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A quarterly publication for engineering system design and applications.

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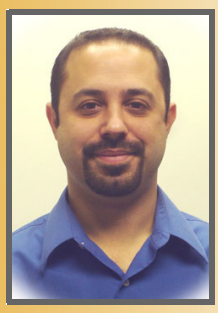
- **Feature:** Learn about the engineering considerations and design techniques used to develop a small form factor (SFF) rugged recorder that can handle the extremely high data rates associated with very wide bandwidth RF signal recording.



"While real-time recording of a gigahertz or more of RF bandwidth is commonly available in 19" rackmountable systems, shrinking this capability into a form factor suitable for UAVs, aircraft pods, or other confined spaces has proven challenging for the industry."

Chris Tojeira, Recording Systems Director

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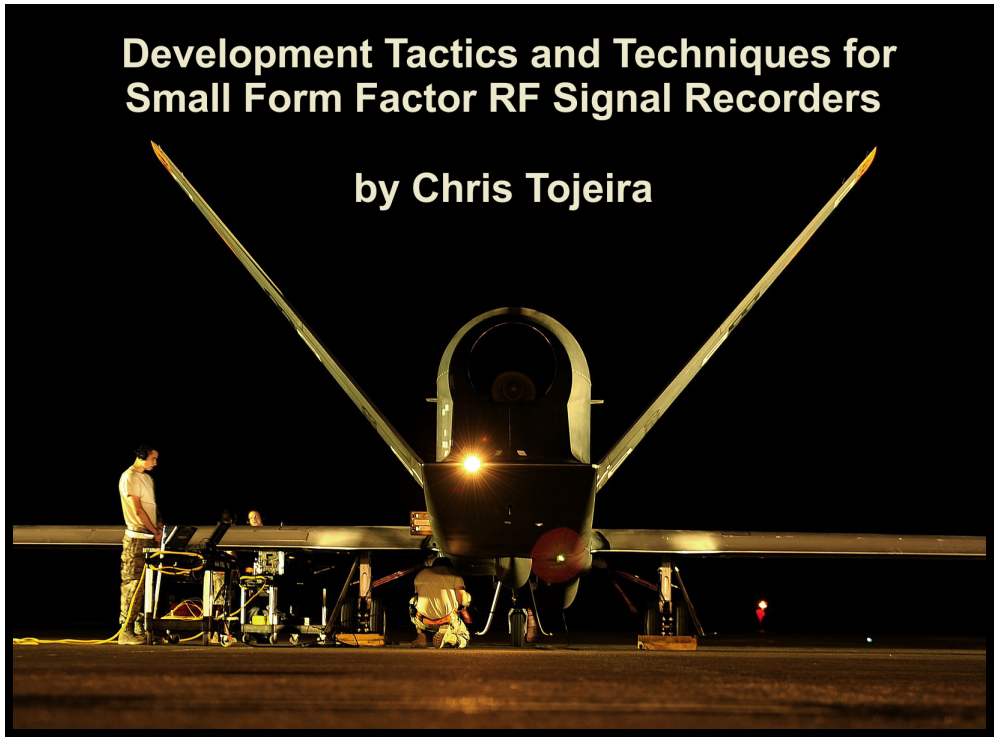

This article discusses the engineering considerations and design techniques used to develop a small form factor (SFF) rugged recorder that can handle the extremely high data rates associated with very wide bandwidth RF signal recording. It is intended to provide engineers with ideas on how to bring this capability into confined and often extreme environments while focusing on military specification compliance, SWaP, and ease of use with confidence.

XMC Solutions Pack Performance in a Small Package

The ability to record wideband RF signals in real time is a critical part of the development of radar, signal intelligence, beamforming and electronic warfare systems. Wideband RF downconverters are now capable of translating a gigahertz of RF bandwidth to intermediate frequencies (IF) with excellent dynamic range. These signals require high performance A/D converters with high enough sample rates and bit resolution to sample the entire band effectively.

A/D converters, paired with the latest FPGA technology in an XMC form factor, provide a signal conversion and processing engine that can sample signals at extremely high data rates in a small package suitable for a small form factor recorder. These XMC modules serve as the recorder's front-end interface and are used to move multiple gigabytes per second of data through the system.

XMC modules are commonly available with A/D converters that have maximum sample rates ranging from 200 MS/s (2 million samples per second) to 6.4 GS/s (6.4 billion samples per second). The sample rate of the A/D converter dictates the maximum RF signal bandwidth that can be sampled and recorded. For example, a 200 MS/s A/D converter with an 80% anti-aliasing filter ➢

can record 80 MHz of signal bandwidth, while a 6.4 MS/s A/D converter with a similarly shaped filter can record over 2.5 GHz of signal bandwidth. Some applications require a very wide bandwidth signal to be captured, while others require the ability to capture several channels of narrower band signals, so it is important to provide an array of A/D converter offerings in an XMC form factor to support our SFF signal recorder.

While the A/D sample rate is important for selecting the front end of a recorder, the dynamic range of the A/D is equally important to effectively match each application's requirement. For an RF signal recorder, dynamic range can be described as the ratio between the largest and smallest signals that can be recorded successfully. Some signal acquisition scenarios require the ability to record very small signals in the presence of potentially very large signals, requiring an A/D converter with excellent dynamic range.

The bit resolution of the A/D converter and the effective number of bits (ENOB) help to express dynamic range to the user. However, A/D converter specifications like spur free dynamic range (SFDR) and signal to noise ratio (SNR) provide an even more useful way to present dynamic range.

High performance 200 MS/s A/D converters provide 16 bits of resolution and offer SFDR specifications greater than 85 dBFS and SNR specifications greater than 75 dBFS, while 6.4 MS/s A/D converters provide 12 bits of resolution and offer SFDR closer to 65 dBFS and SNR closer to 55 dBFS. Typically, the higher the sample rate of the A/D converter, the lower the dynamic range, so it is important to provide a wide array of A/D converters on XMC modules to cover different types of applications.

FPGAs coupled with A/D converters on XMC modules provide an excellent digital signal processing engine for the recorder. Digital downconverters, signal detection, radar gating, and acquisition time stamping are common processing capabilities that are often provided in standard FPGA IP designs. A well-developed set of FPGA IP modules greatly enhances the capabilities of an RF signal recorder.

D/A converters are often included on XMC modules to allow users to play back acquired signals or generate radar pulses. Multi-channel A/D and D/A XMC modules provide phase coherency across all channels. This is an essential capability of any real-time signal recorder.

Precision Time Stamping with Small GNNS Receivers

Extremely small Global Navigation Satellite System (GNNS) receivers have emerged over the last few years with support for Galileo, GPS, and Glonass systems. These small receivers support time-stamping of acquired data with nanosecond precision. The receivers provide 10 MHz reference clocks and PPS signals to the recorder's XMC modules to allow users to capture the exact timing of gated or triggered events.

