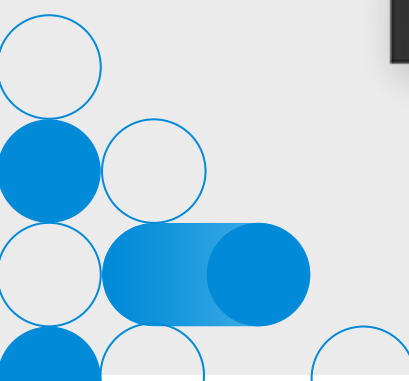




# **Whitepaper: A Comprehensive Guide to Lexar Enterprise's Foresee eMMC Partition Management: Enhancements, Tools, and Techniques**

**FORESEE®**  
**eMMC**



## Executive Summary

In this whitepaper, readers will be introduced to the Foresee eMMC from Lexar Enterprise, which offers a smooth and seamless improvement on traditional eMMC device technology for OEM and industrial customers.

Smart, tailored partition management is a critical part of getting the best out of any eMMC device, and we'll also take a look at some common issues, questions, and scenarios that engineers often encounter around eMMC partition management in industries such as automotive and aerospace.

## Introduction

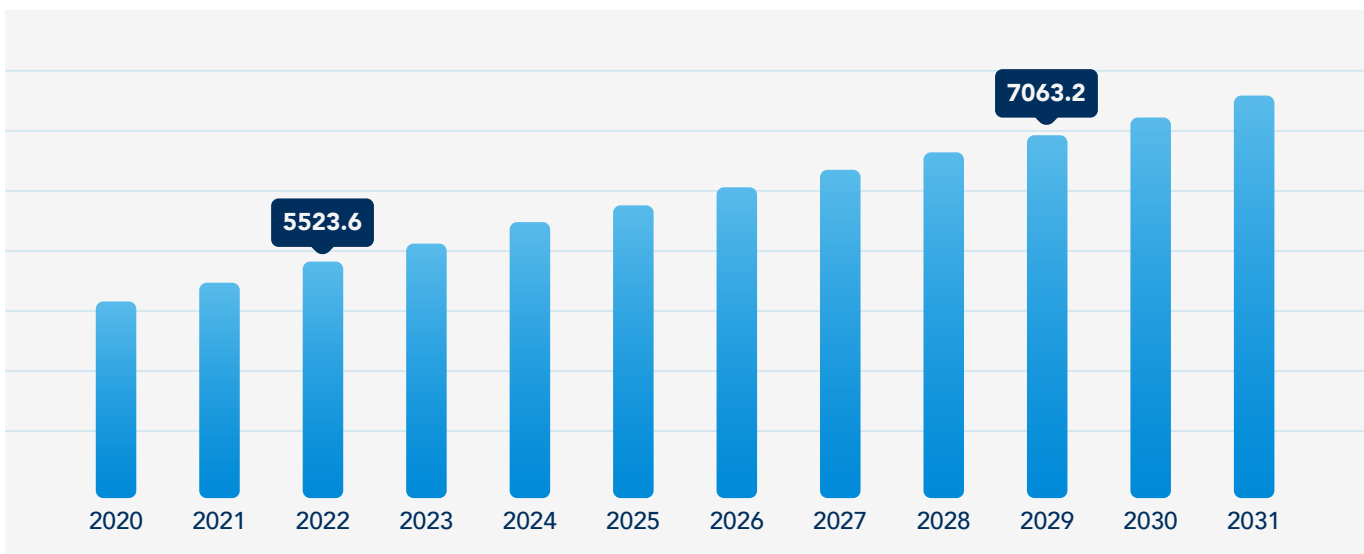
Data from a Business Research Insights report from May 2024 (Embedded Multimedia Card Market Size, Growth, Forecast) indicates a steady growth trajectory for eMMC technology over the next few years.

However, the continued growth of mobile devices, IoT (Internet of Things) devices, and automotive infotainment systems brings unique new challenges as we evolve toward a digitally powered future. Fortunately, new, improved eMMC devices such as Lexar Enterprise's Foresee eMMC technology are perfectly placed to meet those challenges.

