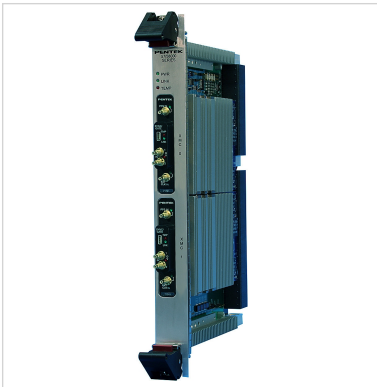


# Onyx 57741 and 58741

1- or 2-channel 3.6 GHz, 2- or 4-channel 1.8 GHz,  
12-bit A/D with wideband DDC  
6U VPX board with Virtex-7 FPGA

## Complete radar and software radio interface solution

- Radar and software radio receiver
- Communications receiver
- Analog signal interface for data recording
- Wideband data acquisition
- Remote monitoring
- Sensor interfaces



**The 57741 and the 58741 consist of one or two 71741 XMC modules mounted on a 6U VPX carrier board.** The 57741 is a 6U board with one 71741 module while the 58741 is a 6U board with two XMC modules rather than one.

These models include one or two 3.6 GHz, 12-bit A/D converters, four or eight banks of memory, and one or two wideband DDCs.

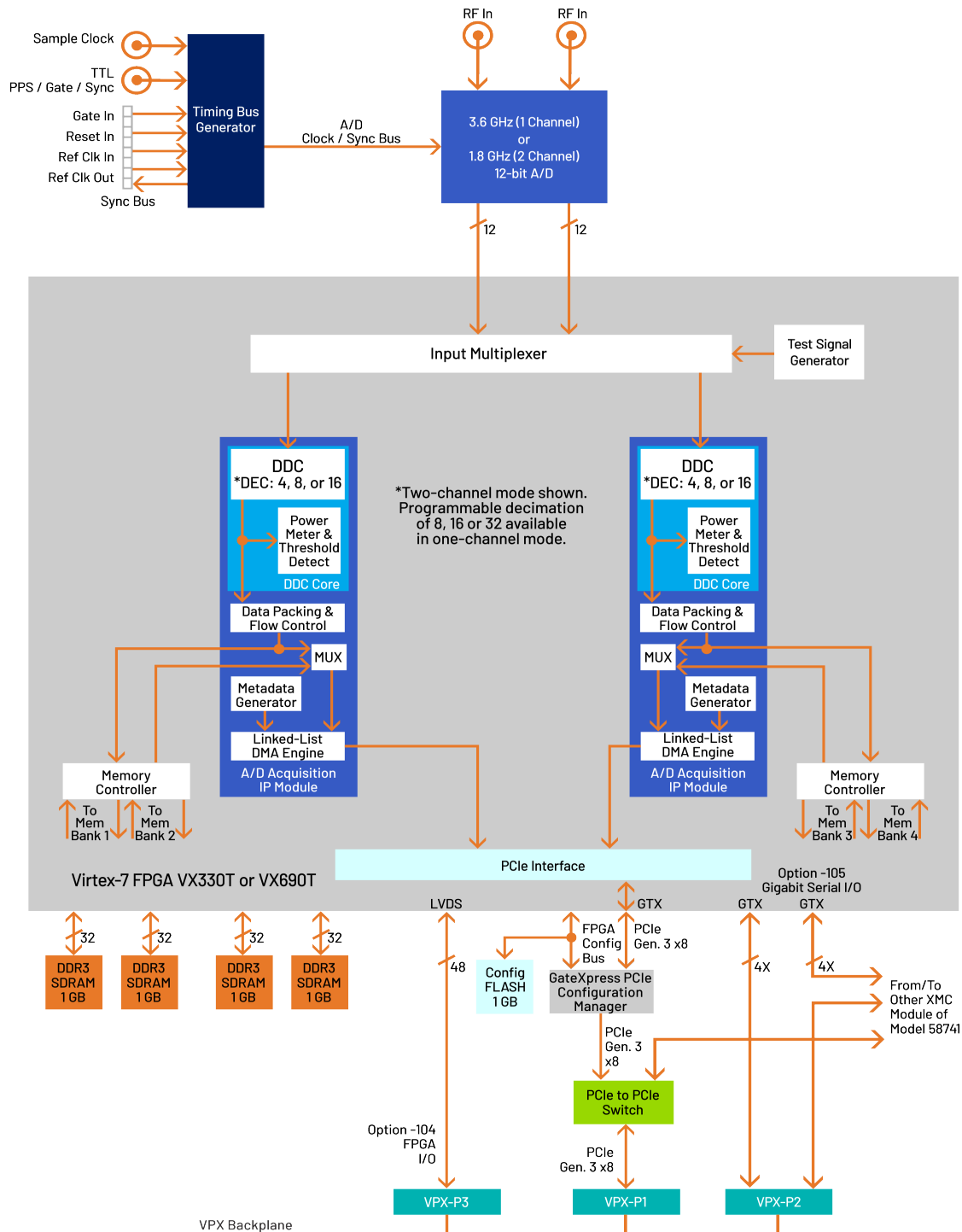
### FEATURES

- Supports Xilinx® Virtex®-7 VXT FPGA
- GateXpress® supports dynamic FPGA reconfiguration across PCIe
- One or two 1-channel mode with 3.6 GHz, 12-bit A/D
- Two or four 2-channel mode with 1.8 GHz, 12-bit A/Ds
- Programmable one- or two-channel DDC (Digital Downconverter)
- Four or eight GB of DDR3 SDRAM
- µSync clock/sync bus for multiboard synchronization
- PCI Express (Gen. 1, 2 & 3) interface up to x8
- Optional user-configurable gigabit serial interface
- Optional LVDS connections to the Xilinx® Virtex®-7 FPGA for custom I/O
- Ruggedized and conduction-cooled versions available

## BLOCK DIAGRAM

Click on a block for more information.

Block diagram 57741 shows half of the 58741. All resources are actually double of what is shown except for the PCIe-to-PCIe Switch and provides 24 LVDS pairs from the 2nd FPGA to VPX-P5.



## THE ONYX ARCHITECTURE

Based on the proven design of the Mercury Cobalt family, Onyx raises the processing performance with the new flagship family of Virtex-7 FPGAs from Xilinx. As the central feature of the board architecture, the FPGA has access to all data and control paths, enabling factory-installed functions including data multiplexing, channel selection, data packing, gating, triggering and memory control. The Onyx 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 Onyx family is delivered with factory-installed applications ideally matched to the board's analog interfaces. The factory-installed functions of these models include one or two A/D acquisition IP modules and one or two wideband DDCs. In addition, IP modules for DDR3 SDRAM 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 these models to operate as turnkey solutions, 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. The GateFlow FPGA Design Kits include all of the factory-installed modules as document source code. Developers can integrate their own IP with the factory-installed functions or use the GateFlow kit to completely replace the IP with their own.

