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Ai-RIO™

Small Form-Factor Remote I/O Subsystem



Space Configuration



M&A / Defense Configuration

- ***Ai-RIO™ - Space-qualified Remote I/O Interface Unit with Mil & Aero Options***
- ***Easily Expandable and Scalable Intelligent RIO/RIU with Dual-core PowerPC Processor***
- ***Minimum Ai-RIO System - CPU and Power Supply Modules***
- ***Additional I/O and Features Expansion by Adding Standardized SFF Module "Slices"***
- ***High Performance with Extremely Low Power Dissipation, <10W (typ.)***
- ***Powerful I/O Capability, includes:***
  - ***One (1) Gb Ethernet port with IEEE-1588 Precision Time Protocol (PTP)***
  - ***Ten (10) RS-422 Serial Ports, 2 RS-422 only, 8 RS-422/485 (8 ports with individual OE)***
  - ***Eight (8) LVDS or RS-422/485 Serial Ports with OE or four (4) SpaceWire ports with LVDS I/O***
  - ***Two (2) CANbus ports***
  - ***Sixteen (16) 3.3V/5V (LV)CMOS GPIO Lines***
  - ***One (optionally two) 1PPS input port(s) for GPS Synchronization***
- ***On-board Temperature Sensors***
- ***On-board A/D Voltage & Current Monitoring with Built In Test (BIT) for High Reliability***
- ***28VDC Input Power (18 to 36V)***
- ***Micro-DSub or Compact Mil-D-38999 Front- or Side-Mount Panel Connectors***
- ***Linux and VxWorks 6.9 RTOS Support***
- ***Stand-alone RIU Command & Response Operation with Aitech's RIO-NET™ Software***
- ***Available in 100% Software Compatible, Air-Cooled Series 100 for Software Development***
- ***Conduction-Cooled Qual and Flight Units, Series 200 and 500***
- ***Radiation Tolerant Versions for LEO, MEO and GEO Missions***
- ***Low Weight - <1.3 kg (2.7 lbs)***

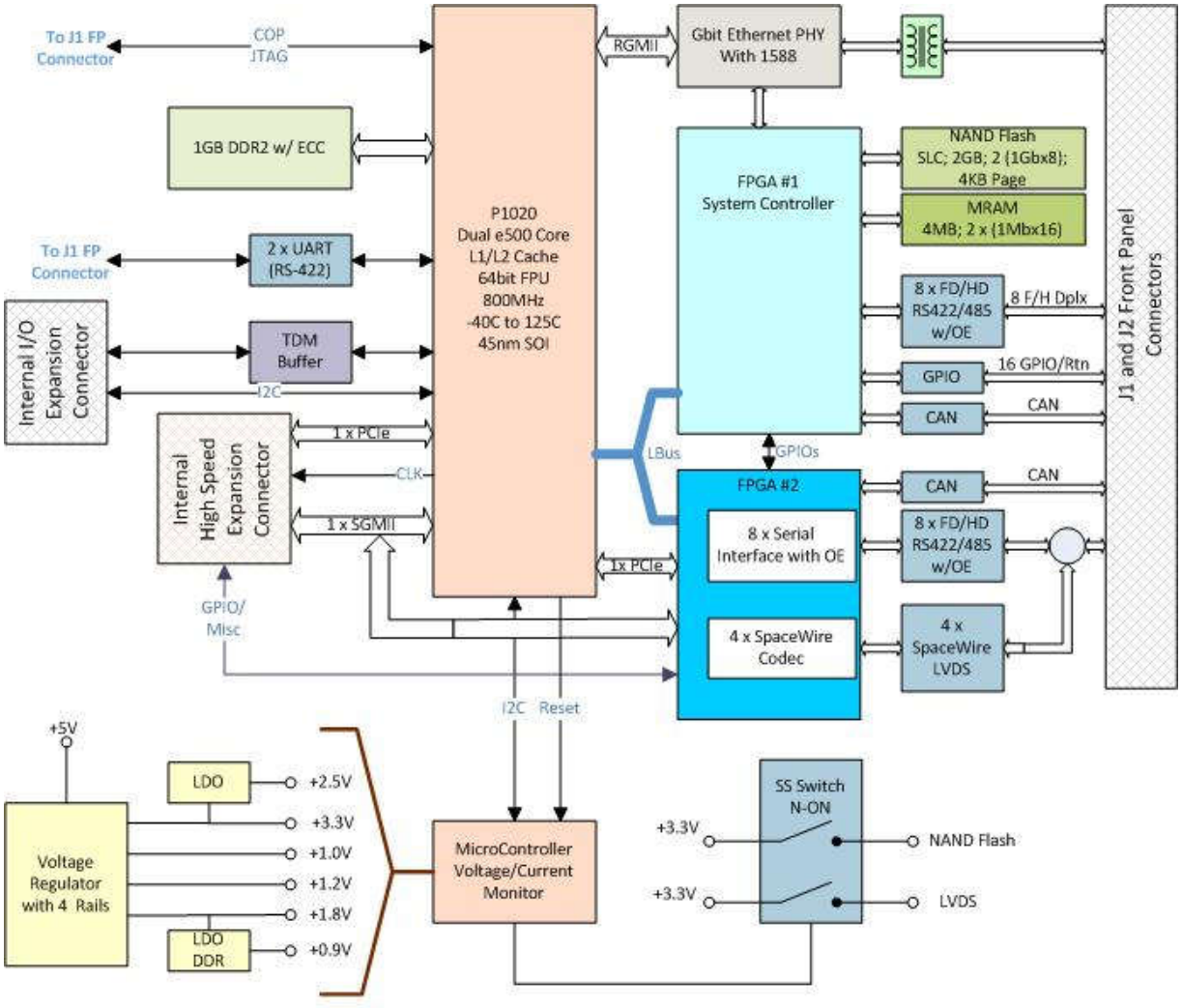
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Ai-RIO – Powerful Processing in a Rugged, Small Form Factor

