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# PC/104 and small form factors

THE JOURNAL of MODULAR EMBEDDED DESIGN

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WINTER 2013/2014
VOLUME 17 NUMBER 4

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## 2014 BUYER'S GUIDE PG. 26

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High-Performance Extreme Rugged Computer (HPERC) from ADLINK Technology, Inc.

Page 29

## LOW-POWER PROCESSORS DRIVE SFFs IN RUGGED TRANSPORTATION


BEGINNING ON PG. 10



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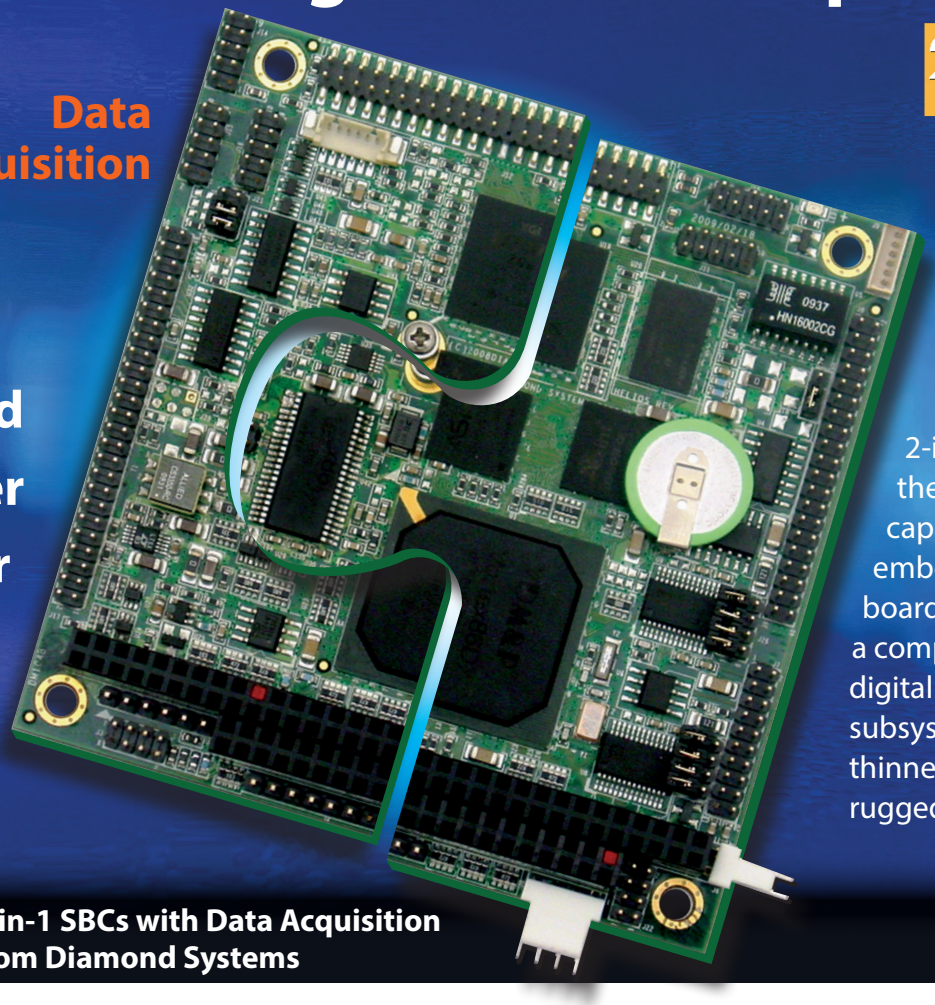
# Simplify Your Design Using 2-in-1 Single Board Computers

2 in 1

**Data Acquisition**



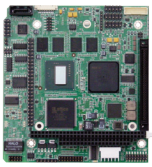
- More Rugged
- Thinner
- Lighter

**SBC**

2-in-1 SBCs combine the core computing capabilities of a typical embedded single board computer with a complete analog and digital data acquisition subsystem, resulting in an thinner, lighter and more rugged product.

2 in 1 **2-in-1 SBCs with Data Acquisition from Diamond Systems**

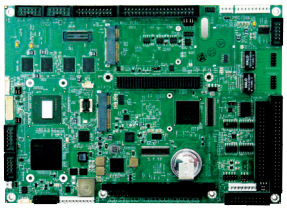
## *Athena III*
**PC/104 SBC**



**CPU Features**
1.6GHz E680T CPU
1GB soldered RAM
4 USB, 4 RS-232/422/485
1 gigabit Ethernet
VGA & LVDS LCD

**DAQ Features**
16 16-bit A/D
4 12-bit D/A
24 digital I/O
2 counter/timers

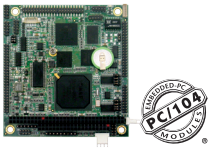
## *Hercules III*
**EBX SBC**



**CPU Features**
1.6GHz E680T CPU
2GB soldered RAM
5 USB, 6 serial,
2 gigabit Ethernet
VGA & LVDS LCD
Wide range power supply

**DAQ Features**
32 16-bit A/D
4 12-bit D/A
40 digital I/O
2 counter/timers
4 PWM outputs

## *Helios*
**PC/104 SBC**

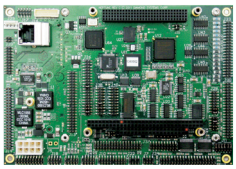


**CPU Features**
800Hz – 1GHz Vortex86DX CPU
256MB soldered RAM
4 USB, 4 serial, 1 LAN
VGA & LVDS LCD

**DAQ Features**
16 16-bit A/D
4 12-bit D/A
40 digital I/O
2 counter/timers

All products are -40°C/+85°C. All data acquisition features supported by industry-leading Universal Driver programming library.

## *Neptune*
**EPIC SBC**



**CPU Features**
1.6GHz Intel Atom N270,
1.66GHz Core Duo LV,
1.0GHz AMD T40N, or
1.65GHz AMD T56N CPU
Up to 2GB SO-DIMM SDRAM
4 USB, 6 serial, 2 Ethernet
VGA & LVDS LCD
Wide range power supply

**DAQ Features**
32 16-bit A/D
4 12-bit D/A
24 digital I/O
8 opto in, 8 opto out
2 counter/timers

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RUGGED, POWERFUL

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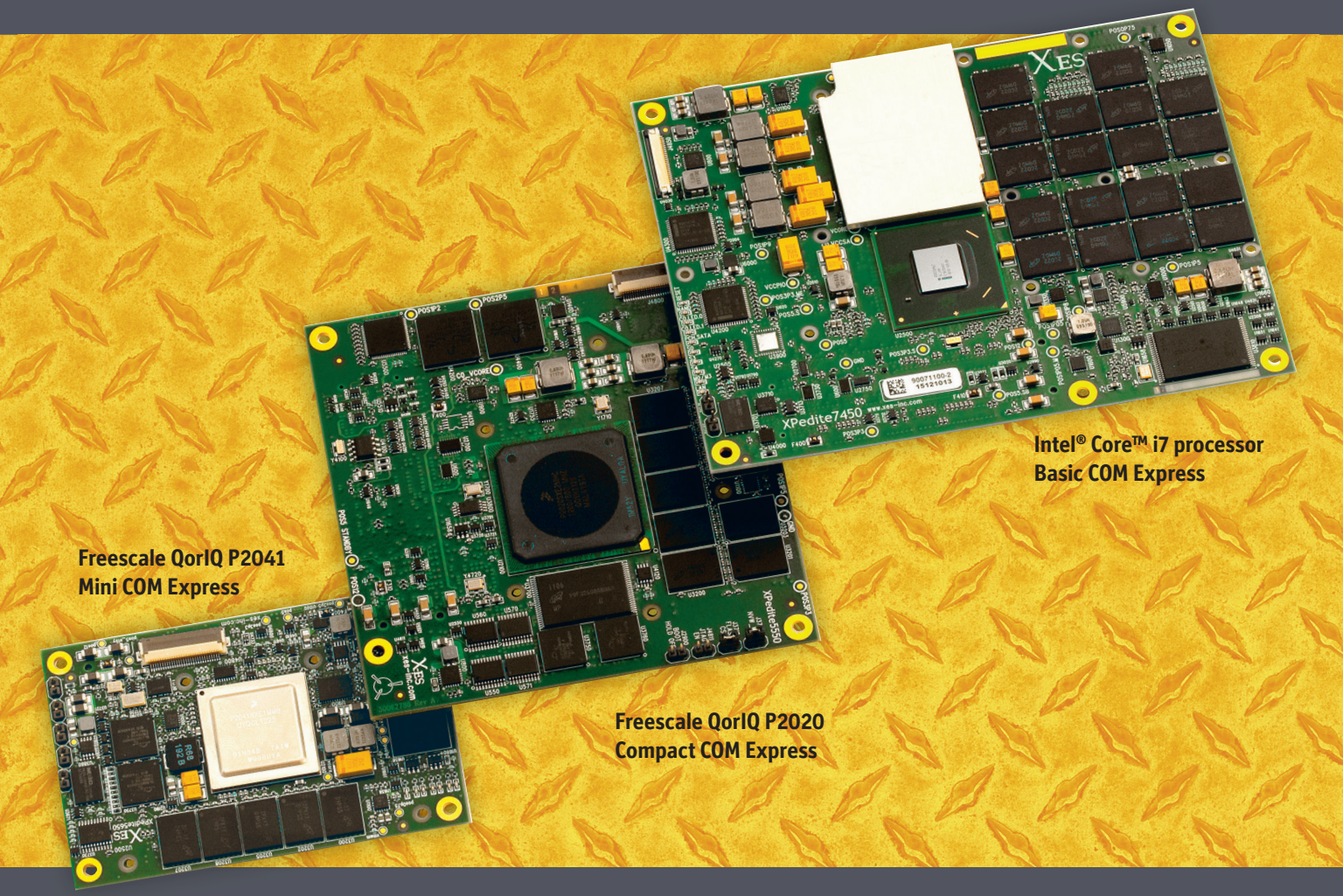


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# PC/104 and small form factors

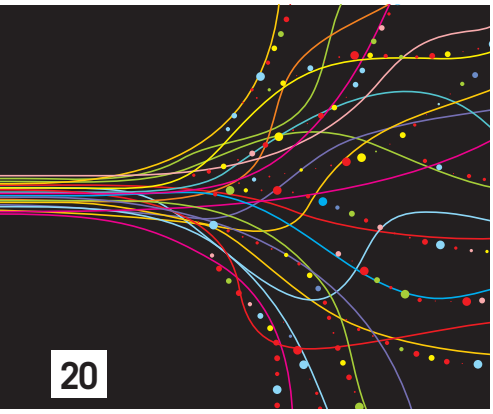
THE JOURNAL of MODULAR EMBEDDED DESIGN

Volume 17 • Number 4

**ON THE COVER:**
The 2014 Buyer's Guide issue of *PC/104 and Small Form Factors* looks how innovations in processing technology are enabling Small Form Factors (SFFs) in low-power, rugged transportation designs. In addition to a market prospectus dissecting the diverse SFF board market, the 2014 Buyer's Guide includes industry vertical solutions such as the High-Performance Extreme Rugged Computer (HPERC) system from ADLINK Technology, Inc.

## Features



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AMD

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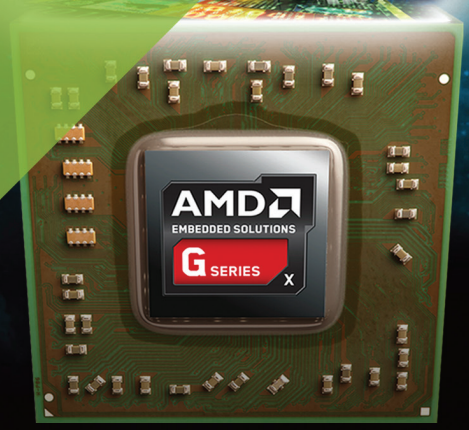


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small MATTERS

By Brandon Lewis

# MILCOM meetings project SFF surge, standardized PC/104 packaging possibilities

Foot traffic was down at MILCOM 2013 in San Diego, perhaps due to reduced Department of Defense (DoD) travel budgets, or hard feelings about the lack of exhibitor refunds following the cancellation of MILCOM 2012, or both. However, low foot traffic doesn't necessarily translate to a bad show, and several exhibitors noted several productive client meetings.

For the press, low attendance is a boon as it affords the opportunity to interact with as many merchants as possible; during my time on the show I encountered a number of vendors displaying Small Form Factor (SFF) alternatives to backplane-based systems. As the government shifts to smaller, lower-cost electronics, Commercial Off-The-Shelf (COTS) SFFs are primed for an expanded role in military deployments, evident in exhibitions like the harsh-environment PCIe/104 and COM Express boards from Orion Technologies in Orlando, FL (www.oriontechnologies.com), Massachusetts-based SIE Computing Solutions' (www.sie-cs.com) ruggedized SFF subsystems, and a PCIe/104-based modular mission computer from Elma Electronic in Fremont, CA (www.elma.com) to name just a few (Figure 1).

