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Cobalt 57651/58651

2- or 4-channel 500 MHz A/D with DDCs, DUCs with 2-or 4-channel 800 MHz D/A 6U VPX boards with Virtex-6 FPGA

Complete radar and software radio interface solution

- Radar and communication receiver and transmitter
- Electronic Warfare transponder
- Waveform signal generator
- Wideband data acquisition
- Remote monitoring
- Sensor interfaces

Models 57651 and 58651 consist of one or two 71651 XMC modules mounted on a VPX carrier board. The 57651 is a 6U board with one 71651 module while the 58651 is a 6U board with two XMC modules rather than one.

These models include two or four A/Ds, two or four multiband DDCs, one or two DUCs, two or four D/As, one or two beam formers, and four or eight banks of memory.

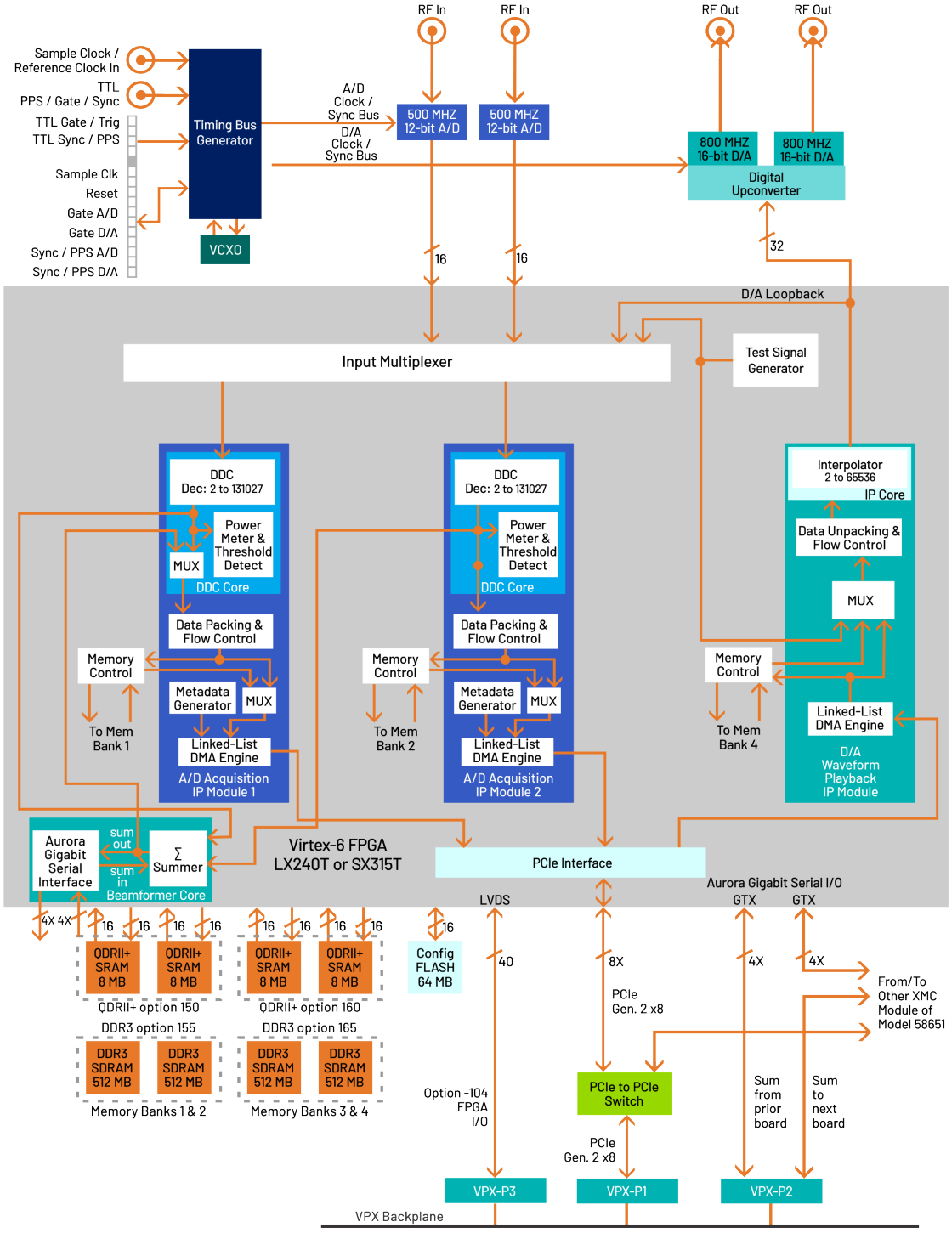
FEATURES

- Supports Xilinx® Virtex®-6 LXT and SXT FPGA
- Two or four 500 MHz 12-bit A/Ds
- Two or four multiband DDCs (digital downconverters)
- One or two DUCs (digital upconverters)
- Two or four 800 MHz 16-bit D/As
- One or two multiboard programmable beamformers
- Up to 2 or 4 GB of DDR3 SDRAM; or 16 or 32 MB of QDRII+ SRAM
- PCI Express (Gen. 1 & 2) interface up to x8
- Sample clock synchronization to an external system reference
- LVPECL clock/sync bus for multiboard synchronization
- Optional LVDS connections to the FPGA for custom I/O
- Ruggedized and conduction-cooled versions available

BLOCK DIAGRAM

Click on a block for more information.

Block diagram 57651 shows half of the 58651. 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 COBALT ARCHITECTURE

The Cobalt® Architecture features a Xilinx 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 factory-installed functions of these models include two or four A/D acquisition and one or two D/A waveform playback IP modules. Each of the acquisition IP modules contains a powerful, programmable DDC IP core. The waveform playback IP module contains an interpolation IP core, ideal for matching playback rates to the data and decimation rates of the acquisition modules. IP modules for either DDR3 or QDRII+ memories, a controller for all data clocking and synchronization functions, a test signal generator, a programmable beamforming IP core, an Aurora gigabit serial interface, and a PCIe interface complete the factory-installed functions and enable these models to operate as complete 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-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.

A/D CONVERTER STAGES

The board's analog interface accepts two or four analog HF or IF inputs on front panel SSMC connectors with transformer coupling into two or four Texas Instruments ADS5463 500 MHz, 12-bit A/D converters.

The digital outputs are delivered into the Virtex-6 FPGAs for signal processing, data capture and for routing to other module resources.

A/D ACQUISITION MODULES

