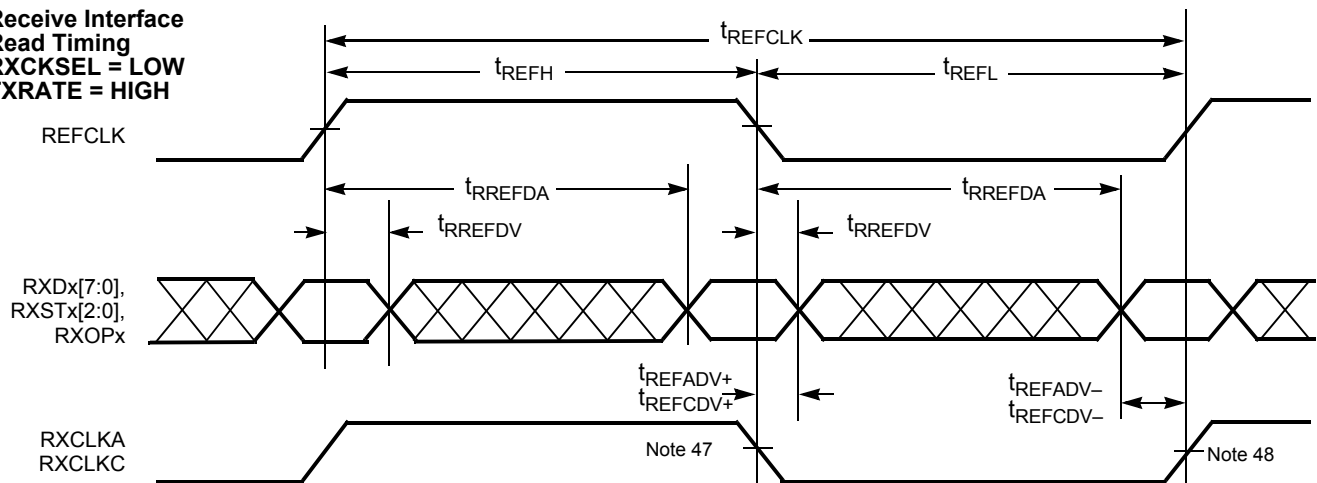
| Parameter    | Description            | Test Conditions  | Max. | Unit |
|--------------|------------------------|--|------|------|
| $C_{INTTL}$  | TTL Input Capacitance  | $T_A = 25^\circ\text{C}$ , $f_0 = 1\text{ MHz}$ , $V_{CC} = 3.3\text{V}$ | 7    | pF   |
| $C_{INPECL}$ | PECL input Capacitance | $T_A = 25^\circ\text{C}$ , $f_0 = 1\text{ MHz}$ , $V_{CC} = 3.3\text{V}$ | 4    | pF   |

**Notes:**

38. This parameter is 649 ps for CYW15G0401DXB
39. While sending continuous K28.5s, outputs loaded to a balanced 100 $\Omega$  load, measured at the cross point of differential outputs, over the operating range.
40. While sending continuous K28.7s, after 100,000 samples measured at the cross point of differential outputs, time referenced to REFCLK input, over the operating range.
41. Total jitter is calculated at an assumed BER of 1E –12. Hence: total jitter ( $t_j$ ) = ( $t_{RJ} * 14$ ) +  $t_{DJ}$ .
42. Also meets all Jitter Generation and Jitter Tolerance requirements as specified by SMPTE 259M, SMPTE 292M, OBSAI RP3, CPRI, ESCON, FICON, Fibre Channel and DVB-ASI.
43. Receiver UI (Unit Interval) is calculated as  $1/(f_{REF} * 20)$  (when RXRATE = HIGH) or  $1/(f_{REF} * 10)$  (when RXRATE = LOW) if no data is being received, or  $1/(f_{REF} * 20)$  (when RXRATE = HIGH) or  $1/(f_{REF} * 10)$  (when RXRATE = LOW) of the remote transmitter if data is being received. In an operating link this is equivalent to  $t_B$ .

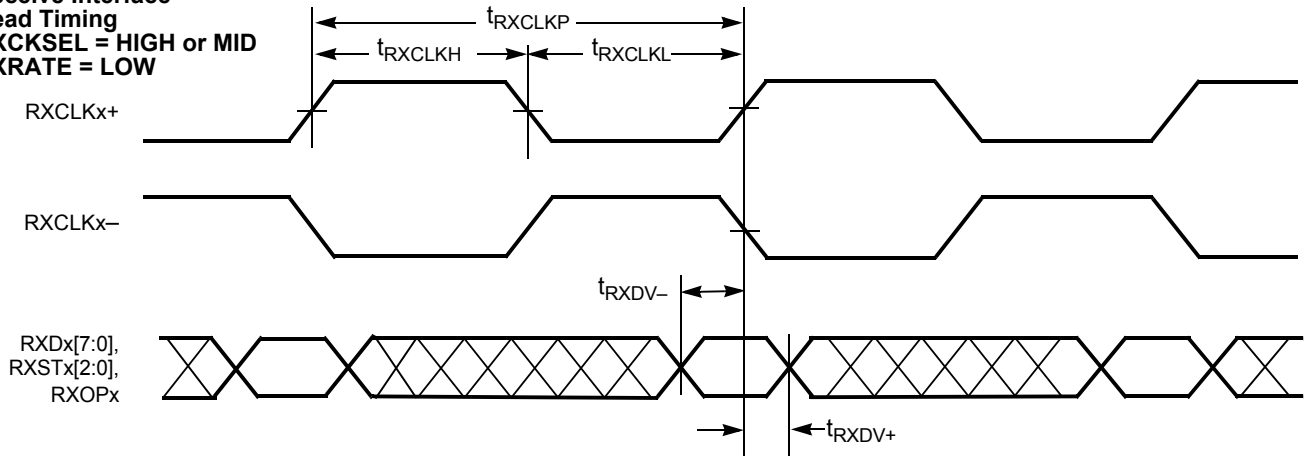
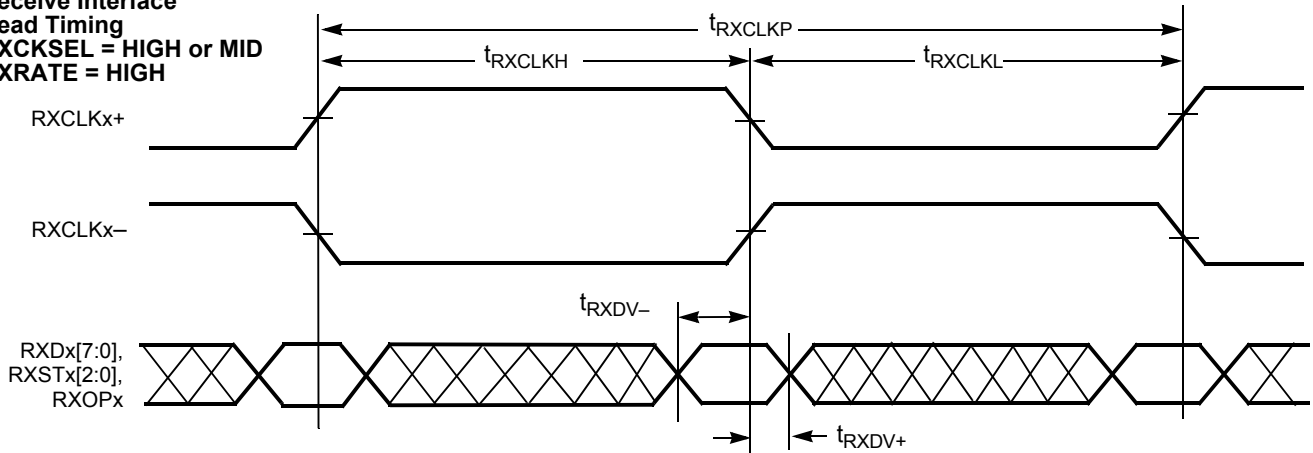
**CYP(V)(W)15G0401DXB HOTLink II Transmitter Switching Waveforms**
**Transmit Interface Write Timing  
 TXCKSEL ≠ LOW**

**Transmit Interface Write Timing  
 TXCKSEL = LOW  
 TXRATE = LOW**

**Transmit Interface Write Timing  
 TXCKSEL = LOW  
 TXRATE = HIGH**

**Transmit Interface TXCLKO Timing  
 TXCKSEL = LOW  
 TXRATE = HIGH**

**Notes:**

- 44. When REFCLK is configured for half-rate operation (TXRATE = HIGH) and data is captured using REFCLK instead of a TXCLKx clock (TXCKSEL = LOW), data is captured using both the rising and falling edges of REFCLK.
- 45. The TXCLKO output is at twice the rate of REFCLK when TXRATE = HIGH and same rate as REFCLK when TXRATE = LOW. TXCLKO does not follow the duty cycle of REFCLK.
- 46. The rising edge of TXCLKO output has no direct phase relationship to the REFCLK input.

