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2018 RESOURCE GUIDE

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PC/104 and small form factors

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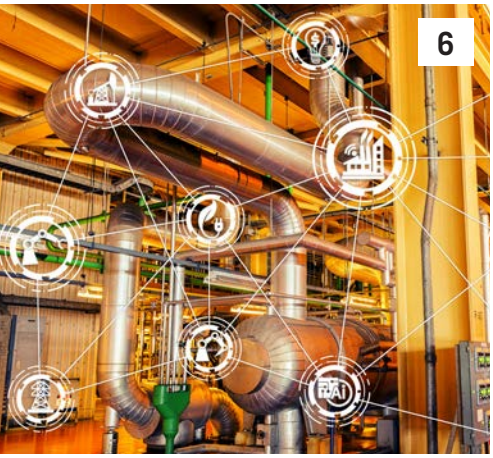
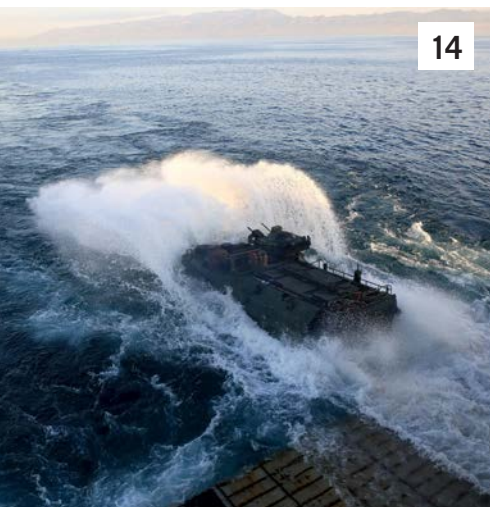
ON THE COVER:
The 2018 PC/104 and Small Form Factors Resource Guide features products used in the industrial automation and control, military/aerospace, medical, infotainment, and transportation industries. Pictured on the cover: The Parvus DuraCOR XD1500 from Curtiss-Wright Defense Solutions.





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PC/104 Consortium

By Stephen St. Amant, PC/104 Consortium President

PC/104: the smart play

"It just doesn't go out of style."
Is the blue blazer timeless? That's what I hear. What about PC/104? Absolutely. In the embedded market space, longevity is key. Embedded systems go through rigorous testing and qualification; the systems need to last. While new form factors and specifications sprout up continually, PC/104 is a solid, time-tested architecture that can be trusted in applications that require reliability, wide industry support, flexibility, and long-term sustainability. Systems built with the PC/104 stacking architecture are versatile. Based on their configuration, they can be tailored for any number of transportation, industrial, defense, mining, gaming, and aerospace needs.

"A LEGO brick is not particularly exciting."
Stackable things are great, but not especially noteworthy. Take LEGO bricks, for example. While the toy building bricks click together masterfully, it's really the things that can be created with those bricks – that's what becomes exciting and beautiful. Likewise, with PC/104 it's difficult to speak at length about the physical aspects: the compact footprint, the corner mounting holes, the robust self-stacking bus connectors. These are all important hallmarks of the form factor. However, it's the embedded systems that can be achieved using the technology – that's the real benefit and beauty of PC/104. Continually growing, always with an eye toward the next generation while still supporting legacy infrastructure – that's PC/104.

"Tom Hanks was good then, and he's even better now."
Back when PC/104 was first introduced, it garnered a lot of attention and many early adopters. A vibrant ecosystem grew based on the stackable ISA bus. After that came the stackable PCI bus. Most recently, the high-speed, self-stacking PCI Express bus has expanded the capabilities of what PC/104 can accomplish in small spaces. Because of the form factor's modularity and the innovative, adaptive nature of the companies that design and build to the PC/104 specifications, today's PC/104-based products are better than ever. As new technologies come to the fore, PC/104 manufacturers adopt and integrate. In this way, PC/104 continues to play essential roles in the very latest embedded computing systems.

"Nothing takes the place of quality ingredients."
If one chooses to design with the right form factor, the right architecture, it lays the framework for an embedded system that more than meets application needs. Self-stacking buses, a wide array of multicore processors, and leading-edge I/O peripherals afford rapid uptime – critical for quickly changing landscapes such as those in IoT [Internet of Things], M2M [machine to machine], and industrial embedded computing – while keeping costs relatively low. PC/104, with its well-known, comprehensive evolutionary path, protects designers from choosing a specification that's here today and gone tomorrow.

"Room for one more?"
Systems change. Requirements change. Component availability changes. Technology advances. How does one design a system that has staying power? How does one protect against obsolescence? By adopting a modular architecture that anticipates change. PC/104 does just that: Its flexibility and ability to bring together diverse I/O peripherals into a single system give PC/104-based systems clear advantages.

"See you tomorrow."
PC/104 will continue to be vibrant in the coming years because the companies who build to the spec continue to innovate. It's an ecosystem full of trailblazing industry leaders who have built embedded systems for decades. They know customer pain points. They avoid design pitfalls. They anticipate end-of-life issues. They plan for long life cycles and long-term customer support. They build products that combat challenging environmental situations while also battling the issues of procurement and ever-changing technology.

How does one design a system that has staying power? How does one protect against obsolescence? By adopting a modular architecture that anticipates change. PC/104 does just that: Its flexibility and ability to bring together diverse I/O peripherals into a single system give PC/104-based systems clear advantages.

If your calendar says February 2018, head to Nuremberg, Germany to see exhibits from many of the PC/104 member-companies who are showing at embedded world (Feb. 27 to March 1). If you manufacture embedded hardware, think about spinning your technology onto PC/104. Our specifications are free to download at www.pc104.org.

Small form factors, big time markets

By OpenSystems Media Staff

Whether you're talking about PC/104 and PCe/104 for rail and military applications or COM Express for gaming and IoT applications, small-form-factor solutions for embedded computing are hot across multiple markets. Reduced size, weight, and power (SWaP) requirements are spurring innovation in smaller footprint designs that pack as much performance as larger solutions.

PC/104 has been an excellent choice for applications with long design cycles, such as military avionics, command-and-control applications, rail and transportation systems, and legacy industrial devices. Designers of these solutions know how to handle the long-term commitment and obsolescence challenges that come with such systems. In newer video and imaging applications, PC/104e is getting some looks.

When users want to create embedded video or imaging application, they find that PC/104 boards and systems are the right choice for their designs. PC/104 provides a compact yet easily expandable architecture. It is suitable for harsh environments where imaging applications may be needed, thanks to its rugged and reliable connectors. It's resistant to shock and vibration, which can be important for imaging. And of course, it's compatible with PCs, which keeps down development cost and time.

Plenty of products are still being introduced that meet this venerable and proven specification. In particular, PCIe/104 offers many of the interfaces an imaging application may need, such as four-port

Gigabit Ethernet (GbE) and USB 3.0 connections. Moreover, it maintains flexibility for future expansion. The PCIe/104 OneBank expansion interface for high-performance systems has enabled smaller, lighter, and more energy-efficient solutions.

One recent example of a vision system that takes advantage of PCIe/104 is a fish-counting system developed for the National Marine Fisheries Service by PC/104 Consortium members ADL Embedded Solutions Inc., and RTD Inc. The Service needed a camera system that could withstand the vibrations of a trawler in the water while providing real-time image processing.

RASPBERRY PI ON PC/104

By Adam Parker

The Pi/104 was originally designed when I was working as an Industrial Internet of Things (IIoT) developer. I worked for a startup, and a common sales pitch was "our stack can run on something as small as a Raspberry Pi." No one took us up on that, not because they weren't familiar with the Raspberry Pi, but because the Pi in SBC form is a bit silly in an industrial cabinet. Its shortcomings drove design decisions.

The carrier was designed to meet the full industrial temp spec (-40 °C to +85 °C), compared to the Pi's typical commercial spec. The compute module does have a slightly subpar memory component (IIRC) that narrows the spec to -20 °C to 85 °C, but that can't be avoided.

Another design decision was to fix the USB power supply. Having 5 V available isn't unheard of in an industrial cabinet, but it's not common. So I sized the power supply to at least take in 12 V and 24 V. What we eventually got was 8 V to 35 V. The module also accepts power through its OneBank or the USB OTG [on-the-go] port for convenient desktop powering. The rest of the design was largely to make usual hobbyist Pi user feel at home, giving developers something they could play with on the weekends, not just at work.

In the end, I chose PC/104 because of its credentials and long standing in the industry. There are CM products in Phoenix's Din Rail cases, but they tend to carry everything plus the kitchen sink to meet the needs of all projects instead of simply giving customers the expandability to build what their project needs.

The big asterisk on the Pi/104's PC/104 credentials has been correctly identified by LinuxGizmos.com: Unfortunately, the CM1/CM3 is short on buses, as it doesn't have ISA, PCI, or PCI Express. So we chose to adhere to what we believed to be the spirit of the OneBank connector. We populated the power, ground, and the two USB channels.

The final product is a very functional IIoT platform. Obviously, not every PCI Express/OneBank card will work, but OneBank to mPCIe alone can be a powerful add-on. The maiden voyage for the card was a demo with a 3G cellular modem (Huawei EM820W) in the slot and the onboard Ethernet going to a Modbus TCP rack for data acquisition. It's also been demoed as a SoftPLC using OpenPLC (note that Phoenix Contact also has a soft PLC platform that can run on the Pi).

The card is available for a limited time on CrowdSupply. If you need any higher resolution media or any other changes, just ask. (www.crowdsupply.com/parker-microsystems/pi-104)

***Adam Parker** is a control-systems engineer turned IIoT developer who now works as an IoT firmware developer in the Dallas-Fort Worth area. He's also a ham-radio operator, open-source contributor, and avid SBC collector.*

Several companies have products that are compatible with the PCIe/104 standard. They include the H264-HD-2SDI from Advanced Micro Peripherals (Figure 1), the Lion rugged PC/104 single-board computer from VersaLogic, Coaxlink Duo PCIe/104 from Euresys, the OI110 dual-camera link from Sundance Technology, the SK220 PCIe/104 carrier module from Perfectron, the Model 953-ET encoder/decoder from Sensoray, and Connect Tech's Xtreme/GPU.

COM Express small form factor gains popularity

COM Express, meanwhile, has taken off in gaming for slot machines; newer industrial applications for manufacturing automation; robotics; and military intelligence, surveillance, and reconnaissance (ISR) payloads for unmanned aircraft. It's also getting some play within the Internet of Things (IoT).

"From the Connect Tech perspective, we are seeing a significant interest in COM Express Type 7, [which has] the ability to leverage server-class processing power

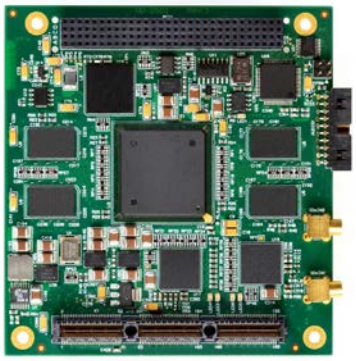


Figure 1 | The dual HD-SDI H.264 encoder for PC/104-Express from Advanced Micro Peripherals enables designers to add high-definition HD-SDI video capture with H.264/MPEG-4 AVC (Part 10) encoding to their embedded PC equipment designs.

that was previously unavailable under the COM Express standard," says Michele Kasza, vice president of sales at Connect Tech (Guelph, Ontario). "Access to Intel Xeon D processors and being able to hit scalable computing performance with access to four, eight, and 16 core processors makes Type 7 an exciting new option. What was originally only available in large rackmount systems can now be accessed in small-form-factor solutions, ruggedized, and ready-to-deploy compute platforms. The other key feature is the introduction of high-bandwidth 10 GbE network communication. Our customers can now make use of this high-bandwidth connectivity using native Xeon D 10G capabilities."

