

# PRO-4600

## Software Defined Radio Small Form Factor Processing Engine

3U  
cPCI



### Benefits

- Rugged design to support deployment in harsh environments
- Optimized for wireless modem applications requiring low latency and high data throughput
- Minimize power requirement per slot with modular architecture and data flow routing strategies
- Supports multiple industry standards providing easy interface from digital IF to Ethernet
- Accelerate application development, simplify the programming model and ensure code portability with *quicComm*<sup>™</sup> API, common across all *flexComm*<sup>™</sup> products
- Rapid optimization of size, weight, power and cost to meet fielded application or program requirements. Spectrum's Modified COTS process reduces your time to deployment by up to 2 years

### Applications

The PRO-4600 is designed for size, weight and power limited applications, including those deployed in harsh environments, such as:

- Tactical Military Communications (MILCOM)  
- ground vehicular, airborne, unmanned aerial vehicles (UAV) and shipborne
- Electronic Warfare (EW) including Electronic Attack - jamming
- Military Satellite Communications (MILSATCOM) Terminals

### Features

- 3U CompactPCI<sup>®</sup> form factor
- Available in conduction-cooled and air-cooled versions. Rugged conduction-cooled carrier versions follow the IEEE 1101.2 specification and operate with ANSI VITA 20 compliant XMC modules. Conformal coating is optional.
- XMC interface (ANSI VITA 42.0) provides highspeed, low latency, deterministic data flow to an industry standard mezzanine. Compatible with PMC and ePMC (Solano<sup>®</sup>) modules.
- Xilinx<sup>®</sup> Virtex-4<sup>™</sup> technology for wideband processing and low power operation
- FPGA "wrapper" abstracts board-level logic to accelerate FPGA firmware development
- TMS320C6416T DSP for baseband processing and compatibility with legacy waveforms
- MPC8541E general purpose processor for baseband processing and control
- Gigabit Ethernet via rear panel
- Green Hills<sup>®</sup> INTEGRITY<sup>®</sup> Real-Time Operating System with MULTI<sup>®</sup> and Wind River<sup>®</sup> VxWorks<sup>®</sup> with Tornado<sup>®</sup>
- Spectrum's *quicComm*<sup>™</sup> API hardware abstraction layer
- Optional Software Communication Architecture (SCA) Core Framework
- Optional CORBA Object Request Broker (ORB)

### Description

The PRO-4600 is a 3U CompactPCI heterogeneous processing engine that employs a combination of a Virtex-4 FPGA, a TMS320C6416T DSP and an MPC8541E general purpose processor to support the black-side processing requirements of size, weight and power-limited software defined radio (SDR) applications. The PRO-4600 is equipped with a single-width XMC site, capable of hosting Parallel RapidIO (XMC) modules as well as Spectrum's Enhanced PMC (ePMC) modules and industry-standard PMC modules.

