

# Ensemble® 6000 Series

## Dual AMD GPGPU Processing

### OpenVPX GSC6201 6U GPGPU Module



Over 4 TFLOPS of high-performance stream processing in a single 6U OpenVPX slot for rugged environments

- Industry's highest performance using latest generation AMD Radeon™ HD 6970M and HD 7970M GPGPU
- Mercury's StreamDirect™ for GPGPUs increases overall system efficiency and intelligence gathering
- Industry standard MXM form factor ensures rapid access to latest generation GPGPUs, including over 4 TFLOPS in a single 6U slot with the AMD Radeon HD 7970M
- Open standards OpenCL™ and Mercury's Scientific Algorithm Library (SAL™) for optimized, platform-independent C/C++ application development
- Rugged conduction-cooled module exceeds strict VITA 47 standards for shock and vibration to operate in the harshest environments

The Ensemble® GSC6201 is a 6U OpenVPX™ carrier module that integrates two high-performance AMD GPGPUs for applications that can benefit from massively parallel processing on streams of high-bandwidth data. GPGPUs offer some of the highest GFLOP processing performance as well as the highest GFLOP/Watt performance efficiency in the industry.

#### Meeting Today's Processing Demands

Commercial and defense applications such as radar, Electro-Optical/Infrared (EO/IR), electronic warfare and cyber generate large amounts of raw sensor or network data that need to be processed in real-time to extract actionable intelligence. Each new generation of sensor arrays ushers in higher resolutions and frame rates; along the same lines, network traffic is also increasing exponentially. Consequently, the input levels from both of these data streams are now reaching Big Data proportions. By offloading compute-intensive operations to GPGPUs such as Fast Fourier Transforms (FFTs), matrix multiplication, Constant False Alarm Rate (CFAR), QR Decomposition (QRD), Synthetic Aperture Radar (SAR), video codecs (H.264, JPEG2000), pattern recognition or deep packet inspection, system architects can engineer solutions that can meet today's processing demands — with room to scale for higher performance requirements in the future while preserving significant IP investment.

The GSC6201 is Mercury's 4th generation 6U dual GPGPU MXM module, backed with a history of field-proven deployments in a number of defense programs since 2008. Updates to the new GSC6201 include higher I/O bandwidth, StreamDirect for GPGPUs and support for both AMD Radeon HD 6970M and HD 7970M.

#### StreamDirect for GPGPUs: Faster Intelligence

Mercury's StreamDirect writes data directly from the sensor straight into GPGPU memory, reducing data latency by 50 percent, thereby allowing the raw data to be processed immediately for analysis and intelligence. It does this by bypassing the CPU that previously served as traffic manager. Because the CPU is no longer the bottleneck, additional sensor/GPGPU processing slices can be added to the system to significantly increase processing capability while optimizing for SWaP. Previously, systems that used GPGPUs relied on host CPU memory copies to transfer data from the sensor to GPU. Incoming streams of sensor data had to first be written to the host CPU memory allocated for the sensor, and then copied to another buffer allocated for the GPU, and then written to GPU memory where the data is processed. Copies to and from the host CPU adds unnecessary latency between the sensor and GPU, which can affect time-sensitive applications such as electronic warfare. While subsequent software updates reduced the number of memory copies, reducing latency, the data still had to go through the host CPU before being sent to the GPU.

*Mercury Systems is a best-of-breed provider of commercially developed, open sensor and Big Data processing systems, software and services for critical commercial, defense and intelligence applications.*