GNNS receivers also allow systems to record the latitude, longitude, and ➢

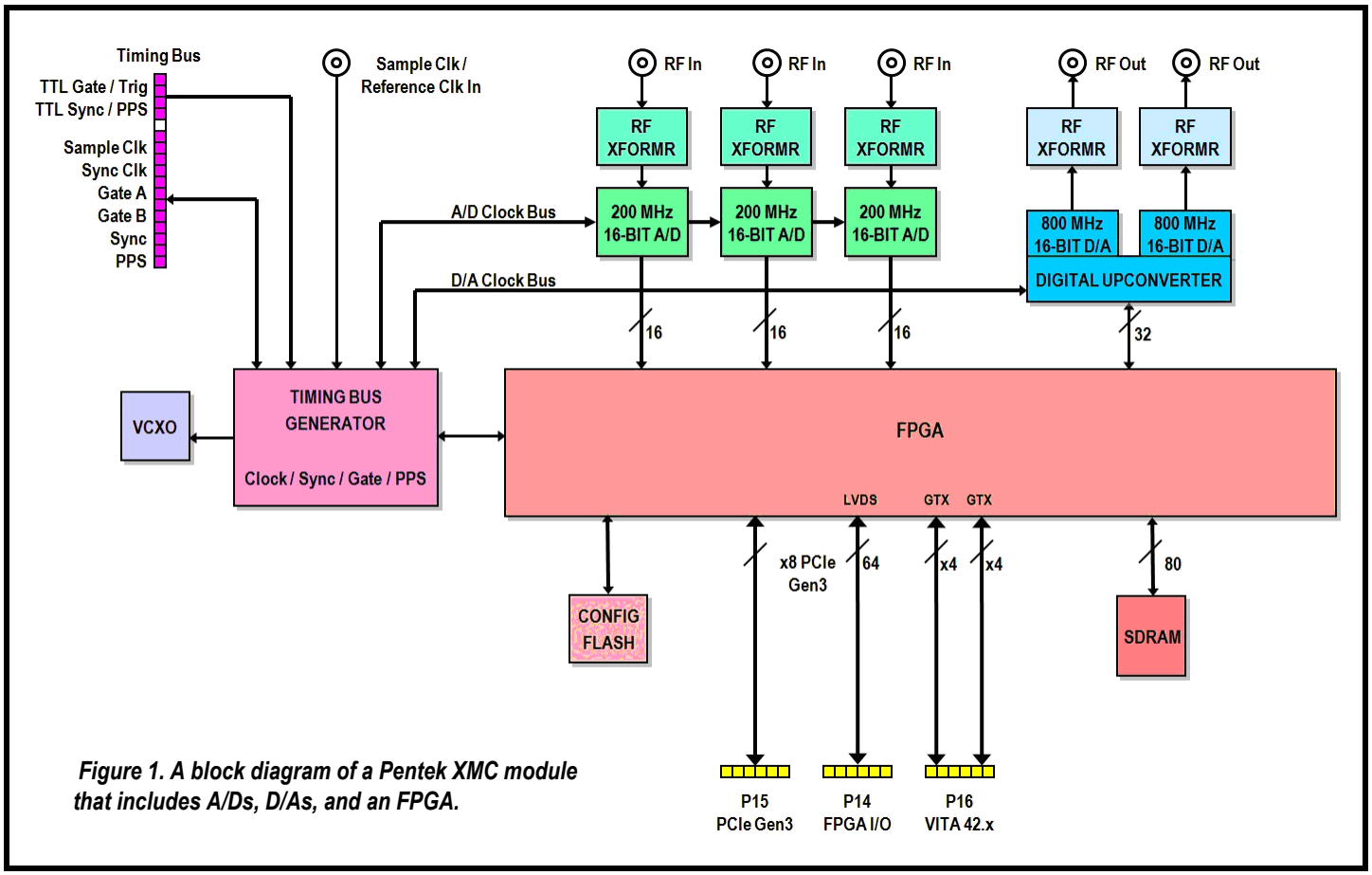

Figure 1. A block diagram of a Pentek XMC module that includes A/Ds, D/As, and an FPGA.

altitude of the recorder for logging flight paths, vehicle movement, or static ground location, if required. GNNS receivers often provide options for oven-controlled oscillators for operation across a wide range of temperatures and accelerometers to improve time and position accuracy during rapid acceleration, allowing them to operate in a wide range of environments.

Drive Packs Simplify High Capacity Data Storage

Streaming data to disk in real-time at rates in the gigabytes per second has been achievable in large rackmount recorders by striping data over a RAID array of many SSDs. High-performance RAID controllers not only provide lightning-fast write speeds but offer redundancy, protecting against the rare but disastrous disk failure that could occur during a mission. RAID controllers also utilize SSD features to provide data encryption and secure erase capabilities.

Another feature typically seen in rackmount recorders is front panel removable drives. An array of as many as 48 drives, mounted to sleds, can be inserted and removed individually from the front of the system. This allows users to remove all recorded data while allowing the recorder to remain mounted in a rack. It also allows users to maintain multiple sets of drive arrays to minimize downtime between missions.

Figure 2. Pentek's QuickPac™ drive pack provides up to 30 TB of solid state storage in a small package. These pictures show the QuickPac drive pack and OS drive removed and partially ejected from the Talon Model RTX 2589 3.6 GS/sec Ultra Wideband RF/IF Extreme 1/2 ATR Recorder.

The challenge of maintaining the features and performance of larger form factor recorders is facilitated by the growing solid state storage demand driven by data centers. V-NAND flash technology has enabled solid state drive capacity and write rates to continue to increase in very small package sizes. These inherent advances in solid state technology provide a path for shrinking the data storage array, allowing simpler and smaller designs with performance and features equal to those of far larger systems.

Small drive packs, containing an array of solid state devices, provide storage speed and capacity previously only available with many individually removable SSDs. By designing the packaging of a storage array into a drive pack, the job of managing a high drive-count system is replaced with the job of managing a single drive pack, providing a tremendous ease-of-use benefit.

A single high-insertion-cycle connector designed into the drive pack provides a far more reliable mechanism for the removable storage media than the standard SATA connectors typically available in rackmount systems. Well-designed ➢

Figure 3. Pentek's Talon RTX SFF recorders provide a plenum tube that runs through the chassis.

drive packs are capable of holding tens of terabytes of data and are capable of storage speeds in the gigabytes per second. Drive packs must be designed for easy removal while the recorder remains mounted in the vehicle or aircraft.

Creative Thermal Management Techniques Allow for Operation in Harsh Environments

One of the issues in reducing the package size of the data storage media is maintaining a thermal environment that will allow the drive pack to perform at its highest level. Solid state memory controllers will throttle access speeds if the thermal environment is not properly managed.

This issue is not only an important concern for the storage media but for all electronics in a SFF recorder. A set of A/Ds can draw 10 watts or more. FPGAs often draw 25 watts or more. CPUs typically draw between 35 and 90 watts. High performance RAID controllers often draw 15 to 25 watts. And drive packs can draw tens of watts. While efforts can be made to minimize power consumption, heat management is one of the most critical aspects of a recorder's design.

Many RF signal recorders are installed in aircraft pods, naval ships, or other outdoor environments with little or no protection from the environment. In order to operate in a wide array of environments it is important to protect all electronics from environmental elements such as water, humidity, sand, dust, and salt fog. A hermetically sealed chassis is desirable, but brings with it the issue of heat mitigation of internally mounted electronics.

Custom-designed heat sinks that provide conductive thermal paths to the walls of the recorder's chassis provides some relief, but chassis walls still require sufficient air flow to be effective. Plenums can be used to create air channels throughout the chassis to provide a more efficient cooling design. Custom heat sinks that are integrated into the plenum's walls provide an ultimate level of cooling by allowing air to be channeled directly through all of the electronics' heat sinks. This allows all system electronics to remain sealed from the outside environment while being adequately cooled.

Integrating a fan into the plenum helps assure air flows through the heat sinks, providing an excellent cooling solution. This is ideal for systems running in hot environments like an aircraft idling on the tarmac of an air base or a military vehicle running in the dessert. But what about cold environments, like an aircraft pod at high altitude or an unpressurized UAV flying in the arctic? It is equally important that our RF signal recorder is able to run at very cold temperatures.

One of the advantages of sealing all system electronics from the outside environment is that the electronics can self-heat more easily than if they were directly exposed to the cold environment. This self-heating process is compromised if a fan in the plenum tube is blowing cold air across heat sinks, so it is very important to provide control over this fan.

Integrated fan controllers should be provided to monitor the environment and switch fans off to allow for self-heating and then re-engage when components become hot. This balance between hot and cold is easily calibrated, ultimately providing a recording system that can operate at both temperature extremes. Note that while the measures described above for thermal management will help to provide an ideal environment for the recorder's electronics, it is important to use industrial-grade components whenever possible. ➢

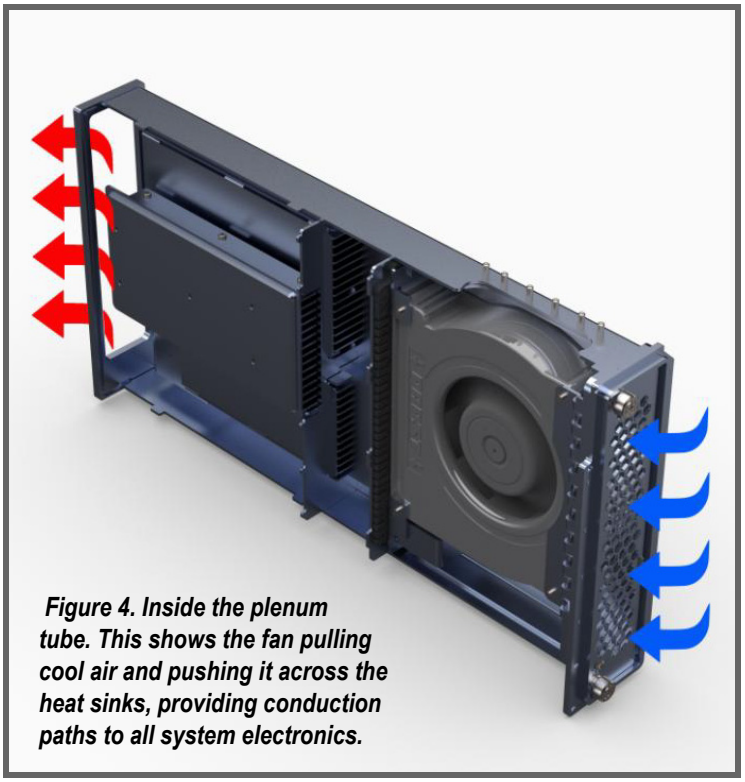

Figure 4. Inside the plenum tube. This shows the fan pulling cool air and pushing it across the heat sinks, providing conduction paths to all system electronics.