"COM Express is very hot right now," says Roy Keeler, senior product manager and manager of business development, aerospace and defense, ADLINK Technology (San Jose, California). "COM Express can be used in multiple military applications where reduced SWaP is a priority, such as unmanned aerial vehicles (UAVs), avionics, and more.

"It is being used to operate subsystems, for instance. Mostly subsystems have a box with some I/O added to it and use COM Express as a controller," Keeler continues. "In areas where you don't need high compute power, you can build a standalone solution that leverages a NVIDIA Jetson TX2, for instance. The enticing thing about COM Express is

> "COM Express can be used in multiple military applications where reduced SWaP is a priority, such as unmanned aerial vehicles (UAVs), avionics, and more."
> – *Roy Keeler, ADLINK.*

its flexibility when it comes to multiple pinouts and module sizes that are all available right off the shelf. It also has multiple display and video outputs with 16 lanes of PCIe x16 or two PCIe x8 outputs, which translates to a lot of I/O coming in a small package. You can also tailor the compute power based on SWaP requirements – from a Xeon to a Core i5.

"COM Express is also a busless system, so you don't need a backplane, which makes it attractive for customers who do not need the high-speed switched fabrics that come with a VPX system," Keeler notes. "It has the same processing power and no backplane."

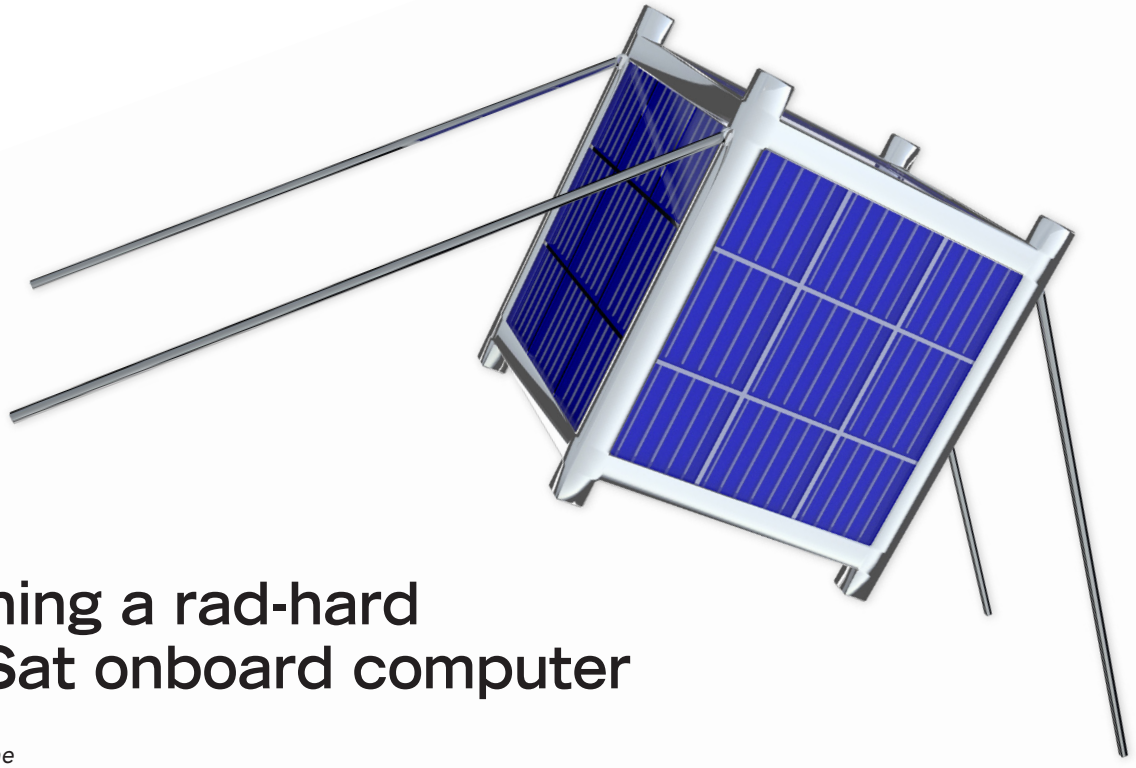
COM Express update added functionality

As Kasza mentions, the latest update to COM Express adds server-grade functionality to COM Express embedded computing systems. Revision 3.0 of COM Express provides for a new Type 7 connector and the addition of up to four 10 GbE interfaces on the board, according to the PCI Industrial Computing Manufacturers Group (PICMG). The organization says previous revisions of the specification were limited to a single GbE interface. The higher speed ports enabled by the update open up new markets such as data centers, where the high compute density of COM Express can result in increased rack utilization. The 10 GbE ports are also ideal for high-bandwidth video applications such as surveillance. Another change to the specification includes increasing the number of PCI Express lanes to 32 across the Type 7 connector, a move that provides a wealth of connectivity and interface options. These include the ability to facilitate the use of general-purpose graphics processing units (GPGPUs).

COM Express growth: Emblematic of the strength of the overall computer-on-module market.

"Computer-on-module market growth is just outstanding for certain types of form factors, and COM Express crosses both industrial and military lines," says Mike Southworth, a product marketing executive with Curtiss-Wright Defense Solutions (Ashburn, Virginia). "When we started to integrate COM Express modules into our system architectures, we reduced our legacy system size by more than 25 percent, increased system technology reuse, and overcame our traditional thermal-management challenges.

"COM modules works quite well for reduced SWaP applications in avionics and other applications that require the smallest SWaP possible," Southworth adds. **SFF**



Designing a rad-hard CubeSat onboard computer

By Ross Bannatyne

A CubeSat is a miniature satellite that conforms to a standard specification of 10 cm on each side and weighs no more than 1.33 kilograms. Often these cubes are concatenated to form larger structures. This standardization in satellite technology has provoked a significant growth in their use, as economies of scale in components, subsystems, launch equipment, and logistics have enabled many cost-effective new ventures.

There now exists a vibrant ecosystem of suppliers that provide plug-and-play CubeSat components that fit together inside the standard CubeSat form factor. Thus far, much of the technology has been based on commercial off-the-shelf (COTS) electronics, although there is a growing trend to judiciously use radiation-hardened integrated circuits that are designed to mitigate against the effects of space radiation. The goal is to improve the system reliability by ensuring that the electronics operate in a radiation-filled environment while maintaining a modest budget; CubeSats are intended to be an inexpensive alternative to traditional, higher-cost satellites.

Because of the interest in selective-component hardening as a means of improving mission success rate, a reference design was created for a CubeSat onboard computer (OBC) that uses radiation-hardened components. This reference design can be downloaded and modified by CubeSat designers to meet different mission requirements. A block diagram of the OBC is shown in Figure 1.

The reference design is Pumpkin CubeSat Kit Bus-compatible, as the signals on the PC/104 connector conform to the published Pumpkin CubeSat interface specification. There are many plug-and-play boards that use this standard. In space-constrained designs, the PC104 connector is sometimes relinquished due to its size.

The OBC uses the VORAGO Technologies VA10820 ARM Cortex-M0 microcontroller, a radiation-hardened low-power device that supported with the ARM development ecosystem.

The MCU – already immunized against latch-up – provides a 50 MHz ARM Cortex-M0 core, program and data memory, general-purpose I/O (GPIO), and on-chip peripherals such as timers and serial communications (SPI [serial peripheral interface bus], UART [universal asynchronous receiver-transmitter], and inter-integrated circuit protocol [I^2C]). When the system boots up, the SRAM program memory on the microcontroller is loaded from the Cypress CYPT15B102 rad-hard FRAM. Program code executes from SRAM and is protected by an error detection and correction (EDAC) subsystem and a scrub engine.

The EDAC corrects bit errors that can occur due to single-event upsets (SEUs) as the CPU fetches words from the SRAM memory. The scrub engine is a complimentary subsystem that autonomously sweeps through memory sequentially to detect and correct

bit errors before the EDAC would be exposed to them. There are five syndrome bits for every byte in the 32-bit data words, making it possible to detect two bit errors per byte and correct one bit in each byte of the 32-bit memory word. This arrangement enables the correction of up to four bit errors (one per byte) per 32-bit data word.

Single-event upsets (SEU) can cause a change of state by a single ionizing particle striking a device; SEUs can affect both memory cells or logic circuits. Another radiation-mitigating feature of the MCU architecture is the implementation of dual interlocked cell (DICE) latches and triple modular redundancy (TMR) on internal registers. While the EDAC and scrub subsystems address SEUs in memory, the DICE latches and TMR implementation address SEUs in logic circuits.

The OBC uses Cypress CYPT15B102 ferroelectric random-access memory (FRAM) as it has good radiation performance and interfaces easily to the MCU via a SPI port. A second FRAM, the Cypress FM25V20A, is also implemented as a backup. The FM25V20A is a COTS automotive-grade memory with the same SPI interface. This memory can be used to provide temporary nonvolatile storage when performing in-orbit reprogramming: If the CubeSat receives a wireless program code update in orbit, both the original and new code images will be required so that the system can recover to a known good state in the event of a problem during reprogramming. The recovery function is the main reason a second FRAM device is included. The second FRAM device could of course be another rad-hard CYPT15B102, but the automotive-grade COTS device was selected to reduce cost. (If in-orbit reprogramming is not a system requirement, the second FRAM device may not be required).

A Cypress CYRS16B256 rad-hard flash device is also connected to the microcontroller on an SPI communications port. The purpose of this device is to act as a data-storage bank. Any data that is collected during the mission (for example, from sensors in the payload) can be stored in its 32 Mbytes of memory. Depending on the radiation profile expected during the mission, a designer might consider replacing this device with the COTS-equivalent integrated circuit, the Cypress S25FL256L.

