DATASHEET

Ensemble® 6000 Series
OpenVPX, Intel 3rd Generation Xeon 12-core, Infiniband/Ethernet High Density Server-Class Processing Blade
HDS6603 Processing Module

Most Powerful, Rugged, Single Slot Intel Server-Class Processing Power for Advanced Radar, IMINT and Other Compute Intense Applications

- **6U OpenVPX™ single 1-inch slot module**
- **Dual Intel® 1.8GHz 12-core Xeon® (with Haswell architecture) server-class processors**
- **Wellsburg bridge architecture**
- **1.38 TFLOPS peak processing power**
- **40 Gigabit Ethernet or InfiniBand high bandwidth switching:**
  - **– Ethernet ecosystem; 10GBASE-KX4, 10GBASE-KR and 40GBASE-KR4**
  - **– Or InfiniBand ecosystem; SDR, DDR, QDR and FDR10**
- **Up to 32 GB DDR4-2133 SDRAM (per processor)**
- **Gen3 PCIe co-processing and I/O expansion plane communications**
- **Air-cooled and rugged Air Flow-By™ & Conduction-cooled options**

The HDS6603 is Mercury's fourth generation Intel® Xeon® server-class, OpenVPX™ processing capability that leverages over four years of advance IRAD to deliver the first single slot module to break the 1 TFLOP general processing benchmark.

Dual Intel Xeon x86 processors, each with 12 cores, Haswell architecture and Wellsburg Bridge (collectively called Grantley) and the support of unrestricted 40Gb/s Ethernet and FDR10 fabric bandwidth deliver scalable and unmatched general processing horsepower. Mechanical ruggedness and the effective Air Flow-By cooling technology ensure the highest MTBF even under full throttle, continuous processing conditions.

The HDS6603 is part of Mercury's Xeon server-class ecosystem of OpenVPX building blocks that includes other Intel Haswell and Xeon processor solutions, 40 Gb/s Ethernet/InfiniBand switches and intelligent mezzanine carrier boards. These may be quickly configured and developed in the lab using concurrent engineering disciplines and Mercury's 6 and 16 slot development chassis. Supporting Mercury's Xeon server-class ecosystem is Mellanox's Connect-X3 40Gb/s enabled fabrics and tuned signal channels for unrestricted 40Gb/s and faster fabrics.

Mercury's Xeon server-class OpenVPX ecosystem is the most powerful Open System Architecture (OSA) available for general processing, enabling true on-platform cloud processing at the tactical edge. Eminently suited to Radar, Electro-Optical/InfraRed (EO/IR) and complex Image Intelligence (IMINT) applications, this standard 1-inch, 6U OpenVPX form factor module enables compute capabilities that were never previously possible adding new functionality and autonomy to modern missions.

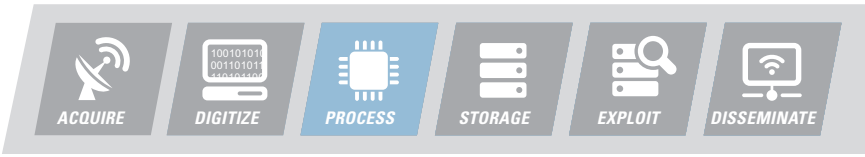
Haswell Ecosystem

Intel's Haswell architecture includes Fused, Multiple-Add (FMA) which is especially valuable for radar processing applications, that routinely requires the summing of vast arrays of multiplied numbers. The inclusion of FMA enables complex radar and similar operations to be performed approximately twice as quickly as before as Fast Fourier Transformations (FFTs) and other matrix manipulations are now handled more efficiently than ever before.

Xeon Server-Class Ecosystem

The HDS6603 features two Intel 64-bit Xeon (E5-2648L v3) 12-core processors. The HDS6603 is Mercury's fourth generation of Xeon server-class technology and demonstrates a high Technology Readiness Level (TRL). HDS6603 utilizes unique and robust packaging technologies to support two instances of high-pin-count Land Grid Array (LGA)

Mercury Systems is the better alternative for affordable, secure processing subsystems designed and made in the USA. These capabilities make us the first commercially based defense electronics company built to meet rapidly evolving next-generation defense challenges.



processors in a rugged, embedded form factor. The dual 12-core processors are linked via two instances of the high-speed, low-latency Quick Path Interconnect (QPI) interface, each of which provides a 38 GB/s (bi-directional) data transfer rate, for a staggering total of 76 GB/s of bandwidth between processors. This interconnected processor architecture is optimized for the intense data movement needed by high performance processing algorithms, such as all-to-all corner turn operations. From a software perspective, this QPI architecture allows the HDS6603 to be configured with a single kernel NUMA-aware operating system running across both processor devices.

