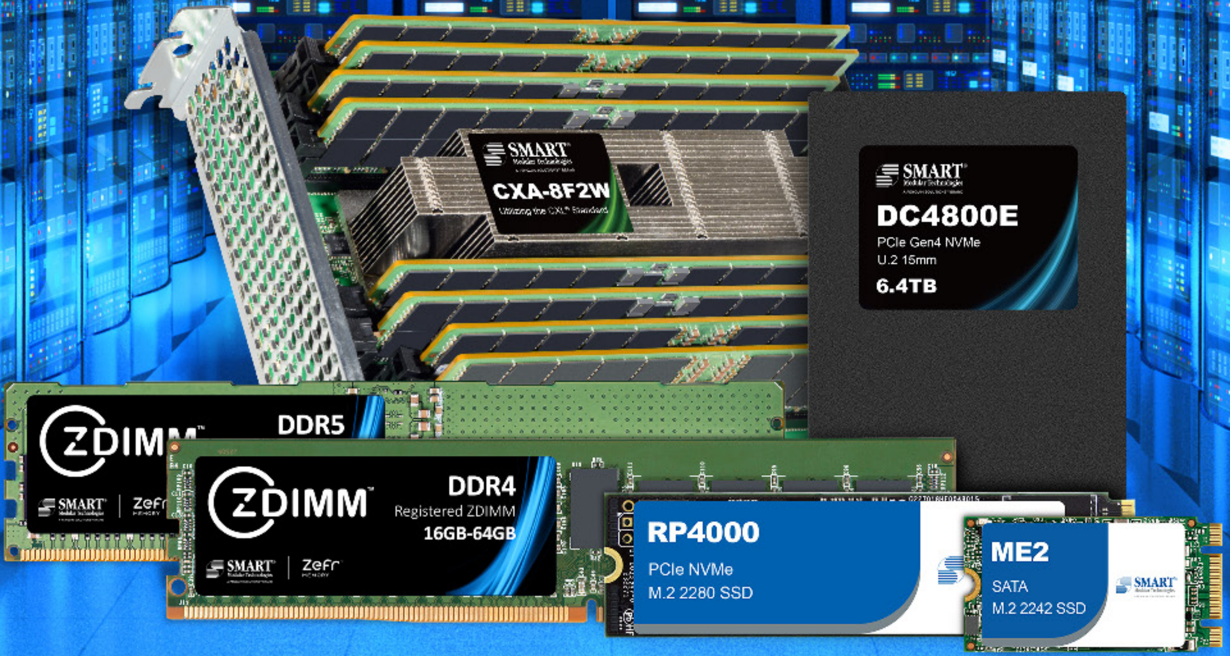
SMART®
Modular Technologies
A PENGUIN SOLUTIONS™ BRAND



Think Memory.
Think SMART.

Memory Modules / Flash Storage

Zefr™ ZDIMMs / Data Center SSDs / CXL® Memory

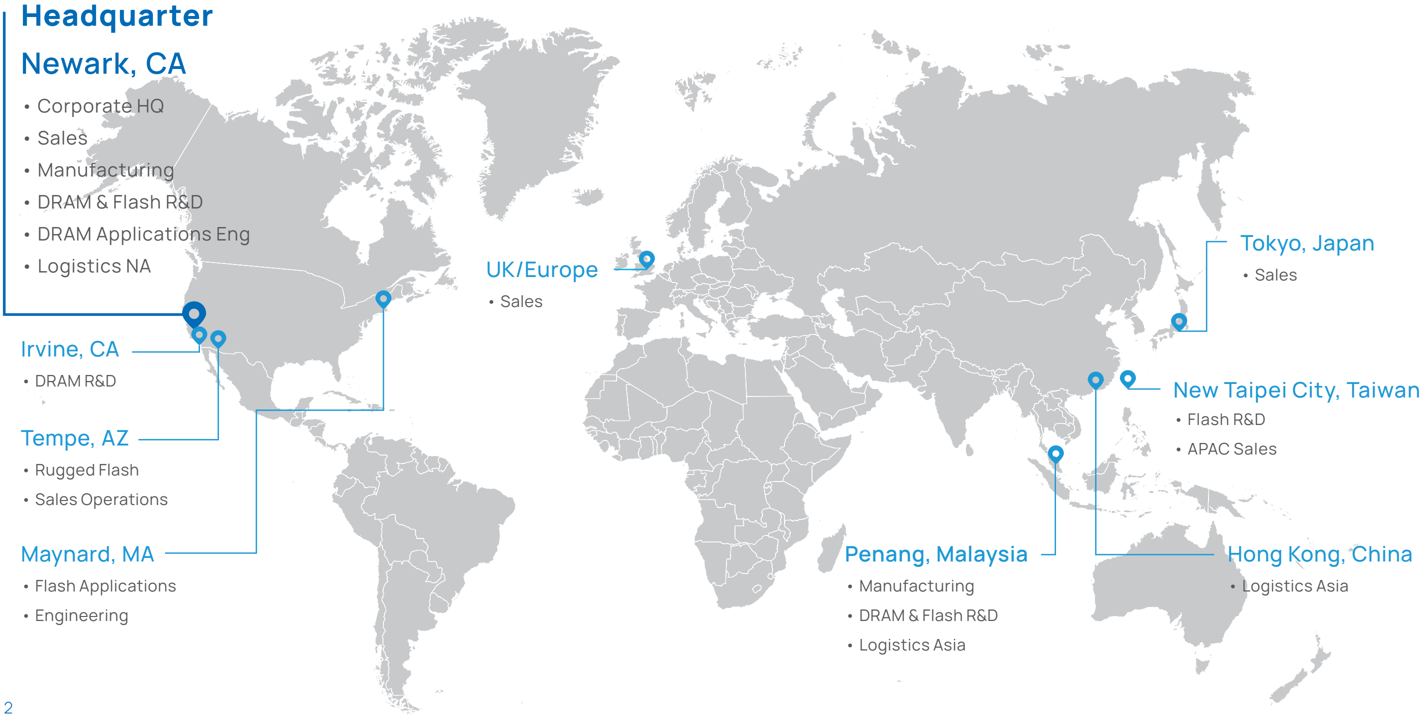
About SMART Modular Technologies

SMART Modular Technologies, a subsidiary of Penguin Solutions (Nasdaq: PENG), is a global leader in specialty memory, storage and hybrid solutions serving the electronics industry for over 30 years. In addition to standard and ruggedized product lines, SMART Modular offers custom designs to various applications, including computing, networking, communications, storage, mobile, military, defense, aerospace and industrial markets. Focused on providing extensive customer-specific design capabilities, technical support and value-added testing services, SMART collaborates closely with their global OEM customers throughout their design process and across multiple projects to create reliable and efficient solutions for demanding applications with differentiated requirements.

Why SMART Modular

- **Serving the Industry for Over 30 Years**
  Dedicated in specialty memory, Flash storage and hybrid solutions for leading OEMs.
- **Advanced Products with Quality Assurance**
  Taking innovations from the design stage through manufacturing and the supply chain.
- **Trusted Customer Relationships**
  Customer-specific design capabilities, technical support and testing services.
- **Long-Term Partnerships with Suppliers**
  Leveraging leading suppliers' pricing component availability to the customer's advantage.
- **Build-to-Order Manufacturing with Lifecycle Management**
  Long-term, consistent support throughout all market and technology cycles.
- **Broad Customer Base in Diverse Industry Sectors**
  Include Data center, storage server, HPC, edge computing, IIoT, networking, and industrial markets.
- **Proof of Concept for Emerging Standards and Technologies**
  Gaining competitive advantages through early testing for risk reduction and improved time-to-market.

