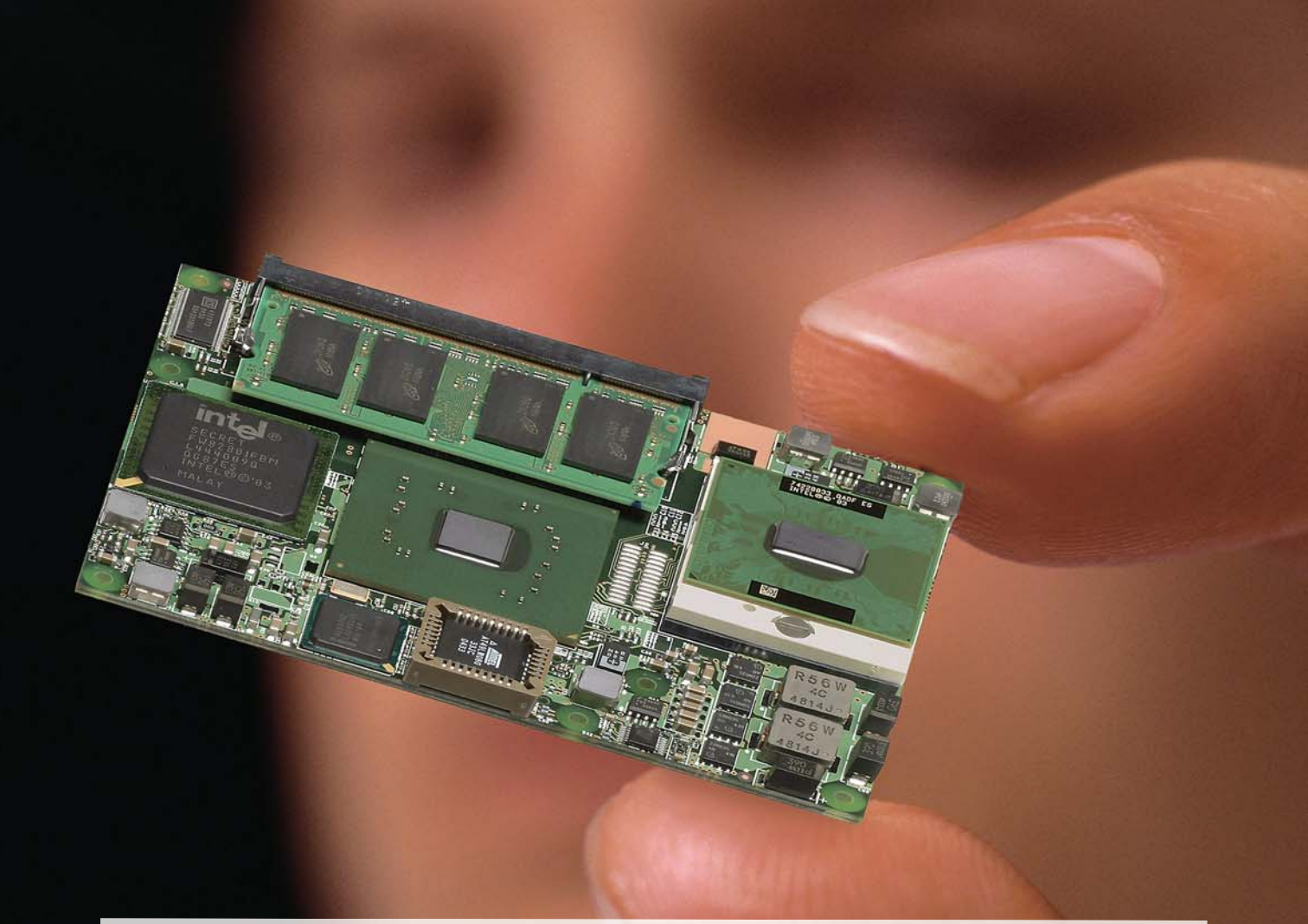

BY WARREN WEBB • TECHNICAL EDITOR

Serial streams shrink embedded-system designs

MOBILE- AND SMALL-FORM-FACTOR-PRODUCT DESIGNERS TURN TO FABRIC TECHNOLOGY AND OFF-THE-SHELF COMPUTER MODULES TO BEAT THE COMPETITION.

