# FLASH MEMORY GUIDE

Kingston®, the world's leading independent manufacturer of memory products, offers a broad range of Flash cards, USB Flash drives and Solid-State Drives (SSD) (collectively called Flash storage devices) that employ Flash memory chips for storage. The purpose of this guide is to explain the various technologies and Flash memory offerings that are available.

Note: Due to changes in Flash technology, specifications listed in this document are subject to change without notice

## Flash memory: Empowering a New Generation of Flash Storage Devices

Toshiba invented Flash memory in the 1980s as a new memory technology that allowed data to be saved even when the memory device was disconnected from its power source. This data can include various types of files such as documents, images, videos, audio files, software applications and more. Since then, Flash memory technology has evolved into the preferred storage medium for a variety of consumer and industrial devices.

In consumer devices, Flash memory is widely used in:

- Notebook computers
- Tablets
- Global Positioning Systems (GPS)
- Television set-top boxes
- Portable and home video game consoles
- Dashboard cameras
- Toys
- Personal computers
- Digital cameras (DSLR, mirrorless, camcorders etc.)
- Mobile phones
- Electronic musical instruments
- Drones
- Action cameras
- Fitness trackers
- Automobiles

Flash memory is also used in many industrial applications where reliability and data retention in power-off situations are key requirements, such as in:

- Security systems/IP cameras
- Embedded computers
- Networking and communication products
- Retail management products (e.g. handheld scanners)
- Military systems
- Set-top boxes
- Wireless communication devices
- Point of sale devices

Please note: Most Kingston Flash memory is designed and tested for compatibility with consumer devices. For industrial applications or special use applications that go beyond the standard daily consumer usage, it is recommended that you contact Kingston directly. A special configuration may be required, especially in applications that will greatly impact flash cell endurance.

## SSD, flash card and USB flash drive capacity

Some of a Flash storage device's listed capacity is used for formatting and other functions and is thus not available for data storage.

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When a Flash storage device is designed and manufactured, steps are taken to ensure that the device operates reliably and to permit the host device (computer, digital camera, tablets, mobile phone etc.) to access the memory cells – i.e. to store and retrieve data on the Flash storage device. Formatting includes the following operations:

1. Testing each memory cell in the Flash storage device.
2. Identifying all defective cells and taking steps to ensure that no data will be written to or read from a defective cell.
3. Reserving some cells to serve as "spares". Flash memory cells have a long but finite lifetime. Therefore, some cells are held in reserve to replace any memory cells that may fail over time.
4. Creating a File Allocation Table (FAT) or other directory. To enable Flash storage devices to store and access customer files conveniently, a file management system must be created to allow any device or computer to identify the files stored in the Flash storage device. The most common type of file management system for Flash storage devices is the File Allocation Table (FAT), which is also used on hard drives.
5. Reserving some cells for use by the Flash storage device's controller, e.g. for storing firmware updates and other controller-specific information.
6. Where applicable, reserving some cells for special features. For example, the specification for Secure Digital (SD) cards requires reserved areas to support special copy-protection and security features.
7. The Flash storage device is given a label or name, which is used to identify it when it is connected to a computer.
8. The Flash storage device is made available for use, either by mounting it within a computer's operating system or by making it available to a device such as a camera or mobile phone.

## Features of Kingston's flash storage products

The reported capacity of a drive is often smaller than the capacity indicated on its label. This discrepancy arises because systems use both decimal (base 10) and binary (base 2) measurements to determine drive size. The total number of usable bytes on the drive is the basis for these measurements.

### Decimal (base 10) capacity

To determine the decimal capacity, divide the total number of bytes on the drive by the number of bytes per gigabyte in base 10 (1,000,000,000 bytes).

In decimal terms:

- 1 megabyte (MB) = 1,000,000 bytes
- 1 gigabyte (GB) = 1,000,000,000 bytes
- 1 terabyte (TB) = 1,000,000,000,000 bytes

### Binary (base 2) capacity

To determine the binary capacity, divide the total number of bytes on the drive by the number of bytes per gigabyte in base 2 (1,073,741,824 bytes).

In binary terms:

- 1 megabyte (MB) = 1,048,576 bytes
- 1 gigabyte (GB) = 1,073,741,824 bytes
- 1 terabyte (TB) = 1,099,511,627,776 bytes

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**Example calculation**

For a drive labelled as 1 TB in decimal (base 10):

- Decimal capacity: 1,000,000,000,000 bytes
- Binary capacity:

Binary Capacity in GB = 1,000,000,000,000 bytes / 1,073,741,824 bytes per GB ≈ 931 GB

Thus, a drive labeled as 1 TB in decimal appears as approximately 931 GB in binary when viewed on a system.

Kingston's Flash storage devices offer many advantages.

- Flash storage device warranty*: Kingston warrants to the original end-user customer that its products are free from defects in material and workmanship on the terms and conditions set forth herein: (*Note: Warranty subject to change)

  **Product Lifetime Warranty**:** The following Kingston products are covered by this warranty for the product lifetime: Memory modules including ValueRAM®, HyperX®, Kingston FURY™, Server Premier, Retail Memory and Kingston system-specific memory; flash memory cards including Secure Digital, Secure Digital HC and XC (excluding Industrial Temp and Endurance cards), CompactFlash, MultiMediaCard, SmartMedia and flash adapters. (**Product lifetime is defined as the normal time expectancy for the use of products in the industry. However, the lifetime warranty may be subject to definitions as set by different countries. For Russia, the lifetime warranty is determined to be for a period of ten (10) years from the date of purchase by the original end user customer.)

  **Five-Year Warranty:** The following Kingston products are covered by this warranty for a period of five years from the date of purchase by the original end-user customer: USB DataTraveler® drives (excluding DataTraveler 2000), Design-In Client DRAM ("CBD"), IronKey™ drives (excluding IKVP80ES, IKKP200, IKKP200C, IKD500SM) and Industrial Temp microSD cards (SDCIT).

  **Five-year conditional SSD warranty:** The following Kingston products are covered by this warranty, based on which of the following events occurs first: (i) five (5) years from the date of purchase by the original end user customer; (ii) when the usage of a SATA SSD as measured by Kingston's implementation of the SMART attribute 231, labelled as **"SSD Wear Indicator"**, reaches a normalised value of one (1) as indicated by Kingston's SSD manager ("KSM"), or (iii) when the usage of an NVME SSD as indicated by Kingston's implementation of the Health attribute "Percentage Used" reaches or exceeds a normalised value of one hundred (100) as indicated by the KSM.

  The KSM is specified in the datasheet for the products and is available via Kingston's website at kingston.com/SSDmanager. For SATA SSDs, a new unused product will show a wear indicator value of one hundred (100), whereas a product that has reached its warranty limit will show a wear indicator value of one (1). For NVMe SSDs, a new unused product will show a **Percentage Used** value of zero (0), whereas a product that reaches its warranty limit will show a **Percentage Used** value of greater than or equal to one hundred (100).

