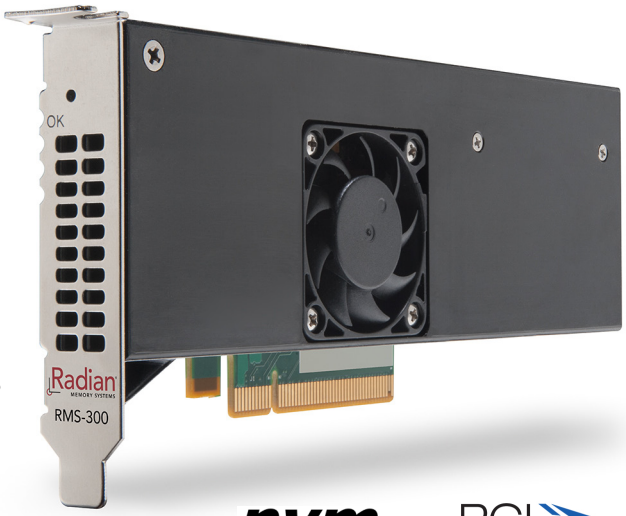
Radian MEMORY SYSTEMS

RMS-300

PCIe x8 Gen3 NVRAM Log Device

RMS-300

- PCIe x8 Gen3 Host Bus Interface
- PCIe Low Profile/Short-Length Form Factor
- DDR4 NVRAM Capacities: 8GB or 16GB
- On-Board Ultracapacitors
  (no remote ultracapacitor pack required)
- NVMe Multi-Channel DMA Engines supporting NVMe Command set
- Support for Programmed I/O (PIO) Operations
- Fault Tolerant Flush-to-Flash™ Backup System
- DuraLife™ Ultracapacitor Power Management System
- DiaLog™ OEM Diagnostic Lifecycle Monitoring

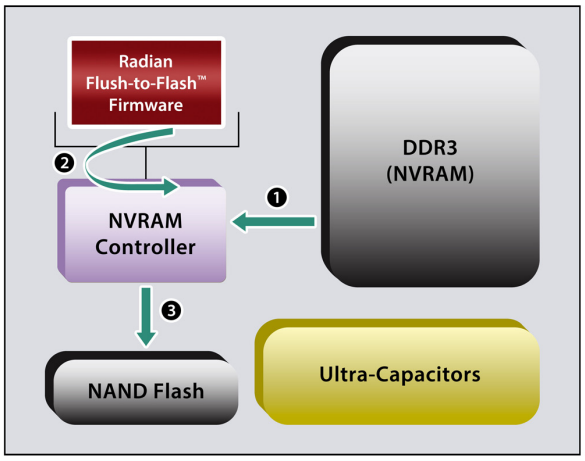


With exceptional, consistent performance for small random writes and unlimited write endurance, the RMS-300 is an ideal solution for intent logs, journaling, or any metadata operations requiring low latency persistent storage. As a target for larger batched write commits, the device provides predictable write throughput of over 4 GB/s. The RMS-300 is visible as a standard block device that supports DMA operations and where memory can be mapped into host PCI address space for direct Programmed I/O accesses.

NVMe

Led by an Intel® consortium of more than 80 companies, NVMe is a new standard for nonvolatile PCIe memory devices. Providing a more standardized, simplified, and richer range of block device capabilities, NVMe involves an efficient register interface and command set optimized for storage memory.

This includes an interface that supports host multi-core architectures, ensuring multiple threads running on each core have their own queues and interrupts without requiring specific locks. The specification also includes enterprise-level error reporting and management capabilities. Based upon a Queuing and Command Set architecture, queues and the register set are standardized, including the priority/arbitration, while leaving the number and size of queues as vendor configurable. The result is a simplified interface involving only eleven registers and highly efficient operations, where read/writes require just one register access and completion acknowledgements similarly require just one register update.