SMART Modular Global Footprint



Headquarter

Newark, CA

- Corporate HQ
- Sales
- Manufacturing
- DRAM & Flash R&D
- DRAM Applications Eng
- Logistics NA

Irvine, CA
- DRAM R&D

Tempe, AZ
- Rugged Flash
- Sales Operations

Maynard, MA
- Flash Applications
- Engineering

UK/Europe
- Sales

Penang, Malaysia
- Manufacturing
- DRAM & Flash R&D
- Logistics Asia

Tokyo, Japan
- Sales

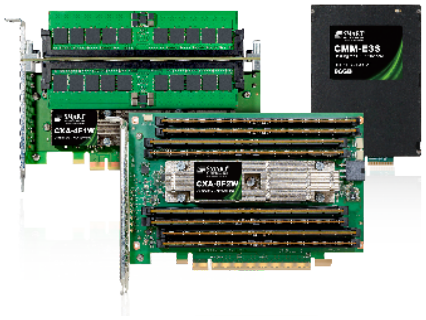
New Taipei City, Taiwan
- Flash R&D
- APAC Sales

Hong Kong, China
- Logistics Asia

DRAM Modules

Durable Industrial Memory Modules for Intensive Workloads

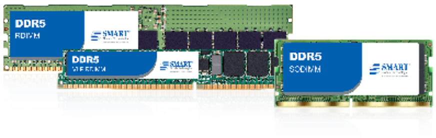
SMART's DRAM module portfolio sets the standard for industrial-grade memory solutions, delivering exceptional quality and reliability. Backed by SMART's extensive expertise in design, production, rigorous testing, and logistics, these modules are built to excel in the most demanding industrial applications. As an active participant in industry standards, SMART is committed to leading the way by offering advanced memory solutions tailored to meet the efficient computing requirements of today's data-intensive applications. Choosing SMART's industrial memory modules provides businesses with a significant advantage in reliability and performance, ensuring that these modules not only meet but exceed industry benchmarks, consistently delivering optimal performance and unmatched durability in even the most challenging industrial environments.



CXL® Memory Solutions

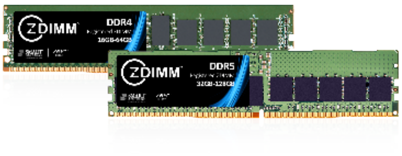
Advanced Serial Memory

CXL memory solutions leverage the CXL protocol to provide high-speed, low-latency memory expansion.



Memory Modules

SMART's Memory Module designation conveys it's continued commitment to provide durable and reliable memory modules required by industrial workloads.



Zefr ZDIMM

ZDIMMs (Zefr Memory Module) utilize SMART's Zefr™ proprietary screening process, ensuring the industry's highest levels of uptime and reliability.

Advanced Serial Memory

For High-Performance and Low-Latency Memory Expansion

Compute Express Link® (CXL®) is an open interconnect standard designed to address the industry's need for more high-bandwidth memory per core. The standard built upon the physical and electrical interfaces of PCIe® allows for flexible, scalable and economical memory architectures that can be independently added or removed without the need to replace or upgrade the entire system.

A Breakthrough Solution for Memory-hungry Applications

Today's applications, like generative AI (LLM), digital twins, image recognition, high-frequency trading (HFT), and content delivery networks (CDN), demand massive memory capacity, bandwidth, and low latency. CXL® meets these memory-hungry needs with high-performance, low-latency memory expansion for modern computing challenges, enabling real-time data processing, large database access, and efficient AI/ML execution.

LLM

- Real-Time Chatbots and Virtual Assistants
- Multimodal Data Processing
- Code Assistance and Code Generation
- Speech-to-Text and Real-Time Translation

Image Recognition

- High-Precision Simulation and Modeling
- Real-Time Data Stream Processing
- AI/ML Data Analysis
- Large Databases and Historical Data Access

CDN

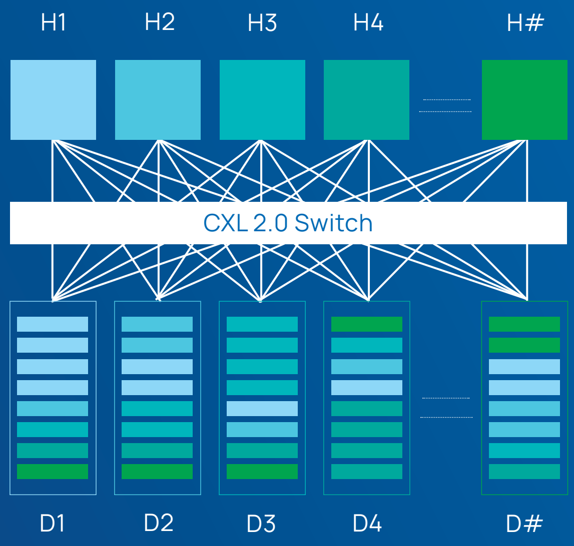
- Video Streaming
- On-line Gaming
- Social Media
- E-commerce

Digital Twins for SMART Factory

- High-Precision Simulation and Modeling
- Real-Time Data Stream Processing
- AI/ML Data Analysis
- Large Databases and Historical Data Access

High-Frequency Trading (HFT)

- Real-Time Market Data Processing
- Real-Time Data Analytics and Visualization
- Algorithmic Trading Models
- Latency Reduction Systems



Memory Pooling

CXL 2.0 supports switching to enable memory pooling for efficient memory allocation. At 2.0 level, device can be partitioned as Multiple Logical Devices (MLD), allowing up to 16 hosts to simultaneously access different portions of the memory.

As an example, Host 1 (H1) can use half the memory in Device 1 (D1) and a quarter of the memory in D2 to finely match the memory requirements of its workload to the available capacity in the memory pool. The remaining capacity in D1 and D2 can be used by H2-H#. This architecture makes a better use of available resources without stranded memory.

SMART® Modular Technologies
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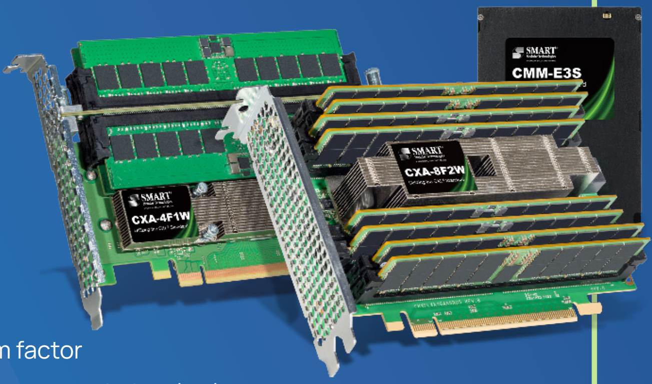
Key to
Memory Capacity & Bandwidth Expansion

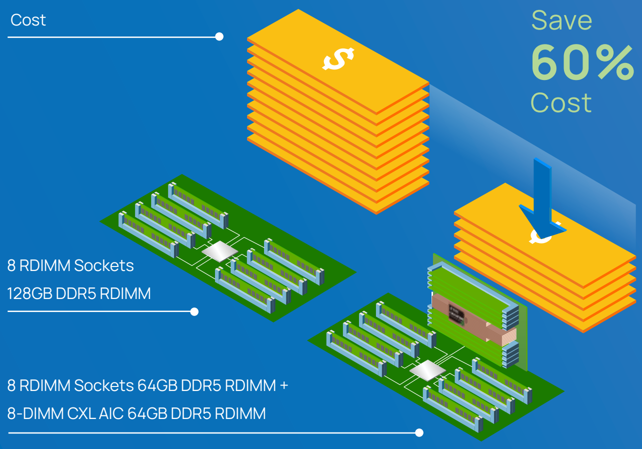
Advanced Serial Memory Utilizing CXL® Standard