A new wave of extremely compact embedded computing platforms is finding its way into industrial, medical, consumer, and other space-critical applications. Despite their compact size, these small, off-the-shelf computing elements offer designers full processing performance and complete I/O features in both proprietary and standards-based form factors. These undersized but capable computer modules let designers skip the most complex portion of embedded-product design and concentrate on the custom circuitry unique to their design and reduce hardware- and software-development schedules.

As systems shrink and clock speeds escalate, product designers face the daunting task of developing a high-performance, state-of-the-art processor section to drive their custom embedded circuitry and still meet footprint constraints. To bypass this complex design and beat the competition to market, many designers are turning to new, small-form-factor, plug-in modules that integrate the CPU and standard peripherals. These off-the-shelf processor modules allow designers to trade substantial savings in NRE (nonrecurring-engineering) charges for slightly higher recurring costs.

Plug-in processors, also known as COM (computer-on-module) processors or core modules, make sense in embedded-system designs in which a single pc board houses all electronics, including the CPU, processor peripheral interfaces, mass storage, and application-specific circuitry. Single-board electronics typically find use in smaller or portable embedded systems, such as instrumentation, medical products, set-top boxes, kiosks, and game consoles. With a compatible baseboard design, you can purchase a large portion of the system's computer and general-purpose electronics on a replaceable plug-in module to shorten design schedules, ease system debugging, simplify upgrades, and reduce life-cycle costs.

A replaceable processor section provides several technical and economic advantages over traditional single-board designs. For example, designers can provide their embedded systems with a more sophisticated processor section to take advantage of advanced features, such as networking, graphical displays, complex software, and real-time operating systems, that would be difficult to implement on a restricted design budget. Instead of designing with an 8-bit processor with limited peripherals, processor and peripheral modules allow designers to easily step up to a 16- or 32-bit processor with a choice of state-of-the-art I/O.

Specifying an off-the-shelf processor section also affects the makeup of the embedded-system-design team. Depending on the complexity of the processor section, you may be able to reduce the number of designers a project requires. The software-design team becomes a major beneficiary because a working CPU section becomes available long before the hardware debugging of application-specific devices. Because most embedded-hardware-debugging problems occur in the more complicated CPU section, a module computer also bypasses many of the headaches of system checkout.

MEZZANINE MOVEMENT

The plug-in-processor concept is not new; however, small-form-factor designers have struggled to get the needed functions from existing modules. Along with numerous proprietary modules, the current PPMC (Processor PCI Mezzanine Card) and PC/104 standards provide off-the-shelf computing hardware to support plug-in-processor designs. PPMC is an extension of the original PMC (PCI Mezzanine Card) concept of providing replaceable I/O modules in embedded systems. VITA (VMEBus International Trade Association) maintains the PPMC specification, VITA32. With a connector arrangement meant for stacking boards without a card cage or backplane, a PC/104 computer board can also serve as a mezzanine processor on an embedded baseboard. These modules have the additional advantage of letting designers stack another I/O module on top of the processor if they run out of board space.

To increase bandwidth, reduce the number of connector pins, and reduce overall board area, module computer manufacturers are turning to switched-fabric technologies, such as Ethernet, PCI Express, Rapid I/O, and InfiniBand. Switched-fabric architectures eliminate many of the problems associated with parallel, multidrop bus schemes. Datapaths may change dynamically to support multiple simultaneous data transfers. Each connection is also a direct point-to-point

AT A GLANCE

- Fabric-based module computers package the CPU, mass storage, and peripheral interfaces on a replaceable mezzanine card.
- Small-form-factor computing modules allow designers to update and retrofit embedded devices without product redesign.
- A new COM Express standard compresses a high-performance processor and PCI Express interface into a 125×95-mm form factor.
- MicroTCA packages Advanced-MC (Advanced Mezzanine Card) modules directly into a backplane for smaller, lower cost applications.

datapath, yielding better electrical characteristics and higher bandwidth than bus architectures. A sophisticated switched-fabric system can also increase system availability by routing around defective paths or nodes.