ACQUIRE



DIGITIZE



PROCESS



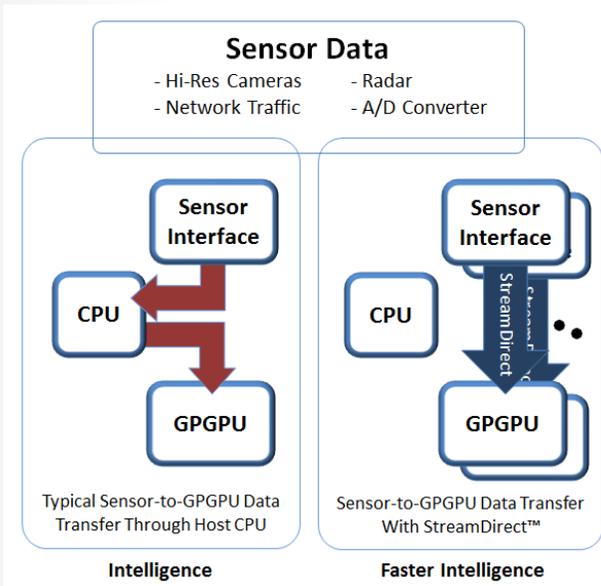
STORAGE



EXPLOIT



DISSEMINATE

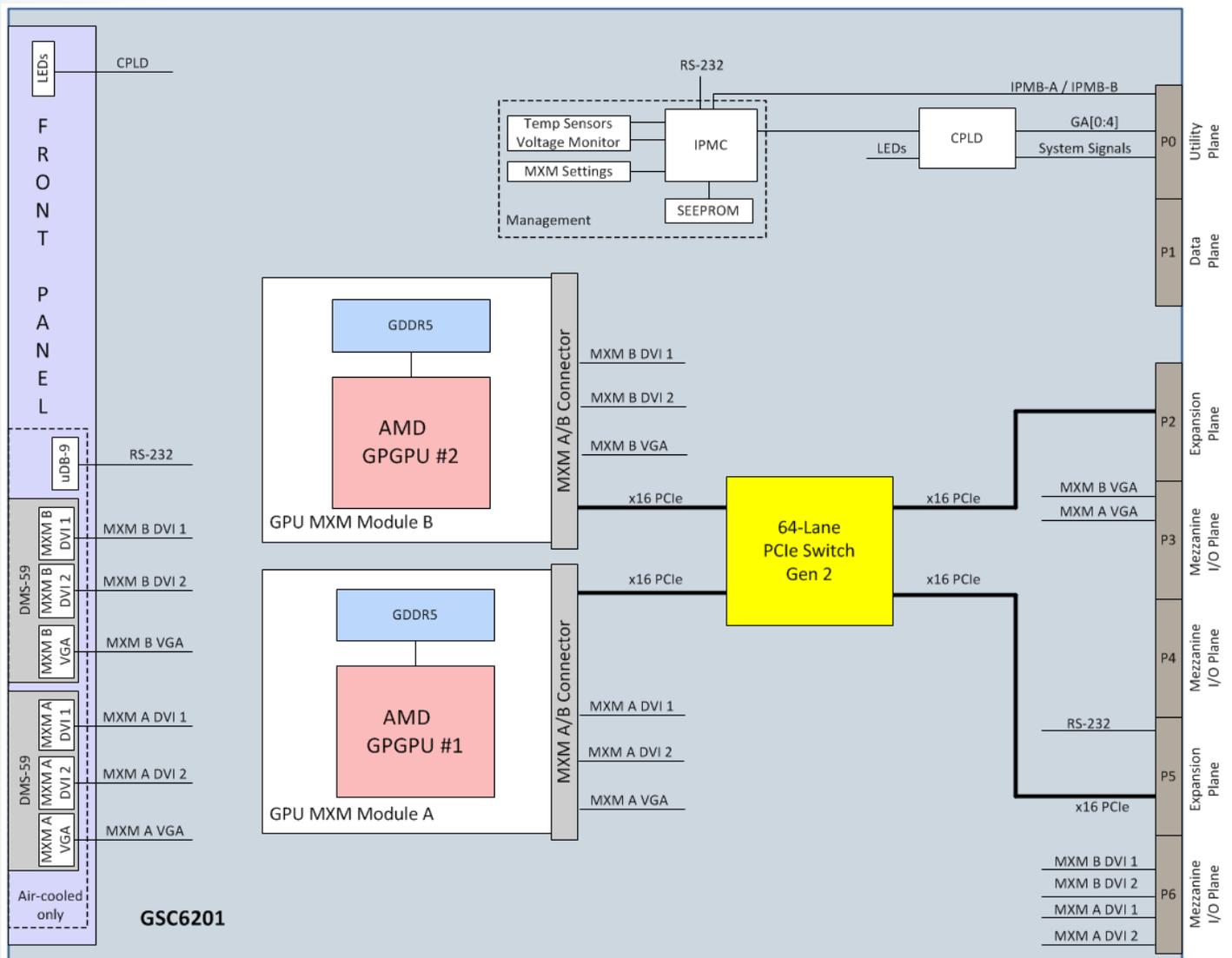


**Figure 1.** StreamDirect reduces the time from raw data to intelligence by 50 percent by writing sensor data directly into the GPU's memory for immediate processing.

