The Pentek Pipeline

Winter 2016 • Vol. 25, No. 1

Pentek, Inc.
One Park Way, Upper Saddle River, NJ 07458
Tel: (201) 818-5900 • Fax: (201) 818-5904
email: pipeline@pentek.com
http://www.pentek.com

A quarterly publication for engineering system design and applications.

In This Issue

- **Feature:** The feature article in this issue describes how Giga-tronics, Incorporated used Pentek Model 78620 boards with Giga-tronics products to simulate radar systems.

"This article explores a fully modular system that is highly reconfigurable and can be used to create emitters, not only for testing purposes, but versatile enough for rapid prototyping or for meeting the needs of fast-cycle technology procurements."

Mark Elo, Vice President of Marketing, Giga-tronics, Incorporated

- **Product Focus:** Model 78620 and Talon RTR 2750
- Q&A with Pentek

Free Resources

- Subscribe to The Pentek Pipeline
- To receive automatic notification about a Pentek product's documentation and life cycle, set up a YourPentek profile
- *Technical Handbooks* - Helpful information about various technical topics
- *Catalogs* - Pentek's segment catalogs highlight products by function

Follow Us!

Simulation of Modern Radar Systems using Pentek Model 78620 Boards with the Giga-tronics GT-ASGM18A Advanced Signal Generator and GT-ASAM18A Advanced Signal Analyzer

by Mark Elo, Vice President of Marketing, Giga-tronics, Incorporated

To simulate a modern, frame-based radar, a system needs to rapidly create or schedule signals that are fundamentally complex in nature and can vary considerably over time based on mission, mode, and environmental considerations. Multiple Pulse Repetition Intervals (PRIs), different types of Modulation on Pulse (MOP), as well as rapid changes in amplitude and frequency (which include the effects of Doppler, group delay, and clutter) need to be taken into account and combined with multi-mission operations such as communications, electronic attack, or counter measures scheduling.

This article explores a fully modular (and COTS[1]) hardware system that is highly reconfigurable and can be used to create emitters, not only for testing purposes, but versatile enough architecturally for rapid prototyping or for meeting the needs of fast-cycle technology procurements.

Introduction: Radar Systems

A radar system can be broken down into four distinct areas of operation:

1. **Waveform creation:** The ability to create a specific waveform and schedule its playout in the form of a radar mode with specific RF characteristics (pulse width, modulation) and an applicable PRI.
2. **Microwave transmission system:** The ability to upconvert the waveform with sufficient frequency and amplitude agility.
3. A **microwave downconversion system** with sufficient frequency and amplitude agility.
4. An IF processing system providing the appropriate **signal processing** to determine range, velocity, and any other environmental conditions that will affect the radar's next set of waveforms or mode.

If we consider technology evolution, computer processing has technology changes yearly, signal processing and IF technology every five years, and microwave moves at a slower, ten-year pace. The four areas listed above can be mapped to physical hardware modules – each with defined characteristics and known physical interfaces – allowing the creation of a system that maps to the appropriate technology life cycles more efficiently than a traditional radar design.

1. **Waveform creation:** Pentek Cobalt® Model 78620 PCIe module with signal development software.
2. **Microwave transmitter:** Giga-tronics GT-ASGM18A ultra-fast frequency switching Advanced Signal Generator.
3. **Microwave receiver:** Giga-tronics GT-ASAM18A ultra-fast frequency switching Advanced Signal Analyzer.
4. **Signal processing:** Pentek Model 78620 PCIe module with signal processing software/firmware. ➢

1. COTS - Commercial-Off-The-Shelf

Simulation of Modern Radar Systems using Pentek and Giga-tronics Products

Waveform Creation and Signal Processing

The Pentek Model 78620 high-performance PCIe board is based on the Xilinx Virtex-6 FPGA. Pentek Model 78620 is used in many EW (electronic warfare) applications, and can be mounted in most modern COTS PCs. As a multichannel, high-speed data converter, Model 78620 is suitable for connecting with the IF input of a microwave up/downconverter such as the Giga-tronics GT-ASGM18A Advanced Signal Generator and GT-ASAM18A Advanced Signal Analyzer. The Pentek Model 78620's built-in data acquisition and waveform generation features offer an ideal turnkey solution for radar and electronic warfare baseband signal simulation.