Because of its compatibility with driver and operating-system software, several module standards include PCI Express. The developers of PCI Express based it on LVDS (low-voltage differential signaling) for maximum bandwidth between nodes. The basic PCI Express link comprises two signal paths that use small differential-voltage swings and constant-current line drivers to communicate at 2.5 Gbps in each direction. Designers expect this data rate to increase to 10 Gbps in each direction as silicon production technology improves. Low-voltage swings deliver low noise signals at low power consumption. You can easily increase the bandwidth of an individual PCI Express link by simply adding signal pairs, or "lanes," until you reach the desired performance level. The PCI Express specification supports one-, two-, four-, eight-, 16-, and 32-lane widths.

PFU, Kontron, Intel, and RadiSys originally sponsored COM Express, an open PICMG (PCI Industrial Computer Manufacturers Group) industry standard for COMs for small-form-factor designs. The standard implements new technologies in such a way that designers can maintain compatibility with legacy circuitry or create new legacy-free products. COM Express includes PCI Express to replace the PCI bus, PCI Express Graphics to replace AGP (Accelerated Graphics Port), and Serial ATA (Advanced Technology Attachment) to replace Parallel ATA. The processor-architecture-agnostic COM Express defines only industry-standard system-I/O interfaces.

For COM Express, PICMG defined a compact basic form factor measuring 125×95 mm and an extended form factor measuring 155×110 mm. With the same connector and pin definitions, the two sizes are interchangeable, and the extended form factor allows for double the memory capacity and dual-channel memory configurations. COM Express board-to-board connectors comprise two rows of 220 pins each. The required first row includes pins for PCI Express, Serial ATA, display, system and power management, networking, and power and ground interfaces. The optional second row provides digital video and legacy PCI and IDE signals plus additional PCI Express, networking, and power and ground signals.

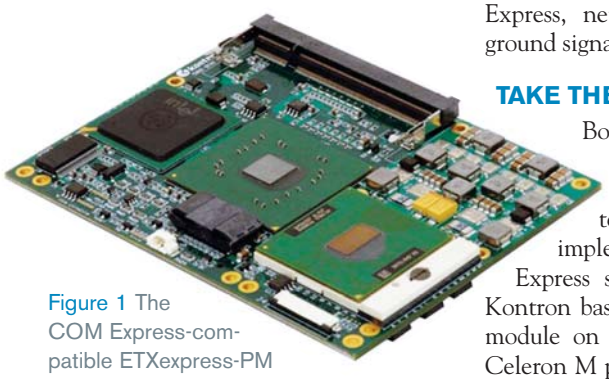

Figure 1 The COM Express-compatible ETXexpress-PM module from Kontron provides a low-power processor along with state-of-the-art-I/O interfaces.

TAKE THE EXPRESS

Board manufacturers have adapted the ETX (Embedded Technology Extended) Express form factor to implement the PICMG COM Express specification. For example, Kontron based its new ETXexpress-PM module on the Intel Pentium M and Celeron M processors, as well as on the Intel 915GM chip set; the module conforms to COM Express (**Figure 1**). PCI Express is the primary datapath, and a 32-bit PCI 2.1 interface supports legacy PCI-bus applications. The ETXexpress-PM will support four PCI Express lanes and PCI Express cards, as well as established hardware, such as the 32-bit PCI bus. For applications that require real-time video capabilities, the ETXexpress-PM has both Intel Extreme Graphics 2 and PCI Express graphics. The board also has 10/100BaseT Ethernet-port networking and USB 2.0 for external peripherals. ETXexpress COM modules will also provide optional interfaces for Serial ATA, Parallel ATA, LVDS multimedia ports, and ACPI (Advanced Configuration and Power Interface) for power management.

