Odin TeleSystems Inc.

Thor-4-ExpressCard
Technical Description

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Table of Contents

1 Abstract

This document provides a technical description of Odin TeleSystems' Thor-4-ExpressCard adapter card. This presentation is targeted to systems integrators and application developers who are developing telecommunications systems and/or software applications using the Thor-4-ExpressCard product. The purpose of this document is to provide the needed information about the hardware to allow software developers to efficiently integrate Thor-4-ExpressCard into their overall system under design.

For information on how to develop host applications utilizing the OTX Hardware Device Driver Application Programming Interface (API), please refer to the "Programmer's Guide for OTX Hardware API" document (Odin TeleSystems Inc. document number 1411-1-SAA-1006-1). For information on how to develop custom DSP applications, please refer to "Programmer's Guide for OTX C54x DSP Software Development Kit" (Odin document number 1412-1-SAA-1007-1). And finally, for help on how to install the Thor-4-ExpressCard card and the OTX Device Driver Software, please refer to the Installation Guide for OTX PCMCIA Adapters (Odin TeleSystems Inc. document number 1512-1-HCA-1003-1).

2 Thor-4-ExpressCard Overview

Thor-4-ExpressCard is a dual span T1/E1/J1 adapter in the ExpressCard/54 format. The ExpressCard Standard is promoted by the Personal Computer Memory Card International Association (PCMCIA) and it is quickly gaining ground in today's PC laptop designs.

The Thor-4-ExpressCard is a member of the Odin Telecom frameworX (OTX) product family. It is supported by the OTX device driver (Window and Linux) and accessed through the OTX Hardware Application Programming Interface (API).

The Thor-4-ExpressCard is equipped with four T1/J1 or E1 interfaces at the speeds of 1.544 Mbps and 2.048 Mbps, respectively. 2 interfaces (Li0 and Li1) have transmitters as well as receivers. The other two interfaces (Li2 and Li3) have only receivers (no transmitters). The card is normally used in one of two modes: monitoring mode or terminating mode. In monitoring mode the four pins of each RJ-45 connector connects to two receivers (Li0/Li2 and Li1/Li3 respectively). In monitor mode the transmit functionality of the interface should be tri-stated via an API function call. In terminating mode, only the Li0 and Li1 interfaces are used (for transmitting and receiving).

Each interface can be individually configured in T1, J1, or E1 mode. Thor-4-ExpressCard supports all popular frame formats and line coding.

In addition to the four T1/E1/J1 interfaces it is also equipped with one Texas Instruments TMS320VC5510 400 MIPS DSP, which can perform many time critical tasks such HDLC encoding/decoding and tone detection/generation. It is also possible to write custom DSP applications using the OTX C55x DSP Software Development Kit.

Equipped with the appropriate OTX software modules, Thor-4-ExpressCard can be utilized in a variety of T1/E1, Integrated Services Digital Network (ISDN), Frame Relay, Signaling System #7 (SS#7), and Voice over IP (VoIP) applications.

3 Physical specifications

Thor-4-ExpressCard is an extended ExpressCard/54 module designed to be seated in any standard ExpressCard/54 slot. The card measures 54mm (width) x 118.5mm (length) x 18mm (max height). Please see Figure 1:

