

## Features

- Small form factor rugged enclosure
- Conduction-cooled
- Designed to the IP67 specification for dust and water immersion
- Sealed military-grade circular connectors
- Incorporates [Xilinx® Zynq® UltraScale+™ RFSoc FPGAs](#)
- 16 GB of DDR4 [SDRAM](#)
- On-board [GPS](#) receiver
- Optional dual [100 GigE UDP](#) optical interface
- Optional fan cooling for benchtop use
- [Navigator® BSP](#) for software development
- [Navigator® FDK](#) for custom IP development
- [Free lifetime applications support](#)



## Applications

- High-bandwidth data streaming
- Waveform signal generator
- Multimode data acquisition system
- Communication receiver and transmitter
- Electronic Warfare transponder
- Analog I/O for digital recording and playback
- Remote monitoring
- Sensor interfaces

### Strategies for Deploying Xilinx's RFSoc



**PENTEK**

## General Information

The Quartz® Model 6350 is a high-performance, small form factor system based on the Xilinx Zynq UltraScale+ RFSoc. The RFSoc integrates eight RF-class A/D and D/A converters into the Zynq's multiprocessor architecture, creating a multichannel data conversion and processing solution on a single chip.



The Model 6350 delivers RFSoc performance in small footprint with a complete system in a ruggedized enclosure ideal for deployment in harsh environments.



Complementing the RFSoc's on-chip resources are the 6350's sophisticated clocking section, a low-noise front end for RF input and output, 16 GBytes of DDR4, a gigabit serial optical interface capable of supporting dual 100 GigE connections, an optional GPS receiver, and general purpose I/O signal paths to the FPGA.

## Architecture

The 6350 design places the RFSoc as the cornerstone of the architecture. All control and data paths are accessible by the RFSoc's programmable logic and processing system. A full suite of Pentek developed IP and software functions utilize this architecture to provide data capture, processing and waveform generating solutions for many of the most common application requirements.

## Extendable IP Design

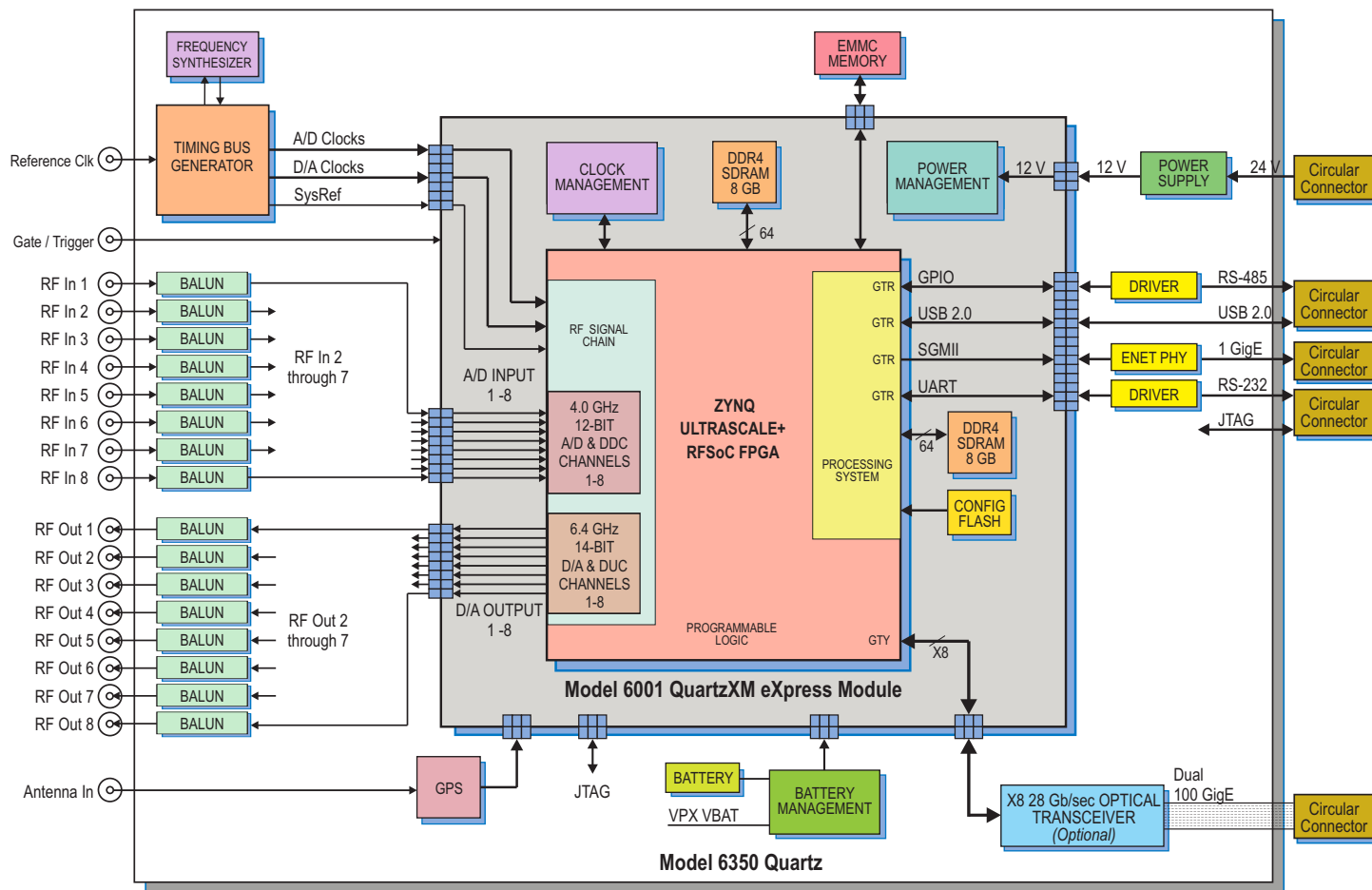
For applications that require specialized functions, users can install their own custom IP for data processing. The Pentek [Navigator FPGA Design Kits \(FDK\)](#) include the board's entire FPGA design as a block diagram that can be edited in Xilinx's Vivado® IP Integrator. In addition to the IP Integrator block diagrams, all source code and complete IP core documentation is included. Developers can integrate their own IP along with the Pentek factory-installed functions or use the Navigator kit to completely replace the Pentek IP with their own.