**CYP(V)(W)15G0401DXB HOTLink II Transmitter Switching Waveforms (continued)**
**Transmit Interface  
 TXCLKO Timing  
 TXCKSEL = LOW  
 TXRATE = LOW**

**Switching Waveforms for the CYP(V)(W)15G0401DXB HOTLink II Receiver**
**Receive Interface  
 Read Timing  
 RXCKSEL = LOW  
 TXRATE = LOW**

**Receive Interface  
 Read Timing  
 RXCKSEL = LOW  
 TXRATE = HIGH**

**Notes:**

47. RXCLKA and RXCLKC are delayed in phase from REFCLK, and are different in phase from each other.
48. When operated with a half-rate REFCLK, the setup and hold specifications for data relative to RXCLKA and RXCLKC are relative to both rising and falling edges of the respective clock output.



**Switching Waveforms for the CYP(V)(W)15G0401DXB HOTLink II Receiver (continued)**
**Receive Interface**
**Read Timing**
**RXCKSEL = HIGH or MID**  
**RXRATE = LOW**

**Receive Interface**
**Read Timing**
**RXCKSEL = HIGH or MID**  
**RXRATE = HIGH**




**Table 25. Package Coordinate Signal Allocation**

| Ball ID | Signal Name | Signal Type  | Ball ID | Signal Name | Signal Type    | Ball ID | Signal Name | Signal Type    |
|---------|-------------|--------------|---------|-------------|----------------|---------|-------------|----------------|
| A01     | INC1-       | CML IN       | C04     | INSELB      | LVTTTL IN      | E19     | VCC         | POWER          |
| A02     | OUTC1-      | CML OUT      | C05     | VCC         | POWER          | E20     | VCC         | POWER          |
| A03     | INC2-       | CML IN       | C06     | PARCTL      | 3-LEVEL SEL    | F01     | TXPERC      | LVTTTL OUT     |
| A04     | OUTC2-      | CML OUT      | C07     | SDASEL      | 3-LEVEL SEL    | F02     | TXOPC       | LVTTTL IN PU   |
| A05     | VCC         | POWER        | C08     | GND         | GROUND         | F03     | TXDC[0]     | LVTTTL IN      |
| A06     | IND1-       | CML IN       | C09     | BOE[7]      | LVTTTL IN PU   | F04     | RXCKSEL     | 3-LEVEL SEL    |
| A07     | OUTD1-      | CML OUT      | C10     | BOE[5]      | LVTTTL IN PU   | F17     | BISTLE      | LVTTTL IN PU   |
| A08     | GND         | GROUND       | C11     | BOE[3]      | LVTTTL IN PU   | F18     | RXSTB[1]    | LVTTTL OUT     |
| A09     | IND2-       | CML IN       | C12     | BOE[1]      | LVTTTL IN PU   | F19     | RXOPB       | LVTTTL 3-S OUT |
| A10     | OUTD2-      | CML OUT      | C13     | GND         | GROUND         | F20     | RXSTB[0]    | LVTTTL OUT     |
| A11     | INA1-       | CML IN       | C14     | TXMODE[0]   | 3-LEVEL SEL    | G01     | TXDC[7]     | LVTTTL IN      |
| A12     | OUTA1-      | CML OUT      | C15     | RXMODE[0]   | 3-LEVEL SEL    | G02     | TXCKSEL     | 3-LEVEL SEL    |
| A13     | GND         | GROUND       | C16     | VCC         | POWER          | G03     | TXDC[4]     | LVTTTL IN      |
| A14     | INA2-       | CML IN       | C17     | TXRATE      | LVTTTL IN PD   | G04     | TXDC[1]     | LVTTTL IN      |
| A15     | OUTA2-      | CML OUT      | C18     | RXRATE      | LVTTTL IN PD   | G17     | DECMODE     | 3-LEVEL SEL    |
| A16     | VCC         | POWER        | C19     | LPEN        | LVTTTL IN PD   | G18     | OELE        | LVTTTL IN PU   |
| A17     | INB1-       | CML IN       | C20     | TDO         | LVTTTL 3-S OUT | G19     | FRAMCHAR    | 3-LEVEL SEL    |
| A18     | OUTB1-      | CML OUT      | D01     | TCLK        | LVTTTL IN PD   | G20     | RXDB[1]     | LVTTTL OUT     |
| A19     | INB2-       | CML IN       | D02     | TRSTZ       | LVTTTL IN PU   | H01     | GND         | GROUND         |
| A20     | OUTB2-      | CML OUT      | D03     | INSELD      | LVTTTL IN      | H02     | GND         | GROUND         |
| B01     | INC1+       | CML IN       | D04     | INSELA      | LVTTTL IN      | H03     | GND         | GROUND         |
| B02     | OUTC1+      | CML OUT      | D05     | VCC         | POWER          | H04     | GND         | GROUND         |
| B03     | INC2+       | CML IN       | D06     | RFMODE      | 3-LEVEL SEL    | H17     | GND         | GROUND         |
| B04     | OUTC2+      | CML OUT      | D07     | SPDSEL      | 3-LEVEL SEL    | H18     | GND         | GROUND         |
| B05     | VCC         | POWER        | D08     | GND         | GROUND         | H19     | GND         | GROUND         |
| B06     | IND1+       | CML IN       | D09     | BOE[6]      | LVTTTL IN PU   | H20     | GND         | GROUND         |
| B07     | OUTD1+      | CML OUT      | D10     | BOE[4]      | LVTTTL IN PU   | J01     | TXCTC[1]    | LVTTTL IN      |
| B08     | GND         | GROUND       | D11     | BOE[2]      | LVTTTL IN PU   | J02     | TXDC[5]     | LVTTTL IN      |
| B09     | IND2+       | CML IN       | D12     | BOE[0]      | LVTTTL IN PU   | J03     | TXDC[2]     | LVTTTL IN      |
| B10     | OUTD2+      | CML OUT      | D13     | GND         | GROUND         | J04     | TXDC[3]     | LVTTTL IN      |
| B11     | INA1+       | CML IN       | D14     | TXMODE[1]   | 3-LEVEL SEL    | J17     | RXSTB[2]    | LVTTTL OUT     |
| B12     | OUTA1+      | CML OUT      | D15     | RXMODE[1]   | 3-LEVEL SEL    | J18     | RXDB[0]     | LVTTTL OUT     |
| B13     | GND         | GROUND       | D16     | VCC         | POWER          | J19     | RXDB[5]     | LVTTTL OUT     |
| B14     | INA2+       | CML IN       | D17     | BOND_INH    | LVTTTL IN PU   | J20     | RXDB[2]     | LVTTTL OUT     |
| B15     | OUTA2+      | CML OUT      | D18     | RXLE        | LVTTTL IN PU   | K01     | RXDC[2]     | LVTTTL OUT     |
| B16     | VCC         | POWER        | D19     | RFEN        | LVTTTL IN PD   | K02     | RXCLKC-     | LVTTTL OUT     |
| B17     | INB1+       | CML IN       | D20     | MASTER      | LVTTTL IN PD   | K03     | TXCTC[0]    | LVTTTL IN      |
| B18     | OUTB1+      | CML OUT      | E01     | VCC         | POWER          | K04     | LFIC        | LVTTTL OUT     |
| B19     | INB2+       | CML IN       | E02     | VCC         | POWER          | K17     | RXDB[3]     | LVTTTL OUT     |
| B20     | OUTB2+      | CML OUT      | E03     | VCC         | POWER          | K18     | RXDB[4]     | LVTTTL OUT     |
| C01     | TDI         | LVTTTL IN PU | E04     | VCC         | POWER          | K19     | RXDB[7]     | LVTTTL OUT     |
| C02     | TMS         | LVTTTL IN PU | E17     | VCC         | POWER          | K20     | RXCLKB+     | LVTTTL I/O PD  |
| C03     | INSELC      | LVTTTL IN    | E18     | VCC         | POWER          | L01     | RXDC[3]     | LVTTTL OUT     |



