KIOXIA


# New Use Cases for Universal Flash Storage[1]

## *Understanding the Opportunities that UFS Memory Provides*

Universal flash storage (UFS) is a solid state storage device targeted for applications that require high-speed performance at low-power consumption, and is widely used in smartphones today. UFS devices were first introduced in 2013[2] by KIOXIA Corporation (formerly Toshiba Memory Corporation) and were based on version 1.1 of the UFS specification issued by JEDEC®.

A key performance advantage of UFS devices is the serial interface speed supported by the UFS specification – which is significantly faster than the parallel interface supported in the Embedded MultiMediaCard[3] (e-MMC) specification (the managed flash memory precursor to UFS). The current UFS v3.1 specification supports an interface speed up to 2.33 gigabytes per second[4] (GB/s), and almost six times faster than the current e-MMC v5.1 specification interface speed at up to 400 megabytes per second (MB/s) (Figure 1).

Additionally, the UFS architecture uses independent input and output data lanes that enable read and write operations to occur simultaneously, whether the device is configured for sequential read and write operations, or in random read and write mode. The data bus that is supported by the e-MMC specification is shared for input and output, and only enables either a read or write operation, but not at the same time.

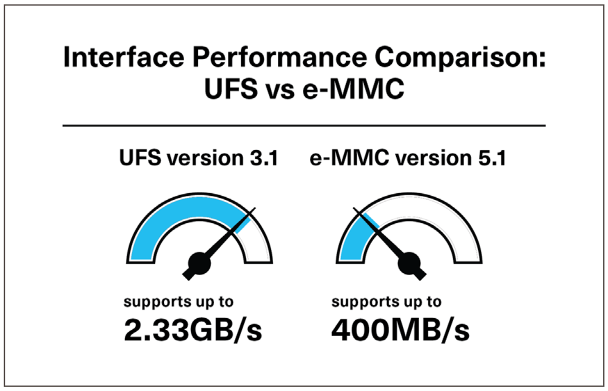


*Figure 1: Interface speed comparison between UFS and e-MMC specifications*

## UFS Devices are En Vogue

With the combination of higher performance and a full-duplex architecture, demand for UFS memory is extremely heightened. Of the total worldwide GB demanded for managed flash memory, UFS devices are projected to account for around 90% of this demand by 2024[5] (Figure 2).

As we look back at UFS memory, it was first introduced into smartphones, and has expanded into other applications such as Augmented Reality (AR) / Virtual Reality (VR), tablets and automotive systems. Recently, UFS memory has made its way into industrial and Internet of Things (IoT) applications, of which three use cases are presented in this brief to demonstrate the possibilities in this market segment.

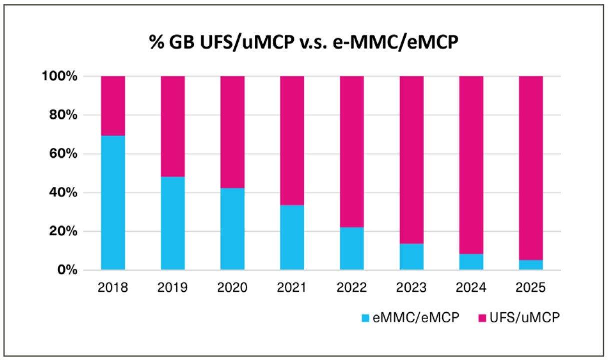


*Figure 2: Flash memory market share for UFS and e-MMC devices (Source: Forward Insights[5])*

## Use Case 1: 5G Fixed Wireless Access

With 5G telecommunications, increased network speed, lower network latencies and the ability to add more network connections are the key benefits. Its services are enabling many new 'smart' technologies, of which, mobile and fixed wireless access (FWA) is included. To enable 5G FWA, a 5G antenna must be mounted outside of a building to act as a transciever to the local 5G tower and must be connected to a 5G router located within the building (Figure 3):

