# HEROSYS


# HEROSYS Industrial Solutions

## SSD & DRAM

Product Guidebook

V2.2.1

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「PROFESSIONALISM FIRST, QUALITY FOREMOST」

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# Why HEROSYS?

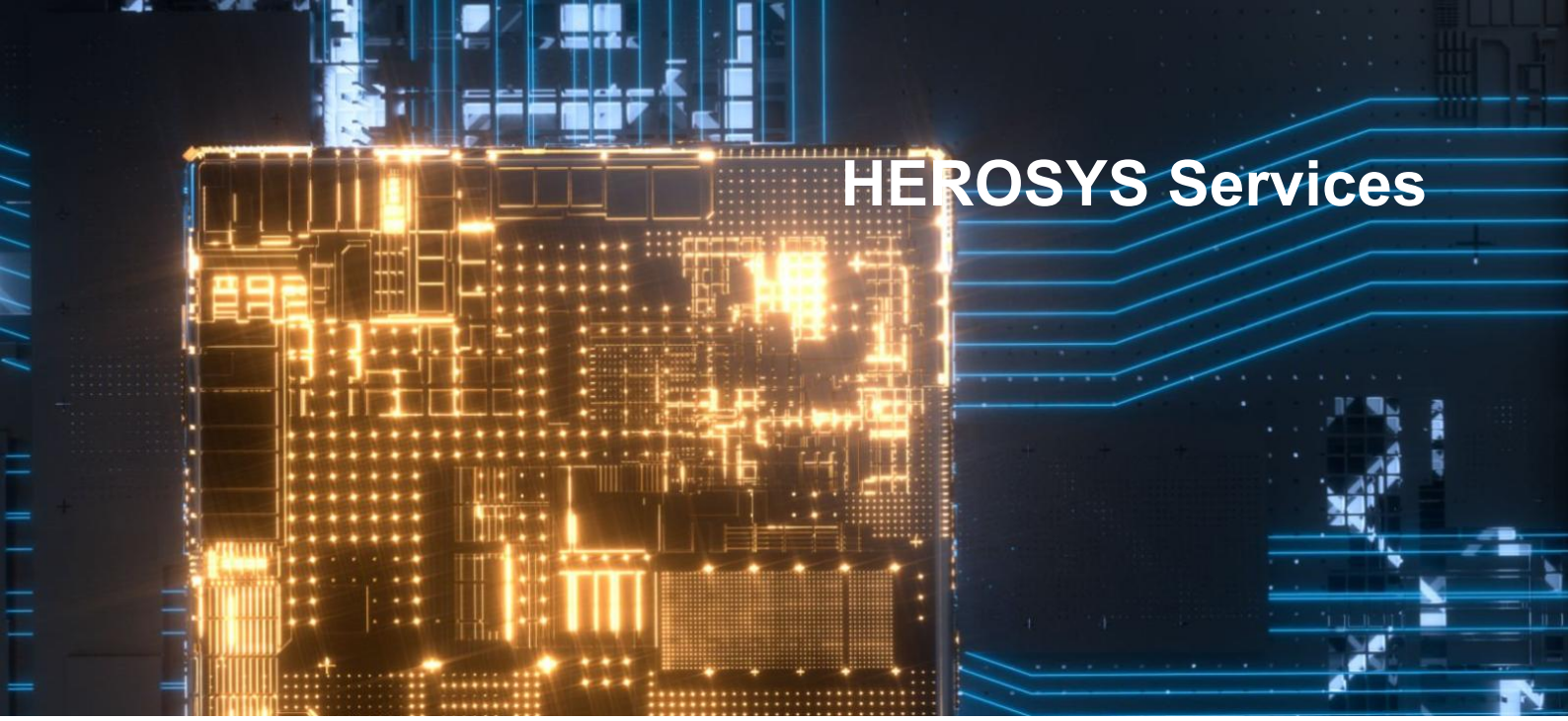
HEROSYS, originating from Taiwan, has over a decade of experience in the industrial memory and storage field. With a solid foundation in platform-level development and supply chain integration, we have built a comprehensive capability to serve various industrial sectors.

Due to early policy and industry restrictions, HEROSYS products were initially limited to the Taiwan domestic market. In recent years, with the lifting of related restrictions, we have officially expanded into the Chinese mainland and global markets, with Shenzhen HEROJE serving as mainland sales headquarters to drive strategic partnerships and application deployment.

Guided by the principle of “Professionalism First, Quality Foremost”, we are committed to delivering reliable, long-term solutions for system manufacturers and industrial users. Our product offerings include industrial memory (DRAM), solid-state drives (SSD), embedded motherboards, CPU modules, and customized modular industrial solutions. Our products are widely used in embedded systems, industrial control, medical devices, servers, edge computing, surveillance, and ICT, meeting both standard and highly customized requirements. We support flexible engagement from single component selection to full platform integration, helping customers shorten development cycles, reduce integration risks, and enhance system performance.