The latter exhibition interested me the most perhaps in that Elma Electronic's move into packaging for SFF boards is a fairly recent one. Flemming Christiansen, Managing Director, Sundance Multiprocessor Technology in Buckinghamshire, UK (www.sundance.com) was also intrigued by the possibilities, as the notion of "standardized packaging" for PC/104 could move the ecosystem from a strictly board focus into a system-level arena.

"PC/104 vendors have been selling boards like distributors sell components to us: we ship them, we wrap them, but we don't actually consider how they are going to be used next," Christiansen says. "That is what we need to think – that these boards are going to need a home.

"Historically, PC/104 has been sold as a board only, and customers would typically buy it from a single source," Christiansen says. "Typical systems were three to four boards due to the limitations of sharing the PC/104 bus. Packaging was typically provided by either the original vendor or was home grown to suit the customer's environmental requirements.

"The introduction of high-speed PCI Express has enabled PC/104 to enter the typical marketplace of CompactPCI, VPX, and others that are backplane- and bus-based," Christiansen says. "The biggest problem for [Sundance] is that we can't be compatible with the RTDs, and the VersaLogics, and the ADLs, because then we have to go and actually engineer enclosure, and our boards to match their boards. But, if the approach is to look at every PC/104 board as not just a board but like a blade and add them up as you go along, then individually the manufacturers – whether they are the CPU manufacturers or the DSP manufacturers or the FPGA manufacturers, whoever – would have to conform to that standard, or it could be an optional, extra standard enclosure. That would be ideal because it would max the stackability, give a way of making it compatible between different vendors, and it would bring the cost down.

"The advantage of a 'stackable' bus is that it will allow small, commercial-grade enclosures to be designed – maybe even printed in plastic with a 3D printer – whereas industrial-grade [enclosures] would be in metal of some sort, and the super enclosures in better metal," Christiansen says. "If they were identical in form and shape, then prototypes could be started in plastic and move forward with metal for the final solution. Some systems could be IP4x and others IP68, and so on. This would allow customers to shop around and know mechanically it will work and electronically it will work, and they just have to do the various software – which is how it is in PXI, VME, and CompactPCI. It would enhance the flexibility of what I believe is a very flexible way of building systems, and I believe that PC/104 is in a position to take a larger market share of SFF systems with a common way of packaging the boards into stacks that become systems."

**Figure 1** | Elma Electronic's F-Series PCIe/104 Platform provides an example of possible packaging options for Small Form Factor (SFF) boards.

Although turnkey suppliers of PC/104 systems stand to take a loss from standardized packaging, the concept could yield deeper penetration of PC/104 technology into applications that have traditionally relied on bladed systems. Perhaps this warrants a deeper look from the Consortium.

For more ideas on standardized PC/104 packaging, you can contact Flemming at flemming.c@sundance.com.

*Brandon Lewis, Asst. Managing Editor*
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# Small Form Factor SIG

www.sff-sig.org

By Alexander Lochinger, SFF-SIG President

## Ruggedizing RAM for industrial systems

When it comes to rugged computing, the ANSI/VITA 47-2005 (R2007) specification has earned its stripes as a guide for validation testing and product development. We like our backplane connectors, circuit boards, and chassis mounting structures to be reliable over shock, vibration, and temperature loads. Too often, however, the Single-Board Computers (SBCs) inside are using consumer DIMM or SODIMM memory sticks. The Small Form Factor Special Interest Group (SFF-SIG) addresses this problem with XR-DIMM.

"Industrial systems" is a broad category that describes computing devices in many form factors deployed in many environments. Such environments include extremes of temperature, shock, vibration, humidity, dust, and so on – not a place for your average desktop or notebook computer, nor for the average computer RAM. Simply calling a motherboard "industrial" doesn't fix the RAM connector vulnerability.

Low-cost motherboards feature vertical DIMM slots or horizontal SODIMM card-edge sockets that were developed for computers that sit on desks and in datacenters, not for industrial environments where temperatures vary over much wider ranges. Rapid temperature changes create conditions known as "thermal shock." If the connector pins don't wipe the gold-plated card-edge fingers well enough, tiny air pockets can form between the metal surfaces. This can cause code and data bit errors due to intermittent contacts or open circuits. The risk is worse depending on humidity and dust in the environment, and even shocks caused by forklifts and machines.

### Reconnecting the boards

By contrast, board-to-board mated connectors are designed to achieve high reliability in these types of environments. Board-to-board mated pairs have substantial connector wiping during insertion, and also have strong retention forces. The SFF-SIG used these benefits to define a truly rugged-by-design module standard called XR-DIMM. Ruggedness is achieved by using a 240-pin Samtec BTH/BSH connector pair on the memory module and CPU board, along with two mounting holes (Figure 1). The module can be secured with two screws to better resist shock and vibration, in sharp contrast to the socket "wings" that hold a SODIMM in place.

The name "XR-DIMM" stands for "eXtreme Rugged Dual In-line Memory Module." The XR-DIMM specification defines both unbuffered and registered versions that are analogous to their SODIMM counterparts while also being tested for ruggedness according to the ANSI/VITA 47-2005 (R2007) specification.

### The right sizing

XR-DIMM is a small 67.5 mm x 38 mm module that stacks 7.36 mm above the CPU board. There is enough space underneath for tiny passive components on the surface of the CPU board, reducing the overall volume occupied by the electronics. XR-DIMM uses DDR3 technology, which is mainstream in the industrial market. Memory sizes up to 8 GB, with optional Error-Correction Circuitry (ECC), are supported using either 9-chip or 18-chip designs. Using a module offers greater capacity and flexibility compared to soldering RAM directly to the CPU board. XR-DIMM is narrower than a SODIMM, allowing it to fit on most small form factor CPU boards, even on processor AdvancedMCs (AMCs).

The pin definition for XR-DIMM closely aligns with the SODIMM pin definition, making it easy to convert an existing SODIMM-based design to a rugged XR-DIMM-based design. SMART Modular, Swissbit, and Virtium are building XR-DIMM modules, some of which have ECC memory for the best reliability in industrial systems.

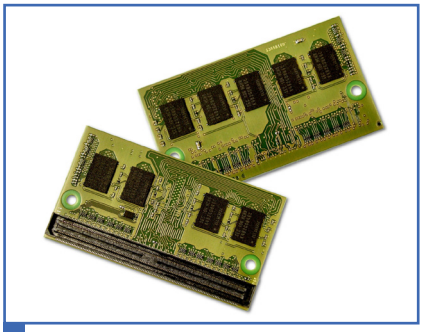

**Figure 1** | A Swissbit DDR3 module with ECC support provides rugged reliability for industrial systems.

### An eye to the future

Besides RAM signals, the XR-DIMM pin definition also includes a SATA interface to enable the development of dual-function modules containing both DDR3 and flash memory for a Solid-State Disk (SSD) implementation in the future. For forward-looking designers, it's even possible to create a high-value power-fail solution that copies from RAM directly to the SSD on the same module, since shutting down a large Operating System (OS) takes many seconds.

The SFF-SIG continues to recommend the use of true embedded building blocks in the design of industrial systems, and offers a full family of CPU and memory module specifications for board designers. The XR-DIMM specification is freely available on the SFF-SIG website (www.sff-sig.org) and can be downloaded free of charge and without licensing or registration.

**Small Form Factor**
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By Dr. Paul Haris, PC/104 Consortium Chairman and President

# PC/104 in vehicles and industrial applications

Last issue I wrote about PC/104's long history with military applications and how the architecture was a natural fit for the military's desire to move away from MIL-SPECS and leverage the innovative, lower cost commercial market. This issue deals with in-vehicle and industrial applications, which means the discussion of how the PC/104 architecture has been and continues to be used has become that much more broad. But to try and address these fields in their entirety would fill novels.

Today, the rate at which new and advanced functionalities are being incorporated in vehicles and industrial applications is accelerating. No longer do you just have a turbine engine with sensors on it that report back parameters to be monitored. Now engines have multiple, built-in, condition-based maintenance devices and computers that monitor and adjust in real time the operations of those engines to increase engine lifecycles and reduce overhaul maintenance that can be extremely time consuming and costly, both in actual maintenance as well as downtime costs. Additionally, vehicles no longer just get you from one point to another. Now vehicles, whether personal, industrial, or military, have a multitude of subsystems, and these subsystems are changing all the time with advancements in computational power and functionality. Since so much time is spent in them, the marketplace is demanding that vehicles incorporate functionalities that are extensions of our homes, jobs, and command posts. They have extensive built-in safety devices to not only protect life and property, but also to record all internal and external operational and environmental data to allow the building of better vehicles, determine causes, and help future training of personnel. And since all of these functionalities are being put in-situ where they are needed, they need to be small, easy to maintain and service, and readily upgradable.

As such, it is becoming ever more difficult for Original Equipment Manufacturers (OEMs) and systems integrators to create all of these subsystems in-house while striving to reduce their time to market. And since these subsystems are covering a vast amount of specialized fields, trying to maintain an in-house expertise is also extremely difficult and costly. No longer may it be feasible for the engine manufacturer to design the computer systems and PCB layouts for each field. Today's Small Form Factor (SFF) computer board designs often require advanced PCB layout and manufacturing techniques. System-level designers are driven to rely on specialized companies to help with the subsystems. The requirements for standardization to help reduce the risks of product lifetime costs places a premium on selecting specifications that show clear fundamental design with sound and stable evolutionary paths for upgradability and maintenance. This is where the PC/104 architecture has excelled for the last 21 years, because when all is said and done it can be boiled down to a simple truth: when you have the fundamentals down, all else can be built upon it.

The PC/104 architecture is analogous to this (Figure 1). Its design and backward-compatible evolutionary path is built on fundamental building blocks that allow it to be utilized across sectors without losing its universality. Its stackable bus structures with predefined pinouts not only serve to ensure interoperability across manufacturers, but also provide inherent ruggedness that allow it to be used by the most benign and most hostile of applications. Its onboard I/O-centric design allows quick installation and utilization without having OEMs build baseboards to be operational. And since it is a stackable architecture, OEMs can readily search the market for peripheral modules with the functionality they need to quickly create a multitude of solutions that satisfy their requirements. Compound this with its small size of 3.55" by 3.78" and its extensive proven use in the field, and it is easy to see why PC/104 is found in many vehicles and industrial applications throughout the world, including in lab equipment, peppermills, trucks, tanks, ships, aircraft, and spacecraft to name a few. More than ever, engineers are finding PC/104 as their go-to architecture to meet current system requirements while ensuring viability for whatever new technology is around the corner.

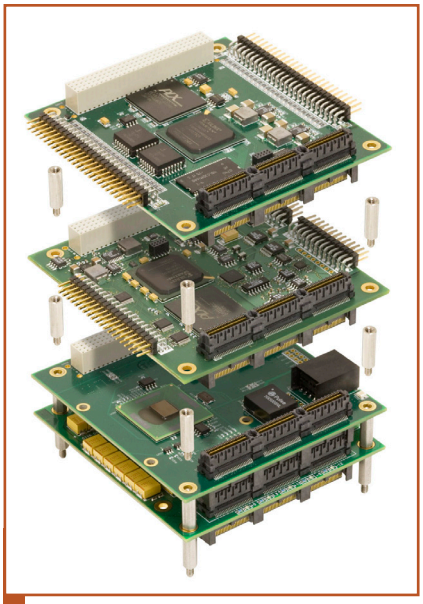

**Figure 1** | The PC/104 architecture relies on an evolutionary roadmap that provides universal building blocks for embedded applications and an upgrade path for emerging technology requirements.

*For more information visit the PC/104 Consortium website at www.pc104.org.*

Q & A

# Intel Atom E3800 SoCs improve power, performance for SFF designs

*Interview with Max Domeika, Intel Corporation*

Improvements to the Intel Atom family of processors have yielded a new class of Systems-on-Chip (SoCs) that provide a range of core, clock speed, and thermal envelope options in a scalable package for small form factor developers. Max Domeika, Embedded Software Technologist, Developer Products Division, Intel Corporation, reviews some of the features and benefits of the new SoCs, as well as some of the tools available to aid in processor migration. Edited excerpts follow.

**SFF:** ***What are the major improvements on the Intel Atom E3800 Series processors (formerly known as "Bay Trail"), and what sets them apart from previous versions of Atom?***

**DOMEIKA:** The Intel Atom processor E3800 product family contains numerous improvements over previous generations of Intel Atom processors. Three significant improvement areas are in integration, performance, and power utilization. The processor is a single-die SoC design, compared to previous designs comprising two chips, one for the CPU and one for the chipset. The Intel Atom processor E3800 SoC family comprises a CPU, GPU, I/O interfaces, security, and media engines, which provide benefits in terms of reducing Bill-Of-Materials (BOM) costs and general power and performance improvements (Figure 1).