Aitech's intelligent Ai-RIO Remote I/O interface Unit (RIU) product line represents a new paradigm in platform Remote I/O management intended primarily for the Earth-Orbit Space and rugged Mil & Aerospace applications.

At the heart of the Ai-RIO is a powerful, dual-core P1020 PowerPC processor teamed with two (2) leading-edge, radiation-tolerant FPGA's providing a large, superset of I/O and onboard functionality in a small, 5.5" x 5.5" Small Form Factor EMI/EMC enclosure. Connectors to the outside world can be either micro D-Subs for Space, or standard, micro MIL-DTL-38999 "Mighty Mouse" type circular military connectors for defense.

The Ai-RIO is an intelligent, modular, easily scalable system-of-systems allowing the expansion of internal I/O, memory or other internal resources by the addition of expansion modules (or "slices"). The basic configuration is two (2) module "slices"; one the modular Power Supply Unit (PSU) and the other is the CPU module. The CPU provides two (2) internal expansion busses; a high-speed PCIe bus and a TDM (Time Division Multiplexed) bus with 512 channels geared toward expansion of slower I/O. Up to eight Ai-RIO modules can be simply stacked together onto the base CPU/PSU configuration to expand the subsystem's I/O, power switching, mass/SSD FLASH memory or other functionality.



Ai-RIO Block Diagram

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Onboard I/O capabilities of the Ai-RIO CPU module in the base configuration includes one Gigabit Ethernet port, ten (10) high-speed RS-422/485 serial UART communications ports, 8 additional RS422/485 or LVDS UART serial ports, 2 CANbus ports, 16 GPIO discrete I/O's and a 1PPS port. Additional I/O expansion modules can be added to the base configuration to easily expand the Ai-RIO's capability and functionality.

Functional Description

Processor and System Architecture

The highly integrated design of the Ai-RIO guarantees top performance and versatility for conduction- or air-cooled defense and aerospace and Space applications.

Not only a Remote I/O Unit, the Ai-RIO is also a powerful, stand-alone command and data handling processing (C&DH) platform achieved by combining a high performance dual-core PowerPC P1020 processor and extensive supporting memory and I/O arrays. In addition, the Ai-RIO's CPU architecture is designed to utilize all bus interfaces efficiently to maximize data parallelism.

Processor

The P1020 has an on-chip 32KB instruction and 32KB Data L1 caches protected by parity as well as a 256KB L2 cache with ECC. Running at a CPU speed from 533 to 800MHz, the Core Complex Bus (CCB) can be configured to run from 266MHz to 600MHz to tailor performance versus power dissipation.

An onboard FPGA augments the processor local bus by providing control of the redundant boot EEPROMs, interfaces to the User Flash, WDT and controls other various board reset and control functions.

Memory

The Ai-RIO implements large on-board memory to support the user applications. Memory resources include 1GB of 32 bit-wide, fast DDR2 (Double Data Rate-2) SDRAM with ECC protection, 2GB of User Flash, and 2MB of redundant Boot EEPROM with failover protection provided by a system controller implemented in the FPGA.

I/O and Features Expansion

In addition to its superior processing power, the Ai-RIO provides flexible and scalable I/O expansion capabilities relative to its small form factor.

Two internal busses of the Ai-RIO's CPU module provides built-in I/O, memory and the ability to add features expansion by adding electrical & mechanical extension modules to the CPU/PSU base pair. Expansion modules can be single- or double-width, where a single-width module contains only one PWB and a double-width module has two (2) PWBs secured and mounted to provide additional features or I/O scalability. All internal electronics modules are conduction-cooled and in a EMI/EMC Faraday cage.