**Table 25. Package Coordinate Signal Allocation (continued)**

| Ball ID | Signal Name              | Signal Type    | Ball ID | Signal Name | Signal Type    | Ball ID | Signal Name               | Signal Type   |
|---------|--------------------------|----------------|---------|-------------|----------------|---------|---------------------------|---------------|
| L02     | RXCLKC+                  | LVTTTL I/O PD  | T17     | VCC         | POWER          | V20     | RXSTA[0]                  | LVTTTL OUT    |
| L03     | TXCLKC                   | LVTTTL IN PD   | T18     | VCC         | POWER          | W01     | TXDD[5]                   | LVTTTL IN     |
| L04     | TXDC[6]                  | LVTTTL IN      | T19     | VCC         | POWER          | W02     | TXDD[7]                   | LVTTTL IN     |
| L17     | RXDB[6]                  | LVTTTL OUT     | T20     | VCC         | POWER          | W03     | $\overline{\text{LFID}}$  | LVTTTL OUT    |
| L18     | $\overline{\text{LFIB}}$ | LVTTTL OUT     | U01     | TXDD[0]     | LVTTTL IN      | W04     | RXCLKD-                   | LVTTTL OUT    |
| L19     | RXCLKB-                  | LVTTTL OUT     | U02     | TXDD[1]     | LVTTTL IN      | W05     | VCC                       | POWER         |
| L20     | TXDB[6]                  | LVTTTL IN      | U03     | TXDD[2]     | LVTTTL IN      | W06     | RXDD[4]                   | LVTTTL OUT    |
| M01     | RXDC[4]                  | LVTTTL OUT     | U04     | TXCTD[1]    | LVTTTL IN      | W07     | RXSTD[1]                  | LVTTTL OUT    |
| M02     | RXDC[5]                  | LVTTTL OUT     | U05     | VCC         | POWER          | W08     | GND                       | GROUND        |
| M03     | RXDC[7]                  | LVTTTL OUT     | U06     | RXDD[2]     | LVTTTL OUT     | W09     | TXCLKO-                   | LVTTTL OUT    |
| M04     | RXDC[6]                  | LVTTTL OUT     | U07     | RXDD[1]     | LVTTTL OUT     | W10     | $\overline{\text{TXRST}}$ | LVTTTL IN PU  |
| M17     | TXCTB[1]                 | LVTTTL IN      | U08     | GND         | GROUND         | W11     | TXOPA                     | LVTTTL IN PU  |
| M18     | TXCTB[0]                 | LVTTTL IN      | U09     | RXOPD       | LVTTTL 3-S OUT | W12     | SCSEL                     | LVTTTL IN PD  |
| M19     | TXDB[7]                  | LVTTTL IN      | U10     | BOND_ALL    | OPEN DR        | W13     | GND                       | GROUND        |
| M20     | TXCLKB                   | LVTTTL IN PD   | U11     | REFCLK-     | PECL IN        | W14     | TXDA[2]                   | LVTTTL IN     |
| N01     | GND                      | GROUND         | U12     | TXDA[1]     | LVTTTL IN      | W15     | TXDA[6]                   | LVTTTL IN     |
| N02     | GND                      | GROUND         | U13     | GND         | GROUND         | W16     | VCC                       | POWER         |
| N03     | GND                      | GROUND         | U14     | TXDA[4]     | LVTTTL IN      | W17     | $\overline{\text{LFIA}}$  | LVTTTL OUT    |
| N04     | GND                      | GROUND         | U15     | TXCTA[0]    | LVTTTL IN      | W18     | RXCLKA-                   | LVTTTL OUT    |
| N17     | GND                      | GROUND         | U16     | VCC         | POWER          | W19     | RXDA[4]                   | LVTTTL OUT    |
| N18     | GND                      | GROUND         | U17     | RXDA[2]     | LVTTTL OUT     | W20     | RXDA[1]                   | LVTTTL OUT    |
| N19     | GND                      | GROUND         | U18     | RXOPA       | LVTTTL OUT     | Y01     | TXDD[6]                   | LVTTTL IN     |
| N20     | GND                      | GROUND         | U19     | RXSTA[2]    | LVTTTL OUT     | Y02     | TXCLKD                    | LVTTTL IN     |
| P01     | RXDC[1]                  | LVTTTL OUT     | U20     | RXSTA[1]    | LVTTTL OUT     | Y03     | RXDD[7]                   | LVTTTL OUT    |
| P02     | RXDC[0]                  | LVTTTL OUT     | V01     | TXDD[3]     | LVTTTL IN      | Y04     | RXCLKD+                   | LVTTTL I/O PD |
| P03     | RXSTC[0]                 | LVTTTL OUT     | V02     | TXDD[4]     | LVTTTL IN      | Y05     | VCC                       | POWER         |
| P04     | RXSTC[1]                 | LVTTTL OUT     | V03     | TXCTD[0]    | LVTTTL IN      | Y06     | RXDD[5]                   | LVTTTL OUT    |
| P17     | TXDB[5]                  | LVTTTL IN      | V04     | RXDD[6]     | LVTTTL OUT     | Y07     | RXDD[0]                   | LVTTTL OUT    |
| P18     | TXDB[4]                  | LVTTTL IN      | V05     | VCC         | POWER          | Y08     | GND                       | GROUND        |
| P19     | TXDB[3]                  | LVTTTL IN      | V06     | RXDD[3]     | LVTTTL OUT     | Y09     | TXCLKO+                   | LVTTTL OUT    |
| P20     | TXDB[2]                  | LVTTTL IN      | V07     | RXSTD[0]    | LVTTTL OUT     | Y10     | N/C                       | NO CONNECT    |
| R01     | RXSTC[2]                 | LVTTTL OUT     | V08     | GND         | GROUND         | Y11     | TXCLKA                    | LVTTTL IN PD  |
| R02     | RXOPC                    | LVTTTL 3-S OUT | V09     | RXSTD[2]    | LVTTTL OUT     | Y12     | TXPERA                    | LVTTTL OUT    |
| R03     | TXPERD                   | LVTTTL OUT     | V10     | BONDST[0]   | OPEN DR        | Y13     | GND                       | GROUND        |
| R04     | TXOPD                    | LVTTTL IN PU   | V11     | REFCLK+     | PECL IN        | Y14     | TXDA[0]                   | LVTTTL IN     |
| R17     | TXDB[1]                  | LVTTTL IN      | V12     | BONDST[1]   | OPEN DR        | Y15     | TXDA[5]                   | LVTTTL IN     |
| R18     | TXDB[0]                  | LVTTTL IN      | V13     | GND         | GROUND         | Y16     | VCC                       | POWER         |
| R19     | TXOPB                    | LVTTTL IN PU   | V14     | TXDA[3]     | LVTTTL IN      | Y17     | TXCTA[1]                  | LVTTTL IN     |
| R20     | TXPERB                   | LVTTTL OUT     | V15     | TXDA[7]     | LVTTTL IN      | Y18     | RXCLKA+                   | LVTTTL I/O PD |
| T01     | VCC                      | POWER          | V16     | VCC         | POWER          | Y19     | RXDA[6]                   | LVTTTL OUT    |
| T02     | VCC                      | POWER          | V17     | RXDA[7]     | LVTTTL OUT     | Y20     | RXDA[5]                   | LVTTTL OUT    |
| T03     | VCC                      | POWER          | V18     | RXDA[3]     | LVTTTL OUT     |         |                           |               |
| T04     | VCC                      | POWER          | V19     | RXDA[0]     | LVTTTL OUT     |         |                           |               |



### X3.230 Codes and Notation Conventions

Information to be transmitted over a serial link is encoded eight bits at a time into a 10-bit Transmission Character and then sent serially, bit by bit. Information received over a serial link is collected ten bits at a time, and those Transmission Characters that are used for data characters are decoded into the correct eight-bit codes. The 10-bit Transmission Code supports all 256 eight-bit combinations. Some of the remaining Transmission Characters (Special Characters) are used for functions other than data transmission.

The primary use of a Transmission Code is to improve the transmission characteristics of a serial link. The encoding defined by the Transmission Code ensures that sufficient transitions are present in the serial bit stream to make clock recovery possible at the Receiver. Such encoding also greatly increases the likelihood of detecting any single or multiple bit errors that may occur during transmission and reception of information. In addition, some Special Characters of the Transmission Code selected by Fibre Channel Standard contain a distinct and easily recognizable bit pattern that assists the receiver in achieving character alignment on the incoming bit stream.

#### Notation Conventions

The documentation for the 8B/10B Transmission Code uses letter notation for the bits in an eight-bit byte. Fibre Channel Standard notation uses a bit notation of A, B, C, D, E, F, G, H for the eight-bit byte for the raw eight-bit data, and the letters a, b, c, d, e, i, f, g, h, j for encoded 10-bit data. There is a correspondence between bit A and bit a, B and b, C and c, D and d, E and e, F and f, G and g, and H and h. Bits i and j are derived, respectively, from (A,B,C,D,E) and (F,G,H).

The bit labeled A in the description of the 8B/10B Transmission Code corresponds to bit 0 in the numbering scheme of the FC-2 specification, B corresponds to bit 1, as shown below.

|                          |   |   |   |   |   |   |   |   |
|--------------------------|---|---|---|---|---|---|---|---|
| FC-2 bit designation—    | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| HOTLink D/Q designation— | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| 8B/10B bit designation—  | H | G | F | E | D | C | B | A |

To clarify this correspondence, the following example shows the conversion from an FC-2 Valid Data Byte to a Transmission Character.

```

FC-2  45H
      Bits: 7654 3210
            0100 0101

```

Converted to 8B/10B notation, note that the order of bits has been reversed):

```

Data Byte Name  D5.2
      Bits:  ABCDE  FGH
            10100  010

```

Translated to a transmission Character in the 8B/10B Transmission Code:

```

Bits:  abcdei  fghj
      101001  0101

```

Each valid Transmission Character of the 8B/10B Transmission Code has been given a name using the following convention: cxx.y, where c is used to show whether the Transmission Character is a Data Character (c is set to D, and SC/D = LOW) or a Special Character (c is set to K, and SC/D = HIGH). When c is set to D, xx is the decimal value of the binary number

composed of the bits E, D, C, B, and A in that order, and the y is the decimal value of the binary number composed of the bits H, G, and F in that order. When c is set to K, xx and y are derived by comparing the encoded bit patterns of the Special Character to those patterns derived from encoded Valid Data bytes and selecting the names of the patterns most similar to the encoded bit patterns of the Special Character.

Under the above conventions, the Transmission Character used for the examples above, is referred to by the name D5.2. The Special Character K29.7 is so named because the first six bits (abcdei) of this character make up a bit pattern similar to that resulting from the encoding of the unencoded 11101 pattern (29), and because the second four bits (fghj) make up a bit pattern similar to that resulting from the encoding of the unencoded 111 pattern (7). This definition of the 10-bit Transmission Code is based on the following references.