  Please refer to the following SSD warranty table for product-specific warranty information:

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| 5-Year Conditional Warranty Table (SATA SSD) | |
|---|---|
| Drive Family | Part number |
| DC600M | SEDC600Mxxx |
| DC500 | SEDC500xxx |
| DC400 | SEDC400S37xxx |
| DC450R | SEDC450Rxxx |
| KC400 | SKC400S37xxx |
| KC600 | SKC600xxx |
| M.2 SATA G2 | SM2280S3G2xxx |
| UV500 | SUV500xxx |
| **5-Year Conditional Warranty Table (NVME SSD)** | |
| Drive Family | Part number |
| A1000 | SA1000M8xxx |
| DC1000B | SEDC1000BM8xxx |
| DCP1000* | SEDC1000Hxxx* |
| KC1000 | SKC1000xxx |
| KC2000 | SKC2000xxx |
| DC1000M | SEDC1000Mxxx |
| DC1500M | SEDC1500Mxxx |
| KC2500 | SKC2500xxx |
| A2000 | SA2000M8xxx |
| KC3000 | SKC3000xxxx |
| Kingston Fury Renegade | SFYRxxxx |
| **5 Year Conditional Warranty Table (Portable SSD)** | |
| XS1000 | SXS1000xxxx |
| XS2000 | SXS2000xxxx |

* If the usage of one or more of the four (4) individual M.2 SSDs that make up the DCP1000 shows a Percentage Used value that reaches or exceeds a normalised value of one hundred (100), the product is no longer covered under warranty.

**Three-year warranty:** The following Kingston products are covered by this warranty for a period of three years from the date of purchase by the original end-user customer: IronKey™ Vault Privacy 80 External SSD (IKVP80ES), Keypad 200 (IKKP200), Keypad 200C (IKKP200C), High Endurance microSD card (SDCE), Industrial card (SDCIT2, SDIT), DataTraveler microDuo3 G2 (DTDUO3G2) and HyperX Savage (SHSS37Axxx).

**Three-year conditional SSD warranty:** The following Kingston products are covered by this warranty, based on which of the following events occurs first: (i) three years from the date of purchase by the original end user customer; (ii) when the usage of a SATA SSD as measured by Kingston's implementation of the SMART attribute 231, labelled as "SSD Wear Indicator", reaches a normalised value of one (1) as indicated by the Kingston SSD Manager ("KSM"); or (iii) when the usage of an NVME SSD as measured by Kingston's implementation of the health attribute "Percentage Used" reaches or exceeds a normalised value of one hundred (100) as indicated by KSM.

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The KSM is specified in the datasheet for the specific product and is available via Kingston's website at kingston.com/SSDmanager. For SATA SSDs, a new unused product will show a wear indicator value of one hundred (100), whereas a product that has reached its warranty limit will show a wear indicator value of one (1). For NVMe SSDs, a new unused product will show a Percentage Used value of zero(0), whereas a product that reaches its warranty limit will show a Percentage Used value of greater than or equal to one hundred (100).

Please refer to the following SSD warranty table for product-specific warranty information:

| Three-Year Conditional Warranty Table (SATA SSD) | |
|---|---|
| Drive Family | Part number |
| A400 | SA400S37xxx |
| Q500 | SQ500S37xxx |
| UV400 | SUV400S37xxx |
| HyperX Savage EXO | SHSX100xxx |
| **Three-Year Conditional Warranty Table (NVMe SSD)** | |
| NV1 | SNVSxxx |
| NV2 | SNV2xxx |

**Two-year warranty:** The following Kingston products are covered by this warranty for a period of two years from the date of purchase by the original end user customer: IronKey™ D500SM, DataTraveler® Bolt Duo, MobileLite® Wireless - Gen 3, MobileLite Wireless – Gen 2, MobileLite Reader, microSD Reader, Nucleum, Workflow Station and Workflow Readers. Products under the Kingston Customisation Programme. Kingston Customisation Programme products are limited to credit or refund during the two-year warranty period. In some instances, Kingston may, at its option, elect to replace defective products ordered through the Kingston Customisation Programme with functionally equivalent products.

**One-year warranty:** The following Kingston products are covered by this warranty for a period of one year from the date of purchase by the original end-user customer: MobileLite Wireless – Gen.1, DataTraveler Accessory Kit, Wi-Drive®, TravelLite SD/MMC Reader and Bali microSDHC Class 10 UHS-1.

If a product has been discontinued, Kingston, at its sole discretion, shall either repair the product, offer to replace it with a comparable product or provide a refund at the lesser of the purchase price or the product's current value.

Repaired or replacement products will continue to be covered by this limited warranty for the remainder of the original warranty term or ninety (90) days, whichever is longer.

This limited warranty applies only to the original end-user customer and is subject to the terms and requirements described herein. This limited warranty is non-transferable. Products purchased as part of a kit require that the kit be returned in its entirety in order to be eligible for warranty.

Embedded and DRAM component products: For additional product-specific warranty information, please see the warranty statements for **Embedded**, **DRAM** and **Design-in SSD** components.

For further details, see **kingston.com/company/warranty.asp**

- Solid state: Flash storage devices, as semiconductor storage devices, have no moving parts and are therefore not subject to the mechanical failure issues of hard drives. Their overall data reliability has enabled them to dominate the convenience-oriented portable memory products market, operating silently with a zero-decibel noise level.

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- Small physical size (or form factor): Flash storage devices are designed to be transported easily. Convenience is an important criterion, especially for consumer and corporate applications.
- High data reliability: Flash memory is very reliable and many of the Flash storage device types also include Error Correction Code (ECC) checking and advanced wear levelling.
- Kingston Flash data retention: Kingston Flash storage devices primarily use SLC/MLC/TLC/QLC Flash memory. Data retention on Flash memory is dynamic since the amount of time the memory has been cycled affects data retention. Important information should always be backed up on other media for long-term safekeeping.
- Wear-levelling technology: Kingston Flash storage devices incorporate controllers that use advanced wear-levelling technology, which distributes the number of program/erase (P/E) cycles across the Flash memory evenly. Wear-levelling thus extends the useful life of a Flash memory card (for details, see the Kingston Flash Cell Endurance section below).
- Flash cell endurance: Non-volatile Flash memory cells have a finite number of program/erase (P/E) cycles. Simply put, every time data is written to or erased from a Flash storage device, the number of program/erase cycles decrease and are eventually used up to the point that the Flash memory is no longer usable.
- For Multi-Level Cell (MLC) flash, up to 10,000 program erase (P/E) cycles based on current lithography process at the time of writing. For Single-Level Cell (SLC) flash, up to 100,000 program erase (P/E) cycles. For Triple-level Cell (TLC), up to 3000 program erase (P/E) cycles. For Quad-Level Cell (QLC), up to 1000 program erase (P/E) cycles. The lithography of the flash memory die plays a key role in cell endurance and decreases as the size of the cell becomes smaller.
- Flash memory technology: Multi-Level Cell (MLC) Flash uses multiple levels per cell, which allows more bits to be stored using the same number of transistors. MLC NAND Flash technology uses four possible states per cell. With Single-Level Cell (SLC) technology, each cell can be stored in two states. For Triple-Level Cell (TLC), the bits are allowed to be stored in eight possible states. For Quad-Level Cell (QLC), the bits are allowed to be stored in sixteen possible states. The lithography of the flash memory die plays a key role in cell endurance and decreases as the size of the cell becomes smaller.
- Write amplification factor: Write Amplification Factor or "WAF" is a crucial metric used to evaluate the efficiency of data writes in flash NAND storage devices and is present in all flash storage devices. The write amplification factor is the ratio between the amount of data written from the host and the amount of data written to the Flash memory chips. A high WAF indicates inefficient data management and can lead to reduced performance, increased wear and shorter lifespan of the flash memory.
- Automatic bad sector remapping: Kingston Flash controllers automatically lock out sections with bad memory cells ("bad blocks") and move the data to other sections ("space blocks") to avoid data corruption. During factory formatting, spare blocks are set aside on the flash storage device for remapping bad sectors over time to extend the useful life and reliability of the flash storage device.
- High-quality connectors: Kingston's Flash storage devices always use highly rated mating connectors to ensure long life and reliable usage of the Flash memory device.
- Operating temperature and humidity:
  SSD: 0 – 70°C, humidity: 85% RH
  USB Flash drives: 0 – 60°C, humidity: 20% to 80% RH
  SD and Micro SD: -25°C – 85°C, humidity: 5% to 95% RH
  Card readers: 0 – 60°C, humidity: 95% RH