The [Navigator Board Support Package \(BSP\)](#), the companion product to the Navigator FDK, provides a complete C-callable library for control of the 6350's hardware and IP. The Navigator FDK and BSP libraries mirror each other where each IP function is controlled by a matching software function, simplifying the job of keeping IP and software development synchronized.

The Navigator BSP includes support for Xilinx's PetaLinux running on the ARM Cortex-A53 processors. When running under PetaLinux, the Navigator BSP libraries enable complete control of the 6350 either from applications running locally or on the ARMs, or using the Navigator API, control and command from remote system computers.



## 6350 Block Diagram



## A/D Converter Stage

The 6350 accepts analog IF or RF inputs on eight front panel coax connectors. These inputs are transformer-coupling into the RF signal chain of the RFSoc. Inside the RFSoc, the analog signals are routed to eight 4 GSPS, 12-bit A/D converters. Each converter has built-in digital down-converters with programmable 1x, 2x, 4x or 8x decimation and independent tuning. The A/D digital outputs are delivered into the Zynq's programmable logic and processor system for signal processing, data capture or for routing to other resources.

In addition to the A/D's built-in decimation, an additional stage of IP based decimation provides another 16x stage of data reduction, ideal for applications that need to stream data from all eight A/Ds.

## D/A Converter Stage

The RFSoc's eight D/A converters accept base-band real or complex data streams from the FPGA's programmable logic. Each 6.4 GSPS, 14-bit D/A includes a digital upconverter with independent tuning and interpolations of 1x, 2x, 4x and 8x. Each D/A output is transformer coupled to a coax connection located on the front panel.

## Clocking and Synchronization

An on-board timing bus generator uses a programmable frequency synthesizer to generate the sample clock and all required timing signals. The on-board sample clock can also be locked to a reference clock received through a front panel coax connector. A multifunction gate/trigger input is also available on the front panel for external control of data acquisition and playback.

## Memory Resources

The 6350 architecture supports 8 GBytes of DDR4 SDRAM memory accessible from the Programmable Logic. User-installed IP, which, along with the Pentek supplied DDR4 controller core within the FPGA can take advantage of the memory for custom applications. An additional 8 GBytes bank of DDR4 SDRAM is available to the Processing System as program memory and storage.

## 100 GigE Interface

The Model 6350 supports eight 28 Gb/sec full duplex optical lanes to a miniature rugged circular connector. With the built-in 100 GigE UDP interface or installation of a user provided serial protocol, this optical interface enables a high-speed gigabit data streaming path between the box and data storage or processing subsystems.

