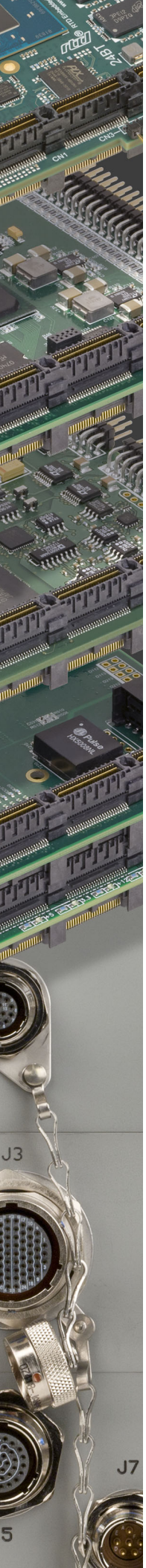
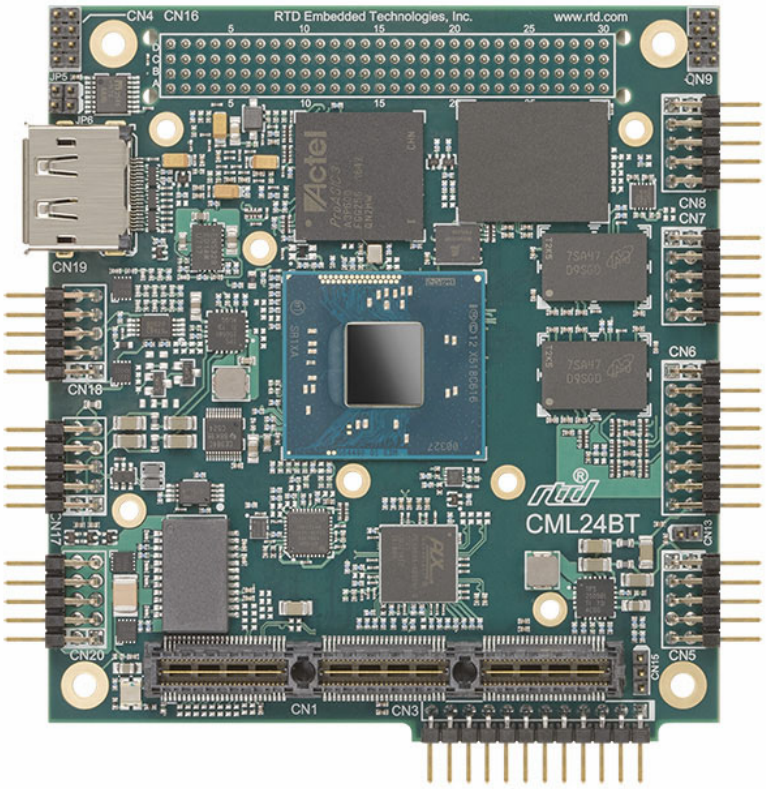


CML24BT cpuModules™



User's Manual

BDM-610000084 Revision E

www.rtd.com

ISO9001 and AS9100 Certified

"Accessing the Analog World"®

CML24BT cpuModules™ User's Manual

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Revision History

Revision	Date	Reason for Change
A	05/27/2016	Initial release
B	01/03/2018	Throughout: Add missing PCI bus documentation Throughout: Correct designator shown in labels for COM2&4 Throughout: Update trademark for "Intel Atom®" Intro: Add weights for IDAN-CML24BT Intro: Add ordering part numbers for boards which include flat-heatspreaders Connecting: Add warning to indicate that CN3 is not intended to power the CPU while any peripheral cards are connected Connecting: Corrrect number of PCIe links shown in "PCIe Link Configuration" Using: Update the Linux compatibility section Using: Under operating systems, added installation notes for Legacy and UEFI boot otions Using: Eliminate the pulse widths described in the aDIO event and match mode sections as they are incorrect. As described under the Electrical Specifications, the minimum aDIO update interval is 1ms. Appendix A: JP6 functionality has been changed from bus-stack-error-detect to reserved. Appendix A: Add footnotes to the PCI device table Appendix A: Correct the heatsink shown for CML24BTD and CML24BTQ; added labels to indicate heatsink orientation Appendix A: Update 3D dimensional drawings for the passive heatsinks to show PCB Appendix A: Add 3D dimensional drawings for the flat-heatspreaders
C	03/12/2018	Throughout: Update board photo Throughout: Add ordering option with Trusted Platform Module (TPM) Intro: Correct descriptions for flat-heatspreader ordering options Intro: Add Mean Time Before Failure (MTBF) Reference: Improve description for flat-heatspreader mounting locations
D	02/07/2019	Throughout: TPM text from "optional" to "standard" Throughout: Connector CN15 is reserved Getting Started: Remove mention of a PCI to ISA bridge.
E	10/1/2019	Throughout: Clarify that the TPM is standard on all boards. Throughout: Change TPM 1.2 to TPM 2.0 Using: Indicate that write protection of the onboard SATA storage can be enabled/disabled in the BIOS setup

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Chapter 1 Introduction

This manual provides comprehensive hardware and software information for users developing with the CML24BT PCI/104-Express cpuModule.

Note *Read the specifications beginning on page 11 prior to designing with the cpuModule.*

This manual is organized as follows:

Chapter 1	***Introduction*** introduces main features and specifications
Chapter 2	***Getting Started*** provides abbreviated instructions to get started quickly
Chapter 3	***Connecting the cpuModule*** provides information on connecting the cpuModule to peripherals
Chapter 4	***Using the cpuModule*** provides information to develop applications for the cpuModule, including general cpuModule information, detailed information on storing both applications and system functions, and using utility programs
Appendix A	***Hardware Reference*** lists jumper locations and settings, physical dimensions, and processor thermal management
Appendix B	***Troubleshooting*** offers advice on debugging problems with your system
Appendix C	***IDAN™ Dimensions and Pinout*** provides connector pinouts for the cpuModule installed in an RTD Intelligent Data Acquisition Node (IDAN) frame
Appendix D	***Additional Information*** lists sources and websites to support the cpuModule installation and configuration
Appendix E	***Limited Warranty***

CML24BT cpuModules

RTD's CML24BT cpuModule represents the latest in low power PCI Express embedded controllers. Based on an Intel Atom® E3800 Series processor and chipset, the CML24BT is offered with either a low power 1.46 Ghz Single-Core processor, a 1.33GHz Dual-Core processor, or a 1.91 GHz Quad-Core proccessor. The DDR3 memory interface on the single- and dual-core models operate up to 1066 MT/s (533 MHz) while the quad-core is 1333-MT/s (666 MHz). All memory chips are soldered directly onto the board.

The video interface of the cpuModule's Intel Atom's processor supports dual analog SVGA and DisplayPort outputs. The two video outputs are independent, and can display separate images and display timings, with audio support on the DisplayPort. Maximum resolution of both video outputs is 1920 x 1200.

A Serial-ATA (SATA) controller provides links to one disk drive on the PCIe bus connector as well as an onboard solid-state disk drive which issoldered to the board for maximum reliability. Network connectivity is provided by one integrated 10/100/1000 Mbps Ethernet controller. High-speed peripheral connections include USB 2.0, with up to 480 Mb/sec data throughput. One additional SATA link and four USB 2.0 connections permit further expandability on the top and bottom-side PCIe/104 Type 2 connectors. The bottom PCIe/104 connector also has four x1 PCI Express Gen 2.0 links. Other features include RS-232/422/485 COM ports and Advanced Digital I/O (aDIO).

RTD has gone the extra mile to include additional advanced features for maximum flexibility. These include an onboard surface-mount flash drive with a standard SATA interface. An Advanced Watchdog Timer is provided that can generate an interrupt or reset when the timer expires. The CML24BT is also available in a rugged and fanless IDAN enclosure.

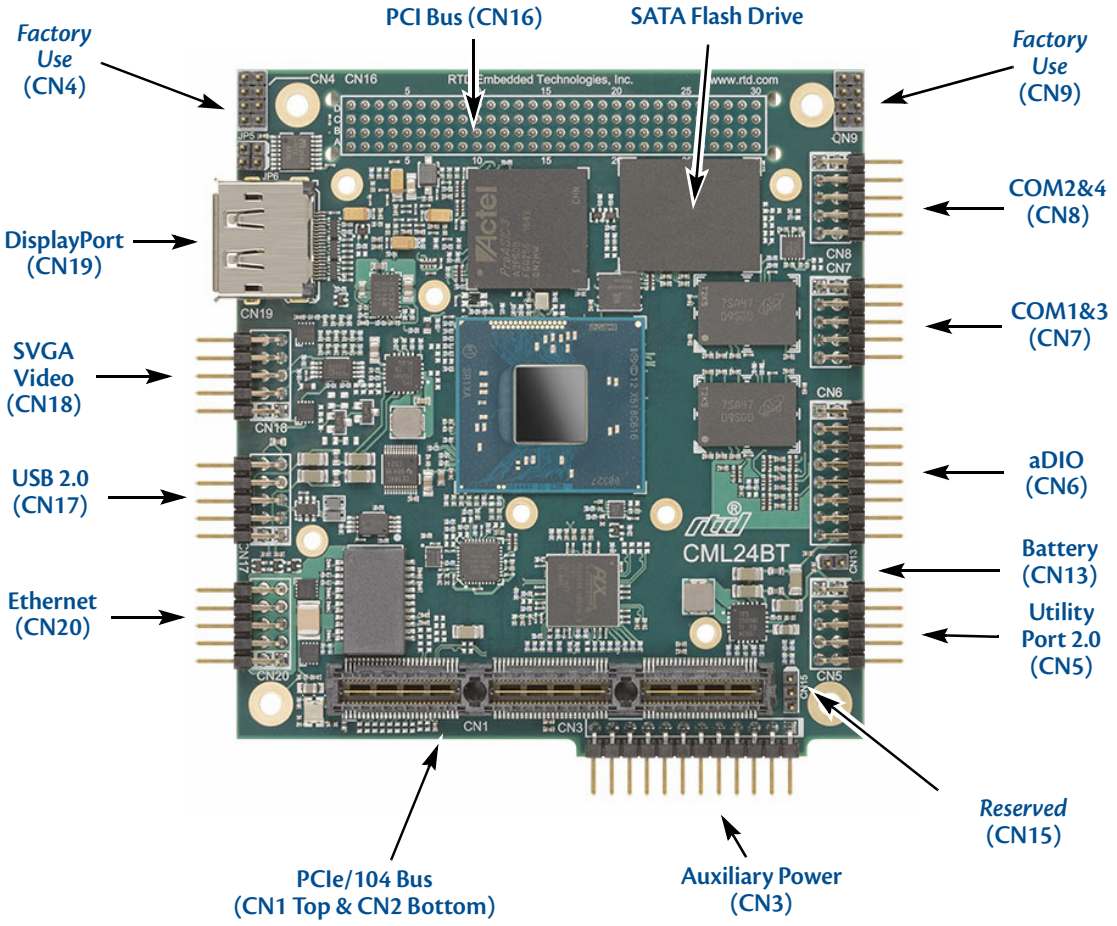

Figure 1 CML24BT cpuModule (top view)

You can easily customize the cpuModule by stacking PCI-104, PCI/104-Express, or PCIe/104 modules such as video controllers, Digital Signal Processors, drive carriers, LAN controllers, or analog and digital data acquisition modules. Stacking modules onto the cpuModule avoids expensive installations of backplanes and card cages, and preserves the module's compactness.

The cpuModule uses the RTD Enhanced BIOS. Drivers in the BIOS allow booting from hard disk, or UEFI shell, thus enabling the system to be used with traditional disk drives or nonmechanical drives. Booting to USB devices is also supported.

The cpuModule and BIOS are compatible with any real-time operating systems for PC compatible computers, although these may require creation of custom drivers to use the aDIO and watchdog timer.

aDIO

RTD's exclusive aDIO™ is 12 digital bits configured as 8 bit-direction programmable and 4-bit port-direction programmable I/O, plus 2 strobe inputs giving you any combination of inputs and outputs. Match, event, and strobe interrupt modes mean no more wasting valuable processor time polling digital inputs. Interrupts are generated when the 8 bit-direction programmable digital inputs match a pattern or on any value change event. Bit masking allows selecting any subgroup of eight bits. The strobe input latches data into the bit-programmable port and generates an interrupt.

Ordering Information

The CML24BT cpuModule is available with a selection of processors and heatsinks. The cpuModule can also be purchased as part of an Intelligent Data Acquisition Node (IDAN™) building block, which consists of the cpuModule and a milled aluminum IDAN frame. The IDAN building block can be used in just about any combination with other IDAN building blocks to create a simple but rugged PC/104 stack. Refer to Appendix C, *IDAN™ Dimensions and Pinout*, for more information. The CML24BT cpuModule can also be purchased as part of a custom-built RTD HiDAN™ or HiDAN*plus* High Reliability Intelligent Data Acquisition Node. Contact RTD for more information on its high reliability PC/104 systems.

CML24BT Model Options

The basic cpuModule model options are shown below. Refer to the RTD website (www.rtd.com) for more detailed ordering information and any new variations that may be available.

Table 1 CML24BT cpuModule Model Options[1]

Part Number	Description	Stack Height
CML24BTS1460HR-4096/S32GX	Intel Atom® E3815, Single Core 1.46 GHz 4GB DDR3-SDRAM	15.24mm
CML24BTD1330HR-4096/S32GX	Intel Atom® E3825, Dual Core 1.33 GHz 4GB DDR3-SDRAM	15.24mm
CML24BTQ1910HR-4096/S32GX	Intel Atom® E3845, Quad Core 1.91 GHz 4GB DDR3-SDRAM	22mm
CML24BTS1460HR-4096/S32GXF	CML24BTS1460HR-4096/S32GX with Flat Heatspreader	15.24mm
CML24BTD1330HR-4096/S32GXF	CML24BTD1330HR-4096/S32GX with Flat Heatspreader	15.24mm
CML24BTQ1910HR-4096/S32GXF	CML24BTQ1910HR-4096/S32GX with Flat Heatspreader	22mm

1. All ordering options include a Trusted Platform Module (TPM).

Cable Kits and Accessories

For maximum flexibility, RTD does not provide cables with the cpuModule. You may wish to purchase the CML24BT cpuModule cable kit (P/N XK-CM108), which contains:

- Utility Port 2.0 multi-function cable (2x USB 2.0 ports, battery, reset button, power button, speaker)
- Two serial port cables (DIL-10 to DSUB-9)
- VGA monitor cable (DIL-10 to high density 15-pin DSUB)
- aDIO cable (DIL-16 to DSUB-25)
- Two USB cables (5-pin SIL to USB A)
- PCIe/104 Type 2 break-out board (provides standard PC interfaces for SATA and USB devices)
- Ethernet cable (DIL-10 to RJ-45)

For additional accessories, refer to the RTD website.

Board Features

- Intel Atom® E3800 Series Processor:

Part Number	Cores	Core Frequency	L1 Cache (data)	L1 Cache (instruction)	L2 Cache	Stack Height
CML24BTS1460	One	1.46 GHz	32 KByte	32 KByte	512 KByte	0.600" (15.24mm)
CML24BTD1330	Two	1.33 GHz	32 KByte[1]	32 KByte[1]	512 KByte[1]	0.600" (15.24mm)
CML24BTQ1910	Four	1.91 GHz	32 KByte[1]	32 KByte[1]	512 KByte[1]	0.866" (22mm)

1. Discreet L1 and L2 cache structures for each core

  - Intel Atom® technology
    - E3815 Single Core Processor
    - E3825 Dual Core Processor
    - E3845 Quad Core Processor
  - ACPI 5.0 compliant
  - Thermal Throttling reduces clock speed to prevent thermal runaway
  - 22 nm process
  - Max Core Temperature of 110 C
- 2-4 GBytes BGA DDR3 SDRAM
  - Single-channel memory interface
  - Transfer rates up to 1333 MT/s Data Rate
  - Surface Mounted for maximum reliability
- Stackable 156-pin PCIe/104 Type 2 bus on top
  - One SATA 2.0, Rev 2.0 3GB/s
  - Two USB 2.0
  - ATX Power Supply Signaling
  - RTC Battery
- Stackable 156-pin PCIe/104 Type 2 bus on bottom
  - Four PCI Express x1 Links. Gen 2, 5 GT/s
  - Two USB 2.0
  - ATX Power Supply Signaling
  - RTC Battery
- Stackable 120-pin PCI bus
  - 4 Bus master add-on cards capable
  - 3.3V or 5V PCI bus signaling
- Advanced Thermal Management
  - Thermal Monitor throttles processor and memory to prevent thermal runaway
  - Passive Fanless Heatsink
  - Modified heatsinks and flat heat spreaders are available
  - Passive Structural Heatsink & Heatpipes in IDAN and HiDAN System Configurations
- Advanced Configuration and Power Interface (ACPI)

  - ACPI 5.0 Compliant
  - Wake events include:
    - USB event (device insertion, keyboard keystroke, etc.)
    - Power Switch
    - etc.
- Real-Time Clock (external battery required to maintain time only)
- Nonvolatile storage of CMOS settings without battery
- Advanced Watchdog timer
- Complete PC-compatible Single Board Computer
- Trusted Platform Module (TPM)
  - Fully compliant to the Trusted Computing Group (TCG) Trusted Platform Module (TPM) version 2.0 specification
  - Provides for secure storage of cryptographic keys

I/O

- Analog VGA Interface
  - RGB CRT output
  - Maximum Resolution 1920 x 1200
- DisplayPort Interface
  - Embedded DisplaypPort (eDP) 1.3
  - DisplayPort, DVI, and HDMI
  - Audio over DisplayPort
- Gigabit Ethernet
  - Intel 82574IT Controller (PRO1000 Series)
  - 10/100/1000 Auto-negotiation
  - Jumbo Frame Support (9kB)
  - Automatic MDI/MDI-X crossover capable
- Software-configurable RS-232/422/485 serial ports
  - 16550 compatible UARTs for high-speed
  - 120 Ohm Termination resistors for RS-422/485 through BIOS Configuration
  - Fully jumperless configuration
  - Increased FIFO size of 512 bytes
  - Supports echo cancellation, Auto-RTS and Auto-CTS
  - Each serial port can be configured as two limited serial ports for a total of four serial ports
- Advanced Digital I/O (aDIO)
  - One 8-bit bit-programmable I/O with Advanced Digital Interrupt Modes
  - One 4-bit port programmable as input or output
  - Event Mode Interrupt generates an interrupt when any input bit changes
  - Match Mode Interrupt generates an interrupt when input bits match a preset value
  - External Strobe Mode latches 8 data inputs and generates and interrupt
  - Two Strobes can be configured as readable inputs
- Two USB 2.0 (Universal Serial Bus) Ports
  - Supports 480 Mb/s (high-speed), 12Mb/s (full-speed), and 1.5Mbs (low speed) peripherals
  - Automatic resettable over-current protection (500 mA @ 5 Vdc per port)
  - USB Boot capability
  - Seven ports total (3 on 0.1" I/O headers, 4 on PCIe bus connectors)
- Serial ATA (SATA)
  - Two SATA revision 2.0 links
    - One link to the top-side PCIe connector
    - One link to the onboard surface-mount SATA Flash drive
  - Onboard 32 GB SATA Flash drive
    - Built in Wear Leveling, Error Correction and Bad Block Management
    - SMART supported (Self-Monitoring, Analysis and Reporting Technology
  - Compatability mode supports legacy operating systems.
- Utility Port 2.0 Connector

  - 1x USB 2.0 (Universal Serial Bus) Port with over-current protection
  - Speaker port (0.1 W output)
  - Hardware Reset input
  - Soft Power Button input
- Battery input for Real Time Clock
- Power Management
  - ACPI 5.0 Support - Advanced Configuration and Power interface
  - ATX support for “Soft Off”
  - ATX Power signals

RTD Enhanced BIOS

- User-configurable using built-in Setup program
- Flash-based CMOS Setup; no battery required to store CMOS settings
- Supports boot from SATA or USB
- UEFI (Unified Extensible Firmware Interface) Shell
- Special RTD Reliability Enhancements

Block Diagram

The next figure shows a simplified block diagram of the CML24BT cpuModule.