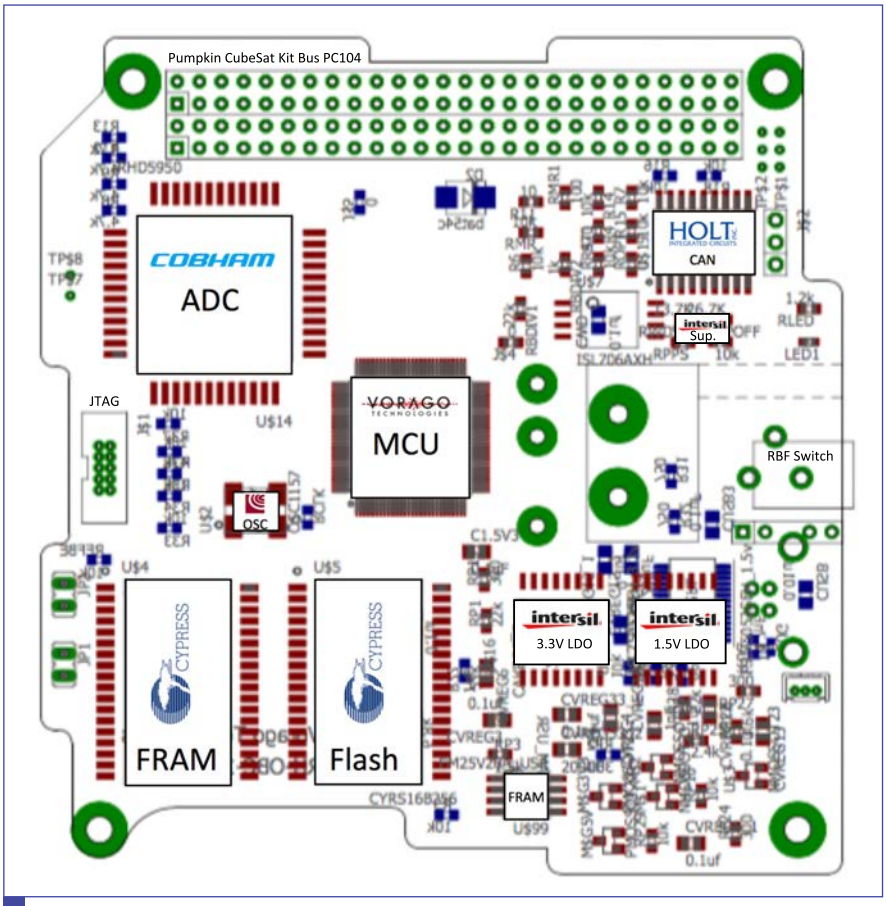


Figure 1 | CubeSat OBC reference design block diagram

For short-duration missions in low Earth orbit (LEO), designers often use COTS devices. While there is a risk of unrecoverable upsets, it is sometimes considered a trade-off against cost that is acceptable. The biggest risk to system operation is latch-up: All CMOS [complementary metal oxide semiconductor] devices are susceptible to latch-up due to ionizing radiation particle strikes. When a device latches up, a parasitic structure on the CMOS die becomes forward-biased and creates a short circuit from VDD to VSS (positive to negative). This causes a large current to flow through the device and pulls down VDD. It is therefore good practice to have a chip or circuit in the system that is latch-up-immune that will detect this condition occurring and can reset the system to resolve the latch-up condition. Normally, the VA10820 microcontroller performs this function in "selectively hardened" CubeSat systems. Note that latch-up can destroy a CMOS device despite a reset attempt, so the only safe way to really protect a system is to use fully latch-up-immune components throughout the system. This design is more expensive than using COTS and is at the crux of the CubeSat design challenge: How much risk is one willing to bear, given that mitigating against radiation effects with rad-hard devices is more expensive than using COTS?

If the microcontroller is latch-up-immune, there is at least one device that can be relied upon as the rad-hard mainstay of the radiation mitigation strategy. Another useful device that would be considered as a rad-hard mainstay would be the supervisor chip.

An Intersil ISL706A supervisor device is used in the system. (The circuit configuration is shown in Figure 2.) This supervisor performs three important functions. The first function is to hold the MCU in reset until the power supply reaches an appropriate level to power up the MCU. The second function is to observe the system power supply as a latch-up warning monitor. If any device in the system latches up, the supply voltage will be pulled down. The ratio of the potential divider implemented with resistors

R1 and R2 controls the threshold at which power fall input (PFI) on the supervisor chip triggers. For this reference design, the threshold has been set to 2.75V. In the event that the 3.3V rail drops to this level, a reset will be asserted to the MCU that will in turn reset the system. In most cases, the latched-up device will recover when the system is rebooted.

The third function that the supervisor device performs is as an additional independent watchdog. There is already a watchdog in the MCU, a timer that is periodically reset by the firmware to ensure that the code is executing properly. If the code hangs up and the on-chip watchdog is not reset by the firmware, an interrupt is generated that will cause a chip reset. The main failure mode that would be concerning for the MCU watchdog is a loss of clock. This condition is addressed by the supervisor device, as it acts as an external watchdog that operates similarly to the MCU watchdog, using a firmware-controlled periodic toggle signal from a GPIO line on the MCU. If this signal is not toggled at least once every 1.6 seconds, the supervisor will assert a hard reset to the MCU.

The reference design is powered by a 5V supply that is sourced either from an external supply preflight power connector (when used on the bench) or from the Pumpkin CubeSat Kit Bus across the PC/104 connector. There are three voltage supply rails used in the system: 5V, 3.3V, and 1.5V. The 5V rail supplies two Intersil ISL7502SEH rad-hard LDOs [Low Drop Out regulators]. All of the I/O on the board uses 3.3V signaling, whereas 5V is required for the analog-to-digital converter and 1.5V is required for the MCU core voltage. Each of the LDOs have an enable input that is routed to the specified pins on the Pumpkin CubeSat Bus PC/104 connector. This setup enables the power supplies on the OBC reference to be controlled by the CubeSat Electrical Power System (EPS) controller board that supplies power to the entire CubeSat system.

The MCU is supplied by a rad-hard 50 MHz clock device supplied by Frequency Management. The MCU internal clock speed can be adjusted dynamically in software.

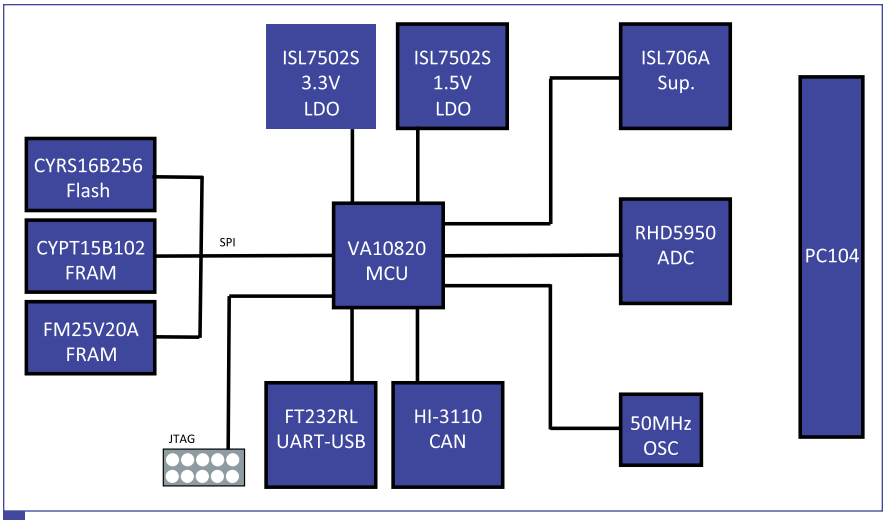


Figure 2 | Supervisor circuit

It can be operated at a lower speed, which may be an option to optimize power consumption. Many CubeSat applications are characterized by long periods of relatively low activity, with bursts of high activity during communications or data sampling periods; during the low-activity periods, the MCU clock speed can be reduced to conserve power.

The MCU is connected to a Cobham Aeroflex RHD5950 analog-to-digital converter (ADC). This is a successive approximation type that has 16 channels, 14-bit resolution, and a 20 µs conversion period. The ADC channels are connected to the analog input signal lines as detailed in the Pumpkin CubeSat Kit Bus specification. One of the ADC channels monitors the system voltage supply rail and another is connected to a resistance temperature detector (RTD). The RHD5950 has single conversion and continuous conversion modes; continuous conversion is useful for oversampling, which enables improvements in resolution and noise. The ADC output pins are connected to GPIO lines on the microcontroller, with the microcontroller also controlling the ADC on-chip multiplexer to determine which analog inputs are sampled.

There are several non-radiation-hardened COTS parts implemented on the board because a rad-hard option was not available. The first such device is a UART-to-USB interface (supplied by FTDI Ltd.). The reason for inclusion of this device in the reference design is to enable a USB interface to the system that can be used on the bench for development work; this interface is not intended for use in orbit. The device will translate USB protocol from an external host to a UART interface on the microcontroller. The USB port can be used as a simple terminal interface to the MCU. The UART-to-USB device is powered only when a USB cable is plugged into the system so will not create problems in the circuit if it is affected by radiation-induced faults.

The second non-radiation-hardened COTS device that is used in the system is an HI-3110 integrated controller area network (CAN) controller and physical layer (PHY). CAN is a popular serial communications protocol used widely in automotive systems that has also found favor with CubeSat designers because of its robust differential signaling characteristics. Whereas TTL level communications interfaces such as UART, SPI, and I^2C are ideal for short-hop intraboard communications, the CAN interface offers a more rugged option for interboard communications within the CubeSat system. If, for example, a sensor is located in a different physical locality, the CAN interface is a good option to communicate with it due to the high noise immunity of the differential signals provided by the PHY. Because this device is not inherently radiation-hardened, special measures are taken to monitor and control it. If it latches up, the supervisor will be triggered by the voltage drop on the supply voltage. The HI-3110 includes internal status registers that are monitored via the SPI communications interface by the MCU. The 3.3V and 5V power supplies to the CAN device is gated so that

the MCU can disable power to the CAN device and reset it if the status register data is ambiguous or indicates that an error has occurred. The power-supply gating circuit is shown in Figure 3.

The reference design includes a JTAG connector on the board to interface with the MCU for programming and debug. A debug pod (such as a Segger J-Link) connects to the JTAG header on the board and through USB to a host computer that is running an integrated development environment (IDE) such as ARM Keil µVision or IAR Embedded Workbench. One of the benefits of using an ARM-based microcontroller is that there is a broad selection of development tools available to support it. To reprogram the FRAM, the code would first be downloaded to the MCU and then be loaded to the FRAM through the SPI connection.

All Pumpkin nanosatellites use a remove-before-flight (RBF) high-current roller-tipped lever switch. It is typically used in conjunction with an RBF pin that presses on the roller, or in an assembly that presses against a wall of a nanosatellite deployment container. This switch, included on the board, provides Common (C), Normally Open (NO), and Normally Closed (NC) terminals. These are routed to the specified CubeSat Kit Bus pins on the PC/104 connector.

There are typically two versions of radiation-hardened devices available from suppliers – a prototype grade and a flight grade. Flight grade devices are screened to a higher level than prototypes although they are form, fit, and functionally identical and use the same die. Prototype-grade parts are usually around half of the price of flight-grade parts and for that reason were selected for use on this reference design.

Different specifications are used to quantify how an IC will perform in radiation-filled conditions including single-event latchup (SEL) and single-event upset (SEU). These are important to understand how often a device can be expected to exhibit bit errors in memory and logic errors due to ionizing particle strikes. The radiation specification most widely discussed for CubeSats is total

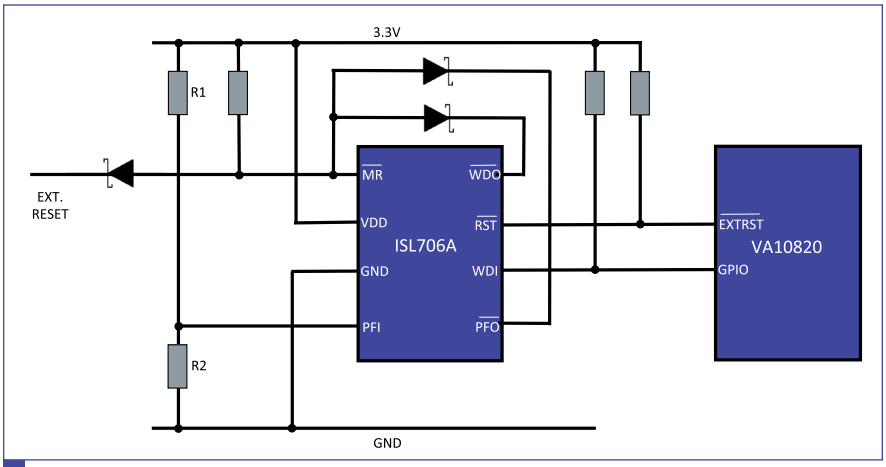


Figure 3 | Power-supply gating circuit protects system against COTS failure in radiation-filled environments.