In this whitepaper, we'll explore common challenges, questions, and scenarios that industrial engineers often encounter around eMMC partition management, and the exciting solutions and improvements that Lexar Enterprise's advanced Foresee eMMC device adds to traditional eMMC devices.

## Why Use eMMC Solutions?

**Global Embedded Multimedia Card Market Size, 2023 (USD Million)**



According to the Business Research Insider report, the global eMMC market size is projected to reach \$7.06 billion by 2029, up from \$5.52 billion in 2022, with a compound annual growth rate of 3.5%. That means a whole lot of eMMC devices on the market. The question is, why?

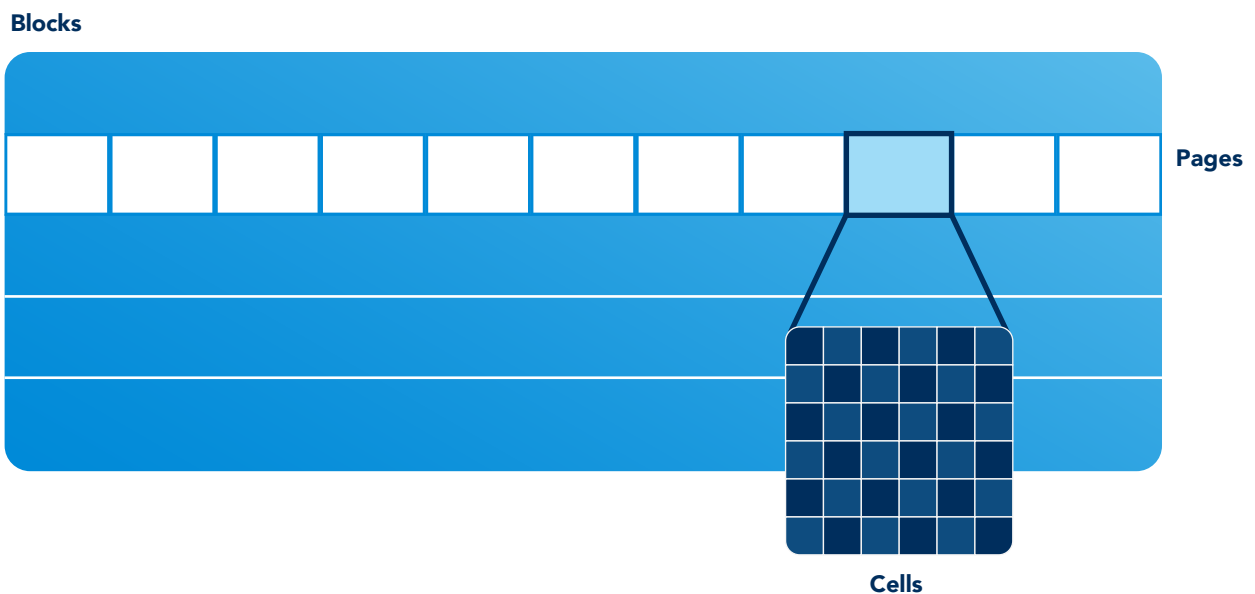
One of the key reasons that eMMC technology, while technically a legacy technology, is its simplicity and ease of integration. That level of compatibility makes eMMC solutions particularly suitable for space-constrained devices and applications where cost efficiency is paramount. Standardized interfaces and protocols ensure near-effortless compatibility across devices and manufacturers, meaning eMMC devices can easily be integrated into a vast range of products. Without being tied to specific platforms, brands, or technologies, eMMC devices also provide versatility in the OEM space. Advancements in NAND flash technology and controller designs, which the Foresee eMMC from Lexar Enterprise makes full use of, have led to significant improvements in eMMC performance, ensuring faster data transfer rates and enhanced reliability than before, all with remarkably low power consumption.

The universal protocol communication featured within Lexar Enterprise’s Foresee eMMC products is another highlight. The host software requires only a universal driver to operate the eMMC, ensuring easy compatibility and simplified memory access without compromising security. The device itself handles data security and data/flash management, performing background memory management tasks without involving the host software at all. This functionality makes the flash management layer of the host system significantly simpler than for other eMMC devices, resulting in knock-on simplification of the host software design.

