ElectronicDesign

FAQ

How Universal Flash Storage (UFS) Is Changing the "Mobile Universe"

What is Universal Flash Storage?

Universal flash storage (UFS) is a storage device targeted for applications that need both high-speed performance and low power consumption, like many modern mobile applications. UFS is a serial-interface device that uses NAND flash technology and was developed to be the higher performance follow-on solution to e-MMC memory, the prior-generation embedded flash memory for mobile applications.

UFS is based on a standard developed and managed by engineering trade association JEDEC Solid State Technology Association (commonly known as JEDEC). UFS was first introduced to the market in 2013 when Toshiba (now Kioxia) brought units to market based on version 1.1 of the JEDEC standard.

The most current standard, JEDEC UFS 3.1, released in 2020, offers faster performance compared to e-MMC. UFS technology is now found in applications with embedded flash memory ranging from smartphones to automotive infotainment systems.

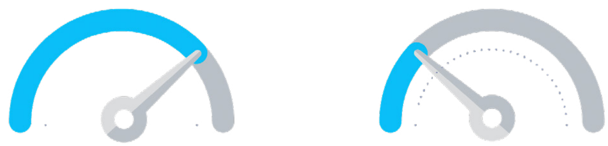
What performance advantages does UFS have over e-MMC?

A key performance advantage for UFS is that its interface speeds are significantly faster than e-MMC. UFS built to the JEDEC 3.1 standard has interface speeds of 2.332 GB/sec, almost six times faster than the 400 MB/sec interface supported by the most recent e-MMC version, 5.1.

In addition, the UFS architecture supports full duplexing so reading and writing of data can happen simultaneously, whether in sequential read-and-write or random read-and-write mode. e-MMC's half-duplex technology allows it to either read or write, but not at the same time. UFS also supports higher storage densities, 32 GB to 1 TB of data. In comparison, e-MMC is typically available in sizes of 4 to 128 GB.

UFS vs. e-MMC Performance Comparison

UFS version 3.1 | **e-MMC version 5.1**



supports **2.33GB/s** | supports **400MB/s**

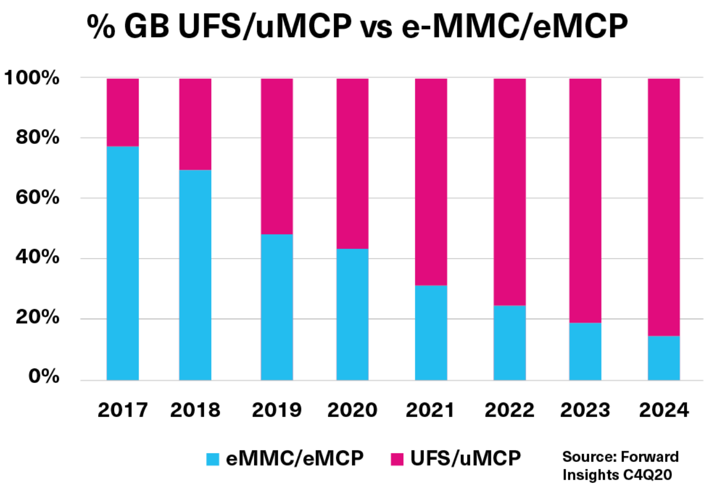
How has this propelled the adoption of UFS?

The ever-increasing performance, speed, and density requirements of small and mobile devices have sped the adoption of UFS over e-MMC in recent years. In 2015, Smartphones were the first applications introduced into the market that utilized UFS to support faster processors, streaming content, and greater storage capacity. Today, UFS is the dominant flash memory in smartphones. The 1.4 to 1.5 billion smartphones sold each year created economies of scale that led other applications to adopt UFS. These include augmented and virtual reality (AR/VR), tablets and 2-in-1 computers, and automotive infotainment systems. When combining overall UFS and e-MMC demand across all applications worldwide in total GB, UFS is expected to account for roughly 70% of the GB demand in 2021, and 85% of the GB demand by 2024, according to Forward Insights' market view update for the fourth quarter of 2020 (see figure).

What are some key features of the latest JEDEC version 3.1 UFS?

Version 3.1 of the JEDEC UFS standard was published in 2020 to supersede 2018's version 3.0. Version 3.1 devices support a High Speed-Gear Four (HS-G4) interface speed of 11.66 Gbits/sec per lane.

Flash Memory Market Share for UFS



Mobile applications continue to transition from using e-MMC to using UFS memory. Of the total worldwide gigabytes demanded by mobile applications for e-MMC/UFS memory, UFS is projected to account for 85% of this demand by 2024, according to Forward Insights' market view update for the fourth quarter of 2020.

Thus, over two lanes, a maximum interface speed of about 23.32 Gbits/sec can be achieved.

The new version also outlines four new features: WriteBooster, Host Performance Booster, Deep Sleep Power Mode, and Performance Throttling Event Notification.

What are WriteBooster and Host Performance Booster?

The three-dimensional memory architecture in modern UFS supports three bits per cell for greater capacity. WriteBooster allows one bit, instead of three bits, to be written per cell which enables faster write speeds due to the nature of how a bit is stored in memory. Then, when the internal UFS controller identifies some down time, it consolidates the bits into the more efficient triple-layer cell (TLC) configuration so that available memory capacity is not ultimately reduced.

This is particularly important as 5G capability and adoption grows. Users will require faster download speeds and will download more data-rich content. WriteBooster helps to ensure that the UFS is not a bottleneck to this process.

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Host Performance Booster improves random read performance by using a portion of the on-board system DRAM to store a portion of UFS's logical to physical table map, a larger portion than what could be stored if just the UFS controller's internal SRAM was used. This enables a reduction in latency.

What are Deep Sleep Power Mode and Performance Throttling Event Notifications?

UFS version 3.1 introduces Deep Sleep Power mode to use less power and extend battery life. This sleep mode achieves zero power consumption as if the device was powered off.

Performance Throttling Event Notifications let the UFS's internal controller throttle down performance if the internal temperature reaches a preset upper limit. This helps avoid overheating and damage to the internal device circuits.

Where will UFS encroach into areas that historically used solid-state drives?

Solid-state drives (SSDs) are common in applications where higher performance and storage capacity trump power consumption and size. Thus, they are typically found in desktop computers where they can be plugged into AC power. Flash memory such as UFS, developed for mobile, battery-powered applications, favors power efficiency over pure density and speed.

UFS densities now overlap with SSD capacities at 512 GB and 1 TB, making them attractive for mobile computing applications like notebooks and 2-in-1 computers.

Will UFS completely replace e-MMC?

Not for the foreseeable future, as applications that need lower storage density will continue to choose e-MMC. UFS has a practical lower density limit of around 32 GB because of market demand and because the faster interface depends on having more die within the memory device to support interleaving.

The older e-MMC technology, on the other hand, continues to support 4 GB, 8 GB, and 16 GB capacities. Thus, it is the flash memory of choice for applications needing less density such as streaming media devices, smart speakers, printers, wearables, IoT devices, and many more applications.