Features

- Available in Add-in Card (AIC) and EDSFF E3.S 2T (2U short) form factor
- ASIC and FPGA-based memory modules supporting multiple interconnect standards
- Customization of features like RAS, memory interleaving, performance tuning, and support for low-power mode
- Debug capabilities for memory and Phy
- Custom packaging, processing, and testing

AIC Form Factor Use Case



Cost

Save
60%
Cost

8 RDIMM Sockets
128GB DDR5 RDIMM

8 RDIMM Sockets 64GB DDR5 RDIMM +
8-DIMM CXL AIC 64GB DDR5 RDIMM

1TB
(128GB DDR5 RDIMM x 8)

=

512GB
(64GB DDR5 RDIMM x 8)

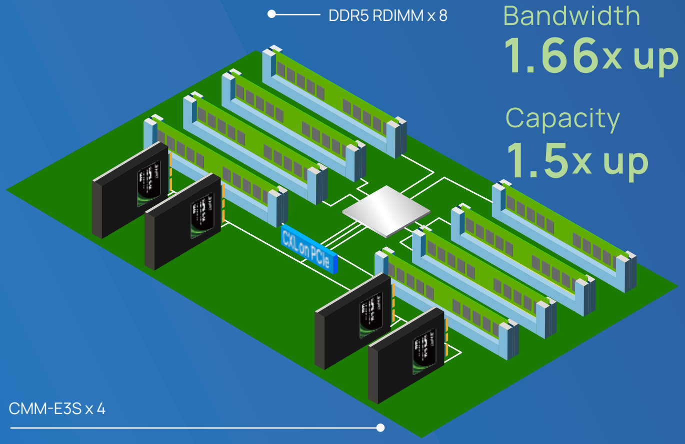
+

512GB
(64GB DDR5 RDIMM x 8)

8 RDIMM Sockets

8 RDIMM Sockets +
8-DIMM CXL AIC

E3.S Form Factor Use Case



DDR5 RDIMM x 8

Bandwidth
1.66x up

Capacity
1.5x up

CMM-E3S x 4

Total Bandwidth
380 GB/s → Total Bandwidth
640 GB/s ↑

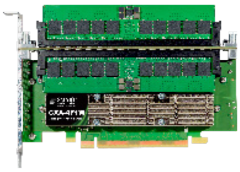
Total Capacity
1 TB → Total Capacity
1.5 TB ↑

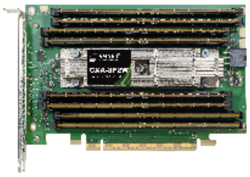
with 8 x DDR5 DIMM

by adding extra 4 x CMM-E3S

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

Advanced Serial Utilizing CXL® Standard





Product	CXA-4F1W	CXA-8F2W
Bus	CXL 2.0 x16	CXL 2.0 x16 (dual x8)
Form Factor	FHHL, 1W	FHHL, 2W
Configuration	4 x DDR5 DIMMs	4 x DDR5-4800 DIMMs
Max Capacity	512GB 128GB (SDP)	1TB 128GB (SDP)
NV Option	-	-
Performance	64GB/s	64GB/s
Latency	200ns	200ns
Power	70W for 512GB	135W for 1TB

Product	CMM-E3S	NV-CMM-E3S
Bus	CXL 2.0 x8	CXL 2.0 x8
Form Factor	E3.S 2T	E3.S 2T
Configuration	DDR5	DDR4
Max Capacity	128GB	32GB
NV Option	-	Yes
Performance	32GB/s	32GB/s
Latency	200ns	200ns
Power	30W	30W

*C Temp (0˚C to +70˚C); I Temp (-40˚C to +85˚C); Ambient Temp (+40˚C to +70˚C)

Memory Modules

Durable and Reliable Memory for Industrial Workloads

SMART's DRAM module portfolio provides a superior level quality, durability and reliability to meet the needs of today's demanding industrial specifications and applications. All DRAM modules are backed by SMART's extensive expertise in design, manufacturing, testing and logistical support.

SMART's industrial memory modules provide an added level of confidence and security, knowing that these products will perform to the highest standards for durability and reliability, while meeting industrial workload requirements and exceeding performance expectations.

Enterprise Quality for High Reliability

Undergoes Triple Stress Testing and Burn-In

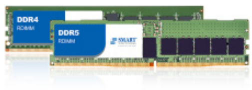
Encryption and Other Features Available

Memory Modules Product Family

DDR5 / DDR4 / DDR3

NVDIMM

LRDIMM



RDIMM

UDIMM

SODIMM

Mini DIMM

MIP™

SMART® Modular Technologies
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Liquid Immersion Memory for Next-Gen Cooling Systems

Enhanced Reliability and Cost-effective Operation for Immersion-cooled Data Center Applications

DDR5 Liquid Immersion RDIMM with Conformal Coating

Combining superior performance of DDR5 technology with enhanced protection for liquid immersion environments, SMART's conformally coated RDIMMs ensure the reliability and longevity in the most demanding data center applications.

Benefits of Conformally Coated RDIMMs

Ensures long-term reliability in liquid cooling

Maintains component identification for easier maintenance and tracking

Maximizes liquid immersion cooling benefits without compromising performance

Servers/Data Centers

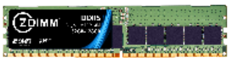
DIMM Type	RDIMM		LRDIMM
Technology	DDR5	DDR4	DDR4
Density	16GB-128GB	4GB-64 GB	128GB, 256GB
Height	31.25mm	31.25mm	31.25mm
Configuration	80bit	72bit	72bit
Speed (MT/s)	4800-5600	2666-3200	3200
Voltage	1.1V	1.2V	1.2V
Operating Temperature*	C/I Temp	C/I Temp	C Temp

Liquid Immersion RDIMM

DIMM Type	RDIMM
Technology	DDR5
Density	32GB-128GB
Height	31.25mm
Configuration	80bit
Speed (MT/s)	4800-5600
Voltage	1.1V
Operating Temperature*	C Temp

ZDIMM™

Registered ZDIMM



DIMM Type	RDIMM	
Technology	DDR5	DDR4
Density	32GB-128GB	16GB-64GB
Height	31.25mm	31.25mm
Configuration	80bit	72bit
Speed (MT/s)	5600	3200
Voltage	1.1V	1.2V
Operating Temperature*	C Temp	C Temp

*C Temp (0˚C to +70˚C); I Temp (-40˚C to +85˚C); Ambient Temp (+40˚C to +70˚C)

Blade/Compact Servers

DIMM Type	VLP RDIMM		VLP/ULP Mini RDIMM
Technology	DDR5	DDR4	DDR4
Density	32GB-48GB	4GB-64GB	8GB-32GB
Height	18.75mm	18.75mm	18.75/17.78mm
Configuration	80bit	72bit	72bit
Speed (MT/s)	4800-5600	2666-3200	2666-3200
Voltage	1.1V	1.2V	1.2V
Operating Temperature*	C/I Temp	C/I Temp	C/I Temp

Networking

DIMM Type	UDIMM		ECC UDIMM	
Technology	DDR5	DDR4	DDR5	DDR4
Density	8GB-48GB	4GB-32GB	16GB-48GB	4GB-32GB
Height	31.25mm	31.25mm	31.25mm	31.25mm
Configuration	64bit	64bit	72bit	72bit
Speed (MT/s)	4800-5600	2666-3200	4800-5600	2666-3200
Voltage	1.1V	1.2V	1.1V	1.2V
Operating Temperature*	C/I Temp	C/I Temp	C/I Temp	C/I Temp