Part Number	Supplier	IC function	TID rating
VA10820	VORAGO	MCU	300
CYRS16B256	Cypress	256MB Flash	150 (R) / 50 (W)
CYPT15B102	Cypress	FRAM	200
ISL7502S	Intersil	LDO	100
ISL706A	Intersil	Supervisor	100
XXX3056	Frequency Management	50MHz clock	100
RHD5950	Cobham	ADC	100
FM25V20A	Cypress	FRAM	N/A
HI-3110	Holt	CAN	N/A
FT232RL	FTDI	USB	N/A

Table 1 | TID performance of OBC reference design ICs

ionizing dose (TID): This is a measure of the amount of energy that can be absorbed in matter (in this case, thematter is silicon) and is denoted in Krad(Si), or kilo units of radiation absorbed dose (in silicon). TID accumulates over time and results in increased source-drain leakage in the MOS transistors in the IC as the device oxide builds up an accumulated charge. There is also an expansion of the depletion region between PMOS and NMOS-type devices. TID accumulation will result in increased leakage current; eventually, the CMOS device will cease functioning as the threshold voltage is pulled down.

CubeSat designers use the IC TID specifications to estimate how long a CubeSat is likely to function before the ICs within the structure will succumb to the effects of TID. This length of time depends on orbit altitude, orientation, and time. In LEO where CubeSats typically fly, the source of TID will be mainly electrons and protons. Details of the TID performance of the ICs on the reference design are given in Table 1. **SFF**

Ross Bannatyne *is director of marketing for VORAGO Technologies, based in Austin, Texas. He was educated at the University of Edinburgh and the University of Texas at Austin. Ross has published a college text called "Using Microprocessors and Microcomputers" and a book on automotive electronics called "Electronic Control Systems" (published by the Society of Automotive Engineers); he also holds patents in failsafe electronic systems and microcontroller development tools. Readers may reach Ross at rbannatyne@voragotech.com.*

Vorago Technologies
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Rugged networking on the move: Best practices for design and test for constrained-space applications

By Charlie Kawasaki

Communications equipment aboard amphibious vehicles, ground vehicles, and aircraft needs to be many things: rugged, small, light, and power-efficient. In this photo, U.S. Marines with the 3rd Assault Amphibian Battalion, 1st Marine Division, depart the USS Rushmore to conduct an amphibious assault during a 2017 exercise. Photo by Cpl. Austin Mealy/courtesy U.S. Marine Corps.

In the unpredictable environment of the battlefield, the fight does not stop just because you are moving. That reality puts warfighters at a distinct disadvantage if they cannot maintain situational awareness at all times, as adversaries equip themselves with the latest wireless technology and smartphones while actively moving in ground vehicles. Mobile Internet Protocol (IP) networking is a necessary response by the Department of Defense (DoD) to counter the many foes who have ready access to this ever-smaller mobile technology. The DoD's moves are enabling U.S. warfighters to be more agile and prepared.

The U.S. Marine Corps NOTM Increment 1 (Inc1) Refresh program is an example of an integrated tactical mobile network working to effectively leverage proven commercial and government technology to enhance communications capabilities. Combat vehicles integrated with networking-on-the-move equipment provide reliable communications, mission command, and situational awareness from anywhere on the battlefield, even in the most remote environments and challenging terrains.

To maintain information dominance, warfighters across all branches of the military require networking-on-the-move to stay on top of complex threat environments.

Along with increased demands on communications systems to provide more capability (such as Wi-Fi or LTE) and more cybersecurity in the field comes the inevitable side effect: Networked systems consume more space.

Ability to handle rugged terrain
When traversing rugged terrain, military vehicles can experience a high level of shock and vibration. Networking-on-the-move systems must be able to stand up to that abuse so that communications are not interrupted.

In the past, methods to deploy access to tactical networks have included commercial off-the-shelf (COTS) equipment originally designed for data-center environments. A new generation of ruggedized COTS equipment is now available that makes mobile battlefield networking more reliable, while continuing to maintain interoperability with enterprise networking equipment, thereby ensuring end-to-end communications.

Address full mobility needs in constrained spaces
Mobility ultimately drives networking-on-the-move, but the amount of available real estate within ground vehicles, aircraft, and ships does not change. Along with increased demands on communications systems to provide more capability (such as Wi-Fi or LTE) and more cybersecurity in the field comes the inevitable side effect: Networked systems consume more space.

As a result, full mobility demands innovation and modernization designed to reduce size, weight, and power (SWaP) requirements. In this realm – with all other things being equal – communications equipment can never be too small, too light, or too power-efficient.

Reliability in challenging vehicle environments
Products intended for mobile battlefield use must meet high standards of environmental testing for shock, vibration, and temperature. Requirements for ground vehicles are stringent; conditions are even more stringent for aircraft, because ill-designed or poorly manufactured communications equipment can put the aircraft and warfighters at great risk. Compliance with third-party testing to MIL-STD-810G and MIL-STD-461F are critical to assure reliably in actual operations in remote or mission-critical settings. These standards are increasingly relevant as DoD increases adoption of COTS technologies in lieu of purpose-built military-only products in order to benefit from the commercial world's rapid pace of technology advancement and cost-saving economies of scale.

What to look for in vendors' design and test best practices
Adapting sensitive, high-performance electronics to withstand conditions found on the network's edge – regardless of industry or application – is no easy task. This reality has led to development of compact rugged network modules designed and manufactured by specialized vendors. These modules typically incorporate COTS equipment and networking software from industry-leading

manufacturers, which makes it easy to securely connect to enterprise networks. However, starting with enterprise-class technology is just the beginning.

Optimized chassis design

The heart of any rugged module is its chassis. The best designs for optimizing SWaP use a variety of materials and design processes, including machined heat sinks and heat-spreader plates incorporating aluminum and copper for efficient heat transfer, machined steel for critical structural elements, sheet metal for electromagnetic (EMI) protection, and plastics and composites for weight savings.

Once designed, the modules should be tested to validate the design. To be certain that rugged equipment will hold up, the best designers follow a regimented test methodology with calibrated, certified, independent test labs – and can make complete and extensive test documents available. To save costs, some vendors will perform their own testing in-house, with some not completing the full range of tests. Some vendors only go as far as claiming their systems are "designed to meet" standards,but do no testing at all. For ultimate confidence, independent testing is an expensive, but necessary step. Once constructed, the system should be tested to make sure that it adheres to standards, under real-world conditions.

Conductively cooled

Since rugged equipment must be able to withstand dust and sand, the traditional method of using cooling fans to drive airflow through the equipment enclosure is not an option. In such conditions, other methods must be used to cool systems, since heat is the mortal enemy of electronics. In a fanless design, efficient heat transfer is vital to ensuring durability. The chassis plays a vital role in dissipating heat – it must be designed with careful attention to optimal heat transfer from critical electronic components on the embedded circuit boards and power supplies. Once designed, the modules can be tested for operations in heat/cold extremes in independent labs.

Protected and reliable power systems

Another environmental challenge faced by rugged systems includes poor quality and unreliable power sources – especially for equipment mounted on vehicles, running on generators, or deployed overseas in countries with poor-quality power. DC power systems can provide power that is inconsistent in voltage, intermittent, and noisy. These problems can be caused by other devices attached to the power sources as well. Additional problems can crop up due to user error such as connecting DC power wires backwards, or by short circuits.

To offset these problems, power supplies must be designed to accept the widest possible range of input voltage (for example, 10 V to 36 V), should be reverse-voltage and short-circuit protected, and should include extensive filters and capacitors to maintain a clean, reliable source of power to internal components. One recent innovation to look for in best-of-class AC power supplies is the use of single-stage AC to DC conversion, which provides higher efficiency, less power loss, and less dissipated heat. These technologies are also smaller in size than traditional two-stage converters and will perform at lower temperature ranges.

Eliminating EMI

Networking equipment mounted in vehicles typically resides in environments shared with many other computers and radios; some may be mounted near radar equipment. In such setups, it's paramount that all of the onboard equipment is designed and tested to ensure it does not cause, and is not susceptible to, EMI, to ensure reliable performance of the equipment and ensure that the equipment does not cause neighboring equipment failure. (Figure 1.)

EMI occurs in the form of both unintended radio "over-the-air" interference and conducted interference through power and data connections; both kinds must be mimimized through shielding and filtering. In networking equipment, typical sources of issue are the power supplies. For defense applications, the standard

MIL-STD 461 is used to test for EMI, including radiated and conducted emissions and susceptibility. This standard is roughly 10 times more stringent than typical FCC standards used for data center and consumer equipment. Because the military standard is so strict, small issues in design and manufacturing can cause systems to fail this test.

100 percent tested in manufacturing

Such stringent testing can be conducted only on a limited number of units, since it's extraordinarily expensive and time-consuming; what's more, the equipment subjected to those tests can't be shipped to customers as "new." However, newly manufactured equipment must be tested throughout the manufacturing process to ensure that the new equipment conforms to design specifications.

Certain types of environmental stress screening (ESS) testing can be conducted safely and efficiently on all new units, ensuring that common failures are identified before ever leaving the factory. The failure rate in this step tends to be about five percent. ESS screening is, to be fair, expensive and time-consuming, but if vendors skimp on stress testing the risk of failure is merely passed on to designers and users.

Real-world tested

While laboratory testing is critical to ensure that test coverage is complete, standardized, and quantifiable, real-world testing also plays a critical role in assessing performance and reliability – exposing equipment to deployment-specific environmental factors that are hard to anticipate and reproduce in a lab.

Moreover, in addition to environmental factors, real-world testing can expose opportunities to improve usability, accessibility, and maintainability – along with gathering observations from end users and operators. Real-world testing also provides designers and programs with confidence that complete systems actually work together as intended.

Designing, testing, and manufacturing rugged, reliable networking equipment is time-consuming, expensive, and detail-oriented. Requiring effective test processes of vendors when selecting networking equipment means that the DoD can ensure that its warfighters can meet any threat. **SFF**

Charlie Kawasaki *joined PacStar in early 2005 to lead the company's technology strategy and future product roadmap for its proprietary product lines. He holds extensive experience in product development, software engineering, technology licensing, patent development, business development, product marketing, general management and M&A.*