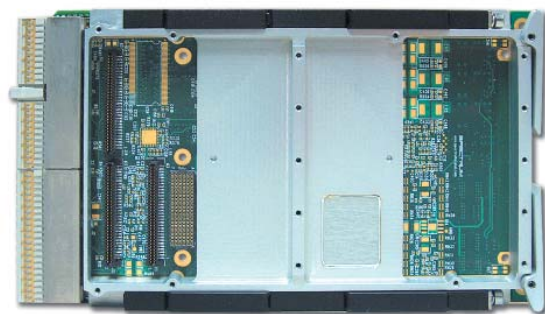


Figure 1. PRO-4600 rugged conduction-cooled carrier

## Block Diagram

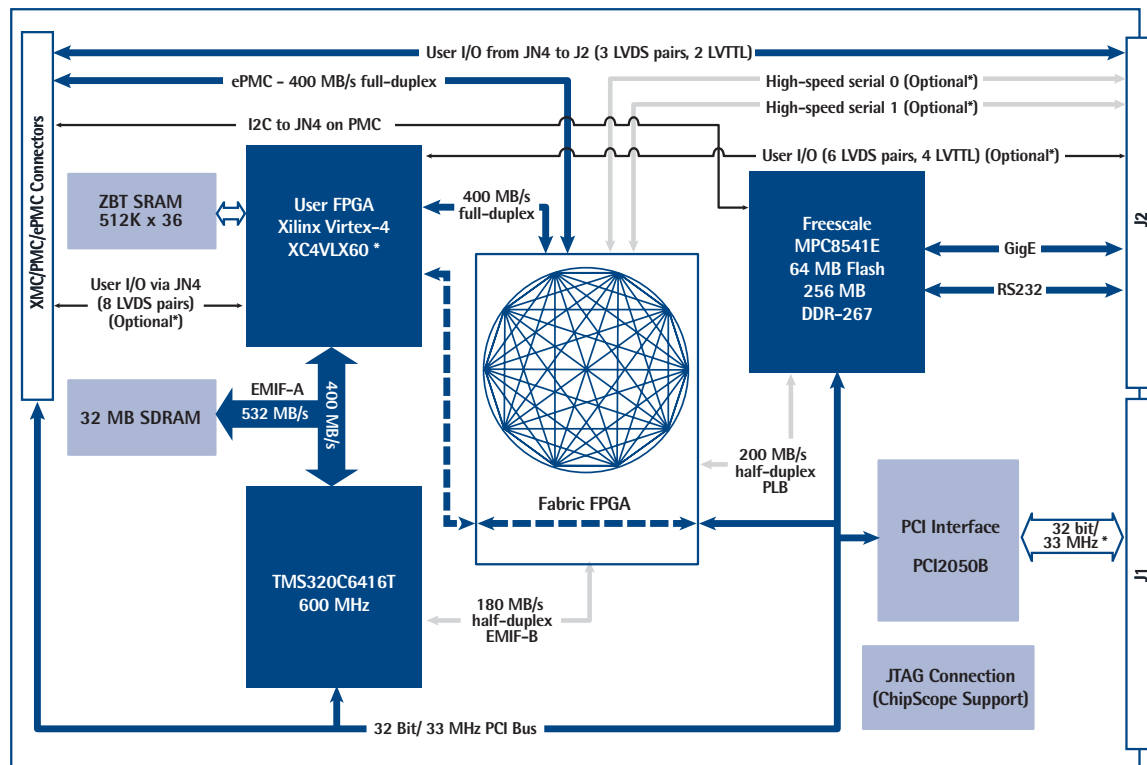


Figure 2. PRO-4600 Block Diagram. \* See future options section of this datasheet for FPGA size and PCI interface to the back panel.

## Architecture

The PRO-4600 is a COTS 3U software radio modem processing engine/carrier card ideal for Tactical MILCOM and other communications applications. Its scalable, modular hardware/software architecture allows for quick modification and adaptation to unique program requirements, thus substantially reducing the high expense and risk associated with developing your own hardware.

The PRO-4600 combines dedicated high throughput, low latency data paths with heterogeneous processing capability and a highly focused software stack, which includes Spectrum's *quicComm* API. Support for an SCA core framework and CORBA ORB are optional.

Application portability from Spectrum's 6U platform to this 3U platform has been a primary design consideration. The PRO-4600 provides a compact single-slot design for trial and deployment of applications initially developed on the SDR-3000 6U cPCI platform.

## Processors

### [ User Programmable FPGAs ]

For intermediate frequency/high data rate processing, the PRO-4600 contains a user-programmable XC4VLX60 Virtex-4 FPGA, supplied with an additional bank of 512K x 36 zero bus-turn-around SRAM and shares 32 MB of SDRAM with the TMS320C6416T DSP processor. The following table illustrates the technical specifications of this FPGA and provides an estimate of the FPGA resources available to the user, taking into account the resources used for Spectrum's FPGA hardware abstraction "wrapper":

Device	4LVX60	Approximate Resources Available to Application
Logic Cells	59,904	50,000
Block RAM (Kbits)	2,880	2,376
DSP Slices	64	64
Digital Clock Management Blocks	8	5

Figure 3. User programmable FPGA attributes and estimated resources available to user. For systems that do not require a user programmable FPGA, a version of the PRO-4600 is available with no user programmable FPGA.

### [ TMS320C6416T DSP Processor ]

A 600 MHz TMS320C6416T processor provides baseband processing with lower power consumption, as well as providing support for legacy waveform code. The C6416T DSP shares 32 MB of SDRAM with the user-programmable XC4VLX60 Virtex-4 FPGA.

The DSP processor is connected to the Fabric FPGA crossbar allowing flexible, high-performance channelized data flow.

### [ General Purpose Processor ]

The PRO-4600 supports a 666 MHz Freescale MPC8541E general purpose processor (GPP), with 256 MB of 264 MHz DDR SDRAM and 64 MB Flash. The MPC8541E supports the high performance e500 core with floating-point support and a Gigabit Ethernet controller. Balancing processor performance with I/O system throughput, the MPC8541E is a powerful processor for both baseband signal processing and system control.