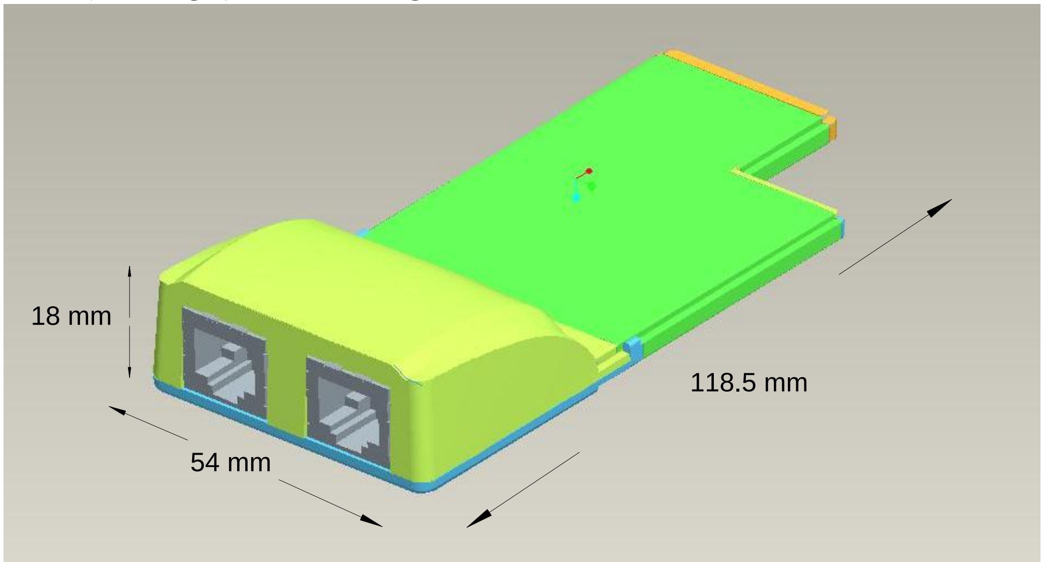


Figure 1

The green portion of the card is inserted into the ExpressCard/54 slot, and the yellow portion (the bulge) extends beyond the slot.

The bulge contains two RJ48C connectors; for the T1/E1/J1 interfaces. The two connectors are marked Li0 and Li1.

In monitor mode (receive only) the connector marked Li0 connects to Li0 (pin 1,2) and Li2 (pin 3, 5). The connector marked Li1 connects to Li1 (pin 1,2) and Li3 (pin 3, 5).

In terminating mode (transmit and receive) the Li0 connector connects to the Li0 receiver (pin 1, 2) and Li0 transmitter (pin 3, 5). The Li1 connector connects to the Li1 receiver (pin 1,2) and Li1 transmitter (pin 3,5).

Please note that colors indicated in Figure 1 are not the actual colors of the card.

4 Data Architecture

Internally, Thor-4-ExpressCard utilizes serial TDM (Time-Division Multiplexed) data streams for transfer of data or voice. The internal serial TDM data streams are called “Highways.” The external interfaces (E1/T1/J1) are referred to as “spans”.

The Thor-4-ExpressCard physically utilizes 8.192 Mbit/sec TDM highways for data routing.

The DSP can process data from ether the incoming E1/T1/J1 spans or from the host by way of DMA transfer via the Burst device. The DSP can supply data to either the outgoing E1/T1/J1 span or to the host by way of DMA transfer via the Burst device. This is described in further details in chapter 4.1 and chapter 4.2.

The physical serial highways provide data paths between physical devices as shown in Figure 2.