Each Model 78620 includes three A/Ds, two D/As, and four banks of memory. In addition to supporting PCI Express Gen. 2 as a native interface, Model 78620 also includes optional general-purpose and gigabit serial card edge connectors for application-specific I/O (see Figure 1).

Microwave Up- and Down-conversion

The Giga-tronics GT-ASGM18A Advanced Signal Generator and GT-ASAM18A Advanced Signal Analyzer are high-fidelity, coherent, fast-frequency-switching, up- and downconverters ideal for transmitting and receiving signals at frequencies between 100 MHz and 18 GHz. These units are based on AXIe, an open system modular instrumentation standard, which is an extension of AdvancedTCA® (a trademark of PICMG).

The Giga-tronics GT-ASGM18A and GT-ASAM18A have built-in, high-speed, high-signal-fidelity, local oscillators, allowing for broadband, extremely agile, coherent frequency switching. Because these units are based on the industry standard AXIe modular platform, multiple phase-coherent channels of upconversion and downconversion can be used to emulate specific types of radars or create a wave-front and emulate the angle of arrival. ➢

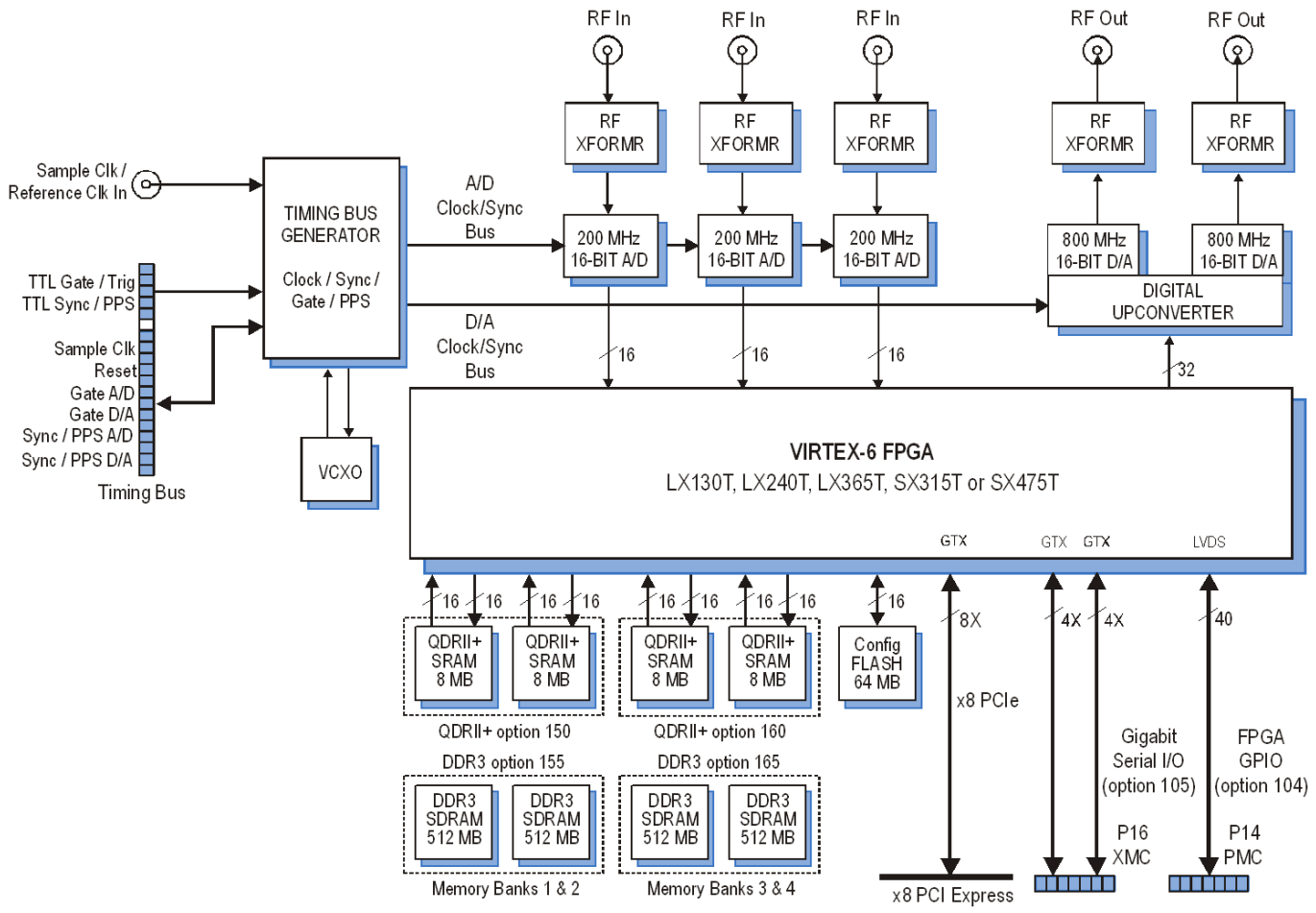


Figure 1. Pentek Model 78620 Block Diagram

Simulation of Modern Radar Systems using Pentek and Giga-tronics Products

The Giga-tronics GT-ASGM18A and GT-ASAM18A can take an IF signal from a Pentek Model 78620 and up- or down-convert it to any frequency within an 18 GHz range. The GT-ASGM18A and GT-ASAM18A can coherently retune to any frequency in less than a microsecond and can maintain an amplitude flatness typically within +/- 1 dB over that frequency range. The optional high-speed microwave output attenuator extends the range of the output by 90 dB, allowing for a signal creation range that exceeds 100 dBc.

IF Conversion

Matching the IF signals from Pentek's Model 78620 requires IF conversion to take a 30 MHz IF signal chosen to utilize the best performance from the 78620 and match that to the 1200 MHz IF of the microwave up- and downconverters. The Giga-tronics GT-SRM100A System Reference Module provides 10 MHz, 100 MHz, and 1200 MHz outputs that can be used as LOs (local oscillators) to drive IF up- and downconverters, as shown in Figure 4 (on page 4).

Putting it all Together

Figure 5 (on page 4) shows an example system using four independent RF channels. A similar block diagram can be used for the receiver. The radar control and ➢