Telecommunication

DIMM Type	SODIMM		ECC SODIMM		
Technology	DDR5	DDR4	DDR5	DDR4	DDR3
Density	8GB-64GB	2GB-64GB	16GB-64GB	4GB-64GB	2GB-64GB
Height	30mm	30mm	30mm	30mm	30/25.4mm
Configuration	64bit	64bit	64bit	72bit	72bit
Speed (MT/s)	4800-5600	2400-3200	4800-5600	2666-3200	1600-1866
Voltage	1.1V	1.2V	1.1V	1.2V	1.35V/1.5V
Operating Temperature*	C/I Temp	C/I Temp	C/I Temp	C/I Temp	C/I Temp

*C Temp (0˚C to +70˚C); I Temp (-40˚C to +85˚C); Ambient Temp (+40˚C to +70˚C)

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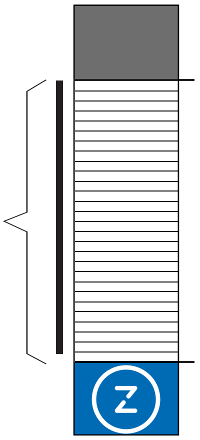
Zefr™
MEMORY

Ultra-High Reliability Zefr™ ZDIMM Memory

Eliminate over **90%** of Memory Reliability Failures

Industry Standard Memory Reliability isn't Sufficient



Conventional Memory
DPPM Range: 3000+

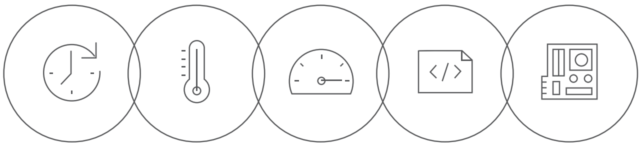
3000 DPPM
Industry Typical

90% +
Improvement
in Reliability

200 DPPM
Zefr ZDIMM

Zefr Screens Memory to Real-World Conditions

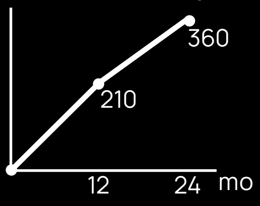
Zefr ZDIMM has been intensely processed to filter out weak memory modules. The Zefr Process combines five key testing ingredients.



Case Study

An HPC System Integrator built identical systems with standard and Zefr memory.

Standard Memory

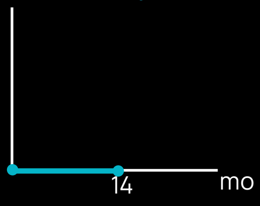


Purchase 18,384 Standard RDIMMs
Build Cluster A:

- 1,532 Nodes
- Twelve 16GB RDIMMs per Node

Field Failures since Platform Bring up:
360 Failures

Zefr Memory



1Purchase 18,384 Standard RDIMMs
Build Cluster B:

- 1,532 Nodes
- Twelve 16GB RDIMMs per Node

Field Failures since Platform Bring up:
0 Failures

For more information, please visit **https://www.smartm.com/product/list/zefr-zdimm**

Compact Systems

DIMM Type	VLP UDIMM	VLP/ULP ECC UDIMM		
Technology	DDR3	DDR5	DDR4	DDR3
Density	4GB-8GB	32GB-64GB	16GB-32GB	4GB-8GB
Height	18.3mm	18.75mm	17.78mm	18.75/18.3mm
Configuration	64bit	72bit	72bit	72bit
Speed (MT/s)	1600	4800-5600	2666-3200	1600
Voltage	1.35V/1.5V	1.1V	1.2V	1.35V/1.5V
Operating Temperature*	C Temp	C/I Temp	C/I Temp	C Temp

Aerospace/Military

DIMM Type	ECC SODIMM	
Technology	DDR4	DDR3
Density	4GB-32GB	2GB-16GB
Height	30mm	30/25.4mm
Configuration	72bit	72bit
Speed (MT/s)	2666-3200	1600-1866
Voltage	1.2V	1.35V/1.5V
Operating Temperature*	C/I Temp	C/I Temp

DIMM Type	MIP
Technology	DDR4
Density	2GB-16GB
Height	22.25mm
Configuration	72bit
Speed (MT/s)	2933-3200
Voltage	1.2V
Operating Temperature*	C/I Temp

*C Temp (0˚C to +70˚C); I Temp (-40˚C to +85˚C); Ambient Temp (+40˚C to +70˚C)

Flash Storage

Flexible Customization Solutions for Industrial Flash Storage

SMART's Flash product line delivers reliable storage solutions across diverse applications, from data centers to mission-critical aerospace and defense. We provide customized industrial flash storage with early proof of concept initiatives without high-volume requirements, making us the trusted partner for OEMs including telecommunications and networking. Here are the key areas where we provide customization:

Hardware

- Power Loss Protection Circuitry (Part of SafeData™)
- Capacity
- Form Factor
- Connectors/Interface
- Thermal Throttling Alerts
- Conformal Coating
- Customized Functions
- Burn In
- Extended Temperature

NVMSentry™ Firmware

- Security Features
  - Secure Boot
  - Secure Erase
  - TCG Opal 2.01
- Specialized custom functions
- Read/Write Performance and QoS/latency tuning
- SMART vendor-specific attributes and log pages
- pSLC firmware
- Power consumption optimization
- Endurance optimization
- Custom Over Provisioning

Data Center SSDs

SMART's Data Center SSDs are everything you need for data center storage – fast, cool and consistent.

Embedded SSDs

SMART's Flash product designation conveys its continued commitment to provide durable and reliable Flash storage required by diversified applications.

RUGGED SSDs

SMART's RUGGED SSD combines high performance, superior reliability and data security into a single ruggedized design.

Next-Generation Data Center SSDs

Meet three major demands for data center applications

SMART Modular's next-generation SSD family is designed for demanding Applications and stringent SLA's. Today's compute applications place extraordinary demands on data center servers and continue to increase the need for consistent and reliable performance from the underlying hardware. The ability to meet Service Level Agreements (SLA's) that rely on frequent access to data is highly dependent on the SSD storage controller design.

Architected for Low Power

SMART's DC SSD family uses a hardware-accelerated architecture that runs cooler while maintaining maximum performance. Low power operation helps achieve energy conservation standards and also increases server density per square foot. Save up to 200W per server in a standard 2U/24 configuration.

Peak Performance

SMART's data center SSDs run full-throttle for maximum throughput.

	Read	Write
Sequential (GB/s) Gen4	7.1 GB/s	4.6 GB/s
Random (KIOP/s) Gen4	1,490	180

Low Power

SMART's low power architecture keeps the SSDs running cool.