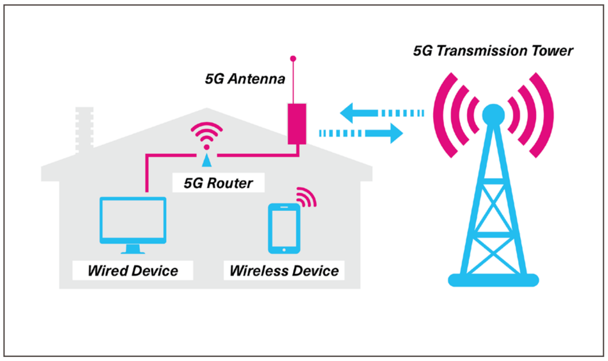


*Figure 3: A 5G fixed wireless access configuration*

This 5G router provides 5G, dual-band WiFi 6 and LAN connectivity options for interfacing to the outside world. The router can be used in residential or business environments as it supports enterprise grade security, as well as mobile and cloud-based device management. The feature-rich capabilities and high-performance requirements needed for 5G FWA make UFS memory a good fit for this use case.

With the latest UFS v3.1 specification boasting up to 2.33GB/s data transfers, these speeds can enable faster boot and device initializations (including configuration and management software), and Over-The-Air (OTA) updates. The increased capacity, coupled with the flexibility of Pseudo SLC (pSLC) NAND technology[6], provides reliable high bandwidth buffering with plenty of storage available for the boot code, firmware and operating system.

## Use Case 2: Enterprise Security Cameras

Modern-day high-end enterprise security cameras (Figure 4) offer advanced features such as facial and object recognition, heat motion maps, and a variety of analytics gathered from Artificial Intelligence (AI) and Machine Learning (ML) algorithms. When AI and ML algorithmic processing and analysis is added to surveillance recordings, even more data is consumed. To prevent this high level of processing from tying up local server or cloud resources, the optimal solution is to record, store and process data where it is captured, at the camera itself (known as edge computing). Computing and storage 'at-the-edge' (Figure 5) provides faster data transfer rates, preserves data integrity (if a network connection is lost or compromised), and, most importantly, reduces the risk of cyberattacks over Network Video Recorders (NVRs).

*Figure 4: Enterprise security camera*

For enterprise security camera applications, requirements include: (1) small storage form factors given the limited real estate available in these devices; (2) large storage densities given the abundance of data that is collected and needs to be processed at the edge; (3) very fast transfer rates to collect and store recorded data; and (4) low power consumption as some cameras run on batteries and need extended battery life to continuously record data without a shut down or compromise.

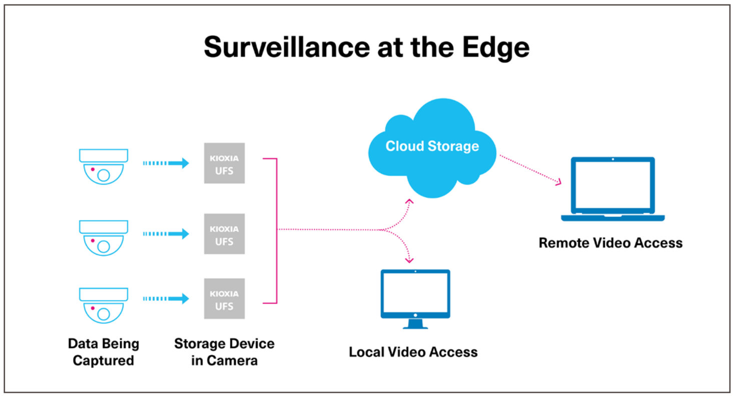


*Figure 5: Enterprise security camera edge configuration*

UFS memory is a good choice for today's enterprise security cameras and can store up to one terabyte[7] (TB) of data, enough to continuously capture more than ten days' worth[8] of high resolution video. Its small 11.5 x 13mm package also fits neatly in these space-constrained devices. The current UFS v3.1 specification is the fastest version of UFS to date, enabling edge computing for real-time data analysis with minimal latency. Devices based on the e-MMC specification do not have the bandwidth performance or storage densities to match UFS memory for this use case.

## Use Case 3: Industrial Scanners / Point-of-Sale Systems

Industrial scanners and Point-of-Sale (POS) systems are used for logistics, warehousing and many distribution processes key to the supply chain. Providing reliable track and trace operations, these devices need to be rugged and trusted in the environments that they are used. Most scanners and POS systems are hand-held and battery operated, feature high resolution displays and optical scanning functions, and support input methods such as touch and key pads (Figure 6).