The host processor is connected to the Fabric FPGA crossbar via an optimized Processor Local Bus (PLB) path that implements a channelized data flow. The MPC8541E can boot from flash or boot from a host file system. As a future option, a facility is available that will zeroize the flash in an emergency situation, effectively erasing all content and rendering the unit inoperable.\*

### [ Overall Data Flow ]

In order to facilitate highly flexible, yet high-performance communications, the PRO-4600 architecture uses a fabric crossbar. This provides dedicated, high throughput, low latency data paths between all processors and the most important external data interfaces. A separate "soft real-time" data path is provided via the on-board PCI bus that is primarily used for control. By isolating signal from control, determinism and performance is assured. In addition, a hardware interrupt scheme is provided, allowing tight synchronization between the user programmable FPGA, DSP, GPP and XMC/PMC site.

\* See future options section of this datasheet.

### [ XMC ANSI VITA 42.0 Compliant ]

The ANSI VITA 42.0 XMC base standard defines physical features that enable switched communications between a standard PMC mezzanine card and its carrier. The PRO-4600 is a ANSI VITA 42.0 XMC compliant carrier card which is capable of supporting either Spectrum's high-speed Solano Communications Technology or ANSI VITA 42.1 Parallel RapidIO.

### [ Solano Communications Technology ]

The PRO-4600 supports two Solano links via the XMC interface. The Solano Communications Technology used in the ePMC specification provides high bandwidth deterministic data paths between ePMC mezzanine modules and ePMC carriers. Each Solano high-speed link is capable of greater than 200 MB/s full-duplex communications and requires much less power than Parallel RapidIO. Two Solano links are electrically equivalent to one RapidIO link.

### [ Parallel RapidIO Compatibility\* ]

The ANSI VITA 42.1 Parallel RapidIO standard uses a point-to-point scalable switched-fabric for its transport layer. Using LVDS signaling with a double-data-rate clocking methodology, data rates of up to 500 MB/s full-duplex are supported. The PRO-4600 supports a single Parallel RapidIO link to its XMC mezzanine site. RapidIO benefits the designer who requires an industry standard high-speed fabric and interface.

### [ Serial I/O Backplane Links\* ]

The PRO-4600 supports two serial I/O links to the rear panel that are typically used to interface to a digitizing RF front-end. These links are capable of supporting standards such as Aurora, serial FPDP, serial RapidIO or other custom protocols. In addition to this, the serial links can be used to create larger systems of collaborating PRO- 4600 boards. Each serial link is capable of supporting link rates at up to 320 MB/s full-duplex. In an air-cooled chassis, the high-speed serial links can be routed from the cPCI J2 connector to rear-panel SLINK connectors via the TM2-4900 Rear Transition Module, and can be routed between boards using SLINK cables. In a conduction-cooled chassis, these signals would normally be routed via the backplane.

### [ General-Purpose I/O (GPIO) ]

A number of GPIO lines are provided to facilitate user-defined communications to external devices. These include:

# GPIO	Location	Organized
16	J2 cPCI connector and the User FPGA	6 differential pairs plus 4 single-ended lines
16	JN4 PMC connector and the User FPGA	8 differential pairs
8	JN4 PMC connector and the J2 cPCI connector	3 differential pairs plus 2 single-ended lines

The differential pairs are capable of running at a rate up to 213.3 MHz while the single ended lines are suitable for lower speed information. Typical uses of GPIO include controlling the RF front-end using automatic gain control (AGC), frequency hop synchronization between the modem and RF stages, time code input from a GPS receiver, and sync distribution between slots.

### [ cPCI Bus]

In order to facilitate control and communication with other system boards, a 32-bit/33 MHz PCI bus interface to the cPCI backplane is provided.