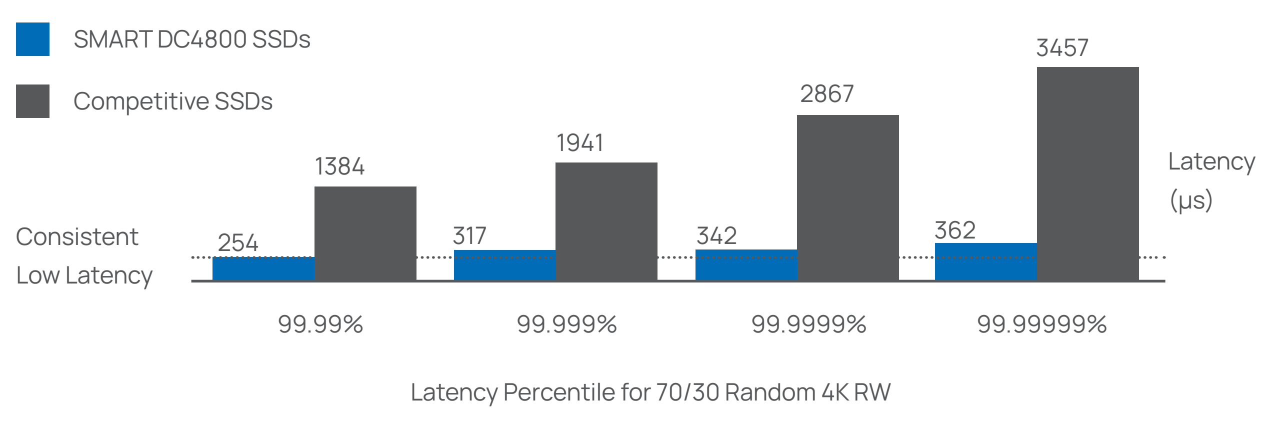
- Industry-leading low Idle and Active Power
- Less heat leaving more headroom for NAND to run fast
- Reduced OpEx costs for SSDs and cooling

Enterprise Features

Our SSDs are designed for a diverse range of data center applications

- E2E Data protection, TCG, OPAL, eDrive
- Secure Platform Boot
- Multiple Namespaces
- 1 and 3 DWPD
- SMART/Health Log Telemetry
- External Power Loss Protection

atency Percentile for 70/30 Ran
dom 4K RW



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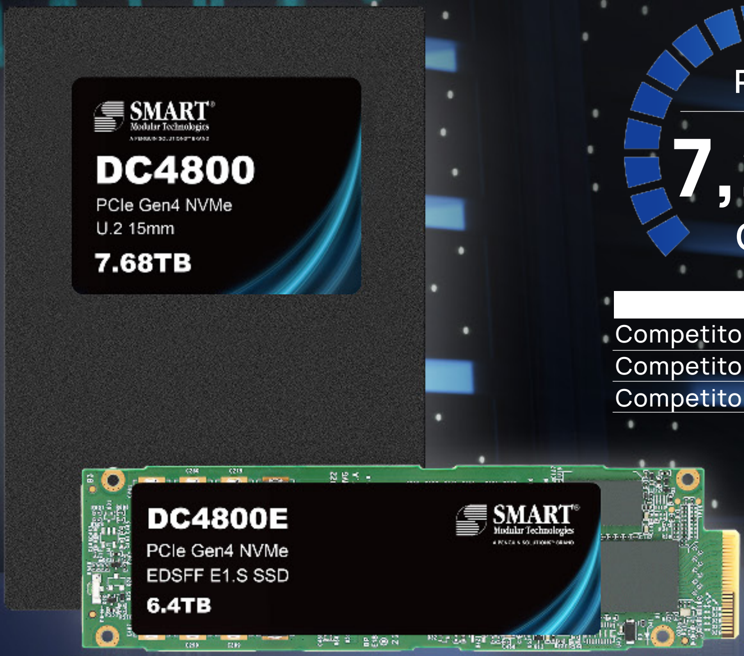
OPEN
Compute Project
SOLUTION PROVIDER®



Read 🏆
7,293
GB/s

Write 🏆
4,385
GB/s

	Read (GB/s)
Competitor M	4,026
Competitor T	3,194
Competitor W	3,300

	Write (GB/s)
Competitor M	2,180
Competitor T	1,253
Competitor W	3,196

DC4800/E PCIe NVMe Data Center SSDs

Fast, Cool and Consistent

Designed for data center, hyperscaler and cloud server applications

Maximum sustained performance capable of fully saturating the server's PCIe Gen 3/4/5

Superior Quality of Service (QoS) with 7-nines (99.99999%) of latency consistency

Hardware-accelerated SSD design to significantly reduce thermal throttling

Product Family

Form Factor	Form Factor	Capacity	DWPD
DC4800	U.2 EDSFF E1.S	1.92TB, 3.84TB, 7.68TB	1
DC4800E	U.2 EDSFF E1.S	0.8TB, 1.6TB, 3.2TB, 6.4TB	3

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

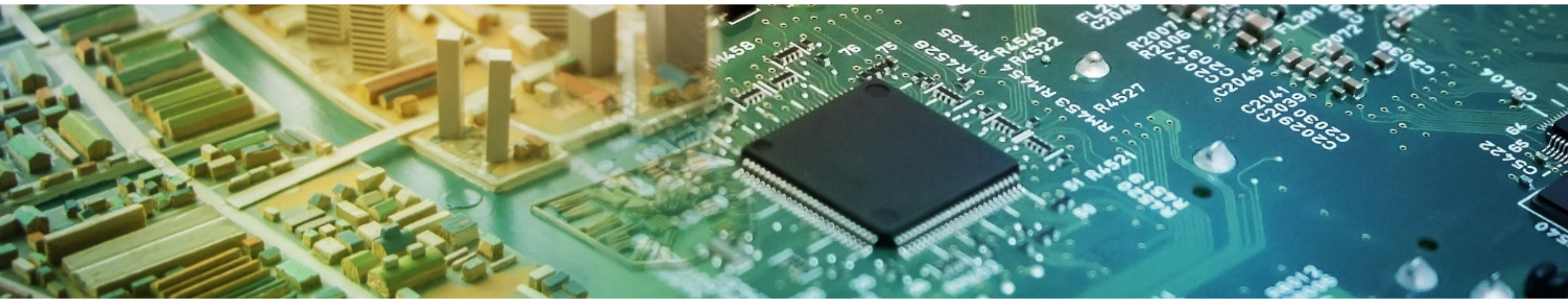
Embedded SSDs

Durable and Reliable Industrial Flash Solutions

SMART Modular is dedicated to providing a diverse range of Flash storage form factors, meticulously designed and manufactured to meet the rigorous demands of rapidly evolving embedded applications across various sectors, including telecom, networking, storage, industrial control, medical, IIoT, transportation, and video surveillance. SMART Modular's comprehensive capabilities and meticulous attention to detail ensure that quality controls and stringent processes are integrated into every phase of its design, procurement, and manufacturing cycle. From the careful selection of specialized materials and components that adhere to SMART's strict standards, to the completion of the product, each unit undergoes a rigorous design verification test (DVT) process, passing extensive checklists of criteria, followed by a final inspection before release.