*Figure 6: Industrial scanners are used for logistics, warehousing and many distribution processes*

These devices also have limited space for storage components and require small form factors, low power consumption for longer battery life, and the computing power and interface speed to handle multiple tasks. Industrial scanners and POS systems also use a high level operating systems (such as Android™, Linux® or Microsoft Windows®) so that required applications can be installed. Typically, 32 gigabytes[7] (GB) to 128GB are used to store the OS, applications and user data in an industrial scanner or POS system.

UFS memory is also a good choice for this use case, as the 11.5 x 13mm package with low power consumption fits well in rugged industrial environments. Additionally, the fast flash memory interface speed of the latest UFS v3.1 specification delivers very fast boot-ups and device initializations that enable industrial scanners and POS systems to respond quickly from sleep mode. UFS memory can also enable new industrial applications as software development on well-known operating systems is proven, echoing what has occurred in the smartphone market.

## Summary

With high performance, low power consumption and a full-duplex architecture, UFS has become the dominant flash memory deployed in smartphones today, and continues to be adopted into other applications such as the industrial and IoT segments. 5G fixed wireless access, enterprise security cameras and industrial scanners / POS systems are just a few of these new applications that are a good match for UFS memory. This is due to their need for small storage form factors, large storage densities, fast transfer rates and low power consumption to extend battery-life for battery-operated devices.

Though UFS memory usage and demand is dominant, it is not expected to completely replace e-MMC memory in the foreseeable future – due to the fact that there are applications which require the lower storage density that e-MMC memory provides.

General information for KIOXIA managed flash memory types is available here.

**NOTES:**

[1] Universal Flash Storage (UFS) devices are based on the UFS specification, of which, v3.1 specification is the current release issued by JEDEC and published in January 2020.

[2] Source: KIOXIA, as of February 2013, https://www.prnewswire.com/news-releases/toshiba-ships-samples-of-industrys-first-universal-flash-storage-devices-190309341.html.

[3] Embedded MultiMediaCard (e-MMC) is a specification developed by JEDEC for mobile applications. The current release is v5.1, published in February 2015.

[4] Read and write speed may vary depending on the host device, read and write conditions, and file size.

[5] Source: Forward Insights NAND and SSD Insights, Report FI-NFL-NQ1-Q221, Q2 2021, Market View Update for Q2 2021, published May 2021.

[6] Pseudo SLC is a capability within NAND flash memory that effectively converts Triple-Level Cell (TLC) NAND flash memory (3-bits per cell) or Multi-Level Cell (MLC) NAND flash memory (2-bits per cell) to Single-Level Cell (SLC) type cells (1-bit per cell). When configured to pSLC NAND technology, each cell's reliability, specifically Write/Erase (W/E) endurance and data retention characteristics, substantially improve. The trade-off is a reduction of bits available for storage in the area allocated for pSLC.

[7] Definition of capacity - KIOXIA Corporation defines a kilobyte (KB) as 1,000 bytes, a megabyte (MB) as 1,000,000 bytes, a gigabyte (GB) as 1,000,000,000 bytes and a terabyte (TB) as 1,000,000,000,000 bytes. A computer operating system, however, reports storage capacity using powers of 2 for the definition of 1Gbit = $2^{30}$ bits = 1,073,741,824 bits, 1GB = $2^{30}$ bytes = 1,073,741,824 bytes and 1TB = $2^{40}$ bytes = 1,099,511,627,776 bytes and therefore shows less storage capacity. Available storage capacity (including examples of various media files) will vary based on file size, formatting, settings, software and operating system, and/or pre-installed software applications, or media content. Actual formatted capacity may vary.

[8] Source: CCTV Calculator at https://www.cctvcalculator.net/en/calculations/storage-needs-calculator/ and based on a commonly used Full HD surveillance camera configuration with 30 frames per second, 1920x1080 resolution, H.264 video compression, and 10-days of recording with 90% motion detection. This single camera configuration requires about 400GB of data storage. Assuming that a smart surveillance camera will also require more metadata than 400GB, a UFS device with 1TB capacity can continuously capture 10 days' worth of high resolution video.

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