## XILINX VIRTEx-7 FPGA

The Xilinx Virtex-7 FPGA site can be populated with one of two FPGAs to match the specific requirements of the processing task. Supported FPGAs are VX330T or VX690T. The VX690T features 3600 DSP48E1 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 or logic, the lower-cost VX330T can be installed.

## A/D CONVERTER STAGE

The board's analog interface accepts analog HF or IF inputs on a pair of front panel SSMC connectors with transformer coupling into a Texas Instruments ADC12D1800 12-bit A/D. The converter operates in single-channel interleaved mode with a sampling rate of 3.6 GHz and an input bandwidth of 1.75 GHz; or, in dual-channel mode with a sampling rate of 1.8 GHz and input bandwidth of 2.8 GHz.

The ADC12D1800 provides a programmable 15-bit gain adjustment allowing the 71741 to have a full scale input range of +2 dBm to +4 dBm. A built-in AutoSync feature supports A/D synchronization across multiple boards.

The A/D digital outputs are delivered into the Xilinx® Virtex®-7 FPGA for signal processing, data capture or for routing to other board resources.

## A/D ACQUISITION IP MODULES

These models feature two or four A/D Acquisition IP Modules for easy capture and data moving. The IP modules can receive data from the A/Ds, or a test signal generator. The IP modules have associated memory banks for buffering data in FIFO mode or for storing data in transient capture mode.

In single-channel mode, four banks are used to store the single-channel of input data. In dual-channel mode, two memory banks store data from input channel 1 and two memory banks store data from input channel 2. In both modes, continuous, full-rate transient capture of 12-bit data is supported.

The memory banks are supported with a DMA engine for moving A/D data through the PCIe interface. This powerful linked-list DMA engine is capable of a unique Acquisition Gate Driven mode. In this mode, the length of a transfer performed by a link definition need not be known prior to data acquisition; rather, it is governed by the length of the acquisition gate. This is extremely useful in applications where an external gate drives acquisition and the exact length of that gate is not known or is likely to vary.