Value-Added Features:

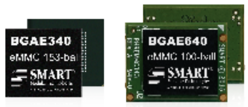
- Optimized for Enterprise and Industrial Applications
- Available in C Temp (0°C to +70°C) and I Temp (-40°C to +85°C)
- Multiple NAND Options: TLC, eTLC, MLC, SLC, and pSLC
- Extensive Burn-In to Ensure Field Reliability
- Customized Options with Advanced Features Available
- SafeDATA™ Technology Safeguards In-Flight Data During Sudden Power Loss (SPL)
- Available in Broad Range of Capacities
- NVMSentry ™ customized firmware support



Embedded SSDs Product Family

Embedded SSDs

- 2.5"
- M.2 (2230/2242/2280/22110)
- mSATA
- Slim SATA
- EDSFF E1.S



BGA

- eMMC
- BGA NVMe

Memory Cards

- SD Cards
- microSD Cards
- CF Cards

USB

- eUSB
- USB Flash Drives

Enterprise SSDs

- EDSFF E1.S, E3.S
- U.2

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Modular Technologies
A PENGUIN SOLUTIONS™ BRAND

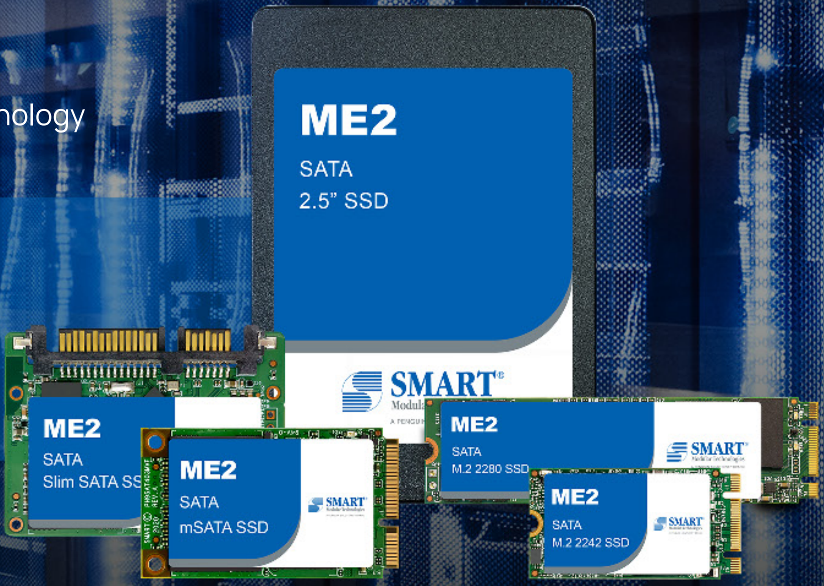
The Ideal SSD Boot Drives for Embedded and Data Center

- The Latest Generation 3D NAND Technology
- 1 DWPD For Five Years
- SMART's Proprietary NVMSentry™ Firmware
- Optional SafeDATA™ Power Loss Data-Protection Technology
- TCG OPAL 2.0 and AES 256 Encryption
- Support I-Temp (-40°C to +85°C)
- Single Event Upset (SEU) Mitigation Technology

SEU mitigation

ME2

SATA SSDs

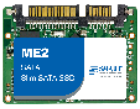


MP3000

PCIe NVMe SSDs

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

ME2 SATA SSDs



Specifications						
Interface		SATA III 6Gb/s				
Form Factor		2.5"	M.2 2242-D3-B-M	M.2 2280-D3-B-M	mSATA (MO-300A)	Slim SATA (MO-297)
Max. Performance	Read	540MB/s	540MB/s	540MB/s	540MB/s	540MB/s
	Write	460MB/s	460MB/s	460MB/s	460MB/s	460MB/s
Capacity		240GB-1920GB	240GB-960GB	240GB-1920GB	240GB-1920GB	240GB-1920GB
DRAM		V	V	V	V	V
Input Voltage		5V ± 10%	3.3V ± 5%	3.3V ± 5%	3.3V ± 5%	3.3V ± 5%
Data Integrity	SafeDATA	Optional	-	Optional	-	-
	Advanced Error Detection & Correction	V	V	V	V	V
Security	AES 256 Encryption	V	V	V	V	V
	TCG OPAL 2.0	V	V	V	V	V
	Security Erase (ATA)	V	V	V	V	V
Reliability	MTBF	> 2,000,000 hours				
	Shock Operating	1500 g half-sine, 0.5 msec, 1 shock along each axis, X, Y, Z in each direction				
	Vibration Operating	20G 80-2000Hz, 1.52mm 20-80Hz, 3 axis				
	Operating Temperature*	C/I Temp	C/I Temp	C/I Temp	C/I Temp	C/I Temp
Durability	DWPD (for 5 Years)	1 (Enterprise Workload)	1 (Enterprise Workload)	1 (Enterprise Workload)	1 (Enterprise Workload)	1 (Enterprise Workload)
	Pseudo-SLC	-	-	-	-	-
	Thermal Throttling	V	V	V	V	V
	Wear-Leveling / Garbage Collection / TRIM	V	V	V	V	V

Recommended/Suggested Applications

- AI
- Data Center
- Industrial
- Networking
- Surveillance

*C Temp (0°C to +70°C) ; E Temp (-25°C to +85°C) ; I Temp (-40°C to +85°C)

MP3000 PCIe NVMe SSDs

Specifications				
Interface		PCIe Gen4 x4		
Form Factor		EDSFF E1.S	M.2 2280-D3-M	M.2 22110-D3-M
Max. Performance	Read	3500MB/s	3500MB/s	3500MB/s
	Write	2900MB/s	2900MB/s	2900MB/s
Capacity		240GB-1920GB	240GB-1920GB	240GB-1920GB
DRAM		V	V	V
Input Voltage		12V ± 10%	3.3V ± 5%	3.3V ± 5%
Data Integrity	SafeDATA	Optional	Optional	Optional
	Advanced Error Detection & Correction	V	V	V
Security	AES 256 Encryption	V	V	V
	TCG OPAL 2.0	V	V	V
	Security Erase (ATA)	V	V	V
Reliability	MTBF	› 2,000,000 hours		
	Shock Operating	1500 g half-sine, 0.5 msec, 1 shock along each axis, X, Y, Z in each direction		
	Vibration Operating	20G 80-2000Hz, 1.52mm 20-80Hz, 3 axis		
	Operating Temperature*	C/I Temp	C/I Temp	C/I Temp
Durability	DWPD (for 5 Years)	1 (Enterprise Workload)	1 (Enterprise Workload)	1 (Enterprise Workload)
	Pseudo-SLC	Optional	-	-
	Thermal Throttling	V	V	V
	Wear-Leveling / Garbage Collection / TRIM	V	V	V

Recommended/Suggested Applications

- AI
- Data Center
- HPC
- Networking
- Storage
- Telecommunication

*C Temp (0°C to +70°C) ; E Temp (-25°C to +85°C) ; I Temp (-40°C to +85°C)

SMART®
Modular Technologies
A PENGUIN SOLUTIONS™ BRAND

SEUs Mitigation Technology

Reduce Service Costs and Improve Up-time in Critical 24/7 applications

ME2 SATA SSD Series & MP3000 PCIe/NVMe SSD Series

Single-event upsets (SEUs) are inadvertent changes in bit status that occur in digital systems when high-energy neutrons or alpha particles randomly strike. SEUs pose a significant threat to electronic devices, particularly SSDs, by causing temporary errors that can lead to abnormal operation or even total system failure.

Engineered with advanced SEU mitigation technology, ME2 and MP3000 SSDs deliver exceptional reliability and performance in the most demanding environments, especially important for tough-to-repair remote deployments.