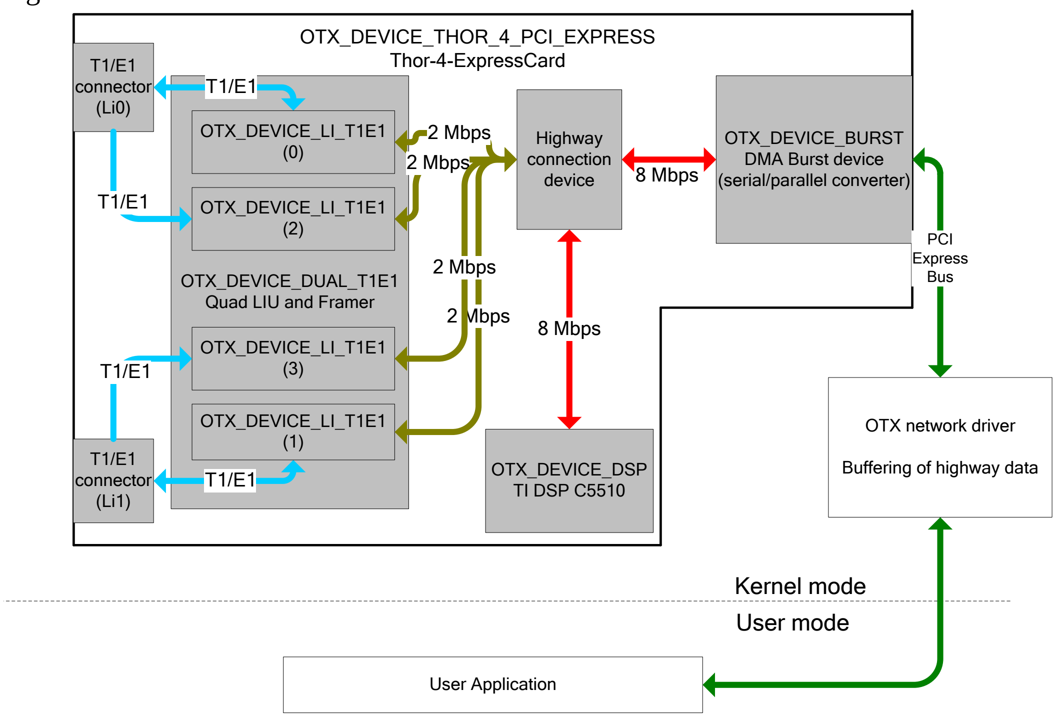


Figure 2

The red lines indicate 8.192 Mbps (128 timeslot) highways. The yellow lines indicate 2.408 Mbps (32 timeslot) highways. The blue lines indicate 1.544 Mpbs (T1/J1) or 2.048 Mbps (E1) data. The green lines indicate 32-bit wide parallel data. All data paths except for the blue T1/E1 data paths to Li2 and Li3 are bidirectional.

The highway connection device mixes timeslots from the various sources (T1/E1 devices, the DSP device, and the Burst device) in a fixed pattern. I.e. a certain timeslot of Line Interface 0 will always appear on a certain timeslot on the Burst and DSP highway. Pipes can be created as a logical conduit for data transfer between the different highway devices, but the timeslot selection for the T1/E1 devices is predetermined by the hardware design.

The T1E1 device, the DSP and the Burst device can be configured to take its data from one of two sources. This switching is controlled by attributes.

The switch for the source of the Burst device is illustrated in Figure 2. The Burst device is sourced by the T1E1 device by default, but it can be sourced by the DSP device by setting the OTX_ATTR_BRD_S2P_SOURCED attribute to OTX_BRD_S2P_SOURCED_DSP.

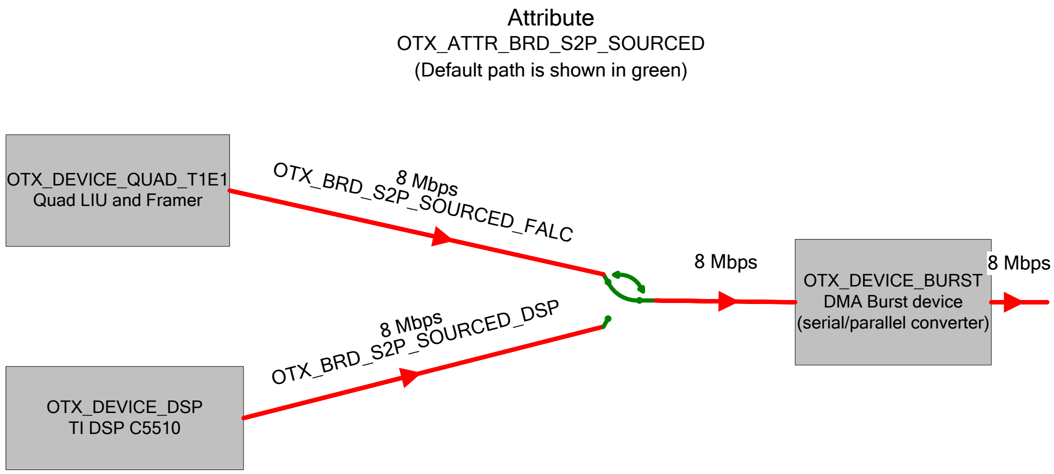


Figure 3

The switch for the source of the T1E1 device is illustrated in Figure 2. The T1E1 device is sourced by the DSP as default, but it can also be source by the Burst device by setting the OTX_ATTR_BRD_FALC_SOURCE attribute to OTX_BRD_FALC_SOURCED_P2S.