The saying, “old, but gold” applies perfectly to modern applications of eMMC technology. Some of its key features – such as wear leveling, bad block management, and error correction mechanisms – ensure robust, reliable data integrity, security, and longevity, that never goes out of style. These features are crucial for applications requiring reliable and durable storage, like automotive embedded systems and industrial-grade automation, alongside consumer and OEM electronics.

eMMC products now represent a mature and widely adopted flash storage technology, well-suited to the growing data demands of various industries. Combining compact forms, cost-effectiveness, low power consumption, and reliability, Foresee eMMC devices from Lexar Enterprise are ideal for any application where reliability, performance, and security in embedded storage are needed.

## Wear Leveling and Partition Management



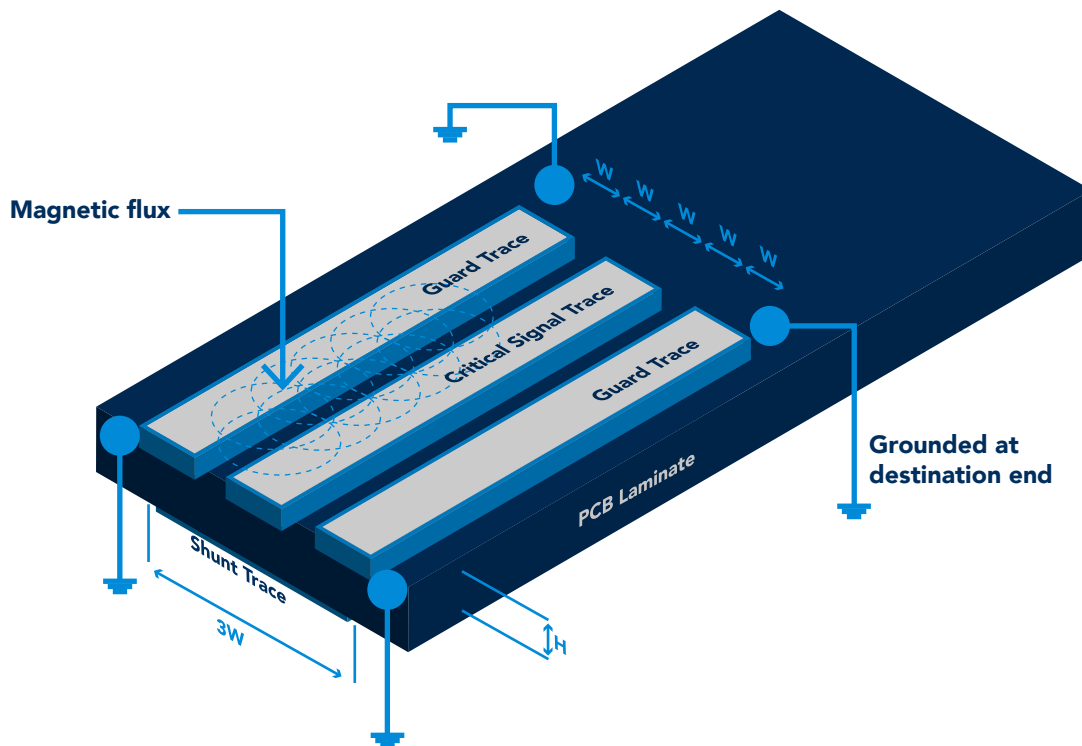
As flash memory is composed of “blocks”, each block is only expected to last through a certain number of program and erase cycles. Wear leveling allows the maximum possible block lifespan by using each block’s erase cycles in a balanced way for a more efficient, durable product. Wear leveling also ensures no block is overused (leading to bad blocks), extending the overall service life of the eMMC.

Lexar Enterprise’s product developers use a dedicated flash research and development team to conduct in-depth feature analyses of the flash used. This allows the team to choose the appropriate wear-leveling thresholds for optimal efficacy. While user partitioning choices can have an impact on efficiency, the result is a more robust product with fantastic performance and reliability.