## GPS

A GPS receiver provides time and position information to the FPGA and ARM processors. This information can be used for precise data tagging. The GPS provides a 1 PPS and 10 MHz reference clock to the FPGA.

## Optimized IP

Xilinx has created an integrated processing solution in the RFSoc that is unprecedented. The key to unlocking the potential of the RFSoc is efficient operation using optimized IP and application software. Pentek helps streamline the process from development to deployed application by providing a full suite of built-in functions. These address the data flow and basic processing needed for some of the most common applications.

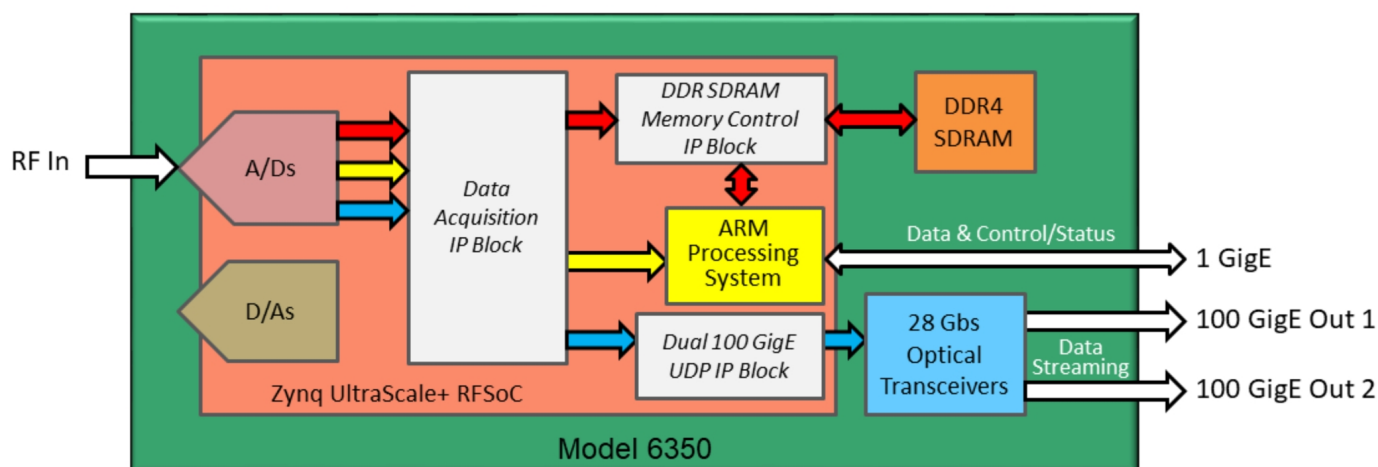
Several example applications using the Pentek [Model 6350](#) are described below. For each example, the board's included IP is all that is needed to demonstrate the application and may satisfy the full set of requirements for any particular application. These applications can also be the starting point for adding additional IP from the Pentek [Navigator](#) IP library or for adding custom IP.

### Example Application 1 - High Bandwidth Data Streaming

The RFSoc's eight 4 GSPS A/Ds are capable of producing an aggregate data rate of 64 GB/sec when all channels are enabled. While capturing this much raw data is not feasible, the A/Ds' built-in digital down converters can reduce this data throughput in many applications to a rate reasonable for the data streaming and storage components downstream in the system.