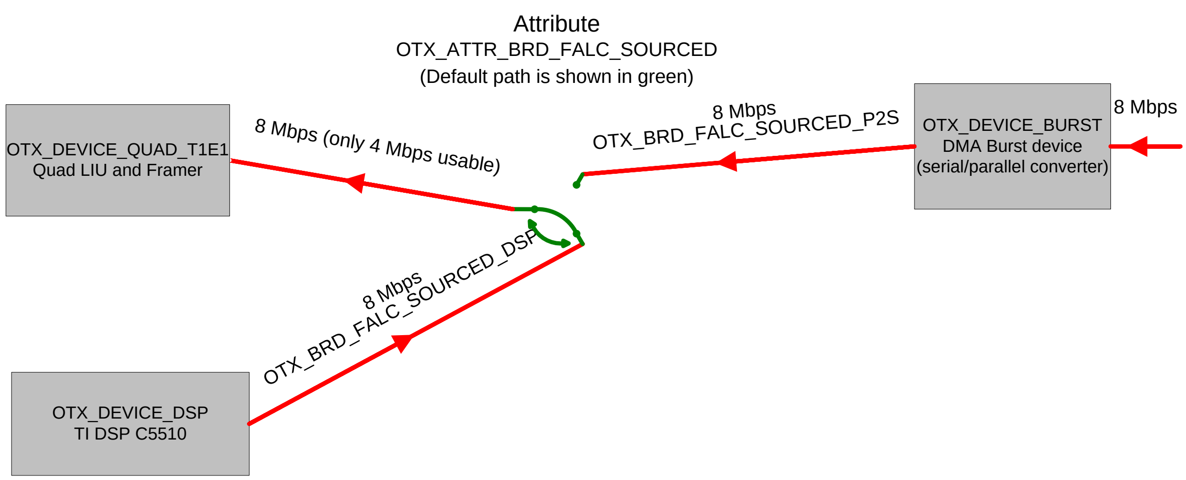


Figure 4

The switch for the source of the DSP device is illustrated in Figure 2. The DSP is sourced by the T1E1 device by default. However, it can be sourced by the Burst device by setting the OTX_ATTR_BRD_DSP_SOURCED attribute to OTX_ATTR_DSP_SOURCED_P2S.

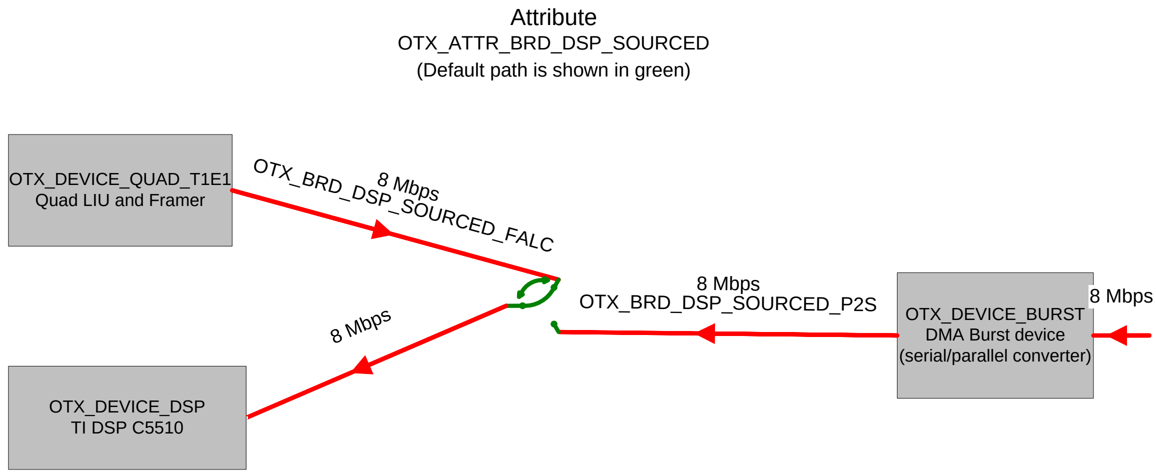


Figure 5

To illustrate the highway/timeslot allocation we show the two highway directions separately. One direction is outgoing data (data that sent from the host (user) application to reach the board, or ultimately, leave the board. The other direction is incoming data (data that will be received by the host application). Please see the following two chapters.

4.1 Outgoing Data

The outgoing data is defined as the data that is sent out on the E1 or T1 spans..

The source for the outgoing data can be switched in two different ways. The T1/E1 devices can either be sourced from the DSP device or from the Burst device. The source is determined by the setting of the OTX_ATTR_BRD_FALC_SOURCED attribute.

- OTX_ATTR_BRD_FALC_SOURCED=OTX_BRD_FALC_SOURCED_P2S Figure 6. In this configuration the T1/E1 devices will get their data from the Parallel to Serial Device (the Burst Device).
- OTX_ATTR_BRD_FALC_SOURCED=OTX_BRD_FALC_SOURCED_DSP In this configuration the T1/E1 devices will get their data from the DSP device.

The attribute is set by calling the OtxDrvSetAttributeValueUint32() function in the OTX HW API. The default setting for this attribute is OTX_BRD_FALC_SOURCED_P2S. You can read the value of the attribute by calling OtxDrvGetAttributeValueUint32(). For more details of this attribute please refer to the OtxBrdD.h header file or see Figure 4.

Figure 6 illustrates the highway and timeslot mapping when the T1/E1 devices are sourced by the Burst Device.