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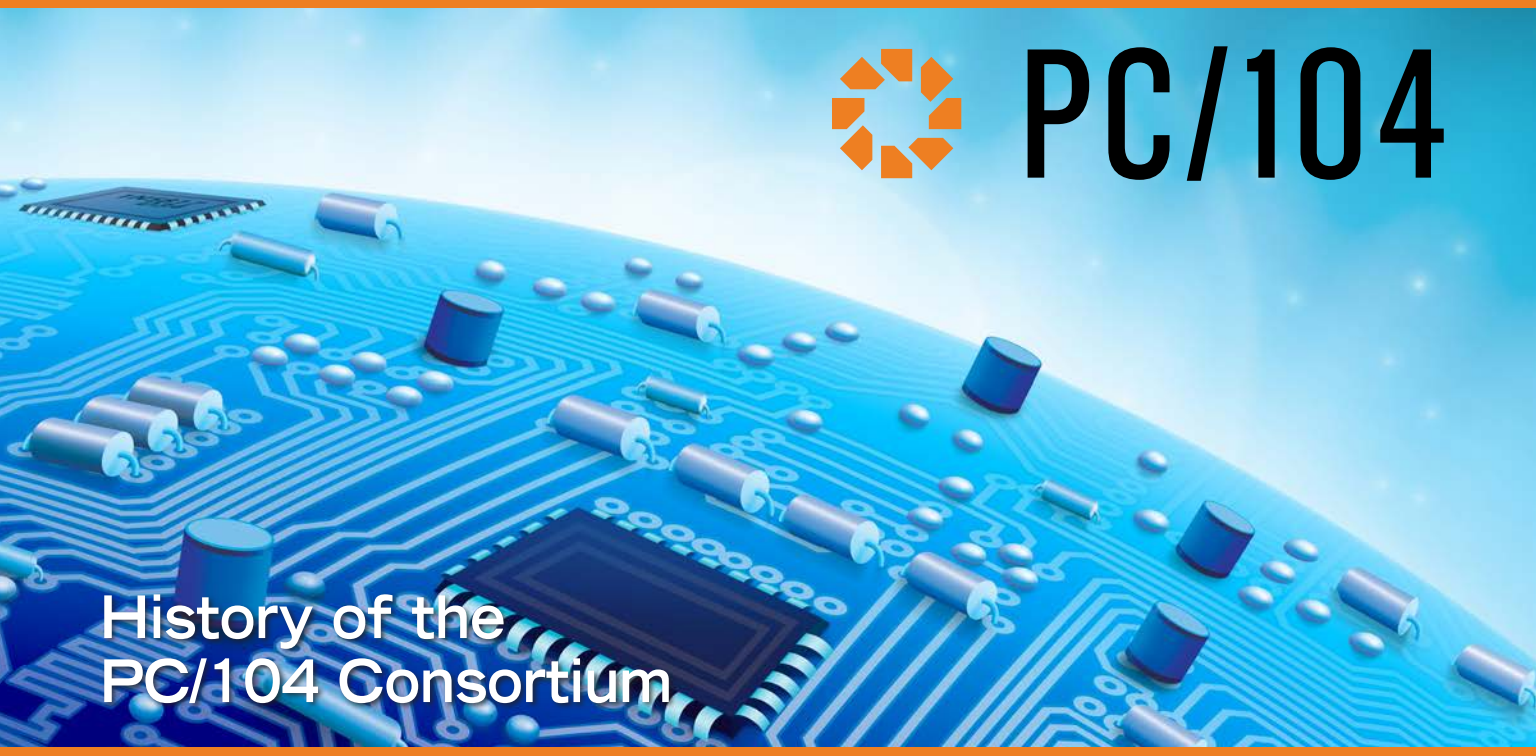
Figure 1 | The close quarters shared by networking and other equipment on a military vehicle can cause electromagnetic interference, which must be minimized through shielding and filtering. Photo courtesy PacStar.



History of the PC/104 Consortium

The PC/104 Consortium was established in February 1992 by 12 companies with a common vision of adapting desktop computer technology for embedded applications. This consortium has had a tremendous, positive effect on the embedded computer marketplace. The initial release of the PC/104 specification in March of 1992 was an open design offering the power and flexibility of an IBM compatible personal computer in a size ideally suited for embedding. Simple and elegant in design, while small but rugged in performance, PC/104 technology bridged the successes of the past with the promises of future innovations.

The ISA bus of the original IBM PC — as established by the IEEE P996 specification – is still fully supported today by PC/104 technology over two decades after it was created.

When demand for a faster, higher-bandwidth bus emerged, the PC/104 Consortium once again followed the desktop PC by adding a PCI bus to the ISA bus. Following on, PC/104-Plus was introduced in February of 1997. By keeping the ISA bus and adding the PCI bus, this specification became an addition to the technology rather than a replacement of any existing technology.

When desktop PCs stopped using the ISA bus, the PC/104 Consortium was ready with PCI-104 technology. The concept of PCI with no ISA was introduced in the original PC/104-Plus specification and was subsequently formally recognized with its own specification in November 2003. Once again, the PC/104 Consortium followed the desktop PC while keeping the legacy specifications intact.

This growth pattern underscores the PC/104 Consortium's desire to support the legacy technology while developing new solutions for the future. Longevity is a requirement for embedded systems and remains one of the hallmarks of PC/104 technology. This aspect is proven time and again by the number of PC/104, PC/104-Plus, and PCI-104 products on the market today, as well as by the number of PC/104 sites on other form-factor boards.

To learn more about PC/104 Consortium organization and membership, please visit www.pc104.0g or email the organization at info@pc104.org.

PC/104 Consortium Founding Members

Ampro	DMS Systems	Real Time Devices
Automation Instruments	Enclosure Technologies	Reflection Technology
BG Technologies	IOTech Inc.	Voice Connection
Diamond Systems	Quantum Software Systems	Xecom

Types of PC/104 Specifications

- **PC/104:** Like the original PC bus itself, PC/104 is thus the expression of an existing de facto standard, rather than being the invention and design of a committee. In 1992, the IEEE began a project to standardize a reduced form-factor implementation of the IEEE P996 (draft) specification for the PC and PC/AT buses, for embedded applications. The PC/104 specification has been adopted as the "base document" for this new IEEE draft standard, called the P996.1 Standard for Compact Embedded-PC Modules.

- The key differences between PC/104 and the regular PC bus (IEEE P996) are compact form factor, with size reduced to 3.6 by 3.8 inches; unique self-stacking bus, which eliminates the cost and bulk of backplanes and card cages; pin-and-socket connectors, in which rugged and reliable 64- and 40-contact male/female headers replace the standard PC's edge card connectors; and relaxed bus drive (6 mA), which lowers power consumption to one or two watts per module and minimizes component count.

- **PC/104-Plus:** This specification establishes a standard for the use of a high-speed PCI bus in embedded applications. Incorporating the PCI bus within the industry-proven PC/104 form factor brings many advantages, including fast data transfer over a PCI bus, low cost due to PC/104's unique self-stacking bus, and high reliability due to PC/104's inherent ruggedness.

- **PCI-104:** To accommodate the gradual replacement of ISA bus devices with PCI devices, the PCI-104 was approved by the PC/104 Consortium. PCI-104 is a PCI-only architecture that accommodates the advances of PCI devices in a small, rugged form factor.

- **PCI/104-Express:** Incorporating the PCI Express bus within the industry-proven PC/104 architecture brings many advantages for embedded applications, including fast data transfer, low cost due to PC/104's unique self-stacking bus, high reliability due to PC/104's inherent ruggedness, and long term sustainability.

- **EPIC:** The EPIC specification defines a physical platform for midsized embedded single-board computer (SBC) with multiple I/O expansion options. Its size is midway between the industry standard PC/104 stackable format and EBX SBC format. This size board will support larger processors requiring large heat sinks. The added space also allows for combining features on an SBC which would normally be found on multiple PC/104 modules.

- **EPIC Express:** Its size is midway between the industry-standard PC/104 stackable format and the EBX SBC format. This board emphasizes I/O connector area. The added space also allows for combining features on an SBC which would normally be found on multiple PC/104 modules.

- **EBX:** The EBX form factor, combining a standard footprint with open interfaces, is small enough for deeply embedded applications, yet large enough to contain the functions of a full embedded computer system: CPU, memory, mass storage interfaces, display controller, serial/parallel ports, and other system functions.

- **EBX Express:** Allows easy and modular addition of functions not contained in standard product offerings. This EBX system expansion is based on popular existing industry standards — PC/104, PCI, PC/104-Plus, PCI-104, and PCMCIA.

- **"Adopt-a-spec":** Any group or individual(s) having a specification for an embedded technology that implements and/or supports PC/104 technology may present the specification to the Consortium for consideration as a standard.

  Please see website (http://pc104.org/hardware-specifications/adopt-a-spec) for additional information.

PC/104 Consortium Members at Embedded World

February 27-March 1, 2018 | Nuremberg, Germany | www.embedded-world.de/en

PC/104 CONSORTIUM MEMBER	BOOTH NUMBER
ADLINK Technology	Hall 1/1-540
ADL Embedded Solutions	Hall 1/1-554
Advantech Co.	Hall 2/2-338
Axiomtek	Hall 1/1-456
bplus GmbH	Hall 1/1-438
Connect Tech	Hall 2/2-318
Diamond Systems	Hall 3/3-558
ept Inc.	Hall 3/3-551
Fastwel Co.	Hall 1/1-512
MicroMax Computer Intelligence	Hall 2/2-529
Perfectron Co.	Hall 1/1-430
PC/104 Consortium	Hall 4A/4A-261
Samtec.	Hall 4A/4A-240
VersaLogic	Hall 3/3-259
WinSystems Inc.	Hall 2/2-620

Listings and locations are subject to change.

PC/104 Consortium 2017-2018 Member Directory

ADLINK Technology
www.adlinktech.com

Advanced Micro Peripherals
www.ampltd.com

ADL Embedded Solutions
www.adl-usa.com

Advantech Co.
www.advantech.com

Alpha Project Co.
www.apnet.co.jp

Axiomtek
www.axiomtek.com

bplus GmbH
www.b-plus.com/en/home.html

Connect Tech
www.connecttech.com

Diamond Systems
www.diamondsystems.com

Douglas Electronics
www.douglas.com

Dynamic Engineering
www.dyneng.com/pc104.html

ept Inc.
www.ept.de

EVOC Intelligent Technology
www.evoc.com

Fastwel Co.
www.fastwel.com

Hivertec
www.hivertec.com

MicroMax Computer Intelligence
www.micromax.com

Perfectron Co.
www.perfectron.com

PC/104 and Small Form Factors
www.smallformfactors.mil-embedded.com

RAF Electronic Hardware
www.rafhdwe.com

RedWave Labs
www.redwavelabs.com

RTD Embedded Technologies
www.rtd.com

Samtec
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www.versalogic.com

WinSystems Inc.
www.winsystems.com

Listings are subject to change.

The future of Ethernet

By Ronen Isaac, MilSource

With Ethernet becoming the ubiquitous connectivity standard for service providers, enterprises, and military applications, we are letting go of proprietary networking technologies and heading directly into industry standard networking based on Ethernet.

For those of you new to the Ethernet game, let's first establish that Ethernet standards are collaboratively developed, challenged, and approved by the Institute of Electrical and Electronics Engineers (http://ieee.org/). To ensure interoperability among all electrical and networking devices, this standards body reviews and ratifies and publishes the standards from anything electrical to anything networking. Within computing and networking, the Ethernet Alliance (EA, http://ethernetalliance.org) has been established as a global, nonprofit consortium of vendors, industry experts, universities, and governments that work together to bring Ethernet standards to the marketplace.

The EA is key to making Ethernet technology open and innovative, and tried and tested. For all of us tech geeks, the EA previously published a great poster; the latest one is the Ethernet Roadmap.

So where are we now? Ethernet speeds are running anywhere from 10 megabits per second (Mbps) to 400 gigabits per second (Gbps). For easy reference, let's start somewhere everybody is familiar with: home Internet connections. Although it's now rare, some rural home connection speeds can be as low as 10 Mbps. Most high-speed Internet home services are currently maxing out at about 60 Mbps for copper-based services, while fiber services are now offering "near-gigabit Ethernet" speeds.

In the enterprise, connectivity options from service providers mean that workstations are equipped with 1000BASE-T network interface cards (NICS) and enterprise LANs run gigabit Ethernet (1000BASE-T) switches and routers to support connectivity between locally connected devices. In enterprise data centers, most server-to-server connectivity – up until the last two years – were running over fiber cables connecting the devices at speeds of up to 10 Gbps. However, with the enormous amounts of data and the advent of cloud-based services, data centers adopted 40 Gbps technology faster than any other Ethernet technology in the history of networking. Now data center-to-data center connectivity (between two data centers or between a data center and a service provider network) is running at either 40 Gbps or 100 Gbps (a standard ratified by the EA and IEEE back in 2010).

Currently being tested and ratified are technologies that will bring speeds up to 400 Gbps, typically used by service providers and large-scale cloud providers, and 50 Gbps (expecting ratification in 2018-2019) that will supplant 40 Gbps connections in data centers because of its more efficient use of electrical "traffic lanes."