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For detailed product environmental specifications, check Kingston's product pages and datasheets for more information.

- High capacity: Flash storage devices can provide large storage capacities in a very small form factor. This flexibility makes them ideal for consumer uses, such as digital film or storage for documents, where portability and convenience are important.

Please note: Some of the listed capacity is used for formatting and other functions and is thus not available for data storage.

- High performance: Kingston's Ultra High Speed (UHS) Flash cards and Hi-Speed/SuperSpeed DataTraveler USB Flash drives are faster than many standard Flash products and many competitive products. Kingston's engineers test and select high-performance controllers to ensure that Kingston's Flash cards are among the performance leaders. Please see the Appendix for information about USB, Hi-Speed and Super Speed USB performance. Kingston standard Flash products offer moderate performance levels for general purpose applications.
- Low power consumption: Unlike standard DRAM memory that needs to be constantly powered on to maintain its data, Flash memory is non-volatile and does not require power to maintain its data. Flash memory's low power consumption results in longer battery life for the host device.
- Plug-and-play support: Kingston's flash memory line supports plug-and-play. With plug-and-play technology and compatible computer operating systems, a Flash storage device can be inserted into a computer or a Flash media reader and be quickly recognised and accessed by the computer.
- Hot-swapping support: Hot-swapping allows for plugging or unplugging Flash storage devices into a compatible computer or reader without needing to power off and restart the computer. This feature enhances the portability and convenience of Flash storage devices for transferring data, pictures or music between two computers or devices.

## Non-volatile NOR and NAND flash technologies

Unlike Dynamic Random Access Memory (DRAM), Flash memory is non-volatile. Non-volatile memory retains data even without being powered on. For example, when a computer is turned off, all data that was in the computer's DRAM memory becomes lost. However, when a flash storage device is removed from a digital camera, all data (and pictures) remains saved on the flash storage device. The ability to retain data is key for Flash memory applications such as digital film for digital cameras, mobile phones, tablets and other transportable devices.

There are two major Flash memory technologies: NOR and NAND. Each technology has strengths that make it ideal for different kinds of applications, as summarised in the following table:

| | NOR Flash | NAND Flash |
|---|---|---|
| High-Speed Access | Yes | Yes |
| Page-Mode Data Access | No | Yes |
| Random Byte Level Access | Yes | No |
| Typical Uses | Networking device memory | Industrial storage |

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### NOR flash memory

NOR, named after the specific data mapping (Not OR), is a high-speed Flash technology. NOR Flash memory provides high-speed random-access capabilities, being able to read and write data in specific locations in the memory without having to access the memory in sequential mode. Unlike NAND Flash, NOR Flash allows the retrieval of data as small as a single byte. NOR Flash excels in applications where data is randomly retrieved or written. NOR is most often found built into cellular phones (to store the phone's operating system) and PDAs, and is also used in computers to store the BIOS program that runs to provide the start-up functionality.

### NAND flash memory

NAND Flash was invented after NOR Flash and is named after the specific mapping technology used for data (Not AND). NAND Flash memory reads and writes in high-speed, sequential mode, and handles data in small block sizes ("pages"). NAND Flash can retrieve or write data as single pages but cannot retrieve individual bytes like NOR Flash.

NAND Flash memory is commonly found in solid-state hard drives, audio and video Flash media devices, television set-top boxes, digital cameras, mobile phones (for data storage) and other devices where data is generally written or read sequentially.

For example, most digital cameras use NAND-Flash-based digital film, as pictures are usually taken and stored sequentially. NAND flash is also more efficient when pictures are read back, as it transfers whole pages of data very quickly. As a sequential storage medium, NAND Flash is ideal for data storage.

NAND Flash memory is less expensive than NOR Flash memory and can accommodate more storage capacity in the same die size.

Flash memory which stores a single bit per cell (e.g. a value of "0" or "1" per cell) is known as Single-Level Cell (SLC) Flash.

## Die-stacking, 3D NAND and multi-level cell/multi-bit cell flash technologies

To economically increase the amount of bit storage that a Flash memory chip can accommodate, manufacturers use 3D NAND and multi-level cell or multi-bit cell technologies. These technologies result in a Flash memory chip having the capability to store more data in a single chip.

### 3D NAND and die-Stacking

3D NAND flash technology and die stacking represent significant advancements in semiconductor memory design. 3D NAND involves stacking memory cell layers vertically within a single chip, offering higher capacities and improved performance compared to traditional planar NAND. While die stacking typically finds more application outside NAND flash memory, it can still be utilised alongside 3D NAND technology, resulting in configurations like DDP (Double-Die Package), QDP (Quad-Die Package), ODP (Octo-Die Package), all the way up to HDP (16-die package). Die-stacking technology enables higher capacity in small form factors such as a USB drive or M.2 SSDs. Dual-die and quad-die packages. These configurations combine the advantages of both technologies, including increased storage capacity, enhanced performance and cost efficiency.

To understand how 3D NAND works, let's delve into the process and components involved:

NAND Flash memory consists of memory cells organised into a grid-like structure. Each memory cell can store multiple bits of information using multiple voltage levels, typically 2, 3 or 4 bits per cell (MLC, TLC, or QLC respectively).

Planar NAND structure: Initially, NAND flash memory was built in a planar structure, where the memory cells were arranged side by side on a single layer. However, as technology advanced, it became challenging to increase the storage capacity while keeping the chip size within manageable limits. To overcome the limitations of planar NAND structure, manufacturers started utilising 3D NAND techniques to increase storage capacity, while maintaining a small form factor.