For each transfer, the DMA engine can automatically construct metadata packets containing a sample-accurate time stamp and data length information. These actions simplify the host processor's job of identifying and executing on the data.

## DDC IP CORE

Within each FPGA is a powerful DDC IP core. The core supports a single-channel mode, accepting data samples from the A/D at the full 3.6 GHz rate. Additionally, a dual-channel mode supports the A/D's 1.8 GHz two-channel operation.

In dual-channel mode, each DDC has an independent 32-bit tuning frequency setting that ranges from DC to  $f_s$ , where  $f_s$  is the A/D sampling frequency.

In single-channel mode, decimation can be programmed to 8x, 16x or 32x. In dual-channel mode, both channels share the same decimation rate, programmable to 4x, 8x or 16x.

The decimating filter for each DDC accepts a unique set of user-supplied 16-bit coefficients. The 80% default filters deliver an output bandwidth of  $0.8 \cdot f_s / N$ , where  $N$  is the decimation setting. The rejection of adjacent-band components within the 80% output bandwidth is better than 100 dB. Each DDC delivers a complex output stream consisting of 16-bit I + 16-bit Q samples at a rate of  $f_s / N$ .

## CLOCKING AND SYNCHRONIZATION

These models accept a 1.8 GHz dual-edge sample clock via a front panel SSMC connector. A second front panel SSMC accepts a TTL signal that can function as Gate, PPS or Sync.

A front panel  $\mu$ Sync bus connector allows multiple boards to be synchronized, ideal for multichannel systems. The  $\mu$ Sync bus includes gate, reset, and in and out reference clock signals. Two boards can be synchronized with a simple cable. For larger systems, multiple boards can be synchronized using the Model 5792 or 5892 high-speed sync board to drive the sync bus.

## MEMORY RESOURCES

The Onyx architecture supports four or eight independent DDR3 SDRAM memory banks. Each bank is 1 GB deep and is an integral part of the board's DMA capabilities, providing FIFO memory space for creating DMA packets. Built-in memory functions include multichannel A/D data capture, tagging and streaming.

## PCI EXPRESS INTERFACE

These models include an industry-standard interface fully compliant with PCI Express Gen. 1, 2 and 3 bus specifications. Supporting PCIe links up to x8, the interface includes multiple DMA controllers for efficient transfers to and from the board.

## GATEXPRESS FOR FPGA CONFIGURATION

The Onyx architecture includes GateXpress<sup>®</sup>, a sophisticated FPGA-PCIe configuration manager for loading and reloading the FPGA. At power up, GateXpress immediately presents a PCIe target for the host computer to discover, effectively giving the FPGA time to load from FLASH. This is especially important for larger FPGAs where the loading times can exceed the PCIe discovery window, typically 100 msec on most PCs.

The board's configuration FLASH can hold four FPGA images. Images can be factory-installed IP or custom IP created by the user, and programmed into the FLASH via JTAG using Xilinx iMPACT or through the board's PCIe interface. At power up the user can choose which image will load based on a hardware switch

setting. Once booted, GateXpress allows the user three options for dynamically reconfiguring the FPGA with a new IP image:

- The first is the option to load an alternate image from FLASH through software control. The user selects the desired image and issues a reload command.
- The second option is for applications where the FPGA image must be loaded directly through the PCIe interface. This is important in security situations where there can be no latent user image left in nonvolatile memory when power is removed. In applications where the FPGA IP may need to change many times during the course of a mission, images can be stored on the host computer and loaded through PCIe as needed.
- The third option, typically used during development, allows the user to directly load the FPGA through JTAG using Xilinx iMPACT.

In all three FPGA loading scenarios, GateXpress handles the hardware negotiation simplifying and streamlining the loading task. In addition, GateXpress preserves the PCIe configuration space allowing dynamic FPGA reconfiguration without a host computer reset to rediscover the board. After the reload, the host simply continues to see the board with the expected device ID.

## READYFLOW

Mercury provides ReadyFlow<sup>®</sup> BSPs (Board Support Packages) for all Cobalt, Onyx, and Flexor products. Available for both Linux and Windows, these packages:

- Provide a path for quick start-up through application completion
- Allow programming at high, intermediate and low levels to meet various needs
- Are illustrated with numerous examples
- Include complete documentation and definitions of all functions
- Include library and example source code.