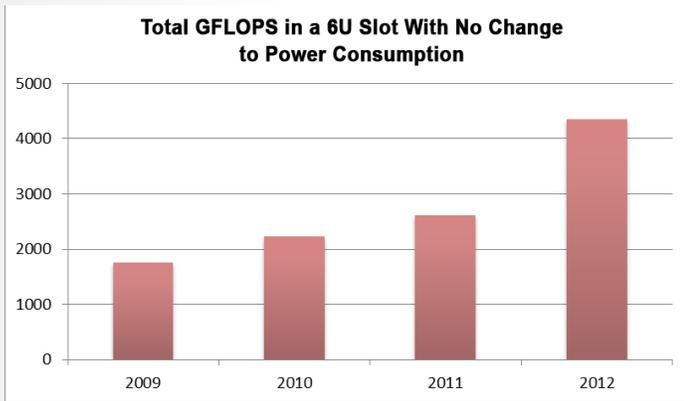
Mercury's StreamDirect™ creates a direct, high-bandwidth DMA channel between sensor and GPU without requiring host CPU intervention. This increases the overall system efficiency of the GPGPU subsystem by increasing throughput, reducing data latency from sensor to the GPGPU by 50 percent, allowing fabrics such as Serial RapidIO® and 10 Gigabit Ethernet to stream data directly to the GPGPU, and enabling a single CPU to host a higher number of GPGPUs for optimal SWaP.

### AMD Radeon HD 6970M and 7970M MXM

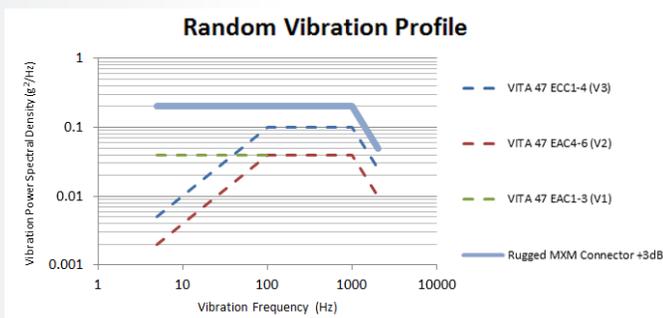
AMD's Radeon HD 6970M and newest HD 7970M deliver the highest performance and GFLOPS/Watt efficiency in the industry. The HD 7970M alone, built on 28nm semiconductor process technology, squeezes in a higher density of processors while maintaining the same power profile as its predecessors. This means even higher performance at over 2 TFLOPS per MXM and higher GFLOP/Watt while maintaining complete software Intellectual Property (IP) compatibility between product generations.



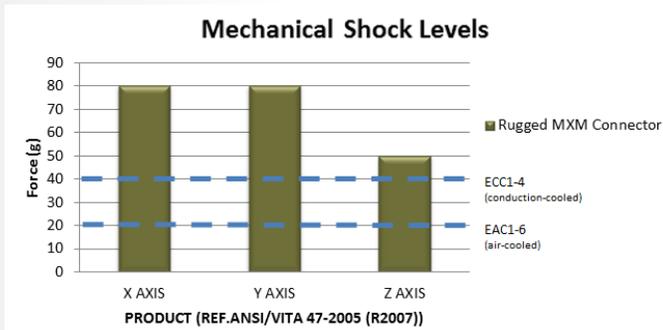
**Figure 2.** GSC6201 functional block diagram with two AMD Radeon embedded GPGPU MXMs.



**Figure 3.** GPU technology is evolving at such a rapid pace that the industry benefits from a significant bump in performance every year. Within a span of three years, the total GFLOPS available has increased by a factor of almost 2.5x. This provides over 4TFLOPS of performance in a single 6U slot with no changes to the power budget, increasing the overall efficiency of the system..



**Figure 4.** Random sine vibration sweep (5-2000 Hz, 10G peak, 2 hour/axis). Performance of Mercury-developed rugged MXM Connector (solid line) exceeds VITA 47 standards by being tested +3 dB above conduction-cooled specifications).