One of the internal expansion buses, a high-speed PCIe bus, typically interfaces to processor-bus speed devices like mass memory SSDs or added SSDRAM or NAND FLASH. A 512-channel TDM bus provides communication paths to the I/O modules, allocating up to 64, 16bit TDM cannels per module, up to 8 modules. The TDM bus operates at 8.192MHz, providing 1 ms (max) update rate to the I/O modules.

I/O Interfaces

In addition to its superior processing power, the Ai-RIO's CPU module provides many I/O capabilities, with added internal hardware on each I/O module to add BIT (Built In Test). Of the 64 available TDM channels per I/O module, 4 channels are reserved for module ID and BIT stimulation and response function calls.

Ethernet Port

One (1) 10/100/1000 BaseT GbE Ethernet interface is provided on the Ai-RIO CPU module.

The Gigabit Ethernet controller (MAC) is integrated in the P1020 processor with internal FIFOs and DMA engines, allowing high bandwidth for data transfer through these interfaces. High performance physical layer devices complete this GbE interface. Precision Time Protocol is also implemented in compliance with IEEE-1588 to allow time synchronization between the host and the Ai-RIO, or between multiple Ai-RIOs.

Serial Communication RS422/485 Ports

Up to ten (10) high-speed asynchronous serial UART ports support RS422 or RS-485 physical interfaces.

Up to eight (8) additional serial UART ports support RS-422/485 or LVDS signaling levels. See ordering options below. Sixteen serial ports have individual OE associated with the port.

Spacewire Ports

An I/O option is available to provide four (4) Spacewire ports from the I/O FPGA in place of eight (8) Serial UART ports. See ordering information below.

1PPS Port

A 1PPS input port for device timing synchronization is provided, typically provided by a GPS receiver. Optionally one of the serial ports may be used as a second 1PPS port.

Discrete I/O

Sixteen (16) (LV)CMOS (3.3V or 5V) discrete I/O ports, individually programmable as inputs or outputs in two groups of eight, are routed to the CPU module's I/O

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connectors. The voltage selection of 3.3V vs. 5V is a factory assembly option.

I/O Routing

All I/O interface signals are available at the Ai-RIO's I/O connectors mounted on the top or side of the enclosure. Each module carries its module-specific I/O out to each modules' dedicated I/O connectors. All I/O connectors can be either micro-Dsubs for Space, or micro D38999 circular connectors for Aerospace and Defense systems.

System Support Devices

Watchdog Timers

The Ai-RIO provides three watchdog timers. There is one internal watchdog associated with each e500 core which, when enabled and configured to mode 3, generates an internal CPU interrupt after the first internal timer expiration period and a hardware reset request after the second expiration period. The expiration period is programmable.

The third Watchdog timer is external to the processor located in the Radiation Tolerant FPGA. When enabled, it resets the whole board after the first expiration period.

Software

Test and Diagnostic Features

The Ai-RIO is supplied with an extensive firmware package, including; startup firmware (boot software), AIMon monitor/debugger tool for VxWorks, AIDiag diagnostic tool, and BIT. BIT may be executed during power-up or at any time after the Ai-RIO subsystem has been booted.

A JTAG/COP interface to the processor is provided for debugging and development purposes.

Operating Systems

For those customers who wish to develop their own embedded applications, a complete Linux kernel with BusyBox operating environment, or a Wind River VxWorks 6.9 Board Support Package (BSP) is available.

RIONet

For those applications where a Remote I/O interface is all that is needed, Aitech's RIO-NET™ application is available for Remote Interface Unit (RIU) stand-alone operation on a command/response network.

Radiation Performance

The Ai-RIO is a radiation Tolerant design with mitigation with immunity to destructive Latch-up. The Ai-RIO has been tested and characterized directly by Aitech for radiation effects, tested with proton beam to 25 krads (Si) TID at varied flux rates. The VxWorks BSP offers added mitigation of Single Event Upsets; the resulting cross-sections are available upon request.

The P1020 dual-core processor is manufactured using 45nm SOI technology and is immune to latch-up; other components in the standard configuration are latch-up immune to at least 37 MeV-cm^2/mg. Please contact your Aitech representative directly for the detailed data on radiation immunity and EEE parts ordering options.

Component Selection

For Series 500, the flight-qualified parts used on the Ai-RIO product were carefully selected and up-screened to meet or exceed Grade 2 NASA Goddard Space Flight Center (GSFC) EEE-INST-002, April 2008. Other EEE component selection criteria (e.g. Grade 3) are also available; please contact your Aitech representative for additional information.

Mechanical Features

The Ai-RIO is encapsulated as a Small Form Factor (SFF) modular and expandable 6061/T6 flight-grade Aluminum enclosure where the internal electronics are internally conduction-cooled, and mechanically fixed to the chassis for maximum thermal transfer.