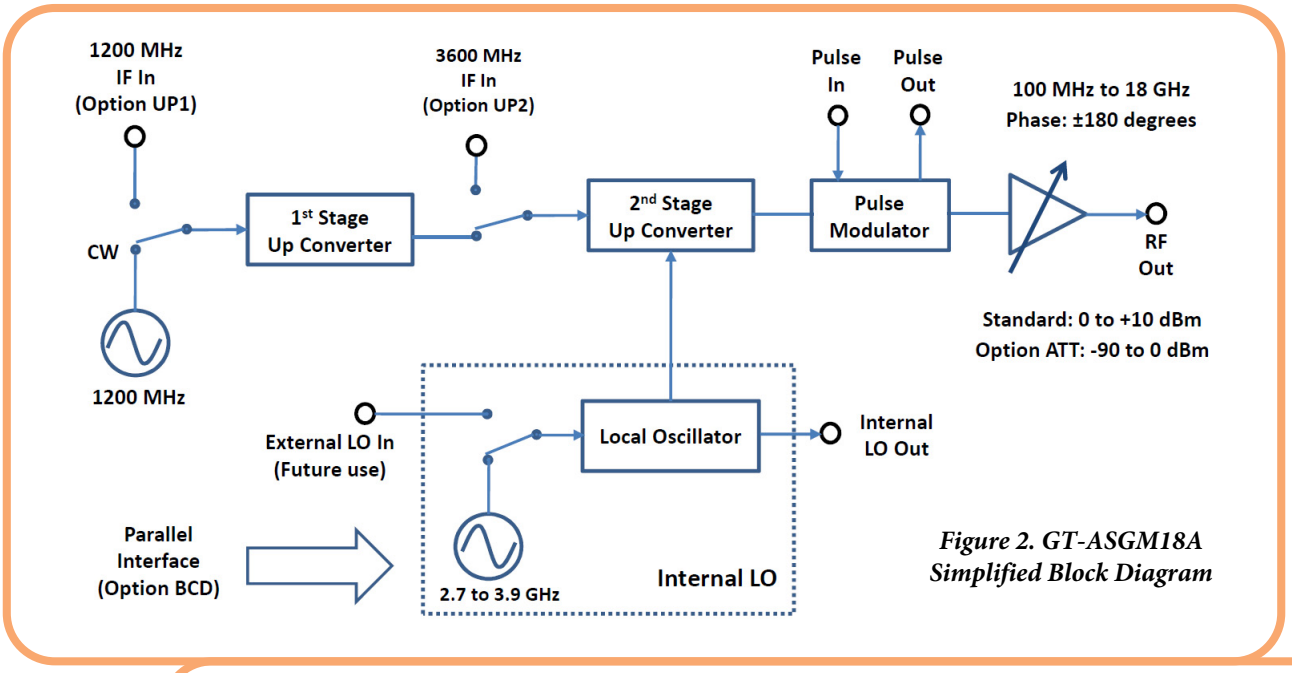


Figure 2. GT-ASGM18A Simplified Block Diagram

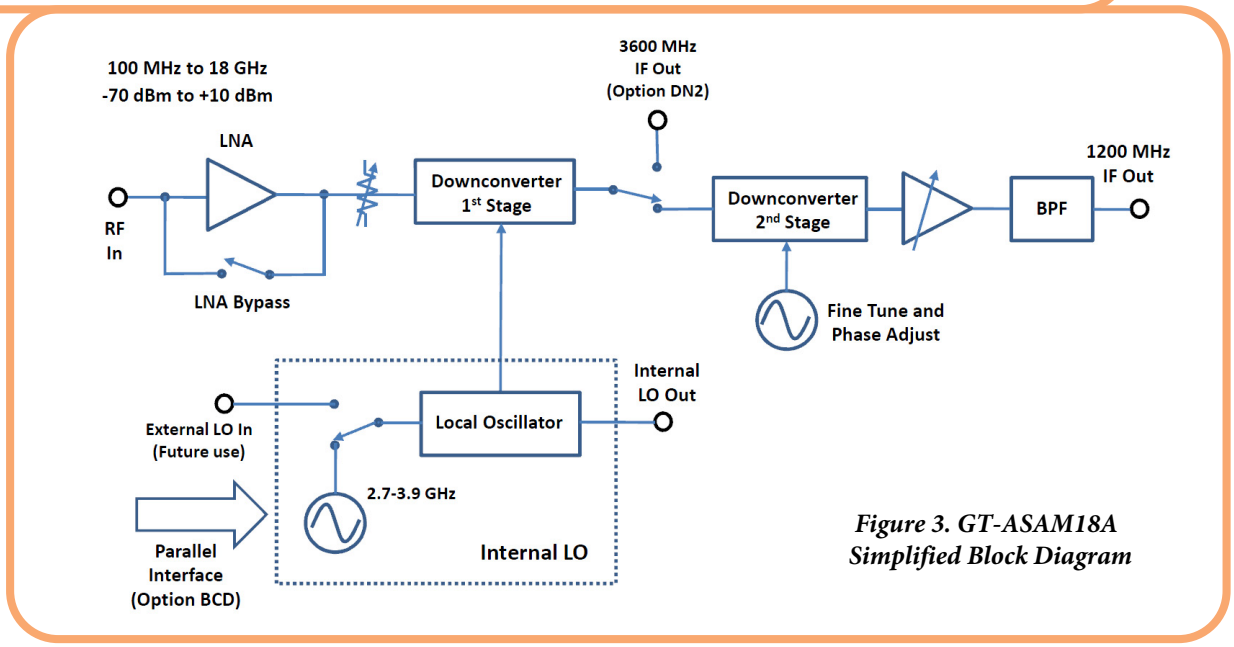


Figure 3. GT-ASAM18A Simplified Block Diagram

Simulation of Modern Radar Systems using Pentek and Giga-tronics Products

scheduling software schedules the waveform playout times, and a LAN connection from the receiver PC and RF subsystem determines the next mode (PRI or waveform) based on the nature of the received signal. The waveforms are scheduled within the Pentek Model 78620 AWG (arbitrary waveform generator) and the frequency and amplitude of the waveform is controlled in real time across PCIe. Optionally, fine timing resolution can be maintained by taking a trigger line from the Pentek boards and using that to deterministically control frequency and amplitude changes in the RF chassis.

Conclusions