So where does Ethernet sit for military applications? While central data centers and field offices are running at the same pace of traditional enterprises, field applications are lagging behind a bit on the adoption curve. Examples of less-complex network applications include dismounted soldiers or small unmanned aerial systems, where compute and communications devices just need to be able to communicate with each other. Gigabit Ethernet, carrying traffic at speeds of as fast as 1,000 Mbps/1 Gbps, is a de facto standard in mobile platforms that need to support higher volumes of traffic, delay sensitive data (video, sensors, VoIP), or carry multiple devices on the same platform (computer, IP phone, IP camera, sensors, etc).

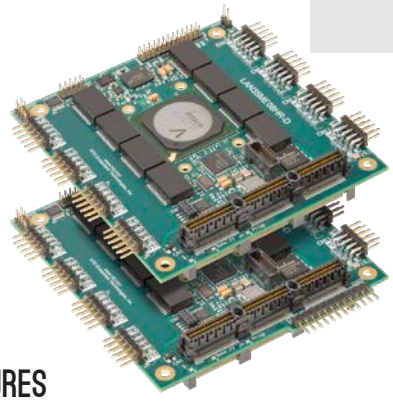
As military programs look to the future – where mobile platforms such as the Joint Light Tactical Vehicle, tanks, and mobile missile launchers will require hundreds of sensors for situational awareness and feeding high-resolution, high-frame-rate cameras for intelligence – current programs are looking to implement 10 Gbps links for on-vehicle aggregation of this traffic to computers or video cameras.

Forward-looking programs are also looking at 40 Gbps links and communications hubs, such as Ethernet switches, simply because the efficiency of running data through four lanes of 10 Gbps will make data communication almost immediate and deliver zero lag time for on-vehicle communications. Having said that, it is important to note that while 40 Gbps traffic will be efficient while onboard the vehicle, traffic and communications speeds traveling off the vehicle to central command will still be limited by current wireless connectivity rates running at about 150 Mbps. Yes, 150 Mbps. This disparity illustrates the importance of having all possible intelligence and compute power on the vehicle so that only mission-critical data will have to be sent back to central command.

What does the future hold? As of 2017, the EA has already done formal functional and interoperability testing with vendors offering 400 Gbps routers and switches. Between 2018 and 2020, 50 Gbps and 200 Gbps will be tested and adopted. Thousands of 25 GbE servers – and eventually 50 GbE servers in hyperscale data centers, such as cloud service providers – will drive the need for 400 GbE to the metropolitan area networks (MANs) and wide-area networks (WANs). In the not-too-distant future, testing will begin on 200 Gbps, 8,000 Gbps, and, astonishingly, data rate speeds of 1 Tbps and 1.6 Tbps, with expected testing and ratification of the standards by the year 2020.

***Ronen Isaac** is the general manager for MilSource (www.militaryethernet.com) in El Segundo, California.*

IoT



Managed Scalable GigE Switch

The LAN35MH08HR is an 8-port 10/100/1000 Managed Ethernet switch. This switch module has a total of 10 ports: eight ports are provided to I/O connectors, one port is available to the host CPU through a x1 PCI Express GigE controller, and one port is used as a stacking switch expansion port allowing full compatibility with RTD's managed and unmanaged StackNET™ Ethernet switch family. Additionally, this allows the CPU to use the switch without the need for external cables. The LAN35MH08HR can also be used as an expandable, standalone 8-port Ethernet switch.

The onboard CEServices Carrier Ethernet switching software provides a rich Layer 2 switching solution with Layer 3-aware packet processing. All of the industry-standard Managed Ethernet Switch features found in an enterprise rackmount switch are provided, such as VLANs, Spanning Tree, QoS, and SNMP. Additionally, the CEServices software provides features for carrier and timing-critical networks such as OAM, Synchronous Ethernet, and IEEE 1588. The switch may be configured via a web GUI interface, or a command-line console via USB, Telnet, or SSH.

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FEATURES

- -40 to +85°C operation, passively cooled
- PCIe/104 stackable bus structure
- Eight 1000/100/10 Mbps Ethernet ports plus one host port and one stacking switch expansion port
- Onboard tri-color LED for each Ethernet Port
- RJ-45 jacks or 10-pin right-angle headers
- Fully-managed Layer 2 Ethernet Switch with Layer 3-aware packet processing
  - *Support for all major Enterprise switching features such as VLANs, Spanning Tree, QoS, and SNMP*
  - *Manageable via web GUI interface, SSH, Telnet, and Serial Console*
  - *Industry-standard CLI interface*
- Onboard PCI Express Ethernet Controller for interface to host cpuModule
- USB Device Port for Serial Console command-line interface
- Passive heat sink included ▪ Available in stackable, rugged enclosures

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IoT

RTD Off-the-Shelf Mission Computer

RTD's standard HiDANplus® embedded computer system provides a robust Commercial-Off-the-Shelf (COTS) solution enabling rapid uptime for mission-critical applications. The system includes a rugged single board computer, power supply, mSATA card carrier, and room for an additional peripheral module. Without increasing the enclosure size, functional upgrades can include high-performance data acquisition, versatile networking options, or enhanced capabilities from a variety of special-purpose add-in modules. Additional configuration options include a removable SATA drawer.

The milled aluminum enclosure with advanced heat sinking delivers passively-cooled performance from -40 to +85°C. Integrated tongue-and-groove architecture with EMI gaskets create a watertight solution with excellent environmental isolation. Keyed cylindrical connectors offer easy cable connections while maintaining the integrity of the environmental seal.

FEATURES

- -40 to +85°C standard operating temperature
- Designed for high ingress protection in harsh environments
- Milled aluminum enclosure with integrated heat sinks and heat fins
- Rugged Intel and AMD-based Single Board Computers
- High-performance, synchronized power supply
- mSATA card carrier and optional 2.5" removable drive
- Designed to include an additional PCIe/104, PCI/104-Express or PCI-104 peripheral module without increasing overall enclosure size

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RTD Embedded Technologies, Inc.
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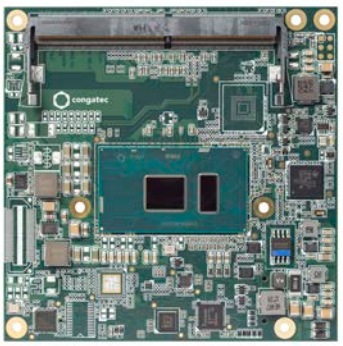
conga-TC175

The compact **conga-TC175** Computer-on-Modules (COMs) based on the 7th generation of Intel® Core™ SoC processors (codename Kaby Lake) offer compelling features with increased CPU performance, dynamic HDR graphics thanks to 10-bit video codec, and support of the optional, super-fast 3D Xpoint-based Intel® Optane™ memory.

These high-performance Computer-on-Modules based on the 7th generation of Intel® Core™ processors from Intel's IOTG embedded roadmap provide the performance required by many of the new application fields of embedded computing within a low power envelope of only 15 W. Demand is found virtually everywhere: from industrial, medical and transportation applications to infotainment and retail as well as in building and home automation.

Thanks to its compatibility with the previous generation, these modules with the widely improved microarchitecture can be integrated in nearly all embedded applications thanks to their compact footprint of only 95 mm x 95mm. Furthermore they are a perfect drop-in upgrade for all existing systems based on the standardized COM Express without additional design effort. The standardized COM Express form factor, congatec's extensive industrial driver implementations as well as personal integration support and individual customization services make it particularly easy for developers to integrate this generation. Target applications are found wherever fanless and completely sealed systems must offer high performance.



FEATURES

- The conga-TC175 COM Express Compact modules come equipped with three different low-power dual-core variants of Gen 7 Intel® Core™ i7, i5 and i3 SoC processors and offer also a cost efficient Intel® Celeron® variant.
- The TDP of all variants is configurable from 7.5 to15 Watts, which makes it easier to adapt the application to the energy concept of the system.
- All modules support up to 32 GB fast and energy efficient dual channel DDR4 memory, which boasts significantly more bandwidth and higher energy efficiency than conventional DDR3L implementations.
- The Intel® Gen 9 HD Graphics 620 offers high graphics performance with latest DirectX 12 capabilities and supports up to three independent displays with up to 4k @ 60 Hz via eDP 1.4, DisplayPort 1.2 and HDMI 2.0a.

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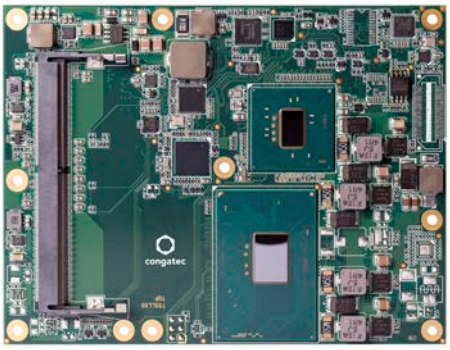
COMs and SOMs

conga-TS175

The high-performance conga-TS175 Server-on-Module equipped with the high-end Intel® Xeon® and Gen 7 Intel® Core™ processors (codename Kaby Lake) sets a new benchmark for module-based high-end embedded computers and modular industrial workstations that need to process massive workloads.

Application areas for these high-end COM Express Type 6 Server-on-Modules can be found everywhere where data intensive streams need to be processed and displayed in real time. Target markets include big data processing embedded clouds, edge and fog servers, medical imaging systems, video surveillance and vision-based quality control, simulation equipment, host systems for virtualized control technology, vision systems in industrial control rooms and other plant-wide supervision systems or high-end professional gaming and digital signage.

Compared to their predecessors, the new modules host increased CPU frequencies and performance, more dynamic HDR graphics thanks to 10-bit video codecs, and support super-fast Intel® Optane™ memory offering a significantly lower latency while handling the same size of data packets compared to NAND SSDs. These new modules set the latest state-of-the-art benchmark for high-end Server-on-Module applications and high-end embedded use cases with hyper threading within an embedded power envelope of less than 45 Watts.



FEATURES

- High scalability from Intel® Xeon® processors to Intel® Core™ i3 processors within a 45 to 25 W TDP envelope.
- High bandwidth for data intensive applications with up to 32 gigabytes of fast dual channel 2400 DDR4 memory – including ECC support option.
- Extensive graphics capabilities for up to three independent 4k-UHD displays via a broad range of interfaces including DisplayPort 1.4, HDMI 2.0 with HDCP 2.2 as well as eDP 1.4 and dual channel LVDS and VGA for legacy displays.

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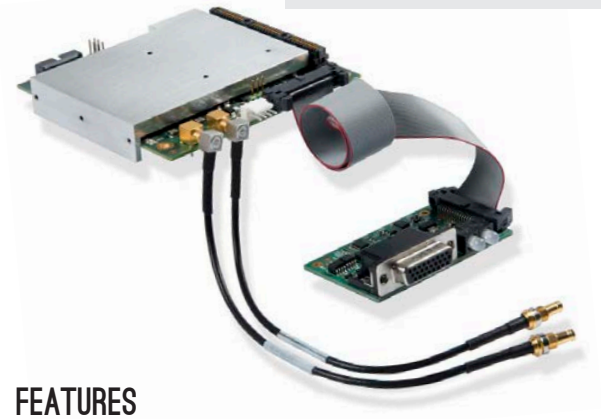
EURESYS™
Excellence in vision

Coaxlink Duo PCIe/104

The **Coaxlink Duo PCIe/104** from Euresys is a **ruggedized CoaXPress frame grabber compliant with the PCIe/104 form factor.**

It features an extended operating temperature range, optional conformal coating and is able to withstand high levels of shock and vibration. It provides two CoaXPress CXP-6 (6 Gbit/s) camera connections and a PCIe 2.0 (Gen 2) x4 bus. CoaXPress carries high-speed digital video over standard coaxial cables and is suitable for embedded video applications.

The **Coaxlink Duo PCIe/104** can be customized to fit your requirements.



