

# Jade 71841

1-channel 3.6 GHz A/D with DDC,  
2-channel 1.8 GHz A/D with DDC  
XMC module with Kintex UltraScale 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 Jade® 71841 is a high-speed data converter with programmable DDCs (digital downconverters).** It is suitable for connection to HF or IF ports of a communications or radar system. Its built-in data capture feature offers an ideal turnkey solution as well as a platform for developing and deploying custom FPGA-processing IP.

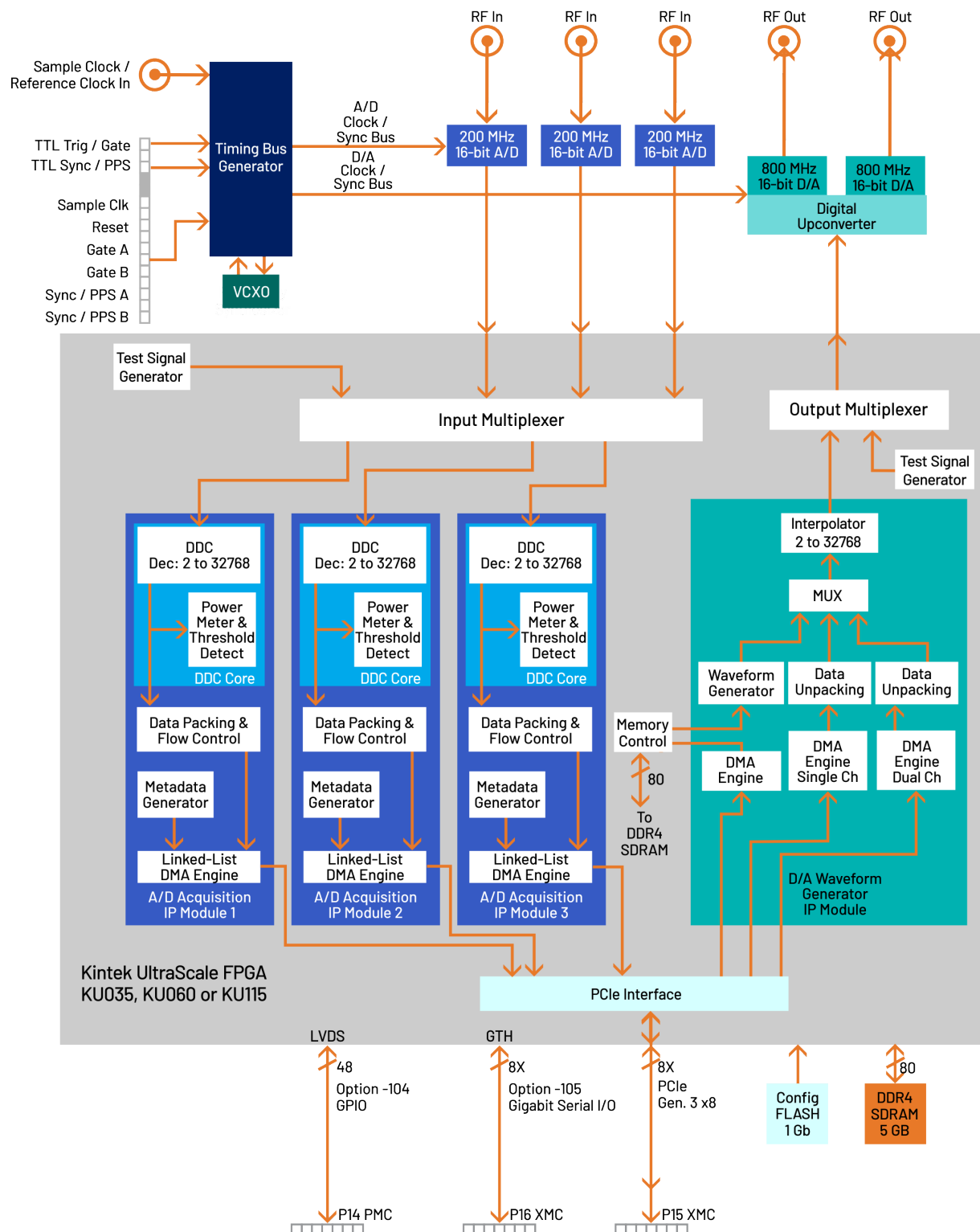
It includes a 3.6 GHz, 12-bit A/D converter and a large DDR4 memory. In addition to supporting PCI Express Gen. 3 as a native interface, the 71841 includes optional high-bandwidth connections to the Kintex UltraScale FPGA for custom digital I/O.