Designing for Military Specifications and Compliance

MIL-STD-810, Environmental Engineering Considerations and Laboratory Tests, is a United States military standard that emphasizes tailoring equipment's environmental design and test limits for the conditions that it will experience throughout its service life. The standard also establishes test chamber methods that replicate the effects of environments on the equipment rather than imitating the environments themselves.

MIL-STD-810 addresses a broad range of environmental conditions that include: low pressure for altitude testing; exposure to high and low temperatures plus temperature shock (both operating and in storage); rain (including windblown and freezing rain); humidity, fungus, salt fog for rust testing; sand and dust exposure; explosive atmosphere; leakage; acceleration; shock and transport shock; gunfire vibration; and random vibration. The standard describes environmental management and engineering processes that can be of enormous value to generate confidence in the environmental worthiness and overall durability of a system design. (Wikipedia, 2018)

While operating environments vary greatly, meeting as many criteria in the MIL-STD-810 specification as possible is imperative to providing a reliable and robust product. Anodized metal with form-in-place gaskets allows for sealed protection against rain, humidity, fungus, salt fog, and sand and dust exposure. CAD software provides simulation analysis tools to assist with thermal design and structural integrity. Well-executed design techniques help assure a smooth laboratory testing process.

MIL-STD-461 is another popular military specification requirement for RF signal recorders. MIL-STD-461 provides the requirements for the control of electromagnetic interference (EMI) emissions and susceptibility characteristics of electronic, electrical, and electromechanical equipment and subsystems designed or procured for use by activities and agencies of the Department of Defense (DoD). (NTS, 2018)

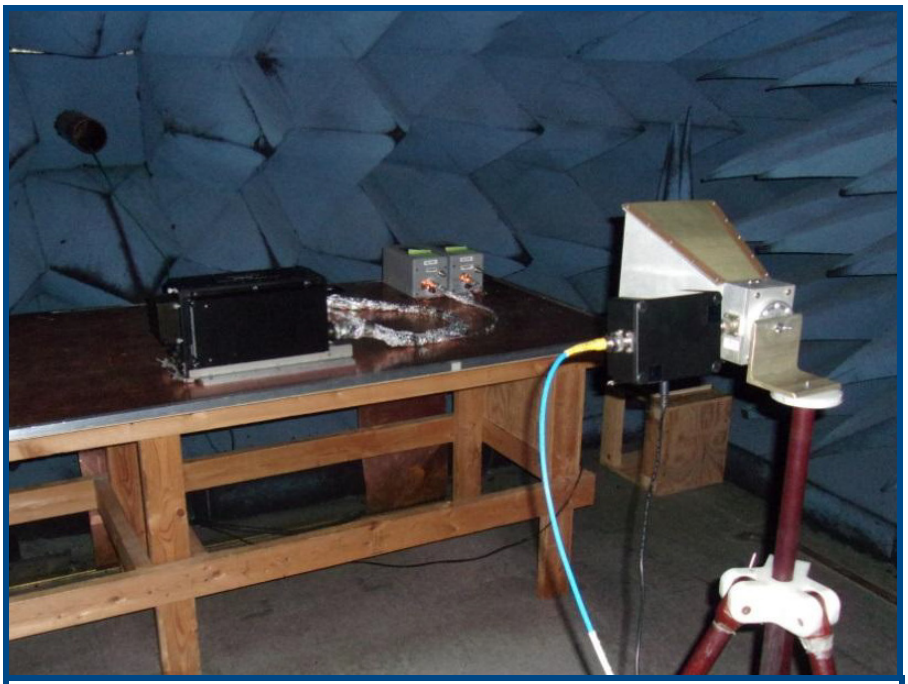

Figure 5. A Talon RTX Extreme 1/2 ATR Recorder signal recorder being tested to MIL-STD-461

RF test laboratories use anechoic chambers to run a series of MIL-STD-461 tests that include radiated emissions, radiated susceptibility, conducted emissions, and conducted susceptibility for a range of frequencies. It is typical to cover a radiated range up to 18 GHz and a conducted range up to 10 MHz on power leads.

It is important to take the appropriate design steps to meet MIL-STD-461 compliance since iterative independent laboratory testing becomes very expensive. Design techniques used to control EMI include the use of RF emission filters and RF gaskets to prevent radiated electromagnetic emission and susceptibility. Additionally, an in-line EMI power filter designed for the internal power supply can be used to protect against conducted emission and susceptibility.

Why the Obsession with SWaP?

The term SWaP has become a commonly used buzzword to describe the requirement for electronic systems that are small in size, weight, and power consumption. Why the obsession with SWaP? A lot of it has to do with sophisticated electronics small enough for unmanned vehicles. Another is placing computer power, displays, communications, and sensors on an already overburdened infantryman. Overall, today's focus on small, lightweight electronic systems that don't use much power has to do with bringing as much capability to the forward edge of battle as possible. (Keller, 2013)

While we have already focused on reducing the size of our RF signal recorder, designing for weight and power reduction require additional strategies. The good news is that weight and power have a direct relationship in that the lower the power consumption, the less heat dissipated by the system. Removal of heat from the system's electronics via conduction requires conductive materials such as aluminum or copper. While copper is more effective for conducting heat, its density is far greater than aluminum, adding undesirable extra weight to the recorder.

In order to design for reduced weight we must minimize the power consumption of the system and use lightweight ➢

Figure 6. (above) The back of Talon RTX Model 2586 200 MS/sec RF/IF Extreme 1/2 ATR recorder.

Figure 7. (below) The front of the Talon RTX Model 2586 where the system fan, operating system SSD and QuickPac drive pack are easily accessible

materials like aluminum with efficient thermal paths to the cooling channels designed into the system. High-speed recording systems often do not require a tremendous amount of processing power. Since hardware DMA controllers are used to move data to disk, processors are often used to simply "manage" the data flow. Intel's latest i7 processors are now offered in versions with lower clock rates and power consumption. An eighth generation i7, clocking at 2.4 GHz, limits power consumption to 35 watts and can be configured to draw as little as 25 watts.

Furthermore, efficient FPGA designs allow digital signal processing to reside in smaller, more efficient FPGAs. Xilinx's Kintex Ultrascale family offers excellent performance with significant power reduction over previous-generation FPGAs. Component selection and an efficient design help to control the power consumption and dissipation of the recorder, allowing us to use less material for heat sinking and reduce the total weight of the package.

Ease–of–Use Considerations

While SWaP factors are important design considerations during the development of a SFF RF signal recorder, it is equally important that the system is designed to be easy to use from both a hardware and software standpoint. Designing a system in a standard form factor helps to simplify the installation process by providing familiar mounting mechanisms in a common and proven footprint. ARINC 404 is an aeronautical standard that specifies mechanical dimensions of line replaceable units (LRUs) and their racking systems in aircraft. ARINC 404 specifies dimensions for several sizes of ATRs (Air Transport Racks), providing us with a choice of standard footprints for a signal recorder.

It is important to design a system that can be installed in an aircraft or vehicle in a permanent fashion but still provide accessibility to the user. Easy-to-swap modular components like fans, drives, and other parts of non-volatile memory within the recorder allows the system to be serviced and sanitized of classified or otherwise sensitive data easily. All removable components should be accessible via the front panel of the system using captive hardware without the requirement of special tools. ➢

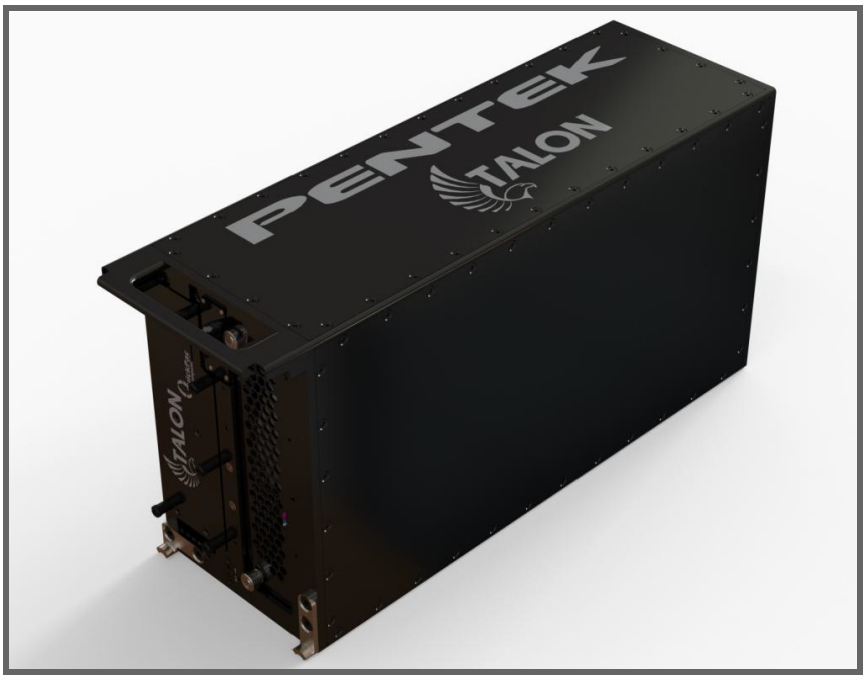

Figure 8. The Talon RTX Model 2586 recorder's rear panel connectors

Software should include a straightforward and simple Application Programming Interface (API) to control the system as well as a suite of RF signal analysis tools to allow users to instantly analyze recorded data. RF signal recorders typically provide a gigabit Ethernet interface for control of the unit from an external computer. This interface can also be used to stream data to allow users to monitor RF signals prior to, during, and after recording signals.