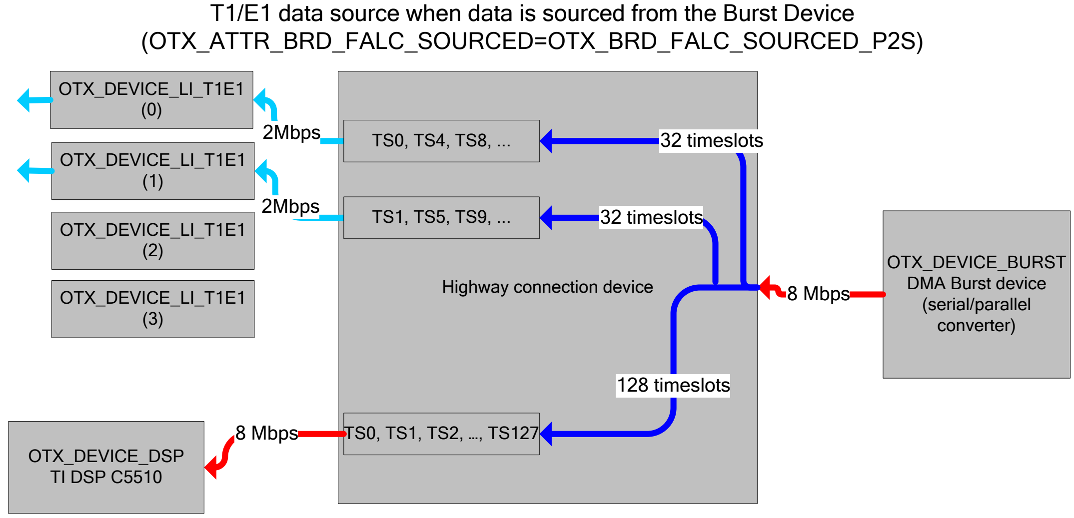


Figure 6

Figure 7 illustrates the highway and timeslot mapping when the T1/E1 devices are sourced by the DSP Device. Please note that Li2 and Li3 do not get any data since these two interfaces do not transmit on the E1/T1 span on this board.

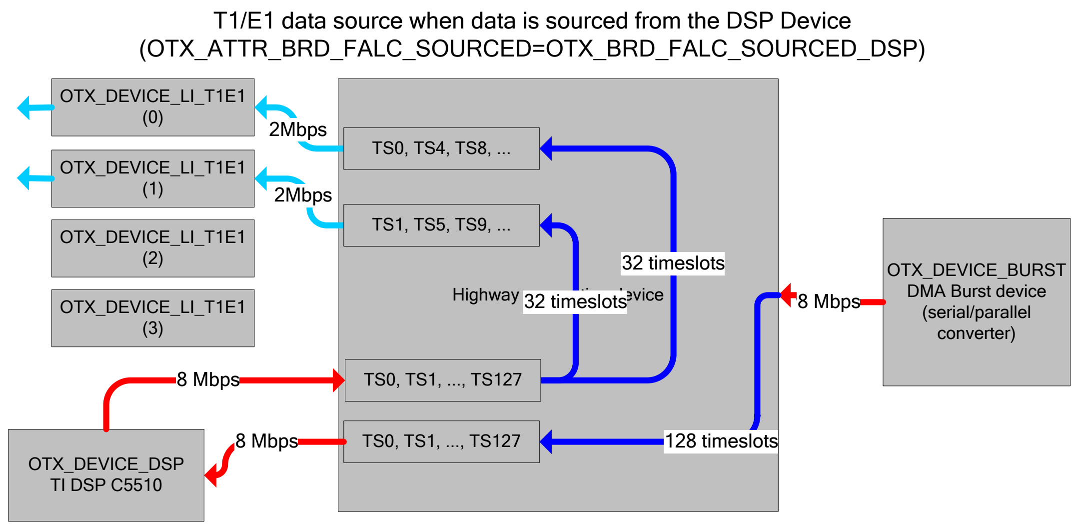


Figure 7

Since Li2 and Li3 do not transmit on the E1/T1 spans, please note that half of timeslots (TS2, TS3, TS6, TS7, …, TS126, TS127) of the outgoing DSP highway have no destination when the T1/E1 device is sourced from the DSP device.

4.2 Incoming Data

The incoming data is defined as data that is received on the E1 or T1 spans. The incoming data (8Mbps) comes from all four T1/E1 spans (Li0 through Li3). The incoming data goes to the DSP device as well as the Burst device by default.