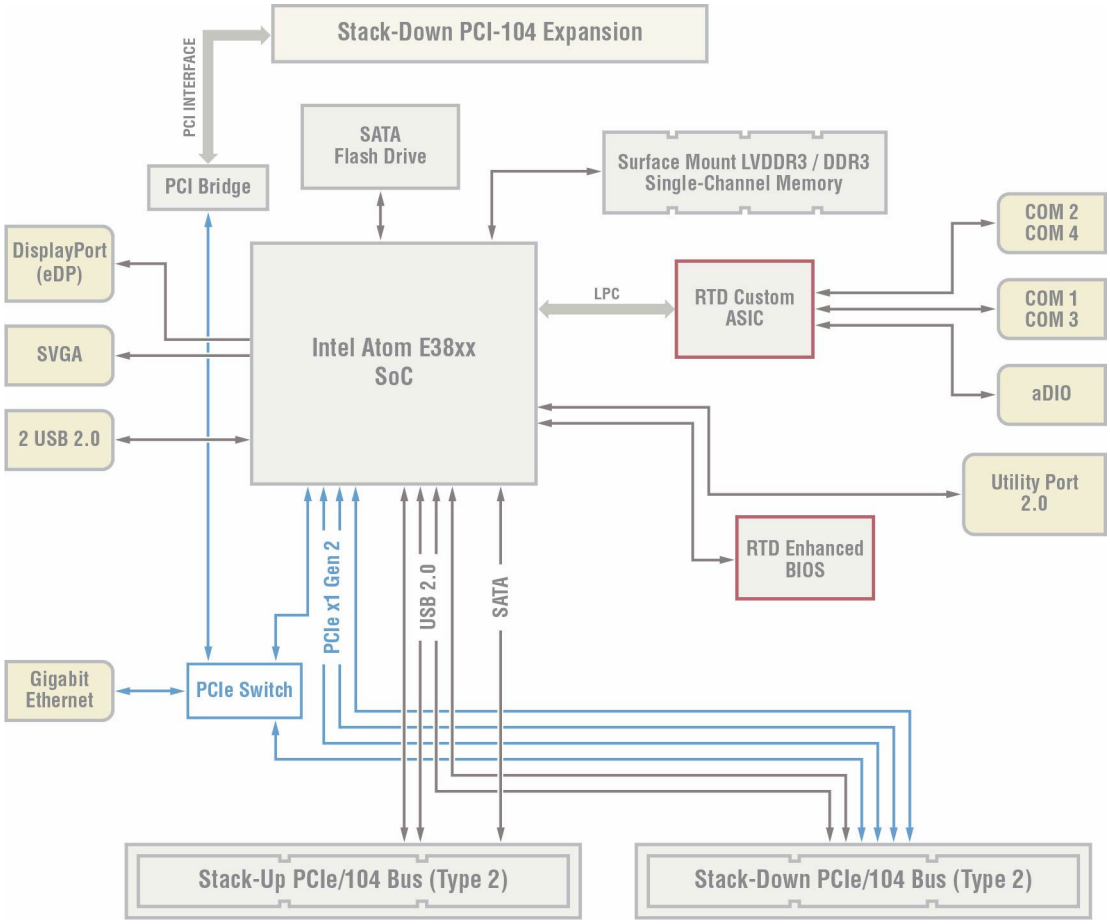

Figure 2 CML24BT cpuModule Simplified Block Diagram

Specifications

Physical Characteristics

Basic dimensions and the weight of the CML24BT are listed below. For a more detailed dimensional drawing, refer to the *Physical Dimensions* section on page 80.

- Dimensions
  - Board Size
    - Length (L): 95.885 mm L (3.775")
    - Width (W): 90.170 mm W (3.550")
  - Stand-off Height Above the CPU:
    - Single- and Dual-core models: 15.240 mm (0.866")
    - Quad-core models 22.000 mm (0.866")
  - Stand-off Height Below the CPU:
    - All versions: 15.240mm (0.600")
- Approximate Weight with Heatsink
  - Single-core models: 0.12 kg (0.26 lb)
  - Dual-core models: 0.16 kg (0.36 lb)
  - Quad-core models: 0.19 kg (0.42 lb)
- Approximate IDAN weight
  - All models: 0.63 kg (1.38 lb)

Power Consumption

Exact power consumption depends on the actual application. Typical power consumption of the CML24BT is listed in Table 3. It is expected that power consumption of a typical application will be a combination of these scenarios.

Table 2 Typical Power Consumption

Part Number	Typical Power Consumption
CML24BTS615HR-4096	6.3 W
CML24BTD1330HR-4096	6.8 W
CML24BTQ1910HR-4096	8.7 W

Note *The measurements listed above are intended to represent common usage scenarios. The cpuModule's power consumption is heavily influenced by the running software and system activity.*

Operating Conditions

Table 3 Operating Conditions

Symbol	Parameter	Test Condition	Min.	Max.
V_{CC5}	5V Supply Voltage		4.75V	5.25V
V_{CC3}	3.3V Supply Voltage		n/a[1]	n/a
V_{CC-12}	-12V Supply Voltage		n/a[1]	n/a
V_{CCSTBY}	5V Standby Voltage[2]		4.75V	5.25V
I_{CCSTBY}	5V Standby Current[2]		-	500mA
Ta	Ambient Operating Temperature[3]		-40	+85C
Ts	Storage Temperature		-40	+70C
Rh	Humidity	Non-Condensing	0	90%
MTBF	Mean Time Before Failure (hours)[4]	CML24BTS1460HR-4096/S32GX	481,907	
		CML24BTD1330HR-4096/S32GX	481,907	
		CML24BTQ1910HR-4096/S32GX	481,907	

1. The -12V and external +3.3V rails on the PCI-104 bus connector are not used by the cpuModule. Any requirements on these signals are driven by other components in the system, such as a PCI device.
2. 5V Standby is used to power the board when the main supply is turned off (power down modes S3-S5). It is not required for board operation.
3. With supplied heat sink solution. Depending on the CPU usage, performance may degrade as the ambient temperature approaches the maximum. Contact RTD Tech Support for more information.
4. Calculation Model: Telcordia Issue 2; Calculation Method: Method 1 Case 3; Temperature: +30C; Environment: Ground Benign, Controlled

Electrical Characteristics

The table below lists the Electrical Characteristics of the CML24BT. Operating outside of these parameters may cause permanent damage to the cpuModule.

Table 4 Electrical Characteristics

Symbol	Parameter	Test Condition	Min.	Max.
		PCI		
V_{OH}	Output Voltage High	I_{OH} = –0.5 mA	2.9 V	3.3 V
V_{OL}	Output Voltage Low	I_{OL} = 6.0 mA	0.0 V	0.55 V
V_{IH}	Input Voltage High	—	1.8 V	5.5 V
V_{IL}	Input Voltage Low	—	-0.5 V	0.9 V
I_{VIO}	Supply Current for VIO	—		500 mA
		USB Ports		
Ioc	Overcurrent Limit	Each port	0.5 A	5.0 A
		SVGA Port		
V_{OH}	Output Voltage High HSYNC, VSYNC	I_{OH} = –8.0 mA	2.4 V	3.3 V
V_{OL}	Output Voltage Low HSYNC, VSYNC	I_{OL} = 8.0 mA	0.0 V	0.5 V
V_{OH}	Output Voltage High DDC_*	I_{OH} = –4.0 mA	2.4 V	3.3 V
V_{OL}	Output Voltage Low DDC_*	I_{OL} = 8.0 mA	0.0 V	0.4 V
V_{IH}	Input Voltage High DDC_*	—	2.0 V	5.5 V
V_{IL}	Input Voltage Low DDC_*	—	-0.3 V	0.8 V
I_{DDCvcc}	Supply Current for DDC Electronics	—		500 mA
		DisplayPort		
I_{VCC}	Supply Current	—		500 mA
		Serial Ports - RS-232		
V_{OH}	Output Voltage High	R_L = 3 k	5.0 V	7.0 V
V_{OL}	Output Voltage Low	R_L = 3 k	-7.0 V	-5.0 V
V_{IH}	Input Voltage High	—	2.0 V	15 V
V_{IL}	Input Voltage Low	—	-15 V	0.6 V
		Serial Ports - RS-422/485		
V_{OD1}	Differential Output	R_L = 100 Ohm	2.0 V	
V_{OD2}	Differential Output	R_L = 54 Ohm	1.5 V	
V_{OC}	Common Mode Output	R_L = 54 or 100 Ohm		3.0 V
V_{TH}	Differential Input Threshold		-200 mV	-50 mV
V_I	Absolute Max Input Voltage		-18 V	18 V

Table 4 Electrical Characteristics

Symbol	Parameter	Test Condition	Min.	Max.
		aDIO		
V_{OH}	Output Voltage High	I_{OH} = –29 mA	2.4 V	3.3 V
V_{OL}	Output Voltage Low	I_{OL} = 17 mA	0.0 V	0.5 V
V_{IH}	Input Voltage High	—	1.8 V	5.5 V
V_{IL}	Input Voltage Low	—	-0.3 V	0.8 V
$I_{ADIOvcc}$	Supply current	—		500 mA
T_{MIN}	Update Interval	—	1ms	
		Utility Port 2.0 Connector (CN5)		
V_{RTC}	Input RTC Voltage[1]	—	2.3 V	3.6 V
I_{RTC}	RTC Battery Current	—		< 4 uA
$I_{UTILvcc}$	Utility Supply Current	—		500 mA

1. Only required to maintain date and time when power is completely removed from the system. Not required for board operation.

Migrating to RTD's Intel E3800 Series cpuModules

When migrating to RTD's Intel E3800 Series cpuModules, there are several differences from some preceding RTD cpuModule product families of which the customer should be aware.

Connector Pinout & Function Differences

The Intel E3800 Series cpuModules have several connector-related differences, which are summarized below. Complete information about the connectors on the CML24BT can be found in Chapter 3, *Connecting the cpuModule*.

New I/O Connectors

The CML24BT cpuModule introduces a new I/O connector that was not present on some previous RTD cpuModules:

- **DisplayPort (CN19)**
  - Provides video and audio output
  - Unlike legacy LVDS and flat panel connectors which needed to have their BIOS pre-configured to a specific manufacturer's flat panel parameters, the DisplayPort connector is compatible with any display that has a DisplayPort interface.

Connector Differences

While some connectors on the CML24BT have identical pinouts as on previous cpuModule generations, the features of the connector are sometimes different. Other connectors have entirely different pinouts than those on previous cpuModule generations. Connectors with pinout and feature differences include:

- **Auxiliary Power Connector (CN3)**
  - 12 pins (unlike the 10-pin connector on RTD Montevina cpuModules)
  - +5V and +12V inputs (unlike +5V only auxiliary power connectors found on previous RTD cpuModule generations)
    - While the RTD Intel E3800 Series CPU only requires +5 volts, +12V may optionallly be connected to CN3 if it is required by any other device in the system.
  - The Auxilliary Power Connector excludes ATX power signaling. The ATX power signals are provided on the PCIe/104 Type 2 and PCI-104 bus connectors.
- **Utility Port 2.0 (CN5)**
  - Replaces the legacy Utility Port multi-function connector
  - Replaces the PS/2 Mouse and Keyboard connections with one USB 2.0 port
  - The pinout of the Utility Port 2.0 is **not** compatible with previous generations of RTD cpuModules.
- **COM Ports (CN7 and CN8)**
  - Connector **CN7** can be configured to output Serial POST codes out of the TXD pin when in single RS-232 mode (unlike RTD Montevina cpuModules, where the DTR pin was configured for serial POST code output on the second port of CN7 in dual-port mode). For more information, refer to *Serial Power-On-Self-Test (POST) Code Output* on page 76.
  - Of all single and dual-port modes, only the single RS-232 pinout is compatible with previous generations of RTD cpuModules.
  - Dual-mode COM port pinouts permit dual RS-232, dual RS-422, and dual RS-485 modes. Unlike some previous generations of RTD cpuModules, a dual "combined" mode with RS-232 and RS-422/458 is not supported.

- Unlike some previous cpuModule generations, the single-mode RS-422/485 pinouts of the CML24BT do not include the DCD, DSR, DTR, and RI signals.
- When a COM port connector is configured for dual-port mode, enabling/disabling COM port termination enables/disables the termination for both ports on that connector. (Some previous generations of cpuModules have the ability to independently enable/disable termination on both ports when configured for dual-mode.)

Software Differences

The Intel E3800 Series cpuModules have several software-related differences, which are summarized below. Complete information about these CML24BT features can be found in Chapter 4, *Using the cpuModule*.

aDIO

While the 16-pin aDIO connector is pin-for-pin compatible with previous generations of RTD cpuModules (such as the Intel Core 2 Duo series), the hardware is slightly different, and requires that writes ands reads to/from the aDIO ports happen no more than once per millisecond. Migrating legacy software to the E3800 Series that utilizes RTD's Advanced Digital I/O may require that you add this delay prior to all reads and writes.

UEFI Shell

Previous generations of RTD cpuModules contained a Failsafe Boot ROM image, which permitted the cpuModule to boot to a DOS prompt even when no disk drives were connected to the system. The RTD E3800 Series cpuModules provide a similar prompt, called the Unified Extensible Firmware Interface (UEFI) Shell, which provides an enviroment to execute simple commands when no bootable devices are connected to the system.

Contact Information

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Chapter 2 Getting Started

For many users, the factory configuration of the CML24BT cpuModule can be used to get a PC/104 system operational. You can get your system up and running quickly by following the simple steps described in this chapter, which are:

1. Before connecting the cpuModule, the user must be properly grounded to prevent electrostatic discharge (ESD). For more information, refer to *Proper Grounding Techniques* on page 28.
2. Connect power.
3. Connect the Utility Port 2.0 cable.
4. Connect a USB keyboard.
5. Connect a monitor to the SVGA connector or DisplayPort interface.
6. Default BIOS configuration.
7. UEFI (Unified Extensible Firmware Interface) shell.

Refer to the remainder of this chapter for details on each of these steps.

Connector Locations

Figure 3 shows the connectors of the CML24BT cpuModule.

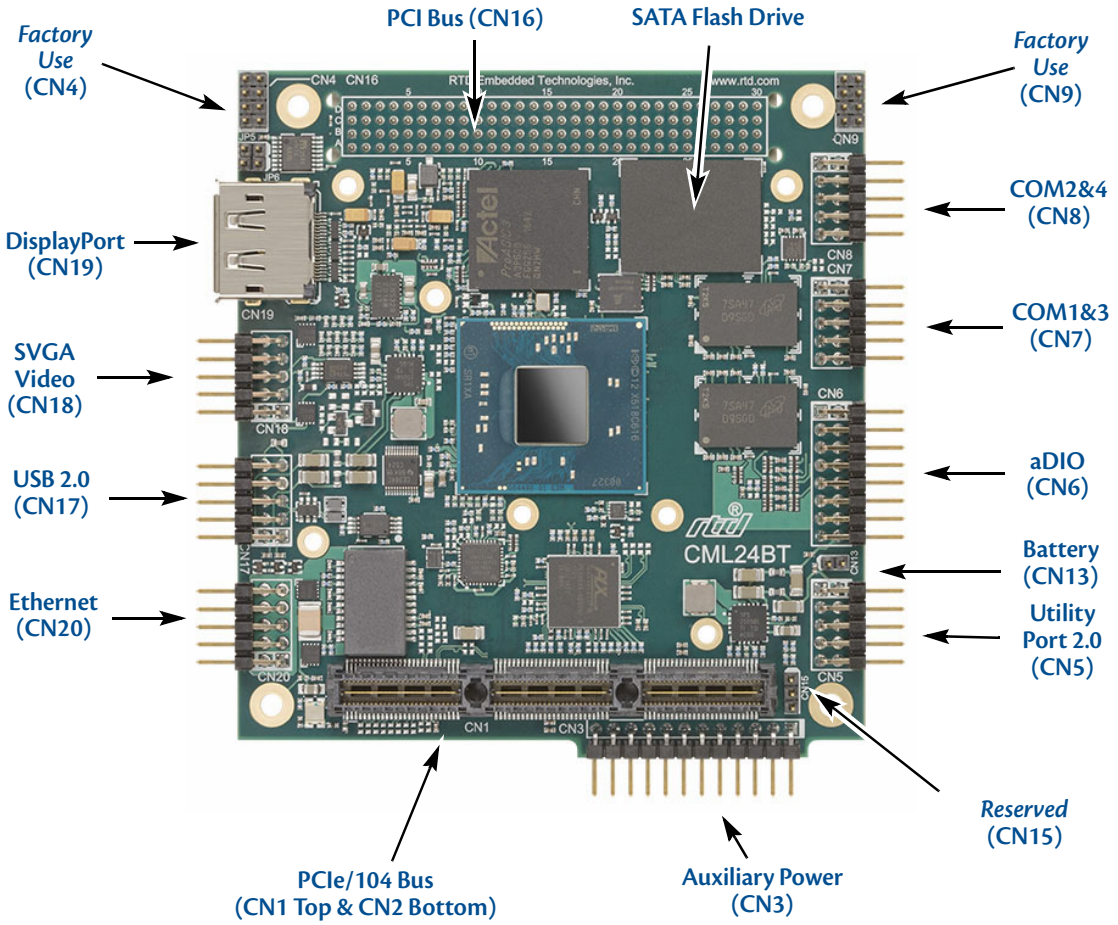


Figure 3 CML24BT Connector Locations

Note *Pin 1 of each connector is indicated by a white silk-screened square on the top side of the board and a square solder pad on the bottom side of the board. Pin 1 of the bus connectors match when stacking PCIe/104 or PCI-104 modules.*

Table 5 CML24BT Basic Connectors

Connector	Function	Size and Pitch	Mating Connector
CN1	PCIe/104 Type 2 Bus (Top)	156-pin, 0.635mm	Samtec ASP-129646-03
CN2	PCIe/104 Type 2 Bus (Bottom)	156-pin, 0.635mm	Samtec ASP-129637-03
CN3	Auxiliary Power	1x12, 0.1"	FCI 65039-025LF
CN5	Utility Port 2.0	2x5, 0.1"	3M 89110-0001
CN6	aDIO	2x8, 0.1"	3M 89116-0001
CN7	Serial Port 1 (COM 1&3)	2x5, 0.1"	3M 89110-0001
CN8	Serial Port 2 (COM 2&4)	2x5, 0.1"	3M 89110-0001
CN13	RTC Battery Input (optional)	1x2, 2mm	FCI 69305-002LF
CN15	*Reserved*	1x3, 2mm	FCI 69305-003LF
CN16	PCI-104 (PCI) Bus	120-pin, 2mm	Samtec ESQT-130-02-G-Q-368
CN17	USB 2.0	2x5, 0.1"	3M 89110-0001
CN18	Video (SVGA)	2x5, 0.1"	3M 89110-0001
CN19	DisplayPort	Molex P/N Series 47272-xxxx	Molex P/N Series 68783-xxxx
CN20	Ethernet	2x5, 0.1"	3M 89110-0001

WARNING *If you connect power incorrectly, the module will almost certainly be damaged or destroyed. Such damage is not covered by the RTD warranty! Please verify connections to the module before applying power.*

Power is normally supplied to the cpuModule through the top or bottom PCIe connectors (**CN1** or **CN2**). If you are placing the cpuModule onto a stack that has a PCIe/104 power supply, you do not need to make additional connections to supply power.

Alternatively, if you are using the cpuModule without a PC/104 stack or with a stack that does not include a power supply, refer to *Auxiliary Power (CN3)* on page 30 for an alternative method on how to power the cpuModule.

Selecting the Stack Order for the CML24BT

There are several things to consider when selecting the order of boards in the stack. Before selecting the order, be sure to determine which bus connector on each board is the "Active" bus. Typically, if a peripheral module has both PCIe and PCI bus connectors, only the PCIe is active and the PCI is pass-through. The following is a list of rules to use to determine the stack order:

1. The PCIe connectors above and below the CPU have completely separate signals. Therefore it is possible to attach boards to the PCIe connector above and below the CPU.
2. Any board that uses a SATA link must be within one board of the CPU.
3. Any board that uses a PCIe link must be within six boards of the CPU. Peripheral boards that repopulate a PCIe link should be placed closer to the CPU than any peripheral boards that use a PCIe link without repopulating.
4. To preserve power integrity, it is recommended that there be no more than six boards between the CPU and the power supply.
5. In order to maintain maximum performance over the full temperature range, it is recommended that a PCIe spacer be used between the CPU and any board immediately above it.
6. A maximum of four PCI boards may be attached to any PCI bus. If more than four PCI boards are needed in a system, a PCIe to PCI bridge is required.
7. The CPU or PCIe to PCI bridge (if one exists in the stack) must be at one end of the PCI bus segment, and all of the peripheral cards at the other end. There may be up to eight PCI pass-through connectors between the CPU or PCIe to PCI bridge and the peripheral cards.
8. There must be no more than two boards between the first PCI peripheral and the last PCI peripheral. If there are four PCI peripheral cards in a PCI bus segment, there may not be any PCI pass-through connections between them.
9. The standard CPU has the PCI connection below the board only. This means that all boards with an active PCI bus interface must be below the CPU. Contact RTD sales if it is required to have a PCI board above the CPU.

Stack Example

The figure below shows an example of a complete system stack. Most systems will be a subset of this example. This example stack may be further expanded with PCIe to PCIe bridges or a PCIe to PCI bridge.