HEROSYS strictly selects premium  original high-quality components and manufactured in Taiwan. Each product undergoes rigorous testing that exceeds industry standards, including high/low temperature cycles, stress testing, and compatibility verification, ensuring 100% testing coverage and reliable, long-term supply.

Beyond quality assurance, we adopt a market-competitive pricing strategy to offer cost-effective, high-performance solutions to clients across the Chinese and international markets. We aim to create new opportunities and long-term value together with our partners across various industries.



# HEROSYS Services




## SSD Data Recovery Services

When a solid-state drive (SSD) experiences issues such as drive dropouts, unrecognized devices, bad sectors, accidental deletion, or system failures, valuable data can be lost in an instant. We offer professional SSD data recovery services, equipped with dedicated tools and an experienced technical team. Our services support a wide range of SSD brands and interfaces, providing comprehensive diagnostics and data recovery solutions.

Whether it's mission-critical enterprise data or important personal files, we are committed to helping you retrieve lost data as quickly as possible—ensuring minimal disruption to your business operations or personal digital life.

**This is a paid service.*


## Real-Time SSD Health and Lifespan Monitoring Tool

While solid-state drives (SSDs) offer excellent performance, they have a finite lifespan. As they approach their endurance limits, the risk of data corruption or device failure increases significantly. Our professional SSD monitoring solution provides real-time tracking of drive health through dedicated software—monitoring key indicators such as TBW (Total Bytes Written), wear level, and temperature anomalies.

The system delivers proactive alerts before the SSD reaches critical wear levels, helping users back up data or replace drives in advance. This significantly reduces the risk of data loss and safeguards both enterprise and personal information security.

**This is a paid service.*

# Reliable Storage Solutions for Every Industry Need

**In today's digital landscape, businesses encounter increasing demands for data handling, cybersecurity, and operational performance.**

HEROSYS delivers highly reliable and high-performance DRAM and SSD solutions that help enterprises streamline system processes, enhance productivity, and drive digital advancement. From industrial automation and cybersecurity to rugged systems deployed in mission-critical environments, we offer flexible and robust storage foundations to support your success in today's rapidly evolving market landscape.

**Smart Automotive**
Supports high-speed data processing and storage demands for autonomous driving and in-vehicle systems.

**Factory Automation**
Enhances productivity and system uptime with high-performance storage solutions.

**Servers & Networking**
Scalable solutions designed to accelerate connectivity and strengthen IT infrastructure.

**Transportation**
Enables smoother operations and improved efficiency through real-time data processing.

**Rugged Systems**
Engineered to withstand extreme conditions, ensuring reliable performance in critical applications.

**Healthcare**
Delivers dependable storage to ensure data integrity and seamless operation of medical equipment.

**Surveillance Systems**
Ensures 24/7 reliable recording and outstanding durability for uninterrupted monitoring.

**Defense & Military**
Provides stable and robust storage performance in harsh environments to support mission-critical operations.

# SSD Data Protection Card



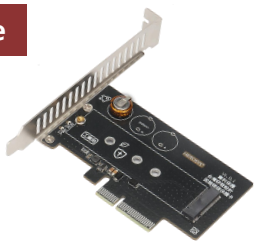

## SSD Data Protection Card X-SHIELD Series

- End-to-End Data Protection: Ensures data consistency and integrity throughout the entire transmission path, effectively preventing data corruption.
- Power Loss Protection Mechanism: Automatically activates protection during unexpected power outages to prevent data loss and SSD damage.
- SSD Protection Mechanism: Prevents hardware damage caused by abnormal power loss and extends the SSD's lifespan.
- Power Purification Technology: Filters out power noise, surges, and ripple to ensure stable power supply quality.
- Stable Chip Design: Ensures reliable data storage in flash memory under various power conditions.
- Temperature Monitoring & Overload Protection: Built-in sensor module monitors operating conditions and proactively safeguards system security.
- Supports SSD models with both SATA and M.2 interfaces.
- Provides real-time inline protection with zero latency.

**Auto power-off protection to prevent data loss**

**Zero-latency physical circuit**

**Plug-and-play convenience**



| Model Name | X-SHIELD-SAT-100 | X-SHIELD-PCI-100 |
|---|---|---|
| Interface | SATA | PCIe |
| Connector | 7+15 Pin male | Single-sided M.2 2280-M |
| Power Loss Protection | Provided | Provided |
| Max. Sequential R/W (MB/Sec) | Data pass-through, speed is as per SSD specificati | Data pass-through, speed is as per SSD specificati |
| Operating Voltage | 5.0V±5% | 5.0V±5% |
| Operating Temperature (℃) | WT 0°C to 70°C<br>STD -40°C to 85°C | WT 0°C to 70°C<br>STD -40°C to 85°C |