### [ Ethernet and RS232 Interfaces ]

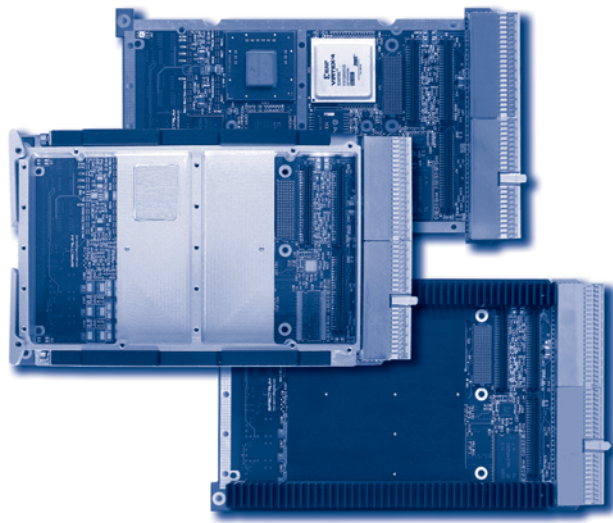
The PRO-4600 is equipped with industry-standard Ethernet and RS232 interfaces to the rear panel via the cPCI J2 connector. In an air-cooled chassis, these are routed to the rear panel connectors via Spectrum's TM2-4900 Rear Transition Module. In a conduction-cooled chassis, these signals would normally be routed via the backplane. The Ethernet interface is a triple-speed 10/100/1000 BaseT connection.

## [ Operation in Rugged Environment ]

In order to address tactical military needs for harsh environments, the PRO-4600 is designed in accordance with DRAFT ANSI VITA 47 CC3 to support conduction cooling, extended temperature range, and increased shock and vibration immunity using embedded stiffening, heat sinks and wedge locks. For protection against high levels of humidity and other environmental contaminants, the PRO-4600 can be conformally coated with a protective sealant. Temperature sensors are mounted to allow the software application to monitor the temperature of the “hot” components.

## [ Modified COTS Optimization ]

The PRO-4600 hardware and software architecture is based on Spectrum’s Tactical MILCOM reference designs resulting in a quick turn-around to optimize the product to meet the size, weight, power, cost and/or ruggedization characteristics of fielded applications. In addition to this, the PRO-4600 supports independent hard and soft real-time communications fabrics that allow the use of custom data-routing techniques. Using the Modified COTS (MCOTS) process, Spectrum works with its customers to provide an MCOTS solution while substantially minimizing the time-to-deployment. For more information on the benefits of Spectrum’s MCOTS process, please contact Spectrum Sales.



PRO-4600 can be quickly optimized for size, weight, power, cost and/or ruggedization for specific deployment environments

## Software

### [ quicComm ]

The PRO-4600 software interface is via a *quicComm* SDK that is available on all supported platforms. *quicComm* software abstracts the underlying hardware providing users with basic transport level access and control of Spectrum’s *flexComm* products. This significantly accelerates user application development. *quicComm* is standard across all *flexComm* products, allowing code portability. This software includes a board support package for control and data handling which allows configuration and control of the data links between processors and mezzanine cards, initiates and manages data transfers, manages interrupt, and is used to load applications onto the DSP and user programmable FPGA.

Spectrum provides software examples with the PRO-4600 SDK including:

- GPP communicates via Ethernet
- GPP sets up a logical and physical channel to receive and transmit data through the Processor Local Bus (PLB) interface
- DSP sets up a logical channel to receive and transmit data through the EMIF-B bus to the Fabric FPGA
- \*GPP sets up a logical and physical channel to transmit and receive data between the user programmable FPGA and the PLB
- \*DSP sets up a logical channel to transmit and receive data with the user programmable FPGA over the EMIF-A bus

The above examples provide application developers with a basis to commence their own application software. This benefits the developer to obtain quick familiarity with data flow details resulting in substantial time-savings upon the commencement of application development.

For more information on *quicComm*, please consult the *quicComm* datasheet.

### [ FPGA Wrappers ]

As a part of Spectrum's quicComm package, an FPGA wrapper is provided to abstract all board level interfaces on the Virtex-4 FPGA, including the interfaces to the analog converters, communication fabrics and control. The wrapper is designed so users can expedite the integration of third-party or custom FPGA IP cores into the PRO- 4600. See Figure 3 "User Programmable FPGA Attributes" which shows an estimate of the FPGA resources available for the user.

### [ FPGA cores\* ]

Virtex-4 compatible cores can be used on the PRO-4600. In order to accelerate FPGA development, high-quality cores can be obtained via a variety of means. Spectrum's Application Engineering Services (AES) organization routinely develops custom IP cores for clients when these are otherwise unavailable. For more information on custom cores, please contact Spectrum Sales.

The Xilinx IP center contains a wide range of free cores including digital upconverters, downconverters, FFTs and filters. The Xilinx AllianceCORE program is a cooperative effort between Xilinx and independent third-party core developers, resulting in a broad selection of industry-standard solutions.