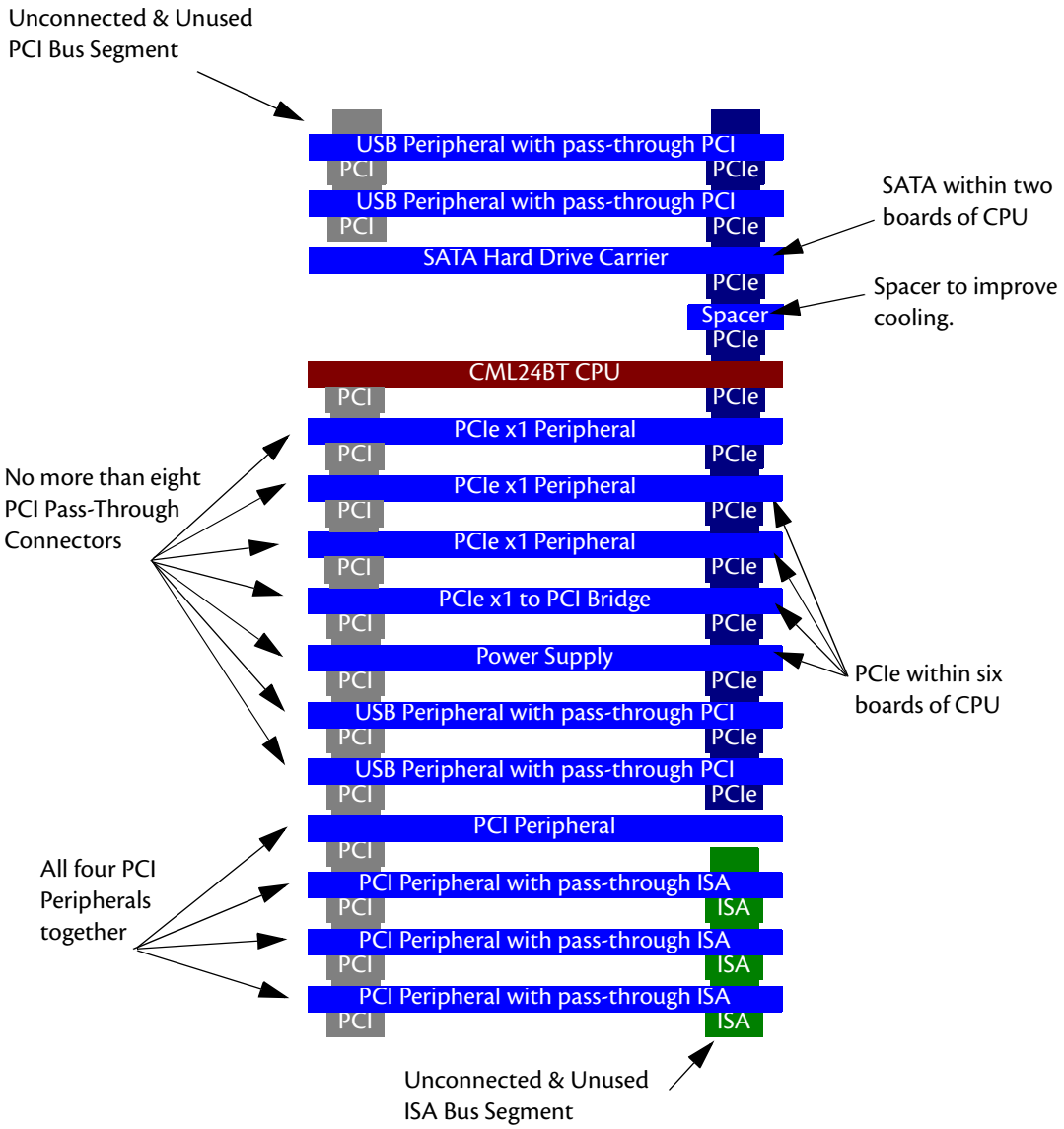


Figure 4 System Stacking Example

Connecting to the Stack

The bus connectors of the cpuModule are simply plugged onto a PC/104 stack to connect to other devices. Follow the procedure below to ensure that stacking of the modules does not damage connectors or electronics.

WARNING *Do not force the module onto the stack! Wiggling the module or applying too much pressure may damage it. If the module does not readily press into place, remove it, check for bent pins or out-of-place keying pins, and try again.*

For mechanical dimensions, including board-to-board spacing, see *Physical Dimensions* on page 80.

1. Turn off power to the PC/104 system or stack.
2. Always work at an ESD protected workstation, and wear a grounded wrist-strap.
3. Select and install stand-offs to properly position the cpuModule on the stack.
4. Remove the cpuModule from its anti-static bag.
5. Check that pins of the bus connector are properly positioned.
6. Check the stacking order; make sure all of the busses used by the peripheral cards are connected to the cpuModule.
7. Hold the cpuModule by its edges and orient it so the bus connector pins line up with the matching connector on the stack.
8. Gently and evenly press the cpuModule onto the PC/104 stack.

Power Input Connections

Power to the board must come from either the top or bottom PCIe/104 Type 2 bus connectors (**CN1** or **CN2**), or the auxiliary power connector (**CN3**). These connectors provide the required +5V DC voltage rail input to the cpuModule. While the RTD Intel E3800 Series CPU only requires +5 volts, +12V may optionallly be connected to CN3 if it is required by any other device in the system.

WARNING *While the PCI bus connector (**CN16**) has a +12V pin, it is not connected to the cpuModule, as the pin does not meet the cpuModule's current requirement. If the cpuModule is only connected to the power supply via the PCI connector, the cpuModule's LED will turn red, indicating that the +12V input rail is not present.*

Connecting to the PCI-104 (PCI) Bus

There are two additional considerations to make when using the PCI bus:

- Slot selection switches on add-in boards
- PCI bus signaling levels

Slot Selection Switches

Unlike PCIe cards, PCI-104 expansion cards have a "slot" selection switch or jumpers. In total, there are 4 PCI cards that can be stacked onto the cpuModule with switch positions 0 through 3. The distance from the CPU determines these switch settings. The card closest to the CPU is said to be in slot 0, the next closest slot 1 and so on to the final card as slot 3.

The "slot" setting method may vary from manufacturer to manufacturer, but the concept is the same. The CPU is designed to provide the correct delay to the clock signals to compensate for the bus length. The correct switch setting ensures the proper clock delay setting, interrupt assignment, and bus grant/request channel assignment. Refer to the expansion board's manual for the proper settings. Each expansion card must be in a different slot.

PCI Bus Signaling Levels

The PCI bus can operate at +3.3 V or +5 V signaling levels. The default PCI bus signaling level is +3.3 V. For more information, contact RTD Technical Support.

WARNING *You will have to ensure that all your expansion cards can operate together at a single signaling level.*

Note *Although it is possible to power the cpuModule through the Auxiliary Power connector, the preferred method is to power it through the bus connector from a power supply in the stack. The cpuModule can have large current transients during operation, which make powering it through wires difficult. Powering through the bus eliminates such problems as voltage drop and lead inductance.*

Connecting to the Utility Port 2.0 Connector

The Utility Port 2.0 connector (**CN5**) implements the following interfaces:

- One USB 2.0 (Universal Serial Bus) port
- Speaker port (0.1 W output)
- Hardware Reset input
- Battery input for Real Time Clock
- Soft Power Button input

To use these interfaces, you must connect to the Utility Port 2.0 connector (**CN5**). The Utility Port 2.0 cable from the RTD cable kit provides a small speaker, two USB 2.0 ports for a keyboard and mouse, a push-button for resetting the system, a soft-power button, and a lithium battery to provide backup power for the real time clock.

Refer to *Utility Port 2.0 Connector (CN5)* on page 32 to connect devices to the Utility Port 2.0 connector.

Booting the CML24BT cpuModule for the First Time

You can now apply power to the cpuModule.If you press **ESC** on a keyboard while booting, the cpuModule will enter Setup. Once you have configured the cpuModule using Setup, save your changes and reboot. If you don't presse **ESC**, the cpuModule will boot using the current settings.

Note *You may miss the initial sign-on messages if your monitor takes a while to power on.*

Note *By default, cpuModules are shipped with a UEFI (Unified Extensible Firmware Interface) shell. When no other bootable device is installed in the system, the system will boot to it exclusively. This internal bootable shell may be disabled in the BIOS screen's boot menu.*

WARNING *Incorrect modifications to the BIOS can cause your system to break. If you are unsure of any changes made to the BIOS there is a* ***Load RTD Defaults*** *option under the* ***Exit*** *tab in the* ***SCU****. This option restores the BIOS to the default factory settings.*

Chapter 3 Connecting the cpuModule

This chapter provides information on all CML24BT cpuModule connectors.

Proper Grounding Techniques — page 28

Connector Locations — page 28

Auxiliary Power (CN3) — page 30

Utility Port 2.0 Connector (CN5) — page 32

SVGA Video Connector (CN18) — page 35

DisplayPort Connector (CN19) — page 36

Serial Port 1 (CN7) and Serial Port 2 (CN8) — page 38

Advanced Digital I/O (aDIO™) Port (CN6) — page 44

USB 2.0 Connector (CN17) — page 45

Ethernet (10/100/1000Base-T and -TX) Connector (CN20) — page 47

PCIe/104 Type 2 Bus (CN1 - Top and CN2 - Bottom) — page 48

PCI-104 PCI Bus (CN16) — page 52

Optional RTC Battery Input (CN13) — page 55

Reserved (CN15) — page 55

Proper Grounding Techniques

Before removing the CML24BT from its static bag, proper grounding techniques must be used to prevent electrostatic discharge (ESD) damage to the cpuModule. Common grounding procedures include an anti-static mat on a workbench, which may connect to an anti-static wrist strap (also known as an ESD wrist strap) on the wrist of the technician or engineer.

Connector Locations

Figure 5 shows the connectors of the CML24BT cpuModule.

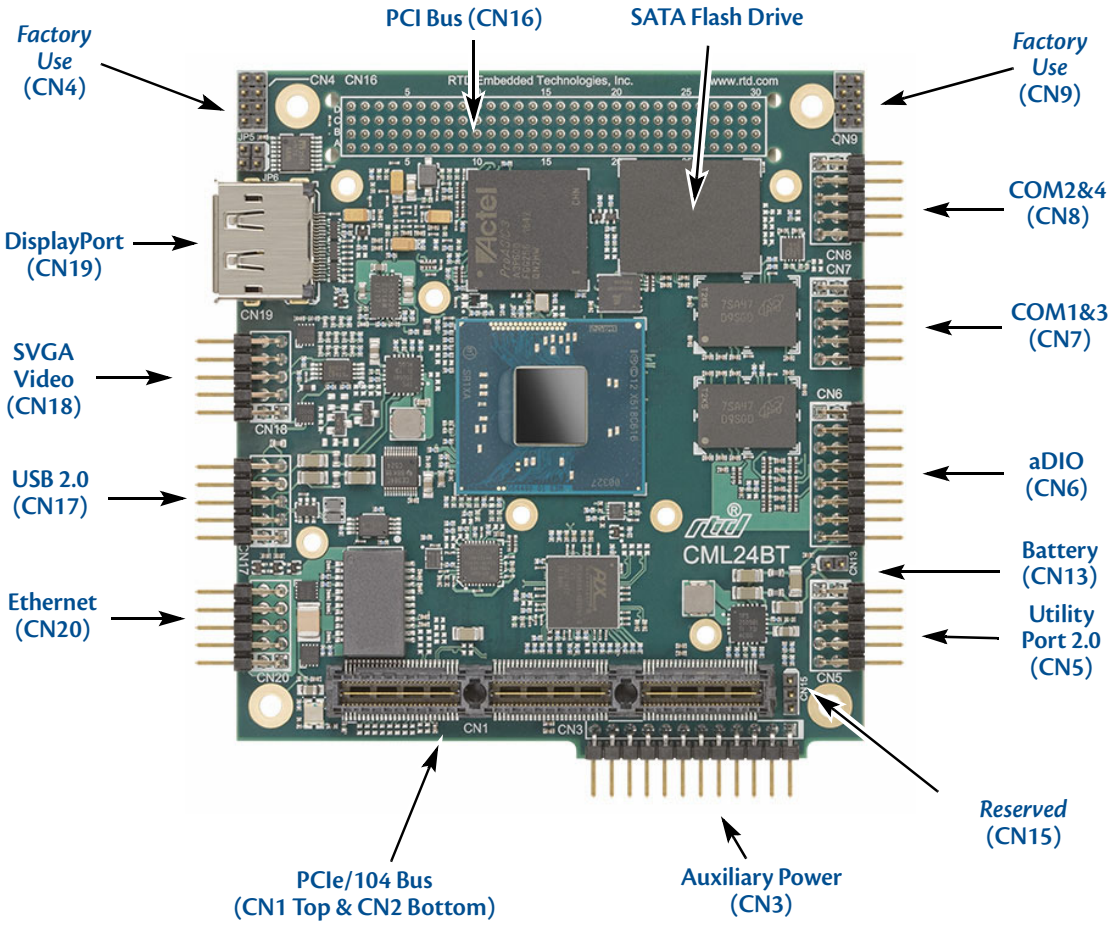


Figure 5 CML24BT cpuModule (top view)

Note *Pin 1 of each connector is indicated by a white silk-screened square on the top side of the board and a square solder pad on the bottom side of the board. Pin 1 of the bus connectors match when stacking PC/104 modules.*

Table 6 CML24BT Basic Connectors

Connector	Function	Size and Pitch	Mating Connector
CN1	PCIe/104 Type 2 Bus (Top)	156-pin, 0.635mm	Samtec ASP-129646-03
CN2	PCIe/104 Type 2 Bus (Bottom)	156-pin, 0.635mm	Samtec ASP-129637-03
CN3	Auxiliary Power	1x12, 0.1"	FCI 65039-025LF
CN5	Utility Port 2.0	2x5, 0.1"	3M 89110-0001
CN6	aDIO	2x8, 0.1"	3M 89116-0001
CN7	Serial Port 1 (COM1&3)	2x5, 0.1"	3M 89110-0001
CN8	Serial Port 2 (COM2&4)	2x5, 0.1"	3M 89110-0001
CN13	RTC Battery Input (optional)	1x2, 2mm	FCI 69305-002LF
CN15	*Reserved*	1x3, 2mm	FCI 69305-003LF
CN16	PCI-104 (PCI) Bus	120-pin, 2mm	Samtec ESQT-130-02-G-Q-368
CN17	USB 2.0	2x5, 0.1"	3M 89110-0001
CN18	Video (SVGA)	2x5, 0.1"	3M 89110-0001
CN19	DisplayPort	Molex P/N Series 47272-xxxx	Molex P/N Series 68783-xxxx
CN20	Ethernet	2x5, 0.1"	3M 89110-0001

Auxiliary Power (CN3)

The Auxiliary Power connector (**CN3**) can be used to supply power to devices that are attached to the cpuModule. These devices include hard drive, front-end boards for data acquisition systems, and other devices.

Power can also be conveyed to the module through the Auxiliary Power connector (**CN3**). The Intel E3800 Series cpuModule only requires +5 VDC and ground for operation. +12 V may optionally be connected to CN3 if it is required by any other device in the system.

Note *Although it is possible to power the cpuModule through the Auxiliary Power connector, the preferred method is to power it through the bus connector from a power supply in the stack. The cpuModule can have large current transients during operation, which make powering it through wires difficult. Powering through the bus eliminates such problems as voltage drop and lead inductance.*

WARNING *System configurations which are powered using CN3 should* ***only*** *be used power the CPU. The connector is not intended to power configurations which consist of peripheral cards.*

If using the Auxiliary Power connector to power the system, care must be taken to ensure good power connections. The power and ground leads must be twisted together, or as close together as possible to reduce lead inductance. A separate lead must be used for each of the power pins. All 5V pins and all ground pins must be connected. Do not use wire smaller than 20 gauge, and take care to ensure the length of the wire does not exceed 2 ft. The power supply solution must be verified by measuring voltage at the Auxiliary Power Connector and verifying that it meets the input voltage specifications. The voltage at the connector should be checked with an oscilloscope while the system is operational.

WARNING *This 12-pin power connector is* ***not*** *compatible with previous generations of RTD cpuModules.*

WARNING *If you connect power incorrectly, the module will almost certainly be destroyed. Please verify power connections to the module before applying power.*

Table 7 Auxiliary Power Connector (CN3)

Pin	Signal	Function
1	GND	Ground
2	+5 V	+5 Volts DC
3	+5 V	+5 Volts DC
4	GND	Ground
5	GND	Ground
6	+12 V[1]	+12 Volts DC
7	+12 V[1]	+12 Volts DC
8	GND	Ground
9	GND	Ground
10	+5 V	+5 Volts DC
11	+5 V	+5 Volts DC
12	GND	Ground

1. +12 V not required for operation of the cpuModule

Utility Port 2.0 Connector (CN5)

The Utility Port 2.0 connector implements the following functions:

- 1x USB 2.0 (Universal Serial Bus) Port
- Speaker port (0.1 W output)
- Hardware Reset input
- Soft Power Button input
- Battery input for Real Time Clock

Table 8 provides the pinout of the Utility Port 2.0 connector.

Table 8 Utility Port 2.0 Connector (CN5)

Pin	Signal	Function	In/Out
1	SPKR	Speaker Output (open collector)	out
2	PWR	+5 V	out
3	RESET#	Manual Push-Button Reset	in
4	DATA–	Bidirectional data line for USB1	in/out
5	PWRSW#	Soft Power Button	in
6	DATA+	Bidirectional data line for USB1	in/out
7	GND	Ground	out
8	GND	Ground	out
9	BAT	RTC Battery Input	in
10	Shield GND	Shield Ground	out

WARNING *The pinout of the Utility Port 2.0 connector is* ***not*** *compatible with previous generations of RTD cpuModules. Attaching a legacy Utility Port harness to the Utility Port 2.0 connector may damage or destroy the cpuModule.*

Facing the connector pins, the pinout is:

9	7	5	3	1
BAT	**GND**	**PWRSW#**	**RESET#**	**SPKR**
Shield GND	**GND**	**DATA+**	**DATA-**	**PWR**
10	8	6	4	2

USB 2.0 Connector

One USB 2.0 compliant connector is available on connector **CN5**. Table 8 provides the pinout of the USB connector.

Note *For proper operation at USB 2.0 speeds, be sure to use a cable that is rated for USB 2.0, such as the cable kit supplied by RTD.*

Speaker

A speaker output is available on pins 1 and 2 of the Utility Port 2.0 connector. These outputs are controlled by a transistor to supply 0.1 W of power to an external speaker. The external speaker should have 8 Ohm impedance and be connected between pins 1 and 2.

System Reset

Pin 3 of the Utility Port 2.0 connector allows connection of an external push-button to manually reset the system. The push-button should be normally open, and connect to ground when pushed. The type of reset generated by this button can be set in the BIOS configuration utility.

Soft Power Button

Pin 5 of the Utility Port 2.0 connector allows connection of an external push-button to send a soft power signal to the system. The push-button should be normally open, and connect to ground when pushed. For more information on the modes of the Soft Power Button, refer to the *Power Management* section in Chapter 4, *Using the cpuModule*

Battery

Pin 9 of the Utility Port 2.0 connector is the connection for an external backup battery. This battery is used by the cpuModule when system power is removed in order to preserve the date and time of the real time clock.

Connecting a battery is only required to maintain time when power is completely removed from the cpuModule. A battery is not required for board operation.

WARNING *The optional RTC battery input connector (**CN13**) should be left unconnected if the multi-function connector (**CN5**) has a battery connected to pin 9.*

SVGA Video Connector (CN18)

Table 9 provides the pinout of the video connector.

Table 9 SVGA Video Connector (CN18)

Pin	Signal	Function	In/Out
1	VSYNC	Vertical Sync	out
2	HSYNC	Horizontal Sync	out
3	DDCSCL	Monitor Communications Clock	out
4	RED	Red Analog Output	out
5	DDCSDA	Monitor Communications Data	bidirectional
6	GREEN	Green Analog Output	out
7	PWR	+5 V	out
8	BLUE	Blue Analog Output	out
9	GND	Ground	out
10	GND	Ground	out

Facing the connector pins of the SVGA Video connector (**CN18**), the pinout is:

9	7	5	3	1
GND	**PWR**	**DDCSDA**	**DDCSCL**	**VSYNC**
GND	**BLUE**	**GREEN**	**RED**	**HSYNC**
10	8	6	4	2

DisplayPort Connector (CN19)

The DisplayPort connector on the CML24BT cpuModule is a standard PC DisplayPort connector complete with latch holes to provide a rugged connecting solution for latching DisplayPort cables.

The DisplayPort supports all mandatory features of the VESA Embedded DisplayPort (eDP) 1.3 standard and supports audio over the connection. Full bandwidth transmission is supported over a two meter cable, with reduced bandwidth transmission supported up to a length of 15 meters.

The connection can directly output single-link HDMI and DVI signals by using a simple passive adapter. Passive adapters acheive HDMI and DVI signaling by adjusting the lower signal levels output by the connector.

Table 10 provides the pinout of the DisplayPort connector.