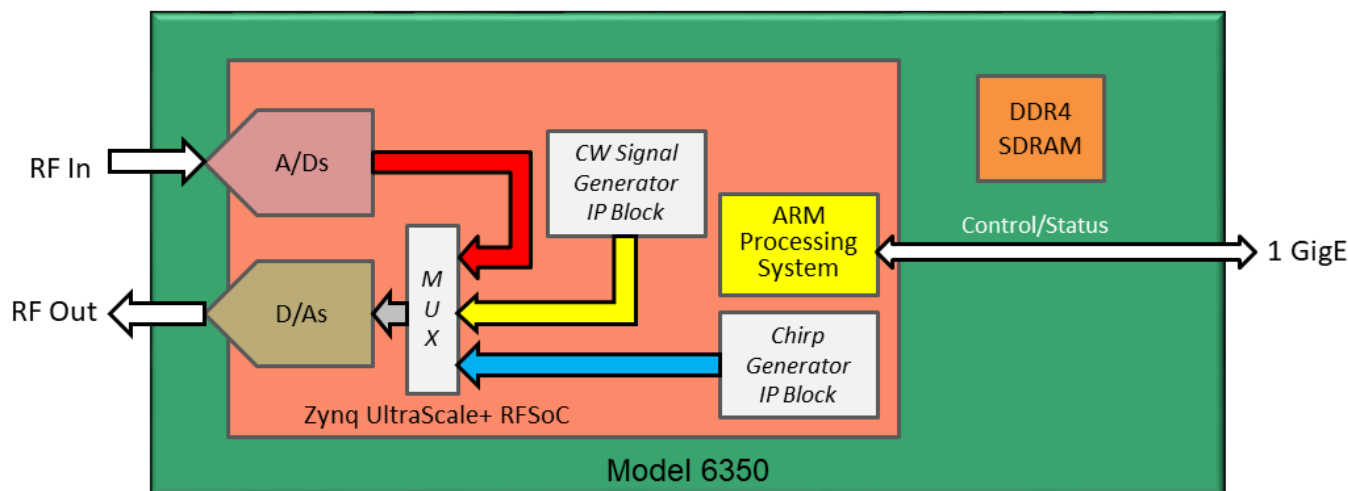
In some applications capturing the raw, full bandwidth data is crucial. The 6350's dual 100 GigE UDP engine provides a high bandwidth path for moving data off of the board (shown with blue arrows). Along with the built-in data acquisition IP, the 6350 can stream two full bandwidth A/D data streams over optical cable to a downstream storage or processing subsystem.

The 6350's built-in IP functions also provide paths for capturing data in the DDR4 SDRAM memory for retrieval by the ARM processing system or the FPGA programmable logic (shown with red arrows) and for sending data over the ARM's 1 GigE interface (shown in yellow arrows).



## Example Application 2 - Analog Loopback and Waveform Generator

The 6350's IP supports multiple D/A signal source options. A simple loopback path allows samples received by the A/Ds to be output through the D/As (shown with a red arrow). A CW signal generator produces a sine output with programmable frequency (shown with a yellow arrow). A chirp generator, ideal for radar applications, outputs sweep signals with programmable frequency, ramp, phase offset, gain offset and length (shown with a blue arrow). The generators also include flexible trigger options with both internal and external triggering.



## Designed for Harsh Environments

The Model 6350 delivers the signal and processing performance of the Quartz RFSoc family in a Small Form Factor (SFF) rugged package. Optimized for SWaP (size, weight and power), the 6350 measures 3.53" H 5.65" W 9.57" D and weighs in at just under 8 pounds.

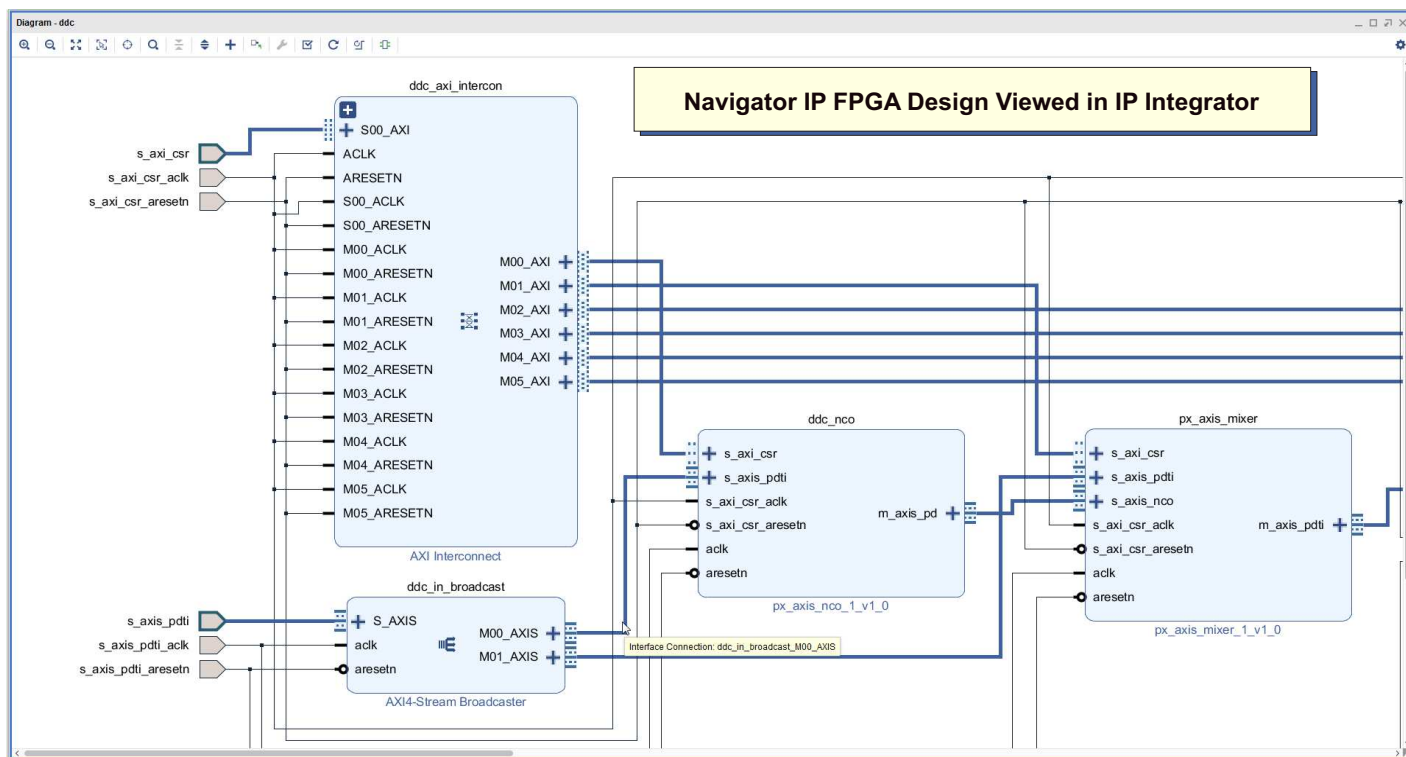
Designed for use in rugged environments, the 6350 is designed to the IP67 specification for dust and water immersion. It's internal 'I-beam' construction creates a chassis that is both extremely rugged and efficient for moving heat out of the box, making it ideal for deployment in the harshest environments and well matched to conduction cooled installations. The 6350 can also be used with an optional fan plate for desktop development.