Advanced SEU Mitigation

Protect data with ECC and self-recovery watchdog timers

Reduced Failure Rate

Reduce potential service cost with much lower Annual Failure Rate
(less than 10/Mu (Million units)

Optimal Performance

Optimize for 24/7 operations with consistent and reliable performance

Maximized Runtimes

Eliminate the need for system reboots or power cycles

RP4000 PCIe NVMe SSDs

Specifications		
Interface		PCIe Gen4 x4
Form Factor		M.2 2280-D3-M
Max. Performance	Read	6000MB/s
	Write	2000MB/s
Capacity		480GB-1920GB
DRAM		V
Input Voltage		3.3V ± 5%
Data Integrity	SafeDATA	Standard
	Advanced Error Detection & Correction	V
Security	AES 256 Encryption	V
	TCG OPAL 2.0	V
	Security Erase (ATA)	V
Reliability	MTBF	› 2,000,000 hours
	Shock Operating	1500 g half-sine, 0.5 msec, 1 shock along each axis, X, Y, Z in each direction
	Vibration Operating	20G 80-2000Hz, 1.52mm 20-80Hz, 3 axis
	Operating Temperature*	C Temp
Durability	DWPD (for 5 Years)	0.7 (Enterprise Workload)
	Pseudo-SLC	-
	Thermal Throttling	V
	Wear-Leveling / Garbage Collection / TRIM	V

Recommended/Suggested Applications

- Data Center
- HPC
- Networking
- Storage Server
- Telecommunication

*C Temp (0˚C to +70˚C) ; E Temp (-25˚C to +85˚C) ; I Temp (-40˚C to +85˚C)

eUSB Flash Drives

Specifications		RU150e	HU250e
Interface		USB 2.0	USB 3.0
NAND Type		SLC	
Max. Performance	Read	35MB/s	150MB/s
	Write	27MB/s	90MB/s
Capacity		1GB-32GB	8GB-32GB
Operating Temperature*		C/I Temp	I Temp
Connector		Pin pitch 2.54mm, H: 7.50mm Pin pitch 2.54mm, H: 9.78mm Pin pitch 2.00mm, H: 3.68mm	Pin pitch 2.00mm, H: 3.68mm Pin pitch 2.54mm, H: 7.42mm

Recommended/Suggested Applications

- Single-board computers for defense, gaming and industrial control applications
- ATCA compute blades
- Industry standard servers

USB Flash Drives

Specifications		RU150	RU350
Interface		USB 2.0	USB 3.0
NAND Type		SLC	TLC
Max. Performance	Read	354MB/s	2700MB/s
	Write	27MB/s	65MB/s
Capacity		1GB-16GB	16GB-256GB
Operating Temperature*		C/I Temp	I Temp
Connector		Type A	Type A

Recommended/Suggested Applications

- Single-board computers for defense, gaming and industrial control applications
- Telecom and networking routers and switches
- ATCA compute blades
- Industry standard servers
- Networking

*C Temp (0˚C to +70˚C) ; E Temp (-25˚C to +85˚C) ; I Temp (-40˚C to +85˚C)

eMMC

Specifications		BGAE 240	BGAE 340	BGAE 440	BGAE 640
Interface		eMMC v5.0 (HS400)	eMMC v5.1 (HS400)	eMMC v5.1	eMMC v5.1 (HS400)
Form Factor		BGA			
NAND Type		MLC/pSLC	MLC/pSLC	pSLC	TLC/pSLC
Max. Performance	Read	540MB/s	250MB/s	300MB/s	320MB/s
	Write	460MB/s	65MB/s	230MB/s	TLC: 170MB/s, pSLC: 250MB
Capacity		4GB to 32GB	4GB to 8GB	20GB	16GB to 128GB
Input Voltage		3.3V ± 10%	3.3V ± 10%	VCC: 2.7 – 3.6V; VCCQ: 1.7 – 1.95V or 2.7 – 3.6V	3.3V ± 10%
Ball Counts		100/153	100/153	100	100/153
Operating Temperature*		W Temp	I Temp	I Temp	E / I Temp

Recommended/Suggested Applications

- Gaming
- Communications
- Defense
- Industrial control equipment
- Networking
- Printers

CF Cards

Specifications		H9	XL
Interface		CF 6.1	CF 4.1
Form Factor		CompactFlash	
NAND Type		SLC	
Max. Performance	Read	100MB/s	30MB/s
	Write	70MB/s	12MB/s
Capacity		64MB-64GB	128MB-8GB
Operating Temperature*		C/I Temp	C/I Temp

Recommended/Suggested Applications

- Gaming
- Communications
- Defense
- Industrial control equipment
- Networking
- Printers

*C Temp (0˚C to +70˚C) ; E Temp (-25˚C to +85˚C) ; I Temp (-40˚C to +85˚C) ; W Temp (-40°C to +105°C)

SD Cards

Specifications		SD 3.01	RD230
Interface		SD 3.01	SD 6.1
Form Factor		SD Card	
NAND Type		SLC	TLC
Max. Performance	Read	98MB/s	95MB/s
	Write	75MB/s	55MB/s
Capacity		1GB-32GB	128GB
Operating Temperature*		C/E/I Temp	I Temp

Recommended/Suggested Applications

- Automotive telematics, navigation, and infotainment
- Digital commercial camcorders
- Telecom and communications
- Embedded computing
- Medical equipment

MicroSD Cards

Specifications		RD130m	RD230m	RD530m
Interface		SD 3.01	SD 6.1	SD 6.1
Form Factor		microSD Card		
NAND Type		SLC	TLC	TLC
Max. Performance	Read	68MB/s	95MB/s	100MB/s
	Write	50MB/s	55MB/s	90MB/s
Capacity		1GB-4GB	32GB	64GB-128GB
Operating Temperature*		E/I temp	I Temp	C Temp

Recommended/Suggested Applications

- Automotive telematics, navigation, and infotainment
- Telecom and communications
- Embedded computing
- Digital commercial camcorders
- Industrial meters and industrial control
- Medical equipment
- Gaming

*C Temp (0˚C to +70˚C) ; E Temp (-25˚C to +85˚C) ; I Temp (-40˚C to +85˚C)

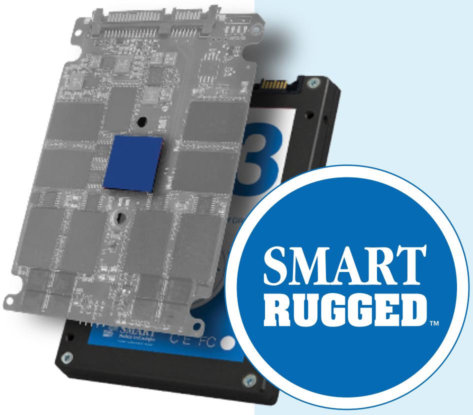
SMART RUGGED

WHEN FAILURE IS NOT AN OPTION

SMART RUGGED pioneered secure, ruggedized solid-state drives and continues to be a technology leader, employing current and next-generation defense-focused designs with physical ruggedization, conformal coating, HW-based erase triggers on each end of the drives, and more. Utilizing Flash technology backed with proven world-class support, SMART RUGGED designs and manufactures high performance military and industrial SSDs with military standard encryption, secure data elimination and write-protect features.

Standard

- Security
- Shock & Vibration
- Conformal Coat
- Humidity Condensation
- Altitude
- Industrial Temperature



Optional

- Specific Shock & Vibration
- Underfill & Staking
- Leaded Process
- Custom FW
- Custom HW
- Extreme Temperature Screening