Table 10 DisplayPort Connector (CN19)

Pin	Signal	Standard Function	DVI / HDMI mode[1]	In/Out
1	LN0+	Main Link, Lane 0 (positive)	TMDS Channel 2 (positive)	out
2	GND	Ground	Ground	out
3	LN0-	Main Link, Lane 0 (negative)	TMDS Channel 2 (negative)	out
4	LN1+	Main Link, Lane 1 (positive)	TMDS Channel 1 (positive)	out
5	GND	Ground	Ground	out
6	LN1-	Main Link, Lane 1 (negative)	TMDS Channel 1 (negative)	out
7	LN2+	Main Link, Lane 2 (positive)	TMDS Channel 0 (positive)	out
8	GND	Ground	Ground	out
9	LN2-	Main Link, Lane 2 (negative)	TMDS Channel 0 (negative)	out
10	LN3+	Main Link, Lane 3 (positive)	TMDS Clock (positive)	out
11	GND	Ground	Ground	out
12	LN3-	Main Link, Lane 3 (negative)	TMDS Clock (negative)	out
13	CFG1	Configuration Pin 1	Cable Adapter Detect	out
14	CFG2	Configuration Pin 2	Consumer Electronics Control[2]	out
15	AUX+	Auxiliary Channel (positive)	DDC Clock	in/out
16	GND	Ground	Ground	out
17	AUX-	Auxiliary Channel (negative)	DDC Data	in/out
18	HPD	Hot Plug Detect	Hot Plug Detect	in
19	DPG	Return for DPV	Return for DPV	out
20	DPV	+3.3V DC Power	+3.3V DC Power	out

1. Requires special passive adapter
2. HDMI mode only

Facing the connector pins of the DisplayPort connector (**CN19**), the pinout is:

19	17	15	13	11	9	7	5	3	1
DPG	AUX-	AUX+	CFG1	GND	LN2-	LN2+	GND	LN0-	LN0+
DPV	HPD	GND	CFG2	LN3-	LN3+	GND	LN1-	LN1+	GND
20	18	16	14	12	10	8	6	4	2

Serial Port 1 (CN7) and Serial Port 2 (CN8)

Serial Port 1 (COM1) is implemented on connector **CN7**, and Serial Port 2 (COM2) is implemented on connector **CN8**. The serial ports are normally configured as PC compatible full-duplex RS-232 ports, but you may use the BIOS Setup program to reconfigure these ports as half-duplex RS-422 or full-duplex RS-422 or RS-485. If you reconfigure the ports, you must also select the I/O address and corresponding interrupt using Setup. Table 11 provides the standard I/O addresses and corresponding interrupts.

Table 11 Serial Port Settings

I/O Address (hex)	IRQ
03F8	IRQ4
02F8	IRQ3
03E8	IRQ4
02E8	IRQ3

Serial Port UART

The serial ports are implemented with a 16550/16750-compatible UART (Universal Asynchronous Receiver/Transmitter). This UART is capable of baud rates up to 115.2 kbaud, and includes a 64-byte FIFO. Refer to any standard PC-AT hardware reference for the register map of the UART.

It is possible to change the slew rate for the UARTs of the cpuModule to allow the serial ports to operate at higher speeds than 115200 bps. For more information see *Chapter 4 - "Non-Standard Serial Port Modes"*.

RS-232 Serial Port (Default)

The default serial port mode is full-duplex RS-232. With this mode enabled, the serial port connectors must be connected to RS-232 compatible devices. Table 12 provides the serial port connector pinout and shows how to connect to an external DB-25 or DB-9 compatible serial connector.

Table 12 Serial Port in RS-232 Mode

Pin	Signal	Function	In/Out	DB-25	DB-9
1	DCD	Data Carrier Detect	in	8	1
2	DSR	Data Set Ready	in	6	6
3	RXD	Receive Data	in	3	2
4	RTS	Request To Send	out	4	7
5	TXD	Transmit Data	out	2	3
6	CTS	Clear To Send	in	5	8
7	DTR	Data Terminal Ready	out	20	4
8	RI	Ring Indicate	in	22	9
9	GND	Signal Ground	—	7	5
10	GND	Signal Ground	—	—	—

Facing the serial port's connector pins, the pinout is:

9	7	5	3	1
GND	**DTR**	**TXD**	**RXD**	**DCD**
GND	**RI**	**CTS**	**RTS**	**DSR**
10	8	6	4	2

RS-422 or RS-485 Serial Port

You may use the BIOS setup utility to configure the serial ports as RS-422 or RS-485. In this case, you must connect the serial port to an RS-422 or RS-485 compatible device.

When using RS-422 mode, you can use the serial ports in either half-duplex (two-wire) or full-duplex (four-wire) configurations.

Note *The cpuModule has a 120 Ohm termination resistor. Termination is usually necessary on all RS-422 receivers and at the ends of the RS-485 bus. Termination resistors can be enabled in the BIOS setup utility.*

When using full-duplex in RS-422 mode, connect the ports as shown in Table 13.

Table 13 Full-Duplex Connections

Port 1	Port 2
RXD+	TXD+
TXD+	RXD+
RXD–	TXD–
TXD–	RXD–

In RS-485 mode, the connection of the ports is always half-duplex, as the transceivers' transmitters are connected to the receivers internally.

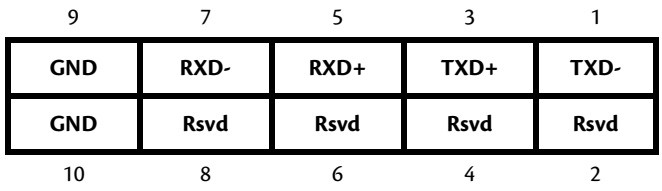
RS-422 Mode Pinout

Table 14 provides the serial port connector pinout when RS-422 mode is enabled.

Table 14 Serial Port in RS-422 Mode

Pin	Signal	Function	In/Out	DB-9
1	TXD–	Transmit Data (–)	out	1
2	—	Reserved	—	6
3	TXD+	Transmit Data (+)	out	2
4	—	Reserved	—	7
5	RXD+	Receive Data (+)	in	3
6	—	Reserved	—	8
7	RXD–	Receive Data (–)	in	4
8	—	Reserved	—	9
9	GND	Signal Ground	—	5
10	GND	Signal Ground	—	—

Facing the serial port connector, the pinout is:



WARNING *The pinout of the COM ports in RS-422 mode is* ***not*** *compatible with previous generations of RTD cpuModules.*

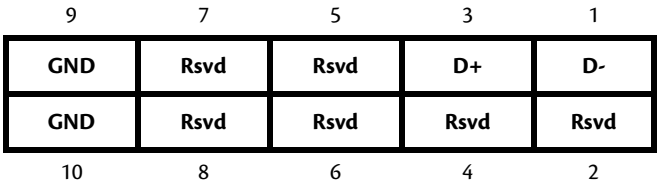
RS-485 Mode Pinout

Table 15 provides the serial port connector pinout when RS-485 mode is enabled

Table 15 Serial Port in RS-485 Mode

Pin	Signal	Function	In/Out	DB-9
1	D–	Data (–)	in/out	1
2	—	Reserved	—	6
3	D+	Data (+)	in/out	2
4	—	Reserved	—	7
5	—	Reserved	—	3
6	—	Reserved	—	8
7	—	Reserved	—	4
8	—	Reseved	—	9
9	GND	Signal Ground	—	5
10	GND	Signal Ground	—	—

Facing the serial port connector, the pinout is:



WARNING *The pinout of the COM ports in RS-485 mode is* ***not*** *compatible with previous generations of RTD cpuModules.*

Note *When using the serial port in RS-485 mode, the serial transmitters are enabled and disabled under software control. The transmitters are enabled by manipulating the Request To Send (RTS*) signal of the serial port controller. This signal is controlled by writing bit 1 of the Modem Control Register (MCR) as follows:*

- If MCR bit 1 = 1, then RTS* = 0, and serial transmitters are disabled
- If MCR bit 1 = 0, then RTS* = 1, and serial transmitters are enabled

Note *For more information on the serial port registers, including the MCR, refer to the Serial Port Programming reference in Appendix D.*

Dual Serial Port Modes

The serial port connectors can be configured as dual serial ports in the BIOS. This enhancement in dual RS-232 comes at the cost of losing the DSR and DTR signals, which are only available in single RS-232 mode.

The mapping between the connectors and COM port numbers is shown in Table 16. The supported combinations of serial port modes are listed in Table 17, which also includes a reference to the corresponding connector pinout.

Table 16 Dual Serial Port Connections

Connector	COM A	COM B
CN7	COM 1	COM 3
CN8	COM 2	COM 4

Table 17 Dual Serial Port Modes

COM A	COM B	Pinout Reference	Echo Mode
RS-232	RS-232	Table 18	—
RS-422	RS-422	Table 19	—
RS-485	RS-485	Table 20	echo cancelled
RS-485	RS-485	Table 19	with echo[1]

1. Dual RS-485 mode with echo uses dual RS-422 mode pinout

WARNING *The dual serial port mode pinouts of the COM ports are* ***not*** *compatible with previous generations of RTD cpuModules.*

Note *The cpuModule has 120 Ohm termination resistors. Termination is usually necessary on all RS-422 receivers and at the ends of the RS-485 bus. Termination resistors can be enabled in the BIOS setup utility. When termination is enabled in dual port mode, it is enabled for both ports.*

Table 18 COM A (RS-232) and COM B (RS-232)

Pin	Signal	Function	In/Out	DB-9
1	DCD1	COM A - Data Carrier Detect	in	1
2	CTS1	COM A - Clear To Send	in	6
3	RXD1	COM A - Receive Data	in	2
4	TXD2	COM B - Transmit Data	out	7
5	TXD1	COM A - Transmit Data	out	3
6	RXD2	COM B - Receive Data	in	8
7	RTS1	COM A - Request To Send	out	4
8	RI1	COM A - Ring Indicate	in	9

Table 18 COM A (RS-232) and COM B (RS-232)

Pin	Signal	Function	In/Out	DB-9
9	GND	Signal Ground	—	5
10	GND	Signal Ground	—	—

Table 19 COM A (RS-422) and COM B (RS-422)[1]

Pin	Signal	Function	In/Out	DB-9
1	TXD1-	COM A- Transmit Data (–)	out	1
2	TXD2-	COM B - Transmit Data (–)	out	6
3	TXD1+	COM A - Transmit Data (+)	out	2
4	TXD2+	COM B - Transmit Data (+)	out	7
5	RXD1+	COM A - Receive Data (+)	in	3
6	RXD2+	COM B - Receive Data (+)	in	8
7	RXD1-	COM A- Receive Data (–)	in	4
8	RXD2-	COM B - Receive Data (–)	in	9
9	GND	Signal Ground	—	5
10	GND	Signal Ground	—	—

1. Dual RS-485 mode with echo uses dual RS-422 mode pinout

Table 20 COM A (RS-485) and COM B (RS-485)

Pin	Signal	Function	In/Out	DB-9
1	D1-	COM A- Data (–)	in/out	1
2	D2-	COM B - Data (–)	in/out	6
3	D1+	COM A - Data (+)	in/out	2
4	D2+	COM B - Data (+)	in/out	7
5	—	Reserved	—	3
6	—	Reserved	—	8
7	—	Reserved	—	4
8	—	Reserved	—	9
9	GND	Signal Ground	—	5
10	GND	Signal Ground	—	—

Advanced Digital I/O (aDIO™) Port (CN6)

Connector **CN6** is configured as an aDIO port. aDIO is 12 digital bits configured as 8-bit programmable and 4-bit port programmable I/O, providing any combination of inputs and outputs. Match, event, and strobe interrupt modes mean no more wasting valuable processor time polling digital inputs. Interrupts are generated when the 8-bit programmable digital inputs match a pattern, or on any value change event. Bit masking allows selecting any subgroup of 8 bits. The strobe input latches data into the bit programmable port and generates an interrupt. Refer to *Advanced Digital I/O Ports (aDIO™)* — page 62 for information on programming the aDIO.

Table 21 aDIO Pinout

CN6 Pin	Function	CN6 Pin	Function
1	P0-0	2	P0-1
3	P0-2	4	P0-3
5	P0-4	6	P0-5
7	P0-6	8	P0-7
9	strobe 0	10	strobe 1
11	P1-0	12	P1-1
13	P1-2	14	P1-3
15	GND	16	+5 V[1]

1. Available during standby.

USB 2.0 Connector (CN17)

Two USB 2.0 compliant connectors are available on connector **CN17**. Table 22 provides the pinout of the USB connector.

Table 22 USB Connector (CN17)

Pin	Signal	Function	In/Out
1	VCC1	Supply +5 V to USB1	out
2	VCC2	Supply +5 V to USB2	out
3	DATA1–	Bidirectional data line for USB1	in/out
4	DATA2–	Bidirectional data line for USB2	in/out
5	DATA1+	Bidirectional data line for USB1	in/out
6	DATA2+	Bidirectional data line for USB2	in/out
7	GND	Ground	out
8	GND	Ground	out
9	Shield GND	Shield Ground	out
10	Shield GND	Shield Ground	out

Note *For proper operation at USB 2.0 speeds, be sure to use a cable that is rated for USB 2.0, such as the cable kit supplied by RTD.*

Facing the connector pins, the pinout of **CN17** is:

9	7	5	3	1
Shield GND	**GND**	**DATA1+**	**DATA1–**	**VCC1**
Shield GND	**GND**	**DATA2+**	**DATA2–**	**VCC2**
10	8	6	4	2

Ethernet (10/100/1000Base-T and -TX) Connector (CN20)

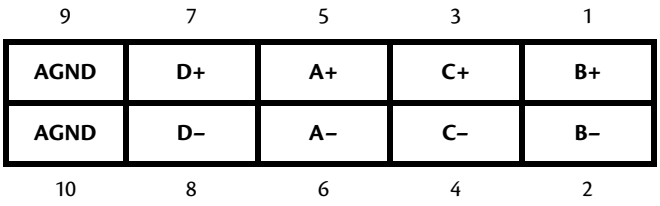
This connector provides a 10/100/1000Base-T Ethernet connection. Table 23 provides the pinout of the Ethernet connector. For 1000Base-T, all four pairs are used for transmit and receive.

To use the onboard 10/100/1000 Ethernet controller, Ethernet must be enabled in the BIOS.

When enabled, the multi-color LED will blink to indicate an Ethernet connection. For more information, refer to the *Multi-Color LED* section on page 71.

Table 23 Ethernet Connector (CN20)

RJ-45 Pin	10-Pin DIL Pin	Signal	Function
3	1	B+ (RX+)	Receive+ (10/100)
6	2	B- (RX–)	Receive– (10/100)
4	3	C+	
5	4	C-	
1	5	A+ (TX+)	Transmit+ (10/100)
2	6	A- (TX–)	Transmit– (10/100)
7	7	D+	
8	8	D-	
—	9	AGND	Ethernet Ground
—	10	AGND	Ethernet Ground



PCIe/104 Type 2 Bus (CN1 - Top and CN2 - Bottom)

Connectors **CN1** and **CN2** carry the signals of the PCIe/104 PCIe bus. These signals match definitions found in the **PCI/104-Express & PCIe/104 Specification Version 3.1** from the PC/104 Embedded Consortium. Table 24 lists the pinouts of the PC/104-Express bus connector.

WARNING *Not all PCIe cards are compatible with the PCIe/104 Type 2 connector. Be sure that all of the boards attached to this bus are compatible before powering the system.*

Table 24 PCIe/104 Type 2 Bus Signal Assignments (Top View)[1]

Pin	Signal		Signal	Pin
1	USB_OC#		PE_RST#	2
3	+3.3V[2]		+3.3V[2]	4
5	USB_1p		USB_0p	6
7	USB_1n		USB_0n	8
9	GND		GND	10
11	PEx1_1Tp *(CN2 only)*		PEx1_0Tp *(CN2 only)*	12
13	PEx1_1Tn *(CN2 only)*		PEx1_0Tn *(CN2 only)*	14
15	GND		GND	16
17	PEx1_2Tp *(CN2 only)*		PEx1_3Tp *(CN2 only)*	18
19	PEx1_2Tn *(CN2 only)*		PEx1_3Tn *(CN2 only)*	20
21	GND		GND	22
23	PEx1_1Rp *(CN2 only)*		PEx1_0Rp *(CN2 only)*	24
25	PEx1_1Rn *(CN2 only)*	+5 Volts	PEx1_0Rn *(CN2 only)*	26
27	GND		GND	28
29	PEx1_2Rp *(CN2 only)*		PEx1_3Rp *(CN2 only)*	30
31	PEx1_2Rn *(CN2 only)*		PEx1_3Rn *(CN2 only)*	32
33	GND		GND	34
35	PEx1_1Clkp *(CN2 only)*		PEx1_0Clkp *(CN2 only)*	36
37	PEx1_1Clkn *(CN2 only)*		PEx1_0Clkn *(CN2 only)*	38
39	+5V_STBY		+5V_STBY	40
41	PEx1_2Clkp *(CN2 only)*		PEx1_3Clkp *(CN2 only)*	42
43	PEx1_2Clkn *(CN2 only)*		PEx1_3Clkn *(CN2 only)*	44
45	CPU_DIR		PWRGOOD	46
47	Reserved		Reserved	48
49	Reserved		Reserved	50
51	Reserved		PSON#	52

Table 24 PCIe/104 Type 2 Bus Signal Assignments (Top View)[1]

Pin	Signal		Signal	Pin
53	STK0		STK1	54
55	GND		GND	56
57	Reserved		Reserved	58
59	Reserved		Reserved	60
61	GND		GND	62
63	Reserved		Reserved	64
65	Reserved		Reserved	66
67	GND		GND	68
69	Reserved		Reserved	70
71	Reserved		Reserved	72
73	GND		GND	74
75	Reserved		Reserved	76
77	Reserved	+5 Volts	Reserved	78
79	GND		GND	80
81	Reserved		SATA_0Tp *(CN1 only)*	82
83	Reserved		SATA_0Tn *(CN1 only)*	84
85	GND		GND	86
87	Reserved		Reserved	88
89	Reserved		Reserved	90
91	GND		GND	92
93	Reserved		Reserved	94
95	Reserved		Reserved	96
97	GND		GND	98
99	Reserved		Reserved	100
101	Reserved		Reserved	102
103	GND		GND	104

Table 24 PCIe/104 Type 2 Bus Signal Assignments (Top View)[1]

Pin	Signal		Signal	Pin
105	STK2		Reserved	106
107	GND		GND	108
109	Reserved		Reserved	110
111	Reserved		Reserved	112
113	GND		GND	114
115	Reserved		Reserved	116
117	Reserved		Reserved	118
119	GND		GND	120
121	Reserved		Reserved	122
123	Reserved		Reserved	124
125	GND		GND	126
127	Reserved		Reserved	128
129	Reserved	+12 Volts[3]	Reserved	130
131	GND		GND	132
133	Reserved		SATA_0Rp *(CN1 only)*	134
135	Reserved		SATA_0Rn *(CN1 only)*	136
137	GND		GND	138
139	Reserved		Reserved	140
141	Reserved		Reserved	142
143	GND		GND	144
145	Reserved		Reserved	146
147	Reserved		Reserved	148
149	GND		GND	150
151	Reserved		Reserved	152
153	Reserved		Reserved	154
155	GND		GND	156

1. Signals marked with (#) are active low.
2. +3.3V is not required for board operation. For power input requirements, see Table 3.
3. +12 Volts not required for operation.

PCIe/104 Type 2 Compatibility

The PCIe/104 Type 2 connector is compatible with any PCI/104-Express or PCIe/104 peripheral module that does not use the x16 Link. This includes any card that uses the PCIe x1 links, USB, or a power supply. In addition, this connector can be used to add SATA devices to the system.

If a card is installed that is not compatible with the Type 2 connector, the CPU will keep the system in soft-off, and the LED will be Cyan to indicate that there is a Bus Stacking Error.

PCIe Link Configuration

This cpuModule supports a total of four PCIe x1 links for system expansion, all of which are on the bottom-side PCIe/104 connector, **CN2**. Three of the links on **CN2** are connected directly to the chipset. The fourth link is connected through a PCIe packet switch, which shares the bandwidth of a single x1 link back to the chipset with the onboard PCIe-to-PCI bridge and the gigabit Ethernet controller. Table 25 below shows the configuration of the PCIe x1 links on CN1 and CN2.

Table 25 CN2 Link Configuration

Link	Location	Connection
Link 3	Closest to CPU	Direct
Link 2		Direct
Link 1		Direct
Link 0	Farthest from CPU	Shared

PCI-104 PCI Bus (CN16)

Connector **CN16** carries the signals of the PCI-104 PCI bus. These signals match definitions of the PCI Local Bus specification Revision 2.1. Table 26 list the pinouts of the PCI-104 bus connector.