These models feature two or four A/D Acquisition IP Modules for easily capturing and moving data. Each module can receive data from either of the two A/Ds, a test signal generator or from the D/A Waveform Playback IP Module in loopback mode.

Each IP module has an associated memory bank for buffering data in FIFO mode or for storing data in transient capture mode. All memory banks are supported with DMA engines for easily moving A/D data through the PCIe interface.

These powerful linked-list DMA engines are 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/D channel ID, 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 each A/D Acquisition IP Module is a powerful DDC IP core. Because of the flexible input routing of the A/D Acquisition IP Modules, many different configurations can be achieved including one A/D driving both DDCs or each of the two A/Ds driving its own DDC.

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. Each DDC can have its own unique decimation setting, supporting as many as two different output bandwidths for the board. Decimations can be programmed from 2 to 131,072 providing a wide range to satisfy most applications.

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 $0.8*f_s/N$, 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 24-bit I + 24-bit Q or16-bit I + 16-bit Q samples at a rate of f_s/N.

BEAMFORMER IP CORE

In addition to the DDCs, these models feature one or two complete beamforming subsystems. Each DDC core contains programmable I & Q phase

and gain adjustments followed by a power meter that continuously measures the individual average power output. The time constant of the averaging interval for each meter is programmable up to 8K samples. The power meters present average power measurements for each DDC core output in easy-to-read registers.

In addition, each DDC core includes a threshold detector to automatically send an interrupt to the processor if the average power level of any DDC core falls below or exceeds a programmable threshold.

A programmable summation block provides summing of any of the DDC core outputs. An additional programmable gain stage compensates for summation change bit growth. A power meter and threshold detect block is provided for the summed output. The output is then directed back into the A/D Acquisition IP Module 1 FIFO for reading over the PCIe. For larger systems, multiple models can be chained together via a built-in Xilinx Aurora gigabit serial interface through the dual 4X serial connector. This allows summation across channels on multiple boards.

D/A WAVEFORM PLAYBACK IP MODULES

The factory-installed functions in these models include one or two sophisticated D/A Waveform Playback IP modules. A linked-list controller allows users to easily play back to the dual D/As waveforms stored in either on-board memory or off-board host memory .

Parameters including length of waveform, delay from playback trigger, waveform repetition, etc. can be programmed for each waveform.

Up to 64 or 128 individual link entries can be chained together to create complex waveforms with a minimum of programming.