A range of radars and radar emulators, from simple single-channel radars to complex multichannel frequency-agile radars, can be created using state-of-the-art waveform creation and processing technologies. All the hardware components are commercially available off-the-shelf and no custom hardware is required. Testing complex devices, such as radar warning receivers or electronic counter measure systems, is simplified with this platform approach, and new types of radar prototypes can be rapidly created and shared between various programs.

For more information about the Giga-tronics GT-ASGM18A and GT-ASAM18A, contact Giga-tronics (email asg-info@gigatronics.com).

For more information about Pentek's Model 78620, go to http://www.pentek.com/go/pipe78620 ❐

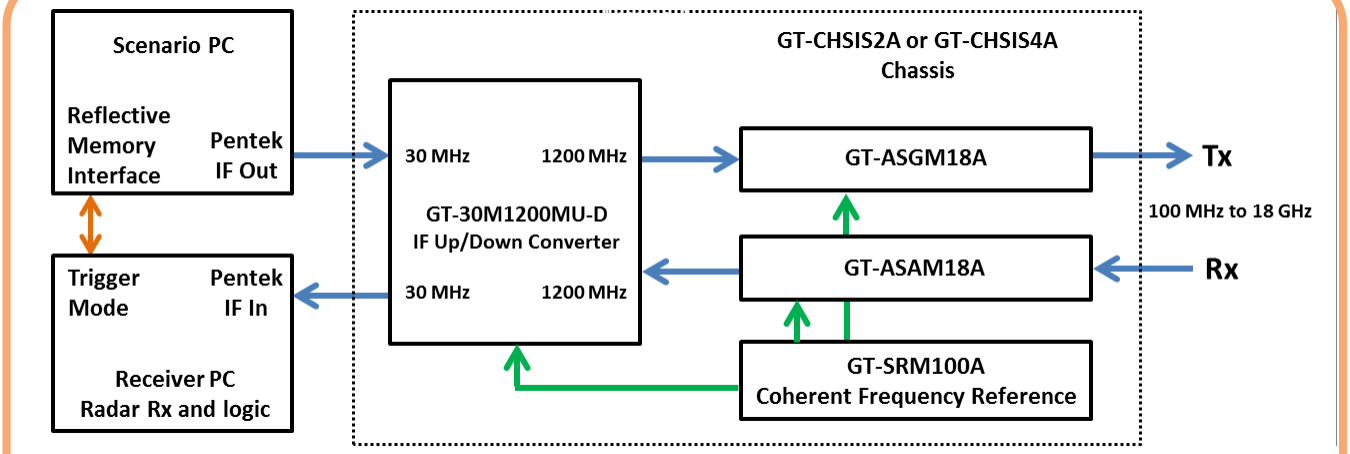


Figure 4. System Block Diagram Showing an IF Up and Downconverter

A four-channel system with two GT-ASGM18A upconverters and two GT-ASAM18A downconverters