Table 26 PCI-104 Bus Signal Assignments[1]

Pin	A	B	C	D
1	GND	+5V_STBY	+5 V	AD00
2	VIO	AD02	AD01	+5 V
3	AD05	GND	AD04	AD03
4	C/BE0#	AD07	GND	AD06
5	GND	AD09	AD08	GND
6	AD11	VIO	AD10	M66EN
7	AD14	AD13	GND	AD12
8	+3.3 V [2]	C/BE1#	AD15	+3.3 V [2]
9	SERR#	GND	PSON#	PAR
10	GND	PERR#	+3.3 V [2]	PME#
11	STOP#	+3.3 V [2]	LOCK#	GND
12	+3.3 V [2]	TRDY#	GND	DEVSEL#
13	FRAME#	GND	IRDY#	+3.3 V [2]
14	GND	AD16	+3.3 V [2]	C/BE2#
15	AD18	+3.3 V [2]	AD17	GND
16	AD21	AD20	GND	AD19
17	+3.3 V [2]	AD23	AD22	+3.3 V [2]
18	IDSEL0	GND	IDSEL1	IDSEL2
19	AD24	C/BE3#	VIO	IDSEL3
20	GND	AD26	AD25	GND
21	AD29	+5 V	AD28	AD27
22	+5 V	AD30	GND	AD31
23	REQ0#	GND	REQ1#	VIO
24	GND	REQ2#	+5 V	GNT0#
25	GNT1#	VIO	GNT2#	GND
26	+5V	CLK0	GND	CLK1
27	CLK2	+5 V	CLK3	GND
28	GND	INTD#	+5 V	RST#
29	+12 V [2]	INTA#	INTB#	INTC#
30	–12 V [2]	REQ3#	GNT3#	GND

1. Signals marked with (#) are active low.
2. +3.3 V, +12 V, and -12 V are pass-through PCI connections only

PCI-104 PCI Bus Signals

The following are brief descriptions of the PC-104 PCI bus signals.

Address and Data

AD[31:00] — Address and Data are multiplexed. A bus transaction consists of an address cycle followed by one or more data cycles.

C/BE[3:0]# — Bus Command/Byte Enables are multiplexed. During the address cycle, the command is defined. During the Data cycle, they define the byte enables.

PAR — Parity is even on AD[31:00] and C/BE[3:0]# and is required.

Interface Control Pins

FRAME# — Frame is driven by the current master to indicate the start of a transaction and will remain active until the final data cycle.

TRDY# — Target Ready indicates the selected devices ability to complete the current data cycle of the transaction. Both IRDY# and TRDY# must be asserted to terminate a data cycle.

IRDY# — Initiator Ready indicates the master's ability to complete the current data cycle of the transaction.

STOP# — Stop indicates the current selected device is requesting the master to stop the current transaction.

DEVSEL# — Device Select is driven by the target device when its address is decoded.

IDSEL[3:0] — Initialization Device Select is used as a chip-select during configuration.

LOCK# — Lock indicates an operation that may require multiple transactions to complete.

Error Reporting

PERR# — Parity Error is for reporting data parity errors.

SERR# — System Error is for reporting address parity errors.

Arbitration (Bus Masters Only)

REQ[3:0]# — Request indicates to the arbitrator that this device desires use of the bus.

GNT[3:0]# — Grant indicates to the requesting device that access has been granted.

System

CLK — Clock provides timing for all transactions on the PCI bus.

RST# — Reset is used to bring PCI-specific registers to a known state.

Interrupts

INTA# — Interrupt A is used to request Interrupts.

INTB# — Interrupt B is used to request Interrupts only for multi-function devices.

INTC# — Interrupt C is used to request Interrupts only for multi-function devices.

INTD# — Interrupt D is used to request Interrupts only for multi-function devices.

Power Supplies and VIO

+5 V — +5 V supply connected to the Auxiliary Power Connector (**CN3**) +5 V supply input.

+12 V — Pass-through +12 V supply; not connected on this cpuModule

–12 V — Pass-through –12 V supply rail; not used on this cpuModule

+3.3 V — Pass-through +3.3 V supply rail; not used on this cpuModule

VIO — This signal is typically the I/O power to the bus drivers on a PCI bus card, or used by the clamp diodes on a PCI bus card. This is always driven by the cpuModule. By default, the signaling level is set to +3.3 V. For information on configuring VIO for +5 V, contact RTD Technical Support.

WARNING *The power +5 V and +12 V power rails are the only supply inputs required for board operation. However, while the PCI bus connector (**CN16**) has +5 V and +12 V pins, the +12 V pin is not connected, as the pin does not meet the cpuModule's current requirement. for +12 V. The cpuModule must be powered by either one of the PCIe/104 Type 2 Connectors (**CN1** or **CN2**) or the Auxiliary Power Connector (**CN3**) to operate. If the cpuModule is only connected via the PCI connector, the cpuModule's LED will turn red, indicating that the +12 V input rail is not present.*

ATX Power Management Signals (optional)

If an ATX power supply is connected to the system, the following signals listed below may be used to wake the system from low power modes. For more information on these signals, refer to the *Power Management* section on page 69.

+5V_STBY — Some low power modes require that +5 V standby power is applied to the cpuModule during the wake event. This signal is an input to the CPU.

PME# — Power Management Event input

PSON# — This is an active low open-drain output used to turn the power supply on when the system is exiting a low power state.

Optional RTC Battery Input (CN13)

The optional RTC battery input is the connection for an external backup battery. This battery is used by the cpuModule when system power is removed in order to preserve the date and time of the real time clock.

Connecting a battery is only required to maintain time when power is completely removed from the cpuModule. A battery is not required for board operation.

Table 27 Optional RTC Battery Input (CN13)

Pin	Signal	Function
1	BAT	RTC Battery Input
2	GND	Ground

WARNING *This optional RTC battery connector (**CN13**) should be left unconnected if the Utility Port 2.0 connector (**CN5**) has a battery connected.*

Reserved (CN15)

Reserved (CN15) should be left unconnected.

Chapter 4 Using the cpuModule

This chapter provides information for users who wish to develop their own applications programs for the CML24BT cpuModule.

This chapter includes information on the following topics:

The RTD Enhanced BIOS — page 58

Operating System Specific Usage — page 60

Non-Standard Serial Port Modes — page 61

Advanced Digital I/O Ports (aDIO™) — page 62

SATA Controller Configuration — page 66

Watchdog Timer Control — page 67

Thermal Management — page 68

Power Management — page 69

Multi-Color LED — page 71

Trusted Platform Module — page 74

Features and Settings That Can Affect Boot Time — page 75

System Recovery — page 76

The RTD Enhanced BIOS

The RTD Enhanced BIOS is software that interfaces hardware-specific features of the cpuModule to an operating system (OS). Physically, the BIOS software is stored in a Flash EPROM on the cpuModule. Functions of the BIOS are divided into two parts.

The first part of the BIOS is known as POST (power-on self-test) software, and it is active from the time power is applied until an OS boots (begins execution). POST software performs a series of hardware tests, sets up the machine as defined in Setup, and begins the boot of the OS.

The second part of the BIOS is known as the CORE BIOS. It is the normal interface between cpuModule hardware and the OS which is in control. It is active from the time the OS boots until the cpuModule is turned off. The CORE BIOS provides the system with a series of software interrupts to control various hardware devices.

Configuring the RTD Enhanced BIOS

The cpuModule Setup program allows you to customize the cpuModule's configuration. Selections made in Setup are stored on the board and are read by the BIOS at power-on.

Entering the BIOS Setup through the Graphical BIOS Menu

You can run Setup by rebooting the cpuModule and repeatedly pressing the **ESC** key. This will bring to you to a graphical BIOS menu with several options described in the table below.

To enter Setup, navigate to the **SCU** option with the arrow keys, and press **Enter**.

Table 28 Graphical BIOS Menu Options

Key	Function
Continue	Exit the graphical menu, and proceed with booting
Boot Manager	Select a device to boot to during the current power cycle, and overrde the selected boot device order in the Setup
Device Management	Set the primary video BIOS during the current power cycle, and view a list of the system's detected devices (disk, video, network, input, etc.)
Boot From File	Displays a list of bootable files in the system
SCU	Traditional BIOS Setup

Field Selection

To move between fields in Setup, use the keys listed below. When you are finished with Setup, save your changes and exit. The system will automatically reboot.

Table 29 Setup Keys

Key	Function
F1	Help
→, ←, ↓, ↑	Move between fields
F5, F6	Selects next/previous values in fields
Enter	Go to the submenu for the field
ESC	To previous menu then to exit menu
F9	Load Setup defaults
F10	Save settings and exit Setup

Main Menu Setup Fields

The following is a list of Main Menu Setup fields.

Table 30 Main Menu Setup Fields

Field	Active Keys	Selections
Main	Press **Enter** to select	Access system information such as the cpuModule's serial number, CPU speed and type, BIOS version, FPGA version, and CMOS time and date settings
Advanced	Press **Enter** to select	Setup advanced RTD cpuModule features, including boot options, aDIO and serial port configuration, and miscellaneous feature control.
Security	Press **Enter** to select	Setup the supervisor and access password
Boot	Press **Enter** to select	Set the system boot sequence
Power	Press **Enter** to select	Set up various power savings modes
Exit	Press **Enter** to select	Save or discard changes and exit the BIOS, or load the default BIOS settings

Note *Future BIOS versions may have slightly different setup menus and options.*

Note *The **Main** page shows the cpuModule's **serial number**, **BIOS Version**, and **FPGA Version**. These numbers can be useful if you need techsupport for your cpuModule.*

WARNING *Incorrect modifications to the BIOS can cause your system to break. If you are unsure of any changes made to the BIOS there is a **Load RTD Defaults** option under the **Exit** tab in the **SCU**. This option restores the BIOS to the default factory settings.*

Operating System Specific Usage

Windows®

The CML24BT is fully supported under Windows 10 and Windows 7. Both 32 bit and 64 bit editions are supported. Drivers for onboard peripherals such as video and Ethernet are provided on thecompanion DVD that is shipped with the board. Updated drivers may be available for download from the RTD website. (www.rtd.com)

Linux®

The CML24BT is fully supported with Linux kernel version 3.11 and onward. Earlier versions of the kernel may not contain drivers for all chipset features (most notably SATA), and may not work as expected.

At the time of publication, RTD has validated openSUSE 13.1, openSUSE 13.2, and Ubuntu 15.10 (all 64-bit) on this platform. However, any standard PC Linux distribution with a 3.11 or newer kernel is expected to work.

UEFI OS Installations

When dealing with UEFI OS installations, the BIOS setting for “EFI/Legcy Device Order” will need to be changed to "EFI devices first”. The default boot order is to boot to “Legacy devices first”, which will render the OS unbootable after an installation.

Non-Standard Serial Port Modes

It is possible to change the input clock rate for the UARTs of the cpuModule to allow the serial ports to operate at higher speeds than 115,200 bps. This is accomplished by modifying the baud rate multiplier for each serial port.

Non-standard baud rates are supported for all COM port modes of the CML24BT. :

Table 31 Baud Rate Multiplier Registers

Connector	Port	Address Range (hex)
CN7 (A)	COM 1	EE0–EE1h
CN7 (B)	COM 3	EE2–EE3h
CN8 (A)	COM 2	EE4–EE5h
CN8 (B)	COM 4	EE6–EE7h

To set an alternate maximum baud rate for a serial port, write the value which corresponds to the desired multplier to the port's baud rate multiplier register:

Table 32 Baud Rade Multipliers

Value	Maximum Baud Rate	
	bps	Multiplier
0x0E28	115,200	1x
0x38A0	460,800	4x
0x713F	921,600	8x
0x7AE1	1,000,000	8.7x

Note *When using the non-standard high speed serial port modes, it is highly recommended to use hardware flow control, whenever possible.*

Advanced Digital I/O Ports (aDIO™)

This board supports 12 bits of TTL/CMOS compatible digital I/O (TTL signaling). These I/O lines are grouped into two ports, Port 0 and Port 1. Port 0 is bit programmable; Port 1 is byte programmable. Port 0 supports RTD's Advanced Digital Interrupt modes. The three modes are strobe, match and event. Strobe mode generates an interrupt and latches Port 0 when the strobe input transitions from low to high. Match mode generates an interrupt when an 8-bit pattern is received in parallel that matches the match mask register. Event mode generates an interrupt when a change occurs on any bit. In any mode, masking can be used to monitor selected lines.

When the CPU boots, all digital I/O lines are programmed as inputs, meaning that the digital I/O line's initial state is undetermined. If the digital I/O lines must power up to a known state, an external 10 k-Ohm resistor must be added to pull the line high or low.

The 8-bit control read/write registers for the digital I/O lines are located from I/O address EC0h to EC3h. These registers are written to zero upon power up. From EC0h to EC3h, the name of these registers are **Port 0 data**, **Port 1 data**, **Multi-Function**, and **DIO-Control** register.

Note *While the 16-pin aDIO connector is pin-for-pin compatible with previous generations of RTD cpuModules (such as the Montevina series), the hardware is slightly different, and requires that writes ands reads to/from the aDIO ports happen no more than once per millisecond. Migrating legacy software to the E3800 Series that utilizes RTD's Advanced Digital I/O may require that you add this delay prior to all reads and writes.*

Note *RTD provides drivers that support the aDIO interface on popular operating systems. RTD recommends using these drivers instead of accessing the registers directly.*

Digital I/O Register Set

Table 33 Port 0 Data I/O Address EC0h

D7	D6	D5	D4	D3	D2	D1	D0
P0.7	P0.6	P0.5	P0.4	P0.3	P0.2	P0.1	P0.0

Port 0 Data register is a read/write bit direction programmable register. A particular bit can be set to input or output. A read of an input bit returns the value of port 0. A read of an output bit returns the last value written to Port 0. A write to an output bit sends that value to port 0.

Table 34 Port 1 Data I/O Address EC1h

D7	D6	D5	D4	D3	D2	D1	D0
Reserved	Reserved	Reserved	Reserved	P1.3	P1.2	P1.1	P1.0

Port 1 Data register is a read/write byte direction programmable register. A read on this register when it is programmed to input will read the value at the aDIO connector. A write on this register when it is programmed as output will write the value to the aDIO connector. A read on this register when it is set to output will read the last value sent to the aDIO connector.

Table 35 Multi-Function I/O Address EC2h

D7	D6	D5	D4	D3	D2	D1	D0

The multi-function register is a read/write register whose contents are set by the DIO-Control register. See the DIO-Control register description for a description of this register.

Table 36 DIO-Control I/O Address EC3h—Read Access

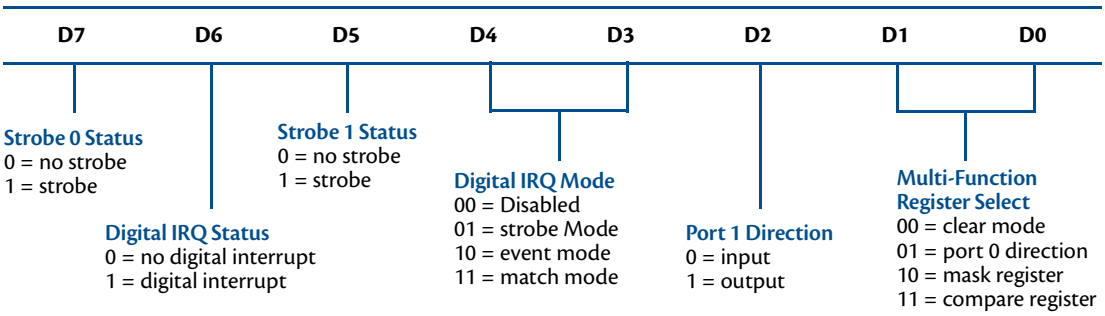


Table 37 DIO-Control I/O Address EC3h—Write Access

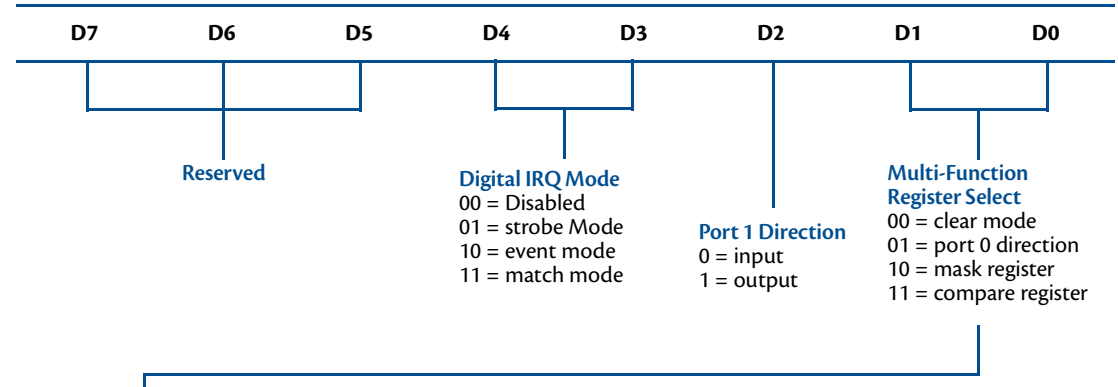


Table 38 Multi-Function at Address EC2h[1]

read/write	00 clear	X	X	X	X	X	X	X	X
0 in, 1 out	01 Port 0 direction	I/O	I/O	I/O	I/O	I/O	I/O	I/O	I/O
0 no mask, 1 mask	10 DIO mask	M7	M6	M5	M4	M3	M2	M1	M0
read/write	11 compare	C7	C6	C5	C4	C3	C2	C1	C0

1. Contents based on bits D0 and D1 of DIO-Control.

Clear Register:

A read to this register Clears the IRQs and a write to this register sets the DIO-Compare, DIO- Mask, DIO-Control, Port 1, and Port 0 to zeros. A write to this register is used to clear the board.

Port 0 Direction Register:

Writing a zero to a bit in this register makes the corresponding pin of the aDIO connector an input. Writing a one to a bit in this register makes the corresponding pin of the aDIO connector an output.

Mask Register:

Writing a zero to a bit in this register will not mask off the corresponding bit in the DIO-Compare register. Writing a one to a bit in this register masks off the corresponding bit in the DIO-Compare register. When all bits are masked off the aDIOs comparator is disabled. This condition means Event and Match mode will not generate an interrupt. This register is used by Event and Match modes.

Compare Register:

A Read/Write register used for Match Mode. Bit values in this register that are not masked off are compared against the value on Port 0. A Match or Event causes bit 6 of DIO-Control to be set and if the aDIO is in Advanced interrupt mode, the Match or Event causes an interrupt.

Port 1 Data register is a read/write byte direction

Interrupts

In order to use an interrupt with aDIO, the interrupt must first be selected in the BIOS setup utility under **Advanced, RTD Advanced Options,RTD aDIO, aDIO Interrupt**. The Digital I/O can use interrupts 3, 5, 6, 10, and 11. To configure the aDIO interrupt, navigage to the BIOS Setup option, the “Advanced”, “RTD aDIO”, and “aDIO Interrupt” menu options. The BIOS will automatically reserve the selected interrupt so that is it not assigned to PCI devices. Then, select the appropriate interrupt mode in the DIO Control register.

Advanced Digital Interrupts

There are three Advanced Digital Interrupt modes available. These three modes are Event, Match, and Strobe. The use of these three modes is to monitor state changes at the aDIO connector. Interrupts are enabled by writing to the **Digital IRQ Mode** field in the **DIO-Control** register.

Event Mode

When this mode is enabled, Port 0 is latched into the DIO-Compare register. The aDIO circuitry includes deglitching logic. To enter Event mode, set bits [4:3] of the DIO-Control register to “10”.

Match Mode

When this mode is enabled, Port 0 is latched into the DIO-Compare register. The aDIO circuitry includes deglitching logic. To enter Match mode, set bits [4:3] of the DIO-Control register to “11”.

Note *Make sure bits [4:3] are set BEFORE writing the DIO-Compare register. If you do not set them first, the contents of the DIO-Compare register could be lost because the Event mode latches in Port 0 into the DIO-Compare register.*

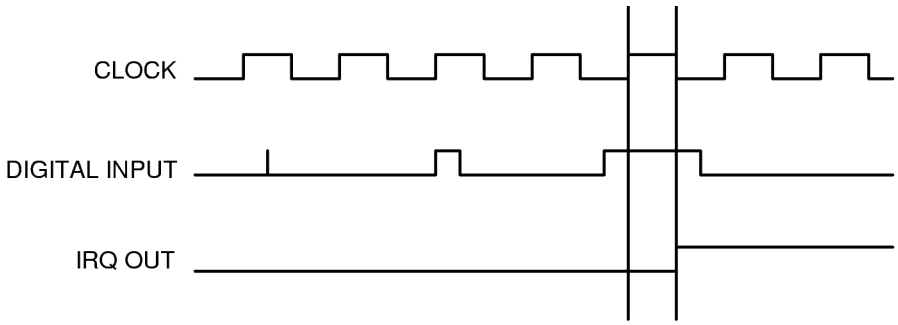


Figure 6 aDIO Match Mode

Strobe Mode

Another interrupt mode supported by aDIO is Strobe mode. This allows the strobe pin of the DIO connector to trigger an interrupt. A low to high transition on the strobe pin will cause an interrupt request. The request will remain high until the Clear Register is read from. Additionally, the Compare Register latched in the value at Port 0 when the Strobe pin made a low to high transition. No further strobes will be available until a read of the Compare Register is made. You must read the Compare Register, and then clear interrupts so that the latched value in the compare register is not lost. To enter Strobe mode, set bits [4:3] of the DIO-Control register to “01”.