## Navigator Design Suite

For applications that require specialized functions, the Navigator Design Suite allows customers to fully utilize the processing power of the FPGA. It includes an FPGA design kit for integrating custom IP into Pentek's factory-shipped design, and a board support package for creating host applications for control of all hardware and FPGA IP-based functions.

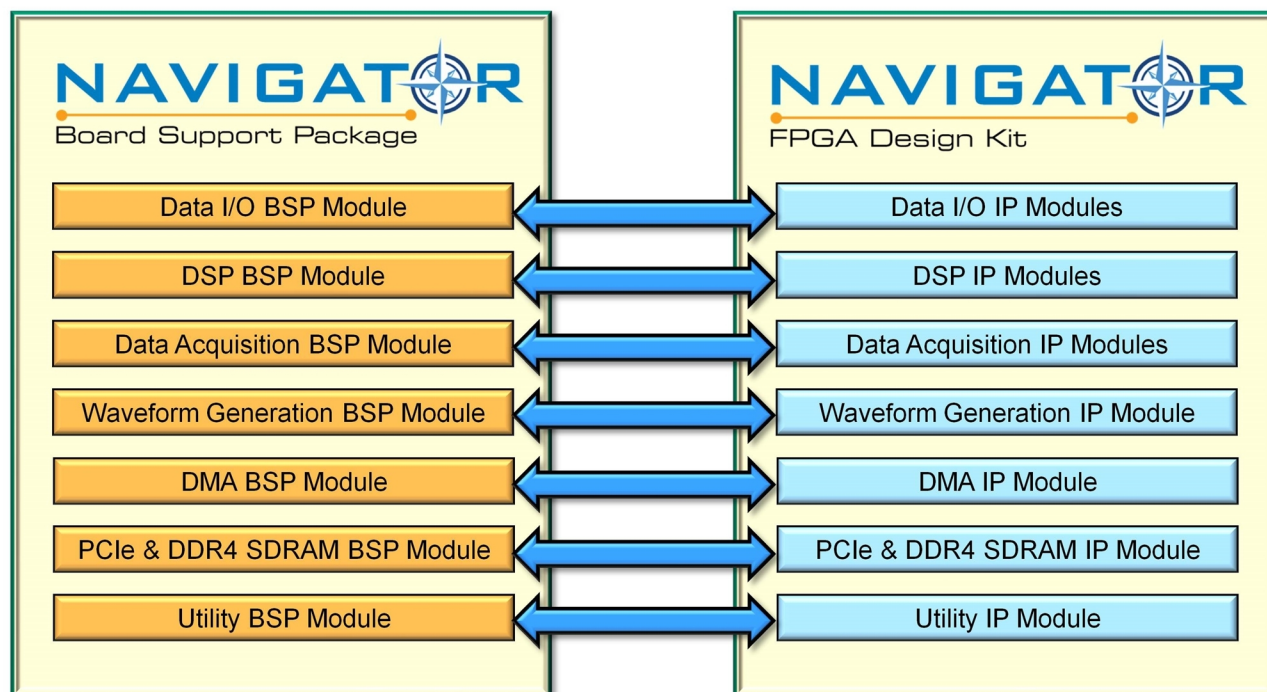


The **Navigator FPGA Design Kit (FDK)** for the Xilinx® Vivado® Design Suite includes the complete Vivado project folder for each Pentek product with all design files for the factory-installed FPGA IP. Vivado's IP Integrator is a graphical design entry tool that visually presents the complete block diagram of all IP