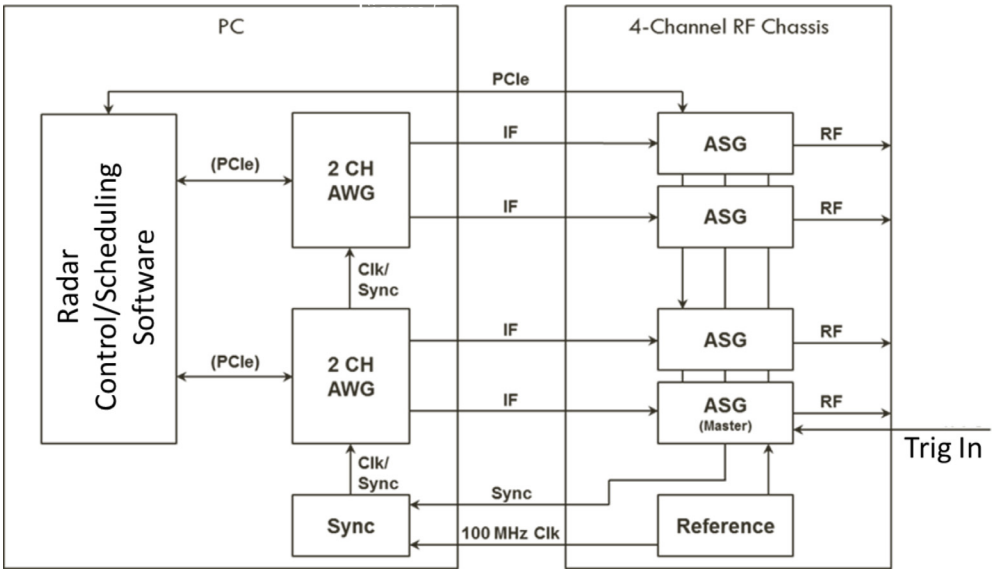


Figure 5. Radar Simulation System Block Diagram

Product Focus

Model 78620

3-Channel 200 MHz A/D, 2-Channel 800 MHz D/A, Virtex-6 FPGA -x8 PCIe Board

Features

- Complete radar and software radio interface solution
- Three 200 MHz 16-bit A/Ds and two 800 MHz 16-bit D/As
- One digital upconverter
- Up to 2 GB of DDR3 SDRAM or 32 MB of QDRII+ SRAM
- Sample clock synchronization to an external system reference
- LVPECL clock/sync bus for multiboard synchronization
- Supports Xilinx Virtex-6 LXT and SXT FPGAs
- PCI Express (Gen. 1& 2) interface up to x8
- Optional user-configurable gigabit serial interface
- Optional LVDS connections to the Virtex-6 FPGA for custom I/O

Model 78620 is a member of the Cobalt® family of high performance PCIe boards based on the Xilinx Virtex-6 FPGA. A multichannel, high-speed data converter, it is suitable for connection to HF or IF ports of a communications or radar system. Its built-in data capture and playback features offer an ideal turnkey solution.

It includes three A/Ds, two D/As and four banks of memory. In addition to supporting PCI Express Gen. 2 as a native interface, the Model 78620 includes optional general-purpose and gigabit serial card edge connectors for application-specific I/O .

The Cobalt Architecture

The Pentek Cobalt architecture features a Virtex-6 FPGA. All of the board's data and control paths are accessible by the FPGA, enabling factory-installed functions including data multiplexing, channel selection, data packing, gating, triggering, and memory control. The Cobalt architecture organizes the FPGA as a container for data processing applications where each function exists as an intellectual property (IP) module.