## FEATURES

- Exceptional dynamic range and analog signal integrity
- Xilinx® Kintex® UltraScale™ FPGA
- One-channel mode with 3.6 GHz, 12-bit A/D
- Two-channel mode with 1.8 GHz, 12-bit A/Ds
- Programmable one- or two-channel DDC (Digital Downconverter)
- 5 GB of 2400 MHz DDR4 SDRAM
- µSync clock/sync bus for multimodule synchronization
- PCI Express interface (Gen. 1, 2 & 3) up to x8
- VITA 42.0 XMC compatible with switched-fabric interfaces
- Optional LVDS port and gigabit serial connections for custom FPGA I/O
- Ruggedized and conduction-cooled versions
- Navigator Design Suite for software and custom IP development

## 71841 BLOCK DIAGRAM

Click on a block for more information.



## THE JADE ARCHITECTURE

Evolved from the proven designs of Mercury's Cobalt® and Onyx® families, Jade® raises the processing performance while lowering the overall power requirements by building on the Xilinx family of Kintex UltraScale FPGAs. As the central feature of the board architecture, the FPGA has access to all data and control paths, enabling factory-installed functions as well as providing an ideal platform for user-created intellectual property (IP).

Each member of the Jade family is delivered with factory-installed applications ideally matched to the board's analog interfaces. The 71841 factory-installed functions include an A/D acquisition IP module and a programmable digital downconverter (DDC). In addition, IP modules for DDR4 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 the 71841 to operate as a complete turnkey solution, without the need to develop any FPGA IP.

## XILINX KINTEX ULTRASCALE FPGAS

Depending on the requirements of the processing task, the Kintex Ultrascale can be selected from a range of FPGAs: KU035 through KU115. The KU115 features 5520 DSP48E2 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, a lower-cost FPGA 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 full-scale input level of the ADC12D1800 can be digitally trimmed from +2 dBm to +4 dBm to simplify system calibration. A built-in AutoSync feature supports A/D synchronization across multiple modules.

The A/D digital outputs are delivered into the Kintex UltraScale FPGA for signal processing, data capture or for routing to other module resources.

## A/D ACQUISITION IP MODULES

The 71841 features an A/D Acquisition IP Module for easy capture and data moving. The IP module can receive data from the A/D, or a test signal generator. The IP module has an associated 5 GB memory bank for buffering data in FIFO mode or for storing data in transient capture mode.

In single-channel mode, all of 5 GB are used to store the single-channel of input data. In dual-channel mode, one half of the memory stores data from input channel 1 and the other half stores data from input channel 2. In both modes, continuous, full-rate transient capture of 12-bit data is supported.

The memory bank is 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 CORES

Within the 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 1.8 GHz two-channel operation.

- In single-channel mode, decimation can be programmed to 8 or 16 to 512 in steps of 16.
- In dual-channel mode, decimation can be programmed to 4 or 8 to 256 in steps of 8 and both channels share the same decimation rate.
- In either mode, the DDC can be bypassed completely.

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

The 71841 accepts 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 71841s can be synchronized with a simple cable. For larger systems, multiple 71841's can be synchronized using the Model 7892 high-speed sync module to drive the sync bus.

## MEMORY RESOURCES

The 71841 architecture supports a 5 GB bank of DDR4 SDRAM memory. User-installed IP along with the Mercury-supplied DDR4 controller core within the FPGA can take advantage of the memory for custom applications.

## PCI EXPRESS INTERFACE

The 71841 includes 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 module.

## XMC INTERFACE

The 71841 complies with the VITA 42.0 XMC specification. Each of the two XMC connectors provides an 8X link with up to 10 Gb/sec per lane. With dual XMC connectors, the 71841 supports x8 PCIe on the first XMC connector (P15), leaving the optional second connector (P16) free to support user-installed transfer protocols specific to the target application.

Option -104 installs the P14 PMC connector with 24 pairs of LVDS connections to the FPGA for custom I/O.

Option -105 installs P16 providing one 8X gigabit link between the FPGA and the P16 XMC connector to support serial protocols.