Wear leveling strategies can be chosen to match each partition’s different attributes. However, why make things complicated if they don’t have to be? With the Foresee eMMC devices from Lexar Enterprise, the user partition utilizes universal leveling no matter how the partitions are set up, making for simplified and easy-to-use partitioning.

If partition it’s a concern, industry best practices such as properly planning partition sizes, avoiding very small partitions, monitoring wear leveling over time, and using a file system that handles wear leveling well, will also help reduce wear.

## eMMC PCB Routing Guidelines to Know

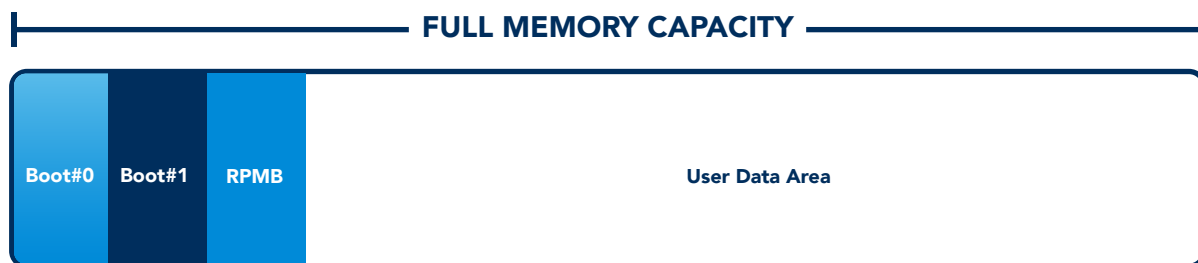


Proper PCB routing is critical to ensure signal integrity, minimize interference, and maximize the performance and reliability of eMMC-based systems. If a job’s worth doing, it’s worth doing right, right? Here are some eMMC PCB routing guidelines and best practices for designing the layout of a durable, efficient PCB when integrating with eMMC devices.

- **Signal Integrity:** Minimizing signal reflections, crosstalk, and impedance mismatches. Controlled impedance traces are used for data and clock lines to ensure they match the characteristic impedance of the transmission lines.
- **Trace Length Matching:** When properly matched to the lengths of critical signal traces (data and clock lines), timing and signal synchronization are ensured, preventing skew and ensuring reliable data transmission.
- **Layer Stackup:** A well-designed layer stackup (accommodating signal routing, power distribution, and ground planes) helps minimize signal distortion and electromagnetic interference (EMI).
- **Power Distribution:** Robust power distribution with low impedance paths is needed for the eMMC and other components. Multiple vias and wide traces can reduce voltage drop and minimize power noise.
- **Grounding:** Low-impedance return paths for signal currents and minimized ground loops can be ensured by implementing a solid ground plane. Connect this ground plane directly to the eMMC's ground pad using multiple vias for optimal grounding.
- **Signal Integrity Analysis:** Simulation tools can be used to evaluate the effects of signal propagation, reflections, and noise on the performance of the eMMC's interface. This helps to both identify potential issues and optimize the PCB layout for improved signal integrity.
- **Placement of Components:** PCB components must be placed to minimize signal routing distances and optimize paths between the eMMC and other components. Ensure that decoupling capacitors are placed close to the power pins of the eMMC device to filter out high-frequency noise.
- **Signal Termination:** Properly terminate signal lines to prevent signal reflection and boost integrity, either through series termination resistors or parallel termination techniques.
- **EMI/EMC Compliance:** PCB layout should comply with electromagnetic interference (EMI) and electromagnetic compatibility (EMC) regulations and standards. Typically, compliance means a minimized loop area, the use of shielding techniques, and following each industry's best practices for EMI/EMC mitigation.

A robust, reliable solution for eMMC-based systems is simple to construct with these basic guidelines in place and tailored to the specific end-use and location of the eMMC device. If there are specific concerns around this issue, the Lexar Enterprise/Foresee eMMC product team is always happy to assist.