It is essential to be able to remotely control the recorder to allow it to operate in unmanned environments. These environments often require the user to create a custom control interface, making the API an important part of the recorder. It is also desirable to provide a fully functional graphical user interface (GUI) to allow users to operate the system immediately out of the box. The GUI should also be able to run remotely.

Applications for SFF RF Signal Recording

RF signal recording is a critical component of any radar, signal intelligence, beamforming, or electronic warfare system. A well-designed system provides excellent RF signal acquisition hardware that is small, lightweight, low-power, and capable of operating in a wide range of operating environments. Features such as drive packs and other serviceable modular components make an RF signal recorder easy to install and maintain in tight spaces, allowing ultra-wide bandwidth RF signal recording to reside in places never before possible.

Ultra-wide bandwidth RF signal recorders have allowed engineers to capture large swaths of the RF spectrum necessary for wide bandwidth radar systems and improved SIGINT capabilities. While real-time recording of a gigahertz or more of RF bandwidth is commonly available in 19-inch rack-mountable systems, shrinking this capability into a form factor suitable for UAVs, aircraft pods, or other confined spaces has proven challenging for the industry. Small, rugged packages must be capable of operating in extreme environments while providing storage capacities and data streaming throughputs similar to those offered by larger systems.

Bringing it all Together

Designed using the techniques described in this article, Pentek offers the Talon RTX SFF product line. Figures 6, 7, and 8 present different views of the Talon RTX SFF recorder. A link to the latest products can be found at: **https://www.pentek.com/go/pentekssffwp**.

All Talon RTX SFF Recorders include the Pentek SystemFlow® recording software. SystemFlow features a Windows-based GUI that provides a simple means to configure and control the recorder. SystemFlow includes signal viewing and analysis tools, that allow the user to monitor input signals prior to, during, and after a recording session. These tools include a virtual oscilloscope, a spectrum analyzer and spectrogram displays. For more information about SystemFlow go to: **https://www.pentek.com/go/penteksfwp**.

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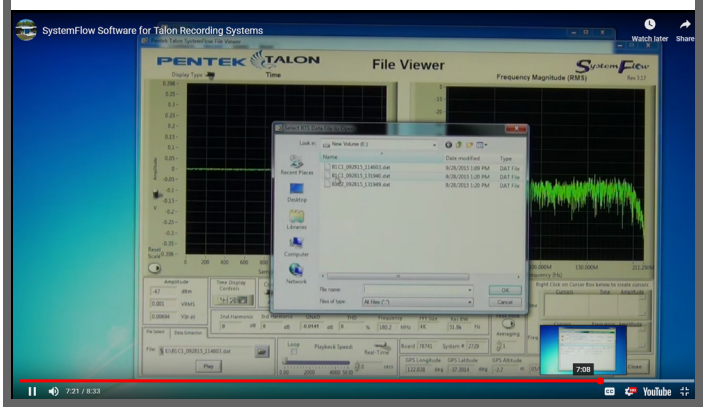
Learn More About Pentek's SystemFlow Software

Click **here** to view a short video explaining what Pentek's SystemFlow software does and how to use it.



Product Focus

Pentek's New Talon Extreme Rugged Wideband 1/2 ATR Recorder Family Delivers Reduced SWaP

TALON RTX EXTREME RECORDER

The **Talon RTX 25xx** series is Pentek's new high-performance small form factor (SFF) recorder product line for extreme operating environments. Optimized for SWaP (size, weight, and power), the rugged, sealed ½ ATR recorders are available with multiple input options and can hold up to 30.7 TB of removable SSD storage. These SFF recorders provide real-time streaming data rates of up to 4 GB/s for ultra-wide bandwidth RF or high-speed recording.

"Our engineering team used years of valuable customer feedback to design a product suitable for almost any environment, while maintaining the real-time recording performance of much larger and far less rugged systems," said Chris Tojeira, Recording Systems Director, Pentek.

Extremely Rugged, Sealed Design

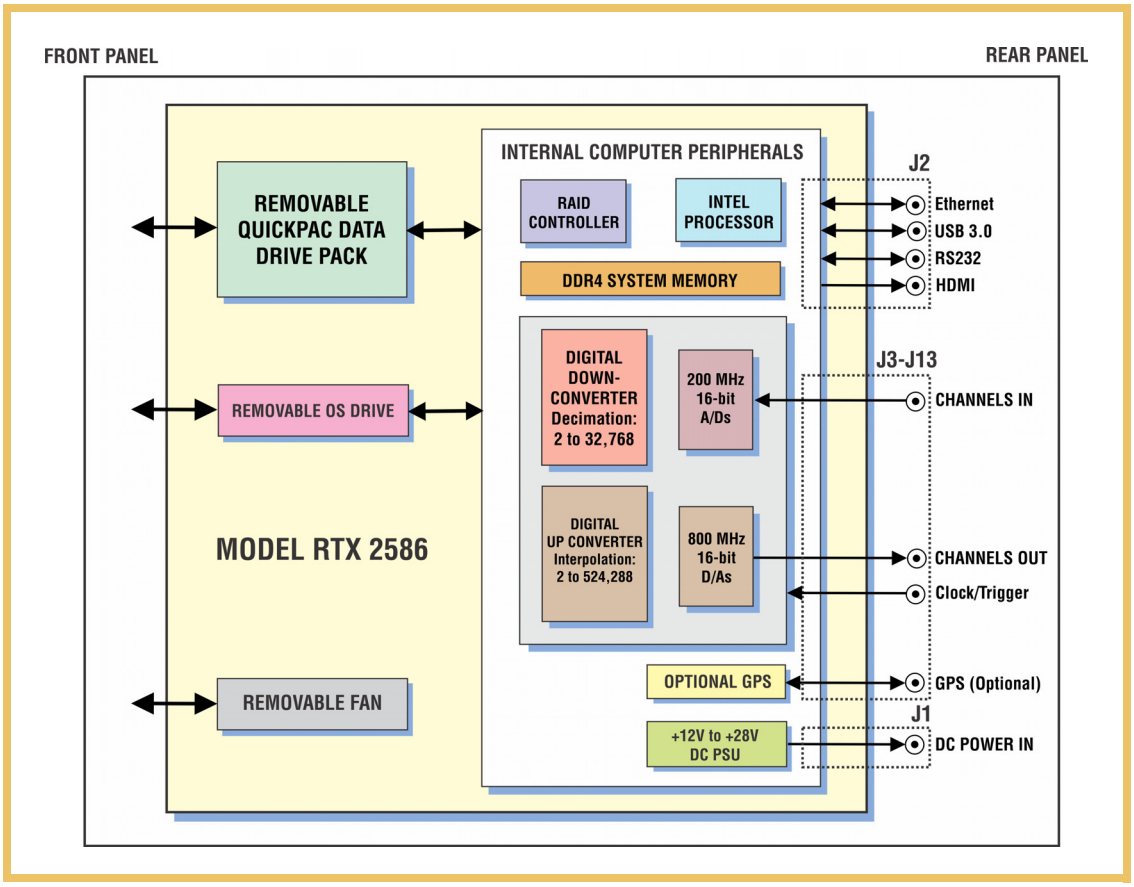
Engineered to operate in the toughest environments with high levels of shock and vibration, the RTX recorder's chassis keeps all electronics sealed from the external environment. The ½ ATR chassis uses military standard circular connectors for I/O to control RF emissions while protecting the recorder's electronics from humidity, water, dust, sand, and salt fog.