blocks so the developer can access every component of the Pentek design. Developers can quickly import, delete, and modify IP blocks and change interconnection paths using simple mouse operations. Navigator FDK includes Pentek's IP core library of more than 100 functions representing a wealth of resources for DSP, data formatting, timing, and streaming operations, all based on the powerful AXI4 standard. Multilevel documentation for each IP core is a mouse click away, and fully consistent with Xilinx IP cores.



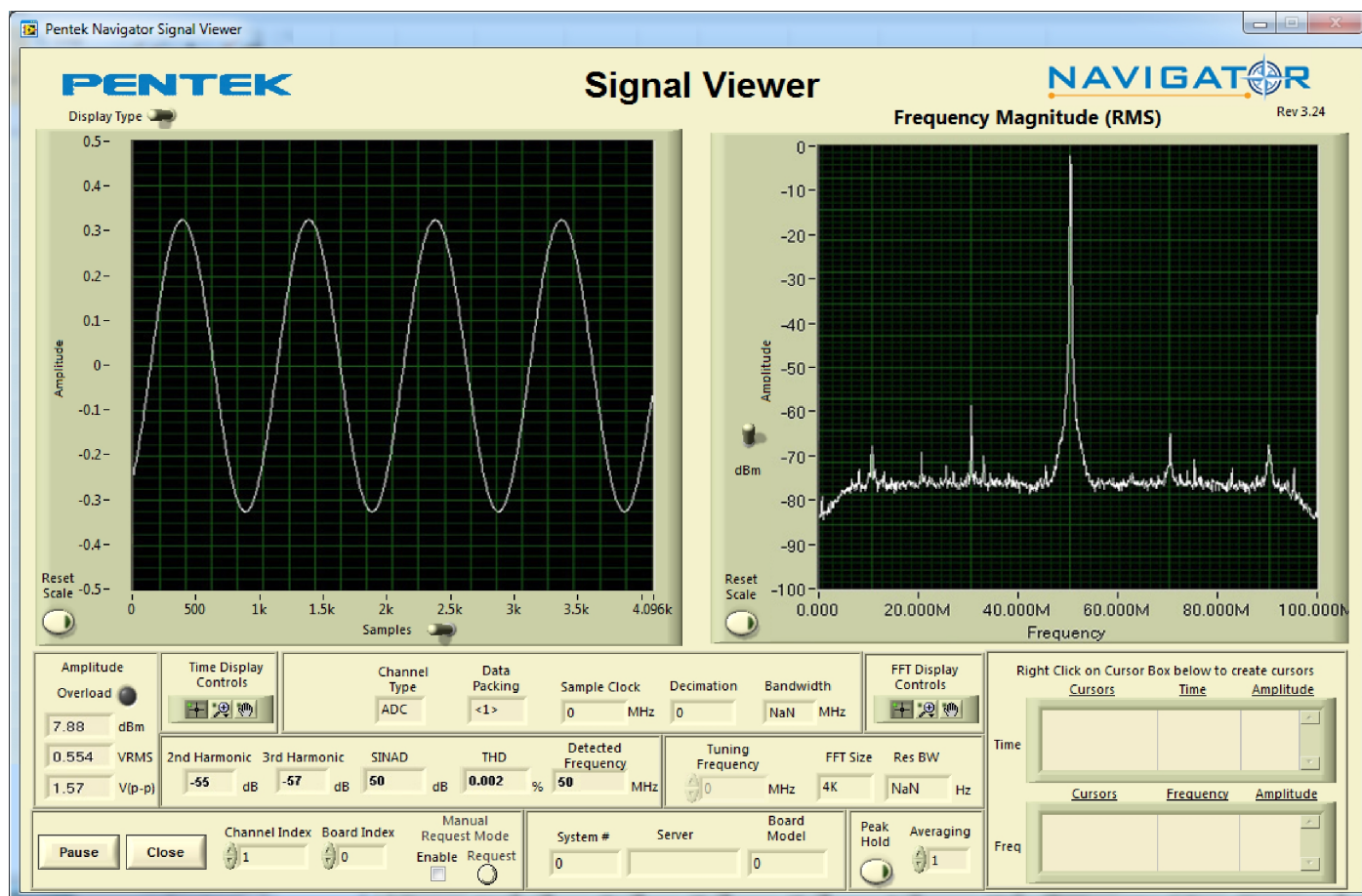
The **Navigator Board Support Package (BSP)** provides software support for Pentek boards. It enables operational control of all hardware functions on the board and IP functions in the FPGA.