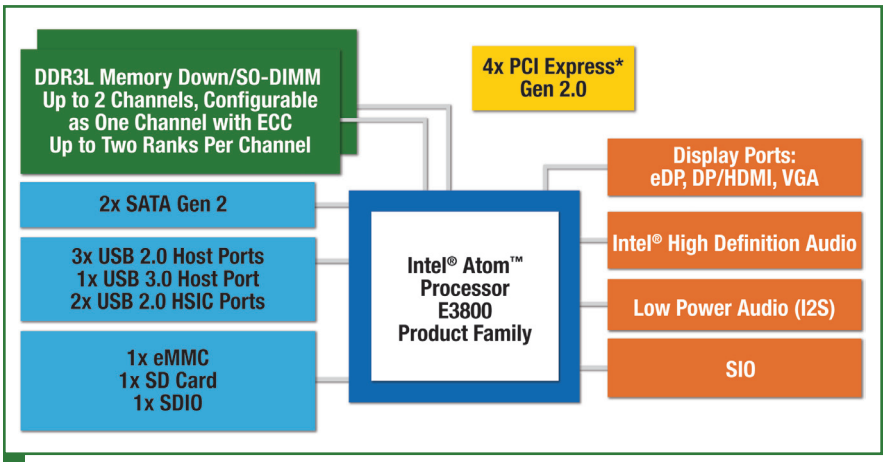


**Figure 1** | The Intel Atom processor E3800 product family is the first generation of Atom processors to utilize a single-die System-on-Chip (SoC) design, which precludes an additional chipset. Depicted here is a general representation of the family's hardware features.

Specific performance improvements result from the CPU design featuring a superscalar out-of-order instruction execution unit, which enables independent instructions to execute when their particular dependencies have been satisfied. This is compared to the previous generation of Intel Atom processors that featured an in-order core; instructions that were stalled awaiting a dependency also stalled other independent instructions. The graphics core has also been enhanced to increase performance for next-generation 3D applications, as well as deliver a seamless visual experience with built-in hardware media acceleration.

The third improvement area is in terms of power utilization. The increased level of integration and process size reduction (22 nm) enable lower power execution. Developers have their choice of a range of Intel Atom processor E3800 SoCs with different balances between raw performance and low power utilization.

**SFF:** ***What benefits do the Intel Atom E3800 Series SoCs bring to developers of small form factor boards and systems?***

**DOMEIKA:** Several models of the Intel Atom processor E3800 SoC family are available with a Thermal Design Power (TDP) ranging from 5 W for the Intel Atom processor E3815 to 10 W for the Intel Atom processor E3845 (Table 1). If a developer desires utmost performance, they could choose to employ the Intel Atom processor E3845, featuring four processor cores, a clock speed of 1.91 GHz, 2 MB L2 cache, and a

| Intel Atom Processor | E3845 | E3827 | E3826 | E3825 | E3815 |
|---|---|---|---|---|---|
| Cores | 4 | 2 | 2 | 2 | 1 |
| Core Speed | 1.91 GHz | 1.75 GHz | 1.46 GHz | 1.33 GHz | 1.46 GHz |
| L2 Cache | 2 MB | 1 MB | 1 MB | 1 MB | 512 KB |
| Memory | DDR3L-1333 | DDR3L-1333 | DDR3L-1066 | DDR3L-1066 | DDR3L-1066 |
| Memory Channels | 2 | 2 | 2 | 1 | 1 |
| TDP | 10 W | 8 W | 7 W | 6 W | 5 W |
| Temp. Range | –40 °C to +110 °C | –40 °C to +110 °C | –40 °C to +110 °C | –40 °C to +110 °C | –40 °C to +110 °C |
| Package | 25 mm x 27 mm | 25 mm x 27 mm | 25 mm x 27 mm | 25 mm x 27 mm | 25 mm x 27 mm |
| ECC | 1 Ch., Configurable | 1 Ch., Configurable | 1 Ch., Configurable | 1 Ch., Configurable | 1 Ch., Configurable |

**Table 1** | The Intel Atom processor E3800 product family range from single to quad-core SoCs with a variety of TDP envelope and clock speed options for small form factor embedded designs.

TDP rating of 10 W. If low power is of utmost consideration, the single processor core Intel Atom processor E3815 can be employed.

The Intel Atom processor E3800 SoC family is well suited for embedded applications in many areas, such as digital signage, multifunction printers, industrial controllers, automotive infotainment, digital security, energy controllers, retail, and military and aerospace systems. The unique combination of low power, high performance, and industrial temperature range enable usages in these segments.

**SFF:** ***What, if anything, should developers migrating to an Intel Atom E3800 processor architecture be aware of? Are there any complications or challenges they will face?***

**DOMEIKA:** One of the benefits of Intel architecture is backwards compatibility, so applications developed for previous Intel Atom processors will function well on the current generation. Oftentimes, the application can execute even more efficiently without change. There are cases where applications will need to be retuned for the new processor or an increased number of processor cores. Fortunately, there are advanced optimization and analysis tools such as the Intel VTune Amplifier XE to assist (see Sidebar 1).

**SFF:** ***What's next for the Intel Atom processors?***

**DOMEIKA:** Performance and power utilization will benefit as technology moves forward. Intel is continuing to add higher levels of integration, higher performing processor and graphics cores, and new capabilities to enable next-generation applications. **SFF**

*Max Domeika is an embedded software technologist in the Developer Products Division at Intel, creating tools targeting the Intel architecture market. Max currently provides embedded tools consulting for customers migrating to Intel architecture. In addition, he sets strategy and product plans for future embedded tools. Max earned a BS in Computer Science from the University of Puget Sound, an MS in Computer Science from Clemson University, and an MS in Management in Science & Technology from Oregon Graduate Institute. Max is the author of Software Development for Embedded Multi-core Systems from Elsevier. In 2008, Max was awarded an Intel Achievement Award for innovative compiler technology that aids in architecture migrations.*

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# Microarchitecture profiling: Intel VTune Performance Analyzer

*By Lori Matassa and Max Domeika*

On desktop operating systems, the Intel VTune Performance Analyzer can create flat profiles, application call graph profiles, and microarchitecture profiles. The Intel® Application Software Development Tool Suite for Intel Atom Processor includes the VTune Performance Analyzer and the VTune Analyzer Sampling Collector (SEP), a target-side profile collector for the Intel Atom processor. For embedded form factors that take advantage of Linux, SEP provides microarchitecture profiling capability. Using SEP requires installation of a kernel daemon that is specific to the particular Linux kernel employed. The source code to the daemon can be built to enable collection on specific Linux kernels. The process of using SEP is similar to oprofile. Facilities for configuring collection, starting, and stopping are provided. Once complete, the profile is then transferred to a host environment for visualization inside of the VTune analyzer GUI.

| Step | Command line or Description |
|---|---|
| 1. Initialize the vtune_drv daemon | /opt/intel/vtune/vdk/insmod-vtune |
| 2. Configure and start profile collection | sep –start -nb –d 0 |
| 3. Start activity | Begin activity to profile. |
| 4. Stop profile collection | sep –stop |
| 5. Produce report | Transfer profile data file to host environment for viewing. |

**Table 1** | SEP profile generation steps.

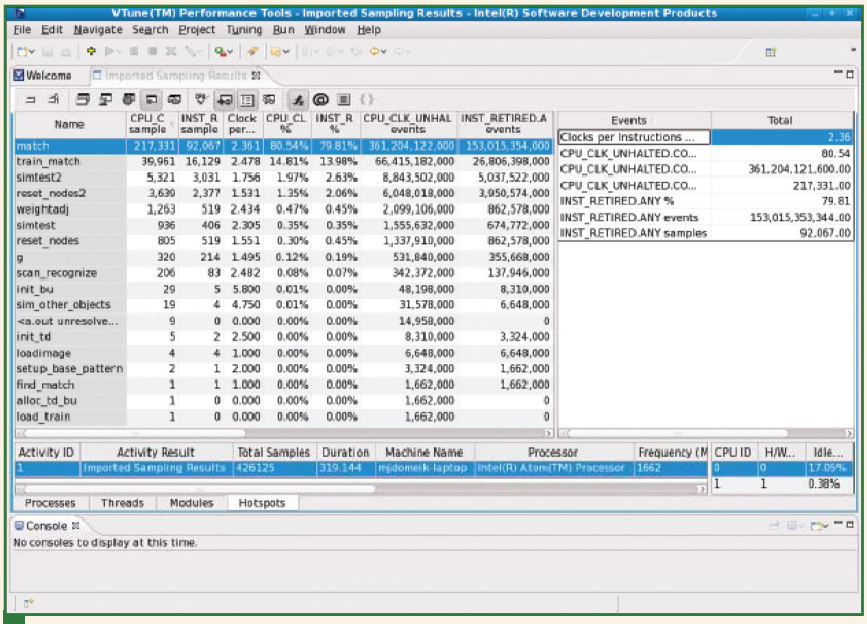


**Figure 1** | VTune Analyzer Flat Profile View

Table 1 describes the steps and command lines employed to configure and collect a profile.

The SEP data collector supports additional options to further configure collection including:

- **Sampling.** Specify duration, interval between samples, sample buffer size, and maximum samples to count.
- **Application.** Specify an application to launch and profile.
- **Events.** Configure events and event masks. Use event-list for a list of supported options.
- **Continuous profiling.** Aggregates data by instruction pointer, reducing space and enabling monitoring and output during execution.
- **Event multiplexing.** Enables collection of multiple events concurrently by modulating the specific event being measured while the application is profiled.

Figure 1 shows a flat profile of a 179.art application collected using SEP and transferred to a host system for analysis under the VTune analyzer GUI. The highlighted ratio in the top right shows the measurement for clock cycles per instruction retired.

*[Editor's note: This sidebar was excerpted from the article "Performance Optimization for the Intel Atom Architecture," originally published in the book Break Away with Intel Atom Processors: A Guide to Architecture Migration. More information can be found at click.intel.com/break-away-with-intel.html. Copyright © 2010 Intel Corporation.]*

**Sidebar 1** | Microarchitecture profiling: Intel VTune Performance Analyzer

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# Rugged transportation designs evolve with low-power x86 advances

*By Dirk Finstel*

New processors blend x86 and Computers-on-Module (COMs) for power-optimized Small Form Factor (SFF) options.

Competitive embedded designs are all about balancing essential requirements like price, performance, development time, longevity, customization, and more. The more options, the better. Yet, in the key area of low power in small, light, and reliable designs, x86 platforms have been challenged by ARM processors (see Sidebar 1, page 19). The Intel evolution continues, however, and developers now have access to a credible option for low-power x86 designs in a very small footprint. The Intel Atom E3800 processor family, formerly known as Bay Trail, is bridging a performance-power-cost gap in x86 and opening a range of new design strategies for embedded markets.

Transportation applications illustrate the value of x86 in low-power system design, capitalizing on flexible Computer-on Module (COM) platforms and Intel Atom advancements. Incorporating new Intel processors, COM Express-based COMs are enabling rugged, low-power designs that meet the rigors of transportation environments. For transportation system developers, adding low power to the familiar environment of x86 design offers tangible competitive value – creating overall benefits beyond power and performance, including simplified software development and access to a well-defined ecosystem.

**Intel roadmaps take on gaps in power, performance, and cost**

The Intel Atom processor E3800 product family are the first Systems-on-Chip (SoCs) developed for intelligent systems – those embedded systems that are designed to be smarter, securely collecting and sharing sensor data to enable new applications or user experiences. The shift from isolated systems to connected intelligent platforms requires not only performance and connectivity, but also the creative design of smaller, rugged devices. Complex processing and real-time data analysis must be seamless, and the device itself must often be unobtrusive or, at the very least, easily integrated into existing settings such as passenger seating areas or in-vehicle systems. Characteristics of the E3800 product family are specifically suited to these demands, and the series is purpose built to enable design innovation in high-performance, Small Form Factor (SFF) intelligent systems.

The E3800 processor family addresses a specific power-performance need – offering more horsepower than previous Intel Atom processors, and touching the performance of entry-level Intel Core processors. Thermal Design Power (TDP) and footprint are smaller than Intel Core and efficiency is improved over previous generations of the Atom. These small, efficient Intel Atom processors feature 22 nm technology and integrate more efficient CPUs, faster graphics, and a built-in security engine on a chip that draws less than 10 watts of power; the resulting low-power profile is ideal for the non-stop performance demands of

> The primary values of the E3800 product family – improved full-HD media performance, immersive 3D graphics, enhanced secure executions, and reliable and efficient computing – are in precise step with the design challenges facing transportation system developers.

intelligent systems. The SoC design also reduces Bill of Materials (BOM), offering a cost advantage in tandem with power and performance gains.