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Charge trap technology: One of the commonly used technologies in 3D NAND is charge trap technology. Instead of using a floating gate (used in planar NAND), charge trap technology employs a 3D charge trap structure. This structure allows for better control over the charge retention properties of the memory cells, resulting in improved performance and reliability.

Vertical connectivity: vertically connected through a complex structure that allows for the stacking of multiple memory cell layers within a single NAND flash chip, currently up to 256-layers per NAND chip. Each layer contains a grid of memory cells used to store data. These layers are stacked on top of each other to increase storage capacity.

Peripheral circuits: In addition to the memory cells, NAND flash devices also contain peripheral circuits, including controllers, error correction mechanisms and data transfer interfaces. These circuits manage the storage operations, ensure data integrity and facilitate communication with the host system.

By employing these layering and stacking techniques, manufacturers can achieve higher storage capacities in NAND flash devices. The number of layers or dies stacked together depends on the specific technology used and the desired storage capacity. Advanced 3D NAND technologies have enabled drives with terabytes (TB) of storage in a small form factor.

It's important to note that 3D NAND is just one aspect of achieving large-capacity drives. The overall storage capacity also depends on factors such as the size of individual memory cells, the number of bits stored per cell (SLC, MLC, TLC or QLC), and the overall manufacturing process advancements.

Overall, 3D NAND and die stacking empower semiconductor memory solutions with higher capacities, better performance, cost efficiency and flexibility, making them integral components in modern storage technologies across a wide spectrum of applications that address the demands for consumer and enterprise NAND-based storage solutions.

### Multi-level cell (MLC)/ triple-level cell (TLC)/ quad-level cell (QLC) flash technologies

NAND and NOR Flash memory chips store one (1) bit value (a "0" or a "1") in each cell. In multi-level Flash technology, two (2) values are stored in each cell. In triple-level Flash technology, three (3) values are stored into each cell. In quad-level flash technology, four (4) values are stored into each cell. Kingston incorporates all mentioned technologies into its line of flash cards, SSDs and DataTraveler USB flash drives. Plus, Kingston leverages new flash technologies once they are tested, reliable and available.

Charge trap technology: One of the commonly used technologies in 3D NAND is charge trap technology. Instead of using a floating gate (used in planar NAND), charge trap technology employs a 3D charge trap structure. This structure allows for better control over the charge retention properties of the memory cells, resulting in improved performance and reliability.

## Flash storage device performance

Flash card storage device performance depends on the following three factors:

- The specific Flash memory chips used: TLC NAND stores three bits of data per cell, whereas QLC NAND stores four bits per cell, resulting in higher density and lower cost per gigabyte for QLC NAND. However, this increased density comes at the expense of reduced endurance and slower performance compared to TLC NAND. TLC NAND typically offers better longevity and faster read and write speeds.
- The Flash storage device's controller: Today's Flash storage devices have a built-in Flash memory controller. This special chip manages the interface to the host device, and handles all the reads from and writes to the Flash chips on the Flash storage device. If the host controller can support faster data transfer speeds, the use of optimised Flash controllers can result in significant time savings when reading or writing data into the Flash memory.

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- The host device to which the Flash storage device is connected: If the host device (computer, digital camera mobile phone etc.) is limited to specific read and write speeds, using faster Flash storage devices will not deliver higher performance. For example, using a USB 20Gbps Flash drive on a computer that supports only USB 5Gbps speeds will not result in faster transfers. In addition, computers need to be properly configured to support faster transfers in both hardware and software. In the case of a PC, the system board will need to have built-in USB 20Gbps connectors, and the operating system (e.g. Windows) will also need to have the proper USB drivers installed to be able to support USB 20Gbps transfers.

For details on USB Performance, refer to Appendix A.

Flash memory product manufacturers provide Speed Class ratings for Flash cards. The SD Association created a way to standardise the speed ratings for memory cards. They are intended to help consumers choose the right memory card for their hardware devices in terms of speed. For details, see kingston.com/en/blog/personal-storage/memory-card-speed-classes.

Kingston works closely with global semiconductor and controller manufacturers to ensure that Kingston Flash devices deliver superior price/performance to its customers. For enthusiasts and advanced customers who demand the highest performance, Kingston offers the Canvas Go! Plus and React Plus line of microSD and SD cards, the DataTraveler 10Gbps, 20Gbps USB Flash drives and Fury SSDs.

## Kingston's flash product lines

Several types of Flash storage devices are available from Kingston:

- USB flash drives (DataTraveler®)
- Encrypted USB flash drives (IronKey™)
- Secure Digital cards (SD, SDHC, SDXC, microSD, microSDHC, microSDXC)
- Solid-state drives (SSDs)
- Embedded solutions (design in)

### USB flash drives

Introduced in 2002, USB Flash drives offer an incredible combination of high storage capacity, fast data transfer rates and great flexibility, all in the palm of your hand. Heralded as an alternative to floppy disks or CDs, USB drives have far more storage capacity than a standard floppy disk or CD-ROM drive replacement. For example, Kingston has a 2TB USB Flash drive that can hold approximately 2,900 CDs (700MB CD) worth of data, 425 DVDs worth of data (4.7GB DVD) and 40 dual Blu-ray disc worth of data (50GB Blu-ray). USB Flash drives provide an easy method for quick downloads and transferring digital files to and from your computer or device.

USB Flash drives incorporate NAND Flash and a controller in a capsulated case. USB Flash drives work with most computers and devices that incorporate the Universal Serial Bus interface, including most PCs, tablets, TVs and mobile phones.

Kingston offers a full line of DataTraveler USB Flash drives. For details, please visit

**https://www.kingston.com/en/usb-flash-drives.**

For details on USB generations visit, **https://www.kingston.com/en/usb-flash-drives/usb-30**

### Encrypted USB Flash Drives

USB flash drives have become indispensable tools for data storage and transfer due to their portability and convenience. However, the increasing threat of data breaches and unauthorised access demands robust security measures to protect sensitive information. Kingston's IronKey line of encrypted USB flash drives offers a reliable solution by ensuring data confidentiality through encryption algorithms and authentication mechanisms.

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Symmetric encryption algorithms, such as AES (Advanced Encryption Standard), are widely used in Kingston's encrypted USB flash drives. They employ a single encryption key to both encrypt and decrypt data. This approach provides fast and efficient encryption, making it suitable for real-time data transfers.

Kingston uses hardware encryption, also known as on-the-fly encryption, which uses a dedicated cryptographic processor within the USB flash drive. This approach offloads the encryption/decryption tasks from the host computer, providing enhanced security and performance.

Kingston offers Enterprise Managed Encrypted USB Flash Drives: Secure USB management allows an organisation to quickly and easily establish a command centre to inventory, audit and control their secure USB storage devices used in Windows/MacOS.

Features include:

- Remote password reset
- Password policy
- Device audit
- Device state management
- Geolocation and geofencing

(Linux support is limited to basic Lock/Unlock commands and full management capability is not available for Linux systems)

Importance of encrypted USB Flash drives:

Data protection: Encrypted USB flash drives protect sensitive data from unauthorised access to ensure confidentiality and prevent data breaches. In case of loss or theft, the encrypted data remains inaccessible without the encryption key, mitigating the risk of data leakage.