## Partitioning eMMC Devices: An Overview



Enabling partitions on an eMMC device is essential for efficient data management and optimal performance. So, how do we get the job done? Below, Lexar Enterprise has the answers to some common partitioning questions we see.

Before attempting to integrate one of Lexar Enterprise's eMMC offerings into industrial applications, you will need a SOC (system on chip) fitted with an eMMC controller module to effectively communicate with the end eMMC device. The software driver must also support the universal eMMC protocol driver interface. With that in hand, it's time to get down to some partitioning nitty-gritty.

## Partition Categories on Lexar Enterprise Foresee eMMC Devices

To ensure a simplified and easy-to-implement eMMC solution, the Foresee eMMC device from Lexar Enterprise uses 3 key partition types:

- **Boot Partition:** Used for storing bootloader and essential firmware required to initialize the device's operating system.
- **Replay Protected Memory Block (RPMB):** This secure storage area protects any sensitive data against issues like replay attacks.
- **User Partition:** The main storage area for an operating system, applications, and user data.

## Why Partition eMMC Storage at All?

With all this built-in functionality, partitioning is just there as an option, right? Not quite.

The Foresee eMMC from Lexar Enterprise allows the host software to select specific user partitions or configure specific partition attributes based on the intended function. This flexibility allows the Foresee eMMC to easily adapt to different data storage/access needs, no matter where it is used. With this in mind, partition management is best seen not as a "feature", but as a cornerstone that ensures reliability and durable performance from consumer-grade and industrial-grade eMMC offerings.

With the Foresee eMMC devices from Lexar Enterprise, hosts can use up to four general-purpose area partitions, each with its own attributes (general, enhanced, or extended). These settings are one-time programmable, and they cannot be edited after configuration, affecting how data is stored, accessed, and organized within each partition.

## What Tools and Techniques are Needed to Partition a Lexar Enterprise Foresee eMMC?

You won't even need a suite of new tools to manage your new Foresee eMMC device. Lexar Enterprise's Foresee eMMC partition function uses standard eMMC protocols, and can be partitioned through common protocol commands according to the specified operation sequence. Simpler, better, and faster – the business dream!

The Foresee eMMC automatically performs these tasks based on the firmware design used. There is no need for manual operation from the user side, making it significantly simpler to implement than other eMMC solutions. The host software can partition the eMMC according to actual usage requirements. After the partition is completed, the eMMC will manage its own data based on the configuration, and the host software doesn't need to participate.

However, optimizing eMMC partition management is crucial for efficient data handling and system performance. Remember to choose the appropriate file system format (e.g., RTOS for Android) based on the specific device requirements and usage patterns. Here are some recommended tools and techniques from the Lexar Enterprise team for the Foresee eMMC.

### Tools for Windows: EaseUS Partition Master

EaseUS Partition Master is a powerful disk management tool that allows users to create, delete, and format partitions on eMMC devices. Because it has an intuitive interface for managing storage resources effectively, it can be used to organize eMMC partitions and optimize device storage.

## **Tools for Linux: fdisk and mmc-utils**

For Linux, the fdisk command-line utility allows users to create, modify, and delete partitions on eMMC drives. Meanwhile, mmc-utils offers a range of other functionalities, including checking the eMMC version, boot configuration, and more.

## **Will Partitioning Affect Wear Leveling?**

Partitioning will have an impact on the wear leveling strategy of the eMMC. Typically, a single large partition will distribute wear evenly, while multiple partitions will have their own unique wear patterns, needing wear leveling to be applied independently within each partition. The Lexar Enterprise Foresee eMMC offering allows for different wear leveling strategies to be customized for different areas of the storage.

For example, if some partitions use the Enhanced attribute, two data storage modes (SLC mode, or MLC/TLC mode) will be used within the eMMC device. As the erase cycles of these block types are different, wear leveling will need to be carried out separately to ensure balanced wear. However, extended partition attributes will not affect wear leveling, as Lexar Enterprise uses global wear leveling to ensure that every similar storage type is used evenly. Enhanced mode (pSLC) offers the lowest wear during write cycles, making this the best choice for critical data needing the highest possible reliability and security.