# Solid State Drive





## SATA III 2.5” SSD Solid State Drive

- Up to 570K random read IOPS performance *1
- Utilizes LDPC (Low-Density Parity-Check) error correction mechanism
- Supports ATA Secure Erase
- Integrated Bad Block Management and Reallocation mechanism
- Implements Page Mapping Flash Translation Layer (FTL)
- Supports TRIM command
- S.M.A.R.T. health monitoring
- Supports power-saving sleep mode
- Industrial-grade shock and vibration resistance design

**SLC SSD with ultra-long write endurance**

**Good Die original chips**

**Full-drive writes daily, stable for 3 years**

| Part Number | HSD-253S C240 GBa | HSD-253S C480 GBa | HSD-253S C960 GBa | HSD-253S C128 GSun | HSD-253S C256 GSun | HSD-253S C512 GSun | HSD-253S C1TSun | HSD-253S C2TSun | HSD-253S C128 GhSLC | HSD-253S C256 GhSLC | HSD-253S C512 GhSLC |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Form Factor | 2.5” | | | | | | | | | | |
| Interface | SATA 3.0 (6Gb/s) | | | | | | | | | | |
| NAND Flash Type | QLC | | | 3D TLC | | | | | hSLC | | |
| Capacity | 240 GB | 480 GB | 960 GB | 128 GB | 256 GB | 512 GB | 1 TB | 2 TB | 128 GB | 256 GB | 512 GB |
| Max. Sequential R/W (MB/Sec) | 525/487 | | | 550/ 520 | | | | | 550/ 520 | | |
| Max. Random R/W (IOPS) | 72K | | | | | | | | | | |
| External DRAM Buffer | No | | | | | | | | | | |
| TBW [1] | 240GB: 80TB<br>480GB: 160TB<br>960GB: 300TB | | | 128GB: 200TB<br>256GB: 400TB<br>512GB: 800TB<br>1TB: 1600TB<br>2TB: 3200TB | | | | | 128GB: 800TB<br>256GB: 1600TB<br>512GB: 3200TB | | |
| Operating Temperature | WT 0°C to 70°C<br>STD -40°C to 85°C | | | | | | | | | | |

1 - Test data from HEROSYS laboratory; actual write volume should account for the OS write amplification effect and factor.

# Solid State Drive




## PCIe Gen3 M.2 2280 SSD Solid State Drive

- Delivers up to 3,500MB/s sequential read and 3,100MB/s sequential write speeds
- Offers up to 570K random read IOPS for exceptional performance
- Utilizes LDPC (Low-Density Parity-Check) error correction mechanism for enhanced data reliability
- Implements Advanced Global Wear Leveling for extended flash endurance
- Integrates Bad Block Management for automatic detection and remapping of defective memory blocks
- Supports End-to-End Data Path Protection to ensure data integrity throughout transmission
- Adopts Page Mapping Flash Translation Layer (FTL) to optimize random access performance
- Supports TRIM command and S.M.A.R.T. health monitoring for sustained speed and drive health insights

**SLC SSD with ultra-long write endurance**

**Good Die original chips**

**Full-drive writes daily, stable for 3 years**

| Part Number | HSD-M23XC128G | HSD-M23XC256G | HSD-M23XC512G | HSD-M23XC1T | HSD-M23XC2T |
|---|---|---|---|---|---|
| Form Factor | M.2 2280 | | | | |
| Interface | PCIe Gen3 x4 | | | | |
| NAND Flash Type | 3D TLC | | | | |
| Capacity | 128 GB | 256 GB | 512 GB | 1 TB | 2 TB |
| Max. Sequential R/W (MB/Sec) | 3500/3100 | | | | |
| Max. Random R/W (IOPS) | 420K | | | | |
| External DRAM Buffer | No | | | | |
| TBW [1] | 128GB: 200TB<br>256GB: 400TB<br>512GB: 800TB<br>1TB: 1600TB<br>2TB: 3200TB | | | | |
| Operating Temperature (℃) | WT 0°C to 70°C<br>STD -40°C to 85°C | | | | |

1 - Test data from HEROSYS laboratory; actual write volume should account for the OS write amplification effect and factor.

**Product Guidebook**

# Solid State Drive




INDUSTRIAL USE

Supports **800+** days of daily full-capacity write stress, built for long-term heavy-duty use.