## FRONT PANEL CONNECTIONS

The front panel includes four SSMC coaxial connectors for clock, PPS, and analog input signals, and a 19-pin  $\mu$ Sync input/output connector. The front panel also includes five LED indicators.



- **PPS Input Connector:** One SSMC coaxial connector, labeled **PPS IN**, for input of an external PPS or Gate signal.
- **PPS LED:** The green **PPS IN** LED illuminates when a valid PPS signal is detected. This LED will blink at the rate of the PPS signal.
- **Sync Bus Connector:** A  $\mu$ Sync 19-pin connector, labeled **SYNC\GATE**, provides clock reset, reference clock, and gate inputs for A/D processing, and a reference clock output for synchronizing multiple boards using an external sync module.
- **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 illuminates in the following ways when a valid link has been established over the PCIe interface: Gen 1 – the LED blinks slowly (less than once per second); Gen 2 – the LED blinks about once per second; Gen 3 – the LED is constantly on.
- **Analog Input Connectors:** Two SSMC coaxial connectors, labeled **IN 1** and **IN 2**, for analog signal inputs to the ADC12D1800 A/D converter. **IN 1** is connected to the Q input of the ADC12D1800; **IN 2** is connected to the I input.
- **ADC Overload LED:** There is one red **OV** overload LED for the A/D input. This LED indicates an overload detection in the ADC12D1800, or an ADC FIFO overrun.
- **Clock Input Connector:** One SSMC coaxial connector, labeled **EXT CLK IN**, for input of an external sample clock for the ADC12D1800 A/D converter.
- **Clock LED:** The green **EXT CLK IN** 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.