SMART RUGGED SSD LINE-UP

	T6EN			T6CN			T5EN	
Interface	PCIe			PCIe			PCIe	
Form Factor	E1.S	U.2	M.2 2280	E1.S	U.2	M.2 2280	U.2	M.2 2280
NAND Flash Type	3D TLC			3D TLC			3D TLC	
Capacity	960GB-7,680GB	960GB-15,360GB	960GB-7,680GB	960GB-7,680GB	960GB-15,360GB	960GB-7,680GB	3D TLC: 480GB-3,840GB pSLC: 160GB-1,280GB	3D TLC: 480GB-1,920GB pSLC: 160GB-640GB
Sustained Read/Write Performance	3,500MB/s Read, 3,000MB/s Write	3,500MB/s Read, 3,000MB/s Write	3.200MB/s Read, 3,200MB/s Write	3,500MB/s Read, 3,000MB/s Write	3,500MB/s Read, 3,000MB/s Write	3.200MB/s Read, 3,200MB/s Write	3,200MB/s Read, 1,600MB/s Write	
Reliability								
MTBF	2M Hours, Telcordia 20°C			2M Hours, Telcordia 20°C			2M Hours, Telcordia 25°C	
Data Reliability	1 in 10^{17} bits read							
Data Retention	10 years @ 25°C			10 years @ 25°C			10 years @ 25°C	
Endurance	I-Temp: 9,600 TBW (with 15,360GB)			C-Temp: 16,800 TBW (with 15,360GB) I-Temp: 9,600 TBW (with 15,360GB)			3D TLC: 625 TDW pSLC: 6,250 TDW	
Power Loss Protection	U.2 & E1.S only			U.2 & E1.S only			pFail	No pFail
Warranty	1 Year			1 Year			1 Year	
Environmental								
Operating Temperature	I-Temp[5]			C/I-Temp[5]			I-Temp[5]	
Storage Temperature	Commercial (-40°C to 85°C); Industrial (-50°C to 95°C)			Commercial (-40°C to 85°C); Industrial (-50°C to 95°C)			-55°C to +95°C	
Operating Shock	50G (11 ms,duratio, half sine wave)[3]			50G (11 ms,duratio, half sine wave)[3]			50g half-sine, 11 ms, 3 shocks along each axis[3]	
Operating Vibration	10G (peak, 10-2000Hz)[3]			10G (peak, 10-2000Hz)[3]			10g rms, 10-2000Hz[3]	
Relative Humidity	5% - 95% non-condensing[3]			5% - 95% non-condensing[3]			5% - 95% non-condensing[3]	
Altitude	24,384 m (80,000 ft)[3]			24,384 m (80,000 ft)[3]			24,384 m (80,000 ft)[3]	
Conformal Coating	Optional			Optional			Optional	
Security (Protection & Data Elimination)								
ATA Password	-	-	-	V	V	V	-	-
AES 256-bit	V	V	V	V	V	V	V	V
Write Protect	V	V	V	-	-	-	-	V
External HW Trigger	V	V	V	-	-	-	V	V
Erase Key and Flash	V	V	V	-	-	-	V	V
TCG Opal 2.0	V	V	V	-	-	-	V	V
FIPS 140-2	-	-	-	-	-	-	-	-
MIL Erase Sequences								
NSA-9-12	V	V	V	-	-	-	V	V
DoD NISPOM 5220.22-M	V	V	V	-	-	-	V	V
DoD NISPOM 5220.22-M-Sup 1	V	V	V	-	-	-	V	V
NSA/CSS Manual 130-2	V	V	V	-	-	-	V	V
NSA/CSS Manual 9-12	V	V	V	-	-	-	V	V
Army AR 380-19	V	V	V	-	-	-	V	V
Navy NAVSO P-5239-26	V	V	V	-	-	-	V	V
Air Force AFSSI-5020	V	V	V	-	-	-	V	V
RCC –TG IRIG 106-07	V	V	V	-	-	-	V	V

[1] Estimated. Official MTBF pending

[2] Based on 128 KByte block transfers and continuous, sequential writes to the drive. The number does not include file system overhead, which may vary depending on the file system. The total life span of the drive depends on both the write endurance numbers and MTBF. TDW → Total Drive Writes = (Terabytes Written) *1000 / (Drive Capacity GB)

[3] Design Specification. Testing Pending

[4] FIPS 140-2 Inside

[5] C-Temp (0°C to +70°C); I-Temp (-40°C to +85°C)

	T5E		S5E	T5PF	T5PFLC	
Interface	SATA		SATA	SATA	SATA	
Form Factor	2.5"	M.2 2280	2.5"	2.5"	2.5"	M.2 2280
NAND Flash Type	3D TLC		SLC	3D TLC	3D TLC	
Capacity	3D TLC: 120GB-3,840GB pSLC: 40GB-1,280GB	3D TLC: 120GB-1,920GB pSLC: 40GB-640GB	60GB-480GB	480GB-3,840GB	120GB-1,920GB	240GB-960GB
Sustained Read/Write Performance	520MB/s Read, 500MB/s Write		530MB/s Read, 490MB/s Write	500MB/s Read, 470MB/s Write	500MB/s Read, 470MB/s Write	
Reliability						
MTBF	2M Hours, Telcordia 25°C		2M Hours, Telcordia 25°C	2M Hours, Telcordia 25°C[1]	2M Hours, Telcordia 25°C[1]	
Data Reliability	1 in 10^{17} bits read					
Data Retention	10 years @ 25°C		10 years @ 25°C	10 years @ 25°C	10 years @ 25°C	
Endurance	3D TLC: 1,000 TDW pSLC: 10,000 TDW		30,000 TDW	2,100 TDW	2,100 TDW	
Power Loss Protection	pFail	No pFail	pFail	pFail	No pFail	
Warranty	1 Year		1 Year	1 Year	1 Year	
Environmental						
Operating Temperature	C/I-Temp[5]	I-Temp[5]	I-Temp[5]	I-Temp[5]	C/I-Temp[5]	
Storage Temperature	-55°C to +95°C		-55°C to +95°C	-55°C to +95°C	-55°C to +95°C	
Operating Shock	50g half-sine, 11 ms, 3 shocks along each axis[3]		50g half-sine, 11 ms, 3 shocks along each axis	50g half-sine, 11 ms, 3 shocks along each axis[3]	50g half-sine, 11 ms, 3 shocks along each axis[3]	
Operating Vibration	16.4g rms, 10-2,000 Hz	10g rms, 10-2000Hz[3]	16.4g rms, 10-2,000 Hz	16.4g rms, 10-2,000 Hz[3]	16.4g rms, 10-2,000 Hz[3]	
Relative Humidity	5%-95% non-condensing					
Altitude	24,384m (80,000 ft)		24,384 m (80,000 ft)	24,384 m (80,000 ft)	24,384 m (80,000 ft)	
Conformal Coating	Optional		Optional	Optional	Optional	
Security (Protection & Data Elimination)						
ATA Password	V	V	V	V	V	V
AES 256-bit	V	V	V	V	V	V
Write Protect	V	Optional	V	V	-	-
External HW Trigger	V	-	V	V	-	-
Erase Key and Flash	V	-	V	V	-	-
TCG Opal 2.0	V	V	V	V	V	V
FIPS 140-2	-	-	-	V[4]	V[4]	V[4]
MIL Erase Sequences						
NSA-9-12	V	-	V	-	-	-
DoD NISPOM 5220.22-M	V	-	V	V	-	-
DoD NISPOM 5220.22-M-Sup 1	V	-	V	V	-	-
NSA/CSS Manual 130-2	V	-	V	V	-	-
NSA/CSS Manual 9-12	V	-	V	V	-	-
Army AR 380-19	V	-	-	V	-	-
Navy NAVSO P-5239-26	V	-	V	V	-	-
Air Force AFSSI-5020	V	-	V	V	-	-
RCC -TG IRIG 106-07	V	-	V	-	-	-

[1] Estimated. Official MTBF pending

[2] Based on 128 KByte block transfers and continuous, sequential writes to the drive. The number does not include file system overhead, which may vary depending on the file system. The total life span of the drive depends on both the write endurance numbers and MTBF. TDW → Total Drive Writes = (Terabytes Written) *1000 / (Drive Capacity GB)

[3] Design Specification. Testing Pending

[4] FIPS 140-2 Inside

[5] C-Temp (0°C to +70°C); I-Temp (-40°C to +85°C)

SMART® Modular Technologies

A PENGUIN SOLUTIONS™ BRAND

Think Memory.
Think SMART.

For more product details, please contact the SMART sales team or visit our website.

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