**Figure 5.** Mechanical shock levels for each axis for Mercury-developed rugged MXM connector (green bars) compared to the VITA 47 air-cooled (EAC) and conduction cooled (ECC) standards (dashed lines).

To keep up with the rapid evolution of GPGPU technology, the GSC6201 is a carrier card built using two industry-standard Mobile PCIe® Modules (MXM) from AMD. Because of the modular nature of the MXM, the GSC6201 carrier card only needs to be engineered once while maintaining the flexibility of updating GPUs. This approach saves significant engineering development time, allowing programs to deploy with the latest, highest performing embedded GPGPU technology as soon as they are available from AMD.

To meet the harshest operational environments, the GSC6201 uses rugged MXM connectors specifically engineered by Mercury to exceed the mechanical requirements of VITA 47, while maintaining the flexibility to upgrade the GSC6201 to next-generation GPGPUs such as the Radeon HD 7970M.

### Open Software Environment

Mercury leverages over 25 years of multicomputer software expertise across its many platforms, including the latest multicore processors found in GPGPUs. This strategy is fully applied to the GSC6201 module. Because the processor, memory and surrounding technologies are leveraged across product lines, software developed on the GSC6201 can interface seamlessly with other Mercury products.

The GSC6201 runs on Red Hat® Linux® with MRG real-time kernel extensions. Several software development environments are available for the GSC6201 processing module:

- OpenCL™: An open-source standard for cross-platform and parallel programming.
- Mercury's Scientific Algorithm Library (SAL™) with MathPack™: A high-throughput, low-latency signal processing library containing efficient algorithms with the fewest possible instructions and computing resources. Port legacy applications to the latest generation hardware or support cross-platform development while taking advantage of unique, highly optimized processing functions for each hardware platform.

### VPX-REDI

The VPX™ (VITA 46) standard defines 6U boards with a modern, high-performance connector capable of supporting today's high-speed fabric interfaces. VPX is most attractive when paired with the Ruggedized Enhanced Design Implementation standard – REDI™ (VITA 48). The GSC6201 module is implemented as a 6U VPX-REDI conduction-cooled board with an air-cooled variant available in the same VPX form factor for less rugged environments.

Targeted primarily for harsh-environment embedded applications, VPX-REDI offers extended mechanical configurations supporting higher functional density, such as Two-Level Maintenance (2LM). 2LM allows relatively unskilled maintenance personnel to replace a failed module and restore the system to an operational state in a limited time period, minimizing potential damage to the module.

## Open Standards Mean Interoperability and Planning for the Future

The OpenVPX Industry Working Group was an industry initiative launched by defense prime contractors and COTS system developers to take a proactive approach to solving the interoperability issues associated with the VITA 46 (VPX) family of specifications. This group has created an overarching system specification defining VPX system architecture through pinout definitions to establish a limited set of application-specific reference solutions. These OpenVPX standard solutions provide clear design guidance to COTS suppliers and the user community, assuring interoperability across multi-vendor implementations.

### Specifications

#### GPGPU

Two AMD GPGPU MXMs designed specifically for embedded GPGPU applications

##### AMD Radeon HD 7970M

28nm GPGPU Architecture  
2,560 total processors (1,280 processors per MXM)  
4,352 total peak theoretical GFLOPS (2,176 peak theoretical per MXM)  
x32 total PCIe 2.0 lanes (x16 PCIe 2.0 per MXM)  
4 GB total GDDR5 memory (2 GB per MXM)  
    256-bit Memory Interface  
    307.2 GB/s Memory Bandwidth (153.6 GB/s per MXM)

##### AMD Radeon HD 6970M

40nm GPGPU Architecture  
1,920 total processors (960 processors per MXM)  
2,610 total peak theoretical GFLOPS (1,305 peak theoretical per MXM)  
x32 total PCIe 2.0 lanes (x16 PCIe 2.0 per MXM)  
4 GB total GDDR5 memory (2 GB per MXM)  
    256-bit memory interface  
    230.4 GB/s memory bandwidth (115.2 GB/s per MXM)

#### 64-Lane Configurable PCIe Switch

Configurable switch allows for multiple system-level configurations  
x16 PCIe 2.0 connections to each MXM site (32 lanes total)  
x32 PCIe 2.0 total connections to backplane  
    x16 PCIe 2.0 OpenVPX P2 expansion plane  
    x16 PCIe 2.0 OpenVPX P5 expansion plane