A.X. Widmer and P.A. Franaszek. "A DC-Balanced, Partitioned-Block, 8B/10B Transmission Code" IBM Journal of Research and Development, 27, No. 5: 440-451 (September, 1983).

U.S. Patent 4,486,739. Peter A. Franaszek and Albert X. Widmer. "Byte-Oriented DC Balanced (0.4) 8B/10B Partitioned Block Transmission Code" (December 4, 1984).

Fibre Channel Physical and Signaling Interface (ANSI X3.230-1994 ANSI FC-PH Standard).

IBM Enterprise Systems Architecture/390 ESCON I/O Interface (document number SA22-7202).

#### 8B/10B Transmission Code

The following information describes how the tables are used for both generating valid Transmission Characters (encoding) and checking the validity of received Transmission Characters (decoding). It also specifies the ordering rules to be followed when transmitting the bits within a character and the characters within any higher-level constructs specified by a standard.

#### Transmission Order

Within the definition of the 8B/10B Transmission Code, the bit positions of the Transmission Characters are labeled a, b, c, d, e, i, f, g, h, j. Bit "a" is transmitted first followed by bits b, c, d, e, i, f, g, h, and j in that order.

Note that bit i is transmitted between bit e and bit f, rather than in alphabetical order.

#### Valid and Invalid Transmission Characters

The following tables define the valid Data Characters and valid Special Characters (K characters), respectively. The tables are used for both generating valid Transmission Characters and checking the validity of received Transmission Characters. In the tables, each Valid-Data-byte or Special-Character-code entry has two columns that represent two Transmission Characters. The two columns correspond to the current value of the running disparity. Running disparity is a binary parameter with either a negative (-) or positive (+) value.

After powering on, the Transmitter may assume either a positive or negative value for its initial running disparity. Upon transmission of any Transmission Character, the transmitter will select the proper version of the Transmission Character based on the current running disparity value, and the Trans-

mitter calculates a new value for its running disparity based on the contents of the transmitted character. Special Character codes C1.7 and C2.7 can be used to force the transmission of a specific Special Character with a specific running disparity as required for some special sequences in X3.230.

After powering on, the Receiver may assume either a positive or negative value for its initial running disparity. Upon reception of any Transmission Character, the Receiver decides whether the Transmission Character is valid or invalid according to the following rules and tables and calculates a new value for its Running Disparity based on the contents of the received character.

The following rules for running disparity are used to calculate the new running-disparity value for Transmission Characters that have been transmitted and received.

Running disparity for a Transmission Character is calculated from sub-blocks, where the first six bits (abcdei) form one sub-block and the second four bits (fghj) form the other sub-block. Running disparity at the beginning of the six-bit sub-block is the running disparity at the end of the previous Transmission Character. Running disparity at the beginning of the four-bit sub-block is the running disparity at the end of the six-bit sub-block. Running disparity at the end of the Transmission Character is the running disparity at the end of the four-bit sub-block.

Running disparity for the sub-blocks is calculated as follows:

1. Running disparity at the end of any sub-block is positive if the sub-block contains more ones than zeros. It is also positive at the end of the six-bit sub-block if the six-bit sub-block is 000111, and it is positive at the end of the four-bit sub-block if the four-bit sub-block is 0011.
2. Running disparity at the end of any sub-block is negative if the sub-block contains more zeros than ones. It is also negative at the end of the six-bit sub-block if the six-bit sub-block is 111000, and it is negative at the end of the six-bit sub-block if the four-bit sub-block is 1100.
3. Otherwise, running disparity at the end of the sub-block is the same as at the beginning of the sub-block.

#### Use of the Tables for Generating Transmission Characters

The appropriate entry in *Table 28* for the Valid Data byte or *Table 29* for Special Character byte identify which Transmission Character is to be generated. The current value of the Transmitter's running disparity is used to select the Transmission Character from its corresponding column. For each Transmission Character transmitted, a new value of the running disparity is calculated. This new value is used as the Transmitter's current running disparity for the next Valid Data

**Table 27. Code Violations Resulting from Prior Errors**

|                            | RD | Character   | RD | Character   | RD | Character      | RD |
|----------------------------|----|-------------|----|-------------|----|----------------|----|
| Transmitted data character | –  | D21.1       | –  | D10.2       | –  | D23.5          | +  |
| Transmitted bit stream     | –  | 101010 1001 | –  | 010101 0101 | –  | 111010 1010    | +  |
| Bit stream after error     | –  | 101010 1011 | +  | 010101 0101 | +  | 111010 1010    | +  |
| Decoded data character     | –  | D21.0       | +  | D10.2       | +  | Code Violation | +  |

byte or Special Character byte to be encoded and transmitted. *Table 26* shows naming notations and examples of valid transmission characters.

#### Use of the Tables for Checking the Validity of Received Transmission Characters

The column corresponding to the current value of the Receiver's running disparity is searched for the received Transmission Character. If the received Transmission Character is found in the proper column, then the Transmission Character is valid and the associated Data byte or Special Character code is determined (decoded). If the received Transmission Character is not found in that column, then the Transmission Character is invalid. This is called a code violation. Independent of the Transmission Character's validity, the received Transmission Character is used to calculate a new value of running disparity. The new value is used as the Receiver's current running disparity for the next received Transmission Character.

**Table 26. Valid Transmission Characters**

| Byte Name | Data                                |       | Hex Value |
|-----------|-------------------------------------|-------|-----------|
|           | D <sub>IN</sub> or Q <sub>OUT</sub> |       |           |
|           | 765                                 | 43210 |           |
| D0.0      | 000                                 | 00000 | 00        |
| D1.0      | 000                                 | 00001 | 01        |
| D2.0      | 000                                 | 00010 | 02        |
| .         | .                                   | .     | .         |
| .         | .                                   | .     | .         |
| D5.2      | 010                                 | 00101 | 45        |
| .         | .                                   | .     | .         |
| .         | .                                   | .     | .         |
| D30.7     | 111                                 | 11110 | FE        |
| D31.7     | 111                                 | 11111 | FF        |

Detection of a code violation does not necessarily show that the Transmission Character in which the code violation was detected is in error. Code violations may result from a prior error that altered the running disparity of the bit stream which did not result in a detectable error at the Transmission Character in which the error occurred. *Table 27* shows an example of this behavior.



**Table 28. Valid Data Characters (TXCTx[0] = 0, RXSTx[2:0] = 000)**

| Data Byte Name | Bits      | Current RD- | Current RD+ | Data Byte Name | Bits      | Current RD- | Current RD+ |
|----------------|-----------|-------------|-------------|----------------|-----------|-------------|-------------|
|                | HGF EDCBA | abcdei fghj | abcdei fghj |                | HGF EDCBA | abcdei fghj | abcdei fghj |
| D0.0           | 000 00000 | 100111 0100 | 011000 1011 | D0.1           | 001 00000 | 100111 1001 | 011000 1001 |
| D1.0           | 000 00001 | 011101 0100 | 100010 1011 | D1.1           | 001 00001 | 011101 1001 | 100010 1001 |
| D2.0           | 000 00010 | 101101 0100 | 010010 1011 | D2.1           | 001 00010 | 101101 1001 | 010010 1001 |
| D3.0           | 000 00011 | 110001 1011 | 110001 0100 | D3.1           | 001 00011 | 110001 1001 | 110001 1001 |
| D4.0           | 000 00100 | 110101 0100 | 001010 1011 | D4.1           | 001 00100 | 110101 1001 | 001010 1001 |
| D5.0           | 000 00101 | 101001 1011 | 101001 0100 | D5.1           | 001 00101 | 101001 1001 | 101001 1001 |
| D6.0           | 000 00110 | 011001 1011 | 011001 0100 | D6.1           | 001 00110 | 011001 1001 | 011001 1001 |
| D7.0           | 000 00111 | 111000 1011 | 000111 0100 | D7.1           | 001 00111 | 111000 1001 | 000111 1001 |
| D8.0           | 000 01000 | 111001 0100 | 000110 1011 | D8.1           | 001 01000 | 111001 1001 | 000110 1001 |
| D9.0           | 000 01001 | 100101 1011 | 100101 0100 | D9.1           | 001 01001 | 100101 1001 | 100101 1001 |
| D10.0          | 000 01010 | 010101 1011 | 010101 0100 | D10.1          | 001 01010 | 010101 1001 | 010101 1001 |
| D11.0          | 000 01011 | 110100 1011 | 110100 0100 | D11.1          | 001 01011 | 110100 1001 | 110100 1001 |
| D12.0          | 000 01100 | 001101 1011 | 001101 0100 | D12.1          | 001 01100 | 001101 1001 | 001101 1001 |
| D13.0          | 000 01101 | 101100 1011 | 101100 0100 | D13.1          | 001 01101 | 101100 1001 | 101100 1001 |
| D14.0          | 000 01110 | 011100 1011 | 011100 0100 | D14.1          | 001 01110 | 011100 1001 | 011100 1001 |
| D15.0          | 000 01111 | 010111 0100 | 101000 1011 | D15.1          | 001 01111 | 010111 1001 | 101000 1001 |
| D16.0          | 000 10000 | 011011 0100 | 100100 1011 | D16.1          | 001 10000 | 011011 1001 | 100100 1001 |
| D17.0          | 000 10001 | 100011 1011 | 100011 0100 | D17.1          | 001 10001 | 100011 1001 | 100011 1001 |
| D18.0          | 000 10010 | 010011 1011 | 010011 0100 | D18.1          | 001 10010 | 010011 1001 | 010011 1001 |
| D19.0          | 000 10011 | 110010 1011 | 110010 0100 | D19.1          | 001 10011 | 110010 1001 | 110010 1001 |
| D20.0          | 000 10100 | 001011 1011 | 001011 0100 | D20.1          | 001 10100 | 001011 1001 | 001011 1001 |
| D21.0          | 000 10101 | 101010 1011 | 101010 0100 | D21.1          | 001 10101 | 101010 1001 | 101010 1001 |
| D22.0          | 000 10110 | 011010 1011 | 011010 0100 | D22.1          | 001 10110 | 011010 1001 | 011010 1001 |
| D23.0          | 000 10111 | 111010 0100 | 000101 1011 | D23.1          | 001 10111 | 111010 1001 | 000101 1001 |
| D24.0          | 000 11000 | 110011 0100 | 001100 1011 | D24.1          | 001 11000 | 110011 1001 | 001100 1001 |
| D25.0          | 000 11001 | 100110 1011 | 100110 0100 | D25.1          | 001 11001 | 100110 1001 | 100110 1001 |
| D26.0          | 000 11010 | 010110 1011 | 010110 0100 | D26.1          | 001 11010 | 010110 1001 | 010110 1001 |
| D27.0          | 000 11011 | 110110 0100 | 001001 1011 | D27.1          | 001 11011 | 110110 1001 | 001001 1001 |
| D28.0          | 000 11100 | 001110 1011 | 001110 0100 | D28.1          | 001 11100 | 001110 1001 | 001110 1001 |
| D29.0          | 000 11101 | 101110 0100 | 010001 1011 | D29.1          | 001 11101 | 101110 1001 | 010001 1001 |
| D30.0          | 000 11110 | 011110 0100 | 100001 1011 | D30.1          | 001 11110 | 011110 1001 | 100001 1001 |
| D31.0          | 000 11111 | 101011 0100 | 010100 1011 | D31.1          | 001 11111 | 101011 1001 | 010100 1001 |



