



# NOR | NAND Flash Guide

## Selecting a Flash Storage Solution

Micron has an extensive range of NOR and NAND Flash storage products available, including several code and data Flash memory solutions—from serial and parallel NOR, to raw and managed NAND, to solid state drives (SSDs). Selecting the right solution requires an understanding of each technology, including attributes related to I/O performance, pin count, data integrity differences dependent on the system usage model, and manufacturing longevity requirements. This guide describes the various Flash technologies and provides a systematic way for the system designer to select the optimal nonvolatile memory solution based on key design considerations. The application requirements will ultimately dictate the right solution.

### Getting to Know NOR

NOR Flash devices are primarily used for reliable code storage (boot, application, OS, and execute-in-place (XIP) code in an embedded system). They are available in densities up to 2Gb. NOR devices operate in high-speed burst or page mode for use in XIP environments where code runs directly from the device to minimize system boot time. NOR is easy to implement and requires minimal ongoing management due to the underlying cell structure.

There are two primary types of NOR: serial and parallel. Serial NOR provides a low-cost solution thanks to low pin counts and small package offerings; it is ideal for applications like personal and ultra-thin computers, servers, set-top boxes (STBs), printers, modem/routers, and hard disk drives (HDDs). Parallel NOR delivers higher XIP performance; it is ideal for applications like differential scanning calorimetry (DSC), routers, and STBs.

### Getting to Know NAND

NAND Flash devices are used to store data and code. They are available in 128Mb to 1Tb densities for packaged products. Low-density NAND is ideal for applications like STBs, digital televisions (DTVs), and DSC while high-density NAND is most commonly used in data-heavy applications like SSDs, tablets, and USB drives. There is a continuous effort to reduce the cost/GB of NAND devices, so device lifecycles tend to be shorter with more frequent process lithography shrinks. NAND requires a controller and specific firmware for error code correction (ECC), bad block management, and wear leveling.

There are two primary types of NAND: raw and managed. Raw NAND is offered in a wide range of densities while managed NAND is offered in higher densities. Micron also offers SSDs that use NAND to increase densities and improve reliability, reduce power, and provide excellent drive performance.

## NOR and NAND Features Comparison

### Serial NOR | Parallel NOR

- Low density, low pin count (serial and A/D MUX parallel)
- Long life cycles
- Ease of use
- Reliability, high performance
- Reliable code and data storage
- Fast random access time

### SLC NAND | MLC NAND | Managed NAND

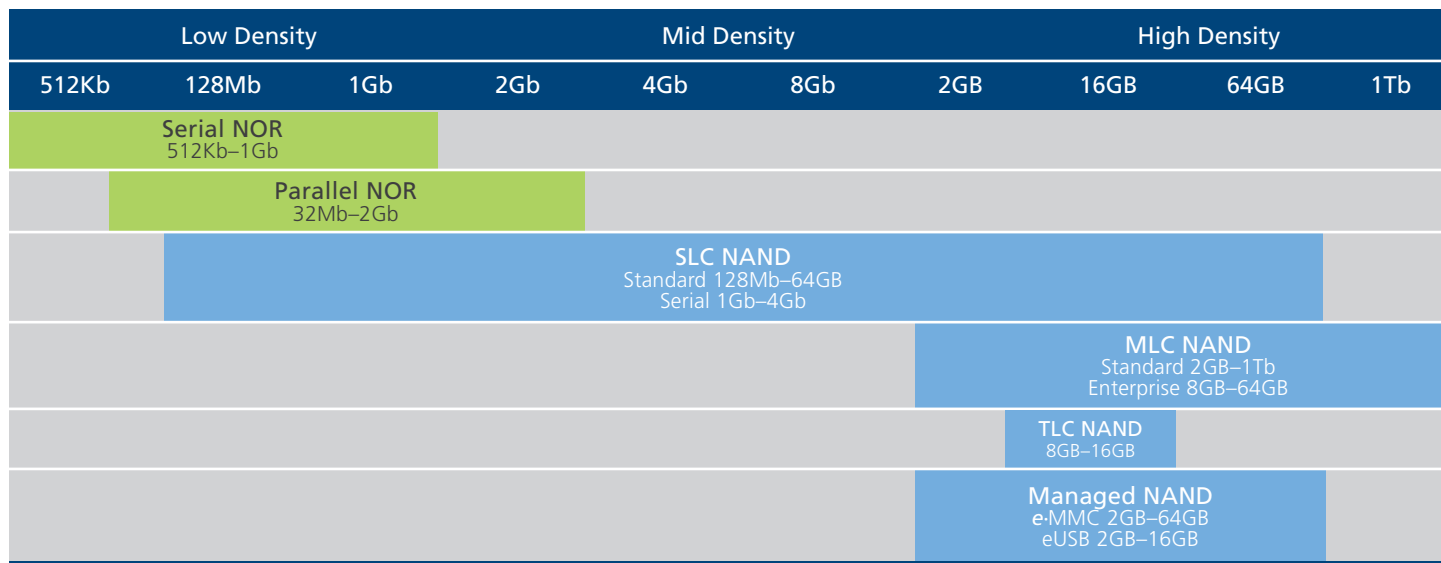
- High density, low pin count
- Requires controller management (SLC, MLC)
- Focused on reliability and performance (SLC), cost/GB (MLC), and reduced time-to-market (managed NAND)
- Mostly data-focused
- Fast writes and reads
- ONFI-compatible
- JEDEC and MMC standard-compliant