RMS-300 Flush-to-Flash Backup System

Flush-to-Flash™

Upon system power failure, the RMS-300 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 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

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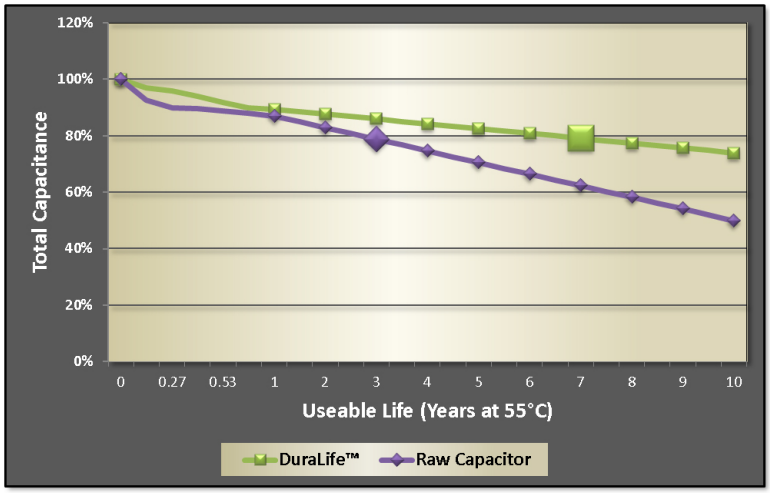
While generally considered superior to lithium-ion batteries for storage applications, ultracapacitors will also degrade over time. Radian's DuraLife™ Power Management System more than doubles ultracapacitor life expectancy, minimizing product maintenance and improving Total Cost of Ownership.



in the event of most potential 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 with 10^{-16} UBER 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 to 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.

DuraLife™

The RMS-300 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-300 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. DuraLife can extend the RMS-300 ultracapacitors replacement threshold from 3 years to over 6 years. This technology thus enables increasing NVRAM storage capacity, system reliability, and the useable product life cycle, reducing Total Cost of Ownership (TCO).

DiaLog™

The RMS-300 includes DiaLog (*Diagnostic Logging*), a host accessible, embedded diagnostic facility with various monitoring functions related to preventive maintenance, reliability, and continuous process and product improvement.

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

On-board health monitoring of components and events are tracked, communicated to the host on a user configured basis, and stored in permanent logs for statistical analysis. These capabilities target both Radian's own internal use for Design Verification and Production Test cycles, and use by OEM customers throughout their Qualification, Production Test, Field Deployment, Repair, and End-of-Life phases.

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RMS-300

PCIe x8 Gen3 NVRAM Log Device

Specifications

PCIe x8 Gen3 Host Interface	Compliant with PCI-Sig PCIe 3.0 Base Specification
NVMe Express	NVM Express specification 1.2
PCIe Low Profile/Short Length Edge Card form factor	Length: 6.6" · Height: 2.7" · Width: 0.8"
Performance	Write Throughput: 5 GB/s Random 4K Write IOPS: 900K Read Throughput: 5.2 GB/s Random 4K Read IOPS: 1 Mil.
NVRAM	8GB or 16GB capacities based upon DDR4 @ 1,600 MHz with backup power provided by on-board ultracapacitors with DuraLife™ and fault tolerant Flush-to-Flash™ system
DRAM ECC	64-bit data/8-bit ECC code detects double bit errors and corrects single bit errors with error injection test function
NAND Flash	Fault Tolerant architecture with SLC NAND Flash for storing data on system/power failure and ensuring data integrity
NAND ECC	Hardware ECC engine provides 10^{-16} UBER
NVMe DMA Engines	Supports NVMe command set, submission/completion queues, and MSI-X vector interrupts
Programmed I/O (PIO)	Support for direct host access 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	Supported on a per packet basis up to 256b packets
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 and standarized NVMe interface (no card removal necessary)
ioctls	RAM size, window size, LED control, error injection*
LEDs	Four LEDs for progress/error codes and initialization with two under host ioctl control during normal operations*
Software Reset	Resets the Controller processors and respective state machines including the PCIe interface
Power Requirement (+12V Rail)	Typical Maximum: 14W @ 55°C Recharge Cycle: Up to 20W @ 55°C with concurrent r/w operations
Ultracapacitor Recharge Time	41 Seconds
Ultracapacitor Replacement	DuraLife Power Management System prolongs ultracapacitor life expectancy to over five years
Operating Temperature	0° to 55°C @ 100 LFM
Storage Temperature	-40°C to 85°C
Weight	.440 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	Upstream driver for NVMe Linux Kernel 2.6.38 and above, or Radian NVMe driver

*Feature requires use of Radian NVMe device driver