ReadyFlow BSPs contain C-language examples that can be used to demonstrate the capabilities of Cobalt, Onyx, and Flexor products. These programming examples will help you get an immediate start on writing your own application. They provide sample code that is known to work, giving you a means of verifying that your board set is operational.

## COMMAND LINE INTERFACE

The Command Line Interface provides access to pre-compiled executable examples that operate the hardware right out of the box, without the need to write any code. Board-specific hardware

operating arguments can be entered in the command line to control parameters: number of channels to enable, sample clock frequency, data transfer size, reference clock frequency, reference clock source, etc.

The Command Line Interface can be used to call an example application from within a larger user application to control the hardware, and parameter arguments are passed to the application for execution. Functions that control data acquisition automatically save captured data to a pre-named host file or are routed to the Signal Analyzer example function for display.

## SIGNAL ANALYZER

When used with the Command Line Interface, the Signal Analyzer allows users to immediately start acquiring and displaying A/D data. A full-featured analysis tool, the Signal Analyzer displays data in time and frequency domains. Built-in measurement functions display 2nd and 3rd harmonics, THD, and SINAD. Interactive cursors allow users to mark data points and instantly calculate amplitude and frequency of displayed signals.



## GATEFLOW

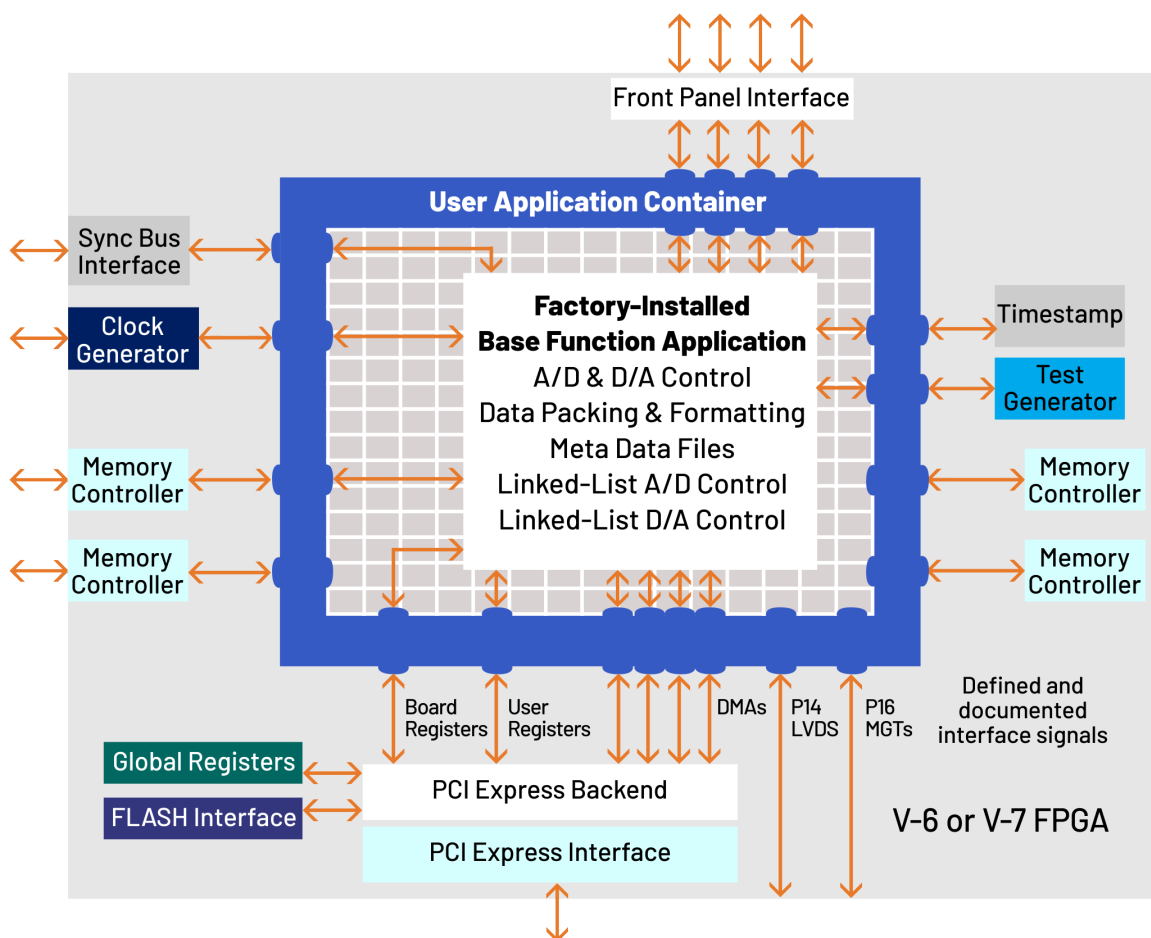
The GateFlow<sup>®</sup> FPGA Design Kit (FDK) allows the user to modify, replace and extend the standard installed functions in the FPGA to incorporate special modes of operation, new control structures, and specialized signal-processing algorithms.