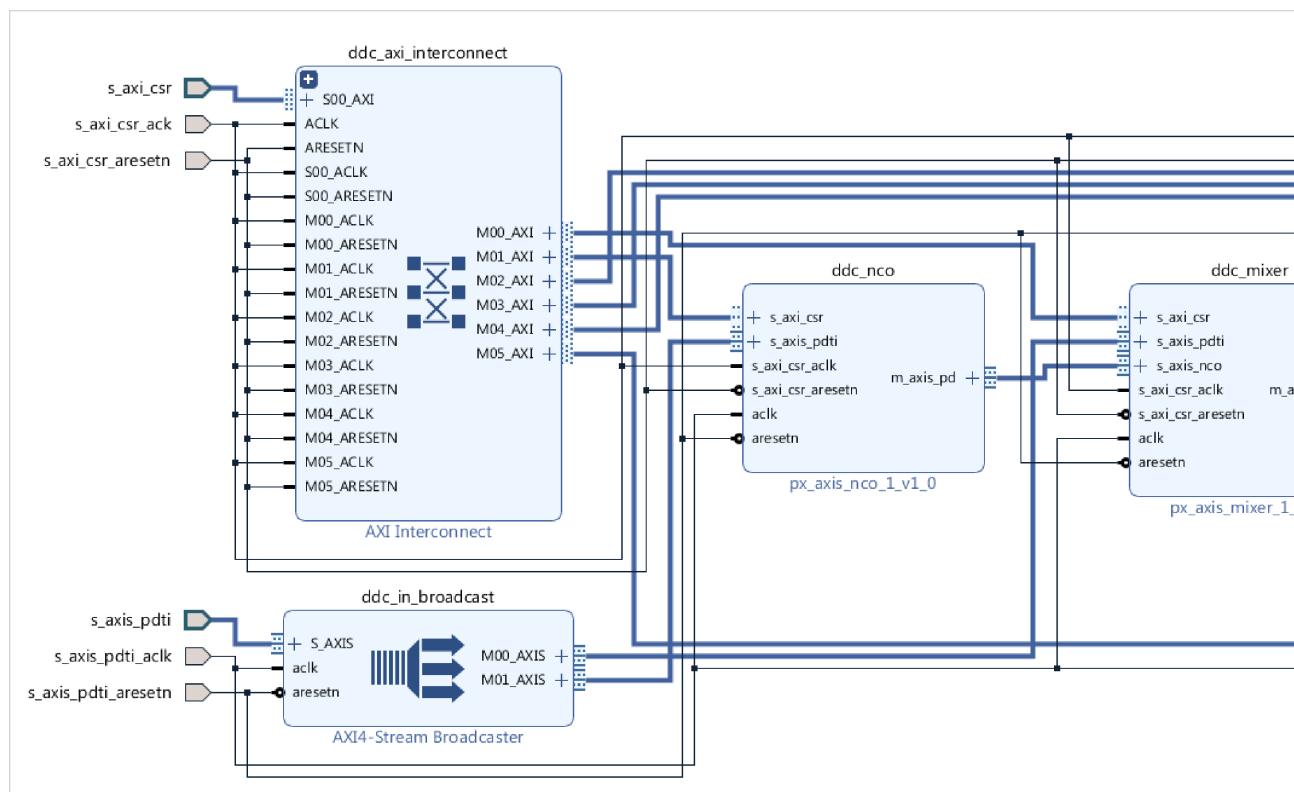
## NAVIGATOR DESIGN SUITE

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 the 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 Jade 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 Jade design. Developers can quickly import, delete, and modify IP blocks and change interconnection paths using simple mouse operations.

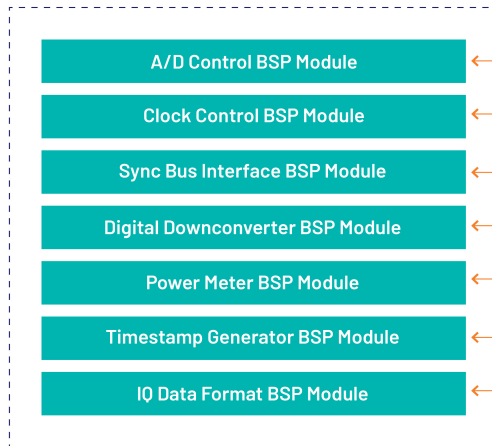
Navigator FDK includes an IP core library of more than 100 functions representing a wealth of resources for DSP, data formatting, timing, and streaming operations, all based on the powerful AXI4 standard. Multilevel documentation for each IP core is a mouse click away, and fully consistent with Xilinx IP cores.