The incoming data is not switched per timeslot. It always has a predefined path. Figure 8 illustrates the highway and timeslot allocation for the incoming data.

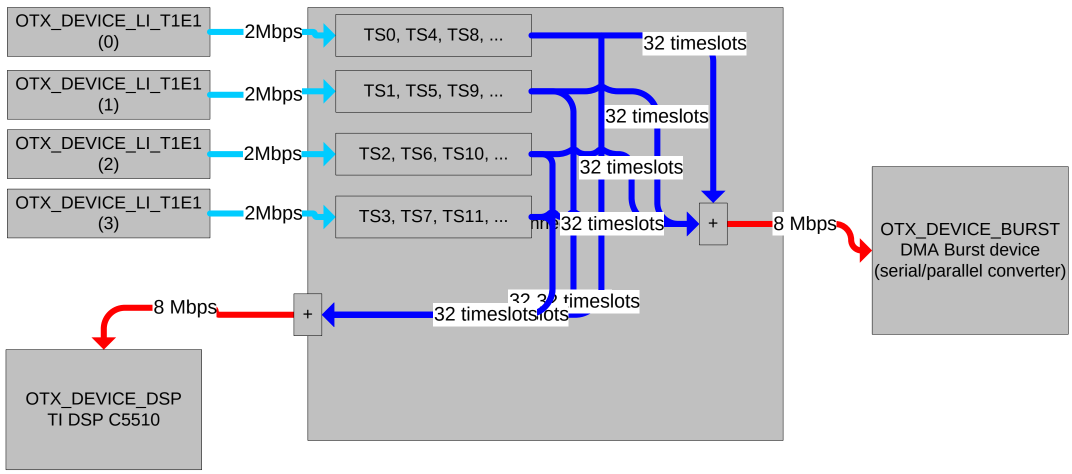


Figure 8

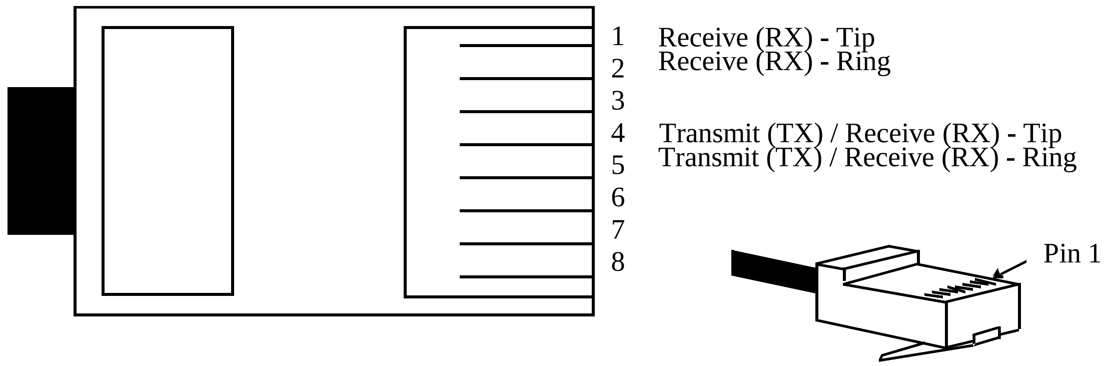
Please note that the 32 timeslots from the T1/E1 device are interspersed on an 8.192 Mbps highway on every four timeslot.

- Li0 maps to timeslots TS0, TS4, TS8, … , TS124 of both the Burst highway and the DSP highway.
- Li1 maps to timeslots TS1, TS5, TS9, … , TS125 of both the Burst highway and the DSP highway.
- Li2 maps to timeslots TS2, TS6, TS10, … , TS126 of both the Burst highway and the DSP highway.
- Li3 maps to timeslots TS3, TS7, TS11, … , TS127 of both the Burst highway and the DSP highway.

Please also not that the highway from the T1/E1 device is always a 2.048 Mbps highway (32 timeslots) no matter if it is configured for E1 or T1. In E1 mode all 32 timeslots are used and mapped to the corresponding timeslot on the E1 span. In T1 mode, TS0 carries the F-bit of the T1 span, and TS1 through TS24 carries the 24 timeslots of the T1 span. Timeslots 24 through 31 of the T1/E1 highway are unused in T1 mode.

5 T1 / E1 Interface Connections

One side of the Thor-4-ExpressCard contains two RJ45/RJ48C connectors. The RJ45 connector provides balanced 100 / 120 ohm transmit and receive connections. The pinout for these two connectors are shown below:



The receive pair is located on pins 1 and 2 (Li0 and Li1).