Compliance: In regulated industries such as healthcare, finance and government, encrypted USB flash drives are often mandatory to comply with data protection regulations. One crucial standard in this regard is the Federal Information Processing Standards (FIPS) issued by the National Institute of Standards and Technology (NIST). FIPS compliance ensures that the encryption algorithms and security mechanisms employed in USB Flash drives meet the stringent requirements set by government agencies.

Portable security: Encrypted USB flash drives offer a portable security solution for professionals and individuals who frequently handle sensitive information on the go. These devices enable secure data storage, sharing and collaboration without compromising data integrity.

### FIPS compliance standards

FIPS are standards and guidelines for federal computer systems that are developed by the National Institute of Standards and Technology (NIST) in accordance with the Federal Information Security Management Act (FISMA) and approved by the Secretary of Commerce. These standards and guidelines are developed when there are no acceptable industry standards or solutions for a particular government requirement. Although FIPS are developed for use by the federal government, many in the private sector voluntarily use these standards. ("Compliance FAQs: Federal Information Processing Standards (FIPS) | NIST," 2021)

FIPS 140-3, the successor to FIPS 140-2, introduces significant advancements in security standards to address evolving cryptographic threats and vulnerabilities:

Modernisation of security practices: FIPS 140-3 reflects a contemporary understanding of security practices. It considers the ever-changing landscape of cyber threats and incorporates lessons learned from security breach-es that have occurred since FIPS 140-2's publication in 2001.

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Increased rigour in testing: FIPS 140-3 mandates more rigorous testing and evaluation processes for crypto-graphic modules. This heightened scrutiny includes comprehensive penetration testing, vulnerability analy-sis and a more detailed examination of potential weak-nesses, ensuring that modules are resilient against so-phisticated attacks.

Stronger algorithmic requirements: The standard raises the bar in terms of cryptographic algorithms. It encour-ages the use of newer and more secure algorithms, re-flecting advancements in cryptographic research. This ensures that cryptographic modules are resistant to con-temporary cryptographic attacks, which may exploit vul-nerabilities in older algorithms.

Enhanced physical security considerations: FIPS 140-3 pays greater attention to physical security requirements. This involves safeguards against tampering, such as im-proved tamper-evidence mechanisms and stronger pro-tections against physical attacks to prevent unauthorised access to cryptographic keys or sensitive data.

Improved key management: The standard places a heightened emphasis on secure key management prac-tices. It outlines stricter guidelines for key generation, storage and handling, reducing the risk of unauthorised access or key compromise.

Adaptation to emerging technologies: FIPS 140-3 acknowledges the increasing integration of cryptograph-ic modules into modern technologies, including cloud computing, IoT devices and mobile applications. It pro-vides guidance on how these modules should be used securely in these emerging contexts.

Compatibility and transition: While FIPS 140-3 aims for robust security enhancements, it also addresses the need for a transition from FIPS 140-2. This includes guidance for organisations currently using FIPS 140-2-compliant modules, ensuring that they can migrate to FIPS 140-3 while maintaining security.

In essence, FIPS 140-3 is designed to fortify the security posture of cryptographic modules by adopting a for-ward-looking approach that considers the evolving threat landscape and incorporates contemporary securi-ty best practices. These enhancements aim to ensure that cryptographic modules provide the highest level of security against both current and future threats.

FIPS 140-2 is a standard that specifies the security requirements for cryptographic modules. It defines four security levels (Level 1 to Level 4) based on increasing security requirements. Here are the key requirements and testing procedures for FIPS 140-2 compliance:

Cryptographic module specification: The cryptographic module must have a detailed specification document that outlines the security features, cryptographic algo-rithms, key management, authentication mechanisms and physical security measures.

Cryptographic algorithm validation: The cryptographic algorithms used in the module, such as AES (Advanced Encryption Standard), must be validated against FIPS-approved standards. This validation ensures that the algorithms meet the necessary security criteria.

Key management: The module must provide secure key generation, storage and handling mechanisms. It should protect the confidentiality and integrity of cryptographic keys throughout their lifecycle. Key management pro-cedures should be robust and resistant to attacks.

Physical security: The module should have physical se-curity mechanisms in place to protect against tampering and unauthorised access. This includes features like tamper-evident coatings, intrusion detection mecha-nisms and secure enclosure designs.

Operational environment: The module should specify the intended operational environment, including tem-perature, humidity and power requirements. It should also address the potential risks associated with the envi-ronment.

Self tests: The module should conduct self tests to verify its integrity and functionality. These tests should detect and report any potential security vulnerabilities or mal-functions.

Design assurance: The module's design and implementa-tion should follow best practices to minimise security vulnerabilities. The design should undergo thorough review and testing to ensure that it meets the necessary security requirements.

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Documentation: The module must have detailed docu-mentation that includes user guides, installation instruc-tions and security policies. The documentation should provide clear instructions on how to use the module securely.

FIPS 197 specifies the Advanced Encryption Standard (AES), a symmetric encryption algorithm. Compliance with FIPS 197 ensures that the AES implementation meets the required security standards. Here are the primary requirements and testing procedures for FIPS 197 compliance:

Key lengths: AES must support key lengths of 128, 192 and 256 bits to provide different levels of encryption strength.

Encryption and decryption: The AES implementation should correctly encrypt and decrypt data using the specified key lengths and algorithm.

Key schedule: The key schedule algorithm should accu-rately generate the round keys required for each round of encryption and decryption.

Inverse cipher: The inverse cipher should correctly de-crypt the ciphertext to recover the original plaintext.

Security analysis: The AES implementation should un-dergo rigorous security analysis to ensure resistance against known cryptographic attacks. This analysis in-cludes examining the algorithm's mathematical proper-ties, key sensitivity, and resistance to differential and linear cryptanalysis.

**Secure Digital cards (SD, SDHC, SDXC, microSD, microSDHC, microSDXC)**

Secure Digital, introduced in late 2001, is a second-generation derivative of the MultiMediaCard (MMC) standard. SD (Secure Digital) and microSD cards have revolutionised the storage industry, providing compact and high-capacity solutions for various electronic devic-es. The SD Card Association, of which Kingston is an ex-ecutive member, sets the standard for Secure Digital cards. Kingston offers a card line-up consisting of the entry-level Canvas Select Plus, mid-tier Canvas Go! Plus and top-performing Canvas React Plus. These cards are covered by Kingston's lifetime warranty. Secure Digital High Capacity (SDHC), starting at 4GB, and Secure Digital Extended Capacity (SDXC), starting at 64GB, offer larger-volume data storage and optimised recording perfor-mance with support for FAT/FAT32/exFAT file formats. In addition, Kingston SDHC and SDXC cards use speed class ratings known as Class 10, UHS speed Class 1 and 3, and Video Speed Class 10, 30, 60 and 90 that deliver a minimum data transfer rate for optimum performance with SDHC and SDXC devices. Although identical in size to the original SD card, the SDHC and SDXC cards are designed differently and are only recognised by SDHC or SDXC host devices. To ensure compatibility, look for the SDHC and SDXC logo on cards and host devices (camer-as, camcorders etc.).