Allocating more space to partitions with heavy write activity, and “over-provisioning” or reserving blocks away from visible partitions to quietly contribute to overall wear leveling in the background and offer “spare” cells as needed, will both help balance wear better.

## **Partitioning Instructions: Default Configurations**

By default, eMMC devices come with a predefined setup. Boot Partition 1 is typically enabled for boot purposes. However, the current boot configuration can be checked through standard tools, such as mmc-utils or fdisk.

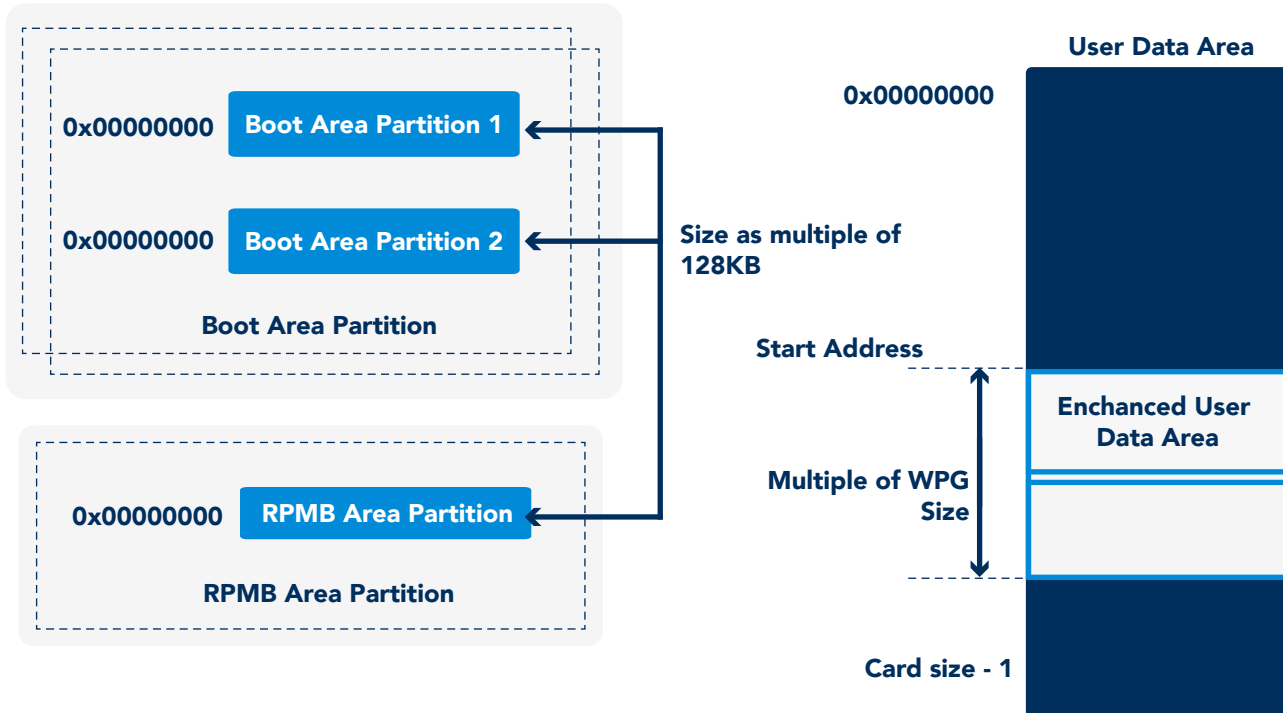
Here, users can easily access details such as the eMMC version, maximum enhanced area size, boot partition size, and more. These tools can also be used to change the boot configuration as needed.

## **Partitioning Instructions: Enhanced Mode (pSLC)**

Don't forget that unexpected power loss can lead to data corruption in all flash devices, eMMC solutions included. While flash memory is generally durable, it is unfortunately a risk inherent to all NAND flash technology. However, running in pSLC, or enhanced mode, will ward off this complication as much as possible, as there is a smaller chance of misinterpreting voltage cells compared to other flash technologies.