**Applying E3800 to transportation design**

The primary values of the E3800 product family – improved full-HD media performance, immersive 3D graphics, enhanced secure executions, and reliable and efficient computing – are in precise step with the design challenges facing transportation system developers. This is a diverse and complex embedded design landscape, fragmented by the very nature of global transportation venues but unified in the need for flexible, reliable, long-term performance. Characterized by extreme conditions, non-stop operation, and ever-increasing processing requirements, transportation deployments often cover a broad spectrum of applications, each managing tremendous performance standards while also delivering ideal passenger service, comfort, and safety.

High-performance computing demands continue to grow in transportation markets, based on data-heavy, real-time applications such as wayside controls or networked passenger communications. Yet existing power and thermal envelopes constrain the evolution of these applications, and reduced power is essential to innovate new levels of performance. The Intel Atom E3800 product family addresses this need, enabling light, passively cooled solutions. Further, software compatibility is maintained through a known and proven software toolchain; and the broadest range of communications standards such as Ethernet, Wi-Fi, 3G/LTE, RF, or wired options can be implemented with reliability and security. With expansive options for industrial temperature range components, focus on reliability levels is apparent.

Multimedia is taking a larger role in transportation design as well, with video encode and decode required in applications ranging from high-definition train operator displays to onboard digital signage to individual passenger entertainment systems. The E3800 family's advancements in visual processing capabilities over previous-generation Intel Atom processors enable faster media conversions, stereoscopic 3D, immersive web browsing, and enhanced HD video transcoding with Gen 7 graphics and highly efficient image processing.

Communications must be continuous, even as systems incorporate multiple connectivity standards and are deployed in varied locations both on and off moving trains and vehicles. The

E3800 family's integration of I/O interfaces is sound – supporting display interfaces with graphics processing, camera interfaces with image processing, audio with Digital Signal Processing (DSP), multiple storage types, and legacy embedded I/O. Expansion capabilities are readily available through industry-standard high-bandwidth interfaces such as PCI Express Gen 2.0, Hi-Speed USB 2.0, and USB 3.0 connectivity.

The Intel Atom E3800 product series features multiple SKUs with quad-, dual-, and single-core offerings that are pin-compatible (Figure 1). These SoCs can handle both single-threaded and multi-threaded processing when more complex computing tasks are required. In addition to being able to handle larger and more demanding processing jobs via multi-threading, good scaling speed improves processing efficiency – essential for the range of data streams coming from sensors, communications, or video applications. When applications are ready for next-generation, low-power performance, E3800-based designs are easily scalable to Intel Core processors within the same architecture.


**Integrating x86 with the design value of COMs**

Longevity of design is an essential part of product development in this market. While passenger convenience or digital advertising applications are less critical, vital operating and safety applications might be deployed non-stop for decades and beyond. Intel's predictable roadmap is of particular importance in these ultra-long deployments, protecting technology investments with extended product availability and supply management.

COMs are well suited to ultra-rugged embedded transportation applications by featuring low power and complex processing functions in a very small footprint. Today these platforms incorporate a broad range of x86 processors for advanced power capabilities and further capitalize on new Atom SoCs for customized power-to-performance ratios. The nature of the COM Express standard is such that all computing elements are contained in the off-the-shelf module itself, while all application customization is held in the accompanying carrier board. Customization can be re-used when processors are swapped out to achieve next-generation performance. Based on this design premise, existing applications today can migrate to next-generation performance by changing processors to more advanced versions such as the Intel Atom E3800 product family. For transportation system OEMs, the COM Express platform is ideal for modular, long-life embedded applications with a critical development cycle, as well as more progressive transportation applications that require frequent processor upgrades without affecting other application design elements.

COM Express-based systems are being used to enable transit agencies to communicate with customers and dispatch, maintain fleets, and collect and analyze operating data. Real-world deployment examples include intelligent train and bus networks that rely on smart, COM-based onboard systems, controlling vehicle-run switches, front and rear doors, wheelchair ramps, stop requests, odometers, emergency alarms, and more. Integrated GPS enables record-

ing of driving data and supports both wireless and cellular transmission, and Class A-certified devices allow testing against Society of Automotive Engineers (SAE) International standards.

**Rugged and secure performance**

As mentioned, transportation deployments can last decades, performing in the physical extremes of high vibration and shock. In turn, transportation industry standards are rigorous, including specific environmental restrictions intended to ensure passenger safety and non-stop performance under these conditions. Specifications such as EN50155 and many others established by the European Committee for Electrotechnical Standardization (CENELEC) and the American Railway Engineering and Maintenance-of-Way Association (AREMA) define all characteristics of electronic equipment implemented on rolling stock, working in tandem with other environmental regulations such as onboard fire and smoke protection. Systems must be carefully designed and managed to comply with safety standards (for example, fire hazard reduction), and the Intel Atom E3800 processor family is a viable option for low-power electronics with less thermal output.

Intelligent transportation networks combining rugged COM Express modules with a custom baseboard incorporating an Intel Atom E3800 processor option are proven tolerant to high levels of shock and vibration, and validated for a greater range of operating temperatures. For example, ADLINK's E3800 COM Express offerings include the cExpress-BT2, cExpress-BT, and nanoX-BT – PICMG COM.0 Rev.2.1 Type 2, Type 6, and Type 10 form factors, respectively — with I/O features typical of x86 architecture: up to 3 PCIe, 2 SATA, and 8 USB ports are provided for scalability in application system layouts (Figure 1). To ensure reliability and stability, all of the modules are verified with international standards for shock and vibration and have an extreme rugged operating temperature range of -40 °C to +85 °C.

Security is also of essential importance in transportation designs, such

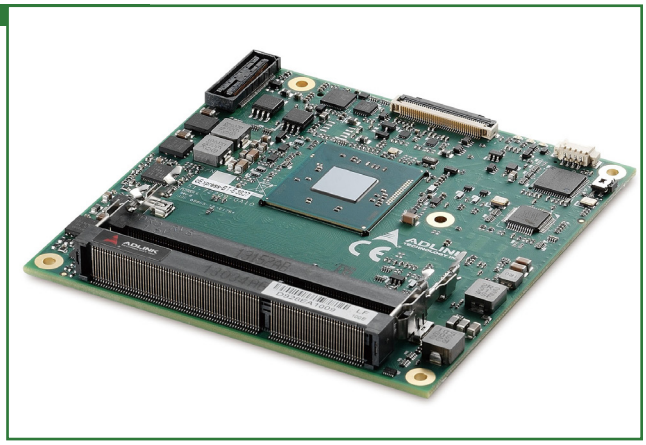

**Figure 1** | The ADLINK cExpress-BT is a 95 mm x 95 mm COM Express compact module built to international standards for harsh environment transportation applications.


as wayside or train control applications, and the E3800 family's built-in security features can be considered a competitive factor in these applications. For security enhancement and content protection, the E3800 family incorporates Intel Advanced Encryption Standard New Instruction (Intel AES-NI), hardware-assisted encryption instructions to enable faster data encryption and decryption. Data is secured as it moves through the transportation network, and is encrypted up to four times faster than earlier generations. E3800 performance improves with encryption and decryption executed in hardware, in contrast to using software algorithms which are costly in terms of cycling and power consumption.

**x86 evolution gives a new look at low power**

Embedded evolution marches on, and developers now have access to a credible option for low-power x86 designs in a very small footprint. The Intel Atom E3800 SoCs can help designers work within transportation industry regulations, performance demands, and low-power design requirements, while still developing the high-compute solutions for which x86 is known. Developed to enable high performance, small form factor intelligent systems, the E3800 processor family addresses a specific power-performance need – blending media and compute performance, low TDP, and reduced BOM in a low-power SoC. Transportation designers are capitalizing on these characteristics, developing lightweight, passively cooled solutions supported by a known and trusted software toolchain and next-generation scalability to Intel Core processors.

As global transportation industry requirements continue to expand – encompassing onboard train management and wayside control systems, remote video surveillance and monitoring, broadband Internet access, and a broad range of passenger information and entertainment systems – designers have a greater range of x86 processor options to develop competitive designs that get to market quickly. Using COM architecture to bring out the E3800 feature set, designers have a proven platform to meet the rigors of transportation design, addressing performance and power with simplified software development and a well-defined ecosystem. **SFF**

*__Dirk Finstel__ has more than 20 years of in-depth experience in leading embedded computer technology, with a proven track record in embedded modules. Currently the Executive Vice President of ADLINK's Global Module Computer Product Segment, Finstel has been Chief Technical Officer and a member of the management board of Kontron AG responsible for global technology, as well as research and development and setting technological strategy. He has held executive-level positions at embedded computing companies since he founded Dr. Berghaus GmbH & Co. KG in 1991 and holds a BS in Computer Engineering & Science.*

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## Considering the overall design value of x86

The low-power foothold of ARM is evident in mobile/portable consumer device markets. Yet, in the embedded realm, determining a design path between these two options is more often affected by a broader range of values. Designing with ARM or x86 has developers evaluating price, processor performance and, of course, power, but also software development and I/O requirements, ecosystem constraints, and overall ease of development.

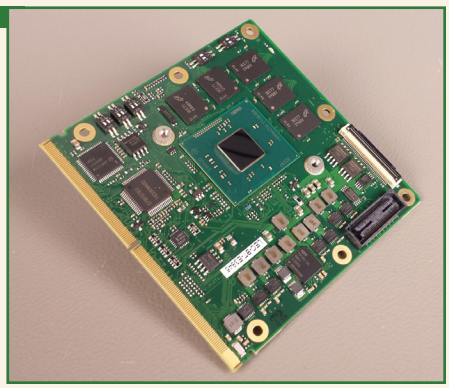
Software is often the most challenging part of system design, with familiar x86 environments well supported by development tools that help implement, debug, and fine tune software. Performance is assured while time to market is reduced. Pinouts and I/O interfaces are also well established in x86, as Intel has been instrumental in defining not just the core microprocessor and instruction-set architecture, but also the architecture of peripherals. Embedded computing products based on the x86 architecture have capitalized on that chip level expertise by providing either proprietary or open-standard products using common I/O interfaces. Common connector pinouts enable the widest range of hardware- and software-compatible peripherals for use in customizing end-user products.

The ARM environment is more complex and differentiated, with a singular focus on SoC products, each usually optimized for a particular application. With less historical focus on building standard I/O definitions, each SoC would be used on a custom board design; also, depending on the target market, I/O options do not emphasize standard buses such as PCI Express. The resulting ARM marketplace includes a number of proprietary form factors and connector definitions that may lock designs to a single vendor that may not support more than a single generation of silicon even as designs move to more advanced SoCs.

Originally designed to standardize the use of ARM processors in applications requiring low power, low cost, and high performance, the Smart Mobility ARChitecture (SMARC) standard for COMs now also supports the low-power Intel Atom E3800 processor family (Figure 1). The E3800 family offers more computational power than its predecessor, and is able to fit the thermal envelope required for applications with temperature and airflow constraints (for example, passive cooling with no forced airflow and +80 °C ambient air). Designers now have more choice and access to backward-compatible, low-energy products, as well as the familiarity of working with the x86 ecosystem.

Each architecture plays an evolving role in embedded design – for example ARM recently made public its embedded roadmap with a series of new SoCs and Accelerated Processing Units (APUs) built from both ARM and x86 cores. Design choices are wide open, and introducing low-power options into the x86 environment creates even more opportunity for competitive, low-power systems in small form factor arenas.

**Figure 1** | ADLINK's SMARC LEC-BT integrates Intel Atom E3800 in a mobile form factor originally intended for ARM-based Systems-on-Chip (SoCs).



