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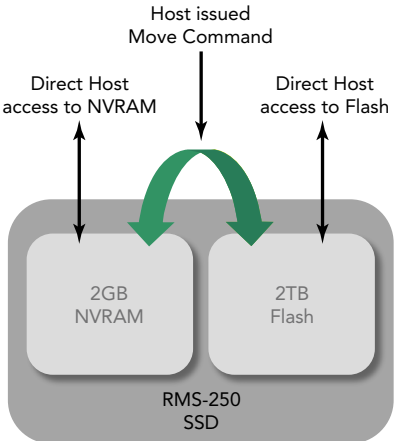
RMS-250

2TB Flash SSD
2GB Host Controlled NVRAM

Host Controlled NVRAM

- Host controls what data is stored in NVRAM
- Host determines what, when and where data should be transferred to/from NVRAM
- Host can issue single delegated move command, transferring data between SSD's NVRAM and Flash without copying data back into system memory



2.5" NVMe x4
NVRAM/Flash SSD

Supports:

- Symphonic™ Cooperative Flash Management firmware
- Up to 2GB host controlled NVRAM
- Up to 2TB eMLC Flash
- Over 300K IOPS in 66% Read/33% Write mix
- 2.5" Form Factor with SFF-8639 connector
- NVMe PCIe x4 Gen3 interface
- DiaLog™ OEM Diagnostic Lifecycle Monitoring
- Fault Tolerant Flush-to-Flash™ Backup System
- DuraLife™ Ultra-Capacitor Power Management System

Supporting the Symphonic Cooperative Flash Management (CFM) firmware, the RMS-250 is a 2TB eMLC SSD that uniquely provides up to 2GB of host controlled local NVRAM.

NVRAM

With a hybrid of NVRAM and Flash, the RMS-250 provides host systems with direct access and control over the up to 2GB of local NVRAM. The architecture enables the host to determine what data should be held in NVRAM, when it should be overwritten, or transferred to Flash. Similarly, the host can control what data should be transferred from Flash into NVRAM.

These operations are highly efficient as a single delegated move command from the host will transfer data between the RMS-250's NVRAM and Flash without copying data over the system bus, through the software stack, and into system memory. This approach reduces overhead from data copying and provides the host a new design space for system-level optimizations.

With exceptional, consistent performance for small random writes and unlimited write endurance, host controlled NVRAM can minimize the updates to Flash, improving Flash wear out and minimizing latency spikes.

The NVRAM is visible as a standard block device that supports DMA operations. It can be utilized as a write-cache, write-ahead log, for intent logs, metadata, journaling, or for any operations requiring frequent access to low latency persistent storage.

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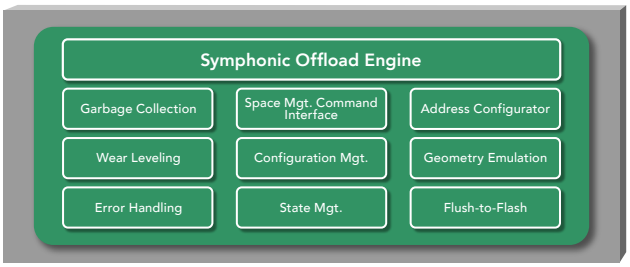
Symphonic Cooperative Flash Management (CFM)
Next Gen data centers require highly deterministic, low latency and cost effective storage that can only be realized with Flash memory. But every Flash SSD solution available today is based upon a Flash-Translation-Layer (FTL) that introduces expensive overhead, unpredictable latency spikes, and suboptimal performance that prematurely wears out the Flash media.

- Magnitude improvement in QoS (latency spikes)
- >80% increase in IOPS & User Bandwidth
- Raw Flash reduced 15% or more
- No device level Write Amplification
- Metrics scale linearly with additional SSDs

Symphonic is a type of Software-Defined Flash that creates a new paradigm for Flash memory management that we call Cooperative Flash Management (CFM). System software, e.g., file systems, block virtualization managers, or object/key value stores have comprehensive capabilities to intelligently manage storage media. But this system software is not equipped to directly perform some of the unique processes required to manage Flash memory.