If the board is configured for transmission, the transmit pair is located on pins 4 and 5 (Li0 and Li1). If the board is configured for monitoring, then pins 4 and 5 are connected to Li2 and Li3).

Transmit/Receive Mode:

Li0: RX on Li0-connector pin 1,2
TX on Li0-connector pin 4,5

Li1: RX on Li1-connector pin 1,2
tX on Li1-connector pin 4,5

Receive-only Mode (tri-stating the TX function):

Li0: RX on Li0-connector pin 1,2
Li2: RX on Li0-connector pin 4,5

Li1: RX on Li1-connector pin 1,2
Li3: RX on Li1-connector pin 4,5

6 API Supported Physical Devices

6.1 Board Device (OTX_DEVICE_THOR_4_PCI_EXPRESS)

The Thor-4-ExpressCard itself is considered a physical device in the OTX HW terminology. An application should always start by opening the board device (after connecting to the OTX Library).

For a single-board Thor-4-ExpressCard configuration (which would be consider normal in today's PC laptops), the sequence number of the board device would be 0 (zero). In case additional ExpressCard slots are available in the host PC and populated with additional Thor-4-ExpressCard boards, then each board will be associated with a sequentially higher device number (for instance device number 1 (one) would be assigned to the second Thor-4-ExpressCard board).

6.2 Quad T1/E1/J1 Device (OTX_DEVICE_QUAD_T1E1)

The quad T1/E1/J1 device OTX_DEVICE_DUAL_T1E1) is the host for the four Li devices (OTX_DEVICE_LI_T1E1). This device must therefore be opened before any of the Li device can be opened.

The sequence number of this device is always 0 (zero).

6.3 T1/E1/J1 Line Interface Devices (OTX_DEVICE_LI_T1E1)

The T1/E1/J1 Line Interfaces (Li) devices handle all of the T1/E1/J1 functionality. There are two Li devices on the Thor-4-ExpressCard; one for each T1/E1/J1 span. Please refer to the OtxT1E1.h and OtxT1E1D.h header files in the OTX HW SDK for the specific API functions available for this type of device.

The two Li devices (OTX_DEVICE_LI_T1E1) are both hosted by the dual T1E1 device (see chapter 6.3). The sequence numbers of these two devices are 0 and 1.

In addition to a standard set of T1/E1/J1 configuration functions the API also offers functions to directly read and write device register values. This feature can be used to configure the device in a customized configuration; not directly supported by the standard OTX HW API.

6.4 Burst Device (OTX_DEVICE_BURST)

The burst device (OTX_DEVICE_BURST) consists of serial to parallel converters and a DMA controller. The application can very efficiently read or write the data directly from the DMA buffers, or have the DMA controller place the data in the host memory and notify the application when data is available. Please refer to the OtxBurst.h and OtxBurstD.h header files in the OTX HW SDK for the specific API functions available for this type of device.

The Burst device (OTX_DEVICE_LI_T1E1) is hosted by the board device (see chapter 6.1). The sequence number for this device is 0 (zero).

6.5 DSP (OTX_DEVICE_DSP)

The DSP on the Thor-4-ExpressCard can be used to run the Standard Program Modules (SPMs) provided in the OTX SDK library. These SPMs, or DSP application packages, provides supports for many common telecom applications; such as tone detection and generation, FSK, and HDLC sending and receiving.

The DSP can also be used to run user developed custom applications. For more information on custom DSP application development, please refer to *"Programmer's Guide for OTX C54x DSP Software Development Kit"* (Odin document number 1412-1-SAA-1007-1).

The DSP device (OTX_DEVICE_DSP) is hosted by the board device. The sequence number for this device is 0 (zero).

7 Line Interface Functionality

7.1 Line Configurations

The Thor-4-ExpressCard line interfaces support several different line codes:

- HDB3 - High Density Bipolar 3
- B8ZS - Bipolar 8 Zero Substitution
- AMI - Alternate Mark Inversion
- AMI with NZC

For the T1 operation mode, the following framing formats can be used:

- F4 - 4-frame multiframe
- F12 - 12 frame multiframe (D3/D4, Superframe)
- ESF - Extended Superframe
- F72 - 72 frame multiframe (SLC96 mode)

For the E1 operation mode, Thor-4-ExpressCard supports the following framing formats:

- Doubleframe
- CRC multiframe

7.2 Fault Monitoring

The line interface subsystem supports fault and performance monitoring. The transceiver subsystem detects and reports the following alarms in the receive streams:

- Framing errors
- Cyclic Redundancy Check (CRC) errors
- Code violations
- Loss of frame alignment
- Loss of Signal (LOS)
- Alarm Indication Signal (AIS)
- E bit errors (E1 only)
- Slip
- Remote Alarm Indication (RAI, Yellow Alarm)

The line interface subsystem also supports the transmitting of the following alarms towards the remote end:

- Alarm Indication Signal (AIS)

- Remote Alarm Indication (RAI, Yellow alarm)
- Auxiliary Pattern (AUXP)

7.3 Loop Back

The line interface subsystem implements a remote loop back for line testing. In the remote loop back mode, the clock and data recovered from the line inputs are routed back to the line outputs through the analog transmitter.

8 Testing features

The Thor-4-ExpressCard configuration offers a variety of features to facilitate low-level T1/E1/J1 testing:

- Full access to F, Y, Si, and Sa bits in E1 mode.
- Full access to FS/DL-bits in T1 mode (including support for the DL-channel protocol according to T1.403-1989 ANSI or to AT&T TR54016 specification).
- Programmable line build-out in T1/J1 mode
- Transparent mode
- Programmable transmit pulse shape and receive input threshold
- Insertion and detection of single alarms (e.g. Code Violation, Framing Errors, etc)
- Support for generation and detection of Loop codes
- Support for channel loopback
- Support for PRBS (BERT patterns)

9 ExpressCard Interface

The Thor-4-ExpressCard board is compliant with the ExpressCard/54 bus specification. The board communications flows through the PCI Express 2.5 Gbps interface specified in the ExpressCard standard. The USB interface of the ExpressCard standard is not used in this design.

10 Clocks

On the Thor-4-ExpressCard board, all the internal TDM data highways and the all the devices processing TDM data are synchronized to one clock reference. The clock reference can be derived from multiple sources and then routed to all the devices. The following clocking sources are supported by the Thor-4-ExpressCard:

OTX_CLOCK_SOURCE_INTERNAL - On-board free running oscillator
OTX_CLOCK_SOURCE_LOCAL_0 - Clock extracted from the incoming T1/E1/J1 span 0 (Li0)
OTX_CLOCK_SOURCE_LOCAL_1 - Clock extracted from the incoming T1/E1/J1 span 1 (Li1)

OTX_CLOCK_SOURCE_LOCAL_2 - Clock extracted from the incoming T1/E1/J1 span 2 (Li2)
OTX_CLOCK_SOURCE_LOCAL_3 - Clock extracted from the incoming T1/E1/J1 span 3 (Li3)

11 JTAG

The Thor-4-ExpressCard contains several JTAG chains which are used for board testing and board configuration during the manufacturing process.

One of the JTAG chains, TMS3, is connected to the DSP and used for a DSP emulator connection when debugging and developing customized DSP software. A special-order case is needed to access the JTAG chains for this purpose. Please contact the Odin TeleSystems Technical Support Team if want need to explore the options to write customized DSP code for this product.

12 Power

The Thor-4-ExpressCard operates from 3.3 Volt and 1.5 Volt power supplied from the ExpressCard slot in host PC. Power consumption is TBD.

13 Certifications

Final certifications are TBD. The Thor-4-ExpressCard will be designed with the following list of planned certifications:

- FCC Part 15 (CFR47, Part 15, Subpart B)
- FCC Part 68
- CE EMC (EN61326-1 Class B Equipment, AS/NZS 2064 Class B Limits)
- Safety EN60950 and UL60950

14 Reference documents

The following documents provide further detailed information related to the Thor-4-ExpressCard board:

- Programmer's Guide for OTX Hardware Driver (Odin document # 1412-1-SAA-1006-1)
- Installation Guide for OTX PCI Adapters (Odin document number 1512-1-HCA-1001-1)
- Programmer's Guide for OTX C54x DSP Software Development Kit (Odin document number 1412-1-SAA-1007-1)

15 Glossary

- OTX – Odin Telecom FrameworX
- DSP – Digital Signal Processor
- SDK – Software Development Kit
- API – Application Programmer Interface
- CPU – Central Processing Unit. Refers to the host PC (laptop) in this document.
- EEPROM – Electrically Erasable Programmable Read Only Memory.
- FPGA – Field Programmable Gate Array.
- LED – Light Emitting Diode
- LS – Least Significant
- MS – Most Significant