*\*Other design considerations include controller type, voltage requirements, individual parameter and feature specifications, security, and software.*



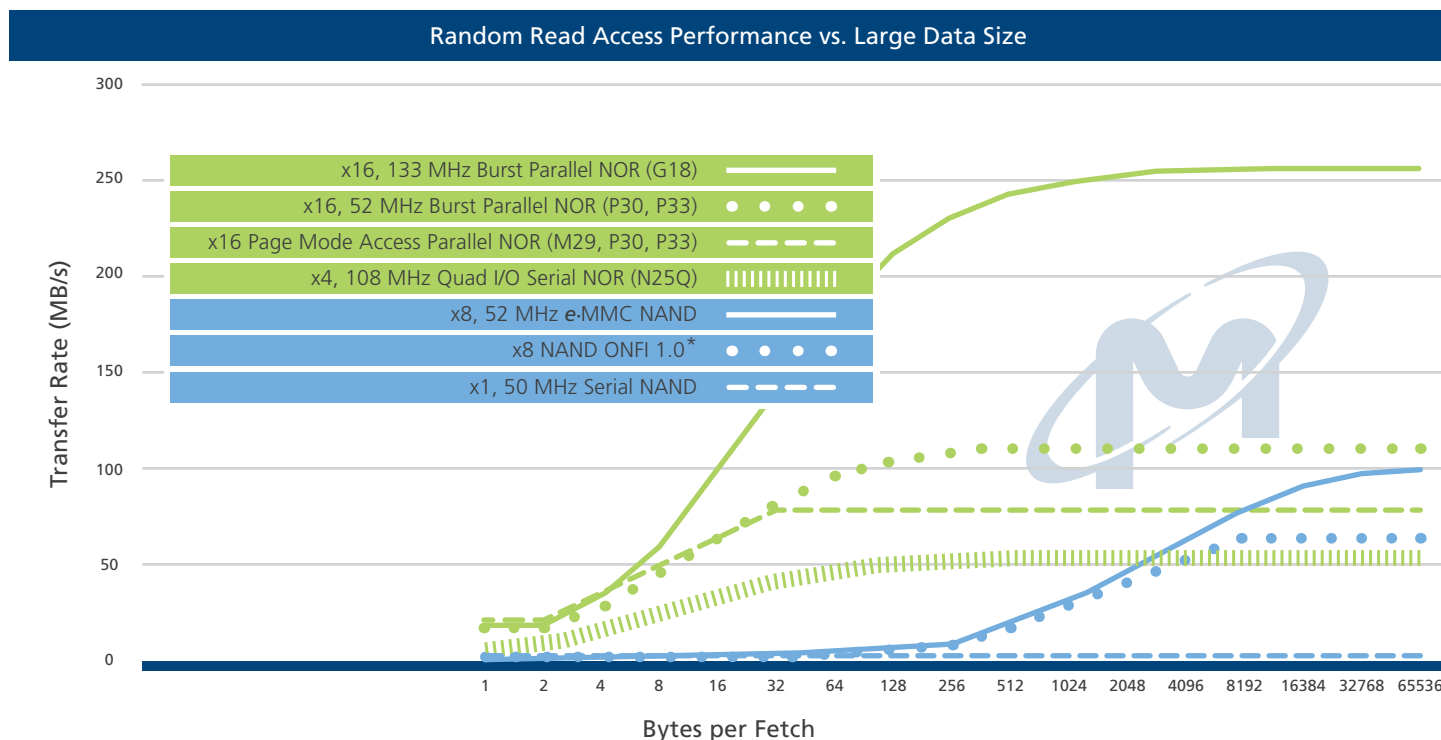
## Densities Offered by Device Type

The chart below shows various NOR and NAND density ranges to help identify the best solution for your application requirements.



## NOR and NAND Read Performance

As shown in the figure below, read performance is mostly governed by bus width and clock speed (e.g., x16 and 133 MHz).



\*Micron offers NAND ONFI 2.X- and 3.X-compliant products.

## Micron Flash Portfolio

Micron has one of the broadest portfolios of NOR and NAND Flash solutions in the industry. We have products that are tailored to meet your application requirements, including a strong product offering for automotive applications, which require more reliability than others.