Replacing the SSD FTL, Symphonic includes a combination of host-side software libraries and SSD firmware that enables system software to cooperatively perform Flash management processes to realize the full potential of Flash storage. The Symphonic functionality includes configurable address mapping, garbage collection, wear leveling, and reliability features that turn the SSD into an offload engine while operating in host address space. The result is a redistribution of host/device responsibilities that removes an inefficient abstraction layer to dramatically improve Quality-of-Service, performance, cost, and endurance while providing the functionality of a data center class product.

Flush-to-Flash
Upon system power failure, the RMS-250 switches to an auxiliary power mode provided by on-board ultracapacitors and data that is stored in volatile DRAM is transferred to persistent NAND memory by the Flush-to-Flash firmware. Once transferred to NAND memory, data is stored in the persistent storage and



Symphonic is a combination of SSD firmware and software that enables systems to cooperatively perform Flash management

not vulnerable to the 72-hour limitations common to battery-based architectures that hold data in volatile DRAM in a self-refresh mode.

Radian's Flush-to-Flash firmware is based on transactional semantics to ensure the utmost in data integrity even in the event of failures that could occur during the flush process. Extensive monitoring and component checks are performed on an on-going basis during normal operations to discover predictive anomalies in advance of failures. NAND Flash memory is regularly scanned for potential errors (bad blocks) and ultracapacitor health is monitored on a continual basis.

However, in the event of a failure during the flush process, such as a lack of power required to perform a complete data transfer, the Flush-to-Flash system ensures that partial data is properly transferred and can be identified accordingly upon restore. A hardware ECC engine in the controller provides error correction functionality and, combined with the firmware implementation, protects data against NAND page or block errors. Extensive use of metadata and error checking is performed on all data upon restore ensure correctness.

The overall Flush-to-Flash system and underlying NAND array are based on a fault tolerant architecture, including overprovisioning resources such as ultracapacitor power and NAND capacity, to address events such as repeated system power blackouts and brownouts. The architecture and design verification test processes further address these conditions in the context of operations such as concurrent host atomic writes, providing the highest levels of enterprise reliability.

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DiaLog™

The RMS-250 includes DiaLog (Diagnostic Logging), a host accessible, embedded diagnostic facility that includes various monitoring functions related to predictive/preventive maintenance, reliability, and continuous process and product improvement.

These capabilities target both Radian's own internal use for Design Verification and Production Test processes, and use by OEM customers throughout their Qualification, Production Test, Field Deployment, Repair, and End-of-Life phases.

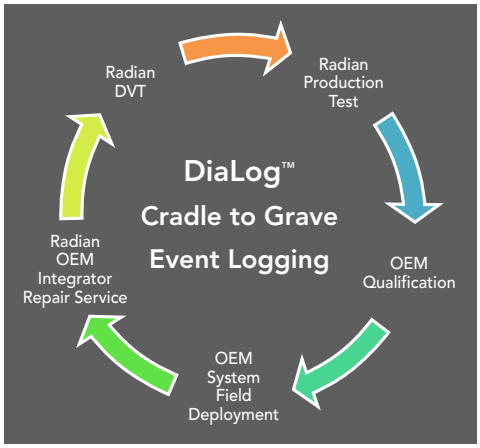
- Measure & Detect
- Diagnose & Predict
- Record & Notify

On-board health monitoring of components and events are tracked utilizing an I2C network and communicated to the host. Tracking and communication have default settings that are user configurable. Status is communicated to the host on an on-going basis and when conditions exceed predefined ranges. DiaLog errors are reported using the NVMe asynchronous notification mechanism and NVMe GetLog requests.

Histograms of all measurements are stored in logs forconfigurable durations. In addition to assisting in predictive failure and service analysis, this information s a valuable tool in meaningful RMA failure analysis.