PFU Systems also offers a family of COM Express-compliant modules targeting healthcare, gaming, entertainment, test, industrial-automation, and security applications. The company's Plug-N-Run G4 modules are available with Intel Pentium M and Celeron M processors, featuring as much as 2 Mbytes of L2 cache, a 533-MHz front-side bus, a 533-MHz DDR2 memory controller, and an integrated Intel graphics-media accelerator (**Figure 2**). The devices allow for flexible man-machine interfaces with built-in USB 2.0, AC 97/HD audio, realistic 3-D-graphics rendering, MPEG-2 decoding, and dual independent-display, high-resolution interfaces. An integrated 10/100BaseTX Ethernet with built-in PXE (preboot execution environment) allows network boot for diskless operation and lower hardware costs. Designers can implement security features for authentication at the user, application, operating system, and BIOS levels. Plug-N-Run G4B modules in the COM Express basic form factor allow as much as 1 Gbyte of DDR2 memory expansion, and modules in the COM Express extended form factor are available with dual-channel memory configurations for as much as 2 Gbytes of memory.

Radisys has introduced the Procelerant CE COM Express-compliant product family, comprising a carrier board and four COMs for use in ultrasmall-form-factor computing systems. The modules feature a variety of Intel processors and as much as 1 Gbyte of DDR2 DRAM, dual display interfaces, an AC97 audio interface, Gigabit Ethernet, PCI Express, and PCI support. The Procelerant CR100 Flex ATX carrier development-platform board enables customers to immediately begin designing with COM Express mod-

ules and use the development platform as a baseline for customer-specific COM Express carrier boards (**Figure 3**). The CR100 carrier boards bring key features from the COM Express module to connectors on the board. The expansion options on the CR100 include two 32-bit, 33-MHz 3.3V PCI slots; one PCI Express card slot; and two one-lane-wide PCI Express slots. These expansion offerings enable customers to move their I/O from PCI to PCI Express using the same module and carrier. The CR100 boards also include an LVDS flat-panel interface; dual DVI-I ports with analog VGA, USB, Serial ATA, and ATA; IEE1394; 100-Mbit Ethernet; and an ATX power connector. Prices for the Procelerant CE products start at $489 (small quantities).

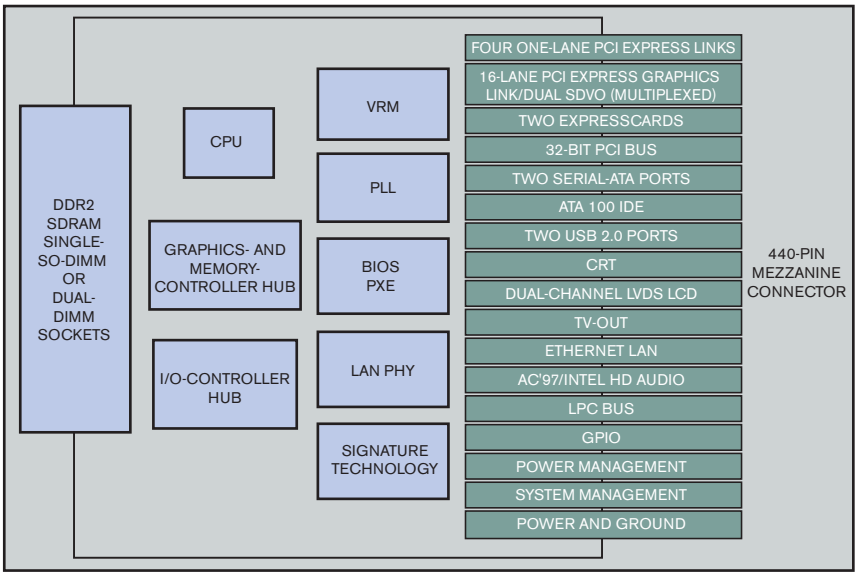

Figure 2 PFU Systems' Plug-N-Run G4 modules provide flexible man-machine interfaces in basic and extended COM Express form factors.