### NOR Choices

#### Serial NOR

Thanks to lower pin counts, serial NOR devices provide a cost-effective solution. They're easy to design in, saving valuable development time while ensuring compatibility with existing and future designs. Serial NOR is also referred to as serial peripheral interface (SPI) NOR.

#### Parallel NOR

Parallel NOR devices provide high performance and security. These feature-rich devices are ideal for long-term use in rigorous industrial settings. Parallel NOR is offered in both standard and high-performance product types, and Micron offers both.

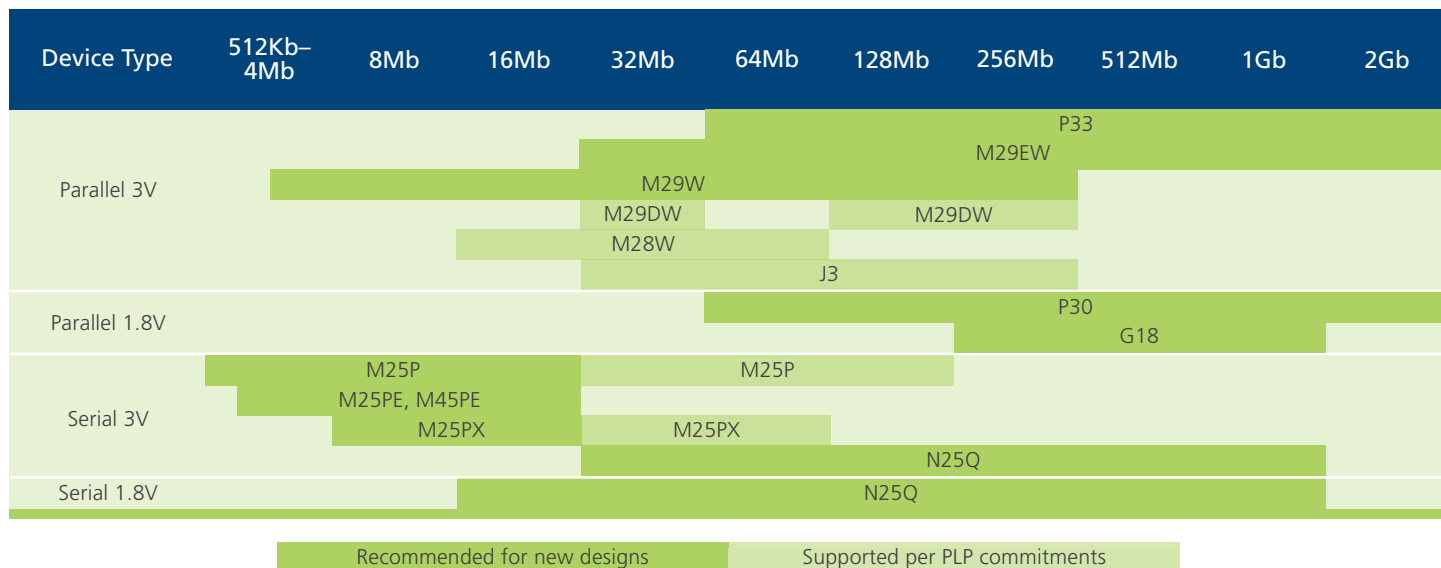
#### Serial and Parallel NOR Features Comparison