Each member of the Cobalt family is delivered with factory-installed applications ideally matched to the board's analog interfaces. The 78620 factory-installed functions include three A/D acquisition and a D/A waveform playback IP modules, ideally matched to the board's analog interfaces. IP modules for either DDR3 or QDRII+ memories, a controller for all data clocking and synchronization functions, a test signal generator, and a PCIe interface complete the factory-installed functions and enable the 78620 to operate as a complete turnkey solution, without the need to develop any FPGA IP.

Extendable IP Design

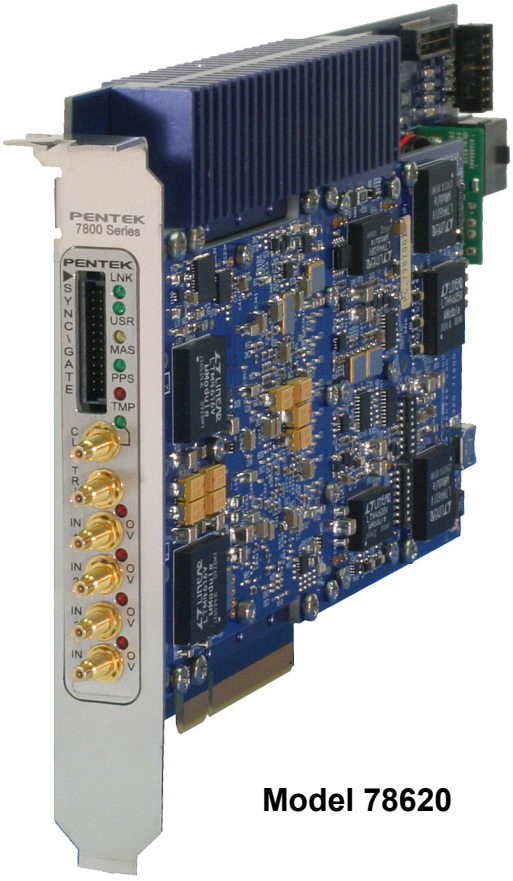
For applications that require specialized functions, users can install their own custom IP for data processing. Pentek GateFlow FPGA Design Kits include all of the factory-installed modules as documented source code. Developers can integrate their own IP with the Pentek factory-installed functions or use the GateFlow kit to completely replace the Pentek IP with their own.

Xilinx Virtex-6 FPGA

The Virtex-6 FPGA site can be populated with a variety of different FPGAs to match the specific requirements of the processing task. Supported FPGAs include: LX130T, LX240T, or SX315T. The SXT part features 1344 DSP48E slices and is ideal for modulation/demodulation, encoding/decoding, encryption decryption, and channelization of the signals between transmission and reception. For applications not requiring large DSP resources, one of the lower-cost LXT FPGAs can be installed.

For more information, go to: www.pentek.com/go/pipe78620. ❐

Cobalt



Model 78620

Product Focus

Talon RTR 2750

Talon RTR 2750 Doubles Channels and Performance while Reducing Cost of Talon Rugged Recorders

Pentek's new Talon® RTR 2750 rackmount recorder, which is optimized for rugged operating environments, increases the performance of the Talon rackmount series with twice the number of channels, over 50% more storage capacity, 25% faster sampling rates, and nearly twice the sustained aggregate recording rate.

The RTR 2750 is a turnkey recording system in a single 4U rackmount chassis. It provides phase-coherent, synchronous recording of sixteen independent input channels at a sustained aggregate data rate up to 8 GB/sec. Transient signals and radar pulses can be precisely captured through external gating and triggering inputs.