The Talon RTX SFF chassis further seals the internal electronics from the outside environment by extracting heat through conduction to an inner plenum that is air-cooled. A thermostat-controlled, removable fan pulls air into the front of the chassis, through the plenum, and then out the back of the chassis. Only the fan is exposed to the outside environment, assuring that all system electronics are protected in the sealed chassis. The inner plenum can be replaced to provide other cooling options, such as liquid or conduction cooling.

Designed to operate from -40°C to +60°C, these recorders can handle most thermal environments, making them ideal for UAVs, aircraft pods, tight equipment bays, military vehicles, and most outdoor environments.

High–Speed Data Storage and Security

Pentek's QuickPac™ drive pack is easily removed from the recorder by loosening a set of captive thumb screws on the front panel. An empty QuickPac drive pack ➢



can replace a full one, minimizing mission down time. A companion offload system for the QuickPac drive pack is available so the recorder can remain in use while the recorded data is transported and reviewed via the offload system at a ground facility. The QuickPac drive pack holds up to 30.7 TB of solid state data storage capacity and supports RAID levels 0, 5, or 6.

For secure applications, a separate operating system drive can be removed, allowing users to extract all non-volatile memory from the system in just a few seconds.

First Available Recorders

The following recorders are the first to be announced under this new family:

- **RTX 2586** - Multichannel RF/IF: Up to four 200 MHz 16-bit A/Ds can capture up to 80 MHz of RF/IF signal bandwidth per channel with excellent dynamic range. It can sample RF/IF signals up to 700 MHz and provides integrated digital downconverters with selectable decimation to 64k. Playback via 800 MHz 16-bit D/As with matching digital upconversion and interpolation is available.
- **RTX 2589** - Ultra Wideband RF/IF: A 3.6 GHz 12-bit A/D provides extremely wideband RF/IF signal capture. With direct sampling, users can record over 1.5 GHz of baseband bandwidth. The RTX 2589 can also be configured as two 1.8 GHz 12-bit A/Ds. Integrated digital downconverters let users "zoom in" on signals at selected tuning frequencies. Selectable sampling rates, DDC decimations and packing modes allow users to exploit the 4 GB/s real-time recording capability.

Ease of Operation

Pentek's SystemFlow® software interface is integrated into every Talon recorder. The software includes the graphical user interface (GUI) that is used to control the recorder with point-and-click configuration management, a client/server communication interface, NTFS file system support, and an application programming interface (API) for custom user applications and control. Signal analysis tools include a virtual oscilloscope, spectrum analyzer, and spectrogram to monitor signals before, during and after data collection. The system can be controlled remotely via the Gigabit Ethernet interface available on one of the MIL STD circular connectors.

Options and Simulator

The Talon SFF recorders offer an optional GPS receiver for precise time and position stamping. Additional QuickPac drive packs with 3.8 to 30.7 TB are available. Computer I/O on all models includes Gigabit Ethernet, USB 3.0, RS-232, and HDMI.

Pentek's **SystemFlow Simulator** provides a "test drive" of the SystemFlow recording software installed on all Talon recording systems. The simulator allows users to operate the standard GUI and the SystemFlow API. A free trial package is available for download here.

For more information

For more information, click **here.** For the latest pricing, delivery and available options, please **fill out this form** and your request will be delivered to the appropriate department. To learn more about our products or to discuss your specific application please email our sales department at **sales@pentek.com**, **contact your local representative** or Pentek directly:

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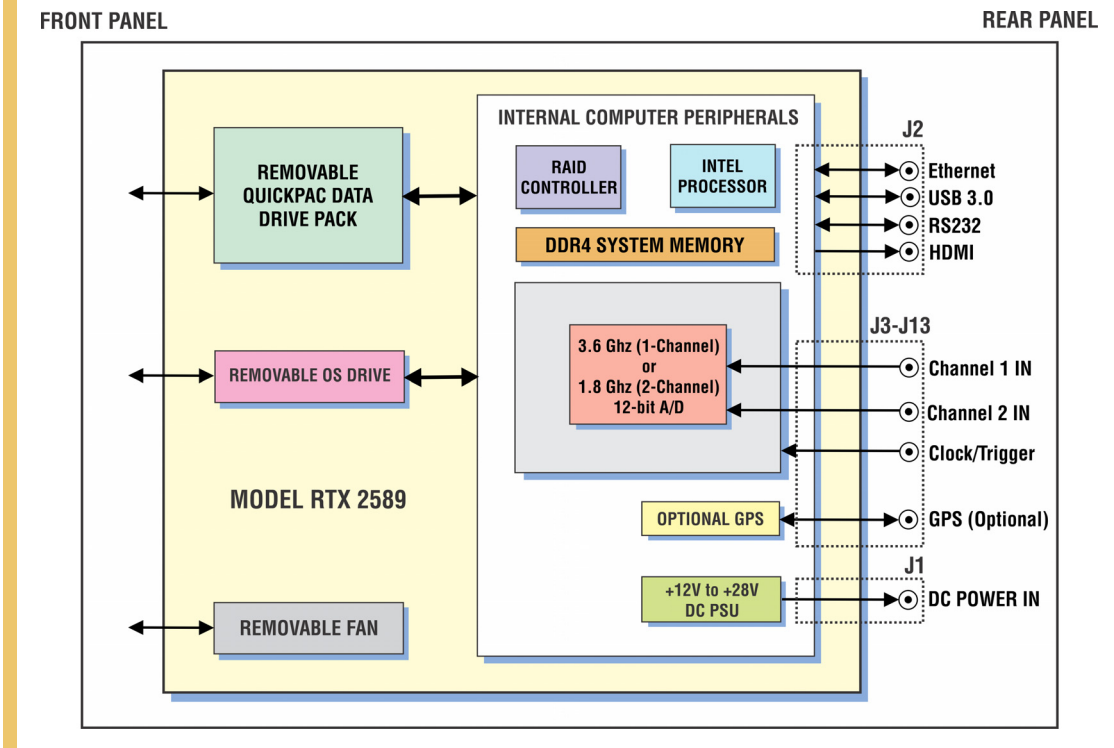


EMBEDDED SYSTEMS ENGINEERING powered by EECatalog

Embedded Systems Engineering interviewed Rodger Hosking, Vice President of Pentek, about Pentek's Model 5950 RFSoC board

Why radar system designers now have the resources at hand to usher in a new level of coverage for military, government, border protection, and homeland security applications.

*by Anne Fisher, Managing Editor, **Embedded Systems Engineering (eecatalog.com)***

EECatalog: Please describe the kinds of radar applications that are now possible with the advent of the Model 5950.

Rodger Hosking, Pentek: While the **Model 5950 RFSoC board** is powerful enough to handle virtually all types of radars, it offers significant advantages for systems with these critical requirements:

- Low latency
- Small size and weight
- High channel density
- Low cost per channel
- Low power

Any one of these drivers could open up new types of radars for deployed environments where older technology made them impractical or impossible. For example, the low latency feature alone could support much more effective EW countermeasure systems, so fighter jets can do better in avoiding detection and evading enemy fire.

In combination, the cumulative effects of the above RFSoC advantages will revolutionize radar system design by integrating the antenna elements, RF circuitry, data acquisition, waveform generation, and digital signal processing into self-contained, distributed sub-systems. Because these can be deployed on smaller platforms like UAVs, and are affordable enough for widespread, remote installations, they offer a radically new level of coverage for military, government, border protection, and homeland security.

EECatalog: What underlying issues had to be addressed before the Quartz™ architecture could achieve latency at a low enough level to allow it to support certain applications?

Hosking, Pentek: Pentek's Quartz architecture is a technology enabler, making RFSoC devices easier to integrate into custom systems. Several man-years of electrical, mechanical, software, and FPGA design efforts yielded the necessary infrastructure to connect power, control, cooling, and shielding, while maintaining maximum performance levels of the RFSoC. The Quartz architecture preserves operation of the RFSoC so that its inherent low latency can be thoroughly exploited within a constrained system environment. ➢

Embedded Systems Engineering Interview with Rodger Hosking, continued

EECatalog: What factors put Pentek in a position to be able to offer a board that capitalizes on RFSoC?

Hosking, Pentek: With more than 30 years' experience in developing and delivering embedded system products that feature tightly integrated data conversion and DSP devices, Pentek is uniquely positioned to understand and anticipate the needs of systems integrators seeking to incorporate RFSoC technology within their offerings. Our **QuartzXM system-on-module architecture** eliminates a huge amount of electrical and mechanical design otherwise required to support the RFSoC chip. This includes critical circuit board and packaging design rules for RF signal paths, clocking and synchronization, power supplies, filtering, and thermal management strategies.