Measurements include:

- Capacitors including capacitance, restore and charge rates
- Temperatures, voltages, currents
- Hardware shorts and opens
- DRAM errors and corrections
- Flash P/E cycles and wear metrics, errors, correctable bits in error, program/read/erase times, disturbs and data scrubbing
- Time and duration of event and event -specific data
- Various counters accumulate statistics over the life of the device



DiaLog provides continuous heart beat monitoring and life cycle management

DuraLife™

The RMS-250 auxiliary power is provided by on-board ultracapacitors, overprovisioned to further ensure data protection in the event of a power failure and to minimize replacement maintenance. While superior to lithium-ion batteries in most respects, including maintaining charge levels, safety, environmental regulatory compliance, and durability, like batteries ultracapacitors will degrade over time where charge capacitance diminishes.

Radian's DuraLife power management system addresses ultracapacitor degradation by combining several techniques with mechanisms to significantly extend the useable life of ultracapacitors. This includes techniques such as dynamic voltage margining which works in concert with the RMS-250 DiaLog™ monitoring system that provides information on applicable ultracapacitor variables such as temperature, and the number, frequency and duration of charge cycles.

DuraLife typically more than doubles the raw ultracapacitor life expectancy. Assuming a required capacitance of 50% of initial maximum charge, below which Radian recommends capacitor replacement, DuraLife can extend the RMS-250 ultracapacitors replacement threshold from 3 years to over 6 years. This technology thus enables increasing system reliability and the useable product life cycle, reducing Total Cost of Ownership (TCO).

Specifications

2.5" form factor, with SFF-8639 connector	Length: 100mm · Width: 69.9mm · Height: 14.8mm
PCIe Gen3 in x4 or 2x2 Gen3 host interface	Compliant with PCI-Sig PCIe 3.0 Base Specification
NVMe Command Set	NVM Express specification 1.0
Flash Capacity Configurations	1TiB or 2TiB Flash 19nm eMLC NAND Flash
NVRAM Capacity Configuration	1GB or 2GB User NVRAM based upon DDR3 @ 1,600 MHz with backup power provided by on-board ultracapacitors with DuraLife™ and fault tolerant Flush-to-Flash™ system
4K Sequential Read	581K IOPS 2,380 MB/s
4K Sequential Write	601K IOPS 2,461 MB/s
Data Center Workload **66% Random 4K Reads** **33% Sequential 16K Writes** **within Random 8MB Segments** **SSD QD = 128**	319K IOPS 1,741 MB/s (2TiB with 2% internal overprovisioning) Fully loaded SSD in 'Steady State' No RAM/NVRAM caching enabled
DRAM ECC	64-bit data/8-bit ECC code detects double bit errors and corrects single bit errors
NAND ECC	Hardware BCH engine with 100b/4320B BCH encoding
NVMe DMA Engines	Supports NVMe command set, submission/completion queues, and MSI-X vector interrupts
Programmed I/O (PIO)	Support for direct host access to NVRAM by mapping memory (mmap) into host PCI address space with configurable window size
Maximum Payload Size	Configurable to 128b or 256b single packet size
Atomicity	NVRAM: Supported on a per packet basis up to 256b packets Flash: Supported on a per logical block basis, 4KiB minimum
BIST and Health Monitoring	DiaLog™ provides OEM hosts the ability to monitor environmental status, component health, create event notifications and log statistics for continuous product life cycle management
Field Upgradeable Firmware Updates	Mechanism for upgrading firmware in the field via host control (no drive removal necessary)
ioctls	RAM size, window size, LED control TRIM, Erase, Query
LEDs	Four LEDs for progress/error codes and initialization with two under host ioctl control during normal operations
Power Requirements (+12V rail)	Typical Maximum: Up to 25W @ 55°C
Ultracapacitor Recharge Time	57 seconds
Ultracapacitor Replacement	DuraLife Power Management System intended to prolong ultracapacitor life expectancy to over five years
Operating Temperature **Storage Temperature**	0° to 55°C @ 100 LFM 40°C to 85°C
Weight	.375 lbs.
Shock	Operating: 5 G Non-Operating: 10 G
Vibration	Operating: 0.5 G Non-Operating: 1.0 G
ESD	1,500 volts, human body model
MTBF	1M hours
Device Drivers	NVMe Linux 2.6.38 and above

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