The Ai-RIO is based upon a common mechanical modular SFF format; each module measures ~5.5" x 5.5" x 1.2" wide. Additional I/O modules widths can vary from 1-2" in width dependent of the connector type (DSub or 38999) or if the module is single-width or dual-width form factor. See the Ai-RIO Users' Guide or Mechanical ICD for exact dimensions.

The Ai-RIO CPU/PSU minimum configuration mass is less than 1.3 kg (2.7 lbs).

Thermal Management

Careful mechanical design and the application of Aluminum heatsinks integrated to each of the modules is combined with a metal enclosure to allow for optimal heat dissipation of the board. The Ai-RIO Power Supply module is equipped with two temperature sensors, located at temperature-critical locations, to monitor board temperature and providing thermal data to the user's application software. The sensors can be polled by the processor. The CPU Module has processor junction temperature monitoring function enabled also designed for polling by the processor. These thermal sensors are available on all three Series 100, 200 and 500 models.

Power Requirements

The Ai-RIO receives its primary power from the 18V to 36V DC power input J1 connector and is filtered via an internal, sealed EMI/EMC-compliant power input filter. Internal, high efficiency step-down power DC-DC converters create all the needed internal voltage rails.

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Internal voltages and control circuitry are galvanically isolated from the 28VDC input power source with reverse voltage protection and TVS over-voltage protection, coupled with synchronous rectification ensuring an overall 92% conversion efficiency. Dedicated internal PSU temperature monitoring, circuits to monitor all input and output voltages and currents helps our customers ensure a stable and reliable compute and/or RIO platform for their applications.

Typical/Nominal Power is as follows:

	Input Current	
Input	**Typ.**	**Max**
28Vdc (Nom)	270mA*	280mA*

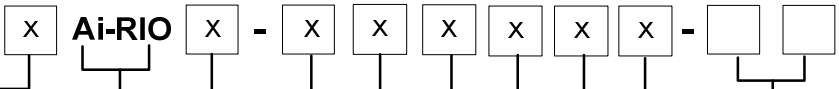
* = Ai-RIO CPU only

Environmental Features

Please Refer to the Aitech Ruggedization Datasheet.

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Ai-RIO Ordering Information



Ruggedization Level
1 = Series 100
2 = Series 200
4 = Series 400 (M&A only)
5 = Series 500 (Space only)

Aitech Item Number

Configuration
S = Space-qualified, EEE components configuration
M = Military / Aero configuration

Cooling
A = Air-cooled (Series 100 only)
R = Conduction (Series 200, 400 & 500 only)

CPU I/O Configuration

Default Ai-RIO I/O's (from Controller Module)	Space Micro -D Variant	Mil/Aero D-Sub Variant	Mil/Aero Mighty Mouse Variant
CANbus	2	1	1
OnePPS Input	1	1	1
Gb Ethernet (10/100/1000 Base T)	1	1	1
CPU JTAG Port	1	1	1
CPU Serial (Rx/Tx pair, RS422/RS485 UARTs)	2	2	2
Cntlr FPGA Serial (Rx/Tx pair, RS422/RS485 UARTs)	8	8	4
GPIO (LVCMOS, 3.3V/5V Tol.)	16	6	4
Additional I/O Options (from Controller Module)	Variant 1	Variant 2	Variant 3
IO FPGA Serial (Rx/Tx pair, Full Duplex) UART	8	0	0
LVDS	0	8	0
Spacewire Ports (Space only)	4	0	0

Connectors Location Options
0 = Top Panel I/O
1 = Side Panel I/O

Power Supply Options
1 = 28VDC Input Mil grade
2 = 28VDC Space Grade

Software Options
1 = Linux
2 = VxWorks
3 = RIONet (Standalone Client/Server)

External I/O Connectors
1 = D-Sub Connectors (Micro-D for Space, D-Sub for M&A versions)
2 = Micro "Might Mouse" -38999 military-grade circular connectors (M&A S200 & S400 only)

Configuration Number – To be Assigned by Aitech
- 00 = Standard Product

Examples: 1Ai-RIO-Axxxxxxx-00, 2Ai-RIO-Rxxxxxx-00, 4Ai-RIO-Rxxxxxx-00, 5Ai-RIO-Rxxxxxx-00, etc.

Notes:
1. Default CPU onboard memory provided: 1 GB DDR2 SDRAM with ECC, 1 GB User Flash, 1 MB dual-redundant Boot Flash.
2. Series 100 (Lab Grade) enclosure is available in Plastic (default) or Aluminum (FFF to S200, 400 and 500) as an option.
3. All I/O cables and Power input cable are provided for S100, terminated in PC-standard I/O connectors for development.
4. All Software and drivers are provided with S100 units as specified in above Software options.

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