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OpenVPX Takes on Tough Industrial Tasks

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An RTC Group Publication

Is There Life Beyond Defense and Aerospace for VPX?

Developed primarily with military applications in mind, the VPX standard has characteristics of ruggedness, high performance and high-speed I/O that lend themselves naturally to non-military, commercial environments where harsh conditions demand top of the line performance and reliability.

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What does a Navy SH-60 helicopter landing on a ship have in common with an oil rig and a coal mine? Answer, they are all extremely dangerous places with harsh environments of temperature and humidity extremes, tremendous amounts of shock and vibration, and gaseous and liquid contaminants.

In 2010, unfortunately, we have become all too familiar with just how dangerous coal mines and off-shore oil rigs can be. Earlier this year, the Upper Big Branch mine explosion in West Virginia killed 25 miners. And more recently, we experienced the devastating consequences of the explosion on the Deepwater Horizon rig that killed 11 and is still causing untold damage to the Gulf of Mexico's environment and economy.

In the aftermath of these disasters, the federal and state governments will most likely tighten the regulation of the oil, gas and mining industries. It is not a stretch to imagine that in order for operators to meet the regulations and avert future disasters there will be a need for improved real-time monitoring, analysis and reaction. Before each of these disasters occurred there were triggers that, if properly monitored and acted upon, could have avoided or minimized the impact. Improved real-time monitoring could detect increased methane levels in mines and problems at the well head 5,000 feet below the surface sooner. The technologies currently used in these industries do not provide the level of real-time monitoring necessary for operators to be able to save lives and avert disasters.

FIGURE 1

The XPedite5470 from Extreme Engineering Solutions is an example of a conduction-cooled 3U VPX Freescale QorIQ P4080-based Single Board Computer; (b) the XCalibur4341 is an example of a conduction-cooled 6U VPX Intel Core i7 processor-based Single Board Computer.

An existing technology that has proven its mettle in deployed embedded real-time military applications is VPX. It is the standard of choice for new systems going into the Navy SH-60 helicopter and many other deployed military applications. It was developed specifically with deployed military applications in mind and supports both 3U and 6U form factors (Figure 1).

Most deployed military applications fit into the C4ISR (Command, Control, Compute, Communications, Intelligence, Surveillance, Reconnaissance) classification. Many deployed C4ISR applications share several characteristics. First, very large amounts of high-speed data stream into these systems from sensors such as digital receivers, A/Ds and cameras. Second, the large amounts of high-speed streaming data have to be moved through the system and processed in real time. Third, these systems are deployed in harsh environments of extreme temperatures, shock and vibration, and exposure to dust, sea salt, chemicals, etc. Fourth, since these systems are deployed on vehicles and aircraft including UAVs, they have severe Size, Weight and Power (SWaP) constraints.

This same technology, with its ability to operate in harsh environments of military applications, is very well suited to handling oil, gas and mine real-time monitoring in support of the stricter requirements these industries will likely incur moving forward. The three primary features of VPX—its ability to operate in harsh environments, handle large amounts of high-speed I/O and process large amounts of data in real time—make it a practical choice for oil, gas and mining monitoring. We will now take a closer look at each of these features.

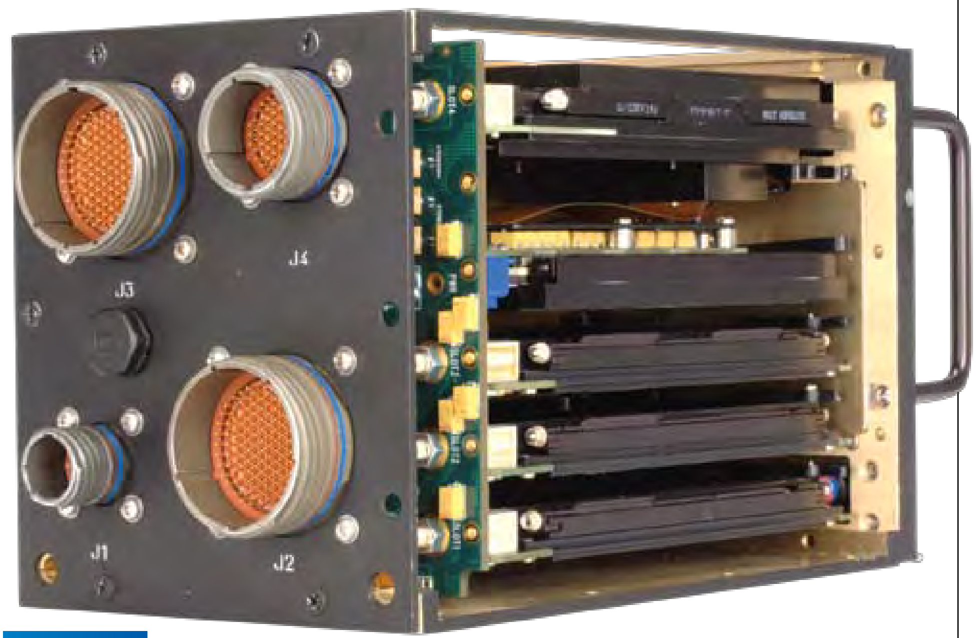

FIGURE 2

The XPand3200 (with a sidewall removed) from Extreme Engineering Solutions is an example of a 1/2 Air Transport Rack (ATR) conduction-cooled chassis that effectively isolates 3U VPX modules from the harsh environment in which it is deployed.

