White Paper M-WP017

SMART Modular Technologies NV-CMM: Modernizing Persistent Memory with CXL® Technology

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Introduction

SMART Modular Technologies has introduced a groundbreaking solution in persistent memory: the Non-Volatile CXL Memory Module (NV-CMM). This innovative technology merges the advantages of high-speed memory access with data persistence, addressing critical challenges in modern computing environments.

Understanding the NV-CMM

The NV-CMM-E3S is a pioneering non-volatile memory module that leverages the Compute Express Link (CXL) standard, incorporating a built-in backup power source to ensure data integrity. This module is engineered to deliver exceptional memory performance while guaranteeing data persistence during unexpected power losses or system failures.

The NV-CMM boasts the following technical specifications:

- Form Factor: E3.S 2T (76mm x 112.75mm x 15.0mm)

- Capacity: 32GB utilizing 16Gb DRAM

- Performance Metrics:

    • Round Trip Latency: ~ 200ns

    • Throughput: 32GB/s

- Interface: CXL x8 Gen 5

- Persistent Memory Features:

    • Non-volatile storage via NAND backup

    • Integrated Energy Source Module (ESM)

    • AES-256 data encryption for enhanced security

NV-CMM Architecture and Operation

The NV-CMM employs a sophisticated architecture that combines volatile DRAM with non-volatile NAND flash memory, orchestrated by an advanced controller system.

Operational Workflow

- **Normal Operation:** During standard runtime, the host system interacts with the DRAM through the high-speed CXL x8 interface, facilitating full speed memory operations.

- **Power Failure Detection:** In the event of a catastrophic failure or power loss, the NV-CMM instantly initiates its backup protocol.

- **Data Preservation:** Utilizing power from its integrated Energy Source Module (ESM), the NV-CMM swiftly transfers data from the volatile DRAM to the non-volatile NAND flash memory.

- **System Recovery:** Upon power restoration, the NV-CMM automatically retrieves data from the NAND and repopulates the DRAM, ensuring seamless data persistence and enabling uninterrupted operation.
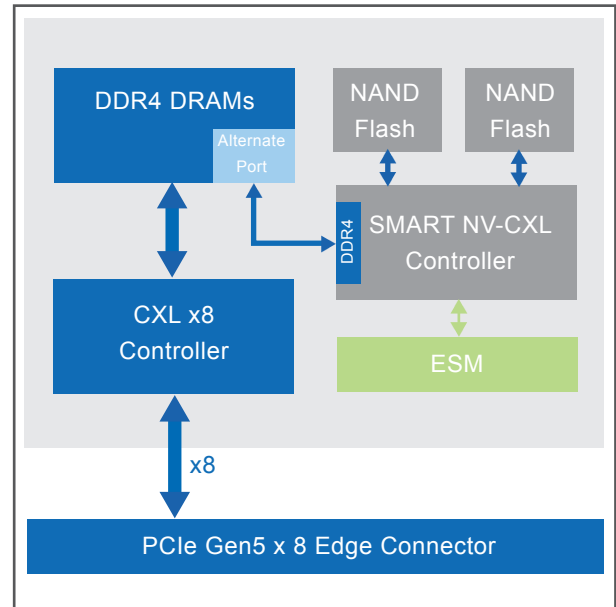
Comparative Analysis: NV-CMM vs. NVDIMM

The NV-CMM shares several key characteristics with Non-Volatile Dual In-line Memory Modules (NVDIMMs), particularly in terms of functionality and application scenarios.

Feature	NV-CMM	NVDIMM-N
Data Persistence	Ensures data integrity during power loss or system failure	Ensures data integrity during power loss or system failure
Performance	High-speed access with ~200ns latency	DRAM-speed read-write latency (~100ns)
Architecture	Combines volatile DRAM, non-volatile NAND Flash, and an NV-Controller to create a persistent solution. CXL serial access.	Combines volatile DRAM, non-volatile NAND Flash, and an NV-Controller to create a persistent solution. Parallel access.
Backup Mechanism	Onboard Energy Source Module (ESM)	External energy source or Backup Power Module (BPM)
Interface	CXL x8 Gen 5	DDR4-3200
Capacity	32GB	16GB to 32GB
Standardization	CXL (industry standard)	JEDEC defined
Write Endurance	Unlimited during normal operation	Unlimited during normal operation

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Advantages of NV-CMM Technology

The NV-CMM offers a compelling set of benefits for modern computing environments:

1. **Ultra-Low Latency:** With a round-trip latency around 200ns , the NV-CMM provides near-instantaneous data access, crucial for time-sensitive applications and dramatically faster than other persistent options.

2. **Exceptional Throughput:** The CXL x8 Gen 5 link provides 32GB/s throughput enabling rapid data transfer, meeting the demands of data-intensive workloads.

3. **Robust Data Persistence:** The ability to preserve data during power loss events significantly enhances system reliability and minimizes downtime.

4. **Advanced Security:** Integrated AES-256 data encryption ensures robust protection for data at rest.

5. **Resource Flexibility:** The CXL interface facilitates dynamic resource allocation and sharing across multiple processors, optimizing system efficiency.

Applications and Use Cases

The NV-CMM is well-suited for a wide range of applications that demand both high-performance memory access and unwavering data persistence:

- **System Acceleration:** The module can be employed for checkpointing and caching operations, substantially improving overall system performance.

- **Large-Scale In-Memory Databases:** NV-CMM provides an ideal solution for database systems requiring rapid access and stringent data integrity measures.

- **Rapid Disaster Recovery:** In the face of power loss or system crashes, NV-CMM enables swift data recovery, minimizing operational downtime.

- **AI and Machine Learning Workloads:** The high throughput and low latency characteristics make the NV-CMM particularly suitable for AI applications that demand rapid data access and processing capabilities.

- **Financial Services and High-Frequency Trading:** Applications in the financial sector, such as high-frequency trading platforms and real-time analytics systems, can leverage the NV-CMM's performance and data persistence features to gain a competitive edge.

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Conclusion: The Future of Persistent Memory

SMART Modular Technologies' NV-CMM represents a significant leap forward in memory technology, effectively bridging the longstanding gap between volatile memory performance and non-volatile storage persistence. By harnessing the power of the CXL standard and incorporating robust backup capabilities, the NV-CMM offers a comprehensive solution to the evolving challenges in modern computing landscapes. As the demand for data-intensive applications continues to surge across industries, technologies like the NV-CMM will play an increasingly pivotal role. These innovations will be instrumental in optimizing system performance, bolstering data integrity, and unlocking new possibilities in computing architecture. The NV-CMM stands at the forefront of this technological revolution, poised to reshape the future of persistent memory solutions.

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For more information, please visit: **www.smartm.com**

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