#### Intelligent Platform Management Interface (IPMI)

On-board IPMI controller  
Voltage and temperature monitor  
Geographical address monitor  
Power/reset control  
On-board CPLD, FRU EEPROM interfaces

#### OpenVPX Multi-Plane Architecture

System management via IPMB-A and IPMB-B link on P0 management plane  
Dual full x16 or dual x8 PCIe on P2 and P5 expansion plane  
4 DVI display outputs on P6 mezzanine I/O plane  
2 analog VGA outputs on P3 mezzanine I/O plane  
4 DVI digital and 2 VGA analog outputs to front panel (air-cooled only)

#### Mechanical

6U OpenVPX (air-cooled and conduction-cooled)  
1.0" slot pitch  
OpenVPX and VPX-REDI

#### Compliance

OpenVPX Standard encompasses VITA 46.0, 46.3, 46.4, 46.6, 46.11  
Compatible with VITA 65  
VITA 46/48.1/48.2 (REDI)  
PCIe

## Environmental

Environmental		Environmental Qualification Levels				
		Air-cooled			Air Flow-By	Conduction-cooled
		Commercial L0	Rugged L1	Rugged L2	Rugged L4	Rugged L3
Ruggedness		•	••	••	•••	•••
Moisture/dust protection		•	••	••	•••	•••
Typical cooling performance		~140W*	~140W*	~150W*	~200W*	~150W**
Temperature	Operating*	0°C to +40°C	-25°C to +55°C	-45°C to +70°C	-40°C to +60°C	-40°C to +71°C
Operating temperature maximum rate of change		N/A	5°C/min	10°C/min	10°C/min	10°C/min
Temperature	Storage	-40°C to +85°C	-55°C to +85°C	-55°C to +125°C	-55°C to +125°C	-55°C to +125°C
Humidity	Operating*	10-90%, non-condensing	5-95%, non-condensing	5-95%, non-condensing	5-95%, non-condensing 100% condensing	5-95%, non-condensing 100% condensing
	Storage	10-90%, non-condensing	5-95%, non-condensing	5-95%, non-condensing	5-95%, non-condensing 100% condensing	5-95%, non-condensing 100% condensing
Altitude	Operating*	0-10,000ft	0-30,000ft	0-30,000ft	0-30,000ft	0-70,000ft
	Storage	0-30,000ft	0-50,000ft	0-70,000ft	0-70,000ft	0-70,000ft
Vibration	Random	0.003 g <sup>2</sup> /Hz; 20-2000 Hz, 1 hr/axis	0.04 g <sup>2</sup> /Hz; 20-2000 Hz, 1 hr/axis	0.04 g <sup>2</sup> /Hz; 20-2000 Hz, 1 hr/axis	0.1 g <sup>2</sup> /Hz; 5-2000 Hz, 1 hr/axis	0.1 g <sup>2</sup> /Hz; 5-2000 Hz, 1 hr/axis
	Sine	N/A	N/A	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 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)	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)	z-axis: 50g; x and y-axes: 80g; (11ms 1/2-sine pulse, 3 positive, 3 negative)
Salt/Fog		N/A	Contact Factory	Contact Factory	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	
<ul style="list-style-type: none"> <li>• Cold Start Testing</li> <li>• Cold Soak Testing</li> <li>• Custom Vibration</li> <li>• CFD Thermal Analysis</li> <li>• Finite Element Analysis</li> </ul>	<ul style="list-style-type: none"> <li>• Safety Margin Analysis</li> <li>• Temperature Cycling</li> <li>• Power Cycling</li> <li>• Environmental Stress Screening</li> </ul>	<ul style="list-style-type: none"> <li>• Engineering Change Order (ECO) Notification</li> <li>• ECO Control</li> <li>• Custom Certificate of Conformity (CofC)</li> <li>• Custom UID Labeling</li> </ul>	<ul style="list-style-type: none"> <li>• Alternate Mean Time Between Failure (MTBF) Calculations</li> <li>• Hazmat Analysis</li> <li>• Diminished Manufacturing Sources (DMS) Management</li> <li>• Longevity of Supply (LOS)</li> <li>• Longevity of Repair (LOR)</li> </ul>
Contact factory for additional information			

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INNOVATION THAT MATTERS™

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