Pentek's **Navigator Board Support Package** includes libraries and drivers for both the ARM processor and the host system processor running under Linux and Windows. Pentek's **Navigator FPGA Design Kit** provides IP source code for standard factory-installed functions and application examples including data acquisition, digital RF memory, data streaming, and waveform generation.

EECatalog: What's the short-term outlook for the Quartz architecture family and what's the long-term outlook? How will Pentek keep the Quartz architecture family relevant going forward?

Hosking, Pentek: Our current Quartz product line consists of the **Model 5950 3U VPX RFSoC** board for OpenVPX and the smaller **QuartzXM module** for custom form factor systems. Our proven track record of supporting customers for success will help ensure design wins and follow-on production for some large program opportunities.

These first products will be followed by other open standard form factor products and new products based on future RFSoC offerings from Xilinx. The software and IP code developed for our first products should easily migrate to these later offerings. Our RFSoC Quartz architecture has enjoyed an exceptional level of initial customer interest, giving strong evidence that this new technology resonates with customers' needs and will play a major role in the embedded market for the foreseeable future.

EECatalog: Both standard 3U OpenVPX and custom boards work with the Model 6001 QuartzXM—is that in anticipation of the 3U OpenVPX/custom balance staying at whatever ratio it is at, or will OpenVPX overtake custom?

Hosking, Pentek: OpenVPX will continue to dominate open-architecture board and backplane systems for deployed military and government applications. As evidenced by healthy market adoption and numerous vendors, OpenVPX will continue to evolve to support new technology and interfaces as required.

When OpenVPX cannot meet the SWaP-C constraints of certain applications, custom form factor systems step up to meet the challenges. Our QuartzXM RFSoM is designed expressly to support these designs by easing the development efforts and preserving maximum performance.

The balance between OpenVPX and custom designs will be driven by customer requirements and may change over time in either direction as new technology, new threats, and new strategies emerge. ❐

Webinar: Strategies for Deploying RFSoC Technology for SIGINT and Radar Applications

This webinar examines how RFSoC compares to the current trends in A/D and D/A converters and the strategies for getting the most performance out of this new family of FPGAs. Engineers involved with SIGINT, communications, countermeasures, triggered radar range gate engineer, wideband real-time transient capture, and multi-mode, high-speed data acquisition can benefit from this webinar. Rodger Hosking recently presented this webinar to the **Association of Old Crows (AOC)**.

To view this on-demand webcast, click **here**.

Product Focus

Model 6001

Pentek's New QuartzXM SoM Speeds Custom Deployment of RFSoC in SWaP Critical Environments

QUARTZ

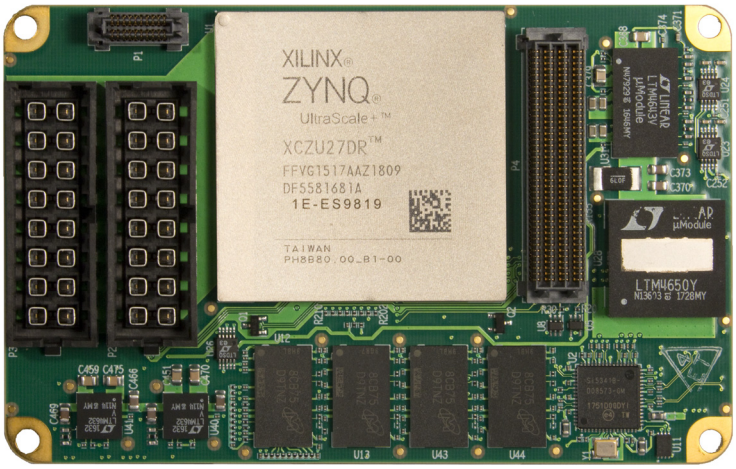
Pentek recently introduced the **Model 6001 Quartz eXpress Module (QuartzXM):** the only high-performance system-on-module (SoM) market offering based on the Xilinx Zynq UltraScale+ RFSoC FPGA with eight integrated RF-class A/D and D/A converters. Measuring only 2.5 by 4 inches, the QuartzXM Model 6001 includes all of the circuitry needed to maximize the performance of the RFSoC. The Model 6001 can be housed on the **Pentek 3U VPX Model 5950** or it can be deployed on a custom carrier. Pentek's complete design kit ensures success for customers building their own carrier.

"By addressing and solving the critical circuit and PCB design challenges on the Model 6001 module, Pentek, as well as our customers, can leverage the design and use the module on a carrier in a standard form factor like 3U VPX as well as custom carriers to match specific application requirements," said Bob Sgandurra, Pentek's director of Product Management. ***"Customers can develop their system software and IP on the 3U VPX product in the lab and then deploy the QuartzXM 6001 wherever it is needed by using custom carriers."***

"The flexibility offered by Pentek's revolutionary modularized RFSoC solution has been well received in the market as users can deploy this new technology in the field in a small footprint, which is critical to Mil-Aero market needs," said David Gamba, Xilinx Senior Director for the Aerospace and Defense Vertical Market.

The Quartz Architecture Difference

Quartz architecture positions the RFSoC as the cornerstone of the design. All control and data paths are accessible by the RFSoC's programmable logic and processing system. The Xilinx Zynq UltraScale+ RFSoC Processor integrates eight RF-class A/D and D/A converters into the Zynq FPGA fabric along with quad ARM Cortex-A53 and dual ARM Cortex-R5 processors, creating a multichannel data conversion and processing solution on a single chip. Complementing the RFSoC's on-chip resources, the QuartzXM 6001 adds:



- Up to 16 GBytes of DDR4 SDRAM
- LVDS connections to the Zynq UltraScale+ FPGA for custom I/O
- GTY connections for gigabit serial communication
- All power supplies and clocking management needed by the RFSoC

Factory Installed IP Advances Development

The QuartzXM 6001 is pre-loaded with a suite of Pentek IP modules to provide data capture and processing solutions for many common applications. Modules include dual 100 GigE interfaces, DMA engines, DDR4 memory controller, test signal and metadata generators, data packing, and flow control. The board comes pre-installed with IP for capabilities such as triggered radar range gate engine, wideband real-time transient capture, flexible multi-mode data acquisition, and extended decimation.

When deployed as the **Model 5950 3U VPX** solution, the QuartzXM can be used out-of-the-box with the built-in functions requiring no FPGA development. When the QuartzXM is deployed on a custom carrier, developers will find the included IP cores an ideal foundation for building custom applications.

RF and Expandable I/O

The QuartzXM 6001 accepts analog IF or RF inputs from the carrier board on a multi-channel connector, delivering the inputs as differential pairs into the RF-signal chain of the RFSoC. The individ- ➢

ual D/A outputs from the RFSoC are delivered to the carrier board through a multichannel connector as differential pairs.

A separate high-speed connector to the carrier provides an interface to all of the digital signals supported by the RFSoC's processing system and programmable logic sections.

- **Parallel:** 32 single ended or 16 pairs of LVDS connections
- **GTY:** 16 full duplex serial lanes at 28 Gb/sec needed for protocols like 100GigE
- **GPIO:** 8 single-ended lines