DIGITAL UPCONVERTER AND D/A STAGES

One or two Texas Instruments DAC5688 DUCs (digital upconverters) and D/As accept baseband real or complex data from the FPGAs and provide that input to the upconvert, interpolate and dual D/A stages.

When operating as a DUC, it interpolates and translates real or complex baseband input signals to any IF center frequency up to 360 MHz. It delivers real or quadrature (I+Q) analog outputs to the dual 16-bit D/A converter. Analog output is through a pair of front panel SSMC connectors.

If translation is disabled, the DAC5688 acts as a dual interpolating 16-bit D/A with output sampling rates up to 800 MHz. In both modes the DAC5688 provides interpolation factors of 2x, 4x and 8x. In addition to the DAC5688, an FPGA-based interpolator core provides additional interpolation from 2x to 65,536x. The two interpolators can be combined to create a total range from 2x to 524,288x.

CLOCKING AND SYNCHRONIZATION

Two internal timing buses provide either a single clock or two different clock rates to the A/D and D/A signal paths.

Each timing bus includes a clock, sync and a gate or trigger signal. An on-board clock generator receives an external sample clock from the front panel SSMC connector. This clock can be used directly for either the A/D or D/A sections or can be divided by a built-in clock synthesizer circuit to provide different A/D and D/A clocks. In an alternate mode, the sample clock can be sourced from an on-board programmable VCXO (Voltage-Controlled Crystal Oscillator). In this mode, the front panel SSMC connector can be used to provide a 10 MHz reference clock for synchronizing the internal oscillator.

A front panel 26-pin LVPECL Clock/Sync connector allows multiple boards to be synchronized. In the slave mode, it accepts LVPECL inputs that drive the clock, sync and gate signals. In the master mode, the LVPECL bus can drive the timing signals for synchronizing multiple boards.

Multiple boards can be driven from the LVPECL bus master, supporting synchronous sampling and sync functions across all connected boards.

MEMORY RESOURCES

The Cobalt architecture supports up to three or six independent memory banks which can be configured with QDRII+ SRAM, DDR3 SDRAM, or as combination of two banks of each type of memory.

Each QDRII+ SRAM bank can be up to 8 MB deep and is an integral part of the board's DMA capabilities, providing FIFO memory space for creating DMA packets. For applications requiring deep memory resources, DDR3 SDRAM banks can each be up to 512 MB deep. Built-in memory functions include an A/D data transient capture mode and D/A waveform playback mode.

In addition to the factory-installed functions, custom user-installed IP within the FPGA can take advantage of the memories for many other purposes.

PCI EXPRESS INTERFACE

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

READYFLOW

Mercury provides ReadyFlow® 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.