The Cobalt (Virtex-6), Onyx (Virtex-7), and Flexor (Virtex-7) architectures configure the FPGA with standard factory-supplied interfaces including memory controllers, DMA engines, A/D and D/A interfaces, timing and synchronization structures, triggering and gating logic, time stamping and header tagging, data formatting engines, and the PCIe interface. These resources are connected to the User Application Container using well-defined ports that present easy-to-use data and control signals, effectively abstracting the lower-level details of the hardware.

## The User Application Container

Shown below is the FPGA block diagram of a typical Cobalt, Onyx or Flexor module. The User Application Container holds a collection of different installed IP modules connected to the various interfaces through the standard ports surrounding the container. The specific IP modules for each product are described in further detail in the datasheet of that product.

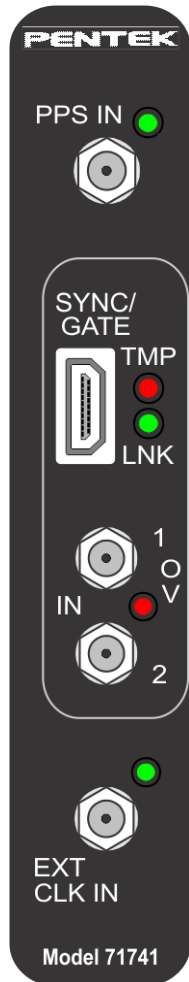
The GateFlow FDK provides a complete Xilinx's ISE or Vivado project folder containing all the files necessary for the FPGA developer to recompile the entire project with or without any required changes. VHDL source code for each IP module provides excellent examples of how the IP modules work, how they might be modified, and how they might be replaced with custom IP to implement a specific function.





## FRONT PANEL CONNECTIONS

The XMC front panel includes four SSMC coaxial connectors and a 19-pin Sync Bus connector for input/output of timing and analog signals. The front panel also includes five LEDs.



- **PPS LED:** The green **PPS** LED illuminates when a valid PPS signal is detected. The LED will blink at the rate of the PPS signal.
- **PPS Input Connector:** The SSMC coaxial connector, labeled **PPS IN** is for input of an external PPS or Gate signal.
- **Sync Bus Connector:** The 19-pin Sync Bus front panel connector, labeled **SYNC/GATE**, provides clock, sync, and gate input/output pins for the Sync Bus.
- **Over Temperature LED:** The red **TMP** LED illuminates when an over-temperature or over-voltage condition is indicated by any of the temperature/voltage sensors on the PCB.
- **Link LED:** The green **LNK** LED blinks when a valid link has been established over the PCIe interface.
- **Analog Input Connectors:** Two SSMC coaxial connectors, labeled **IN 1** and **IN 2** are for each ADC12D1800 input channel.
- **A/D Overload LED:** There is one red **OV** (overload) LED for the A/D input. It

indicates either an analog input overload in the associated ADC12D1800, or an ADC FIFO overrun.

- **Clock LED:** The green **CLK** LED illuminates when a valid sample clock signal is detected. If the LED is not illuminated, no clock has been detected and no data from the input stream can be processed.
- **Clock Input Connector:** One SSMC coaxial connector, labeled **EXT CLK IN**, for input of an external sample clock.