Serial (SPI)			Parallel		
M25P	M25PX	N25Q	M29	P30/P33	G18
<b>Low pin count, cost savings</b>  <b>N25Q (SPI Multi I/O):</b> <ul style="list-style-type: none"> <li>• x1–x4 (quad I/O)</li> <li>• 1.8V or 3V</li> <li>• 4KB subsector erase</li> <li>• 16Mb–1Gb</li> <li>• 108 MHz sync reads (54 MB/s)</li> </ul> <b>M25P (SPI Single I/O):</b> <ul style="list-style-type: none"> <li>• 3V</li> <li>• 512Kb–16Mb</li> <li>• 50 MHz or 75 MHz sync reads (6 MB/s or 9 MB/s)</li> </ul> <b>M25PX (SPI Single I/O):</b> <ul style="list-style-type: none"> <li>• 3V</li> <li>• 8Mb–16Mb</li> <li>• 75 MHz sync reads (19 MB/s)</li> </ul> <b>Mx5PE (SPI Single I/O):</b> <ul style="list-style-type: none"> <li>• 3V</li> <li>• 1Mb–16Mb</li> <li>• 75 MHz sync reads (19 MB/s)</li> </ul>			<b>High performance, security, feature-rich</b>  <b>M29EW/M29W:</b> <ul style="list-style-type: none"> <li>• Spansion command set</li> <li>• 3V</li> <li>• 4Mb–2Gb</li> </ul> <b>P30/P33:</b> <ul style="list-style-type: none"> <li>• 1.8V or 3V</li> <li>• 64Mb–2Gb</li> <li>• 52 MHz sync reads (104 MB/s)</li> </ul> <b>G18:</b> <ul style="list-style-type: none"> <li>• 1.8V</li> <li>• 256Mb–1Gb</li> <li>• 133 MHz sync reads (250 MB/s)</li> <li>• Read-while-write, read-while-erase</li> <li>• A/D, AA/D MUX option (reduces active pin count by more than 50%)</li> <li>• Small 8 x 10mm package</li> </ul>		

## NOR Densities

The chart below shows Micron's NOR products by type and density and highlights the key products recommended for new designs. Most of the recommended products are also included in Micron's Product Longevity Program (PLP), which ensures the products are supported for an extended life cycle (learn more at [micron.com/plp](https://micron.com/plp)).

### Micron Embedded NOR Solutions



## Selecting a Serial NOR Device

If the key features of serial NOR match your design requirements, use the following tables to help select the right serial NOR device for your design. For more details, see the full serial NOR part catalog and find a sales representative at [micron.com](https://micron.com).

### Serial NOR – Quick Features Comparison

Product	Voltage Range	Erasable Sectors	Bus Width	Density Range	MAX Clock/ MAX Data Transfer Rate	Program/ Erase Cycling	Package Options
N25Q	2.7–3.6V 1.7–2.0V	4KB, 64KB uniform	x1, x2, x4	16Mb–1Gb	108 MHz (54 MB/s)	100,000	PDFN, SOP, PBGA
M25P	2.3–3.6V	32KB, 64KB, 64KB uniform	x1	512Kb–16Mb	50 MHz (6 MB/s) 75 MHz (9 MB/s)	100,000	PDFN, SOP
M25PX	2.3–3.6V	4KB, 64KB uniform	x1, x2	8Mb–16Mb	75 MHz (19 MB/s)	100,000	PDFN, SOP, PBGA
M25PE, M45PE	2.3–3.6V	256B, 4KB, 64KB uniform	x1	1Mb–16Mb	75 MHz (19 MB/s)	100,000	PDFN, SOP

\*This table only includes devices recommended for new designs.