RF Engines Ltd. ([www.rfel.com](http://www.rfel.com)) provides individual IP cores and integrated turn-key designs for digital RF signal processing that are highly optimized in terms of speed, power and size compared to cores available from the major FPGA vendors. These include pipelined FFT, tunable PFT, half-band filters, FIR filters, windowing functions and CORDICS. Spectrum can integrate these off-the-shelf cores into your system. Contact Spectrum Sales for more information.

### [ FPGA Tool Flow ]

Although other tools can be used, the PRO-4600 is designed to support the Xilinx ISE Foundation™ tool flow. ISE is an integrated programmable logic design environment that includes schematic capture, power analysis tools, physical synthesis for FPGAs, advanced Place and Route Algorithms, and COREgenerator, a graphical interactive design entry tool that is used to create high-level modules. Xilinx's System Generator tool can also be used to graphically design and simulate FPGA-based algorithms within the Simulink environment from The MathWorks.

### [ Operating System ]

The PRO-4600 supports the Green Hills INTEGRITY real-time operating system (RTOS) with MULTI Integrated Development Environment (IDE) and the Wind River VxWorks RTOS with Tornado. Both of these operating systems are designed for use in embedded systems that require maximum reliability. INTEGRITY is a secure, royalty-free, real-time OS with high-performance features such as:

- Virtual Memory Management
- Rapid Real-time Response
- Networking and Communications Protocols
- Certified under the IEEE and the Open Group
- POSIX Certification Program

MULTI is an integrated development environment for embedded applications using C, C++, embedded C++, and FORTRAN. MULTI can be used to support INTEGRITY, LINUX and VxWorks. The MULTI IDE includes:

- C and C++ compiler
- Debugger
- Text Editor
- Flash Utilities

VxWorks is a leading real-time operating system that features:

- Scalable, high-performance wind® microkernel
- Advanced networking support
- File system and I/O management

VxWorks is bundled with the Tornado II development tool set and includes:

- Windows XP development environment
- C and C++ compiler
- Editor, debugger, simulator, launcher, browser
- The VxWorks operating system
- A choice of the supplemental development tools, including WIND®VIEW, VxSim, StethoScope, TraceScope, MemScope, ProfileScope, Real-time Visualisation Pack, CoverageScope, CodeTEST and Visual SlickEdit

Using Spectrum's MCOTS process, SDR-4000 is capable of fast optimization to support other real-time operating systems (such as Linux).

#### [ Built-in Test\* ]

The PRO-4600 contains a configurable power-on built-in-test (PBIT) that automatically initiates a hardware self-test whenever it is powered on or reset, and provides an indication to the user to verify that the test has passed. In addition to this, user-initiated BIT (IBIT) is available for testing the hardware under the control of a technician.

#### [ CORBA ]

CORBA (Common Object Request Broker Architecture) is an industry standard means of developing distributed, multi-processor, multi-OS, multi-vendor software systems.

The MPC8541E GPP on the PRO-4600 supports an Object Request Broker, or ORB, to facilitate CORBA development if required.

#### [ Software Communications Architecture (SCA) ]

The SCA is an open specification sponsored by the U.S. Department of Defense Joint Tactical Radio System (JTRS) program. It specifies software, hardware, security and networking architecture requirements for open, programmable software defined radio (SDR) systems with flexible, re-programmable communication capabilities. The SCA specifies a common framework to build-up, configure, connect and tear down distributed, embedded radio applications while maximizing waveform portability. An SCA core framework is available for order as an option. Please contact Spectrum Sales for more information.

### Services

#### [ Customer Training ]

Spectrum's training workshops are designed to get your team up and running in the shortest time possible by using a combination of lectures and at least 60% hands-on experience with your system. Experience thus far has shown this service to be an invaluable tool that generates significant cost savings and reduces risk for Spectrum customers.

The standard SDR-4000 training consists of two days with a Spectrum Applications Engineer working with actual hardware. An additional two day course that covers the SCA Core Framework and SCA BSP is available. Alternatively a four day course is offered covering both SDR-4000 and the SCA components. Training can be done either at Spectrum's headquarters in Burnaby, B.C., Canada or at the customer site. For complete detail, please see the training datasheet

#### [ Custom Application Development ]

Spectrum's Application Engineering Services (AES) can assist in the development of your custom application software, including U.S. Department of Defense and ITAR-controlled projects. The scope of these services are tailored to customers' needs, ranging from complete subsystem development to support for SCA operating environment and waveforms. Spectrum's AES team partners with customers' internal application development engineers to augment their development resources. For more information, please see the Application Engineering Services datasheet.

\* See future options section of this datasheet.

