Pick the right flash storage for your embedded application

Is your embedded system failing due to the wrong flash storage? Here's a primer on popular SSD formats and their different attributes.

Solid-state drives (SSDs) are becoming increasingly popular in embedded systems for their reliability, durability, performance, and cost benefits as compared to hard-disk-drive (HDD) solutions. An embedded system usually includes a small-footprint operating system (OS), an application program, and some form of data collection and storage. And in a lot of embedded applications, the data collected is stored temporarily and then uploaded to a central server.

That's why the modular form factors for storage media—CompactFlash, CFast, mSATA, microSD, etc.—are quickly gaining traction in a wide array of embedded applications, including the next-generation multimedia platforms such as 4K video, augmented reality, and virtual reality.

Flash memory is either built into an embedded system, soldered on the board, or it's removable like an SD card. Here, we will chronicle the removable storage media devices that come in different sizes, form factors, and interfaces. And we will show how they serve a diverse array of embedded applications.

It's worth noting that embedded systems employ storage media according to reliability, performance, and price-point considerations. So designers have to make a choice among consumer, commercial, and industrial SSDs based on the design composition of their embedded application.

Here's a look at the most popular SSD formats commonly used in a variety of embedded systems.

CompactFlash, or CF cards, have been serving the storage needs of embedded applications for more than two decades *(Figure 1)*. They're still around, mainly because they eliminate the need for the host system to manage the flash storage.

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Files are stored into the CompactFlash card in the same way they would be stored in an HDD device. And whenever there's a change in a flash memory chip geometry or manufacturer, CompactFlash cards don't require any change the device driver.

That's a big plus for embedded application environments. For instance, in some gaming applications, once code has been finalized and certified, it cannot be modified.

CompactFlash cards are widely used in oil and gas exploration, mining, commercial and military avionics, and process controls systems. They come in a variety of configurations, and the ones serving the industrial-grade applications are based on single-level cell (SLC) NAND flash chips.

Figure 1. CompactFlash cards can be easily and quickly swapped for data logging systems and carrying out an update in the OS software.

Next, there are CFast cards, a follow-on to CompactFlash cards, which are 0.3 mm thicker than the CompactFlash Type I cards. Embedded system designers can store data on CFast and then disable writing to the card so the data can't be modified. That's a handy feature in embedded applications in the gaming and military segments.

And like CompactFlash cards, CFast cards boast a standard host interface, so that flash management functions can be handled internally by the controller chip. However, CFast, while coming in a form factor that's similar to CompactFlash, features a SATA electrical interface.

The SATA lineup

The SATA SSD modules come in a variety of form factors to meet the differing needs of the OEM system design. This includes 2.5-in. SATA SSD, Slim SATA, and mSATA. The SATA-based flash storage devices are especially becoming a popular SSD solution in client PC and enterprise markets.

The SATA storage devices can conveniently serve two- to three-year lifecycle demands in client PC hardware while operating in benign temperature and shock and vibration environments. On the other hand, for enterprise applications, SSDs are mostly used as a cache and they're expected to have a finite lifecycle once the Tera Bytes Written (TBW) endurance is consumed.

What about embedded applications that mandate field operations for five to ten or more years without service? The SATA II cards, designed according to JEDEC and SATA-IO specifications, ensure longevity, data integrity, and 100% uptime.

The industrial SATA SSDs, based on SLC NAND flash-memory chips, can be customized to meet specific industrial design needs. For example, there are industrial-grade SATA II SSDs that provide an optional -45°C to +90°C extended temperature range.

Next up, Slim SATA cards are gaining traction in the industrial environments due to their easy installation and smaller size compared to 2.5-in. SATA SSDs. These devices measure 2.1 by 1.5 in. by 4.0 mm.

Then, there's the miniSATA flash storage module, mostly known as mSATA (Figure 2). This device is housed in an even smaller footprint, 2 by 1.1 in. It's used in embedded systems in a similar fashion to how HDDs are employed in a computer, and it offers a lot of capacity in a small form factor. One caveat to the mSATA module—it requires a special connector.

Figure 2. The host system must have a special connector for the mSATA drive to be inserted.

The mSATA format is highly suitable for embedded systems that demand physically mountable storage devices. The storage device can be secured on the host platform using screws on one end and the card edge connector on the other.

microSD is all the rage

The microSD card, originally designed for smartphones and other portable consumer electronic devices, eventually became the storage technology of choice for embedded systems with space constraints *(Figure 3).* This is because consumer electronics devices couldn't conveniently use the larger SD and miniSD form factors.

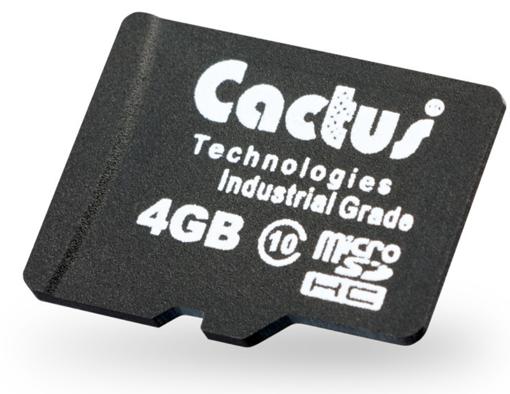

Figure 3. SLC microSD cards can be connected electrically to the SPI or MMC/SD interface available on a processors or microcontroller.

The microSD card, measuring 11 by 15 by 1 mm, can run an operating system and high data transaction applications in an ultra-small package. Not surprisingly, therefore, more embedded applications are embracing the microSD form factor. This includes car infotainment systems, surveillance, body cameras, and drones. Other storage options can be too cost cost-prohibitive for these applications to accommodate the sheer volume of photos and 4K video.

While microSD cards have been a boon for consumer devices for low price points, enabled by ever-shrinking flash chip geometries, industrial applications demand higher endurance levels to facilitate efficient and reliable execution of OS and application program software.

The industrial-grade microSD cards, based on the SLC NAND flash, offer more than 2 million erase/write endurance cycles per logical block. They also offer resistance to shock and vibration characteristics.

The diversity of SSD media storage devices outlined above also mandate a careful review of the target embedded system's storage requirements. Some embedded applications simply call for a smaller memory device to handle a small amount of code.

Choosing between commercial- and industrial-grade memory

Then there are embedded systems, such as healthcare/medical platforms, that require mission-critical data logging and are typically designed with an operating system and application program that could demand 128 Gbytes or more of flash data storage.

Figure 4. The storage requirements in embedded systems vary according to the application demands and the environment in which the embedded application operates.

Next, in certain embedded environments, industrial and telecom, data storage is subjected to extensive writing over a long period of time while operating in extreme temperature and high shock and vibration environments. Moreover, these embedded systems usually demand 100% uptime.

That's where engineers need to choose between a commercial-grade SSD, using mostly multi-level cell (MLC) flash chips, and an industrial-grade SSD, commonly relying on SLC NAND flash. The SSD suppliers like Cactus Technologies offer both options to meet demands of most any embedded application.