SATA Controller Configuration

The CML24BT has two SATA links. One SATA link resides on the top PCIe/104 Type 2 connector (**CN1**), and the second SATA link connects to the onboard SATA storage. Both may be enabled or disabled through the BIOS setup.

SATA Port Mappings, by Connector

Table 39 shows the SATA port configuration of the CML24BT cpuModule:

Table 39 SATA Port Layout

Designator	Physical Position, Index	E3800 Port Index	Channel Assignment (Legacy IDE Mode)
CN1	SATA PCIe link 0	0	Primary Master
n/a	Onboard SATA storage	1	Primary Slave

Onboard SATA Storage

The cpuModule was designed to be used in embedded computing applications. In such environments, rotating media like hard disks and floppy disks are not very desirable. It is possible to eliminate rotating storage devices by placing your operating system and application software into the cpuModule's onboard SATA storage.

The onboard SATA storage supports write protection. Write protection is disabled by default and can be enabled with a menu option in the BIOS setup.

SATA Links on the PCIe/104 Type Connectors

Both SATA links are connected tothe Intel E3800 CPU's SATA controller which can be configured for either ACHI or IDE mode through the BIOS . However, the operating system must support the selected mode for the device to operate correctly. The default configuration for the controller is ACHI mode.

When in IDE mode, the user has an additional option to change the IDE emulation mode to Native Mode or Legacy Mode.When the SATA controller is configured for IDE mode, Native Mode is the default IDE emulation mode.

Native IDE Mode

Native Mode allows more flexibility than Legacy Mode, as it permits the system to modify the resources used by the SATA controller. When in Native Mode, the SATA controller only requires a single IRQ. Unlike Legacy Mode, this IRQ may be changed by the user or the operating system for better distribution of the system IRQs. When IRQs in the system are more evenly distributed, interrupt latency is minimized. The base address of the controller may also be modified.

Legacy IDE Mode

When in this mode, the controller will be fixed to use two interrupts: IRQs 14 and 15. Similarly, the I/O address of the controller will be fixed in the system. When in Legacy Mode, only a primary and secondary channel may be used in the system.

Watchdog Timer Control

The cpuModule includes a Watchdog Timer, which provides protection against programs "hanging", or getting stuck in an execution loop where they cannot respond correctly. The watchdog timer consists of a counter, a reset generator, and an interrupt generator. When the counter reaches the interrupt time-out, it can generate an interrupt. When the counter reaches the reset time-out, the system is reset. The counter is "refreshed," or set back to zero by reading from a specific register. The watchdog can also be put into an "inactive" state, in which no resets or interrupts are generated.

The ability to generate an interrupt allows the application to gracefully recover from a bad state. For example, consider a system that has a reset time-out of 2 seconds, interrupt time-out of 1 second, and the watchdog timer is refreshed every 0.5 seconds. If something goes wrong, an interrupt is generated. The Interrupt service routine then attempts to restart the application software. If it is successful, the application is restarted in much less time than a full reboot would require. If it is not successful, the system is rebooted.

Due to system latency, it is recommended that the Watchdog be refreshed at about half of the reset time-out period, or half of the interrupt time-out period, whichever is applicable.

Register Description

The Advanced Watchdog Timer has a Setup Register and a Runtime Register. The Setup Register is set by the BIOS, and can be adjusted by entering the BIOS Setup Utility, and going to "Advanced", "RTD Advanced Options", "RTD Miscellaneous Feature Control". The Setup Register may also be read by the driver to determine if the Watchdog is enabled, and the interrupt and base address that it is using.

Note *Enabling the watchdog timer in the BIOS does not actually arm it. The watchdog timer can be armed by accessing I/O address E85h, as explained below.*

Table 40 Advanced Watchdog Setup Register E8Bh

D7	D6	D5	D4	D3	D2	D1	D0
Reserved				WDT_IRQ Select Interrupt for WDT 000 = Disabled 001 = IRQ5 010 = Reserved 011 = IRQ10 100 = IRQ11 101 = Reserved 110 = IRQ3 111 = IRQ6			Reg_Enable 0 = Watchdog timer is disabled and Runtime Register will not appear in I/O map 1 = Watchdog Timer is enabled. Runtime Register will appear in I/O map

Table 41 Advanced Watchdog Runtime Register E85h

D7	D6	D5	D4	D3	D2	D1	D0
WDT_Active 0 = Watchdog timer is disabled. 1 = Watchdog is armed and can generate resets and interrupts.	WDT_IRQ_Ena 0 = Watchdog interrupt is disabled. 1 = Watchdog interrupt is enabled.	Reserved		WDT_IRQ_Time Select Interrupt time for WDT 00 = 0.25s 01 = 0.50s 10 = 0.75s 11 = 1.00s		WDT_RST_Time Select Reset time for WDT 00 = 2.00s 01 = 0.50s 10 = 0.75s 11 = 1.00s	

Reading the Runtime Register also refreshes the watchdog timer.

Thermal Management

The cpuModule has several thermal features which can be used to monitor and control the board's temperature when extreme operating conditions are prevalent.

Thermal Warning

The cpuModule includes a Thermal Warning mechanism which will assert a signal when the processor's temperature has reached or exceeded 100 C. At this time, a bit will be set in the reset and event status register to indicate that this temperature has been entered. Although the LED has turned white and a thermal warning bit has been set, the CPU will maintain the current power and operating state.

For more information on the reset status register, refer to *Reset and Event Status Register* — page 72.

ACPI-Enforced Thermal Protection

When the maximum thermal junction temperature of the prcoessor is reached, the system is at risk of malfuctioning, and the cpuModule may become permanently damanged.

For operating system with ACPI support, the system offers two mechanisms to help prevent the processor from reaching its maximum thermal junction temperature -- the **Critical Trip Point** and the **Passive Trip Point**. Both of these temperatures may be configured in the BIOS Setup.

Critical Trip Point

The Critial Trip Point controls the temperature at which an ACPI operating system will shut down the system. Upon entering the Critical Trip state, the operating system will issue a command to the processor, and the CML24BT will immediately transition to the **S5** (Soft-Off) ACPI power state.

To exit the Critial Trip state (and S5), the CPU temperature must be reduced to a point that the internal thermal sensors are below the Critical Trip Point. Next, a power cycle or RSM reset (deepest reset) is required. The reset button may be configured as an RSM reset (default BIOS setting) in the BIOS setup utility.

For more information on the S5 power state, refer to *Advanced Configuration and Power Interface (ACPI)* — page 69.

Passive Trip Point

The Passive Trip Point controls the temperature at which an ACPI operating system will begin to throttle the processor.

Further Temperature Reduction

The cpuModule's temperature is directly related to power consumption. Reducing the power consumption of the cpuModule will have an effect on the cpuModule's temperature. Suggested methods for reducing the cpuModule's power consumption can be found in the *Power Management* section on page 69.

Power Management

The CML24BT cpuModule supports various powering mechanisms which allow the cpuModule to monitor power consumption and temperature, and achieve minimal power consumption states. These unique features include thermal monitoring and thermal throttling, as well as ACPI low power modes. Various wake options are also available to resume normal system power.

Advanced Configuration and Power Interface (ACPI)

The cpuModule supports several different ACPI low power modes, including the S3, S4, and S5 sleeping states. These suspend modes are described below:

- **S3 (Suspend to RAM):** When the system wakes from this mode, operating systems allow applications to resume where they left off, as the state of the application is preserved in memory.
- **S4 (Hibernate):** When the system enters this state, the operating system will save the current state of applications and relevant data to disk, thus allowing the system RAM to be powered down.
- **S5 (Soft-Off):** The system is in a soft off state, and must be rebooted when it wakes.

Power Button Modes

The soft power button input of the Utility Port 2.0 connector (**CN5**) can be configured by the operating system as a suspend button (transition to S3) or as soft power button (transition to S5). Consult your operating system documentation for information on how to configure it. The power button will always cause a transition to S5 if pressed for 4 seconds or longer, without interaction from the operating system.

The soft power button of the Utility Port 2.0 connector (**CN5**) is the only mechanism to wake the system from S4 and S5.

Note *When the reset button of the Utility Port 2.0 connector is configured as a power button (via the BIOS setup utility), it inherits the ACPI suspend and resume features of the power button.*

Low-Power Wake Options

The cpuModule supports several methods of waking from a low power state.

- **Resume from USB:** Operating systems that support S3 permit waking the system from the USB interfaces. Common USB wake methods include insertion of a USB device, a USB keyboard stroke, or movement from another USB device, such as mouse.
- **Resume on RTC Alarm / Timeout:** The RTC Alarm allows the system to turn on at a certain time every day.

PME# or the PME# signal on the PCI bus (**CN16**), or

Table 42 Supported ACPI Resume/Wake Mechanisms

Resume/Wake Mechanism	S3	S4	S5
Wake from USB	Y	—	—
Wake from RTC Alarm / Timeout	Y	—	—
Power Button Input (**CN5**)	Y	Y	Y

AT vs. ATX Power Supplies

Both AT and ATX power supplies may be used with the CML24BT cpuModule, however AT power supplies do not provide any standby power to the cpuModule. When an AT power supply is used to power the system, low power modes that require a standby power to wake the system will not be fully supported.

ATX power supplies do provide a standby power, thus allowing the system to utilize all low power modes supported by the hardware. When an ATX supply is used to power the cpuModule, lower power modes can be achieved. During these low power modes, the standby power from the ATX power supply provides power to a small circuit on the CPU, which is used to watch for a system wake event.

ATX Power Supply Signals

The PCIe/104 Type 2 Bus connectors (**CN1** & **CN2**) provide two ATX style signals., +5V Standby and PSON#. The +5V Standby rail is used to power certain parts of the cpuModule when the main power supply is turned off, i.e. during Suspend-to-RAM (S3), Hibernate (S4), or Soft-Off (S5) power modes. The PSON# signal is an active low open-drain output that signals the power supply to turn on. Use of these signals allows the power consumption to drop to below 1W during standby modes, and still enable any of the wake events.

Reducing Power Consumption

In addition to the CPU's low power modes, power consumption can further be reduced by making some modifications to the BIOS setup. When the following features are disabled in the BIOS, the CPU's power consumption will decrease:

- **Ethernet**
- **USB Ports**
- **SATA Controller**
- **Serial Ports**
- **Multi-Color LED**

Multi-Color LED

The CML24BT has a Multi-Color LED which can be enabled or disabled in the BIOS setup screen. The color of the LED indicates the status of the board, as shown in Table 43.

Table 43 LED Colors

Color	Description
Green	Normal Operation
Blue	SATA Activity
Red[1]	cpuModule is in reset
Yellow (Red + Green)	cpuModule is in Standby
White (R+G+B)	cpuModule is approaching thermal limit[2]
Cyan (Blue + Green)	Ethernet Link at 100 Mbps or Bus Stacking Error
Magenta (Blue + Red)	Ethernet Link at 1000 Mbps
Blink	Ethernet Activity

1. If power is applied to the cpuModule while jumper **JP5** is installed, the LED will be red. This does not indicate that the board is in reset
2. The LED will remain White until the system is shut down.

The LED can also be controlled manually by writing to I/O Port EA7h, as shown in Table 44 and Table 45.

Table 44 Multi-Color LED I/O Address EA5h

D7	D6	D5	D4	D3	D2	D1	D0
Reserved	**Reserved**	**Reserved**	**Reserved**	**Reserved**	**Multi-Color LED**		

The following table lists the color displayed and the value written.

Table 45 Manual LED Colors

I/O Port EA7h Value	Color
0x00	Automatic (see Table 43)
0x08	Off (will reduce system power consumption)
0x09	Blue
0x0A	Green
0x0B	Cyan (Green + Blue)
0x0C	Red
0x0D	Magenta (Red + Blue)
0x0E	Yellow (Red + Green)
0x0F	White (Red + Green + Blue)

Reset and Event Status Register

The cpuModule has several different signals on board which can cause a system reset. If a reset occurs, the reset status register can be used to see which reset (or resets) have been asserted on the cpuModule. These resets may be cleared by the user.

Similar to resets, there are several signals on the cpuModule which indicate that a special event has occured. These may also be monitored and cleared by the user.

- **Examine Resets and Events**: Reading from I/O ports 0xED0h through 0xED3 will indicate if a reset has been asserted or if an event has occured. If a 1 is read, the corresponding reset has been asserted. If a 0 is read from the bit, the reset has not been asserted. For events
- **Clear Reset and Event**: Each reset and event can be cleared by writing a 1 to the selected bit of I/O port 0xED0h.

Table 46 Reset and Event Status I/O Address ED0h - Read Access

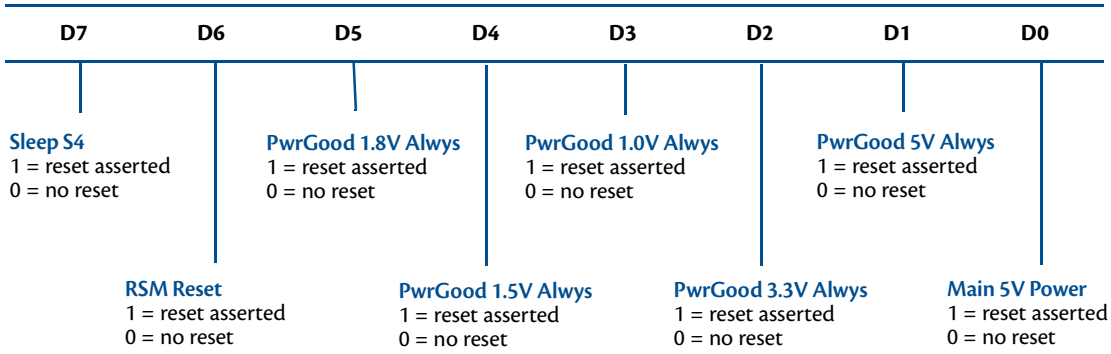


Table 47 Reset and Event Status I/O Address ED1h - Read Access

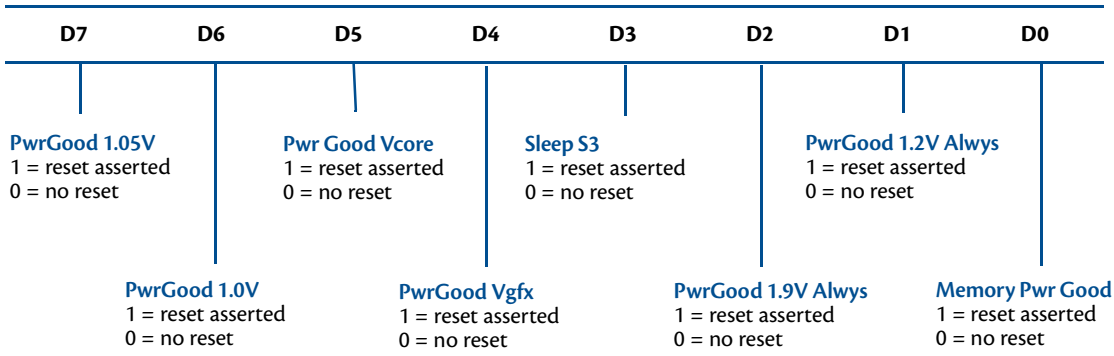


Table 48 Reset and Event Status I/O Address ED2h - Read Access

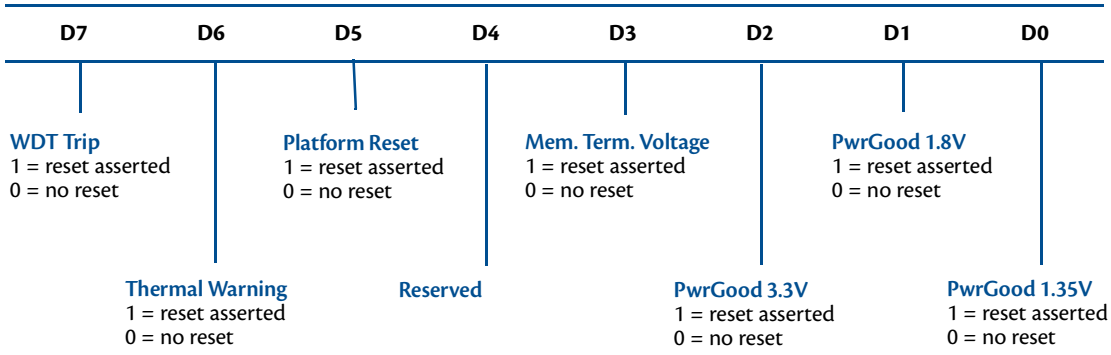
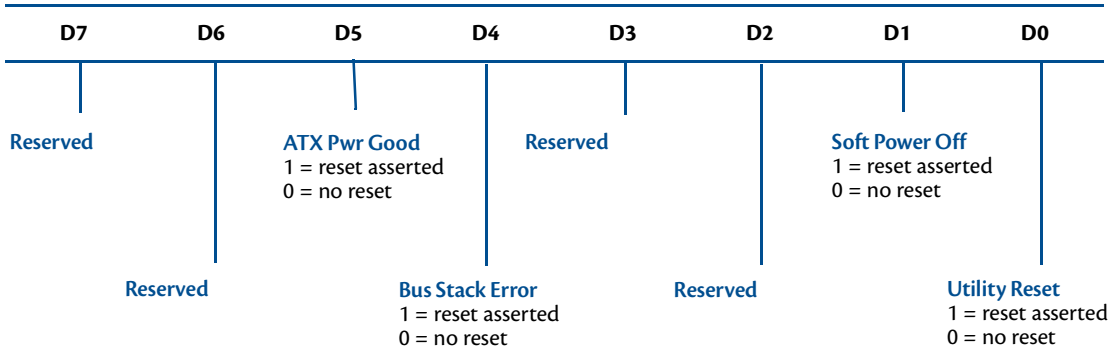


Table 49 Reset and Event Status I/O Address ED3h - Read Access



Trusted Platform Module

The CML24BT cpuModule includes a Trusted Platform Module (TPM) that is fully compliant to the Trusted Computing Group (TCG) TPM version 2.0 specifiction.

The TPM is a controller which uses hardware-based cryptography to securely store paswords, certificates, and encryption keys for authenticating the cpuModule. By enabling TPM functionality, any platform changes which may enable unauthorized access to secure areas of data or execution are denied to the user, thus making the TPM an ideal option for mission critical applications which require greater security.

For more information, refer to the Trusted Platform Module version 2.0 specification.

Features and Settings That Can Affect Boot Time

The boot time of a system is dependent upon numerous system settings as well as devices attached to a system. This section addresses some devices and settings that can increase or decrease a system's boot time.

Boot Device Order

The BIOS contains a list of devices to try booting from. If you wish to boot to a particular device (for example, a hard drive), make sure that it is first in the boot order. This will speed up boot times.

Add-On Cards With BIOS Extensions

Some add-on cards have an integrated BIOS extension. The most common examples are SCSI controllers and network cards with boot ROMs. During POST, the BIOS executes the card's extension code. This extension code is third-party code, which is beyond RTD's control. The BIOS extension will most likely increase the boot time. Exactly how much it increases boot time will depend on the particular card and firmware version.

VGA Controller

VGA controllers have a VGA BIOS that must be initialized during POST. It can take some time to initialize the VGA BIOS. Exactly how long will depend on the particular VGA controller and BIOS version.

Hard Drive Type

During Hard Drive initialization, each device must be probed. Some devices take longer to probe. 2.5-inch hard drives tend to take longer than 3.5-inch ones, because they spin at a lower RPM.

Monitor Type

Some monitors take a while to power on. Desktop flat panels are especially slow. This does not affect the actual boot time of the CPU. However, the CPU may boot before the monitor powers on.

System Recovery

Reset Button Recovery

The CML24BT provides several methods for recovering from an incorrectly configured system. In order to enter the recovery mode, follow the steps below:

1. Remove power from the system, including standby power.
2. Press and hold the reset button attached to the Utility Port 2.0 connector.
3. Apply power to the system while continuing to hold the reset button.
4. Wait the amount of time shown in Table 50 for the desired recovery mode.
5. Release the reset button, allowing the system to boot.

Table 50 Reset Button Recovery Modes

Hold Time[1]	Mode
0-4 seconds	No recovery mode. System will stay in reset while button is pressed.
4-8 seconds	Load Default BIOS Settings
8-12 seconds	Serial POST Code Output

1. To assist with timing while the reset button is pushed, the LED will blink OFF at 5 second intervals.

Load Default BIOS Settings

Loading BIOS defaults allows recovery from an incorrectly configured display device, incorrect boot options, and many other incorrect settings. It is also a good starting point when making BIOS changes. After restoring defaults, the BIOS settings should be reviewed and modified as needed.

The default BIOS can be restored either by using Reset Button Recovery, or the “Load RTD Defaults” option in the BIOS.

Serial Power-On-Self-Test (POST) Code Output

The POST Codes represent a series of events that take place in a system during the Power On Self Test. If the POST fails, the system will not boot as expected. Knowing which POST code the failure occurred may help system debug.