**Sidebar 1** | Considering the overall design value of x86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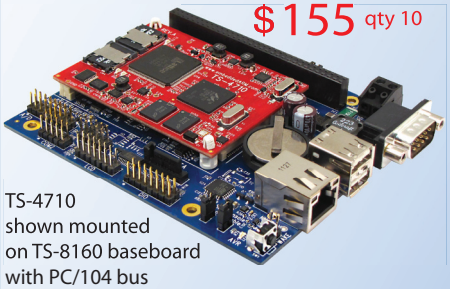

TS-4710 shown mounted on TS-8160 baseboard with PC/104 bus

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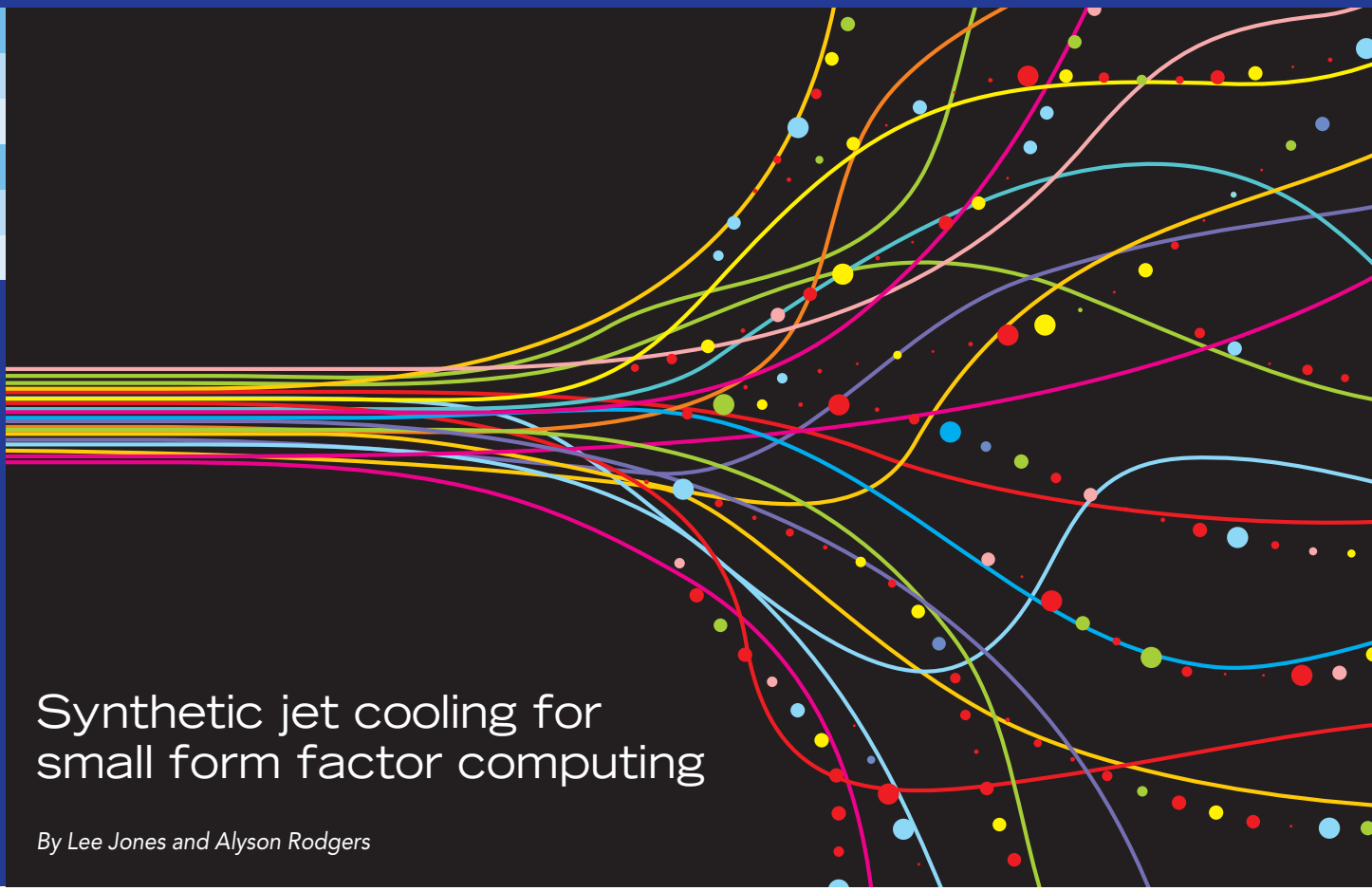

# Synthetic jet cooling for small form factor computing

*By Lee Jones and Alyson Rodgers*

To say that Moore's Law is now in full effect would be an understatement; electronics are becoming exponentially more fast and powerful at an ever-increasing rate. Meanwhile, the sizes of the devices are becoming smaller and smaller, largely due to the needs and wants of consumers. While there seems to be no limit as to how powerful chip designers can make speed and storage, there are several barriers to how small we can continue to make the products that utilize these chips. One of the most critical of these barriers is proper thermal management.

Synthetic jet cooling offers very high heat transfer rates in very compact, highly reliable packages. This enables products to achieve the small size and power density associated with active cooling, without the low system Mean Time Between Failure (MTBF) of fans.

As products become smaller and more feature rich, the heat that builds up can often cause them to become performance limited or fail altogether. In the past, small form factors have relied on large passive heat sinks, unreliable fans, or conduction cooling to transfer heat to a different part of the product. Each of these techniques is becoming increasingly problematic as engineers continue to create smaller designs with more power and higher levels of integration.

Heat sinks take up space within products and also add weight and cost. The thermal dissipation of a passive heat sink alone will not meet the needs of engineers challenged with cutting-edge designs, as there is just too much power packaged into too small a space. Traditionally, when engineers are faced with a critical thermal problem they turn to fans. Unfortunately, fans' rotating machinery contains bearings, and bearings have friction. This means that when you calculate the reliability of your product, you do not anticipate *if* your fan bearing will fail, but *when* your fan bearing will fail. Often the tradeoff between better cooling and low reliability is not worth using fans, which results in defeaturing, reduced performance, and specmanship.

Conduction cooling is no longer an option for most computing devices, and may soon be ineffectual for almost

> Typically, the addition of a SynJet to designs previously cooled by natural convection results in heat sinks less than one-third of the original size and a cooling and heat transfer improvement of up to 60 percent.

all small form factor devices due to the continual rise in heat generated by processors. An active and reliable mode of cooling is needed that can be built into thinner embedded systems that does not hinder design or functionality. To this end, synthetic jets are being applied by electronics developers and manufacturers to address the growing thermal problem.

**How synthetic jets work**

Originally developed for broad applications, such as elimination of flow separation on active flight control surfaces and microfluidic devices for heat transfer and cooling, synthetic jet technology allows for an unsteady, pulsating jet to sweep quickly over the heated surface. The vortices inherent to the flow create a high level of mixing.

SynJets use flexible diaphragms to create a turbulent, pulsating airflow that can be directed at precise locations for hot-spot cooling. The oscillating diaphragms create high-velocity pulses of air. This high-velocity pulse of air removes the heat being conducted by the heat sink, and at the same time pulls entrained air from the area in its wake. This process continues so quickly that the pulses of air aggregate to form what appears to be a steady, unidirectional flow.

Figure 1 shows a simplified example of a SynJet cooler. As the diaphragm moves up and down, the high-velocity jet flow is ejected from the nozzles. The local low pressure created by this high velocity results in the secondary flow – the entrained air – being drawn into the flow field and over the heat sink. This secondary flow provides additional fluid mass that can be used to carry the heat away from the heat sink.

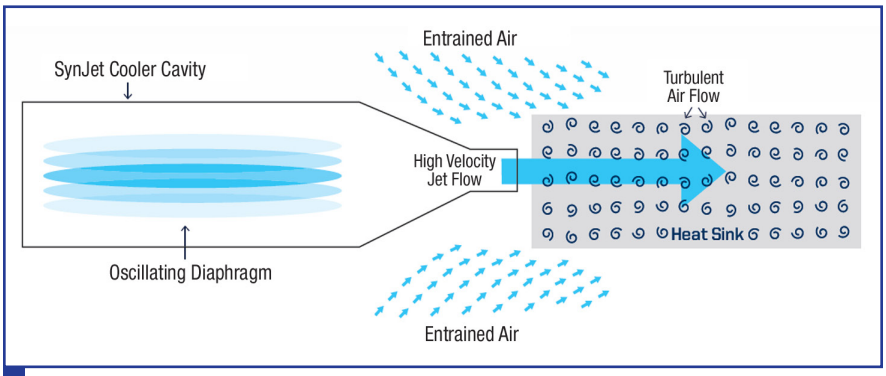


**Figure 1** | This simplified representation depicts how SynJet cooling generates high-velocity pulses of air to combat thermal issues in space-constrained environments.


**Figure 2** | The Nuventix RazorJet is a small form factor, 3 mm synthetic jet used to cool low-wattage electronics.

**Key benefits of synthetic jet technology**

***Size***

Typically, the addition of a SynJet to designs previously cooled by natural convection results in heat sinks less than one-third of the original size and a cooling and heat transfer improvement of up to 60 percent. Product designers use this feature in a number of ways depending on the needs of their customer. Some choose to make their product as small as possible, while others take advantage of the reduced weight to differentiate their product. Regardless of the final configuration, the simple effect of increasing the thermal design envelope opens up new options for the system design.

Additionally, SynJets are a scalable technology. Solutions such as the Nuventix RazorJet are as small as 3 mm in height and used to cool low-wattage electronics such as handheld devices (Figure 2). Higher capacity products have been designed with the ability to cool hundreds of watts of power and are used to cool high-power electronic devices as well as LED lights and datacenters.

***Reliability***

SynJets are inherently reliable, whereas rotating machinery like fans and pumps are inherently unreliable and therefore typically require safeguards and additional technology to increase their reliability. Fans require rotating blades, which create loads and require the use of bearings to extend the life of the fan's motor. These bearings are failure prone so they have to have lubricants added to

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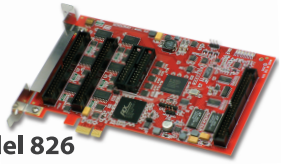

CE

**Model 826**
**Measurement & Control**
- 6 advanced 32-bit counters
- 16 analog inputs, 16-bit, 300 ks/s
- 8 analog outputs, 16-bit, 900 ks/s
- 48 digital I/Os with edge capture
- Supports incremental encoders, pwm/pulse generation
- Watchdog timer

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- Take cooling to the heat source, not the heat to the cooling
- SynJet module can be adapted to today's advanced industrial design
- Create airflow around corners, between slots, and tight spacing
- Ability to generate airflow in all directions

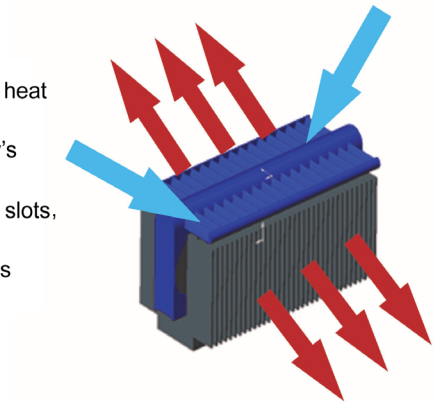

**Figure 3** | Nozzles can be placed anywhere on the boundary of a SynJet cavity to generate airflow in multiple directions.

**Figure 4** | The small size and shape of synthetic jets such as the RazorJet provides a high degree of design flexibility for small form factor products.

them. Lubricants can leak out or become contaminated by particulate so they require seals; therefore, the lifetime of your fan, and thereby your product, is determined by how well bearings are sealed. This is just too complicated and uncertain.

Because SynJets have no need for bearings and thus no friction, they have incredibly high reliability and do not have the complicated technological band-aid stack that fans do. The typical L10 lifetime of a SynJet is 100,000 hours at 60 °C with a 90 percent confidence factor; special classes of SynJets have been developed that have 2.5x that lifetime. On top of the lack of bearings and frictional parts, the diaphragms are designed with ample clearance so they are tolerant to the ingress of particulates such as dust or sand. A 30-year dust test for SynJet coolers has shown virtually no effect on cooling performance.

A number of customers have found that by adding a SynJet, they can increase their system MTBF. This is because having a high-reliability active cooling element in their product lowers the junction temperatures of a number of key components, providing a net system benefit.

### *Quiet*

SynJet designs also result in low acoustics. The lack of frictional parts such as bearings or brushes eliminates typical acoustic issues associated with interfaces used in active cooling. Unlike fans or blowers, synthetic jets like SynJets maintain low acoustic levels over their lifespan, typically maintaining a dBA of approximately 22, which is about the sound of a low whisper.

### *Low power consumption*

Through the development of very efficient actuators, synthetic jets such as the SynJet require very low power to operate. The reason for this is simple and straightforward – the

SynJet is a spring mass system and has a resonance. By operating at a resonant frequency that is typically below 80 Hz, SynJets sip small amounts of power while maintaining their cooling efficacy. Different field configurations and system backpressures can result in different system resonances. Intelligent electronics in the system guarantee operation at the optimal frequency and low power consumption over the life of the product.

### *Geometric flexibility*

Fundamentally, to create a synthetic jet you need to change the volume of a cavity and provide an orifice for fluid to be ejected during the exhalation phase and recharged with fresh air during the inhalation phase. This means that the orifices (or nozzles) can be placed anywhere on the boundary of the volume and flow will be generated (Figure 3). It is possible to make a spherical cavity that generates airflow in all directions as the diaphragms displace the volume.

The implications for product design are significant. The ability to place cooling where you want it and direct airflow where you need it is unprecedented. What this means for product designers is that they can let the cooling system design follow the design requirements of the product, instead of the product design following the design requirements of the cooling.