microSD (SDC) is the mobile platform form factor of the SD card for use in mobile phones and other portable devices. microSD cards are a fraction the size of a stand-ard SD card and, when used with the supplied adapter, can be used in standard SD device slots (for example, in Flash media readers).

microSDHC and microSDXC cards offer higher storage for more music, more videos, more pictures more games – more of everything for today's mobile world. In addition, Kingston microSDHC and microSDXC cards use speed class ratings known as Class 10, UHS speed Class 1 and 3, and Video Speed Class 10, 30, and 90 that deliver a minimum data transfer rate for optimum performance with microSDHC/microSDXC devices. The microSDHC and microSDXC cards allow users to maximise storage for today's revolutionary mobile devices.

| INTERFACE | VOLTAGE | PIN COUNT | SIZE IN MM |
|---|---|---|---|
| Secure Digital/SDHC/SDXC (non-UHS and UHS-I) | 2.7 – 3.3 volts | 9 | 32 x 24 x 2.1 |
| Secure Digital/SDHC/SDXC (UHS-II) | 2.7 – 3.3 volts | 17 | 32 x 24 x 2.1 |
| microSD/microSDHC/microSDXC | 2.7 – 3.3 volts | 8 | 15 x 11 x 1 |

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### Endurance and industrial Secure Digital (SD) cards

For users who want high endurance and retention rates and who want to ensure that their memory cards last for a long time, Kingston offers a solution with Endurance microSD, Industrial microSD and full-size SD cards that promises increased endurance and reliability, and is covered by a 3-year warranty and free technical sup-port.

The Kingston Endurance lineup of microSD cards in-cludes models featuring 32GB, 64GB, 128GB and 256GB capacities. The Kingston Industrial lineup of cards in-cludes models featuring 8GB, 16GB, 32GB and 64GB capacities. Kingston Endurance and Industrial cards are specifically designed to provide extended durability and reliability in high-write intensity scenarios. These cards are engineered with advanced flash memory technology and sophisticated wear-levelling algorithms to enhance their endurance capabilities. Endurance microSD cards typically offer significantly higher program/erase (P/E) cycles compared to standard microSD cards, ensuring prolonged lifespan and consistent performance.

With regards to endurance specifications, these cards boast an impressive number of P/E cycles. For example, Kingston Endurance microSD cards offer ratings of up to 3,000 P/E cycles or Industrial ratings of up to 30,000 P/E cycles. This exceptional endurance allows them to with-stand intensive data writing operations, making them ideal for applications that involve continuous data log-ging, surveillance systems, dashcams or other scenarios where frequent and sustained write operations occur.

Moreover, Endurance and Industrial cards feature ad-vanced error correction mechanisms and data retention technologies, ensuring data integrity and long-term reli-ability. They also incorporate firmware-based power loss protection mechanisms to safeguard against unexpected power interruptions, reducing the risk of data corrup-tion during write operations.

In terms of performance, Kingston's Endurance microSD cards offer up to 95MB/s read and 45MB/s write speeds. Kingston's industrial cards offer a sustained write speed of at least 30MB/s. This enables efficient data read and write operations, facilitating swift access to stored information.

Kingston's Industrial microSD and SD cards offer indus-trial temperature ratings, which are specifically designed to operate reliably in extreme temperature environ-ments and make them suitable for demanding industrial applications. These cards are built with ruggedised com-ponents and advanced technologies to ensure durabil-ity, data integrity and consistent performance, even in harsh conditions. The key feature of Kingston's Industrial microSD and SD cards is their wide temperature range capability. These cards are designed to withstand ex-treme temperature variations, ranging from -40°C to 85°C. This enables them to function seamlessly in envi-ronments with extreme heat, cold or rapid temperature fluctuations, such as industrial automation systems, out-door surveillance, aerospace applications or automotive systems.

Overall, Endurance and Industrial cards combine excep-tional endurance levels, robust data protection features and reliable performance to meet the demands of in-tensive write applications, providing users with a dura-ble and dependable storage solution for their critical data needs.

### Solid-state drives (SSD)

A **solid-state drive** (SSD) is a data storage device that uses solid-state memory to store data with the intention of providing access in the same manner as a traditional hard disk drive (HDD). As of 2023, most SSDs use non-volatile, NAND-based Flash memory to retain data and contain no moving parts. Compared to HDDs, SSDs are typically less susceptible to physical shock, are silent, have lower access and latency times and deliver much higher performance.

Kingston offers a broad range of solid-state drives in various form factors to suit the needs of business pro-fessionals, consumers, system integrators and enthusi-asts. Kingston's business-class SSDs are some of the fast-est in the industry and carry a longer warranty. King-ston's client SSDs offer a good balance of price and per-formance, while enthusiasts will enjoy the ultra-fast per-formance and styling of Kingston's FURY SSDs.

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Flash and SSDs:

There are various types of Flash memory used in SSDs. Single-Level Cell (SLC), Multi-Level Cell (MLC), Triple-Level Cell (TLC) and Quad-Level Cell (QLC). These types of Flash memory offer different performance and en-durance characteristics. Due to the high cost of SLC and MLC Flash memory, TLC and QLC are the more common Flash memory used in SSDs built for client-based note-book and desktop PCs. SSDs that are designed for serv-ers will use specific NAND and controller combinations to meet Data Center (DC) and Enterprise storage re-quirements, plus the controller firmware is optimised for DC/Enterprise workloads. DC/Enterprise SSDs offer higher endurance and are more suitable for high-end server workloads.

SSD endurance: SSD endurance is based on how much you can write to the SSD and is commonly classified in terms of Total Bytes Written (TBW). This is the total amount of data you can expect to write to the drive over its useful lifetime. Flash memory endurance is primarily reduced by die shrinks in the NAND and by something called the **"Write Amplification Factor"** or WAF. WAF is the difference between host writes and the total amount of data written to the NAND per write operation. Flash memory devices like SSDs write in pages. Writing to a page that already contains some data requires the good data in the page to be combined with the new data and rewritten to the Flash. For example, if 2GB of data is written to the SSD, the actual data written to the Flash may be 4GB. In this case the WAF is (2).

SSD storage controllers (SATA): SSDs use sophisticated Flash controllers to communicate between the serial ATA host controller and the Flash chips on the SSD. This special chip manages all the reads from and writes to the Flash memory on the SSD. The SSD controller also man-ages other important functions such as wear-levelling and garbage collection to extend the life of the drive and help maintain consistent performance levels over the life of the drive.