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

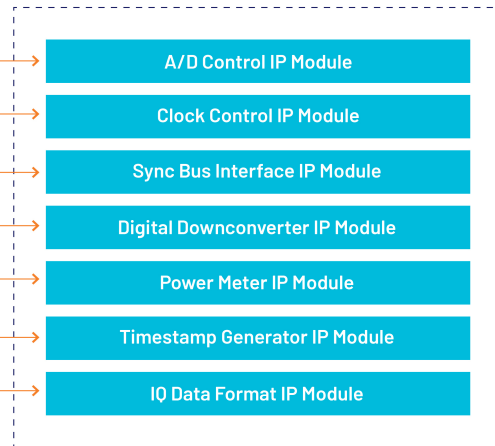


Navigator IP FPGA Design viewed in IP Integrator

## NAVIGATOR BOARD SUPPORT PACKAGE

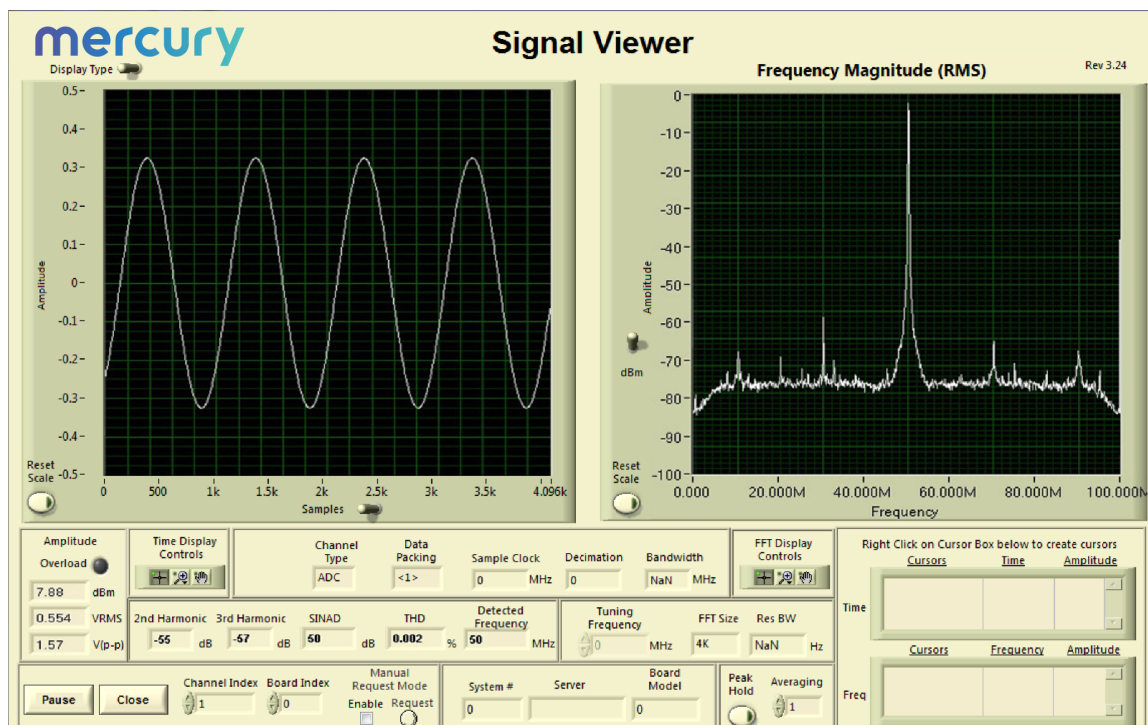


## NAVIGATOR FPGA DESIGN KIT



Because all Jade 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 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 Jade board and Navigator BSP and start viewing analog signals immediately.





## SPECIFICATIONS

### Front Panel Analog Signal Inputs

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

### A/D Converters

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 Level: may be trimmed from +2 dBm to +4 dBm with a 15-bit integer

### Digital Downconverters

Modes: One or two channels, programmable

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

Single-channel mode: decimation can be programmed to 8 or 16 to 512 in steps of 16

Dual-channel mode: decimation can be programmed to 4 or 8 to 256 in steps of 8; both channels share the same decimation value

Either mode: the DDC can be bypassed completely

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 Source

Front panel SSMC connector

### Timing Bus

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

### External Trigger Input

Type: Front panel female SSMC connector, LVTTTL

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

### Field Programmable Gate Array

Standard: Xilinx Kintex UltraScale XCKU035-2

Option -084: Xilinx Kintex UltraScale XCKU060-2

Option -087: Xilinx Kintex UltraScale XCKU115-2

### Custom I/O

Option -104: Installs the PMC P14 connector with 24 LVDS pairs to the FPGA

Option -105: Installs the XMC P16 connector configurable as one 8X gigabit serial link to the FPGA

### Memory

Type: DDR4 SDRAM

Size: 5 GB

Speed: 1200 MHz (2400 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 -713: L3 (conduction-cooled)

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

### Physical

Dimensions: Single XMC module

- Depth: 149.0 mm (5.87 in)
- Height: 74 mm (2.91 in)

Weight: Approximately 14 oz (400 grams)

## ORDERING INFORMATION

Model	Description
71841	1-channel 3.6 GHz A/D with DDC, 2-channel 1.8 GHz A/D with DDC Kintex UltraScale FPGA - XMC

Options:	
-084	XCKU060-2 FPGA
-087	XCKU115-2 FPGA
-104	LVDS FPGA I/O through P14 connector
-105	Gigabit serial FPGA I/O through P16 connector
-702	Air-cooled, Level 2
-713	Conduction-cooled, Level 3
Contact Mercury for compatible option combinations and complete specifications of rugged and conduction-cooled versions. Options may change, so be sure to contact Mercury for the latest information.	

## ACCESSORY PRODUCTS

Model	Description
2171	Cable Kit: SSMC to SMA
7192	High-Speed Synchronizer and Distribution Board
7194	High-Speed Clock Generator
9192	Rackmount High-Speed System Synchronizer

## DEVELOPMENT SYSTEMS

Mercury offers development systems for Jade 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 Jade boards. Please [contact Mercury](#) to configure a system that matches your requirements.

## FORM FACTORS

Jade products are available in standard form factors including 3U VPX, 6U VPX, PCIe, and XMC. The Jade Model 71841 XMC (1-Channel 3.6 GHz or 2-Channel 1.8 GHz 12-bit A/D with DDC, Kintex UltraScale FPGA) has the following variants:

Model	
52841	3U VPX board (single XMC)
57841	6U VPX board (single XMC)
58841	6U VPX board (dual XMC)
71841	XMC module
78841	PCIe board (single XMC)



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