VPX and OpenVPX

First, a short overview of the VPX standard for readers not familiar with VPX. VITA developed VPX as an open industry standard. It defines a modular embedded computing platform based on the familiar 3U and 6U form factors used by VME and CompactPCI. VPX defines a common set of attributes including physical form factors, signal and power supply interfaces, connectors and power supplies. One of the key attributes of VPX is the choice of backplane connectors. These high-performance connectors enable high-speed switched serial fabrics, such as PCI Express and Gigabit Ethernet, to be used to move data between boards and into and out of the system.

As a module, or board-level specification, VPX does not address system-level issues. To address these issues, VITA developed OpenVPX. OpenVPX is a system-level specification that builds on the module-centric VPX specifications. It provides a nomenclature for system integrators, module designers and backplane providers to describe and define aspects and characteristics of a system. OpenVPX addresses interoperability of modules, backplanes, power supplies, enclosures and other system-level components to make it easy for system designers to integrate components from different vendors into a system.

The VPX standard was developed by VITA to address the harsh environments that many military and aerospace applications operate in. Many deployed military applications face temperature extremes, shock, vibration, humidity, dust, airborne and liquid contaminants, and electromagnetic interference (EMI). If that isn't enough, many have to contend with dirty power supplied by vehicle or aircraft electrical systems.

To address these issues, the VPX specifications define a number of standard techniques to isolate system-level components from their environment such as conduction-cooling, full product encapsulation and two-level maintenance. VPX was designed from the ground up to adhere to the strict military environmental testing methods of MIL-STD-810 and electromagnetic interface testing methods of MIL-STD-461. Systems constructed using VPX modular components can survive exposure to the worst case environments.

In addition to addressing environmental issues, VPX has also defined a modular power supply designed to handle the normal, abnormal and emergency power characteristics outlined in MIL-STD-704. Most rugged applications share common requirements such as transient, overvoltage and under voltage conditions specified in this military standard. By leveraging a modular, military ruggedized power supply approach, VPX technology allows system designers in any market to maximize design reuse and efficiency while minimizing program risk and cost.

The VPX standard was developed to support large amounts of high-speed I/O through the backplane connectors. VPX supports both front-panel I/O and rear I/O. 3U VPX supports a total of 64 differential pairs on the backplane connectors, which can be divided between data, control and I/O. 6U VPX extends this to a total of 160 differential pairs. Some of the backplane pins are dedicated for communication between modules while other pins are dedicated to external I/O. The VPX backplane connectors support signaling rates in excess of 6.25 Gbit/s. This provides enough bandwidth to support data and control fabrics consisting of the latest high-speed serial fabric protocols while also providing enough external I/O for raw sensor data.

To support the high-bandwidth, low-latency and low-overhead communication requirements of many C4ISR applications, a switched serial fabric such as PCI Express is utilized to move data through a system. Currently, VPX systems utilize three high-speed serial fabric protocols: Serial RapidIO, PCI Express and Gigabit Ethernet. As an example of a typical ap-