Due to the size, shape, and technology it is exceptionally simple to adapt synthetic jets into a design. Rather than creating a design to manage heat transfer needs, this cooling solution can be made to fit around the design. The RazorJet is the best representative of the remarkable flexibility of the synthetic jet for hot-spot cooling and small form factors, due to the ability to use multiple jets in various formations without sacrificing size and maximizing heat transfer (Figure 4).

### Synthetic cooling solutions for small form factor designs

The future of small form factor devices and mobile and portable electronics relies on a solution to provide efficient cooling and thermal management. Synthetic jet technology may very well be the key. **SFF**

*__Lee Jones__ is the Director of Advanced Development for Nuventix Inc. In his role he is responsible for the technical aspects of product marketing, key account support, and new market development. He received a BSME from Rochester Institute of Technology and an MSME from the University of Texas at Austin.*

*__Alyson Rodgers__ manages Brand Awareness for Nuventix, Inc. She manages consumer and digital marketing as well as updated product information and collateral. Alyson received her Bachelor's degree from the University of Texas at Austin.*

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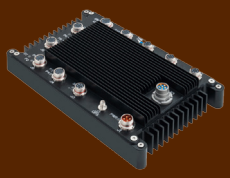
THE GIGABIT ETHERNET NANOSWITCH

When SWAP-C is Mission-Critical



The small, light footprint and powerful performance of the Gigabit Ethernet NanoSWITCH make it ideal for rugged commercial and military field applications. The NanoSWITCH can be ordered in various configurations, ranging from a simple Layer 2 switch to a fully managed Layer 2/3 switch and router. An optional Auxiliary Gateway Processor can be added, along with CAN Bus, MIL-STD-1553, SAASM GPS, SINCGARS and HAVEQUICK Interfaces, PTP, and MEMS Inertial Measurement Units

Features

- Scalable from L2 switch to L2/L3 switch router with auxillary gateway processor, SAASM GPS, CAN, 1553, PTP, and IMU
- 10x 10/100/1000 GigE Port
- 1x 10/100/1000 GigE WAN/Firewall/ Management Port
- Single Core Intel Atom or Dual Core AMD Fusion Auxillary Gateway Processor
- 64 GB SSD for Auxillary Gateway Processor
- 2x CAN Bus Ports
- 1x MIL-STD-1553B Port
- 2x USB 2.0 Port
- 1x Serial Management Port
- 1x Serial COM Port
- 1x VGA Port
- 1x Rockwell Collins GB-GRAM SAASM GPS
- 1x VectorNAV MEMS IMU
- Operating Temperature: -40C to +71C
- Sealed Circular-MIL Connectors
- IP67 Water Resistant
- Shock: 50g @ 25mSec
- Vibration: 5G RMS 10Hz to 2kHz
- 10V to 36V DC
- XX to YY W, Configuration Dependant
- MIL-STD-810 (Environmental),
- MIL-STD-1275 (Ground Vehicle Power)
- MIL-STD-704 (Aircraft Power)
- MIL-STD-461F (EMI)

Applications

- Intra-vehicle network switching
- Distributed architecture vehicle controller
- VICTORY compliant switch, router, timing, and control
- WAN – LAN interconnectivity and firewall
- Shared processing and peripheral communications

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# SFF market fragmentation continues, x86 and ARM set to square off

*By Brandon Lewis, Assistant Managing Editor*

The trend across vertical industries towards smaller and more efficient electronics is driving growth in Small Form Factor (SFF) boards, with new specifications and revisions emerging every year. In particular, a number of Computer-On-Module (COM) form factors have recently entered the merchant board space, with the likes of Qseven and the Smart Mobility Architecture (SMARC) looking to take advantage of surges in mobile connectivity, for example. However, while the addition of new players has contributed to the penetration of SFFs in certain applications, it has also made it difficult for any one standard to establish clear command of the market. As Eric Gulliksen, Senior Analyst at VDC Research in Natick, MA (www.vdcresearch.com) explains, the result has been increased segmentation during a period of "moderately healthy growth" for SFF boards (Figure 1).

"We don't have the system numbers yet, but on the board side we're showing an overall Compound Annual Growth Rate (CAGR) in excess of 5 percent," Gulliksen says. "You've got a whole variety of form factor classes within SFFs. You've got what basically is the embedded motherboard – the EPICs and so forth; you've got COMs; you've got the PC/104 family. Some of them are doing well, some of them not so hot."

"Two-to-three years ago or maybe even four, [COMs] became a mainstream technology," he continues. "That having been said, [there is a] plethora of form factors that people keep tossing out – every company comes out with a new form factor, tries to make it a standard, and they all throw them against the wall to see if any of them stick. What ends up happening is you have such a fragmentation that it's slowing down the growth of COMs in general because nobody wants to bet on a losing horse – they put a horse in the race a lot of times just to see how things run."

"COM Express is doing fine; Qseven looks like it may be viable; the others – SMARC, CoreExpress, and others – have a market share of something like a tenth of a percent," says VDC's Gulliksen. "Sure we could give you a huge CAGR because in the next six or seven years they might go from selling 300,000 to selling 700,000 [boards]. That's a pretty nice CAGR, but it doesn't mean anything."

Consistent with Gulliksen's findings, Toby Colquhoun, Senior Analyst, Electronics and Media, IHS Global Research in Wellingborough, UK (www.ihs.com) projects newer specifications like Micro Qseven (µQseven) growing quickly out of the gates only to obtain a "relatively small fraction of the market in the future," while established architectures like CoreExpress will continue to serve existing customers without much further growth. Colquhoun does note, however, that boards of the System-On-Module (SOM) variety have experienced success lately, though most do not conform to specific standards.

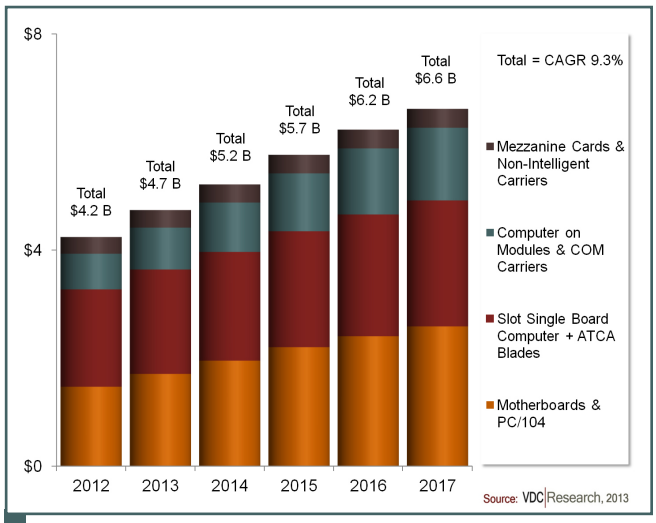


**Figure 1** | Moderately healthy growth in the Small Form Factor (SFF) board industry between 2012 and 2017 will be fragmented between a growing number of SFF standards. Graphic courtesy of VDC Research (www.vdcresearch.com).

"It's not one "form factor" as such, and it's certainly not a new approach, but several vendors produce off-the-shelf technology that can be grouped under the SOM definition," says Colquhoun of IHS. "These products are typically ARM based, but there are a huge number of approaches in terms of which signals are used. This market is reasonably sized – and some suppliers in this segment have grown well in the recent past."

In total revenue terms, IHS Global Research projects that beginning in base year 2012, the 1.4 billion USD market for PICMG 1.x, COMs, and standalone boards will grow 9 percent year-over-year through 2017, Colquhoun says. "In unit terms, the market is projected to grow, on average, at a rate of 14 percent over the same period," he adds (Figure 2).

### ARM makes inroads in embedded SFFs

Though SFF standards have historically been based on x86 processors, ARM's evolution out of the mobile device space is beginning to have an impact on the embedded market, including merchant boards. Indicators from VDC Research show ARM processors making "substantial inroads against the conventional x86 architecture," with broadening IP and lower power functioning as key drivers.

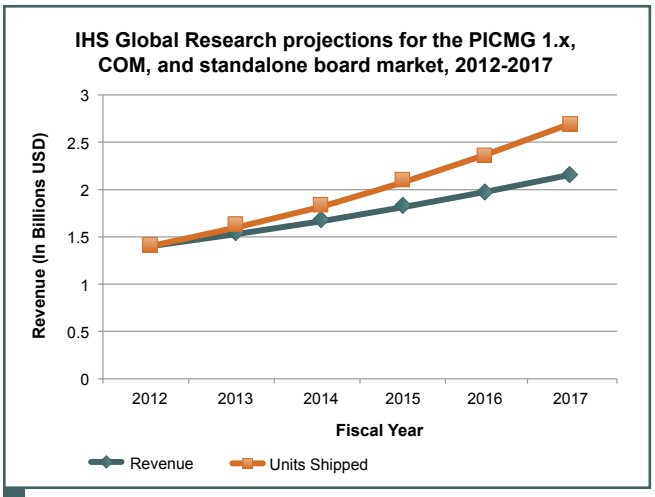


**Figure 2** | IHS Global Research projects that the market for PICMG 1.x, COMs, and standalone boards will grow in revenue at a 9 percent CAGR between 2012 and 2017, with unit shipments rising at a 14 percent clip over the same time frame. Metrics courtesy of IHS Global Research (www.ihs.com).

"We don't have an interview with a vendor in the board market where they are not asking us questions about ARM," says Chris Rommel, Vice President, VDC Research. "That is one of *the* things they are getting the most questions about themselves, so there are certainly the underpinnings for a rapid shift going forward, especially given some of the investments ARM has made in extending its own portfolio of IP. So you will begin to see more broadly within a lot of these smaller form factors a larger penetration of ARM."

"This growth is largely driven by technology changes," says IHS' Colquhoun. "For example, ARM microprocessors lacked some interfaces that are essential for the embedded world – it was only possible to get these interfaces via a bridge chip, which mitigated the space-saving and power-saving benefits of using ARM in the first place. This has changed. High competition for design-ins for tablets and smartphones drove ARM licensees to create very capable products, which are incidentally suitable for the embedded applications as well.

"Due to the investment in software needed to make these projects viable, most ARM technology will be used in COM form factors, as this form factor is economic at relatively high volumes compared to other merchant market standards," Colquhoun continues. "Of the total COM market in 2012, about 44 percent of components sold were ARM-based in terms of units shipped. The revenue picture is a little different obviously as x86 products are lower volume/higher value." IHS projects a 20 percent CAGR for the ARM COM market between 2012 and 2017, as well as a big impact from AMD's x86-based G-Series Systems-on-Chip (SoCs) in 2014, Colquhoun adds.

Beyond size and power benefits, ARM processors are making headway in embedded applications because of their compatibility with traditionally mobile Operating Systems (OSs). Particularly as variants of Windows near End-Of-Life (EOL) and developers begin to investigate alternatives, ARM's track record with platforms like Android will increase in importance, says VDC's Rommel.

"Another force pulling ARM into the ecosystem is the increasing interest in Android as the primary OS in a number of embedded device classes," says Rommel. "And given the longer and deeper history of Android as an OS for ARM-based processors, it creates some additional pull for that semiconductor base in the embedded market as well.

"A survey that we do every year out of our embedded software practice has pretty consistently shown growth in the percentage of engineers saying current projects and future projects are based on ARM, to the point where now one-third of engineers are saying as such," Rommel continues. "Many of those aren't going to be using these traditional deeply embedded, highly ruggedized boards or SFF systems; they are going to be using just an SoC, depending upon the device. But when we look at some of the trending there, we're seeing ARM going into a range of new device classes – everything from enterprise-class servers, but also infotainment and medical devices. In many cases, the reason for selection of ARM for mobile devices is now becoming more germane to some of these traditional embedded device classes: like MIPS per watt performance. There are a lot of OEMs looking for things that just have a lower power profile."

It is also important to note that data from VDC Research shows minimal penetration of SoCs into the merchant board market on the order of 2 percent.

**Software and services still key amidst SFF trend**

As Moore's Law continues advancing to enable more with less, the SFF board industry should remain secure for the foreseeable future. Meanwhile, the emphasis on software will continue to increase in importance as additional functionality can be abstracted from physical components.