The BSP's structure is designed to complement the functions of the FDK by maintaining a one-to-one relationship between FDK and BSP components. For each IP block found in the FDK library, a matching software module can be found in the BSP. This organization simplifies the creation and editing of software to support new IP functions and modifications to existing IP cores.



Because all Pentek boards are shipped with a full suite of built-in IP functions and numerous software examples, new applications can be developed by building on the provided software examples or built entirely new with the BSP's extensive libraries. All BSP libraries are provided as C-language source for full access and code transparency.

The Navigator BSP includes the Signal Viewer, a full-featured analysis tool, that displays data in time and frequency domains. Built-in measurement functions display 2nd and 3rd harmonics, THD (total harmonic distortion), and SINAD (signal to noise and distortion). Interactive cursors allow users to mark data points and instantly calculate amplitude and frequency of displayed signals. With the Signal Viewer users can install the Pentek hardware and Navigator BSP and start viewing analog signals immediately.



## Connections



The front panel of Model 6350 has the following connectors:

- Eight SMA connectors labeled **IN 1-8**, which provide **A/D input** to the A/D converters on the 6350.
- Eight SMA connectors labeled **OUT 1-8**, which provide **D/A output** from the D/A converters on the 6350.



The rear panel of Model 6350 has the following connectors:

- **GATE:** Provides a trigger input. This trigger input is DC-coupled and compatible with the LVTTTL levels, but is 5V tolerant.
- **REF:** Provides an input for an external 10 MHz reference. This signal can be used to lock the on-board sample clock synthesizer to an external reference.
- **USB 2.0 / RS485:** Interfaces to the RFSoc processor's USB 2.0 Port 0.
- **1000 BASE-T:** Provides an Ethernet connection to the 6350 at 1000 Base-T mode.
- **JTAG / RS-232:** Used to download to the FPGA and program QSPI configuration memory.
- **24V DC IN:** Provides power to the 6350.
- **2 x 100GbE:** Provides an optical connector for the 6350.
- **GPS:** For input of an antenna RF signal for the onboard GPS receiver.