*Based on 128 GB

## mSATA SSD Solid State Drive

- 3D NAND Flash, available in TLC / SLC versions
- SATA 6.0 Gb/s interface, compliant with SATA Revision 3.2
- Supports LDPC ECC error detection and correction
- Global Wear Leveling technology
- Bad Block Management mechanism
- Flash Translation Layer: Page Mapping
- S.M.A.R.T. support for real-time status monitoring
- Supports TRIM command and ATA Secure Erase
- Low power consumption mode for extended system uptime
- Temperature monitoring to prevent performance degradation

**SLC SSD with ultra-long write endurance**

**Good Die original chips**

**Full-drive writes daily, stable for 3 years**

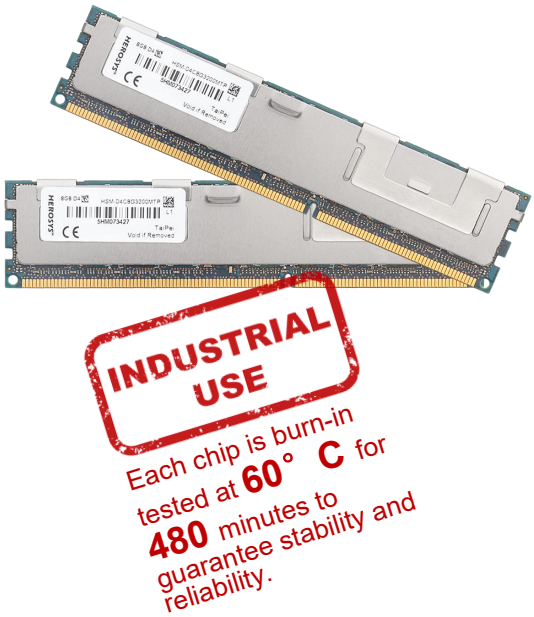
| Part Number | HSD-MS3SC128 GFire | HSD-MS3SC256 GFire | HSD-MS3SC512 GFire | HSD-MS3SC128 GhSLC | HSD-MS3SC256 GhSLC | HSD-MS3SC512 GhSLC |
|---|---|---|---|---|---|---|
| Form Factor | mSATA | | | | | |
| Interface | SATA 3.2 (6Gb/s) | | | | | |
| NAND Flash Type | 3D TLC | | | hSLC | | |
| Capacity | 128 GB | 256 GB | 512 GB | 128 GB | 256 GB | 512 GB |
| Max. Sequential R/W (MB/Sec) | 550/485 | | | | | |
| Max. Random R/W (IOPS) | 63K | | | | | |
| External DRAM Buffer | No | | | | | |
| TBW [1] | 128GB: 200TB<br>256GB: 400TB<br>512GB: 800TB | | | 128GB: 800TB<br>256GB: 1600TB<br>512GB: 3200TB | | |
| Operating Temperature (℃) | WT 0°C to 70°C<br>STD -40°C to 85°C | | | | | |

1 - Test data from HEROSYS laboratory; actual write volume should account for the OS write amplification effect and factor.

**Product Guidebook**

# Memory Module





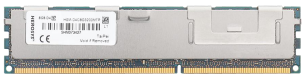

## DDR4 RDIMM Memory Module

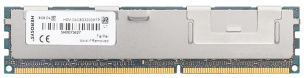
- Supports ECC error detection and correction for improved data accuracy
- On-DIMM temperature sensor for real-time monitoring and overheating prevention
- 16 internal banks (4 bank groups)
- Average refresh interval: ≤ 85°C: 7.8 µs; 85–95°C: 3.9 µs
- Lead-free (RoHS compliant)
- Halogen-free
- 30 µ-inch gold fingers for durability and oxidation resistance
- Optional: Conformal coating / underfill
- Optional: Anti-sulfurization treatment

**ECC auto-correction for safer data**

**Built-in dynamic thermal balance for lasting stability**

**Efficient refresh, reliable performance**





| Part Number | HSM-D4C32G2933 | HSM-D4C64G2933 |
|---|---|---|
| Module Type | RDIMM | |
| Memory Technology | DDR4 | |
| Speed (MT/s) | 2966 | |
| Density | 32 GB | 64 GB |
| Voltage | 1.2 V | |
| Pin Count | 288-Pin | |
| Width | 72-Bit | |
| PCB Height | 1.23” | |
| Operating Temperature (℃) | 0℃ to 85℃ (Tc) | |
| Fully Lead-free Resistor | YES | |