This recovery mode configures serial port connector **CN7** as single RS-232, and sends the POST codes on the transmit pin. The port settings are 115kbps, 8 bits, no parity, one stop bit. When using this recovery mode, the POST codes can be logged on another computer running terminal software. Contact RTD technical support for more details.

Note *POST Codes over the serial port (**CN7**) may also be enabled by installing **JP5** and **JP6** prior to power cycling the cpuModule. For more information, see Jumper Settings and Locations on page 78.*

Appendix A Hardware Reference

This appendix provides information on CML24BT cpuModule hardware, including:

Jumper Settings and Locations — page 78

Onboard PCI/PCIe Devices — page 79

Physical Dimensions — page 80

Heatsink Dimensions — page 81

Flat-Heatspreader Dimensions — page 83

Jumper Settings and Locations

Many cpuModule options are configured by positioning jumpers. Jumpers are labeled on the board as **JP** followed by a number.

Figure 7 shows the jumper locations that are used to configure the cpuModule. Table 51 lists the jumpers and their settings.

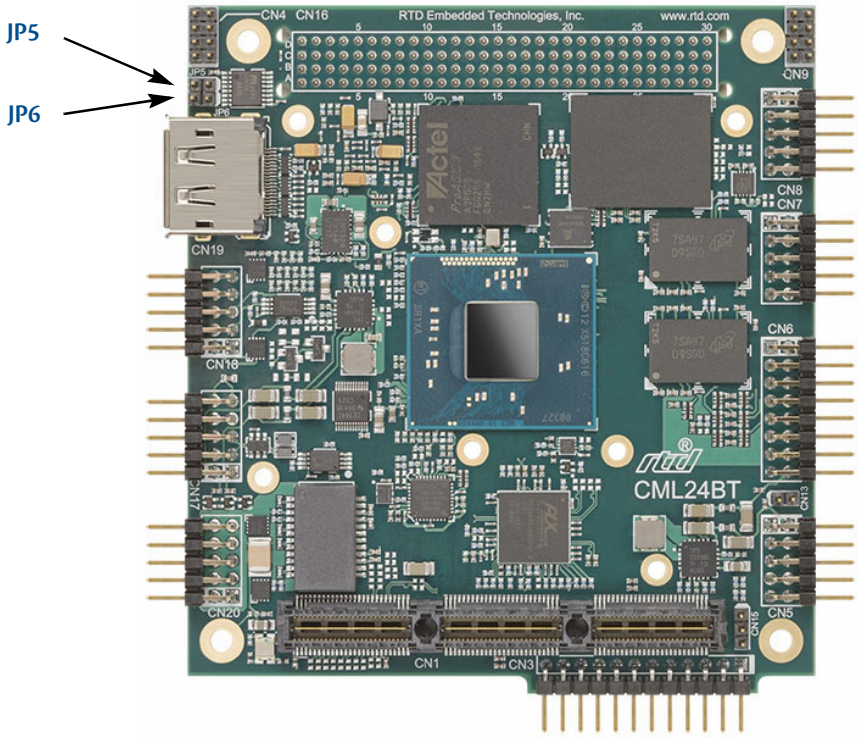


Figure 7 CML24BT Jumper Locations (top side)

Table 51 CML24BT Jumpers

Jumper	Pins	Function	Default
JP5	2	Reserved	open
JP6	2	Reserved	open
JP5 + JP6	2	Used to configure serial port connector **CN7** as single RS-232, and sends the POST codes on the transmit pin. See *Serial Power-On-Self-Test (POST) Code Output* on page 76 **pins 1–2 (JP5 and JP6)**: Enable POST Codes over Serial Port **CN7** **open**: Normal operation	open

Onboard PCI/PCIe Devices

The CML24BT cpuModule has several onboard PCI/PCIe devices, all of which are listed in the table below. This table shows a typical configuration, and the actual devices may change based on BIOS settings.

Table 52 Onboard PCI/PCIe Devices

Device ID	Vendor ID	Description
0F00	8086	Host bridge
0F04	8086	HD Audio Controller
0F31	8086	Video Controller
0F23	8086	SATA Controller (AHCI Mode)[1]
0F18	8086	Intel TXE (Trusted Execution Engine)
0F48	8086	PCI Express Root Port 1
0F4A	8086	PCI Express Root Port 2
0F4C	8086	PCI Express Root Port 3
0F4E	8086	PCI Express Root Port 4
0F34	8086	USB Controller (EHCI)
0F1C	8086	Platform Controller Unit - LPC Bridge
0F12	8086	Platform Controller Unit - SMBus Port
8605	10B5	PCI Express Packet Switch[2]
8112	10B5	PCI Express to PCI Bridge
10D3	8086	Ethernet Controller - Intel 82574 Series (**CN20**)

1.Can change if the BIOS is configured for IDE mode instead of AHCI.
2.This device may appear up to five times in PCI configuration space, depending on how many PCIe links are active.

Physical Dimensions

Figure 8 shows the mechanical dimensions of the CML24BT cpuModule.

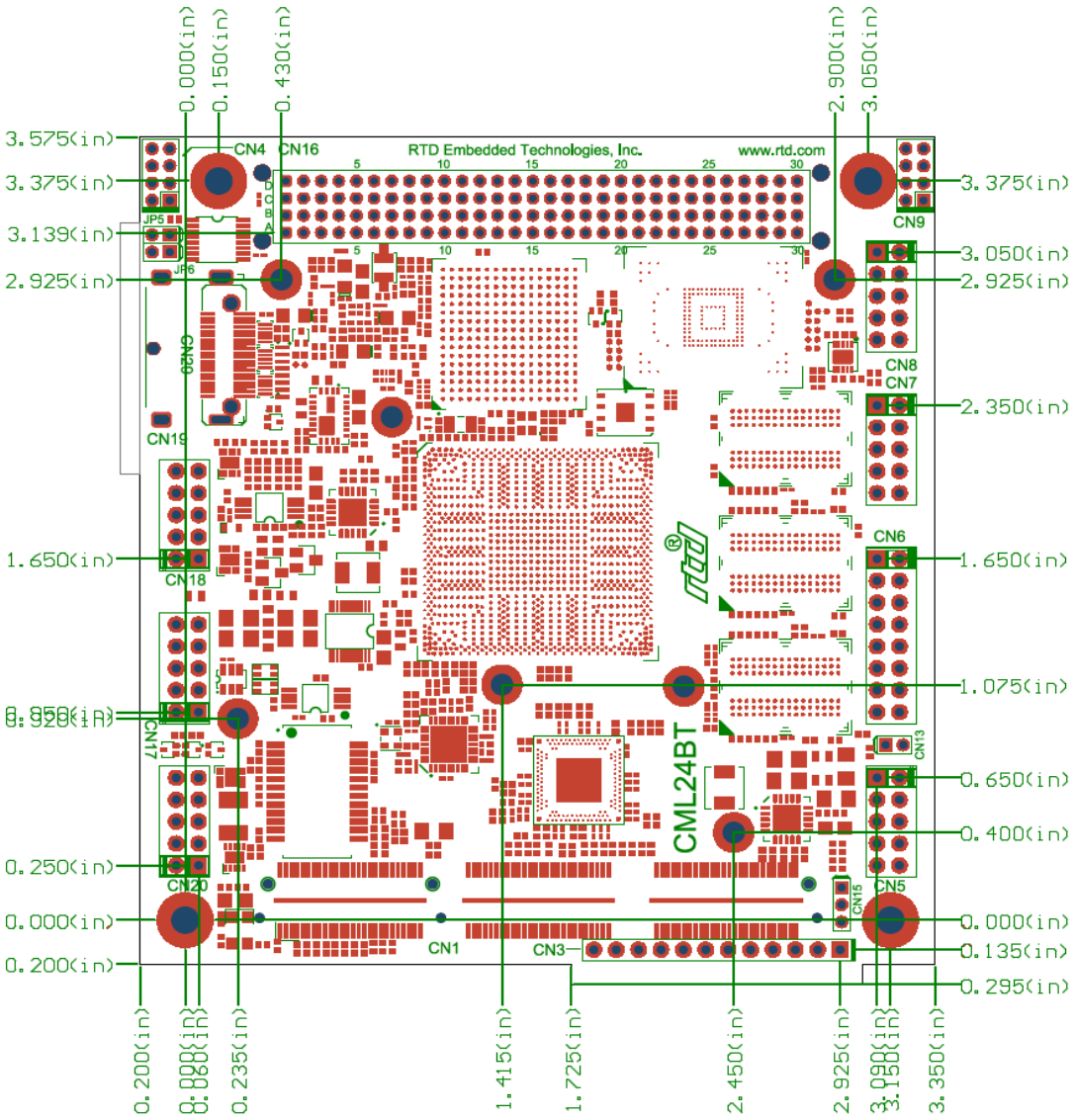


Figure 8 CML24BT Physical Dimensions (±0.005 inches)

Heatsink Dimensions

To maximize the thermal performance of the cpuModule while keeping the total board weight to a minimum, various heatsinks are offered with each ordering part number. Use the table below to correlate the heatsink figure to each ordering part number.

Table 53 CML24BT cpuModule Model Options

Part Number	Core Frequency	Stack Height	Heatsink
CML24BTS1460HR-4096/S32GX	1.46 GHz	0.600" (15.24mm)	Figure 9
CML24BTD1330HR-4096/S32GX	1.33 GHz	0.600" (15.24mm)	Figure 10
CML24BTQ1910HR-4096/S32GX	1.91 GHz	0.866" (22mm)	Figure 11

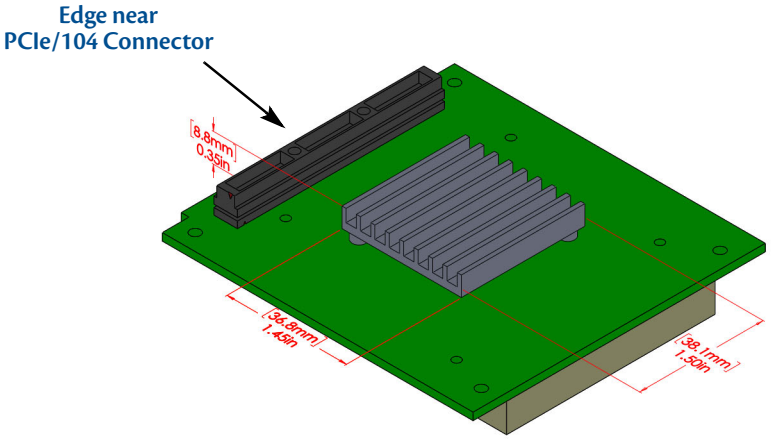


Figure 9 CML24BTS1460 Heatsink

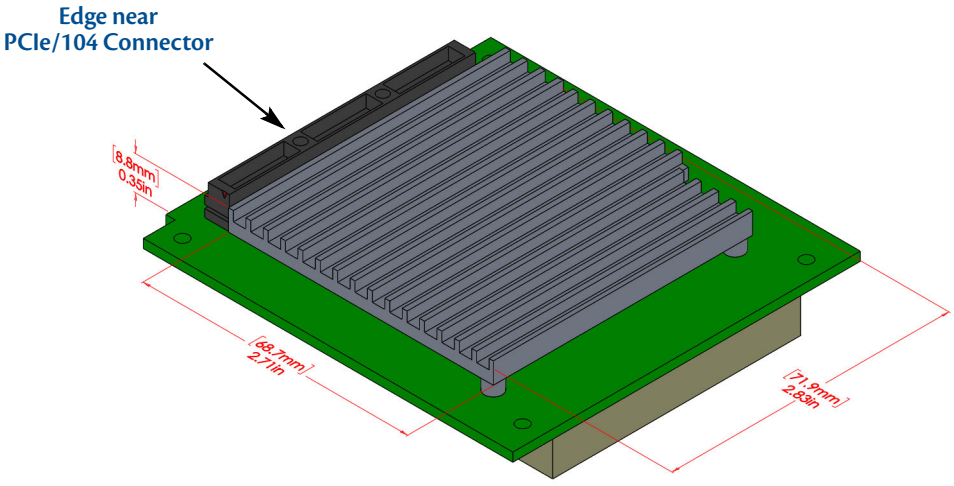


Figure 10 CML24BTD1330 Heatsink

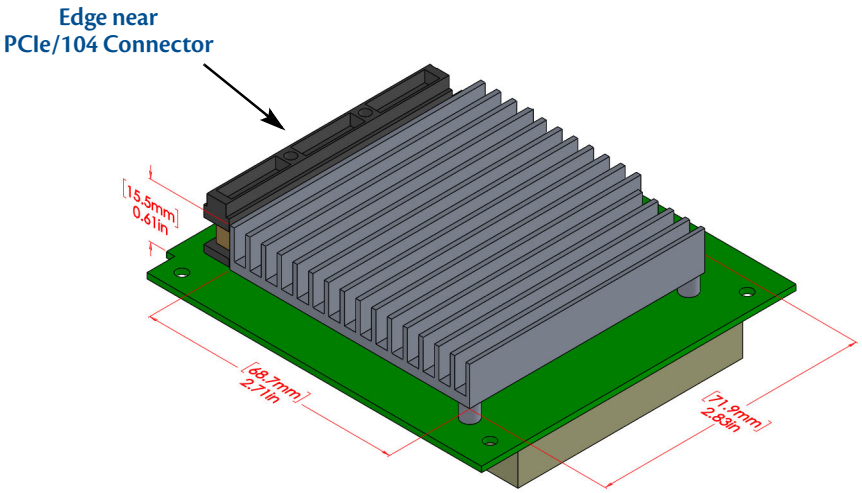


Figure 11 CML24BTQ1910 Heatsink

Flat-Heatspreader Dimensions

For cooling solutions where it is desirable to mount the cpuModule to a flat surface, the CML24BT may be ordered with a flat heatspreader instead of the standard passive heatsink. Each flat-heatspreader has five mounting locations which use 6-32 UNC x 0.207" long threaded insert.

Use the table below to correlate the heatsink figure to each ordering part number.

Table 54 CML24BT cpuModule Model Options

Part Number	Core Frequency	Stack Height	Heatspreader
CML24BTS1460HR-4096/S32GXF	1.46 GHz	0.600" (15.24mm)	Figure 12
CML24BTD1330HR-4096/S32GXF	1.33 GHz	0.600" (15.24mm)	Figure 12
CML24BTQ1910HR-4096/S32GXF	1.91 GHz	0.866" (22mm)	Figure 13

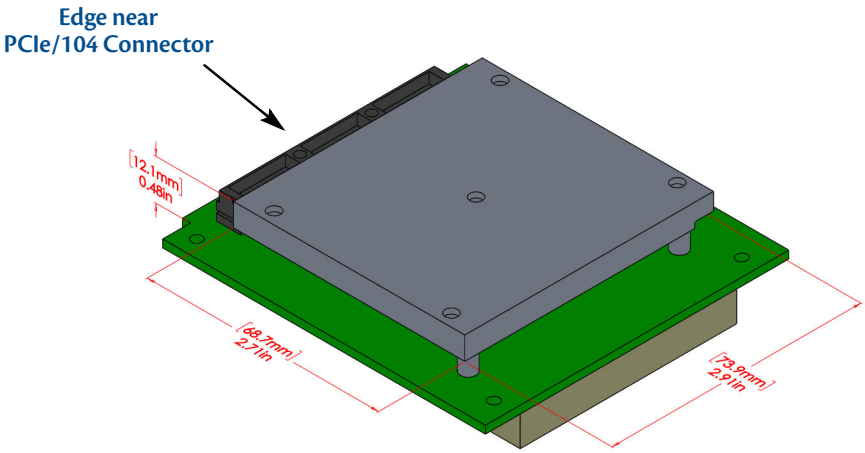


Figure 12 0.600" (15.24mm) Flat-Heatspreader

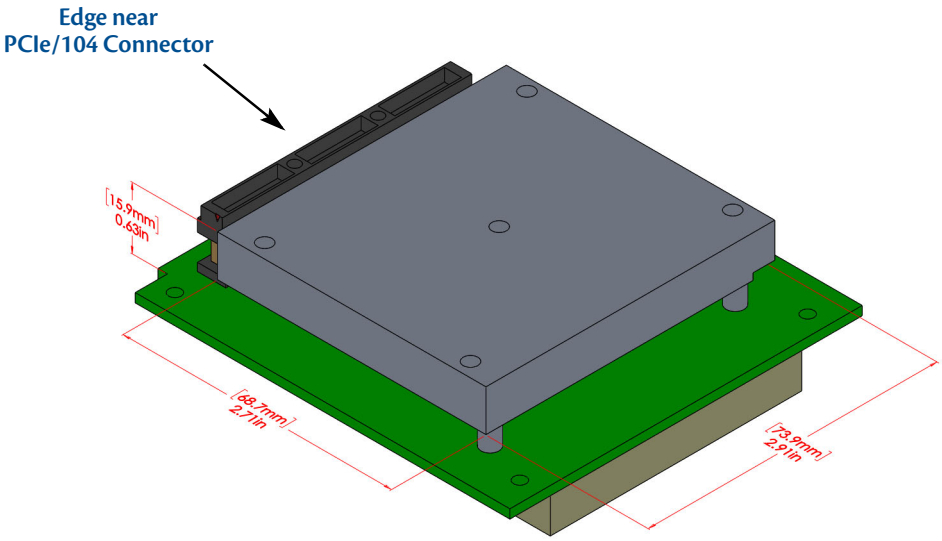


Figure 13 0.866" (22mm) Flat-Heatspreader

Appendix B Troubleshooting

Many problems you may encounter with operation of your CML24BT cpuModule are due to common errors. This appendix includes the following sections to help you get your system operating properly.

Common Problems and Solutions — page 86

Troubleshooting a PC/104 System — page 87

How to Obtain Technical Support — page 88

Common Problems and Solutions

Table 55 lists some of the common problems you may encounter while using your CML24BT cpuModule, and suggests possible solutions.

If you are having problems with your cpuModule, review this table before contacting RTD Technical Support.

Table 55 Troubleshooting

Problem	Additional Symptoms	Possible Cause(s)
cpuModule does not boot (no video output)	LED is red (in reset)	Input power is inadequate. Refer to Chapter 1, *Electrical Characteristics*. Verify input voltages are correct. If power is supplied via **CN3**, check for cabling issues.
		Malfunctioning peripheral card. Remove all peripheral cards from the system.
	LED is yellow (in standby)	cpuModule is in "Soft Off" due to operating system shutdown. Press power button to wake.
		ATX power supply is not turning on. Check jumpers on power supply. Verify PSON# signal.
	LED is cyan (bus stacking error)	See Chapter 3, *PCIe/104 Type 2 Compatibility*
	LED is green (normal operation)	cpuModule may be booted, but video is not connected properly. Attach a keyboard and verify the operation of the Num Lock and Caps Lock LEDs. If they respond as expected, the cpuModule is booted. Check the video cable connections.
		Video output may have been disabled in the BIOS. Try loading BIOS defaults per Chapter 4, *System Recovery*.
		If a PCI device is installed, the slot selection switch/jumpers may not be set correctly.
		Peripheral card may be interfering with boot sequence. Remove all peripheral cards from the system.
cpuModule reboots unexpectedly	cpuModule is running Windows	By default, Windows will automatically reboot when a Bugcheck (Blue Screen) is triggered. Disable this feature in the Control Panel. This will allow you to see the error and identify the root cause.
	cpuModule is powered via Auxiliary Power Connector (**CN3**)	Power cabling issues. Verify all pins on **CN3** are reliably connected with proper gauge wires.
		Power supply noise or current limiting. Check power pins with an oscilloscope and verify they remain in range.
		Power supply may not respond quickly enough to changes in power consumption. Switch to a different power supply (a PCI Express power supply is recommended)
	Peripheral card(s) installed	Peripheral card(s) may be overloading the power supply. Reduce the system to just the cpuModule and power supply and see if the problem re-appears. (Note that **CN3** is intended for powering the cpuModule only.)
cpuModule does not boot to USB device	USB device has a high power draw (e.g. DVD or hard drive)	Some USB devices are not fully compliant and draw too much current. Consider switching to a self-powered USB device with its own AC/DC power supply.
Date/time not saved when system is off	No RTC battery	A battery must be attached to the Utility Port 2.0 connector (**CN5**) to maintain date/time when main power is removed. For a list of alternate battery inputs, refer to *Watchdog Timer Control* — page 67.
System performance lower than expected	LED is white	cpuModule is overheating and the processor is throttling. Increase the cooling (more airflow, larger heatsink, etc).

Troubleshooting a PC/104 System

If you have reviewed the preceding table and still cannot isolate the problem with your CML24BT cpuModule, please try the following troubleshooting steps. Even if the resulting information does not help you find the problem, it will be very helpful if you need to contact technical support.

1. **Simplify the system**. Remove items one at a time and see if one particular item seems to cause the problem.
2. **Swap components**. Try replacing items in the system one-at-a-time with similar items.