# Specifications

[ general ]	Form Factor	3U CompactPCI card
	General Purpose Processor	One 666 MHz Freescale MPC8541E PowerPC with 256 MB of 266 MHz DDR SDRAM and 64 MB Flash
	User Programmable FPGA	A single user programmable Xilinx Virtex-4; XC4VLX60 with 512K x 36 ZBT SRAM The FPGA shares 32 MB SDRAM with the TMS320C6416T DSP processor
	DSP Processor	A single 600 MHz TMS320C6416T processor shares 32 MB SDRAM with the user programmable FPGA
[ buses ]	Host	3U CompactPCI card 32 bit/33 MHz (see future options below)
[ external interfaces ]	High-Speed Serial	Two Aurora links to the CompactPCI backplane via J2 (see future options for other protocols)
	High-Speed Data Ethernet	XMC VITA 42.0 interface for high-speed, low latency data transfer Gigabit Ethernet supported via PICMG 2.16 packet switched backplane
	Low-Speed Serial	RS232 data is routed to J2
	User I/O	GPIO lines between J2/JN4 and JN4/user programmable FPGA (see General Purpose I/O section of this datasheet for line arrangement details) GPIO for user FPGA LVDS and LVTTL buses to J14 and J2 connectors (see table on page 4) LEDs Total of 9 LEDs (2 for DSP, 1 for GPP, 4 for Fabric FPGA, 2 for user programmable FPGA)
	PCI interface to the back panel	32-bit/33 MHz cPCI
[ performance ]	High-Speed Data Transfer Rates	Via Solano: 200 MB/s full-duplex per link x 2 Solano links For Parallel RapidIO (see future options below): 500 MB/s full-duplex (supports single PRIO link) <ul style="list-style-type: none"> <li>• Between the Fabric FPGA &amp; GPP: 120 MB/s read, 180 MB/s write half-duplex</li> <li>• Between the Fabric FPGA &amp; DSP: 60 MB/s interrupt, 240 MB/s polling half-duplex</li> <li>• Between the Fabric FPGA &amp; FPGA: 400 MB/s</li> <li>• DSP to memory via EMIF-A: 532 MB/s at 133 MHz</li> <li>• From GPP to memory: 1064 MB/s</li> </ul>
[ software ]		Please refer to the Software section of this datasheet
[ electrical ]	Supply Voltage (DC)	+3.3 V, +5.0 V, +12V (supplied by cPCI connector)
	Power estimate	22 watts. Includes OS, FPGA wrappers, DSP, Solano links (no high-speed serial), 100BaseT operating on the PRO-4600 33.5 watts includes PRO-4600 with XMC-3321 I/O module receiving and transmitting (DACs and ADCs) and Solano links Power estimates do not include power required by user application code for the GPP or user programmable FPGAs. Further power reduction using Spectrum MCOTS optimization.
[ mechanical ]	Size	100 mm (height) x 160 mm (length)
[ environmental ]	Operating Temperature	Air-cooling: Operational temperature range of 0 to 50 °C, forced air @ 600 LFM Industrial conduction-cooling: Card edge temperature range -40 to + 70° C
	Shock and Vibration	Conduction-cooled version tested in accordance with MIL-STD-810F Conformal Coating Optional. Contact Spectrum Sales for details.
	RoHS	5 of 6 compliant (Pb solder exemption). For RoHS ordering information, other RoHS compliance options or certificates of compliance, please contact Spectrum Sales
[ ordering information ]		OS configuration indicated in brackets 600-00587 PRO-4600 - Commercial, Air-cooled (VxWorks) 600-00583 PRO-4600 - Commercial, Air-cooled (INTEGRITY) 600-00588 PRO-4600 - Industrial, Conduction-cooled (VxWorks) 600-00514 PRO-4600 - Industrial, Conduction-cooled (INTEGRITY)
[ custom configuration ]		For custom or other available configuration, please contact Spectrum Sales
[ future options ]		Future options may be implemented at the discretion of Vecima Networks Inc. or its subsidiaries based on market demand.** ANSI VITA 42.1 standard Parallel RapidIO over XMC Serial I/O interface to the back panel Custom protocol or other such as Serial RapidIO, or serial FPDP Alternate User FPGA sizes Virtex-4 LX40/25 or no user FPGA Built-In Test PBIT, IBIT and power-up, offline and background diagnostics including loop-back tests and libraries for writing custom BIT routines Zeroize the flash Erase all content to render the PRO-4600 inoperable PCI Interface to the back panel 32 bit/66 MHz operation (32 bit/33 MHz standard)