# Memory Module




## DDR5 UDIMM Memory Module

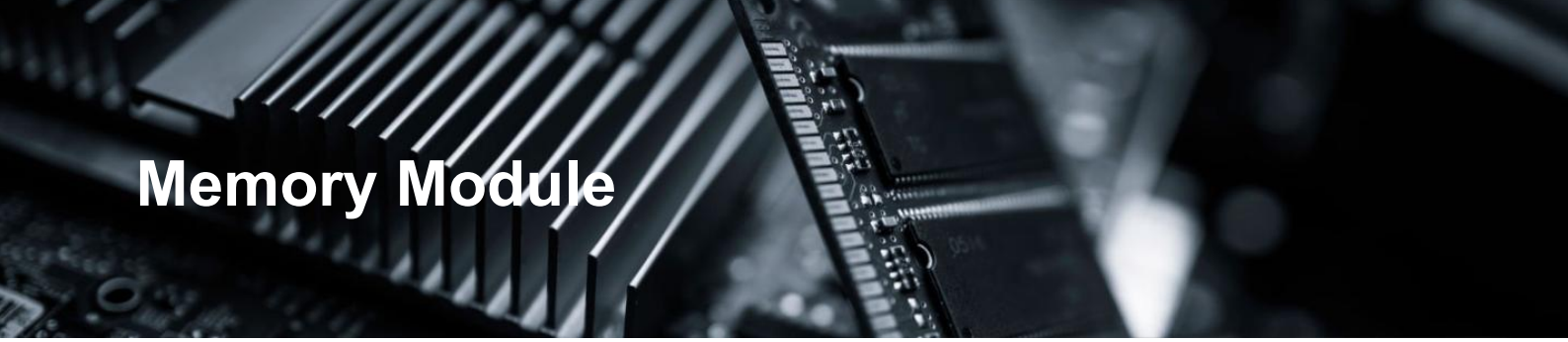
- Compliant with JEDEC standard frequency of 5600 MT/s (CL46)
- Equipped with high-quality DDR5 DRAM chips from top-tier manufacturers (Micron / SK hynix / Samsung)
- Integrated on-DIMM Power Management IC (PMIC) with 5V input support
- On-die ECC (Error Correction Code) mechanism for automatic single-bit error correction
- 288-pin DDR5 UDIMM (Unbuffered Dual In-Line Memory Module)
- Operating voltages: VDD = VDDQ = 1.1V, VPP = 1.8V
- 32 internal banks architecture: 8 bank groups × 4 banks
- RoHS compliant (lead-free)
- Halogen-free
- Optional conformal coating / underfill
- Optional anti-sulfuration protection

**480 min burn-in at 60°C for proven reliability**

**A-Die original chips, guaranteed quality**

**Brand-new, durable, highly reliable**

| Part Number | HSM-D5C8G5600P | HSM-D5C16G5600P | HSM-D5C32G5600P |
|---|---|---|---|
| Module Type | UDIMM | | |
| Memory Technology | DDR5 | | |
| Speed (MT/s) | 5600 | | |
| Density | 8 GB | 16 GB | 32 GB |
| Voltage | 1.1 V | | |
| Pin Count | 288-Pin | | |
| Width | 64-Bit | | |
| PCB Height | 1.23” | | |
| Operating Temperature (℃) | 0℃ to 85℃ (Tc) | | |
| Fully Lead-free Resistor | YES | | |



# Memory Module




## DDR4 UDIMM Memory Module

- Data transfer rates up to 3200 MT/s
- Utilizes original high-quality DDR4 DRAM chips from leading brands (Micron / SK Hynix / Samsung)
- No on-DIMM temperature sensor
- PCB height: 31.25 mm; pin pitch: 0.85 mm
- 288-pin dual in-line memory module (DIMM)
- VDD = VDDQ = 1.2V (operating range: 1.14V to 1.26V)
- IC surface temperature: 0° C to 85° C
- Refresh cycle: 64ms (0° C to 85° C)
- Refresh cycle: 32ms (85° C to 95° C)
- Lead-free (RoHS compliant)
- Halogen-free
- Conformal coating / underfill (optional)
- Anti-sulfurization (optional)

**480 min burn-in at 60°C for proven reliability**

**A-Die original chips, guaranteed quality**

**Brand-new, durable, highly reliable**

| Part Number | HSM-D4C8G3200P | HSM-D4C16G3200P | HSM-D4C32G3200P |
|---|---|---|---|
| Module Type | UDIMM | | |
| Memory Technology | DDR4 | | |
| Speed (MT/s) | 3200 | | |
| Density | 8 GB | 16 GB | 32 GB |
| Voltage | 1.2 V | | |
| Pin Count | 288-Pin | | |
| Width | 64-Bit | | |
| PCB Height | 1.23” | | |
| Operating Temperature (℃) | 0℃ to 85℃ (Tc) | | |
| Anti-Sulfuration | YES | | |