"[The SFF board market] is a larger growth area: you look at a lot of these markets and they are not necessarily garnering incredibly high growth rates," says Rommel of VDC. "There are things that are shrinking and things that are growing, but one thing that also doesn't necessarily incorporate – if you look at the embedded market holistically beyond just some of the merchant boards – is the growing value and investment in a lot of the enabling technologies in software and middleware and additional services. The investment in those technologies is growing at a faster rate than just the more bare-bones hardware by itself." **SFF**

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info@ihs.com

VDC Research
www.vdcresearch.com
info@vdcresearch.com

## 2014 BUYER'S GUIDE INDEX



Bay Trail

**ADLINK Technology, Inc.** — **cExpress-BT Compact COM Express® Module**

ADLINK's COM Express offerings include the cExpress-BT, cExpress-BT2, and nanoX-BT – PICMG COM.0 Rev.2.1 Type 6, Type 2, and Type 10 form factors, respectively – with I/O features typical of x86 architectures: up to 3 PCIe, 2 SATA, and 8 USB ports are provided for scalability in application system layouts. To ensure reliability and stability, all of the modules are verified with international standards for shock and vibration and have an Extreme Rugged™ operating temperature range of -40 to +85°C. The modules feature the latest Intel® Atom™ and Celeron® processors for intelligent systems, which offer a significant performance/watt improvement over previous generations, high integration of both low and high speed I/Os, advanced graphics engine, and virtualization support – all on a sub-10-watt SoC.

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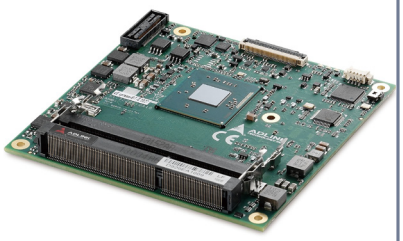


Communications & Networking

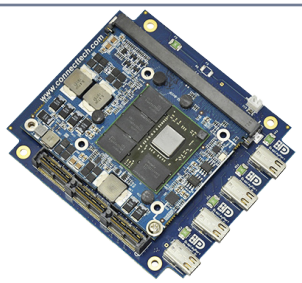
**Connect Tech, Inc. (CTI)** — **Xtreme/GPU**

The Xtreme/GPU brings desktop-level graphics, multimedia features, and GPU processing power to the PCIe/104 form factor; select either AMD or NVIDIA graphical solutions.

The AMD version of this board is a high-end graphics unit used to drive up to four Mini DisplayPort connections for independent use, or leveraging AMD Eyefinity technology, as a single large surface.

The NVIDIA solution, transforms into a processing powerhouse. With access to the NVIDIA CUDA™ Cores, the GPU can become a parallel computational CPU for non-graphical applications.

**www.connecttech.com/XtremeGPU/** — **smallformfactors.com/p9911926**



**Connect Tech, Inc. (CTI)** — **Xtreme/GbE – Managed Carrier Ethernet Switch**

The Xtreme/GbE Managed Carrier Ethernet Switch provides carrier grade Ethernet switching capabilities in an embedded small form factor. It's a highly reliable way to communicate with 10/100/1000 devices in an embedded system powered by the latest generation carrier ethernet switch engine the Vitesse VSC7428. Its embedded 416 MHz MIPS 32-bit CPU, 1Gb DDR2 external memory, and DMA-based frame extraction and insertion supports timing over packet, Ethernet OAM, and performance monitoring.

**FEATURES:** Latest Generation 32-bit Switch Engine • Web GUI or CLI Management • Available with RJ-45 or Rugged Locking Ethernet Connectors • PCIe/104 Form Factor • Single Wide Range Input Voltage +9V to 36V • Extended Temperature Range -40°C to +85°C

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## Epiq Solutions — Matchstiq™ SDR

Epiq Solutions' **Matchstiq™ SDR** combines a broadband RF transceiver with CPU/FPGA processing to provide a complete stand-alone software-defined radio solution with unprecedented flexibility at a fraction of the size, weight, and power (SWaP) of its competitors. Combined with a library of ready-to-run specialty software applications, the Matchstiq™ platform can immediately be used to solve challenging signal processing requirements on day one. As a user's requirements expand, additional software applications can be loaded onto the unit, providing a full-featured suite of capabilities that can be selectively executed at run time. Software and FPGA development kits are available.


**http://epiqsolutions.com/matchstiq/** **smallformfactors.com/p9916370**

## Epiq Solutions — Maveriq™ SDR

Epiq Solutions' **Maveriq™ SDR** is an advanced software defined radio platform combining multiple RF transceivers, internal solid state drive for data recording, and a gigabit ethernet interface for high speed data access. Maveriq™ introduces a paradigm shift in signal processing capabilities packaged in a portable, low power platform, where previous solutions required large and bulky hardware configurations. Combined with a library of ready-to-run specialty software applications, Maveriq™ can immediately be used to solve challenging signal processing requirements on day one. Software and FPGA development kits are available.


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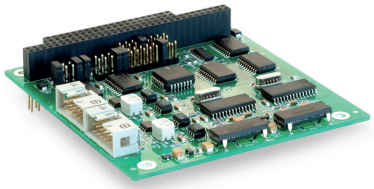
## PEAK-System Technik GmbH — PCAN-PC/104

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.

Device drivers and APIs are available for Windows and Linux.



**www.peak-system.com** **smallformfactors.com/p9910402**

## PEAK-System Technik GmbH — PCAN-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.

Device drivers and APIs are available for Windows and Linux.

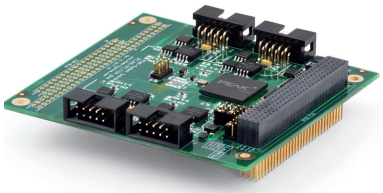
**www.peak-system.com** **smallformfactors.com/p9910403**

## PEAK-System Technik GmbH — 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.

Device drivers and APIs are available for Windows and Linux.



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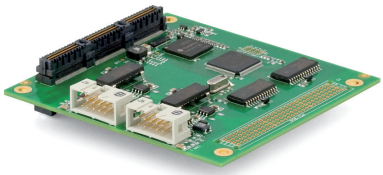
## PEAK-System Technik GmbH — PCAN-PCI/104-Express

The PCAN-PCI/104-Express card enables the connection of one or two CAN networks to a PCI/104-Express system. Up to three cards can be stacked together. 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.

Device drivers and APIs are available for Windows and Linux.



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## Nuventix Inc.

**SynJet XFlow 30 L50-50**

**SynJet Air Cooling** is a new innovative way to cool electronics without the use of fans or large expensive heatsinks. The patented frictionless technology allows the XFlow 30 and other SynJet electronics coolers to ensure extremely reliable cooling while allowing for flexibility and smaller designs. The XFlow 30 is 112mm x 50mm x 30mm and is available for indoor and outdoor applications, including telecommunications and other electronics.

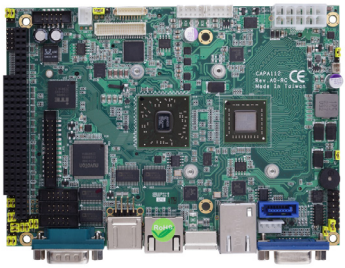
*Features: Extremely Small • Reliable • Flexible • Rugged • Quiet*


**www.nuventix.com** **smallformfactors.com/p9916293**

## Axiomtek

**CAPA112**

Axiomtek developed the CAPA112 low-power graphics-oriented 3.5" embedded board for digital signage, gaming, medical imaging, kiosks/POS, and factory automation. The CAPA112 is powered by the AMD G-Series APU T16R at 615 MHz, T40R at 1.0G Hz, or T40E at 1.0 GHz paired with the A55E FCH chipset and one DDR3 1066 memory slot (up to 4 GB). CAPA112 features one 18/24-bit single/dual channel LVDS and one VGA display for dual view compatibility. Only a +12V DC power input is needed to drive this low-power, extended temperature (-25°C ~ +70°C/-13°F ~ +158°F), 3.5" compact embedded platform for applications.

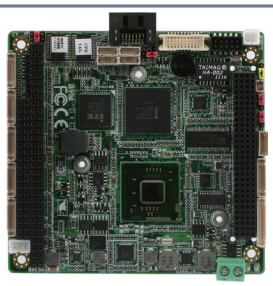


**http://us.axiomtek.com/products/ListProduct.asp?ptype1=202&ptype2=204&ptype3=270** **smallformfactors.com/p9916141**

## EMAC, Inc.

**PFM-CVS**

The PFM-CVS is a fanless Single Board Computer based on the Intel Atom N2600 Dual Core 1.6 GHz processor. This low power PC/104-*Plus* module features four USB 2.0 ports, four COM ports, Gigabit Ethernet, one SATA, and one mSATA/Mini Card (optional). The PFM-CVS supports analog VGA, 18-bit single channel LVDS LCD, PC/104-*Plus* expansion, and up to 2GB of DDR3 1066MHz SODIMM RAM. PC/104-*Plus* expansion allows features to be quickly added using any of EMAC's many PC/104-*Plus* expansion modules. This board is available in standard and wide Temperature. Quantity 1 board pricing starts at $288.

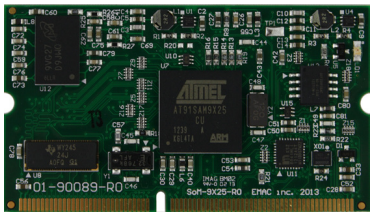


**http://www.emacinc.com/products/pc_compatible_sbcs/PFM-CVS** **smallformfactors.com/p9916300**

## EMAC, Inc.

**SoM 9x25**

Designed and manufactured in the USA, the SoM 9x25 uses the same small SO-DIMM form factor utilized by other EMAC SoM modules and is the ideal processor engine for your next design. All of the ARM processor core is included on this tiny board including: Flash, Memory, Serial Ports, Ethernet, SPI, I2C, I2S Audio, CAN 2.0 B, PWMs, Timer/Counters, A/D, Digital I/O lines, Clock/Calendar, and more. The SoM-9x25 is designed to plug into a custom or off-the-shelf carrier board containing all the connectors and any additional I/O components that may be required. The System on Module approach provides the flexibility of a fully customized product at a greatly reduced cost. Quantity 1 price begins at $190.



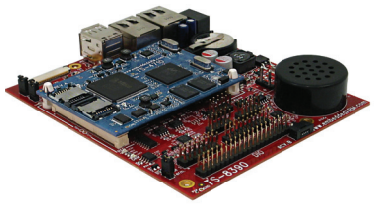
**http://www.emacinc.com/products/system_on_module/SoM-9X25** **smallformfactors.com/p9910299**

## Technologic Systems

**TS-4710 Computer-on-Module**

The TS-4710 is a small and low profile TS-SOCKET Computer-on-Module with Video GPU featuring a Marvell ARM9 PXA166 800MHz CPU or a PXA168 1066MHz. The TS-4710 features a user programmable Lattice XP2 8K LUT FPGA that by default implements several controllers such as high speed SD interface, XUARTs, and SPI. With 2 SD card sockets, this board is able to utilize our DoubleStore technology, making the system extremely reliable. External devices can connect to the TS-4710 using Ethernet, USB host, I2C, SPI, UARTs, or GPIO. Other TS-SOCKET CPU modules include the TS-4200 low power ARM, TS-4600 low cost 450MHz ARM, TS-4712 with 2 Ethernets and TS-4800 iMX5 800Mhz with Video and FPU. Several COTS development carrier boards are available. Also, the TS-TPC-8390 is available as a complete touch panel solution for HMI applications. Prices start at $99 quantity 100.

pricing starts at $139 qty 1 $99 qty 100



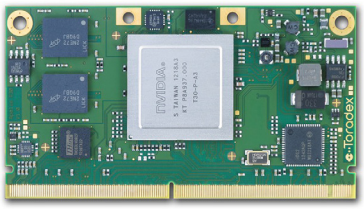
**www.embeddedARM.com** **smallformfactors.com/p9910307**

## Toradex Inc.

**Apalis T30 ARM Computer Module**

The **Apalis T30** with quad-core NVIDIA Tegra 3 processor is the first product in the new Apalis computer module family by Toradex. It comes with a wide range of features to ensure customers can develop the most advanced products based on the latest ARM SoC technology with minimum risk and overhead. Apalis supports a variety of industry standard interfaces, while at the same time providing advanced multimedia and high-speed I/O connectivity, making it suitable for almost any industrial or embedded applications.

Apalis T30 comes with a pre-installed operating system and includes a Windows Embedded Compact Runtime License. The available operating systems are Android, Linux, as well as Windows Embedded Compact 7 and 2013.

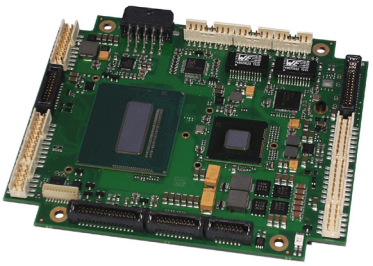


**www.toradex.com** **smallformfactors.com/p9911828**

## ADL Embedded Solutions Inc.

**ADLQM87PC – Industry's Smallest 4th Gen. Intel Core i7 SBC**

The **ADLQM87PC PCIe/104 SBC** delivers the industry's highest GIPS per in$^2$ and the most densely-packed comprehensive set of features. The ADLQM87PC's 17 in$^2$ footprint features 4th generation Intel Core processors with Intel 8-series QM87 PCH chipset, on-board mini-PCIe/mSATA socket for on-board Wi-Fi, GPS, bootable flash storage, a Trusted Platform Module (TPM v1.2), 2x USB 3.0, 16 GB DDR3, 4x SATA 6 Gb/s, 2x GLAN, DisplayPort, HDMI/DVI, VGA, 8x USB 2.0, etc. ... all with a smaller footprint and height than a basic COM Express module with greater temperature range and ruggedness.