## SPECIFICATIONS

57741: One A/D

58741: Two A/Ds

## Front Panel Analog Signal Inputs (2 or 4)

Input Type: Transformer-coupled, front panel female SSMC connectors

## A/D Converters (1 or 2)

Type: Texas Instruments ADC12D1800

Sampling Rate: Single-channel mode: 500 MHz to 3.6 GHz; dual-channel mode: 150 MHz to 1.8 GHz

Resolution: 12 bits

Input Bandwidth: single-channel mode: 1.75 GHz; dual-channel mode: 2.8 GHz

Full Scale Input: +2 dBm to +4 dBm, programmable

## Digital Downconverters (2 or 4)

Modes: One or two channels, programmable

Supported Sample Rate: One-channel mode: 3.6 GHz, two-channel mode: 1.8 GHz

Decimation Range: One-channel mode: 8x, 16x or 32x, two-channel mode: 4x, 8x, or 16x

LO Tuning Freq. Resolution: 32 bits, 0 to  $f_s$

LO SFDR: >120 dB

Phase Offset Resolution: 32 bits, 0 to 360 degrees

FIR Filter: User-programmable 18-bit coefficients

Default Filter Set: 80% bandwidth, <0.3 dB passband ripple, >100 dB stopband attenuation

## Sample Clock Sources (1 or 2)

Front panel SSMC connector

## Timing Bus (1 or 2)

19-pin  $\mu$ Sync bus connector includes sync and gate/trigger inputs, CML

## External Trigger Input (1 or 2)

Type: Front panel female SSMC connector, LVTTTL

Function: Programmable functions include: trigger, gate, sync and PPS

## Field Programmable Gate Arrays (1 or 2)

- Standard: Xilinx Virtex-7 XC7VX330T-2
- Optional: Xilinx Virtex-7 XC7VX690T-2

**Custom I/O**

- Option -104: Provides 24 LVDS pairs between the FPGA and the VPX P3 connector, Model 57741; P3 and P5, Model 58741
- Option -105: Supports serial protocols by providing a 4X gigabit link between the FPGA and VPX P2, Model 57741; or one 4X link from each FPGA to P2 and an additional 4X link between the FPGAs, Model 58741.

**Memory Banks (4 or 8)**

Type: DDR3 SDRAM

Size: 1 GB each

Speed: 800 MHz (1600 MHz DDR)

**PCI-Express Interface**

PCI Express Bus: Gen. 1, 2 or 3: x4 or x8

**Environmental**

Standard: L0 (air-cooled)

- Operating Temp: 0° to 50° C
- Storage Temp: -20° to 90° C
- Relative Humidity: 0 to 95%, non-condensing

Option -702: L2 (air-cooled)

- Operating Temp: -20° to 65° C
- Storage Temp: -40° to 100° C
- Relative Humidity: 0 to 95%, non-condensing

Option -763: L3 (conduction-cooled)

- Operating Temp: -40° to 70° C
- Storage Temp: -50° to 100° C
- Relative Humidity: 0 to 95%, non-condensing

**Physical**

Dimensions:

- Depth: 170.6 mm (6.717 in.)
- Height: 100 mm (3.937 in.)

Weight: VPX Carrier: 110 grams (3.9 oz)

**ORDERING INFORMATION**

Model	Description
57741	3-Channel 200 MHz A/D with DDC, DUC with 2-Channel 800 MHz D/A with Virtex-7 FPGA - 6U VPX
58741	6-Channel 200 MHz A/D with DDCs, DUCs with 4-Channel 800 MHz D/A, and two Virtex-7 FPGAs 6U VPX

Options	Description
-076	XC7VX690T-2 FPGA
-104	LVDS FPGA I/O between the FPGA and P3 connector, 57741; P3 and P5 connectors, 58741
-105	Gigabit link between the FPGA and P2 connector, 57741; gigabit links from each FPGA to P2 connector, 78741
-702	Air-cooled, Level 2
-763	Conduction-cooled, Level 3
Contact Mercury for compatible option combinations.	

**ACCESSORY PRODUCTS**

Model	Description
5792 & 5892	High-Speed Synchronizer and Distribution Board
5794 & 5894	High-Speed Clock Generator
9192	Rackmount High-Speed System Synchronizer



## FORM FACTORS

Onyx products are available in standard form factors including 3U VPX, 6U VPX, PCIe, and XMC. The Onyx Model 71741 XMC (1-Channel 3.6 GHz or 2-Channel 1.8 GHz 12-bit A/D with DDC with Virtex-7 FPGA) has the following variants:

Model	
52741	3U VPX board (single XMC)
57741	6U VPX board (single XMC)
58741	6U VPX board (dual XMC)
71741	XMC module
78741	PCIe board (single XMC)

## DEVELOPMENT SYSTEMS

Mercury offers development systems for Onyx products. They come with all pre-tested software and hardware ready for immediate operation. These systems are intended to save engineers and system integrators the time and expense associated with building and testing a development system that ensures optimum performance of Onyx boards. Please [contact Mercury](#) to configure a system that matches your requirements.



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