**Table 28. Valid Data Characters (TXCTx[0] = 0, RXSTx[2:0] = 000) (continued)**

| Data Byte Name | Bits      | Current RD- | Current RD+ | Data Byte Name | Bits      | Current RD- | Current RD+ |
|----------------|-----------|-------------|-------------|----------------|-----------|-------------|-------------|
|                | HGF EDCBA | abcdei fghj | abcdei fghj |                | HGF EDCBA | abcdei fghj | abcdei fghj |
| D0.2           | 010 00000 | 100111 0101 | 011000 0101 | D0.3           | 011 00000 | 100111 0011 | 011000 1100 |
| D1.2           | 010 00001 | 011101 0101 | 100010 0101 | D1.3           | 011 00001 | 011101 0011 | 100010 1100 |
| D2.2           | 010 00010 | 101101 0101 | 010010 0101 | D2.3           | 011 00010 | 101101 0011 | 010010 1100 |
| D3.2           | 010 00011 | 110001 0101 | 110001 0101 | D3.3           | 011 00011 | 110001 1100 | 110001 0011 |
| D4.2           | 010 00100 | 110101 0101 | 001010 0101 | D4.3           | 011 00100 | 110101 0011 | 001010 1100 |
| D5.2           | 010 00101 | 101001 0101 | 101001 0101 | D5.3           | 011 00101 | 101001 1100 | 101001 0011 |
| D6.2           | 010 00110 | 011001 0101 | 011001 0101 | D6.3           | 011 00110 | 011001 1100 | 011001 0011 |
| D7.2           | 010 00111 | 111000 0101 | 000111 0101 | D7.3           | 011 00111 | 111000 1100 | 000111 0011 |
| D8.2           | 010 01000 | 111001 0101 | 000110 0101 | D8.3           | 011 01000 | 111001 0011 | 000110 1100 |
| D9.2           | 010 01001 | 100101 0101 | 100101 0101 | D9.3           | 011 01001 | 100101 1100 | 100101 0011 |
| D10.2          | 010 01010 | 010101 0101 | 010101 0101 | D10.3          | 011 01010 | 010101 1100 | 010101 0011 |
| D11.2          | 010 01011 | 110100 0101 | 110100 0101 | D11.3          | 011 01011 | 110100 1100 | 110100 0011 |
| D12.2          | 010 01100 | 001101 0101 | 001101 0101 | D12.3          | 011 01100 | 001101 1100 | 001101 0011 |
| D13.2          | 010 01101 | 101100 0101 | 101100 0101 | D13.3          | 011 01101 | 101100 1100 | 101100 0011 |
| D14.2          | 010 01110 | 011100 0101 | 011100 0101 | D14.3          | 011 01110 | 011100 1100 | 011100 0011 |
| D15.2          | 010 01111 | 010111 0101 | 101000 0101 | D15.3          | 011 01111 | 010111 0011 | 101000 1100 |
| D16.2          | 010 10000 | 011011 0101 | 100100 0101 | D16.3          | 011 10000 | 011011 0011 | 100100 1100 |
| D17.2          | 010 10001 | 100011 0101 | 100011 0101 | D17.3          | 011 10001 | 100011 1100 | 100011 0011 |
| D18.2          | 010 10010 | 010011 0101 | 010011 0101 | D18.3          | 011 10010 | 010011 1100 | 010011 0011 |
| D19.2          | 010 10011 | 110010 0101 | 110010 0101 | D19.3          | 011 10011 | 110010 1100 | 110010 0011 |
| D20.2          | 010 10100 | 001011 0101 | 001011 0101 | D20.3          | 011 10100 | 001011 1100 | 001011 0011 |
| D21.2          | 010 10101 | 101010 0101 | 101010 0101 | D21.3          | 011 10101 | 101010 1100 | 101010 0011 |
| D22.2          | 010 10110 | 011010 0101 | 011010 0101 | D22.3          | 011 10110 | 011010 1100 | 011010 0011 |
| D23.2          | 010 10111 | 111010 0101 | 000101 0101 | D23.3          | 011 10111 | 111010 0011 | 000101 1100 |
| D24.2          | 010 11000 | 110011 0101 | 001100 0101 | D24.3          | 011 11000 | 110011 0011 | 001100 1100 |
| D25.2          | 010 11001 | 100110 0101 | 100110 0101 | D25.3          | 011 11001 | 100110 1100 | 100110 0011 |
| D26.2          | 010 11010 | 010110 0101 | 010110 0101 | D26.3          | 011 11010 | 010110 1100 | 010110 0011 |
| D27.2          | 010 11011 | 110110 0101 | 001001 0101 | D27.3          | 011 11011 | 110110 0011 | 001001 1100 |
| D28.2          | 010 11100 | 001110 0101 | 001110 0101 | D28.3          | 011 11100 | 001110 1100 | 001110 0011 |
| D29.2          | 010 11101 | 101110 0101 | 010001 0101 | D29.3          | 011 11101 | 101110 0011 | 010001 1100 |
| D30.2          | 010 11110 | 011110 0101 | 100001 0101 | D30.3          | 011 11110 | 011110 0011 | 100001 1100 |
| D31.2          | 010 11111 | 101011 0101 | 010100 0101 | D31.3          | 011 11111 | 101011 0011 | 010100 1100 |
| D0.4           | 100 00000 | 100111 0010 | 011000 1101 | D0.5           | 101 00000 | 100111 1010 | 011000 1010 |