TELECOM TREATS

Another fabric-based-module computer standard emerged from the recent AdvancedTCA (Telecom Computing Architecture) initiative. Telecom designers wanted a hot-swappable, field-replaceable mezzanine module to lower maintenance costs and reduce downtime. To complement the high-performance features of AdvancedTCA, these new mezzanine modules also required remote management, switched-fabric technology, and a greatly improved power budget. In early 2005, PICMG released the first AdvancedMC (Advanced Mezzanine Card) specifications that define the form factor, connector, power and thermal characteristics, management, clocking, and fabric options. AdvancedMC modules include single-width, double-width, half-height, and full-height form factors. The basic single-width module measures approximately 74×183 mm. On the interconnect side, AdvancedMC supports high-speed serial interconnects, which will eventually include all of the switched fabrics that AdvancedTCA allows. The base specification defines a fabric interface with as many as 21 ports or 42 differential pairs, providing full-duplex, point-to-point connectivity between modules or to the baseboard. At 12.5 Gbps per port, AdvancedMC can handle multiple lanes of protocols, such as Ethernet, PCI Express, Rapid I/O, and InfiniBand.

You can use the single-width, full-height KosaiPM AdvancedMC from Artesyn Technologies with an AdvancedTCA or proprietary carrier cards (**Figure 4**). According to Michael Franco, hardware-engineering manager at Artesyn, "AdvancedMC is the first mezzanine architecture to provide hot swappability and integrated system management, which enables designers to remotely monitor, control, and replace individual modules in the field." Targeting use in embedded control, KosaiPM features a 1.6-GHz Pentium M processor with a 400-MHz, 3.2-Gbyte/sec front-side bus; 1 Mbyte of Level 2 cache; and SIMD (single-instruction-multiple-data) extensions for computationally intensive applications, such as multimedia and packet processing. KosaiPM also features a server-class E7501 north bridge, which gives the Pentium processor high-speed access to as much as 2 Gbytes of local ECC SDRAM. The north bridge also connects to a 64-bit PCI-X bridge, which provides high-speed access to two Gigabit Ethernet channels, as much as 128 Mbytes of flash memory, a USB interface, an I^2C system-management interface, and a front-panel 10/100BaseT management interface. KosaiPM communicates with the carrier card through two Gigabit Ethernet channels and the I^2C-based IPMI (intelligent platform-management interface). Operating-system support for KosaiPM includes carrier-grade Linux.

Figure 3 The Procelerant CR100 Flex ATX carrier board from Radisys serves as a COM Express development platform or carrier-board baseline.

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- "Pump it up: PCI Express," www.edn.com/article/CA316047
- "Fabric technologies reach the mezzanine level," www.edn.com/article/CA605525
- "Profit with plug-in processors," www.edn.com/article/CA238439

KosaiPM costs $1500 (OEM quantities).

SBS Technologies recently introduced the single-width, full-height Telum ASLP10 AdvancedMC processor board with integrated low-power Intel Pentium M processor and dual Gigabit Ethernet channels (**Figure 5**). The module supports full hot-swap capabilities and targets use in wireless base stations, voice over Internet Protocol, test and measurement systems, media servers, base-station controllers, and server blades. The Telum ASLP10 includes as much as 2 Gbytes of 400-MHz DDR2 SDRAM with ECC and an eight-lane PCI Express data port through the AdvancedMC connector. The board also includes a management controller for power sequencing, hot-swap capabilities, and module management. Rubin Dhillon, general manager of SBS Technologies' communications division, says, "The Telum ASLP10 gives system integrators the high performance of the latest Intel Pentium M processor, Gigabit Ethernet bandwidth, and excellent thermal properties, helping them maximize their high-performance system designs. This module is designed to enable today's modular-system architectures." The Telum ASLP10 supports MontaVista Linux carrier-grade and SUSE (Gesellschaft für Software-und Systementwicklung MBH) Linux carrier-grade operating systems. The price for the Telum ASLP10 starts at $1750 (OEM quantities).