## DDR4 SODIMM Memory Module

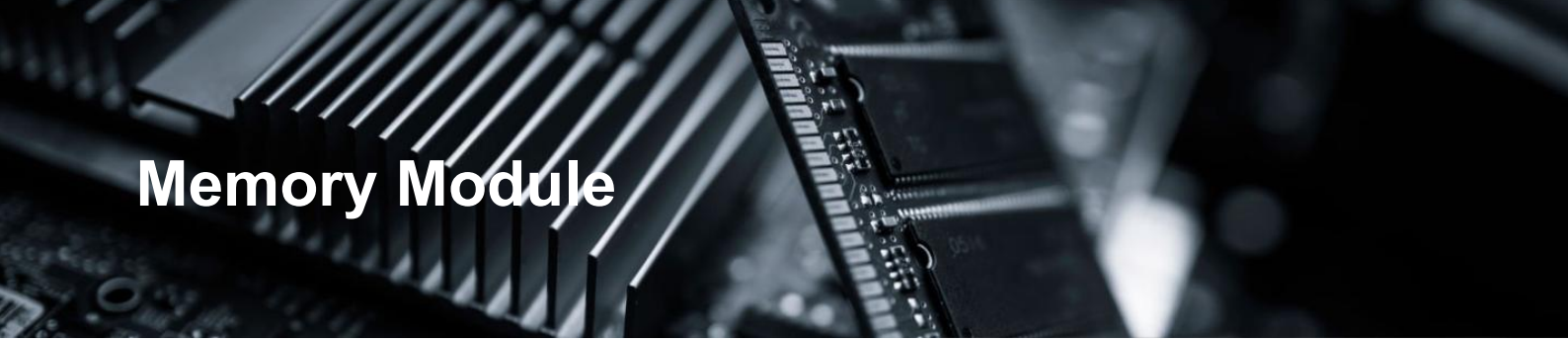
- Data transfer rate up to 3200 MT/s
- Equipped with original high-quality DRAM chips (Micron / SK Hynix / Samsung)
- No on-DIMM temperature sensor
- Module dimensions: PCB height 30.00 mm, pin pitch 0.50 mm
- 260-pin Small Outline Dual In-line Memory Module (SO-DIMM)
- Supply voltage: VDD = VDDQ = 1.2V (operating range: 1.14V to 1.26V)
- When IC surface temperature < 85° C: Average refresh interval = 7.8 µs
- When 85° C ≤ IC surface temperature ≤ 95° C: Average refresh interval = 3.9 µs
- Lead-free (RoHS compliant)
- Halogen-free
- Optional conformal coating / underfill
- Optional anti-sulfuration protection

**480 min burn-in at 60°C for proven reliability**

**A-Die original chips, guaranteed quality**

**Brand-new, durable, highly reliable**

| Part Number | HSM-D4C4G3200M | HSM-D4C8G3200M | HSM-D4C16G3200M | HSM-D4C32G3200M |
|---|---|---|---|---|
| Module Type | SODIMM | | | |
| Memory Technology | DDR4 | | | |
| Speed (MT/s) | 3200 | | | |
| Density | 4 GB | 8 GB | 16 GB | 32 GB |
| Voltage | 1.2 V | | | |
| Pin Count | 260-Pin | | | |
| Width | 64-Bit | | | |
| PCB Height | 1.18” | | | |
| Operating Temperature (℃) | 0℃ to 85℃ (Tc) | | | |
| Anti-Sulfuration | YES | | | |



# Memory Module




## DDR3 UDIMM Memory Module

- Built with high-quality DDR3 DRAM chips from top-tier original manufacturers (Micron / SK Hynix / Samsung)
- No on-DIMM temperature sensor
- PCB height: 30.00 mm; pin pitch: 1.0 mm
- 240-pin dual in-line memory module (UDIMM)
- Operating voltage: 1.35V (tolerance: +0.1V / –0.067V), 1.5V (tolerance: ±0.075V)
- IC surface operating temperature: 0°C to 85°C
- Refresh cycle time (0°C to 85°C): 7.8 µs
- Lead-free, RoHS compliant
- Halogen-free
- Optional conformal coating and underfill for added environmental protection
- Optional anti-sulfuration feature for use in high-sulfur or polluted environments

**480 min burn-in at 60°C for proven reliability**

**A-Die original chips, guaranteed quality**

**Brand-new, durable, highly reliable**

| Part Number | HSM-D3C4G1600P | HSM-D3C8G1600P |
|---|---|---|
| Module Type | UDIMM | |
| Memory Technology | DDR3 | |
| Speed (MT/s) | 1600 | |
| Density | 4 GB | 8 GB |
| Voltage | 1.5V/1.35V | |
| Pin Count | 244-Pin | |
| Width | 64-Bit | |
| PCB Height | 1.18” | |
| Operating Temperature (℃) | 0℃ to 85℃ (Tc) | |
| Anti-Sulfuration | YES | |

# Memory Module




## DDR3 SODIMM Memory Module

- Equipped with high-quality DDR3 DRAM chips from top-tier manufacturers (Micron / SK Hynix / Samsung)
- No on-DIMM temperature sensor
- Module height: 30.00 mm; pin pitch: 0.6 mm
- 204-pin dual in-line memory module (SODIMM)
- Operating voltage: 1.35V (tolerance: +0.1V / –0.067V), 1.5V (tolerance: ±0.075V)
- IC surface temperature range: 0°C to 85°C
- Refresh cycle time at 0°C to 85°C: 7.8μs
- Eight internal banks operating in parallel
- Supports auto precharge option for each burst access
- Supports auto-refresh and self-refresh operations
- Lead-free, RoHS compliant
- Halogen-free
- Optional conformal coating / underfill for enhanced protection
- Optional anti-sulfuration feature for harsh industrial environments