**Table 28. Valid Data Characters (TXCTx[0] = 0, RXSTx[2:0] = 000) (continued)**

| Data Byte Name | Bits      | Current RD- | Current RD+ | Data Byte Name | Bits      | Current RD- | Current RD+ |
|----------------|-----------|-------------|-------------|----------------|-----------|-------------|-------------|
|                | HGF EDCBA | abcdei fghj | abcdei fghj |                | HGF EDCBA | abcdei fghj | abcdei fghj |
| D1.4           | 100 00001 | 011101 0010 | 100010 1101 | D1.5           | 101 00001 | 011101 1010 | 100010 1010 |
| D2.4           | 100 00010 | 101101 0010 | 010010 1101 | D2.5           | 101 00010 | 101101 1010 | 010010 1010 |
| D3.4           | 100 00011 | 110001 1101 | 110001 0010 | D3.5           | 101 00011 | 110001 1010 | 110001 1010 |
| D4.4           | 100 00100 | 110101 0010 | 001010 1101 | D4.5           | 101 00100 | 110101 1010 | 001010 1010 |
| D5.4           | 100 00101 | 101001 1101 | 101001 0010 | D5.5           | 101 00101 | 101001 1010 | 101001 1010 |
| D6.4           | 100 00110 | 011001 1101 | 011001 0010 | D6.5           | 101 00110 | 011001 1010 | 011001 1010 |
| D7.4           | 100 00111 | 111000 1101 | 000111 0010 | D7.5           | 101 00111 | 111000 1010 | 000111 1010 |
| D8.4           | 100 01000 | 111001 0010 | 000110 1101 | D8.5           | 101 01000 | 111001 1010 | 000110 1010 |
| D9.4           | 100 01001 | 100101 1101 | 100101 0010 | D9.5           | 101 01001 | 100101 1010 | 100101 1010 |
| D10.4          | 100 01010 | 010101 1101 | 010101 0010 | D10.5          | 101 01010 | 010101 1010 | 010101 1010 |
| D11.4          | 100 01011 | 110100 1101 | 110100 0010 | D11.5          | 101 01011 | 110100 1010 | 110100 1010 |
| D12.4          | 100 01100 | 001101 1101 | 001101 0010 | D12.5          | 101 01100 | 001101 1010 | 001101 1010 |
| D13.4          | 100 01101 | 101100 1101 | 101100 0010 | D13.5          | 101 01101 | 101100 1010 | 101100 1010 |
| D14.4          | 100 01110 | 011100 1101 | 011100 0010 | D14.5          | 101 01110 | 011100 1010 | 011100 1010 |
| D15.4          | 100 01111 | 010111 0010 | 101000 1101 | D15.5          | 101 01111 | 010111 1010 | 101000 1010 |
| D16.4          | 100 10000 | 011011 0010 | 100100 1101 | D16.5          | 101 10000 | 011011 1010 | 100100 1010 |
| D17.4          | 100 10001 | 100011 1101 | 100011 0010 | D17.5          | 101 10001 | 100011 1010 | 100011 1010 |
| D18.4          | 100 10010 | 010011 1101 | 010011 0010 | D18.5          | 101 10010 | 010011 1010 | 010011 1010 |
| D19.4          | 100 10011 | 110010 1101 | 110010 0010 | D19.5          | 101 10011 | 110010 1010 | 110010 1010 |
| D20.4          | 100 10100 | 001011 1101 | 001011 0010 | D20.5          | 101 10100 | 001011 1010 | 001011 1010 |
| D21.4          | 100 10101 | 101010 1101 | 101010 0010 | D21.5          | 101 10101 | 101010 1010 | 101010 1010 |
| D22.4          | 100 10110 | 011010 1101 | 011010 0010 | D22.5          | 101 10110 | 011010 1010 | 011010 1010 |
| D23.4          | 100 10111 | 111010 0010 | 000101 1101 | D23.5          | 101 10111 | 111010 1010 | 000101 1010 |
| D24.4          | 100 11000 | 110011 0010 | 001100 1101 | D24.5          | 101 11000 | 110011 1010 | 001100 1010 |
| D25.4          | 100 11001 | 100110 1101 | 100110 0010 | D25.5          | 101 11001 | 100110 1010 | 100110 1010 |
| D26.4          | 100 11010 | 010110 1101 | 010110 0010 | D26.5          | 101 11010 | 010110 1010 | 010110 1010 |
| D27.4          | 100 11011 | 110110 0010 | 001001 1101 | D27.5          | 101 11011 | 110110 1010 | 001001 1010 |
| D28.4          | 100 11100 | 001110 1101 | 001110 0010 | D28.5          | 101 11100 | 001110 1010 | 001110 1010 |
| D29.4          | 100 11101 | 101110 0010 | 010001 1101 | D29.5          | 101 11101 | 101110 1010 | 010001 1010 |
| D30.4          | 100 11110 | 011110 0010 | 100001 1101 | D30.5          | 101 11110 | 011110 1010 | 100001 1010 |
| D31.4          | 100 11111 | 101011 0010 | 010100 1101 | D31.5          | 101 11111 | 101011 1010 | 010100 1010 |





**Table 28. Valid Data Characters (TXCTx[0] = 0, RXSTx[2:0] = 000) (continued)**

| Data Byte Name | Bits      | Current RD- | Current RD+ | Data Byte Name | Bits      | Current RD- | Current RD+ |
|----------------|-----------|-------------|-------------|----------------|-----------|-------------|-------------|
|                | HGF EDCBA | abcdei fghj | abcdei fghj |                | HGF EDCBA | abcdei fghj | abcdei fghj |
| D0.6           | 110 00000 | 100111 0110 | 011000 0110 | D0.7           | 111 00000 | 100111 0001 | 011000 1110 |
| D1.6           | 110 00001 | 011101 0110 | 100010 0110 | D1.7           | 111 00001 | 011101 0001 | 100010 1110 |
| D2.6           | 110 00010 | 101101 0110 | 010010 0110 | D2.7           | 111 00010 | 101101 0001 | 010010 1110 |
| D3.6           | 110 00011 | 110001 0110 | 110001 0110 | D3.7           | 111 00011 | 110001 1110 | 110001 0001 |
| D4.6           | 110 00100 | 110101 0110 | 001010 0110 | D4.7           | 111 00100 | 110101 0001 | 001010 1110 |
| D5.6           | 110 00101 | 101001 0110 | 101001 0110 | D5.7           | 111 00101 | 101001 1110 | 101001 0001 |
| D6.6           | 110 00110 | 011001 0110 | 011001 0110 | D6.7           | 111 00110 | 011001 1110 | 011001 0001 |
| D7.6           | 110 00111 | 111000 0110 | 000111 0110 | D7.7           | 111 00111 | 111000 1110 | 000111 0001 |
| D8.6           | 110 01000 | 111001 0110 | 000110 0110 | D8.7           | 111 01000 | 111001 0001 | 000110 1110 |
| D9.6           | 110 01001 | 100101 0110 | 100101 0110 | D9.7           | 111 01001 | 100101 1110 | 100101 0001 |
| D10.6          | 110 01010 | 010101 0110 | 010101 0110 | D10.7          | 111 01010 | 010101 1110 | 010101 0001 |
| D11.6          | 110 01011 | 110100 0110 | 110100 0110 | D11.7          | 111 01011 | 110100 1110 | 110100 1000 |
| D12.6          | 110 01100 | 001101 0110 | 001101 0110 | D12.7          | 111 01100 | 001101 1110 | 001101 0001 |
| D13.6          | 110 01101 | 101100 0110 | 101100 0110 | D13.7          | 111 01101 | 101100 1110 | 101100 1000 |
| D14.6          | 110 01110 | 011100 0110 | 011100 0110 | D14.7          | 111 01110 | 011100 1110 | 011100 1000 |
| D15.6          | 110 01111 | 010111 0110 | 101000 0110 | D15.7          | 111 01111 | 010111 0001 | 101000 1110 |
| D16.6          | 110 10000 | 011011 0110 | 100100 0110 | D16.7          | 111 10000 | 011011 0001 | 100100 1110 |
| D17.6          | 110 10001 | 100011 0110 | 100011 0110 | D17.7          | 111 10001 | 100011 0111 | 100011 0001 |
| D18.6          | 110 10010 | 010011 0110 | 010011 0110 | D18.7          | 111 10010 | 010011 0111 | 010011 0001 |
| D19.6          | 110 10011 | 110010 0110 | 110010 0110 | D19.7          | 111 10011 | 110010 1110 | 110010 0001 |
| D20.6          | 110 10100 | 001011 0110 | 001011 0110 | D20.7          | 111 10100 | 001011 0111 | 001011 0001 |
| D21.6          | 110 10101 | 101010 0110 | 101010 0110 | D21.7          | 111 10101 | 101010 1110 | 101010 0001 |
| D22.6          | 110 10110 | 011010 0110 | 011010 0110 | D22.7          | 111 10110 | 011010 1110 | 011010 0001 |
| D23.6          | 110 10111 | 111010 0110 | 000101 0110 | D23.7          | 111 10111 | 111010 0001 | 000101 1110 |
| D24.6          | 110 11000 | 110011 0110 | 001100 0110 | D24.7          | 111 11000 | 110011 0001 | 001100 1110 |
| D25.6          | 110 11001 | 100110 0110 | 100110 0110 | D25.7          | 111 11001 | 100110 1110 | 100110 0001 |
| D26.6          | 110 11010 | 010110 0110 | 010110 0110 | D26.7          | 111 11010 | 010110 1110 | 010110 0001 |
| D27.6          | 110 11011 | 110110 0110 | 001001 0110 | D27.7          | 111 11011 | 110110 0001 | 001001 1110 |
| D28.6          | 110 11100 | 001110 0110 | 001110 0110 | D28.7          | 111 11100 | 001110 1110 | 001110 0001 |
| D29.6          | 110 11101 | 101110 0110 | 010001 0110 | D29.7          | 111 11101 | 101110 0001 | 010001 1110 |
| D30.6          | 110 11110 | 011110 0110 | 100001 0110 | D30.7          | 111 11110 | 011110 0001 | 100001 1110 |
| D31.6          | 110 11111 | 101011 0110 | 010100 0110 | D31.7          | 111 11111 | 101011 0001 | 010100 1110 |