Enhanced mode allows for better distribution of write/erase cycles evenly over memory cells, protecting the eMMC device's lifespan. It also detects and corrects errors caused by bit flips during data transfers, regularly checks and corrects data integrity in the background, and allocates spare/overprovisioned blocks to replace faulty ones. Proper partition management, of course, helps to mitigate these risks by optimizing wear leveling and ensuring data integrity.

## How to Test and Troubleshoot the Partitioning Function of a Foresee eMMC from Lexar Enterprise



While eMMC devices are generally a “no-fuss” and time-tested technology with simple needs, troubleshooting will still be part of any device lifecycle.

Naturally, hardware connections and power supply integrity should be tested first. From there, perform a diagnostic test to check for bad blocks, corruption, or hardware failures.

To test the partitioning function of a Foresee eMMC device, the enhanced attributes of the entire disk will be set. From there, an aging test must be performed on the whole disk. EXT CSD [268] will show the lifetime erase cycles of MLC/TLC areas, while EXT CSD [269] shows the same for SLC areas.

If the disk is SLC only, pay careful attention to changes detected in the life value of EXT XSD [269] in EXT CSD, as well as the amount of written data. If the disk is configured to have half enhanced attributes and half normal attributes, pay attention to the changes in the life values of both EXT CSD [268] and EXT CSD [269], and the amount of written data in each corresponding area.

If there is no obvious issue, examine signal integrity and PCB layout for any issues affecting data transmission. Don’t forget that operating conditions and environmental factors can also have effects on eMMC performance. If software-related problems are suspected, conduct thorough debugging, including firmware updates and system checks using error logs and diagnostic information.



## Partition Management and Thermal Performance: What to Know

Is it hot in here, or is it just the heady smell of your new device melting? At least you know it isn't your Foresee eMMC device causing the issue. While partition management won't have a direct impact on the thermal performance of Lexar Enterprise's Foresee eMMC, some indirect partitioning factors may have a knock-on effect. These are:

- **Frequency of Read/Write:** Any time data is written or accessed, electrical activity happens. This will inevitably generate some heat due to resistance in the conductive path. Partitions with frequent activity (such as a system log partition) may then contribute to localized heating.
- **Size and Wear Leveling:** The better distributed the wear load on an eMMC is, the more chance there is of avoiding this read/write concentration. The more reduction of wear on individual cells, the better the thermal efficiency.
- **File System Choice and Overprovisioning:** Closely tied to this, the more efficiently the file system handles data placement and wear leveling, the more unnecessary electrical activity can be reduced. This means that smart overprovision can also have a positive impact.
- **System Design:** In any application where thermal management is important, smart system design and proper eMMC placement on the PCB will help reduce any concerns.

## Conclusion

Lexar Enterprise's eMMC solutions offer reliable, secure, consumer-grade, auto-grade 2 and 3, and industrial-grade flash storage solutions for a host of industrial and commercial applications. Smart partition management on these eMMC devices helps ensure an efficient, durable solution perfectly tailored to its specific use scenario, delivering the best possible performance no matter what.

From designing PCBs for eMMC integration, through partition and wear leveling basics or troubleshooting, readers should have the details they need to be confident about all things partition management in eMMC devices such as the Foresee eMMC from Lexar Enterprise.

## About Lexar Enterprise

Building upon the foundation and credibility of the well-established Lexar brand, Lexar Enterprise designs and manufactures memory and storage solutions specific to the high-level B2B market. Lexar Enterprise's Foresee product line provides world-class, durable memory and storage solutions tailored for OEMs, system integrators, industrial, automotive, and commercial customers in the Americas, offering a diverse lineup of products, including:

- OEM, consumer, and industrial-grade storage solutions.
- Mobile memory solutions for commercial and industrial-grade applications.
- Solid-state drives and memory modules for OEM, consumer, and industrial-grade applications.

With a commitment to innovation, performance, quality, and reliability, Lexar Enterprise is perfectly positioned to deliver superior products and support to meet the evolving data storage needs of businesses and industrial applications.