**480 min burn-in at 60°C for proven reliability**

**A-Die original chips, guaranteed quality**

**Brand-new, durable, highly reliable**

| Part Number | HSM-D3C4G1600M | HSM-D3C8G1600M |
|---|---|---|
| Module Type | SODIMM | |
| Memory Technology | DDR3 | |
| Speed (MT/s) | 1600 | |
| Density | 4 GB | 8 GB |
| Voltage | 1.5V/1.35V | |
| Pin Count | 204-Pin | |
| Width | 64-Bit | |
| PCB Height | 1.18” | |
| Operating Temperature (℃) | 0℃ to 85℃ (Tc) | |
| Anti-Sulfuration | YES | |

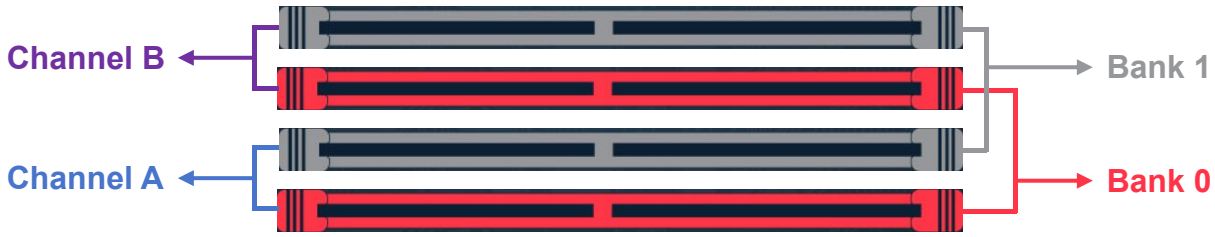



## Can I Install Four Memory Modules on a Motherboard with Four DIMM Slots?

Most consumer motherboards are designed with four DIMM slots to allow users to expand memory capacity. While it is technically possible to install four memory modules, doing so may lead to a reduction in memory frequency and potential stability issues.

Running four modules simultaneously increases overall heat output. Due to the close spacing of the slots, airflow becomes restricted, and module temperatures can rise to 60–70°C. This may cause system instability, memory errors, or even blue screen crashes. The risk is especially high in high-frequency configurations, where maintaining signal integrity becomes more challenging.

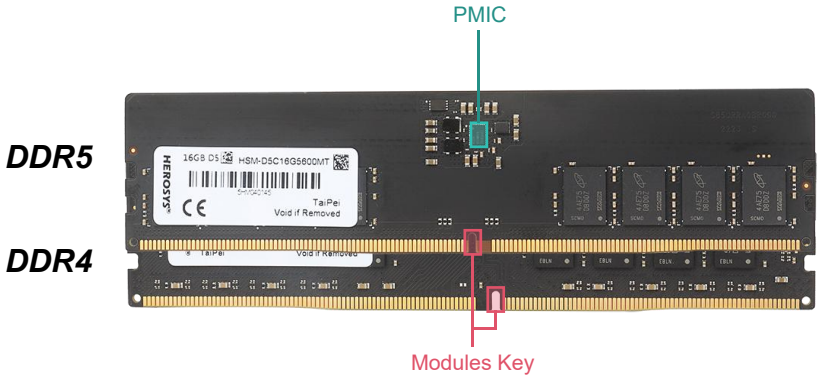
To ensure stable operation, users should pay close attention to usage conditions, system compatibility, and thermal management.




## How to Distinguish Between DDR4 and DDR5 Memory Modules?

While DDR4 and DDR5 memory modules appear visually similar, they can be distinguished by Modules Key, Performance, Power Management, Labeling etc. DDR5 supports significantly higher capacities and bandwidth, with standard speeds starting at 4800 MT/s—much higher than DDR4's typical range of 2133–3200 MT/s.

Before installation, always verify the memory type and ensure compatibility with your motherboard.



## What's the Difference Between DIMM and UDIMM?

DIMM, short for Dual In-line Memory Module, is a general term for memory modules. UDIMM (Unbuffered DIMM) is a specific type of DIMM that does not include a register or buffer, allowing signals to be sent directly to the memory controller. This results in lower latency and typically lower cost, making UDIMMs common in desktop PCs and some industrial systems. In contrast, RDIMM (Registered DIMM) and LRDIMM (Load-Reduced DIMM) include buffering to improve stability and scalability, and are more commonly used in server and enterprise environments.

## Can I Use UDIMM Memory in a DIMM Slot?

No. If the motherboard is not designed to support Unbuffered DIMM (UDIMM) modules, the memory will not be compatible or function properly.

## Can UDIMM Replace SO-DIMM?

No. Although both UDIMM and SO-DIMM use the same DRAM technology, their physical sizes and slot specifications differ, making them incompatible and non-interchangeable.

## What Is an RDIMM Memory Module?

An RDIMM (Registered DIMM) includes an onboard register that buffers commands and control signals between the memory controller and the DRAM chips. This buffering reduces the electrical load on the motherboard's memory controller, enhancing system stability and scalability. RDIMMs are commonly used in servers, data centers, and other high-reliability applications.