Table 29. Valid Special Character Codes and Sequences (TXCTx = special character code or RXSTx[2:0] = 001)<sup>[49, 50]</sup>

| S.C. Code Name                                | S.C. Byte Name                 |                |                                |                           |  |  | Current RD-<br>abcdei fghj | Current RD+<br>abcdei fghj |
|---|--------------------------------|----------------|--------------------------------|---------------------------|--|--|----------------------------|----------------------------|
|   | Cypress                        |                |                                | Alternate                 |  |  |                            |                            |
|   | S.C. Byte Name <sup>[51]</sup> | Bits HGF EDCBA | S.C. Byte Name <sup>[51]</sup> | Bits HGF EDCBA            |  |  |                            |                            |
| K28.0   | C0.0 (C00)                     | 000 00000      | C28.0 (C1C)                    | 000 11100                 |  |  | 001111 0100                | 110000 1011                |
| K28.1 <sup>[52]</sup>                         | C1.0 (C01)                     | 000 00001      | C28.1 (C3C)                    | 001 11100                 |  |  | 001111 1001                | 110000 0110                |
| K28.2 <sup>[52]</sup>                         | C2.0 (C02)                     | 000 00010      | C28.2 (C5C)                    | 010 11100                 |  |  | 001111 0101                | 110000 1010                |
| K28.3   | C3.0 (C03)                     | 000 00011      | C28.3 (C7C)                    | 011 11100                 |  |  | 001111 0011                | 110000 1100                |
| K28.4 <sup>[52]</sup>                         | C4.0 (C04)                     | 000 00100      | C28.4 (C9C)                    | 100 11100                 |  |  | 001111 0010                | 110000 1101                |
| K28.5 <sup>[52, 53]</sup>                     | C5.0 (C05)                     | 000 00101      | C28.5 (CBC)                    | 101 11100                 |  |  | 001111 1010                | 110000 0101                |
| K28.6 <sup>[52]</sup>                         | C6.0 (C06)                     | 000 00110      | C28.6 (CDC)                    | 110 11100                 |  |  | 001111 0110                | 110000 1001                |
| K28.7 <sup>[52, 54]</sup>                     | C7.0 (C07)                     | 000 00111      | C28.7 (CFC)                    | 111 11100                 |  |  | 001111 1000                | 110000 0111                |
| K23.7   | C8.0 (C08)                     | 000 01000      | C23.7 (CF7)                    | 111 10111                 |  |  | 111010 1000                | 000101 0111                |
| K27.7   | C9.0 (C09)                     | 000 01001      | C27.7 (CFB)                    | 111 11011                 |  |  | 110110 1000                | 001001 0111                |
| K29.7   | C10.0 (C0A)                    | 000 01010      | C29.7 (CFD)                    | 111 11101                 |  |  | 101110 1000                | 010001 0111                |
| K30.7   | C11.0 (C0B)                    | 000 01011      | C30.7 (CFE)                    | 111 11110                 |  |  | 011110 1000                | 100001 0111                |
| <b>End of Frame Sequence</b>                  |                                |                |                                |                           |  |  |                            |                            |
| EOFxx <sup>[55]</sup>                         | C2.1 (C22)                     | 001 00010      | C2.1 (C22)                     | 001 00010                 |  |  | -K28.5, Dn.xxx0            | +K28.5, Dn.xxx1            |
| <b>Code Rule Violation and SVS Tx Pattern</b> |                                |                |                                |                           |  |  |                            |                            |
| Exception <sup>[54, 56]</sup>                 | C0.7 (CE0)                     | 111 00000      | C0.7 (CE0)                     | 111 00000 <sup>[60]</sup> |  |  | 100111 1000                | 011000 0111                |
| -K28.5 <sup>[57]</sup>                        | C1.7 (CE1)                     | 111 00001      | C1.7 (CE1)                     | 111 00001 <sup>[60]</sup> |  |  | 001111 1010                | 001111 1010                |
| +K28.5 <sup>[58]</sup>                        | C2.7 (CE2)                     | 111 00010      | C2.7 (CE2)                     | 111 00010 <sup>[60]</sup> |  |  | 110000 0101                | 110000 0101                |
| <b>Running Disparity Violation Pattern</b>    |                                |                |                                |                           |  |  |                            |                            |
| Exception <sup>[59]</sup>                     | C4.7 (CE4)                     | 111 00100      | C4.7 (CE4)                     | 111 00100 <sup>[60]</sup> |  |  | 110111 0101                | 001000 1010                |

**Notes:**

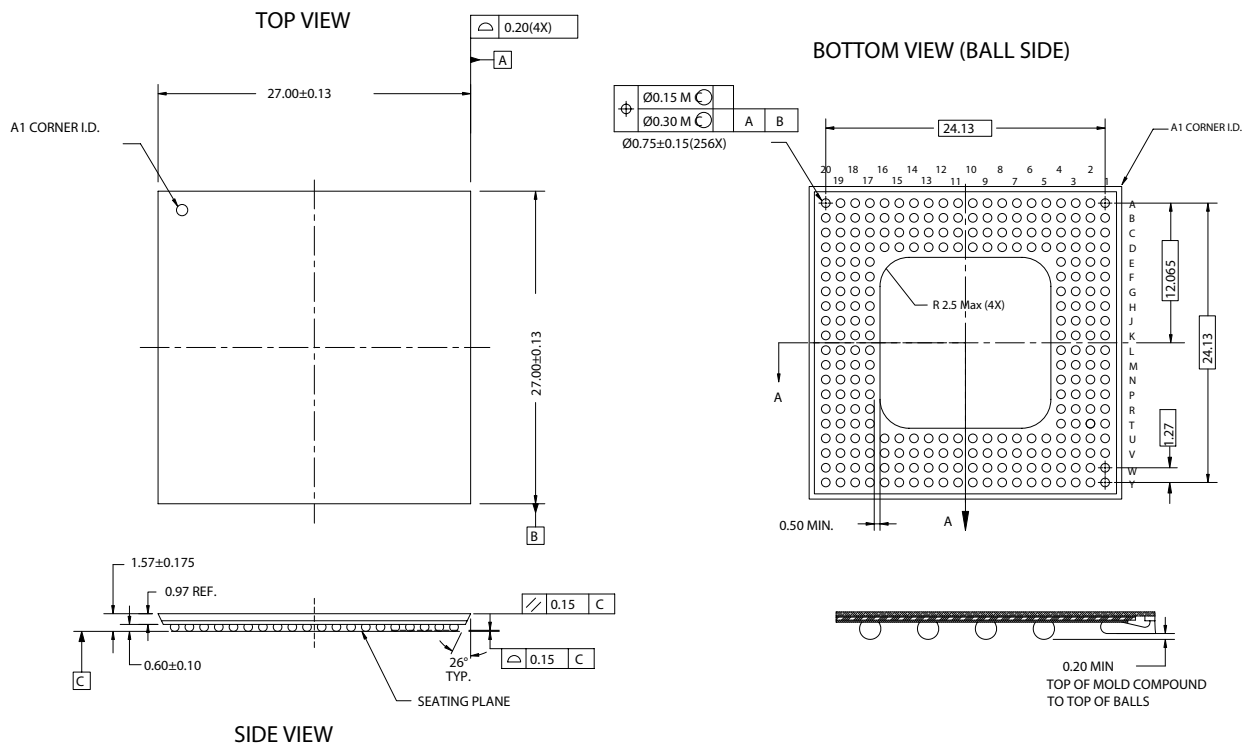
49. All codes not shown are reserved.
50. Notation for Special Character Code Name is consistent with Fibre Channel and ESCON naming conventions. Special Character Code Name is intended to describe binary information present on I/O pins. Common usage for the name can either be in the form used for describing Data patterns (i.e., C0.0 through C31.7), or in hex notation (i.e., Cnn where nn = the specified value between 00 and FF).
51. Both the Cypress and alternate encodings may be used for data transmission to generate specific Special Character Codes. The decoding process for received characters generates Cypress codes or Alternate codes as selected by the DECMODE configuration input.
52. These characters are used for control of ESCON interfaces. They can be sent as embedded commands or other markers when not operating using ESCON protocols.
53. The K28.5 character is used for framing operations by the receiver. It is also the pad or fill character transmitted to maintain the serial link when no user data is available.
54. Care must be taken when using this Special Character code. When a K28.7(C7.0) or SVS(C0.7) is followed by a D11.x or D20.x, an alias K28.5 sync character is created. These sequences can cause erroneous framing and should be avoided while RFEN = HIGH.
55. C2.1 = Transmit either -K28.5+ or +K28.5- as determined by Current RD and modify the Transmission Character that follows, by setting its least significant bit to 1 or 0. If Current RD at the start of the following character is plus (+) the LSB is set to 0, and if Current RD is minus (-) the LSB becomes 1. This modification allows construction of X3.230 "EOF" frame delimiters wherein the second data byte is determined by the Current RD. For example, to send "EOFdt" the controller could issue the sequence C2.1-D21.4- D21.4-D21.4, and the HOTLink II Transmitter will send either K28.5-D21.4-D21.4-D21.4 or K28.5-D21.5- D21.4-D21.4 based on Current RD. Likewise to send "EOFdti" the controller could issue the sequence C2.1-D10.4-D21.4-D21.4, and the HOTLink II Transmitter will send either K28.5-D10.4-D21.4- D21.4 or K28.5-D10.5-D21.4- D21.4 based on Current RD. The receiver will never output this Special Character, since K28.5 is decoded as C5.0, C1.7, or C2.7, and the subsequent bytes are decoded as data.
56. C0.7 = Transmit a deliberate code rule violation. The code chosen for this function follows the normal Running Disparity rules. The receiver will only output this Special Character if the Transmission Character being decoded is not found in the tables.
57. C1.7 = Transmit Negative K28.5 (-K28.5+) disregarding Current RD. The receiver will only output this Special Character if K28.5 is received with the wrong running disparity. The receiver will output C1.7 if -K28.5 is received with RD+, otherwise K28.5 is decoded as C5.0 or C2.7.
58. C2.7 = Transmit Positive K28.5 (+K28.5-) disregarding Current RD. The receiver will only output this Special Character if K28.5 is received with the wrong running disparity. The receiver will output C2.7 if +K28.5 is received with RD-, otherwise K28.5 is decoded as C5.0 or C1.7.
59. C4.7 = Transmit a deliberate code rule violation to indicate a Running Disparity violation. The receiver will only output this Special Character if the Transmission Character being decoded is found in the tables, but Running Disparity does not match. This might indicate that an error occurred in a prior byte.
60. Supported only for data transmission. The receive status for these conditions will be reported by specific combinations of receive status bits.