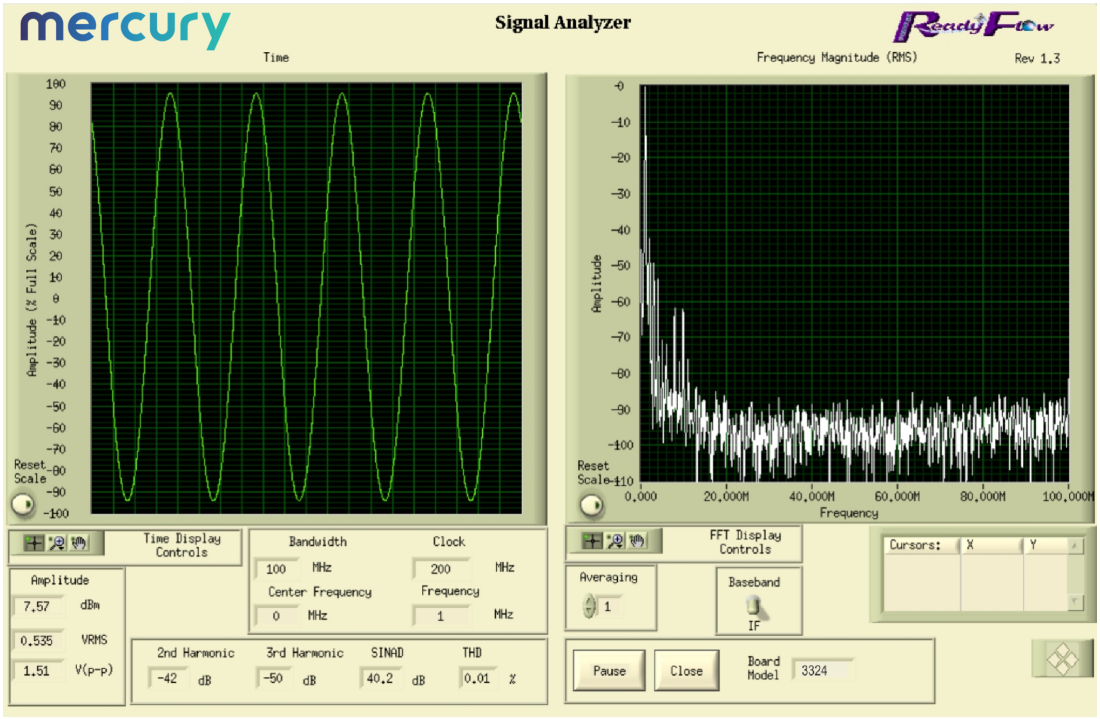
COMMAND LINE INTERFACE

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® 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.

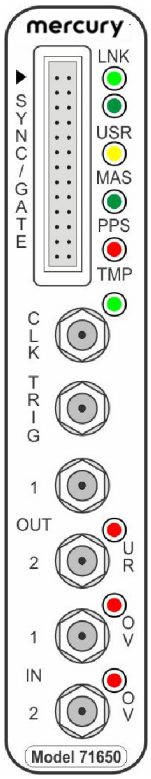
The User Application Container

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 a 26-pin µSync connector, and six SSMC coaxial connectors for input/output of timing and analog signals. The front panel also includes nine LEDs.



- Sync Bus Connectors: The 26-pin Sync Bus front panel connector, labeled SYNC/GATE, provides clock, sync and gate input/output pins for the Low-Voltage Positive Emitter-Coupled Logic (LVPECL) Sync Bus.
- **Link LED:** The green **LNK** LED blinks when a valid link has been established over the PCIe interface.
- **User LED:** The green **USR** LED is for user applications.
- **MAS LED:** The yellow **MAS** LED illuminates when this model is the Sync Bus Master.
- **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.
- **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.
- **Clock Input Connector:** One SSMC coaxial connector, labeled **CLK** for the input of an external sample or reference clock.
- **Trigger Input Connector:** One SSMC coaxial connector, labeled **TRIG** for input of an external gate or trigger signal.
- **Analog Output Connectors:** Two SSMC coaxial connectors, labeled **1 OUT**and **2 OUT** for the DAC5688 output.
- **DAC Underrun LED:** There is one red **UR** (underrun) LED for the D/A output. This LED illuminates when the DAC5688 FIFO is out of data.

  ADC Overload LED: There are two red **OV** (overload) LEDs, one for each A/D input. Use the application ADC Data Control Register to select the signal source for the associated LED.
- **Analog Input Connectors:** Two SSMC coaxial connectors, labeled **1 IN** and **2 IN** for the ADC input channels.

SPECIFICATIONS

57651: 2 A/Ds, 2 DDCs, 1 DUC, 2 D/As;
58651: 4 A/Ds, 4 DDCs, 2 DUCs, 4 D/As

Front Panel Analog Signal Inputs (2 or 4)

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

Transformer Type: Coil Craft WBC4-6TLB

Full Scale Input: +5 dBm into 50 ohms

3 dB Passband: 300 kHz to 700 MHz

A/D Converters (standard) (2 or 4)

Type: Texas Instruments ADS5463

Sampling Rate: 20 MHz to 500 MHz

Resolution: 12 bits

A/D Converters (option -014) (2 or 4)

Type: Texas Instruments ADS5474

Sampling Rate: 20 MHz to 400 MHz

Resolution: 14 bits

Digital Downconverters (2 or 4)

Quantity: Two channels

Decimation Range: 2x to 131,072x in two programmable stages of 2x to 256x and one fixed 2x stage

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: 16-bit coefficients, 24-bit output, with user programmable coefficients

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

D/A Converters (2 or 4)

Type: Texas Instruments DAC5688

Input Data Rate: 250 MHz max.

Output IF: DC to 400 MHz max.