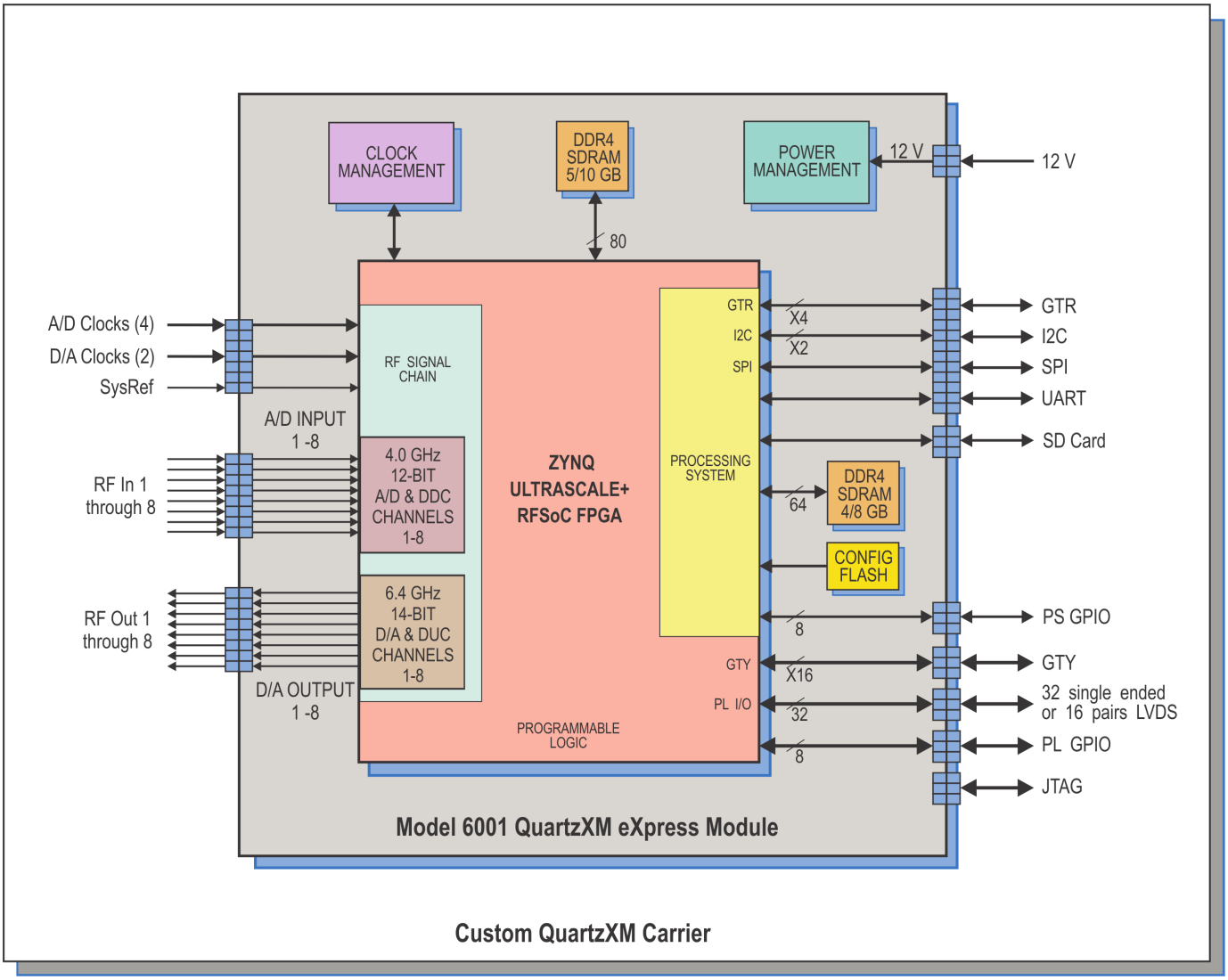
Carrier Design Kit

The design kit supports customers interested in building their own carrier for the Model 6001. The kit encapsulates all of Pentek's electrical and mechanical design knowledge to accelerate application-specific carrier design. The kit includes a review of the customer's design with Pentek's engineering staff; pin definitions and electrical specifications of all signals on the module; 3D models of the module; thermal profiles of the module and components; carrier reference design schematics; PCB stack-up recommendations; PCB design guidelines and routing rules; operating system and bootstrap guidelines.

Navigator Design Suite for Streamlined IP Development

Pentek's Navigator Design Suite includes: **Navigator FDK (FPGA Design Kit)** for custom IP and **Navigator BSP (Board Support Package)** for creating host software applications.

The Navigator FDK includes the board's entire FPGA design as a block diagram that can be edited in Xilinx's Vivado tool suite, along with all source code and complete documentation. Developers can integrate their IP along with the factory-installed functions or use the Navigator kit to replace the IP with their own. The Navigator FDK Library is AXI-4 compliant, providing a well-defined interface for ➢



developing custom IP or integrating IP from other sources.

The Navigator BSP supports Xilinx's PetaLinux on the ARM processors. Users work efficiently using high-level API functions or gain full access to the underlying libraries including source code. Pentek provides numerous examples to assist in the development of new applications

Pre–Configured System Ready for Immediate Use

Model 6001 QuartzXM customers must purchase the **Model 5950 3U VPX** carrier board, which includes the QuartzXM within an open-standard form factor. This allows the user to start IP development and proof of concept designs immediately on a known, tested platform while they develop their own carrier for later deployment. To further speed development tasks, Pentek offers a single-slot 3U VPX development chassis with the Model 5950 installed, along with a rear transition module (RTM) and all needed cables.

For more information

For more information, click **here.** To learn more about our products or to discuss your specific application please email our sales department at **sales@pentek.com**, **contact your local representative** or Pentek directly: John Eklund, Sales Director, Pentek, Tel: +1 (201) 818-5900 ❒

Pentek's New Quartz RFSoC Development Platform Speeds Application Design

- Low-cost, single-slot 3U VPX development chassis
- Supports Pentek's Quartz RFSoC FPGA products
- Dual MPO optical interfaces support 100 GigE high-speed data streaming
- Ideal for defense, radar, wireless, and SIGINT applications

Pentek recently introduced the **Model 8257 3U VPX development chassis** for Pentek's new Quartz RFSoC FPGA product line. Developed specifically for Pentek's Model 5950 Zynq UltraScale+ RFSoC 3U VPX Processor, the Model 8257 chassis features a single-slot backplane, power supply, forced-air cooling, and connectors to support all functions of the 5950. With eight 4 GHz 12-bit A/Ds and eight 6.4 GHz 14-bit D/As, the 5950 with the 8257 chassis provides an integrated platform all ready for immediate development of RFSoC applications. By attaching a workstation, an engineer is ready to create, test, run and debug custom software and FPGA designs.

Ready for Immediate Use

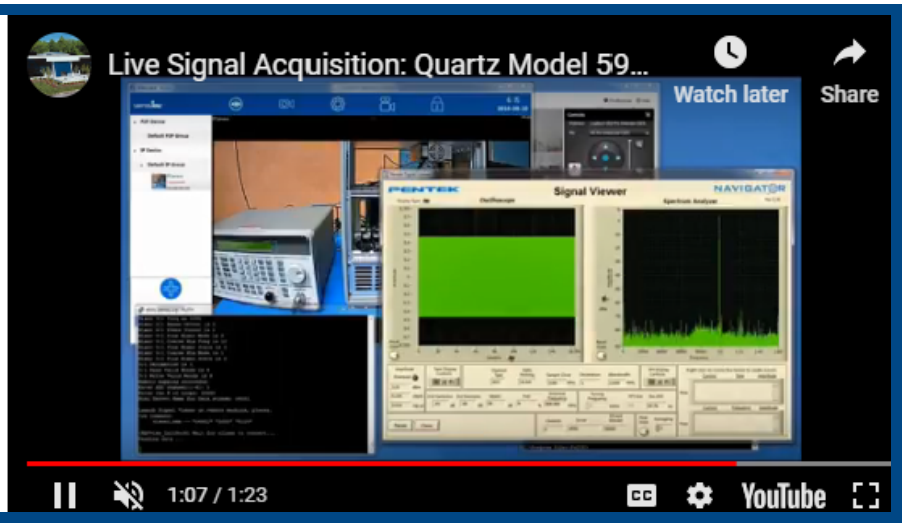
The Model 8257 is configured to accept the user's Model 5950 Quartz 3U VPX board, which houses the **Model 6001 QuartzXM** (QuartzXM eXpress Module) containing the Xilinx Zynq UltraScale+ RFSoC FPGA. The 8257 supports the Model 5901 rear transition module (RTM) for backplane I/O connections, along with all needed cables. Optional MPO (Multiple-Fiber Push-On/Pull-off) optical bulkhead connectors support the 5950's dual 100 GigE interfaces using VITA 66.4.

This platform allows the user to start application and proof of concept designs immediately on a known, tested platform. Developers can connect a notebook or desktop PC with Xilinx's Vivado Design Suite and Pentek's Navigator Design Suite to start development.

Providing power and cooling in a small desktop footprint, the chassis allows access to all required interfaces on the front panel and rear transition module. The Model 8257 is 7.59" W x 12.12" D x 16.75" H,

View the Model 5950 in Action!

To access a live signal acquisition video showing **Pentek's Model 5950** 8-Channel A/D and D/A Zynq UltraScale+ RFSoC Processor and **Model 6001** 8-Channel A/D and D/A Zynq UltraScale+ RFSoC Processor utilizing Pentek's Navigator Signal Viewer, please click **here**.



weighing in at 17.8 lbs. with its 250-Watt power supply.

"The alternative to the Model 8257 is having the user purchase and integrate his own chassis, which would be more expensive and time consuming," said Bob Sgandurra, Pentek's Director of Product Management. ***"This development platform provides an immediate, out-of-the-box, and cost-effective solution, optimized for rapid RFSoC development."***

Development Environment

At the heart of the Model 5950 is Xilinx's Zynq UltraScale+ RFSoC FPGA. The FPGA is equipped with multi-core ARM processors, often eliminating the need for an additional SBC. The FPGA supports communication interfaces typically found on general purpose processors including USB, RS-232, GbE, and DisplayPort. The 5950's rear transition module provides access to these interfaces as well as JTAG and general purpose FPGA I/O.