Serial ATA (SATA) host interface: Kingston's SATA SSDs support the SATA host interface connection, which al-lows Kingston SSDs to connect to most mainstream notebooks, desktop and server computers built within the last decade. Kingston SATA SSDs are compatible with most SATA revision 2, 3Gbps and SATA revision 3, 6Gbps host controllers. Most SATA host controllers provide for backwards compatibility. However, if a SATA host con-troller is limited to specific read and write speeds, using a faster SSD will not result in faster data transfers. For example, if a SATA Rev. 3 SSD is attached to a SATA Rev. 2 host controller, data transfers will only be as fast as the host controller.

| INTERFACE | Speed | VOLT-AGE | PIN COUNT | SIZE IN MM |
|---|---|---|---|---|
| SATA Rev. 2 | 3 Gbps | 5 volts | 22 pin SATA | 69.85 x 100 x 9.5/7 |
| SATA Rev. 3 | 6 Gbps | 5 volts | 22 pin SATA | 69.85 x 100 x 7 |
| **Generation** | **Speed x4** | **Voltage** | **SSD form factor** | **Pin count (M.2 2280 M-key)** |
| PCIe 3.0 | 4 GB/s | 3.3V | M.2 2280 | 75 |
| PCIe 4.0 | 8 GB/s | 1.8V/3.3V | M.2 2280 | 75 |
| PCIe 4.0 | 16 GB/s | 1.8V/3.3V | M.2 2280 | 75 |

NVMe (Non-Volatile Memory Express) protocol: NVMe protocol is specifically designed for SSDs to take advantage of the high-speed PCIe interface. It provides an efficient and streamlined way of accessing and managing SSDs. It leverages the parallelism and low latency of PCIe to deliver significantly faster read and write speeds, reducing data access and transfer times. NVMe enables simultaneous data transfers to and from multiple SSDs. This scalability is particularly beneficial in enterprise environments or systems that require high-speed storage, such as servers or high-performance workstations. NVMe significantly reduces the input/output (I/O) latency compared to SATA-based SSDs. This reduction in latency enhances the responsiveness of the system and improves overall performance, especially in tasks involving heavy data access.

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### mSATA (MO300) and half-slim (MO297) solid state drives

Kingston offers integrators and system builders a small-form-factor mSATA and half-slim SATA SSDs for commercial applications.

MO-300 – mSATA or Mini-SATA, was announced by the Serial ATA International Organisation in September 2009. Applications include netbooks, ultrabooks and other devices that require a smaller solid-state drive. The connector is similar in appearance to a PCI Express Mini Card interface, and is electrically compatible. However, the data signals need to go to the SATA host controller instead of the PCI-express host controller. Not all mini PCIe connections support SATA. You should therefore check with your system provider for more details.

MO-297 – Slim SATA, is a solid-state drive with a purpose-built form factor that delivers great performance in a standard case-less form factor – and is less than half the size of a 2.5" SSD. Slim SATA uses a standard SATA drive and power connection as a 2.5" SSD which makes it compatible with a wide variety of host systems. Slim SATA is an industry-standard JEDEC form factor (MO-297) and provides (4) mounting locations to secure the drive to the system.

M.2 – The M.2 is a next-generation storage form factor designed for ultra-compact SATA and PCIe-based solutions. M.2 is developed by the PCI-SIG and has different key types, determining their compatibility and functionality with M.2 slots. B Key is for PCIe ×2/SATA SSDs, M Key for PCIe ×4 SSDs and B+M Key for versatile support of both types. Match the key type of your M.2 SSD with your system's slot for proper compatibility during installation. M.2 modules are rectangular and provide multiple widths and lengths. However, commercially available M.2 modules are 22 mm wide, with varying lengths of 30, 42, 60, 80 and 110 mm. Not all M.2 connections support SATA, so check with your system provider for more details.

| INTERFACE | INTERFACE | VOLTAGE | PIN COUNT | SIZE IN MM |
|---|---|---|---|---|
| MO-300 | SATA | 3.3 volts | 52 Pin PCIe Mini Card | 50.8 x 30 |
| MO-297 | SATA | 5 volts | 22 pin SATA | 54 x 39 |
| M.2 | PCI Express | 3.3 volts | 75 Pins PCIe M.2 | 22 x 30, 42, 60, 80, 110 |

Kingston works closely with global semiconductor and controller manufacturers to ensure that Kingston SSDs deliver superior price/performance to its customers.

### Embedded and design-in solutions

Kingston® offers a variety of embedded storage and memory products, including eMMC and DRAM components, to customers worldwide. Engineering and development teams help build, connect and create end-to-end solutions. These storage and memory products are perfect storage solutions for mobile/embedded applications and system designers. Products available:

eMMC: is an embedded, non-volatile memory system, comprised of both Flash memory and a Flash memory controller, which simplifies the application interface design and frees the host processor from low-level Flash memory management.

eMCP: eMCP integrates Embedded MultiMedia Card (e•MMC) storage and Low-Power Double Data Rate (LPDDR) DRAM into a Multi-Chip Package (MCP) with one small footprint.

ePoP: provides a highly integrated JEDEC standard component that combines Embedded MultiMedia Card (e•MMC) storage and Low-Power Double Data Rate (LPDDR) DRAM into a Package-on-Package (PoP) solution.

UFS: Universal Flash Storage (UFS) is an ideal storage solution for applications requiring high performance and low power in a single integrated package.

Design-In SSD: Design-In SATA and NVMe solid-state drives created specifically for system designers and builders. Design-In SSDs incorporate advanced controllers that automatically perform wear-levelling, garbage collection and other NAND Flash management features.

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For additional information on Kingston embedded and design-in products, please visit: Embedded Flash and DRAM Solutions for mobile, IoT - Kingston Technology

## Kingston flash media readers

Flash media readers allow Flash storage devices to be used as portable storage for computers as well as for uploading or downloading pictures, music and other data without requiring the original host device (such as a digital camera), and without any additional drain on its batteries.

Flash media readers can enable the transfer of data at higher speeds than a host device can support; for ex-ample, a USB reader will be much faster than a host de-vice (such as a digital camera) using a serial interface. If a host device does not support high-speed transfers, the faster reader will significantly reduce the data transfer times.

Kingston offers Flash media readers for the convenient attachment of Flash storage devices to personal com-puters or notebooks.

For flash media, Kingston offers a USB 5Gbps Media Reader for high-speed data transfers up to 10 times faster than USB 2.0 Media Readers. Kingston also offers convenient portable readers – MobileLite Plus SD and MobileLite Plus microSD Reader for high-performance data transfers to systems supporting Hi-Speed USB 2.0 and USB 5Gbps.

## Caring for your Flash Memory

Kingston® flash memory cards, DataTraveler® USB flash drives and IronKey Encrypted USB flash drives offer convenient and easily transportable storage for pictures, music, video and other important data files.

To minimise data loss and ensure the best results from your Kingston flash storage device, follow these simple recommendations:

1. Replace or recharge batteries in the host device after getting a low-battery warning.

Battery discharge is one of the most common problems causing the loss of pictures or other data on flash stor-age devices. If a battery in the host device dies in the middle of a write operation to the flash storage device, not only can the file being written become corrupted, but the entire device may be damaged as well. For ex-ample, if the File Allocation Table (FAT) directory file update is incomplete and the FAT file is corrupted, some or all files on the flash storage device may no longer be accessible. Make sure to keep devices like cameras and field recorders fully charged.

However, it may be possible to repair the flash storage device using commercially available disk recovery soft-ware. Even with these recovery programs, some data or files on the flash storage device may still be lost, but the rest may be recoverable.