## Serial NOR Application Requirements by Product Family

Application Requirements	512Kb	1Mb	2Mb	4Mb	8Mb	16Mb	32Mb	64Mb	128Mb	256Mb	512Mb	1Gb
Standard SPI	M25P	M25P	M25P	M25P	M25P	M25P	N25Q	N25Q	N25Q	N25Q	N25Q	N25Q
Small-parameter EEPROM replacement		M25PE	M25PE	M25PE	M25PE	M25PE						
Alternative hardware configuration		M45PE	M45PE	M45PE	M45PE	M45PE						
Dual-I/O usage					M25PX	M25PX	N25Q	N25Q	N25Q	N25Q	N25Q	N25Q
High-performance SPI, quad I/O, XIP						N25Q	N25Q	N25Q	N25Q	N25Q	N25Q	N25Q
1.8V (low-power consumption)						N25Q	N25Q	N25Q	N25Q	N25Q	N25Q	N25Q

## Selecting a Parallel NOR Device

If the key features of parallel NOR match your design requirements, use the following table to help select the right device. For more details, see our full parallel NOR part catalog and find a sales representative at [micron.com](http://micron.com).

## Parallel NOR – Quick Features Comparison

Product	Core Voltage	I/O Voltage	Bus Width	Density Range	Sync Burst Read	Multi-Bank (Read-While-Write, Read-While-Erase)	A/D, AA/D MUX Option	Security Features	Program/Erase Cycling	Package Options
M29EW	2.7–3.6V	1.65–3.6V	x8, x16	32Mb–2Gb	No	No	No	Enhanced	100,000	56-pin TSOP 64-ball FBGA
M29W	2.7–3.6V	1.65–3.6V (128Mb, 256Mb) 2.7–3.6V (4–64Mb)	x8, x16	4Mb–256Mb	No	No	No	Enhanced	100,000	56-pin TSOP 64-ball FBGA 64-ball TBGA 48-pin TSOP 48-ball BGA
P30	1.7–2.0V	1.7–3.6V	x16	64Mb–2Gb	52 MHz (104 MB/s)	No	No	Enhanced	100,000	56-pin TSOP 64-ball BGA
P33	2.3–3.6V	2.3–3.6V	x16	64Mb–2Gb	52 MHz (104 MB/s)	No	No	Enhanced	100,000	56-pin TSOP 64-ball BGA
G18	1.7–2.0V	1.7–2.0V	x16	256Mb–1Gb	133 MHz (250 MB/s)	Yes	Yes	Enhanced	100,000	64-ball BGA 8 x 10mm

\*This table only includes devices recommended for new designs.

## NAND Choices

Micron has a diverse portfolio of NAND Flash storage devices—including raw and managed NAND—with varying densities and feature sets that are key considerations for most application designs. Several NAND devices are included in Micron's Product Longevity Program (PLP), which ensures the products are supported for an extended life cycle (learn more at [micron.com/plp](https://micron.com/plp)).

### Raw NAND

Raw NAND provides the lowest cost per bit but requires an external host controller (not contained within the package) to perform all management functions (e.g., ECC, FTL).

#### Single-level cell (SLC)

One bit per cell; highest performance and write endurance; designed for high-end, high-density, mission-critical systems where NAND best-in-class performance and reliability are required and cost reduction is not a major driver

#### Serial SLC NAND

Low-density SLC devices with a NOR-like serial interface

#### Multilevel cell (MLC)

Two bits per cell; balanced performance for a wide range of cost-sensitive, high-density applications; designed for applications where a trade-off between endurance and performance is required for cost control; requires tight technology coupling with the controller; sometimes called mainstream NAND

#### Enterprise MLC NAND

Enterprise MLC uses special programming algorithms to extend write endurance; typically used in high-write workload enterprise applications

#### Triple-level cell (TLC)

Three bits per cell; highest cell density, but lower performance and endurance specifications; most often used in mass storage consumer applications (e.g., USB drives or SD cards) with very high cost sensitivity

### Managed NAND

Managed NAND provides simpler solutions and speeds time-to-market because the controller is embedded within the package to provide ECC and block management.