Optical Interface

The Model 8257 can be equipped with optional dual MPO optical bulkhead connectors, fully compliant with ANSI/VITA 66.4, to support the Model 5950's dual 100 GigE interfaces. The chassis uses these dual optical interfaces to handle high-speed data streaming for built-in factory example functions including data acquisition and waveform generation.

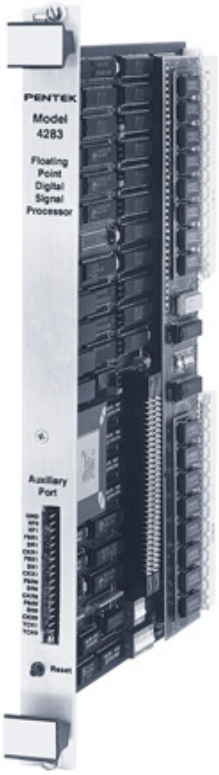
Navigator Design Suite

Pentek's Navigator Design Suite includes Navigator FDK (FPGA Design Kit) for custom IP development and Navigator BSP (Board Support Package) for creating host software applications. Developers can integrate their IP along with the factory-installed functions or use the Navigator kit to replace the IP with their own.

For more information

Email our sales department at **sales@pentek.com** or **contact your local representative** or John Eklund, Sales Director, Pentek, Tel: +1 (201) 818-5900 ❐

Model 8257



Still working reliably, 24 years later...

Once upon a time (May of 1994, to be exact), a customer purchased a Pentek Model 4283 Single TMS320C30 Processor. It has worked reliably for 24 years. Recently, the customer sent it back to us. Not for a repair, but for re-certification (required by an audit). It passed all standard tests and all certification tests and is ready for shipment back to the customer, where it will resume its long and reliable work life.

It is easy to get excited about all of Pentek's newest products, but there are reasons to get excited about Pentek's older products. In this case, a long life of flawless operation.

Pentek offers lifetime support on its products – even discontinued products like this one. As long as replacement parts are available, we will repair it. But, of course, we strive to create products so dependable that repairs are not necessary! Like this one.

Product Focus

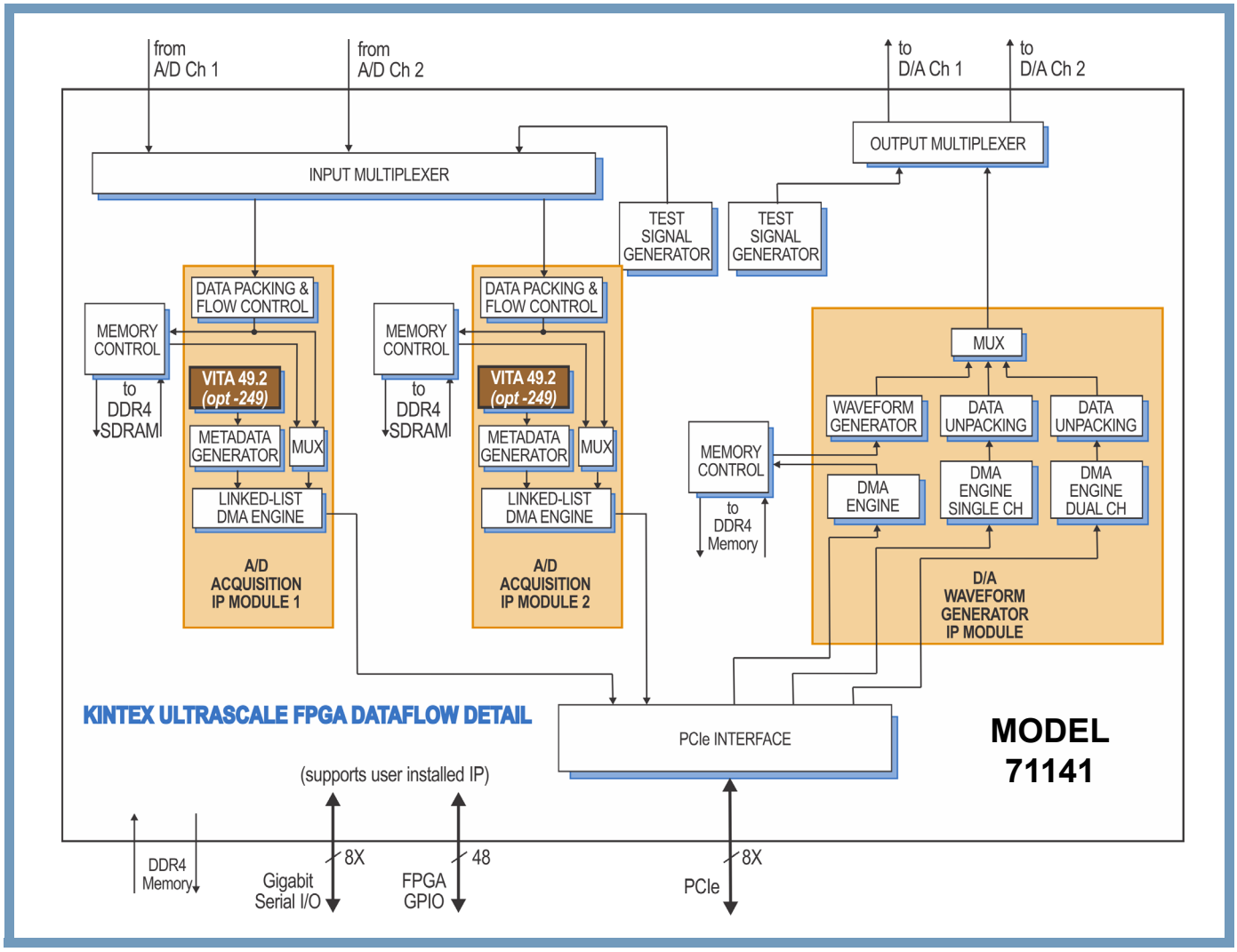
Pentek Adds ANSI/VITA 49.2 Protocol to High-Speed Data Acquisition Boards for Defense, Radar, and Communication Applications

JADE

Pentek recently introduced intellectual property (IP) support for the VITA 49.2 data transport protocol in the **Pentek Navigator Design Suite**. The **Jade Model 71141**(1-Ch. 6.4 GHz or 2-Ch. 3.2 GHz A/D, 2-Ch 6.4 GHz D/A) and **Model 71851** (2-Ch 500 MHz A/D with DDC & 2-Ch 800 MHz D/A with DUC) data converter XMC modules, based on the Xilinx Kintex Ultrascale FPGA, are the first products available with the new IP modules.

The ANSI/VITA 49.2 standard, which is part of the VITA Radio Transport (VRT) family of standards, defines a signal/spectrum data transport protocol that expresses spectrum observation, spectrum operations, and capabilities of RF devices. VITA 49.2 is used for conveying digitized signal information among signal acquisition/generation and processing elements in a communication, radar, or similar system. The Model 71141 and Model 71851 implement the VITA 49 packet format for the ADC/DDC data being moved to host memory via DMA transfers.

Standard elements in the VITA 49.2 packet include: Signal Data Packet Type, Stream Identifier, Integer Seconds Timestamp, Fractions Seconds Timestamp and Trailer. Optional programmable elements that can be added to a packet include: Packet Size and Stream Identifier per the protocol standard. ➢



Precision time-stamping of the digitized elements is a key attribute of VITA 49.2. The Pentek IP automatically inserts timestamping information, per the VITA 49 standard, into the receiver stream data packets. The timestamp is applied at the A/D capture stage to generate the most accurate event capture time possible, regardless of data processing time.

A variety of timestamping methods enable optimization for specific applications including GPS data overlay. For transmitted data packets with VITA 49 information, the output will have the header, stream ID, timestamp, and trailer information removed, delivering only the payload signal data to the D/A converter for transmission.

"The VITA 49 standards fill a huge gap in protocol standards for data transport in RF applications," stated Jerry Gipper, VITA executive director. ***"The standards are gaining acceptance in a rapidly growing number of applications and are being added to requirements in DoD platforms and test equipment."***

"The rapid acceptance of VITA 49.2 makes this an opportune time to add this IP to our Navigator development tools," said Robert Sgandurra, director of Product Management. He added, ***"Our existing IP provided much of this functionality, but this is a more formalized method of providing the data per a widely implemented standard. Paul Mesibov, CTO and co-founder of Pentek, continues to be a key contributor to the development of the VITA Radio Transport series of standards and is also working with many of the other organizations to incorporate VITA 49.2 into their standards."***

Form Factors

The Models 71141 and 71851 are offered in commercial and rugged versions and are available in XMC, cPCI, VPX, AMC and PCIe form factors.

For more information

Email our sales department at **sales@pentek.com** or **contact your local representative** or John Eklund, Sales Director, Pentek, Tel: +1 (201) 818-5900 ❐