## Specifications

### Field Programmable Gate Array

**Type: (standard)** Xilinx Zynq UltraScale+ RFSoc XCZU27DR

**Option -028:** Xilinx Zynq UltraScale+ RFSoc XCZU28DR

**Speed: (standard)** -1 speed grade

**Option -002:** -2 speed grade

### RFSoc RF Signal Chain

#### Analog Inputs

**Quantity:** 8

**Location:** Front panel (IN 1-8)

**Connector Type:** SMA

**Input Type:** Transformer-coupled

**Transformer Type:** Mini-Circuits TCM1-83X+

**Full Scale Input:** +8 dBm into 50 ohms

**3 dB Passband:** 10 MHz to 3700 MHz

#### A/D Converters

**Quantity:** 8

**Sampling Rate:** 4.0 GHz

**Resolution:** 12 bits

#### Digital Downconverters

**Quantity:** 1 per A/D

**Decimation Range:** 1x, 2x, 4x, and 8x

**LO Tuning Freq. Resolution:** 48 bits, 0 to  $f_s$

**Filter:** 80% pass band, 89 dB stop-band attenuation

#### Analog Outputs

**Quantity:** 8

**Location:** Front panel (OUT 1-8)

**Connector Type:** SMA

**Output Type:** Transformer-coupled

**Transformer Type:** Mini-Circuits TCM1-83X+

**Full Scale Output:** +4 dBm into 50 ohms

**3 dB Passband:** 10 MHz to 3700 MHz

#### D/A Converters

**Quantity:** 8

**Sampling Rate:** 6.4 GHz

**Resolution:** 14 bits

#### Digital Upconverters

**Quantity:** 1 per D/A

**Interpolation Range:** 1x, 2x, 4x, and 8x

**LO Tuning Freq. Resolution:** 48 bits

**Filter:** 80% pass band, 89 dB stop-band attenuation

#### Sample Clock

**Source:** On-board programmable clock

#### Reference Clock

**Source:** On-board oscillator, on-board GPS, or external source

**External Source Location:** Rear panel (REF)

**Connector Type:** SMA

**Level:** -10 dBm to +24 dBm

### Gate/Trigger

**Source:** Programmable through software or external connector

**External Source Location:** Rear Panel (GATE)

**Connector Type:** SMA

**Level:** TTL

### GPS

**Source:** On-board

**Antenna Connector Location:** Rear panel (GPS)

**Connector Type:** SMA

### RFSoc Processing System

#### ARM Cortex-A53:

**Quantity:** 4

**Speed:** 1.5 GHz

#### ARM Cortex-R5:

**Quantity:** 2

**Speed:** 600 MHz

#### Processor I/O:

**Interfaces:** USB 2.0 and RS-485

**Location:** Rear panel (USB2.0/RS485)

**Connector Type:** Circular, Glenair Mighty Mouse Series

**Interface:** 1 GigE

**Location:** Rear Panel (1000BASE-T)

**Connector Type:** Circular, Glenair Mighty Mouse Series

**Interface:** RS-232

**Location:** Rear Panel (JTAG/RS-232)

**Connector Type:** Circular, Glenair Mighty Mouse Series

### FPGA I/O

**Optical (Option -110):** 8X full duplex optical lanes @ 28 Gb/sec

**Location:** Rear panel (2x 100GbE)

**Connector Type:** circular, Glenair SuperNine Series

**Protocol:** 100 GigE UDP factory-installed, other protocols supported with user-installed IP

### JTAG

**Location:** Rear Panel (JTAG/RS-232)

**Connector Type:** Circular, Glenair Mighty Mouse Series

### Memory

#### Processing System:

**Type:** DDR4 SDRAM

**Size: (standard)** 4 GB

**Option -151:** 8 GB

**Speed:** 1200 MHz (2400 MHz DDR)

**Type:** eMMC

**Size:** 64 GB

**Programmable Logic:****Type:** DDR4 SDRAM**Size: (standard)** 4 GB**Option -151:** 8 GB**Speed:** 1200 MHz (2400 MHz DDR)**FPGA Configuration FLASH:****Type:** QSPI NOR Flash**Size:** 1 Gb**Environmental****Option -703:** Level [L3](#) (conduction-cooled)**Operating Temp:** -20° to 55° C (with 50° C cold plate)**Storage Temp:** -50° to 100° C**Relative Humidity:** 0 to 100%**Physical****Dimensions:****Depth:** 243.08 mm (9.57 in)**Height:** 89.66 mm (3.53 in)**Width:** 143.51 mm (5.65 in)**Weight:** 8 lbs.**Power:****Voltage:** +12 to +28 VDC (+24 VDC nominal)**Location:** Rear Panel (24VDC IN)**Connector Type:** Circular, Glenair Mighty Mouse Series**Maximum Power Consumption:** 46.62 Watts**Ordering Information**

Model	Description
6350	8-Channel A/D & D/A Zynq UltraScale+ RFSoc Processor in a Rugged Small Form Factor Enclosure

Options:	
-002	-2 FPGA speed grade, -1 standard
-028	XCZU28DR FPGA (XCZU27DR is standard)
-110	Optical interface
-151	8 GB Logic & 8 GB Processor Memory (4 GB & 4 GB is standard)
-703	Conduction-cooled, <a href="#">L3</a>
Contact Pentek for compatible option combinations and complete specifications of rugged and conduction-cooled versions. Storage and general options may change, so be sure to contact Pentek for the latest information.	

**Accessory Products**

Model	Description
2187	6350 Accessories

Model	Description
-150	Development cable set without optical cable
-151	Development cable set with optical cable
-701	Top cover plate with built-in fan, replaces standard top plate for benchtop cooling

**Pricing and Availability**

To learn more about our products or to discuss your specific application please contact [your local representative](#) or Pentek directly:

Pentek, Inc.  
One Park Way  
Upper Saddle River, NJ 07458 USA  
Tel: +1 (201) 818-5900  
Email: [sales@pentek.com](mailto:sales@pentek.com)

**Lifetime Applications Support**

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