FEATURES

- Ruggedized COTS board for industrial and military embedded applications
- Small stackable PCIe/104 form factor
- Extended temperature range: -40 to +85 °C / -40 to +185 °F with conduction cooling (ambient temperature measured inside the enclosure)
- Sustained shock: 20 g/11ms (all axes – half-sine and saw tooth)
- Optional conformal coating
- Two CoaXPress CXP-6 connections: 1,250 MB/s camera bandwidth
- PCIe 2.0 (Gen 2) x4 bus: 1,700 MB/s delivery bandwidth

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PEAK® System

PCAN-PC/104

CAN Interface for PC/104

The PCAN-PC/104 card enables the connection of one or two CAN networks to a PC/104 system. Multiple PCAN-PC/104 cards can easily be operated using interrupt sharing.

The card is available as a single or dual-channel version. The opto-decoupled versions also guarantee galvanic isolation of up to 500 Volts between the PC and the CAN sides.

The package is also supplied with the CAN monitor PCAN-View for Windows and the programming interface PCAN-Basic.

FEATURES

- Multiple PC/104 cards can be operated in parallel (interrupt sharing)
- 1 or 2 High-speed CAN channels (ISO 11898-2)
- Bit rates from 5 kbit/s up to 1 Mbit/s
- Compliant with CAN specifications 2.0A (11-bit ID) and 2.0B (29-bit ID)
- 5-Volt supply to the CAN connection can be connected through a solder jumper, e.g. for external bus converter
- Optionally available with galvanic isolation on the CAN connection up to 500 V, separate for each CAN channel
- Extended operating temperature range from -40 to 85 °C (-40 to 185 °F)

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PCAN-PC/104-*Plus*

CAN Interface for PC/104-*Plus*

The PCAN-PC/104-*Plus* card enables the connection of one or two CAN networks to a PC/104-*Plus* system. Up to four cards can be operated, with each piggy-backing off the next. The CAN bus is connected using a 9-pin D-Sub plug on the slot bracket supplied.

The card is available as a single or dual-channel version. The opto-decoupled versions also guarantee galvanic isolation of up to 500 Volts between the PC and the CAN sides.

The package is also supplied with the CAN monitor PCAN-View for Windows and the programming interface PCAN-Basic.

smallformfactors.mil-embedded.com/p345620

FEATURES

- Up to four cards can be used in one system
- 1 or 2 High-speed CAN channels (ISO 11898-2)
- Bit rates from 5 kbit/s up to 1 Mbit/s
- Compliant with CAN specifications 2.0A (11-bit ID) and 2.0B (29-bit ID)
- 5-Volt supply to the CAN connection can be connected through a solder jumper, e.g. for external bus converter
- Optionally available with galvanic isolation on the CAN connection up to 500 V, separate for each CAN channel
- Extended operating temperature range from -40 to 85 °C (-40 to 185 °F)

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Hardware and Peripherals

PCAN-PC/104-*Plus* Quad

The PCAN-PC/104-*Plus* Quad card enables the connection of four CAN networks to a PC/104-*Plus* system. Up to four cards can be operated, with each piggy-backing off the next. The CAN bus is connected using a 9-pin D-Sub plug on the slot brackets supplied. There is galvanic isolation of up to 500 Volts between the computer and CAN sides.

The package is also supplied with the CAN monitor PCAN-View for Windows and the programming interface PCAN-Basic.

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FEATURES

- Up to four cards can be used in one system
- 4 High-speed CAN channels (ISO 11898-2)
- Bit rates from 5 kbit/s up to 1 Mbit/s
- Compliant with CAN specifications 2.0A (11-bit ID) and 2.0B (29-bit ID)
- 5-Volt supply to the CAN connection can be connected through a solder jumper, e.g. for external bus converter
- Galvanic isolation on the CAN connection up to 500 V, separate for each CAN channel
- Extended operating temperature range from -40 to 85 °C (-40 to 185 °F)

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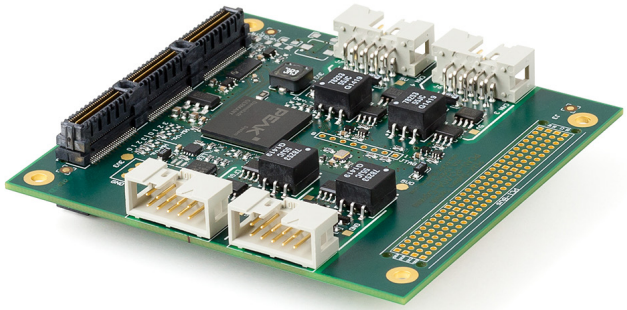
PCAN-PCI/104-Express



The PCAN-PCI/104-Express card enables the connection of one, two, or four CAN busses to a PCI/104-Express system. Up to four cards can be stacked together. The CAN bus is connected using a 9-pin D-Sub plug on the slot brackets supplied. There is galvanic isolation of up to 500 Volts between the computer and CAN sides. The card is available as a single, dual, or four-channel version.

The package is also supplied with the CAN monitor PCAN-View for Windows and the programming interface PCAN-Basic.

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FEATURES

- Up to four cards can be used in one system
- 1, 2, or 4 High-speed CAN channels (ISO 11898-2)
- Bit rates from 5 kbit/s up to 1 Mbit/s
- Compliant with CAN specifications 2.0A (11-bit ID) and 2.0B (29-bit ID)
- 5-Volt supply to the CAN connection can be connected through a solder jumper, e.g. for external bus converter
- Galvanic isolation on the CAN connection up to 500 V, separate for each CAN channel
- Extended operating temperature range from -40 to 85 °C (-40 to 185 °F)

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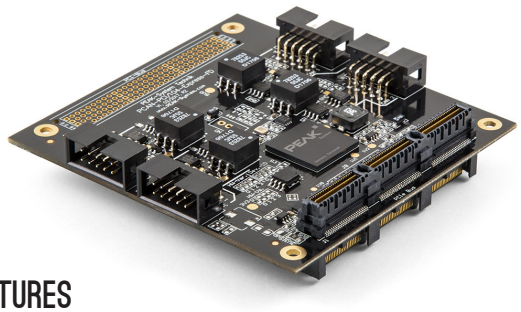
Hardware and Peripherals

PCAN-PCI/104-Express FD



CAN FD Interface for PCI/104-Express

The PCAN-PCI/104-Express FD allows the connection of PCI/104-Express systems to CAN and CAN FD busses. Up to four cards can be stacked together. The CAN bus is connected via 9-pin D-Sub connectors to the supplied slot brackets. There is a galvanic isolation between the computer and the CAN side up to 500 Volts. The card is available as a single, dual, or four-channel version.

The monitor software PCAN-View and the programming interface PCAN-Basic are included in the scope of supply and support the new standard CAN FD.

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FEATURES

- PCI/104-Express card, 1 lane (x1) ▪ Form factor PC/104
- Up to four cards can be used in one system
- 1, 2, or 4 High-speed CAN channels (ISO 11898-2)
- Complies with CAN specifications 2.0 A/B and FD
- CAN FD support for ISO and Non-ISO standards switchable
- CAN FD bit rates for the data field (64 bytes max.) from 15 kbit/s up to 12 Mbit/s
- CAN bit rates from 15 kbit/s up to 1 Mbit/s
- Connection to CAN bus through D-Sub slot bracket, 9-pin (in accordance with CiA® 303-1)
- FPGA implementation of the CAN FD controller ▪ MCP2558FD CAN transceiver
- Galvanic isolation on the CAN connection up to 500 V, separate for each CAN channel
- CAN termination and 5-Volt supply to the CAN connection can be activated through a solder jumper
- Extended operating temperature range from -40 to 85 °C (-40 to 185 °F)
- Optionally available: PCI-104 stack-through connector

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CURTISS-WRIGHT

Parvus DuraCOR XD1500

The **Parvus DuraCOR XD1500** from Curtiss-Wright is a rugged Commercial Off-the-Shelf (COTS), small form factor, modular mission computer server based on the industrial-temp, 12-core, 64-bit Intel Xeon D-1559 (formerly Broadwell-DE) SoC processor. With support for up to 128 GB of DDR-4 RAM memory and integrated 10GBase-T Ethernet, the XD1500 has been optimally designed for size, weight, and power-sensitive airborne, ground vehicle, UAS, ISR and sensor platforms seeking datacenter-class performance at the network edge.

It combines powerful high core-count, floating-point processing with the highest capacity memory architecture available in a rugged embedded system, with incredible I/O and data storage scalability. Supporting an add-on rugged COTS XMC co-processor or I/O module and multiple Mini-PCIe I/O modules for mission-specific avionics/vetronics payload interfaces, the system can be configured with mission-tailored capabilities for C4ISR command and control, image processing, surveillance, virtual machine hypervisor, datacenter server processing, or network functional virtualization applications in harsh deployed environments.

Multiple, ultra-fast Non-Volatile Memory Express (NVMe)-based and SATA3-based solid state disk Flash disk options are available for support of high-capacity removable and/or fixed Flash disk storage, information assurance and operational requirements for encryption, zeorization, and/or high mating cycle SATA interfaces.

FEATURES

- 12-core Intel Xeon Processor-D SoC (D-1559) with up to 128 GB RAM memory
- High-speed VITA 76 connectors for optimized high-speed signal integrity
- 10Gbase-T Ethernet and USB 3.0 ports
- Rugged IP67 chassis with XMC and Mini-PCIe add-on I/O card expansion
- Integrated VGA and HDMI video outputs with XMC GPU/FPGA add-on options
- Removable high-cycle insertion 2.5" SATA; mSATA/NVMe M.2/U.2 SSD
- 28 VDC MIL-1275/704/DO-160 power supply with 50 ms power hold-up

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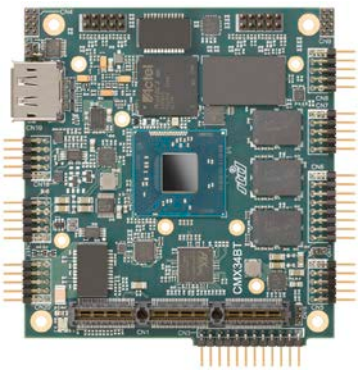
rtd®

Intel Atom E3800-based SBC



The **CMX34BT** is an advanced PC/104 single board computer and controller with a PCIe/104 stackable bus structure. This Intel Atom E3800-based CPU is exceptionally suited for intelligent systems requiring low power consumption in harsh thermal conditions. The CMX34BT-series CPUs are available in quad-core, dual-core, and single-core configurations. Surface-mount Type 2 PCI Express connectors enable users to stack multiple peripheral modules above and below the CPU. All models include 4GB surface-mount single-channel DDR3 SDRAM and a 32GB industrial-grade surface-mount SATA flash drive.

smallformfactors.mil-embedded.com/p373421

FEATURES

- PCIe/104 stackable bus structure
- Available in modular, rugged enclosures and eBuild systems
- Intel Atom E3800 Series Processor
  - *Clock Speed: 1.33 GHz, 1.46 GHz, and 1.91 GHz options*
  - *Max. Core Temperature: 110°C*
- 4GB Single-Channel DDR3 SDRAM (Surface-Mounted)
- 32GB Surface-mounted industrial-grade SATA flash drive
- 4 PCIe x1 Links, One SATA Port, 4 Serial Ports, 9 USB ports, Dual Gigabit Ethernet, Analog VGA, Embedded DisplayPort (eDP) 1.3 with Audio, on-board advanced Digital I/O
- -40 to +85°C standard operating temperature
- Thermal-optimized passive heat sink included

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VERSALOGIC CORPORATION

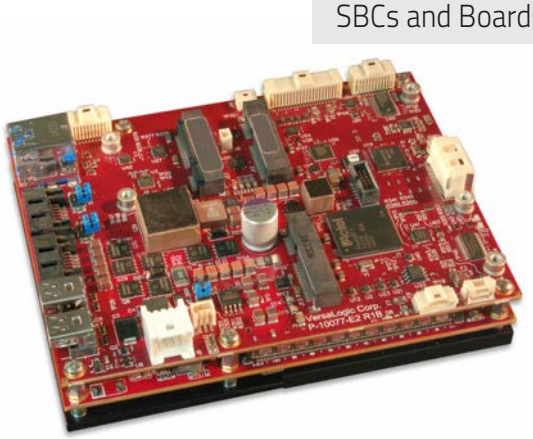
Blackbird (VL-EPU-4562)

Compact Sky Lake Embedded Computer

The **Blackbird** is a compact, rugged x86 type board-level embedded computer. It has been engineered and tested to meet the military and medical industries' evolving requirements to develop smaller, lighter, and lower power embedded systems while adhering to stringent regulatory standards. The Blackbird is a member of the VersaLogic family of ultra rugged embedded x86 computers. This embedded computer, equipped with a 6th Generation Intel Core "Skylake" processor, is designed to withstand extreme temperature, impact, and vibration.