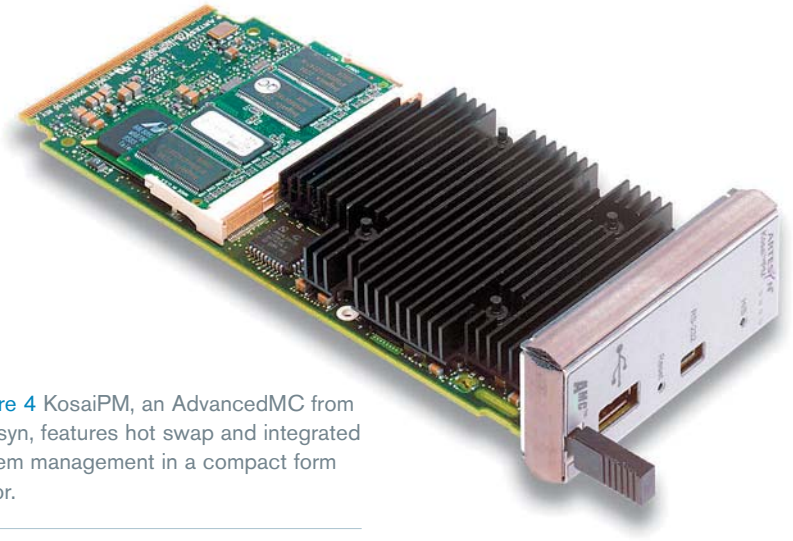

Figure 4 KosaiPM, an AdvancedMC from Artesyn, features hot swap and integrated system management in a compact form factor.

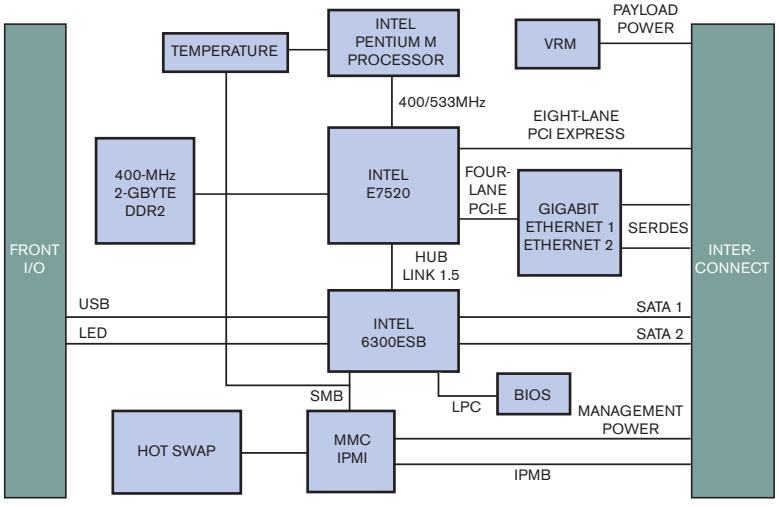

Figure 5 SBS Technologies' AdvancedMC Telum ASLP10 includes a low-power Intel Pentium M processor and dual Gigabit Ethernet channels.

MAKE MINE MICRO

With the high-performance, hot-swap, switched-fabric, and management features of AdvancedMC, designers suggest using these modules to plug directly into a backplane for small, stand-alone systems. As such, MicroTCA in October 2004 became a PICMG draft-system architecture specification. MicroTCA provides a stand-alone chassis with a backplane that directly accepts AdvancedMCs, thereby eliminating the need for an AdvancedTCA carrier board. The smaller form factor makes the concept viable for lower budget applications in telecom and a wide range of embedded-system projects. Although PICMG has not yet released it, a proposed chassis configuration includes a 4U-high×19-in.-wide unit that provides 12V payload power, management, and cooling for as many as 48 half-height, single-width AdvancedMC modules. PICMG is also considering a cube design, measuring approximately 8 in. on a side. Designers are shooting for chassis-hardware costs of approximately $500 by the projected release date of mid-2006.

New fabric-based, small-form-factor-module computers give designers the opportunity to purchase one of the most complex portions of compact- or mobile-product development. High-performance, off-the-shelf processor modules fit many embedded devices, leaving the design team with the application-specific technology, including the electronics, power supply, operator interface, packaging, and software. With a shortened design schedule and early access to a compatible software-development platform, the latest generation of plug-in processors promises to usher in a new era of rapid product development. EDN

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You can reach Technical Editor Warren Webb at 1-858-513-3713 and wwebb@edn.com.