Each input channel includes a 250 MHz 16-bit A/D and an FPGA-based digital downconverter with independent tuning and programmable decimation from 2 to 65536 to capture RF signal bandwidths ranging from 3 kHz to 100 MHz. The RTR 2750 offers a storage capacity up to 61 TB, utilizing up to 32 hot-swappable solid-state drives (SSDs) that can be easily removed or exchanged during a mission to retrieve recorded data.

"The RTR 2750 is the most size- and space-efficient of our recorders," stated Chris Tojeira, product director of Recording Systems, ***"System cost is significantly reduced by doubling the channels in a 4U configuration and the sustained recording rate is double over our existing model."***

The RTR 2750 is ideal for multi-channel radar, signal intelligence, and communications applications, with the flexibility of common or independent signal tuning and bandwidth.

TALON RTR RUGGED RECORDER

Ease of Operation

All Talon recorders are built on a Windows 7 Professional workstation and include Pentek's SystemFlow® software, featuring a GUI (graphical user interface), signal viewer, and API (Application Programming Interface). The GUI provides intuitive controls for out-of-the-box turnkey operation using point-and-click configuration management. Configurations are easily stored and recalled for single-click setup. User settings to configure data format for the signal viewer provide a virtual oscilloscope and spectrum analyzer to monitor signals before, during, and after data collection. The C-callable API allows users to integrate the recorder control into larger application systems. Enhancements to the GUI allow more efficient configuration of the recording channels.

The data format used for storage follows the NTFS standard, allowing users to remove drives from the instrument and read the data using standard Windows-based systems, eliminating the need for file format conversion. For more information, go to http://www.pentek.com/go/pipe2750. ❐

Q&A with Pentek

Q: What is the difference between the RTV, RTS, RTR, and RTX series of recorders?

The **RTV** series is the **value** series of Talon recorders. These are the least expensive Talon recorders and are intended for laboratory use. They are limited in storage and streaming data rates to disk and have very few options available. In addition to their low cost, they also have the advantage of shipping from stock, unlike the other series that typically have lead times from six to eight weeks. These recorders come in a rackmountable PC server chassis.

TALON RTV VALUE RECORDER

TALON RTS COMMERCIAL RECORDER

The **RTS** series is the **commercial** series of Talon recorders. These are intended for benign environments, have great flexibility in channel count and are capable of holding large volumes of data storage. These systems use HDDs (hard disk drives) for data storage and are limited in their sustained data rate to disk. These recorders come in a rackmountable PC server chassis.

The **RTR** series is the **rugged** series of Talon recorders. RTR recorders come in both a portable (briefcase style) and rackmountable PC server chassis form factor. Both use SSDs (solid state drives) to help the systems tolerate shock and vibration. They also include enhanced cooling to allow them to operate in higher-temperature environments (up to 55 deg C.) The RTR series recorders provide the highest streaming data rates to disk of all of the Talon series.

TALON RTR RUGGED RECORDER

TALON RTX EXTREME RECORDER

The **RTX** series is the **extreme rugged** series of Talon recorders. RTX recorders are flight certified, capable of handling high levels of shock and vibration as well as high altitude use. RTX series chassis use Pentek's QuickPac® drive packaging technology that provides the ability to quickly remove and replace 8 data storage SSDs from the Talon recorder. This is especially useful during flight missions where aircraft time is expensive.

The **RTX** series chassis comes in two different form factors. A rackmountable chassis uses high-powered fans to air cool system components. This chassis includes a shock-isolated inner chassis, EMI filters, and a modular rear panel to allow for customized signal connectors.The alternate style RTX chassis focuses on SWaP and is available in a 1/2 ATR style chassis.This conduction-cooled chassis is extremely rugged and is able to operate in the harshest of environments. This chassis uses QuickPac drive packaging technology to provide up to 7.6 TB of storage in a very small package.

Downloadable Segment & Product Catalogs

Analog & Digital I/O

Clock & Sync Generators

Radar & SDR I/O

Processors

Software & FPGA Tools

High-Speed Recorders