Output Signal: 2-channel real or 1-channel with frequency translation

Output Sampling Rate: 800 MHz max. with 2x, 4x or 8x interpolation

Resolution: 16 bits

Digital Interpolators (1 or 2)

Interpolation Range: 2x to 65,536x in two stages of 2x to 256

Beamformers (1 or 2)

Summation: Two channels on-board; multiple boards can be summed via Summation Expansion Chain

Summation Expansion Chain: One chain in and one chain out link via a dual 4X connector using Aurora protocol

Phase Shift Coefficients: I & Q with 16-bit resolution

Gain Coefficients: 16-bit resolution

Channel Summation: 24-bit

Multiboard Summation Expansion: 32-bit

Front Panel Analog Signal Outputs (2 or 4)

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

Transformer Type: Coil Craft WBC4-6TLB

Full Scale Output: +4 dBm into 50 ohms

3 dB Passband: 300 kHz to 700 MHz

Sample Clock Sources (2 or 4)

On-board clock synthesizer generates two clocks: one A/D clock and one D/A clock

Clock Synthesizers (1 or 2)

Clock Source: Selectable from on-board programmable VCXO (10 to 810 MHz), front panel external clock or LVPECL timing bus

Synchronization: VCXO can be locked to an external 4 to 180 MHz PLL system reference, typically 10 MHz

Clock Dividers: External clock or VCXO can be divided by 1, 2, 4, 8, or 16, independently for the A/D clock and D/A clock

External Clocks (1 or 2)

Front panel female SSMC connector, sine wave, 0 to +10 dBm, AC-coupled, 50 ohms, accepts 10 to 800 MHz sample clock or PLL system reference

Timing Bus (1 or 2)

26-pin connector LVPECL bus includes, clock/sync/gate/PPS inputs and outputs; TTL signal for gate/trigger and sync/PPS inputs

Field Programmable Gate Arrays (1 or 2)

Standard: Xilinx Virtex-6 XC6VLX240T-2

Optional: Xilinx Virtex-6 XC6VSX315T-2

Custom I/O

- Option -104: Provides 20 LVDS pairs between the FPGA and the VPX P3 connector, 57651; P3 and P5, 58651

Memory (1 or 2)

- Option -150 or -160: Two 8 MB QDRII+ SRAM memory banks, 400 MHz DDR
- Option -155 or -165: Two 512 MB DDR3 SDRAM memory banks, 400 MHz DDR

PCI Express Interface

PCI Express Bus: Gen. 1 or Gen. 2, 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: -20° to 65° C
- Storage Temp: -40° to 100° C
- Relative Humidity: 0 to 95%, non-condensing

Physical

Dimensions:

- Depth: 171 mm (6.717 in.)
- Height: 100 mm (3.937 in.)

Weight: VPX Carrier: 110 grams (3.9 oz)

ORDERING INFORMATION

Model	Description
57651	2-Channel 500 MHz A/D with DDC, DUC with 2-Channel 800 MHz D/A, and a Virtex-6 FPGA 6U VPX
58651	4-Channel 500 MHz A/D with DDCs, DUCs with 4-Channel 800 MHz D/A, and two Virtex-6 FPGAs 6U VPX

Options	Description
-002*	-2 FPGA speed grade
-014	400 MHz, 14-bit A/Ds
-062	XC6VLX240T FPGA
-064	XC6VSX315T FPGA
-104	LVDS I/O between the FPGA and P3 connector, 57651; P3 and P5 connectors, 58651
-105	Gigabit link between the FPGA and P2 connector, 57651; gigabit links from each FPGA to P2 connector, 78651
-150	Two 8 MB QDRII+ SRAM Memory Banks (Banks 1 and 2)
-155	Two 512 MB DDR3 SDRAM Memory Banks (Banks 1 and 2)
-160	Two 8 MB QDRII+ SRAM Memory Banks (Banks 3 and 4)
-165	Two 512 MB DDR3 SDRAM Memory Banks (Banks 3 and 4)
-702	Air-cooled, Level 2
-763	Conduction-cooled, Level 3

*This option is always required. Contact Mercury for compatible option combinations.

ACCESSORY PRODUCTS

Model	Description
2171	Cable Kit: SSMC to SMA

FORM FACTORS

Cobalt products are available in standard form factors including 3U VPX, 6U VPX, PCIe, and XMC. The Cobalt Model 71651 XMC (2-Channel 500 MHz A/D with DDC and 2-Channel 800 MHz D/A with DUC, Virtex-6 FPGA) has the following variants:

Model	
52651	3U VPX board (single XMC)
57651	6U VPX board (single XMC)
58651	6U VPX board (dual XMC)
71651	XMC module
78651	PCIe board (single XMC)

DEVELOPMENT SYSTEMS

Mercury offers development systems for Cobalt 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 Cobalt boards. Please contact Mercury to configure a system that matches your requirements.

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