### Ordering Information

| Speed    | Ordering Code      | Package Name | Package Type  | Operating Range |
|----------|--------------------|--------------|---|-----------------|
| Standard | CYP15G0401DXB-BGC  | BL256        | 256-ball Thermally Enhanced Ball Grid Array         | Commercial      |
| Standard | CYP15G0401DXB-BGI  | BL256        | 256-ball Thermally Enhanced Ball Grid Array         | Industrial      |
| Standard | CYV15G0401DXB-BGC  | BL256        | 256-ball Thermally Enhanced Ball Grid Array         | Commercial      |
| Standard | CYV15G0401DXB-BGI  | BL256        | 256-ball Thermally Enhanced Ball Grid Array         | Industrial      |
| OBSAI    | CYW15G0401DXB-BGC  | BL256        | 256-ball Thermally Enhanced Ball Grid Array         | Commercial      |
| OBSAI    | CYW15G0401DXB-BGI  | BL256        | 256-ball Thermally Enhanced Ball Grid Array         | Industrial      |
| Standard | CYP15G0401DXB-BGXC | BL256        | Pb-free 256-ball Thermally Enhanced Ball Grid Array | Commercial      |
| Standard | CYP15G0401DXB-BGXI | BL256        | Pb-free 256-ball Thermally Enhanced Ball Grid Array | Industrial      |
| Standard | CYV15G0401DXB-BGXC | BL256        | Pb-free 256-ball Thermally Enhanced Ball Grid Array | Commercial      |
| Standard | CYV15G0401DXB-BGXI | BL256        | Pb-free 256-ball Thermally Enhanced Ball Grid Array | Industrial      |
| OBSAI    | CYW15G0401DXB-BGXC | BL256        | Pb-free 256-ball Thermally Enhanced Ball Grid Array | Commercial      |
| OBSAI    | CYW15G0401DXB-BGXI | BL256        | Pb-free 256-ball Thermally Enhanced Ball Grid Array | Industrial      |

### Package Diagram

**256-Lead L2 Ball Grid Array (27 x 27 x 1.57 mm) BL256**



51-85123-\*E

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Document History Page

| Document Title: CYP(V)(W)15G0401DXB Quad HOTLink II™ Transceiver |         |            |                 |   |
|--|---------|------------|-----------------|---|
| Document Number: 38-02002  |         |            |                 |   |
| REV.   | ECN No. | Issue Date | Orig. of Change | Description of Change   |
| **   | 105840  | 03/21/01   | SZV             | Change from Spec number: 38-00876 to 38-02002   |
| *A   | 108025  | 06/20/01   | AMV             | Changed Marketing part number   |
| *B   | 108437  | 07/19/01   | TME             | Change Marketing part number from CYP15G0401DX to CYP15G0401  |
| *C   | 112986  | 11/12/01   | TPS             | <p>Changed common mode input information and duty cycle of transmit clocks</p> <p>Updated max voltage power and release under ecn control</p> <p>Changed the wording of REFCLK input coupling on both inputs for LVTTTL clock input</p> <p>Addition of TXCLKO+ and the TXCLKO+ specs</p> <p>Changed the TXCLKO clock output to reflect the new timing</p> <p>Changed the Half Clock drawing so that the viald time was at clock edges</p> <p>Changed the input power</p> <p>Changed the spec for the serial output levels at the different terminations</p> <p>Changed the common mode input range of the serial input</p> <p>Increased the Serial input current under the conditions of VCC and min</p> <p>Added to the Duty cycle of the transmit and receiver clock signals</p> <p>The rise time of the serial inputs and receiver were changed</p> <p>The half rate timing drawing changed from not valid at clock edges to viald at clock edges</p> <p>Added new timing line for status valid time of half clock signals</p> <p>Max voltage reduced from 4.2V to 3.8V</p> <p>Matched the common specs with the family of parts</p> |
| *D   |         | 2/26/02    | TPS             | <p>Changed many names from lower case to upper case</p> <p>Changed in five places = to ≠</p> <p>Changed the power to typical to 2.8W</p> <p>Added Escon, DVB-ASI, SMPTE to features</p> <p>Under PARCTL control reworded statement When HIGH</p> <p>Under RXLE Reworded and reformatted the text</p> <p>Under BOND_ALL added when bonding resolution is completed</p> <p>Removed repeated information in Power Control section</p> <p>Corrected statement for bonded BIST</p>   |
| *E   | 118650  | 09/30/02   | LNМ             | <p>Changed TXCLKO description</p> <p>Changed TXPERx description</p> <p>Changed typical power from 2.8W to 2.9W</p> <p>Removed the LOW setting for FRAMCHAR and related references</p> <p>Changed V<sub>ODIF</sub> and V<sub>OLC</sub> for CML output</p> <p>Changed the I<sub>OST</sub> boundary values</p> <p>Changed the t<sub>TXCLKR</sub> and t<sub>TXCLKF</sub> min. values</p> <p>Changed t<sub>TXDS</sub> &amp; t<sub>TXDH</sub> and t<sub>TREFDS</sub> &amp; t<sub>TREFDH</sub></p> <p>Changed t<sub>REFADV-</sub> and t<sub>REFCDV-</sub></p> <p>Changed the JTAG ID from 0C800069 to 1C800069</p>   |
| *F   | 121906  | 02/12/03   | CGX             | <p>Changed Minimum tRISE/tFALL for CML</p> <p>Changed tRXLOCK</p> <p>Changed tDJ, tRJ</p> <p>Changed tJTOL</p> <p>Changed tTXLOCK</p> <p>Changed tRXCLKH, tRXCLKL</p> <p>Changed tTXCLKOD+, tTXCLKOD</p> <p>Changed Power Specs</p> <p>Changed verbiage...Paragraph: Clock/Data Recovery</p> <p>Changed verbiage...Paragraph: Range Control</p> <p>Added Power-up Requirements</p>  |
| *G   | 124996  | 03/21/03   | POT             | <p>Changed CYP15G0401DXB to CYP(V)15G0401DXB to abbreviate title. Type corresponding to the Video compliant parts</p> <p>Reduced the lower limit of the serial signaling rate from 200 Mbaud to 195 Mbaud and changed the associated specifications accordingly</p> <p>Added CYPV15G0401DXB to title</p>  |



**Document History Page** (continued)

| <b>Document Title: CYP(V)(W)15G0401DXB Quad HOTLink II™ Transceiver</b> |                |                   |                        |  |
|---|----------------|-------------------|------------------------|--|
| <b>Document Number: 38-02002</b>  |                |                   |                        |  |
| <b>REV.</b>   | <b>ECN No.</b> | <b>Issue Date</b> | <b>Orig. of Change</b> | <b>Description of Change</b>   |
| *H  | 126908         | 5/12/03           | KKV                    | Corrected footnote 1<br>Implemented corrections to table format  |
| *I  | 128365         | 7/23/03           | PDS                    | Revised the value of $t_{REFDV}$ , $t_{REFADV+}$ and $t_{REFCDV+}$   |
| *J  | 131897         | 12/10/03          | PDS                    | When TXCKSEL = MID or HIGH, TXRATE = HIGH is an invalid mode. Made appropriate changes to reflect this invalid condition.<br>Removed requirement of AC coupling for Serial I/Os for interfacing with LVPECL I/Os.<br>Changed LFIx to Asynchronous output.<br>Expanded the CDR Range Controller's permissible frequency offset between incoming serial signalling rate and Reference clock from $\pm 200$ -PPM to $\pm 1500$ -PPM (changed parameter $t_{REFRX}$ ).<br>Added Table for RXSTx[2:0] status for non-bonded (Independent Channel) mode of operation for clarity. Separated the Receive BIST status to a new Table for clarity.<br>Revised Typical Power numbers to match final characterization data. |
| *K  | 211429         | See ECN           | KKV                    | Minor change: package diagram disappeared from online pdf  |
| *L  | 338721         | See ECN           | SUA                    | Added CYW15G0401DXB part number for OBSAI RP3 compliance to support operating data rate upto 1540 MBaud. Made changes to reflect OBSAI RP3 and CPR compliance. Added Pb-free package option for all parts listed in the datasheet.<br>Changed MBd to MBaud in SPDSEL pin description   |