#### e•MMC Memory

High-capacity NAND Flash device combined with a high-speed, MultiMediaCard (MMC) controller in a single BGA package; ideal for designers looking for MMC-like, application-to-application interoperability for a wide range of networking, industrial, and automotive applications

#### Embedded USB (eUSB)

Small, cost-effective device that is reliable in harsh environments; offers distinct competitive advantages for embedded designs

## Selecting a NAND Device

If the key features of NAND match your design requirements, use the following table to help select the right device. For more details, see our NAND part catalogs and our Choosing the Right NAND page, and find a sales representative at [micron.com](http://micron.com).

### Raw NAND – Quick Features Comparison

Device	Density	Width	Voltage	Benefits
SLC NAND	128Mb–64GB	x8, x16	1.8V, 3.3V	<ul style="list-style-type: none"> <li>• Up to 100,000 P/E cycle endurance</li> <li>• Fastest NAND throughput</li> <li>• Compatible with the ONFI-synchronous interface</li> </ul>
Serial SLC NAND	1Gb–4Gb	x1	3.3V	<ul style="list-style-type: none"> <li>• Enabler of large memory subsystems</li> <li>• Increased power efficiency</li> <li>• High performance, low power</li> <li>• Increased bandwidth</li> </ul>
MLC NAND	2GB–1Tb	x8	3.3V	<ul style="list-style-type: none"> <li>• Solid performance and endurance</li> <li>• 2X the density of SLC NAND at a lower cost per bit</li> <li>• Compatible with the ONFI-synchronous interface</li> </ul>
Enterprise MLC NAND	8GB–64GB	x8	3.3V	<ul style="list-style-type: none"> <li>• Optimized for intensive enterprise applications</li> <li>• High endurance, high capacity, and high reliability (through low-defect and high-cycle rates)</li> <li>• Ideal storage solution for transaction-intensive data servers</li> <li>• Compatible with ONFI 2.1-synchronous interface</li> <li>• 4X to 5X performance improvement compared to legacy NAND interfaces</li> </ul>
TLC NAND	8GB–16GB	x8	3.3V	<ul style="list-style-type: none"> <li>• Higher density in the same footprint but at a lower cost than SLC or MLC NAND</li> </ul>

### Managed NAND – Quick Features Comparison

Device	Density	Interface	Voltage	Benefits
eMMC	2GB–64GB	4.41 and 4.51 JEDEC standard	3.3V	<ul style="list-style-type: none"> <li>• Single-package solution for designers looking for MMC-like application-to-application interoperability</li> <li>• Offered in a variety of densities and options</li> </ul>
eUSB	2GB–16GB	USB 2.0	3.3V, 5V	<ul style="list-style-type: none"> <li>• Reliable in harsh environments</li> <li>• Cost-effective</li> <li>• Small size</li> </ul>

### SSD Solutions

In addition to the standard NOR and NAND packaged products, Micron also offers many NAND-based solid state drive (SSD) solutions for your system designs. Refer to [micron.com](http://micron.com) for more details on these leading-edge SSDs.

#### Client SSD

High reads via a SATA 6 Gb/s interface with backward compatibility to 3 Gb/s SATA; improved boot and application load times; lighter, more durable, and more power-efficient than HDDs

#### Enterprise SATA and SAS SSDs

High steady-state performance with low latencies, optimized error-management features, and multiple drive options offer outstanding performance for enterprise blade servers and system storage

#### Enterprise PCIe SSD

Low-latency, high-IOPS P320h drive; extended endurance, exceptional reliability, and remarkable power efficiency; an ideal solution for optimizing applications with heavy read access

### More Information

View more information about Flash storage solutions and find a sales representative or authorized distributor at [micron.com](http://micron.com).

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