Each processor is capable of delivering a staggering 0.69 TFLOPS (peak), with four high-speed, 15 GB/s DDR4-2133 memory channels raw bandwidth each, for an incredible total peak of 1.38 TFLOPS and 120 GB/s total raw memory bandwidth. The HDS6603 refines the innovative standing memory technology first seen on the HDS6600, HDS6601 and HDS6602 to support up to 128 GB of DRAM on-board for the ultimate in DRAM density in the OpenVPX family of processing modules. Native Gen3 PCIe support is also featured on this processor, linking the processing resources directly to the I/O sources on the module. The HDS6603 also makes use of the Wellsburg Platform Controller Hub (PCH) chipset, which provides additional I/O bridging between the Intel processor and external devices.

Each E5-2648L v3 processor includes a large 30 MB cache, shared between the cores, allowing many high performance calculations to remain cache resident. This accelerates processing by eliminating the potential latency required to access DRAM to fetch upcoming data. The Haswell Bridge family of processors also supports the proven AVX2 instruction set, delivering a revolutionary increase in floating-point algorithm performance that is portable to future Intel architectures.

High Speed Fabric Interfaces

The HDS6603 continues the tradition from Mercury to combine the processing power of Intel processors with high speed switched fabric interfaces.

The HDS6603 compliments Mercury's other OpenVPX module that feature Mellanox's ConnectX-3 host adaptors for data plane communications. Bridging between the native Gen3 PCIe interfaces on the Intel processors and the OpenVPX data plane, the ConnectX-3 can be configured to support InfiniBand (DDR, QDR or FRD10) or 10/40 Gigabit Ethernet as the data protocol. This advancement scales the data plane bandwidth to up to a peak theoretical rate of up to 5 GB/s per port, or 20 GB/s aggregate across the entire four-port OpenVPX data plane. By scaling the data plane bandwidth to match the increase in processing performance, the HDS6603 architecture ensures that the processor is never starved for data.

	Module I/O
	Backplane
InfiniBand	DDR/QDR/FDR10
Or Ethernet	4 x XAUI (10Gb)
USB 3.0	1
USB 2.0	2
Gen 3 PCIe (8x)	32 - Dual full x16 or dual x8
1000BASE-T Gigabit Ethernet	1
1000BASE-BX SERDES Ethernet	2
SATA	2
RS232/RS422	2 x RS-422 4 x RS-232

By utilizing the Mellanox ConnectX-3 device and innovative OpenVPX interconnect technology the HDS6603 is a model for open architecture high performance computing throughout the embedded industry. Mercury OpenVPX subsystems feature robust signal rates that comfortably exceed the margin of the channel to surpass the rate of modern fabrics, delivering the fastest compute solution in the industry with future proof performance headroom.

The HDS6603 module is compliant to the VITA 65 module profile MOD6-PAY-4F1Q2U2T-12.2.1-n, where n can vary based on ConnectX-3 configuration. The HDS6603 is supported in chassis slots compliant with VITA 65 slot profile SLT6-PAY-4F1Q2U2T-10.2.1.

PCIe Architecture

The HDS6603 provides high end Gen3 PCIe backplane interfaces via the native PCIe resources on the E5-2648L v3 processor. In addition to supporting the processor's interface to the ConnectX-3 bridges described above, an additional x16 Gen3 PCIe interface is provided to the OpenVPX expansion plane interface on both the P2 and P5 VPX connectors. These interfaces enable the HDS6603's compatibility with Mercury's GPU, FPGA, or mezzanine carrier modules. The interfaces are user configurable to lower port widths, and can also support Non Transparent (NT) bridge functionality at run time. These configuration options support the construction of complex PCIe trees with many other PCIe-capable devices.

System Management Plane

The HDS6603 module implements the advanced system management functionality architected in the OpenVPX Standard to enable remote monitoring, alarm management, and hardware revision and health status.