How to Obtain Technical Support

If after following the above steps, you still cannot resolve a problem with your CML24BT cpuModule, please gather the following information:

- cpuModule model, BIOS version, and serial number
- List of all boards in system
- List of settings from cpuModule Setup program
- Printout of autoexec.bat and config.sys files (if applicable)
- Description of problem
- Circumstances under which problem occurs

Then contact RTD Technical Support:

Phone: 814-234-8087

Fax: 814-234-5218

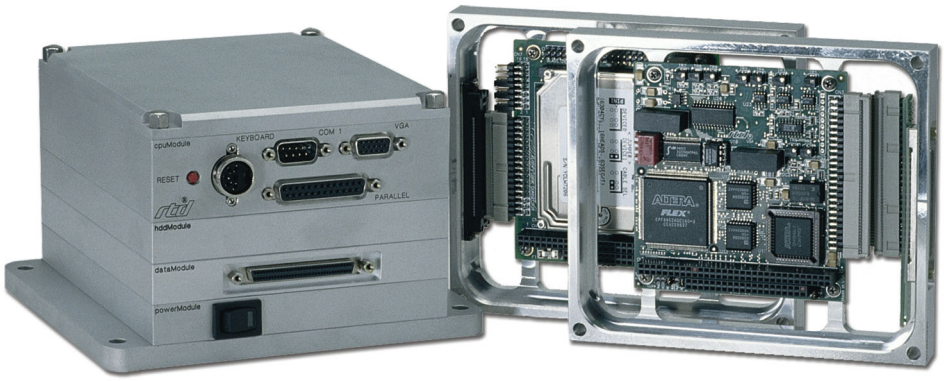
E-mail: techsupport@rtd.com

Appendix C IDAN™ Dimensions and Pinout

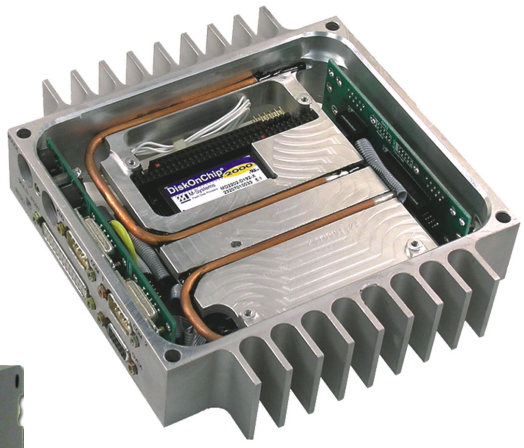
Like all other RTD PC/PCI-104 and PCIe/104 modules, cpuModules can be packaged in Intelligent Data Acquisition Node (IDAN) frames, which are milled aluminum frames with integrated heat sinks and heat pipes for fanless operation. RTD modules installed in IDAN frames are called building blocks. IDAN building blocks maintain the simple but rugged stacking concept of PC/PCI-104 and PCIe/104. Each RTD module is mounted in its own IDAN frame and all I/O connections are brought to the walls of each frame using standard PC connectors.

On the CML24BT, no connections are made from module to module internal to the system other than through the PCI-104 and PCIe/104 Type 2 buses, enabling quick interchangeability and system expansion without hours of rewiring and board redesign.

The CML24BT cpuModule can also be purchased as part of a custom-built RTD HiDAN™ or HiDAN*plus*™ High Reliability Intelligent Data Acquisition Node. This appendix provides the dimensions and pinouts of the CML24BT installed in an IDAN frame. Contact RTD for more information on high reliability IDAN, HiDAN, and HiDAN*plus* PC/PCI-104 systems.



IDAN—Adhering to the PC/PCI-104 and PCIe/104 stacking concept, IDAN allows you to build a customized system with any combination of RTD modules.



IDAN Heat Pipes—Advanced heat pipe technology maximizes heat transfer to heat sink fins.

HiDAN*plus*—Integrating the modularity of IDAN with the ruggedization of HiDAN, HiDAN*plus* enables connectors on all system frames, with signals running between frames through a dedicated stack-through raceway.

IDAN Contents

The IDAN-CML24BT contains both a CML24BT cpuModule and a **SATA34106** storage module which provides a 2.5" SATA interface to the first SATA link on the CPU's top PCIe/104 Type 2 connector (**CN1**).

Also inside the IDAN-CML24BT unit is a CMOS battery which is connected to the battery input connection of the cpuModule's Utility Port 2.0 connector. The frame of the IDAN-CML24BT brings out the cpuModule's multi-color LED as well as the cpuModule's reset button. While a power button is not provided on the exterior of the frame, the reset button is configurable as as a power button through the BIOS Setup utility.

For additional flexbility, the 25-pin "D" connector which provides connections to the cpuModule's aDIO connector (**CN6**) includes connections to several pins on the Utility Port 2.0 connector, which include the reset button input, power button input, and RTC battery input.

For more information on cpuModule's battery input and reset button input on the Utility Port 2.0 connector, refer to the *Utility Port 2.0 Connector (CN5)* on page 32.

IDAN Dimensions

The IDAN frame for the CML24BT is shown in the figure below:

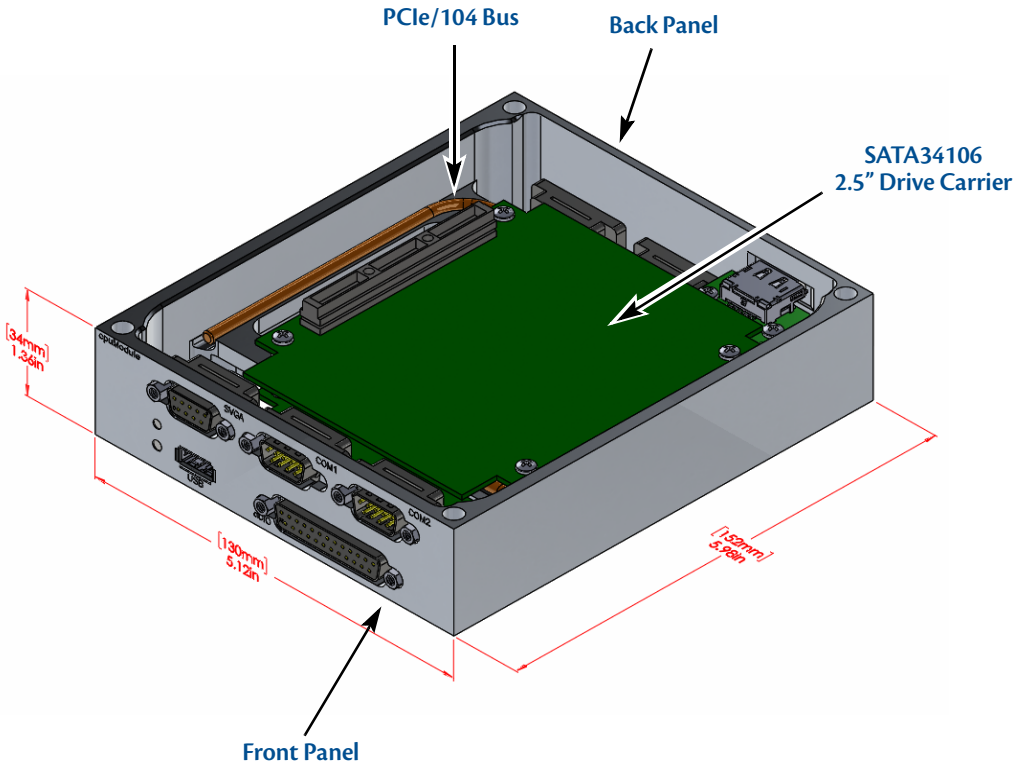


Figure 14 IDAN-CML24BT
Figure 15

IDAN Connector Locations

The diagrams below show the connector locations for the headers of the CML24BT as they are brought out on the front and back panels of the IDAN-CML24BT. For a full description of each connector on the CML24BT, refer to *Connecting the cpuModule* on page 27.

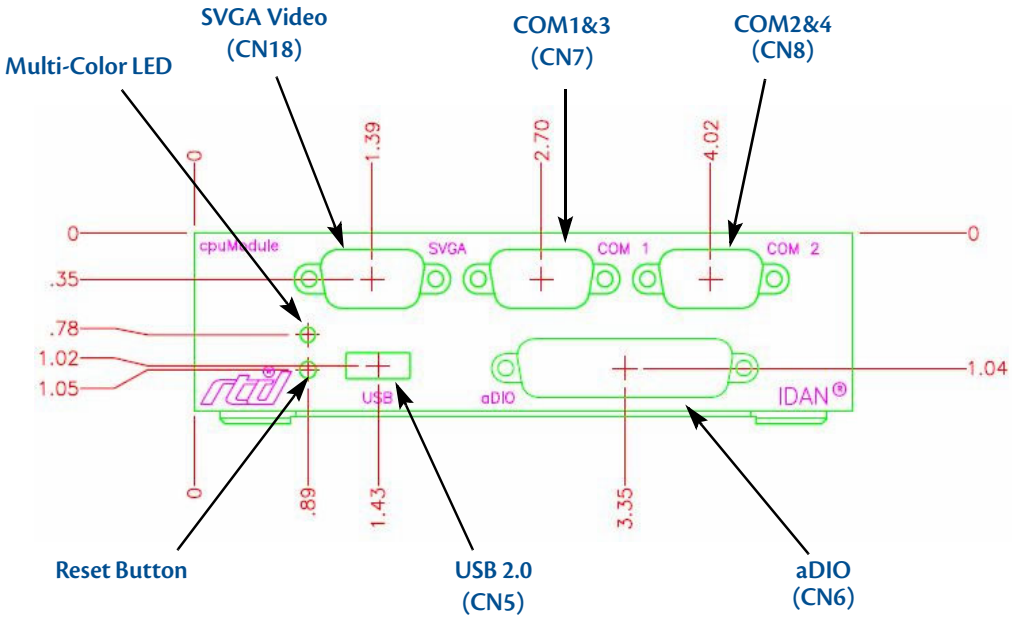


Figure 16 IDAN-CML24BT Front Panel

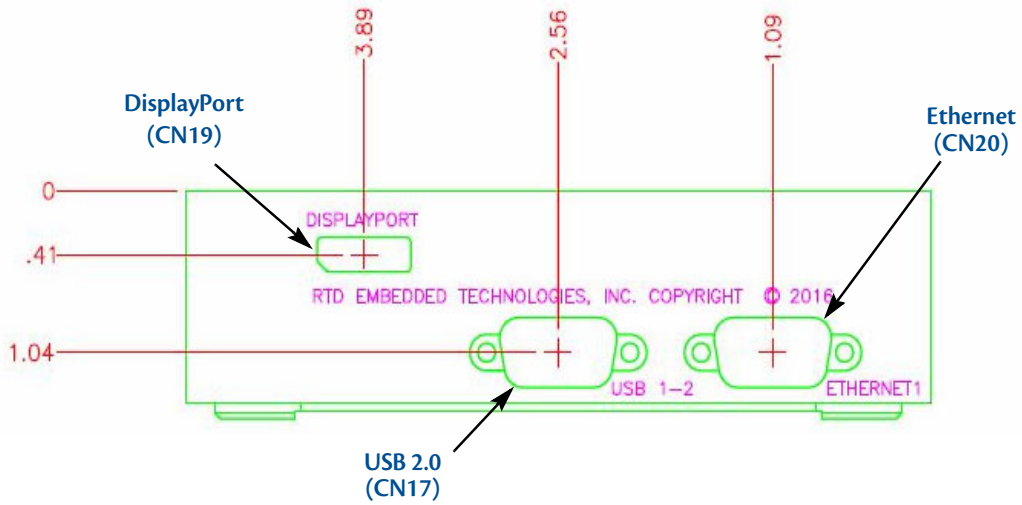


Figure 17 IDAN-CML24BT Back Panel

Table 56 IDAN-CML24BT Connectors

Designator	Function	Connector Description	IDAN Panel Connector	Mating Connector
CN5	USB Port (Utility Port 2.0)	USB Type A	Series "A" Receptacle	Series "A" Plug
CN6	aDIO	25-pin D (female)	Adam Tech DB25SD	Adam Tech DB25PD
CN7	Serial Port 1 (COM1&3)	9-pin D (male)	Adam Tech DE09PD	Adam Tech DE09SD
CN8	Serial Port 2 (COM2&4)	9-pin D (male)	Adam Tech DE09PD	Adam Tech DE09SD
CN17	USB 2.0	9-pin D (male)	Adam Tech DE09PD	Adam Tech DE09SD
CN18	Video (SVGA)	15-pin high-density D (female)	Adam Tech HDT15SD	Adam Tech HDT15PD
CN19	DisplayPort	DisplayPort (female)	Molex 47272 series	Molex 68783 series
CN20	Ethernet	9-pin D (male)	Adam Tech DE09PD	Adam Tech DE09SD

External I/O Connections

Table 57 COM1/COM2 (Single Port Mode)— 9-Pin D Connector (male)

CPU Pin	IDAN Pin (DB-9)	Single RS-232	Single RS-422	Single RS-485
1	1	DCD	TXD–	D–
2	6	DSR	—	—
3	2	RXD	TXD+	D+
4	7	RTS	—	—
5	3	TXD	RXD+	—
6	8	CTS	—	—
7	4	DTR	RXD–	—
8	9	RI	—	—
9	5	GND	GND	GND

Table 58 COM1/COM2 (Dual Port Mode)— 9-Pin D Connector (male)

CPU Pin	IDAN Pin (DB-9)	Dual RS-232	Dual RS-422	Dual RS-485
1	1	DCD1	TXD1-	D1-
3	2	RXD1	TXD1+	D1+
5	3	TXD1	RXD1+	—
7	4	RTS1	RXD1-	—
9	5	GND	GND	GND
2	6	CTS1	TXD2-	D2-
4	7	TXD2	TXD2+	D2+
6	8	RXD2	RXD2+	—
8	9	RI1	RXD2-	—

Table 59 aDIO — 25-Pin D Connector (female)

IDAN Pin #	aDIO Port	CPU Pin # (CN6)	CPU Pin # (CN5)
1	P0-0	1	—
2	P0-2	3	—
3	P0-4	5	—
4	P0-6	7	—
5	Strobe 0	9	—
6	P1-0	11	—
7	P1-2	13	—
8	GND	15	—

Table 59 aDIO — 25-Pin D Connector (female)

IDAN Pin #	aDIO Port	CPU Pin # (CN6)	CPU Pin # (CN5)
9	reserved	—	—
10	reserved	—	—
11	reserved	—	—
12	Soft Power Button Input	—	5
13	GND (for RTC Battery Input)	—	7
14	P0-1	2	—
15	P0-3	4	—
16	P0-5	6	—
17	P0-7	8	—
18	Strobe 1	10	—
19	P1-1	12	—
20	P1-3	14	—
21	+5 V	16	—
22	reserved	—	—
23	reserved	—	—
24	Push-Button Reset Input	—	3
25	RTC Battery Input	—	9

Table 60 SVGA — 15-Pin High Density D Connector (female)

IDAN Pin #	Signal	Function	CPU Pin #
1	Red	Red Analog Output	4
2	Green	Green Analog Output	6
3	Blue	Blue Analog Output	8
4	Reserved	Reserved	—
5	GND	Ground	9
6	GND	Ground	9
7	GND	Ground	9
8	GND	Ground	10
9	+5 V	+ 5 Volts	7
10	GND	Ground	10
11	Reserved	Reserved	—
12	DDC Data	Monitor data	5
13	HSYNC	Horizontal Sync	2
14	VSYNC	Vertical Sync	1
15	DDC CLK	Monitor Clock	3

Table 61 DisplayPort Connector

Pin	Signal	Standard Function	DVI / HDMI mode[1]	In/Out
1	LN0+	Main Link, Lane 0 (positive)	TMDS Channel 2 (positive)	out
2	GND	Ground	Ground	out
3	LN0-	Main Link, Lane 0 (negative)	TMDS Channel 2 (negative)	out
4	LN1+	Main Link, Lane 1 (positive)	TMDS Channel 1 (positive)	out
5	GND	Ground	Ground	out
6	LN1-	Main Link, Lane 1 (negative)	TMDS Channel 1 (negative)	out
7	LN2+	Main Link, Lane 2 (positive)	TMDS Channel 0 (positive)	out
8	GND	Ground	Ground	out
9	LN2-	Main Link, Lane 2 (negative)	TMDS Channel 0 (negative)	out
10	LN3+	Main Link, Lane 3 (positive)	TMDS Clock (positive)	out
11	GND	Ground	Ground	out
12	LN3-	Main Link, Lane 3 (negative)	TMDS Clock (negative)	out
13	CFG1	Configuration Pin 1	Cable Adapter Detect	out
14	CFG2	Configuration Pin 2	Consumer Electronics Control[2]	out
15	AUX+	Auxiliary Channel (positive)	DDC Clock	in/out
16	GND	Ground	Ground	out
17	AUX-	Auxiliary Channel (negative)	DDC Data	in/out
18	HPD	Hot Plug Detect	Hot Plug Detect	in
19	DPG	Return for DPV	Return for DPV	out
20	DPV	+3.3V DC Power	+3.3V DC Power	out

1.Requires special passive adapter
2.HDMI mode only

Facing DisplayPort connector, the pinout is:

19	17	15	13	11	9	7	5	3	1
DPG	AUX-	AUX+	CFG1	GND	LN2-	LN2+	GND	LN0-	LN0+
DPV	HPD	GND	CFG2	LN3-	LN3+	GND	LN1-	LN1+	GND
20	18	16	14	12	10	8	6	4	2

Table 62 USB — 9-Pin D Connector (male)

IDAN Pin #	Signal	Function	Mode	CPU Pin #
1	VCC1	+5 V to USB1	output	1
2	Data USB1–	USB1 Data–	input/output	3
3	Data USB1+	USB1 Data+	input/output	5
4	GND	Ground	—	7
5	Shield GND	Shield Ground	—	9
6	VCC2	+5 V to USB2	output	2
7	Data USB2–	USB2 Data–	input/output	4
8	Data USB2+	USB2 Data+	input/output	6
9	GND	Ground	—	8

Table 63 Ethernet — 9-Pin D Connector (male)

IDAN Pin #	RJ-45 Pin	Signal	CPU Pin #
1	3	B+ (RX+)	1
2	4	C+	3
3	1	A+ (TX+)	5
4	7	D+	7
5	—	Ground	9
6	6	B- (RX–)	2
7	5	C-	4
8	2	A- (TX–)	6
9	8	D-	8

Appendix D Additional Information

Application Notes

RTD offers many application notes that provide assistance with the unique feature set of the CML24BT cpuModule. For the latest application notes, refer to the RTD website.

Drivers and Example Programs

To obtain the latest versions of drivers and example programs for this cpuModule, refer to the RTD website.

Interrupt Programming

For more information about interrupts and writing interrupt service routines, refer to the following book:

Interrupt-Driven PC System Design
by Joseph McGivern
ISBN: 0929392507

Serial Port Programming

For more information about programming serial port UARTs, consult the following book:

Serial Communications Developer's Guide
by Mark Nielson
ISBN: 0764545701

PC/104 Specifications

A copy of the latest PC/104 specifications can be found on the webpage for the PC/104 Embedded Consortium:

http://www.pc104.org

Appendix E Limited Warranty

RTD Embedded Technologies, Inc. warrants the hardware and software products it manufactures and produces to be free from defects in materials and workmanship for one year following the date of shipment from RTD Embedded Technologies, Inc. This warranty is limited to the original purchaser of product and is not transferable.

During the one year warranty period, RTD Embedded Technologies will repair or replace, at its option, any defective products or parts at no additional charge, provided that the product is returned, shipping prepaid, to RTD Embedded Technologies. All replaced parts and products become the property of RTD Embedded Technologies. Before returning any product for repair, customers are required to contact the factory for a Return Material Authorization number.

This limited warranty does not extend to any products which have been damaged as a result of accident, misuse, abuse (such as: use of incorrect input voltages, improper or insufficient ventilation, failure to follow the operating instructions that are provided by RTD Embedded Technologies, “acts of god” or other contingencies beyond the control of RTD Embedded Technologies), or as a result of service or modification by anyone other than RTD Embedded Technologies. Except as expressly set forth above, no other warranties are expressed or implied, including, but not limited to, any implied warranties of merchantability and fitness for a particular purpose, and RTD Embedded Technologies expressly disclaims all warranties not stated herein. All implied warranties, including implied warranties for merchantability and fitness for a particular purpose, are limited to the duration of this warranty. In the event the product is not free from defects as warranted above, the purchaser's sole remedy shall be repair or replacement as provided above. Under no circumstances will RTD Embedded Technologies be liable to the purchaser or any user for any damages, including any incidental or consequential damages, expenses, lost profits, lost savings, or other damages arising out of the use or inability to use the product.

Some states do not allow the exclusion or limitation of incidental or consequential damages for consumer products, and some states do not allow limitations on how long an implied warranty lasts, so the above limitations or exclusions may not apply to you.

This warranty gives you specific legal rights, and you may also have other rights which vary from state to state.

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