The Sky Lake processors feature quad- and dual-core CPUs along with Hyper-Threading logic allowing up to 8 simultaneous threads to be executed. The Blackbird provides great performance and I/O features, moderate power consumption (15 to 26 W typical depending on model), and a compact package. The Blackbird provides compatibility with a broad range of standard x86 application development tools for reduced development time.

The on-board Power Management Unit greatly simplifies system power supply requirements. It features a wide input voltage range of 8 to 30 volts so it is fully compatible with 12 or 24V vehicle applications. It also includes reverse voltage protection, over voltage protection, RF noise filtering, and transient voltage protection, to provide enhanced durability and reliability in the field.



FEATURES

- -40° to +85°C operating temperature models
- Trusted Platform Module (TPM) security chip
- 6th Generation Intel® Core™ "Skylake" processor
- On-board Power Management - 8 to 30 volt DC input (12 and 24 volt system compatible)
- Compact size (95 x 125 x 37 mm) supporting up to 32 GB DDR4 RAM
- Dual USB 3.0 port, Dual mini DisplayPort and LVDS video outputs
- Dual Gigabit Ethernet and three Mini PCIe Sockets

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SBCs and Boards

VERSALOGIC CORPORATION

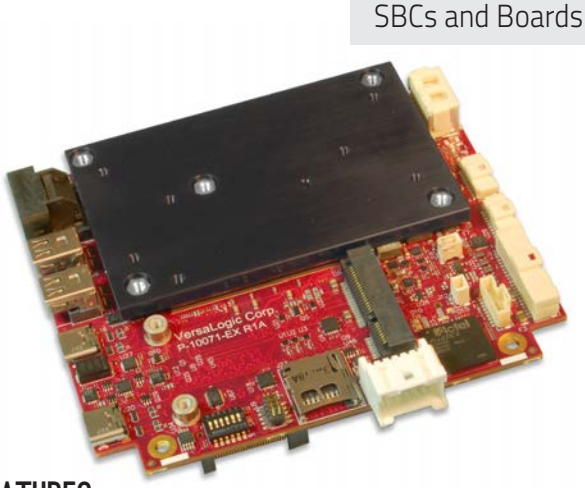
Lion (VL-EPMe-42)

PC/104 with Kaby Lake!

The **Lion** is a high-performance single board computer (SBC) which combines Intel's 7th generation Core "Kaby Lake" processor, with a newer PCIe/104 OneBank expansion interface. Compatible with the PCIe/104-Express format, it includes a legacy PCI connector, and a high-speed PCIe connector. This provides flexible system expansion, while leaving more on-board space available for product features. The single bank connector is mechanically and electrically compatible with PCI/104-Express Type 1 and Type 2 modules. In addition, the Lion also contains a full complement of on-board I/O interfaces, including USB 3.0, USB 2.0, mini PCIe expansion socket, TPM chip, multiple serial interfaces, and 8-bits of digital I/O.

The Lion is available with an embedded i7-7600U, i5-7300U, or i3-7100U type Kaby Lake processor, providing standard clock rates up to 2.8 GHz and Turbo Boost rates to 3.9 GHz. The Kaby Lake processors feature dual-core CPUs and Hyper-Threading logic allowing up to 4 simultaneous threads to be executed.

As with all VersaLogic products, the Lion is designed to support OEM applications where high reliability and long-term availability are required. Lion is backed by a five-year warranty, 5+ year off-the-shelf availability guarantee, and expert US-based technical support.



FEATURES

- 7th Generation Intel® Core™ processor ("Kaby Lake") Dual-core
- PCIe/104 OneBank™ form factor
- TPM (Trusted Platform Module) security chip
- Intel Active Management Technology
- -40° to +85°C Operating Temperature
- Up to 16 GB RAM
- I/O: Dual Gigabit Ethernet, USB 3.0, Mini PCIe socket

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VERSALOGIC CORPORATION

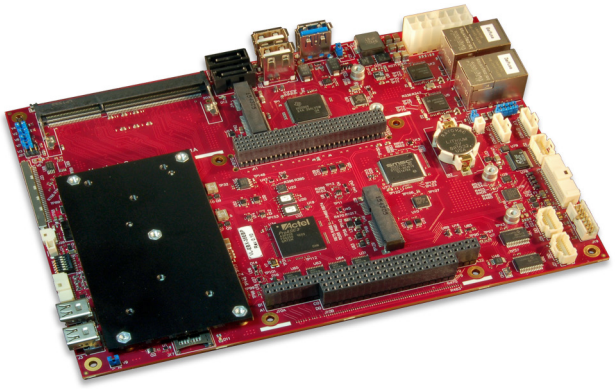
Viper (VL-EBX-38)

EBX "Bay Trail" Embedded Computer SBC

The **Viper** is a low power/high-performance single board computer (SBC) which combines Intel's advanced Bay Trail processor, with a traditional PC/104-*Plus*™ expansion interface. This combination makes it easy to upgrade existing systems to a powerful 4th generation Atom processor, while preserving plug-in expansion to existing specialty I/O boards. In addition, it also contains a full complement of on-board I/O interfaces, including USB 3.0, mini PCIe expansion sockets, TPM chip, A/D, D/A, and 32-bits of digital I/O.

Driven by a low power E3800 (Bay Trail) processor, with clock rates up to 1.9 GHz, the Viper features quad-, dual-, and single-core processor options. Viper is built on the industry-standard EBX form factor. It includes legacy ISA and PCI connectors to interface directly with PC/104-Plus expansion boards.

As with all VersaLogic products, the Viper is designed to support OEM applications where high reliability and long-term availability are required. Viper is backed by a 5-year warranty, 5-year minimum off-the-shelf availability guarantee, and expert US-based technical support. From application design-in support, to its 10+ year extended life programs, the Viper provides a durable embedded computer solution with an excellent cost of ownership.



FEATURES

- -40° to +85°C Operating Temperature
- TPM (Trusted Platform Module) security chip
- EBX™ form factor – PC/104-*Plus* expansion
- 4th Generation Intel® Atom™ processor ("Bay Trail") – Quad-, dual-, and single-core models
- Up to 16 GB RAM
- Dual Gigabit Ethernet
- On board power conditioning – 9 to 15 volt input

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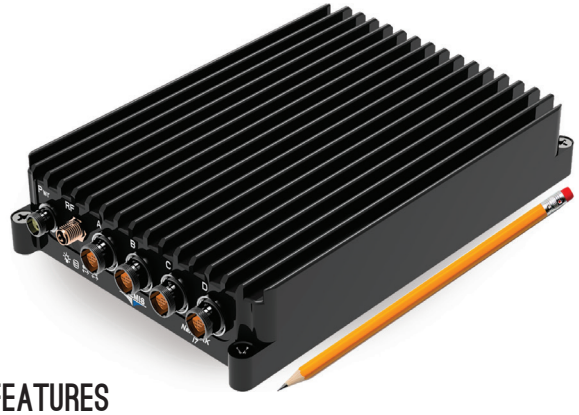
THEMIS

Nanopak i7

The Themis Nanopak i7 computer packs an **Intel Core i7 processor**, **32GB DDR4 memory**, and **1TB FLASH storage** in a small, light-weight, rugged, conduction cooled form factor. Multiple I/O configurations such as USB, VGA**, dual ethernet, GPIO, serial, and power offer users maximum compatibility and flexibility while minimizing size, weight, power and cooling (SWAP-C) to meet engineering constraints on the tactical edge.

The Nanopak i7 supports real time control, data recorders, small storage/communication systems, and mobile robotics, making it an **ideal solution** for military computing on the go.



FEATURES

- Intel 6th Generation Core i7 (Skylake) with AVX2
- 32GB DDR4 Memory
- 1.6lbs, 6.8" x 4.5" x 1.5"
- Configurable USB, Serial, VGA, GPIO, Dual Ethernet
- MIL-STD-461F, IP67 Waterproof
- Noiseless Conduction Cooled Chassis
- Linux, Microsoft Windows

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WinSystems®
The Embedded Systems Authority

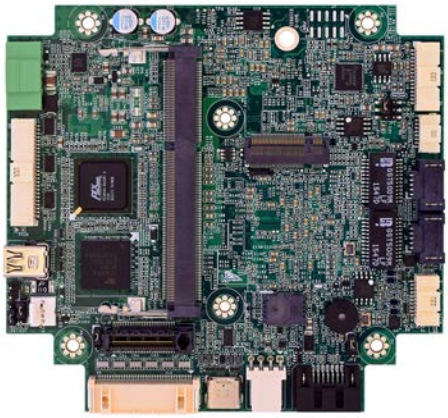
PX1-C415

PC/104 Single Board Computer with PCIe/104™ Onebank™ Expansion

WinSystems' PX1-C415 is a PC/104 SBC with PCIe/104™ OneBank™ expansion and the latest generation Intel® Atom™ E3900 processor. With dual Ethernet and robust I/O, this SBC is ideal for industrial IoT apps and embedded systems in the industrial control, transportation, Mil/COTS, and energy markets.

Datasheet Link:
www.winsystems.com/wp-content/uploads/datasheets/px1-c415-ds.pdf

Product Page Link:
www.winsystems.com/product/px1-c415/



FEATURES

- Intel® Atom™ E3900 Processor
- PC/104 Small Form Factor Single Board Computer (SBC)
- Up to 8 GB DDR3-LV System RAM
- -40°C to +85°C Operating Temperature Range
- Shock and Vibration Tested
- Multiple Displays Supported
- Expansion Options: PCIe/104™ OneBank™, M.2 Socket

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PPM-C412

PC/104-*Plus* Vortex86DX3® Single Board Computer with Dual Ethernet

WinSystems' PPM-C412 is a PC/104-*Plus* form factor SBC featuring the latest generation DM&P® Vortex86DX3® SOC processor. Its small size, low power, rugged design, and extended temperature range make it a great fit for industrial IoT applications and embedded systems in the industrial control, transportation, Mil/COTS, and energy markets.

Datasheet Link:
www.winsystems.com/wp-content/uploads/datasheets/ppm-c412-ds.pdf

Product Page Link:
www.winsystems.com/product/ppm-c412/

We Specialize in Custom Embedded Solutions

FEATURES

- DMP® Vortex86DX3® Processor (Dual core)
- Four USB 2.0 ports
- Two Ethernet ports
- 24 Bidirectional GPIO with event sense
- CompactFlash socket
- Dual video output (VGA, LVDS)
- Fanless: -40°C to +85°C operation

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