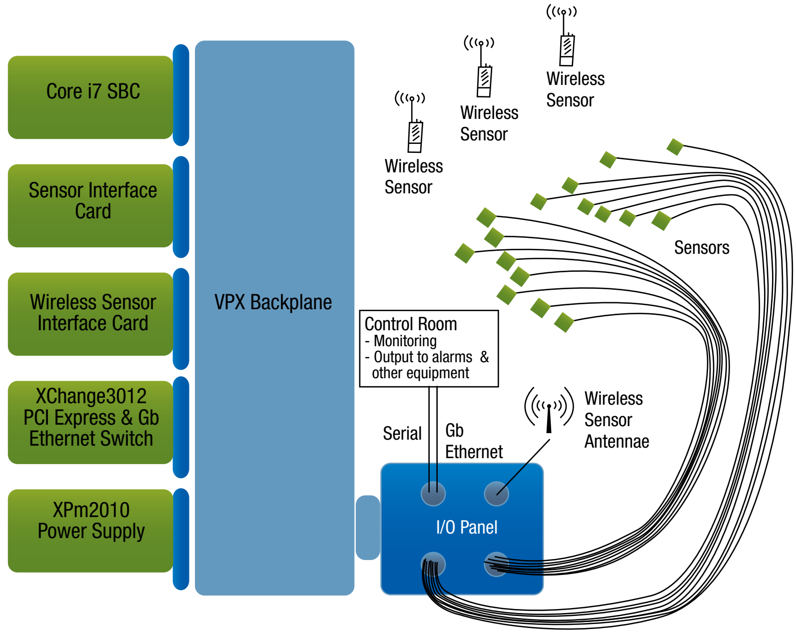

FIGURE 3

An example of real-time monitoring system that is monitoring a number of wired and wireless sensors. With an Intel Core i7 processor-based SBC, the system can process and analyze the sensor data in real time. When a problem is detected, using Gb Ethernet, the system can alert operators and interface directly to other equipment that can mitigate or resolve the problem.

plication, let us consider running a VPX x8 PCI Express link (16 differential pairs) between two adjacent modules in a VPX system. PCI Express 2.0 has a bandwidth of 500 Mbyte/s per lane, which would yield 4 Gbyte/s bandwidth for an x8 Link.

To ensure optimal system performance, the computation bandwidth much be matched with the communication bandwidth. The VPX standard was developed with this in mind. If VPX systems have the processing power to detect incoming missiles traveling at over mach 2, track them, and launch a counterstrike against them, they can handle the processing tasks required for real-time mine and oil rig monitoring. A variety of VPX single- and multi-processor boards are available utilizing today's state-of-the-art processing technologies such as the Freescale QorIQ processor, the Intel Core i7 processor and the Xilinx Virtex-6 FPGA.

With the large amount of processing power that can be put into a system, a very important consideration for high-performance embedded systems is cooling. A typical amount of power consumed by 3U VPX processing cards is in the range of 30 to 70 watts. The amount of power that can be dissipated by a module is heavily dependent on the type of cooling method employed (conduction or air-cooled) as well as the materials and techniques used to extract power. 3U VPX ATR conduction-cooled boxes, when designed properly, can address the thermal challenges of most applications. 6U VPX cards offer a larger surface area and thus improve air-cooling capacity, and therefore work very well in forced air-cooled systems. However, many applications are constrained to conduction-cooling, and it should be noted that 6U cards have the same amount of card edge rail area for conduction-cooling as 3U solutions.

Expanding the Scope of Applications

As we have seen, VPX systems are rugged, they can handle a large amount of high-speed I/O, and they have the capability to process large amounts of data in real time. These are important attributes to achieving more effective real-time mining and oil rig monitoring. Mines and drilling rigs are very harsh environments—having ruggedized systems that can adequately protect the embedded computing hardware from the harsh environment allows for optimal placement of monitoring systems deep in a mine, on an oil rig, or even at the well head. This in turn makes it easier to optimally place sensors that are being monitored. Because of VPX's inherent I/O capabilities, VPX systems can monitor a very large number of sensors. Once data is brought in from the sensors, VPX systems have the processing bandwidth to perform real-time processing and analysis of the data to quickly and effectively deal with a situation before it turns into a disaster.

If real-time mining and oil rig monitoring systems are to be deployed in harsh environments, their internal processing elements need to be isolated from their surrounding environments. Air Transport Rack (ATR) enclosures are a proven method of achieving this. While not part of the VPX specifications, conduction-cooled ATR chassis have been used for years to house military systems deployed in harsh environments of ground vehicles, aircraft and sea vessels (Figure 2). These same enclosures can be leveraged for real-time monitoring systems deployed in the harsh environments of mines and oil rigs.

Using VPX systems for real-time mine and oil rig monitoring shows how a technology developed for one industry and its associated applications, specifically high-end deployed C4ISR systems, can be utilized within other industries. Applications that have similar requirements, namely ruggedization, high communication bandwidth and high computation bandwidth, can leverage this established standard. Leveraging VPX technology allows system designers in any market to maximize design reuse and efficiency while minimizing program risk and cost. They gain access to a thriving and competitive market of Commercial Off the Shelf (COTS) products from a number of vendors. They can develop their own in-house products designed to the VPX specifications. And, they can easily integrate COTS products and VPX products they develop in-house into systems (Figure 3). One other important aspect to VPX that system designers can leverage is software support. There is wide OS and Real-Time Operating System (RTOS) support across VPX products including Windows, Linux, Wind River Systems VxWorks, Green Hills Software Integrity and LynuxWorks LynxOS.

So, to answer the question, "Is there life beyond defense and aerospace for VPX?" Only time will tell. VPX certainly has the features and market support to make it a viable and practical choice for high-end embedded computing applications in industries other than military. With the emergence of VPX as an established and viable technology, a new generation of real-time monitoring equipment can be developed to meet more rigorous mining and oil industry regulations and to help these industries protect miners, oil rig workers, sea life, coastal environments and coastal economies.

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