**www.adl-usa.com** **smallformfactors.com/p9915973**

## ADLINK Technology, Inc.

**HPERC-IBR Extreme Rugged™ System**

Sealed, Rugged COTS Computing Platform – Built around the emerging SWaP and rugged form factor standard VITA75, HPERC's standards-based design provides a non-proprietary solution with ultimate cost/value ratio. Inside the tiny footprint of HPERC™ lives the power of the 3rd generation Intel® Core™ i7 processor and optional GPGPU parallel processing engine. Dual removable Secure Erase RAID-0 SSDs provide screaming 12Gb/s throughput and security for deployment in hostile environments. Easy configuration and expansion allows for fast integration of custom rugged embedded applications. HPERC reserves connector pins for expansion interfaces. The GPGPU sits on a 16-lane 3rd generation PCI Express interface. Uniquely-keyed MIL-DTL-38999 connectors provide a wide array of fast I/O.

**www.adlinktech.com** **smallformfactors.com/p9911835**

## Advanced Micro Peripherals, Ltd.

**StreamCorder-HD**

The StreamCorder-HD is an intelligent, stand-alone, H.264 streaming solution that accepts HD-SDI input at up to 1080p30 and encodes and streams over 100/1000MBit Ethernet. The single board solution is ideal for demanding applications in military, communications, transportation, mining and energy industries. The flexible streaming engine can stream the compressed video direct from the on-board Ethernet port as well as save directly to local storage for later retrieval. Stereo audio embedded in the input HD-SDI source can also be captured and streamed/synchronized with the video. Designed for mobile, UAS and vetronix applications, the StreamCorder-HD supports extraction of KLV (MSB 0605.3 compliant) embedded data contained within the HD-SDI that can be synchronized and streamed with the compressed video. The StreamCorder-HD also features optional on-board Controller Area Network (CAN), 3-axis accelerometer, high sensitivity GPS receiver, altimeter, and 3-axis digital magnetometer (e-compass). These can integrate with other vehicle systems, and data from these sources can be used as metadata embedded within the video and streamed to clients or saved for later analysis.

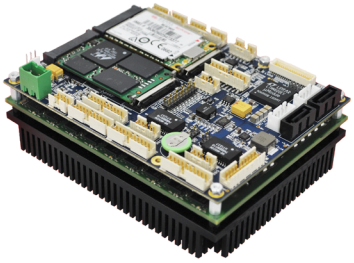
**www.amp-usa.com/stand-alone/h264/streamcorder-hd.php** **smallformfactors.com/p9916255**

## Connect Tech, Inc. (CTI)

**COM Express® Type 6 & Type 10 – Rugged Carrier Boards**

Connect Tech provides small footprint, ruggedized COM Express carriers supporting both COM Express Type 6 and Type 10. These carriers support multiple COM Express vendors and the most current processors, including Intel 4th Generation Haswell and low power Baytrail. With locking pin header connectors these carriers are ideal for space constrained applications, harsh environments, and demanding conditions, and will support extended temperatures. Choose from commercial off-the-shelf options or talk to Connect Tech today about your custom requirements.

**FEATURES:** Rugged, locking pin headers • Type 10 Carrier, 55mm x 84mm • Mini-PCIe/mSATA Expansion • Type 6 Carrier, 95mm x 125mm • Supports latest processor sets, including 4th Generation Intel® Core™ i7 (Haswell) • Extended Temperature Range, -40°C to +85°C



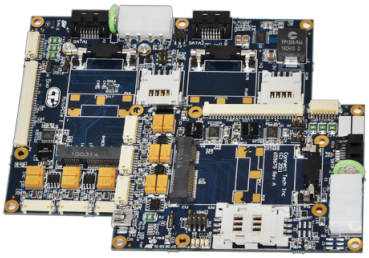
**www.connecttech.com/COMExpress/** **smallformfactors.com/p9916357**

## Connect Tech, Inc. (CTI)

**Qseven Carrier Boards – Ultra Lite & Lite**

Connect Tech Qseven Carrier boards offer a variety of I/O over a number of Off-the-Shelf boards or can be custom designed for your specific application. These carriers support the most current low power processors from Intel and AMD, but can also be used with ARM based modules including Freescale i.MX6. Make use of mini-PCI Express expansion, allowing you to add your choice of peripherals, including Wi-Fi, GPS, Bluetooth or storage depending on your application.

**FEATURES:** Support for most current, low power processors • Integrates with both x86 and ARM processors • Variety of small footprint choices including Pico-ITX (72mm x 100mm) • Carriers support wide temperature range, -40 to +85°C • Optional cable kits available for easy connection to Qseven features



**www.connecttech.com/QSeven-Carrier/** **smallformfactors.com/p9916356**

## North Atlantic Industries

**NAI SIU3-3 – Configured to Customize**

The **SIU3-3** is a highly configurable, rugged system or subsystem ideally suited to support a multitude of Mil-Aero applications that require high-density I/O, communications, Ethernet switching and processing. Leveraging NAI's 3U cPCI boards, the **SIU3-3** delivers off-the-shelf solutions that accelerate deployment of SWaP-constrained systems in air, land and sea applications. NAI intelligent I/O boards and systems can manage, monitor, control and pre-process I/O functions on their own or provide additional I/O capability to existing systems via Ethernet connectivity. Direct Ethernet command and control capability provides an "SBC-less" communications option – effectively reducing single board computer application software development and run-time costs. All products are designed to operate under extreme temperature, shock, vibration and EMI environments.


**www.naii.com** **smallformfactors.com/p9916292**

**Parvus, a Curtiss-Wright Company** — **DuraCOR 80-40**

The DuraCOR 80-40 is a rugged Commercial-Off the Shelf (COTS) tactical mission computer subsystem based on the high performance Intel Core i7 Sandy Bridge processor with a high-speed, stackable PCI-Express bus (PCIe/104) architecture for I/O card expansion. Optimally designed for Size, Weight, and Power (SWaP)-sensitive mobile, airborne, ground, manned or unmanned vehicle applications, the DuraCOR 80-40 combines powerful graphics and multi-core processing with ultra-reliable mechanical robustness and modular I/O expansion for extreme environmental and EMI performance per MIL-STD-810G (thermal, shock, vibration, dust, water, humidity) and MIL-STD-461F.

**www.parvus.com** — **smallformfactors.com/p9915145**

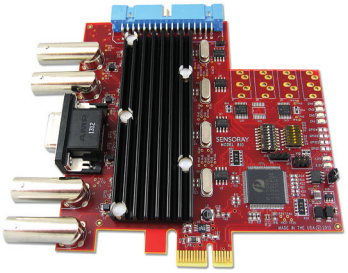
**Parvus, a Curtiss-Wright Company** — **DuraNET 30-2020**

The DuraNET 30-2020 is an ultra-rugged 19-port Cisco IOS-managed Layer 2 network switch integrating Cisco's ESS 2020 Embedded Services Switch technology with an isolated MIL-STD-1275/704 power supply in an IP67 (dust/waterproof) sealed aluminum chassis with MIL-DTL-38999 connectors. Designed for Size, Weight and Power (SwaP)-sensitive harsh military and civil environments (i.e. aircraft, vehicle, mining, industrial), the unit provides reliable local area network (LAN) switching capabilities with the ease of use, secure access, and manageability expected from Cisco-based technology. Two levels of Cisco IOS software (LAN Lite or LAN Base) are available to support access layer connectivity and needs for data, security, voice, and video traffic at the network edge for stationary or mobile network nodes.

**www.parvus.com** — **smallformfactors.com/p9915146**

**Sensoray Co., Inc.** — **Model 810 | PCI-Express 4-Channel Frame Grabber with Audio Capture**

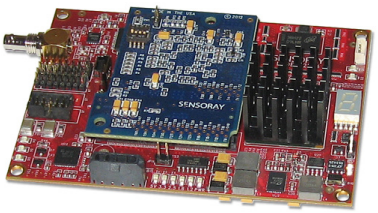
Model 810 is a PCI Express board that simultaneously captures four channels of analog NTSC/PAL video and four channels of stereo audio. It captures raw video frames from each channel at up to full frame rate, resulting in an aggregate frame capture rate of up to 120 fps for NTSC and 100 fps for PAL. The 810's high frame capture rate, coupled with its high performance bus interface, makes it well-suited for applications that require multi-channel audio/video capturing in a compact form factor.



**http://www.sensoray.com/products/810.htm** — **smallformfactors.com/p9916184**

**Sensoray Co., Inc.** — **Model 2224 | HD-SDI Audio/Video H.264 Encoder**

Model 2224 is a USB 2.0 audio/video H.264 MPEG encoder with full screen text/graphics overlay and one SDI input that supports a variety of video resolutions, including 1080p/1080i, 720p and NTSC/PAL. The encoder outputs H.264 High Profile Level 4 for HD and Main Profile Level 3 for SD, multiplexed in MPEG transport stream format. The board's versatile overlay generators, integral HD/SD raw frame grabber, and live preview stream make it ideally suited for a wide range of video processing applications, including High Profile DVRs, NVRs and stream servers.



**http://www.sensoray.com/products/2224.htm** — **smallformfactors.com/p9915954**



**ADLINK Technology, Inc.** — **Low Power CM1-86DX2 PC/104 SBC**

The CM1-86DX2 PC/104 single board computer features an extensive I/O set and full ISA bus support. The SBC is ideal for control applications requiring power efficiency, small form factor design, longevity, and industrial grade ruggedness. Based on DMP's Vortex86-DX2 SoC, the CM1-86DX2 provides all standard peripheral connections of an embedded PC on a printed circuit board with dimensions of 96 mm x 90 mm (3.775" x 3.550"). The Extreme Rugged™ CM1-86DX2 also enables a performance boost for legacy PC/104 systems that continue to utilize the real ISA bus, and supports applications across markets, including transportation, automated manufacturing, and aviation. The CM1-86DX2 comes equipped with ADLINK's Smart Embedded Management Agent (SEMA) for remote device monitoring and management.

**www.adlinktech.com** — **smallformfactors.com/p9916261**



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# Industrial ARM® Single Board Computers

## High-Performance Graphics with Industrial I/O and Expansion

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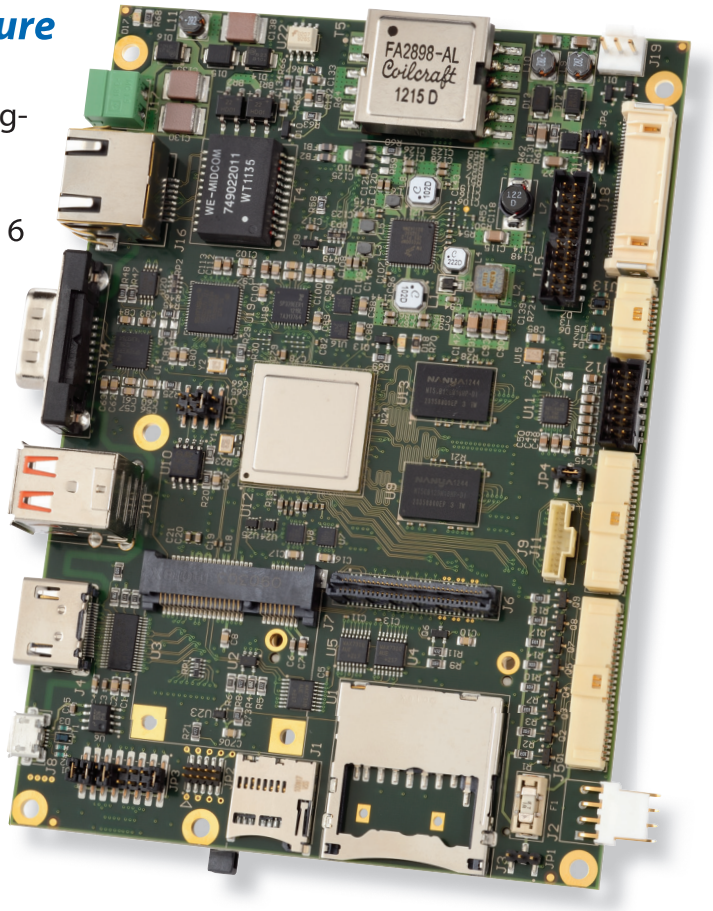


Designed for demanding applications and long-term availability, WinSystems' SBC35-C398 single board computers feature Freescale i.MX 6 industrial application processors with options for expansion and customization.

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- Gigabit Ethernet with IEEE-1588™
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