Using the standard I^2C bus, Intelligent Platform Management Controller (IPMC), and IPMI protocol, the on board system-management block implementation is designed to comply with VITA 46.11. This allows the HDS6603 module to:

- Read sensor values
- Read and write sensor thresholds, allowing an application to react to thermal, voltage, or current variations that exceed those thresholds
- Reset the entire module
- Power up/down the entire module
- Retrieve module Field Replaceable Unit (FRU) information
- Be managed remotely by a Chassis Management Controller at the system level

Additional Features

The HDS6603 module provides all the features typically found on a single-board computer. In addition to the sophisticated management subsystem and fabric interconnect, the HDS6603 module provides users with a toolkit enabling many different application features including:

- Thermal and voltage sensors integrated on-board
- Real-time clock with accuracy better than 10ppm<1second per day
- General purpose timers
- Global clock synchronization capabilities via the OpenVPX utility plane clock signals
- Watchdog timer to support interrupt or reset
- Multiple boot paths, include netboot, USB boot, boot from SATA, or from the on-board 8GB flash device

Open Software Environment

Mercury leverages over 30 years of multicomputing software expertise, including recent multicore processor expertise, across its many platforms. This strategy is fully applied to the HDS6603 module. The same Linux® development and run-time environment is implemented on the HDS6603 module as on other Intel based Mercury OpenVPX modules across the Ensemble 3000 and 6000 Series. Off-the-shelf open software such as OFED and OpenMPI are fully supported by the Mellanox ConnectX-3 data plane.

Mercury's OpenVPX Ecosystem

Sensor processing chain awareness, building blocks and ecosystem Sensor chain awareness is having the technical expertise and resources to design and build capable, compatible solutions along the whole sensor processor chain. From RF/microwave, digital/analog signal manipulation to dense, SWaP optimized processing resources to actionable intelligence dissemination; Mercury's rugged processing subassemblies leverage the best commercial-item technology, enabling prime contractors to win more business.

Modern sensor processing subassemblies are customized assemblies of interoperable building blocks built to open standard architectures. Mercury's hardware and software portfolio of building blocks are physically and electrically interoperable as defined by international industrial standards, including OpenVPX.