To avoid these problems, carry a spare battery if possi-ble or stop using a device when battery power gets very low.

2. Properly remove your flash storage device from the host device.

On computers, it is important to stop a DataTraveler or card reader's USB connection through the OS. To stop a USB drive in Windows 10/11, use the "Safely Remove Hardware" icon in the system tray. To stop a USB drive on MacOS, drag the USB icon from the desktop to the bin or click the Eject button in the mounted volumes list. Computers often "cache" data into memory and may delay the write to USB flash drives. As a rule of thumb, wait a minimum of two minutes after you finish writing data to a DataTraveler drive. On models like the XS2000, XS1000, DTMax and the IronKey series of drives, there is an LED that blinks when the drive is in use.

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Most digital cameras will show a blinking light during flash write operations, so it is important to wait until all operations are completed.

On PCs, it is important to stop a DataTraveler's USB con-nection through Windows (In Windows XP, use the "Safely Remove Hardware" icon in the system tray). For DataTraveler Elite drives, you can use MyTraveler's Eject button. Computers often "cache" data into memory and may delay the write to USB flash drives. As a rule of thumb, wait a minimum of two minutes after you finish writing data to a DataTraveler drive.

3. Properly store flash cards in their plastic cases and close the cap on DataTraveler drives.

Kingston flash memory cards, DataTraveler drives and IronKey Encrypted USB flash drives are designed to re-sist high levels of electro-static discharge. However, ex-treme levels of ESD may cause damage.

In addition, static electricity can also damage flash stor-age devices. For example, on dry days, a person can generate enough static electricity to cause a spark while touching a doorknob or other metal object (this is called electrostatic discharge or ESD).

Kingston flash cards and DataTraveler drives are de-signed to resist high levels of electrostatic discharge. However, extreme levels of ESD may cause damage.

4. Do not force flash storage devices into connectors.

With the exception of drives and readers with USB Type-C connectors, most USB flash drive connectors and flash memory cards are unidirectional. This means that the flash storage device must be inserted in one direction only. If you cannot insert the drive or card, do not force it in. This will prevent damage to the flash storage device or the socket. For more information on the proper in-sertion of flash cards or USB flash drives, consult your host device's user manual. USB Type-C connectors are rotationally symmetrical, so it does not matter which way they are connected.

5. Pack flash storage devices into carry-on luggage if possible.

Tens of millions of flash storage devices are in use worldwide and there have been no verifiable reports of flash storage damage due to airport X-ray scanners.

A 2004 study by the International Imaging Industry Asso-ciation (I3A) verified that today's airport X-ray machines do not appear to pose a risk to flash memory cards.

As a precaution, Kingston recommends that flash cards and DataTraveler drives be treated just like unprocessed film and stored in carry-on luggage, as the passenger screening radiation levels are much lower than those used by newer luggage scanning machines.

6. Always make backups of your data.

Flash storage devices are not infallible and can have their data damaged due to the factors mentioned above. Important information should be backed up to multiple media or even printed on paper for long-term storage. Do not store important data solely on flash storage de-vices.

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## Electromagnetic compatibility information to the user

**FEDERAL COMMUNICATIONS COMMISSION (FCC) STATEMENT:**

This device complies with Part 15 of the FCC Rules. Op-eration is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interfer-ence in a residential installation. This equipment gener-ates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instruc-tions, may cause harmful interference to radio commu-nications. However, there is no guarantee that interfer-ence will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turn-ing the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment to an outlet on a circuit differ-ent from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV techni-cian for help.

*** You are cautioned that changes or modifications not expressly approved by the party responsible for compli-ance could void your authority to operate the equip-ment

**INDUSTRY CANADA (IC) STATEMENT:**

This Class [B] digital apparatus complies with Canadian ICES-003. Cetappareilnumèrique de la classe [B] estconformea'lanorme NUM-003 du Canada.

## For more information:

For additional information on Kingston products, please visit: **kingston.com**

### Appendix: USB Performance

The Universal Serial Bus (USB) is the preferred interface to connect Flash card readers to computers. The latest USB specification is USB4. The older specifications were USB 3.0 and USB 2.0. The USB4 specification includes the USB 3.0 and USB 2.0 speeds for backward-compatibility reasons.

To understand what affects a Flash storage device's per-formance, one needs to consider several factors.

| | |
|---|---|
| **Flash Memory Chip Technology**<br><br>Single-Level Cell (SLC) vs Multi-Level Cell (MLC) /Triple-Level Cell (TLC)/ Quad-Level Cell (QLC) | In general, Flash storage devices built with Multi-Level Cell (MLC) NAND Flash will deliver higher performance than the standard Triple-Level Cell (TLC) and Quad-Level Cell (QLC) NAND Flash or NAND Flash-based cards or DataTraveler.<br><br>Standard Flash cards or the DataTraveler USB drives deliver the best price/performance value for most users of digital cameras, tablets, mobile phones and other electronic devices.<br><br>UHS cards or USB4 and USB 3.2 USB Flash drives will deliver faster reads and writes, ideal for advanced users, photography professionals and enthusiasts.<br><br>Of course, to achieve the performance benefit of faster Flash cards or USB Flash drives, a user must have compatible high-speed devices and properly configured computers. Some digital cameras and other devices require Flash-based high-performance Flash cards for proper functionality. |
| **Host Consumer Devices**<br><br>Digital cameras, mobile phones, drones, tablets, PCs and other devices | The built-in controller interfacing with Flash cards or USB Flash drives in many consumer devices may have limited bandwidth. Please consult your user manual or contact the device manufacturer for specifics.<br><br>All else being equal, the achievable performance level will be the minimum data transfer level supported by the host controller or the Flash card or USB Flash drive. |
| • Connecting Flash cards to computers through Kingston's Media Readers, MobileLite Plus SD and MobileLite Plus microSD readers<br><br>• Connecting USB Flash drives directly to a computer's USB slot | The latest USB specification is USB4. The USB4 specification includes the USB 3.2 and 2.0 speeds for backward-compatibility.<br><br>USB Flash drives and digital media readers/writers require the following language to indicate performance levels:<br><br>USB 2.0: transfers data at a maximum of 480 megabits per second (480Mb/s or 60MB/s). It is also called USB 2.0 Hi-Speed. Hi-Speed USB is up to 40X faster than USB and fully backward compatible with USB through its USB 2.0 Full-Speed mode with a maximum speed of 12Mb/s (or 1.5MB/s).<br><br>USB4 and 3.2: specifications collectively associate to four transfer rates, 40Gbps, 20Gbps, 10Gbps and 5Gbps. USB 40Gbps has a theoretical transfer data rate of 40Gbps; 20Gbps has a theoretical transfer data rate of 20Gbps and so on. All specifications mentioned are backwards compatible but will only run at the USB ports specifications. For example, USB 20Gbps is backwards compatible to USB 2.0, but will perform at USB 2.0 speeds. |

Please note: Some of the listed capacity is used for formatting and other functions and is thus not available for data storage.