## Can UDIMM and RDIMM Memory Modules Be Mixed?

No. Although a motherboard may support either RDIMM or UDIMM, these two types have different architectures and cannot be used simultaneously. Mixing them will not damage the system but can cause failure to boot or error messages. The system will only return to normal operation after installing compatible memory modules. It is recommended to select the memory type according to the motherboard specifications to avoid compatibility issues.

## What Is an LRDIMM Memory Module?

An LRDIMM (Load-Reduced DIMM) is similar to an RDIMM but further incorporates a Data Buffer to significantly reduce signal load. This design enables support for higher memory capacities and bandwidth, making LRDIMMs ideal for large-scale data processing, high-performance computing (HPC), and virtualization environments.

## What Is an HBM Memory Module?

HBM (High Bandwidth Memory) utilizes 3D stacking technology, where multiple DRAM layers are vertically stacked and connected through TSVs (Through-Silicon Vias). These stacked DRAM layers are packaged side-by-side with the processor chip (e.g., HBM2, HBM3). HBM offers extremely high bandwidth and low power consumption, making it widely used in AI training, GPUs, high-performance computing (HPC), and advanced process chips.

## Why Choose PCIe 3.0 SSDs Instead of PCIe 4.0?

PCIe 3.0 offers lower power consumption and heat generation, which is more favorable for the longevity of NAND flash memory. On most industrial motherboards—even those supporting 6th to 12th generation processors—PCIe 3.0 is sufficient to deliver peak performance. Although PCIe 4.0 theoretically provides higher bandwidth, many motherboards only support x4 lanes, resulting in actual read/write speeds comparable to PCIe 3.0. Additionally, the increased power and heat of PCIe 4.0 can negatively affect system stability. In practice, only 13th and 14th generation CPUs can fully unleash the performance potential of PCIe 4.0.

## How many types of NAND Flash are there in SSDs?

The most common NAND Flash types on the market are four:

1. **SLC (Single-Level Cell):** Stores 1 bit per cell. Fastest speed, longest lifespan, highest cost. Used in industrial PCs, servers, and high-reliability applications.
2. **MLC (Multi-Level Cell):** Stores 2 bits per cell. Balanced capacity, cost, and durability. Common in enterprise or high-end laptops.
3. **TLC (Triple-Level Cell):** Stores 3 bits per cell. Larger capacity, lower cost, but shorter lifespan and lower performance. Mainstream for consumer SSDs.
4. **QLC (Quad-Level Cell):** Stores 4 bits per cell. Lowest cost per bit, suitable for large-capacity and read-intensive applications, but shortest lifespan.

## Can data be recovered from a failed SSD?

SSDs differ from traditional HDDs, as they store data on NAND Flash. If the controller or the flash memory itself is damaged, data recovery is generally much more difficult than with HDDs. Recovery possibilities depend on the type of failure:

- Logical errors (e.g., file system corruption, accidental deletion, or formatting): Some data may be recoverable using professional data recovery software.
- Controller or firmware failure: Requires specialized data recovery services, which read NAND chips directly and reconstruct the data.
- Physical NAND damage: If the flash memory itself is physically damaged, full recovery is usually impossible.

## What is ECC UDIMM?

ECC UDIMM (Error-Correcting Code Unbuffered DIMM) is a memory module with built-in error-correcting capability. Based on a standard UDIMM, it includes an ECC mechanism that can automatically detect and correct single-bit errors, reducing the risk of data corruption and enhancing system stability and reliability.

## M.2 SSDs are fast—so why choose SATA SSDs?

M.2 SSDs, especially NVMe models using PCIe channels, offer much higher transfer speeds than traditional SATA SSDs—often several times faster in theory. However, in practice, many users and industries still opt for SATA SSDs due to several reasons:

- High compatibility: SATA is a long-established interface supported by most desktops, laptops, and industrial PC motherboards, ensuring hassle-free installation.
- Proven stability: SATA technology is mature, with well-tested firmware and driver compatibility, offering trusted long-term reliability.
- Lower cost: SATA SSDs of the same capacity are generally cheaper than NVMe M.2 SSDs, making them more attractive for bulk purchases or cost-sensitive projects.
- Lower heat requirements: High-performance NVMe SSDs generate more heat and may require additional cooling, whereas SATA SSDs produce less heat and are easier to deploy.
- Minimal practical difference: For general office, multimedia, or embedded applications, SATA SSDs already deliver significant performance improvements, and the speed gap versus NVMe may not be noticeable.

## What is Random Write?

Random write refers to the process of writing data to non-contiguous locations on an SSD or hard drive. Compared to sequential write, random write requires the controller to frequently access different data blocks, placing higher demands on the controller's performance and the endurance of NAND flash chips.

In practice, random write performance directly affects system boot-up, application launch, and multitasking with many small files. It is an important indicator of an SSD's real-world performance.

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