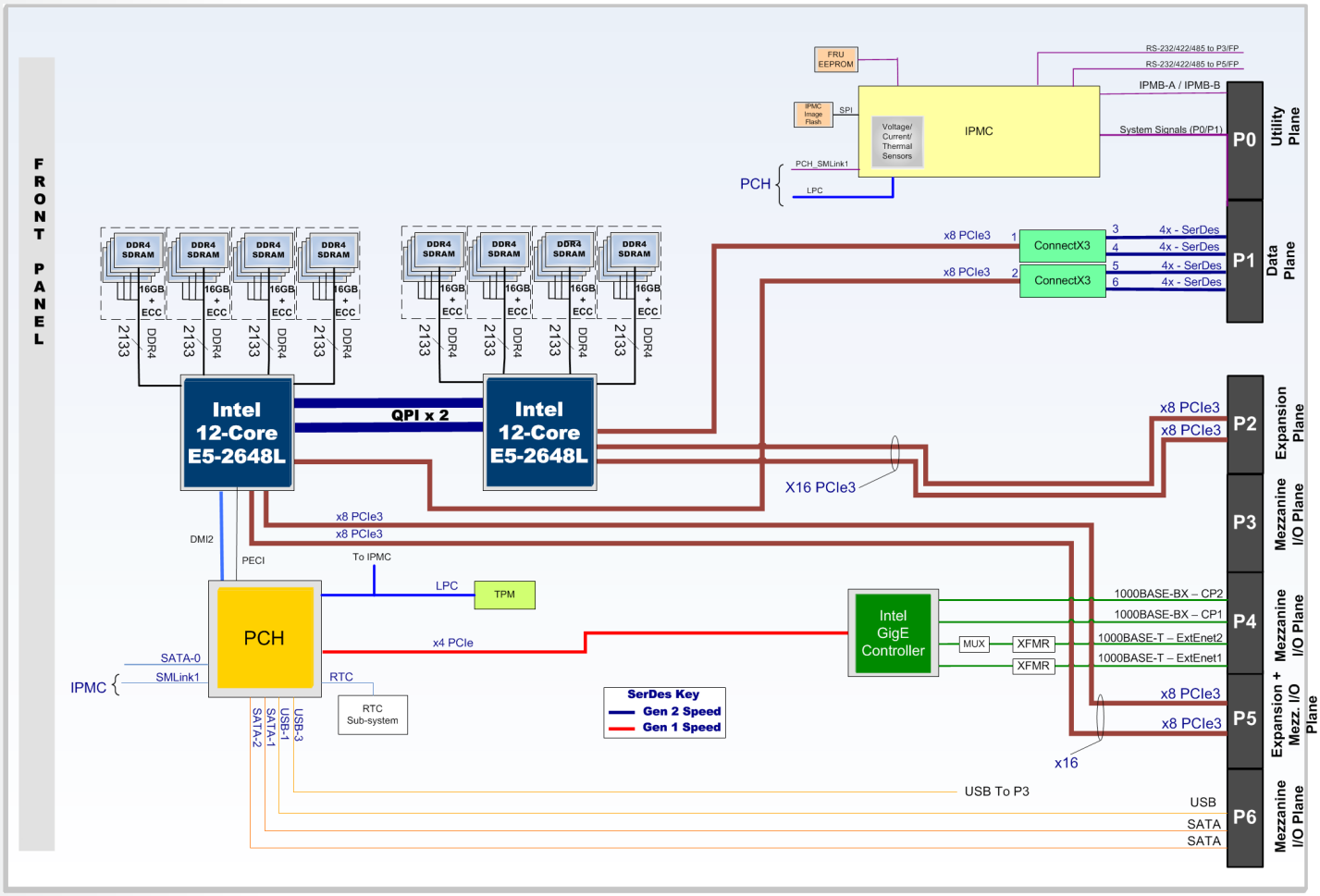


Figure 1. *HDS6603 functional block diagram*

System Bandwidth – The Effect of Interconnect Performance

Bandwidth is critical and especially applicable to switched fabric resources which dictate the responsiveness of the entire subsystem. All modular solutions, including OpenVPX are to some degree, interconnect-bound; they are restricted by the limitations of the best industry interconnect technology. To address this, Mercury fabricates system interconnections with innovative technology which mitigates insertion-loss and cross-talk while maintaining full VITA/ OpenVPX compliance. The resulting system performance boost enables the latest fabrics to run at full, unencumbered speed.

Module Packaging

VPX-REDI

The VPX (VITA 46) standard defines 6U and 3U board formats with high performance interconnects capable of supporting today's high speed fabric interfaces. VPX may be paired with the ruggedized enhanced design implementation standard — REDI (VITA 48). SFM6104 modules when implemented as conduction-cooled or Air Flow-By™ are VPX-REDI compatible. Air-cooled equivalents conform to the same OpenVPX form factor and are suitable for less challenging environments. Targeted for harsh embedded environments, VPX-REDI supports higher functional density and two-level maintenance (2LM). 2LM allows relatively unskilled maintenance personnel to replace a failed module.

Rugged Air Flow-By

Air- and conduction-cooled subsystems rely on filtration to remove contaminants from their cooling air streams. Mercury's Air Flow-By technology eliminates filtration with the most elegant cooling solution available within a sealed and rugged package. Fully compliant to VITA standards (including VITA 48.7), Air Flow-By maintains OpenVPX's 1-inch pitch requirement, is highly resilient to liquid and particle contamination, boosts SWaP, reduces operating temperature, extends MTBF by an order of magnitude and enables embedded deployment of the most powerful and reliable processing solutions. HDS6603 modules are available as air-cooled (various levels of ruggedness), and rugged Air Flow-By and conduction-cooled variants.

Specifications

Processors

Dual Intel 1.8GHz 12-core E5-2648L v3 (Wellsburg Bridge) server-class processors

Peak performance	1.38 TFLOPS per module
Threads per core	2
QPI interface between processors	2 x 9.6 GT/s (or 38 GB/s per processor, per direction, 76 GB/s total) peak performance

Dual Integrated x16 Gen3 PCIe interface

Memory

Up to 64 GB DDR4-2133 with ECC

Raw memory bandwidth: 60 GB/s per processor

BIOS

SPI flash: Dual 8 MB partitions

NAND flash: 8 GB, SATA interface

Data Plane PCIe to Switched Fabric Bridge

Mellanox ConnectX-3 VPI host adapter

Support DDR/QDR/FDR10 InfiniBand or 40 Gigabit Ethernet protocols

Ethernet Connections

Ethernet functions supported by the chipset include:

UDP, TCP, SCTP, ARP, IPv4, IPv6, IEEE1588, flow control, 802.1P (priority) and 802.1Q (VLAN)

IPMI (Intelligent Platform Management Interface)

On-board IPMI controller

Voltage and temperature monitor

Geographical address monitor

Power/reset control

FRU and on-board EEPROM interfaces

FPGA, CPU, and CPLD interfaces

OpenVPX Multi-Plane Architecture

System Management via IPMB-A and IPMB-B link on P0 management plane

InfiniBand or 40 Gigabit Ethernet interfaces on data plane

Dual full x16 or dual x8 PCIe Gen3 expansion plane

Dual 1000BASE-BX Ethernet control plane

Mechanical

6U OpenVPX

1.0" slot pitch

OpenVPX and VPX REDI

Power consumption:

- ~75W per processor
- ~180W per module

Weight:

Air-cooled	2.24lbs
Air Flow-By	3.00lbs
Conduction-cooled	4.1lbs

Standard Compliance

OpenVPX System Standard (VITA 65) encompasses:

- VITA 46.0, 46.3, 46.4, 46.6, 46.11, and VITA 48.1, 48.2 (REDI)
- VITA 65 module profile MOD6-PAY-4F1Q2U2T-12.2.1-n (where n can vary based on ConnectX-3 configuration)

Environmental

		Environmental Qualification Levels		
		Air-cooled	Air Flow-By	Conduction-cooled
		Commercial L0	Rugged L4	Rugged L3
Ruggedness		•	•••	•••
Moisture/dust protection		•	•••	•••
Typical cooling performance		~140W*	~200W*	~150W**
Temperature	Operating*	0°C to +40°C	-40°C to +60°C	-40°C to +71°C
Operating temperature maximum rate of change		N/A	10°C/min	10°C/min
Temperature	Storage	-40°C to +85°C	-55°C to +125°C	-55°C to +125°C
Humidity	Operating*	10-90%, non-condensing	5-95%, non-condensing 100% condensing	5-95%, non-condensing 100% condensing
	Storage	10-90%, non-condensing	5-95%, non-condensing 100% condensing	5-95%, non-condensing 100% condensing
Altitude	Operating*	0-10,000ft	0-30,000ft	0-70,000ft
	Storage	0-30,000ft	0-70,000ft	0-70,000ft
Vibration	Random	0.003 g^2/Hz; 20-2000 Hz, 1 hr/axis	0.1 g^2/Hz; 5-2000 Hz, 1 hr/axis	0.1 g^2/Hz; 5-2000 Hz, 1 hr/axis
	Sine	N/A	10G peak; 5-2000 Hz, 1 hr/axis	10G peak; 5-2000 Hz, 1 hr/axis
	Shock	z-axis: 20g; x and y-axes: 32g; (11ms ½-sine pulse, 3 positive, 3 negative)	z-axis: 50g; x and y-axes: 80g; (11ms 1/2-sine pulse, 3 positive, 3 negative)	z-axis: 50g; x and y-axes: 80g; (11ms 1/2-sine pulse, 3 positive, 3 negative)
Salt/Fog		N/A	10% NaCl	10% NaCl
VITA 47		Contact Factory		

* Customer must maintain required cfm level. Consult factory for the required flow rates.

** Card edge should be maintained below 71°C

Storage Temperature is defined per MIL-STD-810F, Method 502.4, para 4.5.2, where the product under non-operational test is brought to an initial high temperature cycle to remove moisture. Then the unit under non-operational test will be brought to the low storage temperature. The low temperature test is maintained for 2 hours. The product is then brought to the high storage temperature and is maintained for 2 hours. The product is then brought back to ambient temperature. All temperature transitions are at a maximum rate of 10°C/min. One cold/hot cycle constitutes the complete non-operational storage temperature test. This assumes that the board level products are individually packaged in accordance with ASTM-D-3951 approved storage containers. These tests are not performed in Mercury shipping containers, but in an unrestrained condition. Please consult the factory if you would like additional test details.

All products manufactured by Mercury meet elements of the following specifications: MIL-STD-454, MIL-STD-883, MIL-HDBK-217F, and MIL-I-46058 or IPC-CC-830, and various IPC standards. Mercury's inspection system has been certified in accordance with MIL-I-45208A.

Additional Services

Optional Environmental Screening and Analysis Services		Standard Module, Optional Services	
• Cold Start Testing	• Safety Margin Analysis	• Engineering Change Order (ECO) Notification	• Alternate Mean Time Between Failure (MTBF) Calculations
• Cold Soak Testing	• Temperature Cycling	• ECO Control	• Hazmat Analysis
• Custom Vibration	• Power Cycling	• Custom Certificate of Conformity (CofC)	• Diminished Manufacturing Sources (DMS) Management
• CFD Thermal Analysis	• Environmental Stress Screening	• Custom UID Labeling	• Longevity of Supply (LOS)
• Finite Element Analysis			• Longevity of Repair (LOR)
Contact factory for additional information			

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mercury systems™

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