



The Importance of SSD Controller Technology to the Defense and Avionics Industries

A TCS Space & Component Technology White Paper

Introduction

The controller in a solid state drive (SSD) is the heart and brains of the system. It implements in its hardware and firmware the storage protocol commands and other functions that provide for the reliable storage and retrieval of user data on the NAND flash media. It handles wear leveling to even the access across the NAND and extend the life of the SSD in the face of flash wear out. It provides error correction as required by the flash to ensure that defects do not cause loss of data.

Some companies, including TCS, have successfully implemented SSDs using controllers designed by a variety of vendors. Implementing an SSD this way provides for a fast time to market and minimizes the investment required to design the product, because someone else has done the work of controller design. However, there are drawbacks to this method as well. This paper explains why TCS has invested the time, effort and R&D budget to develop its own controller and what the benefits are to TCS' customers.

What is an SSD Controller?

Figure 1 shows a simple block diagram of a typical SSD including detail on the controller internals. The entire controller is managed by a microprocessor subsystem which decodes incoming host commands and sets up the internal data paths to execute those commands. The microprocessor is also where advanced functionality is implemented, such as secure erase, wear leveling, garbage collection, TRIM and SMART commands. The actual data movement is controlled by the buffer manager, a set of DMA engines which move data between NAND, the DRAM buffer and the host interface.

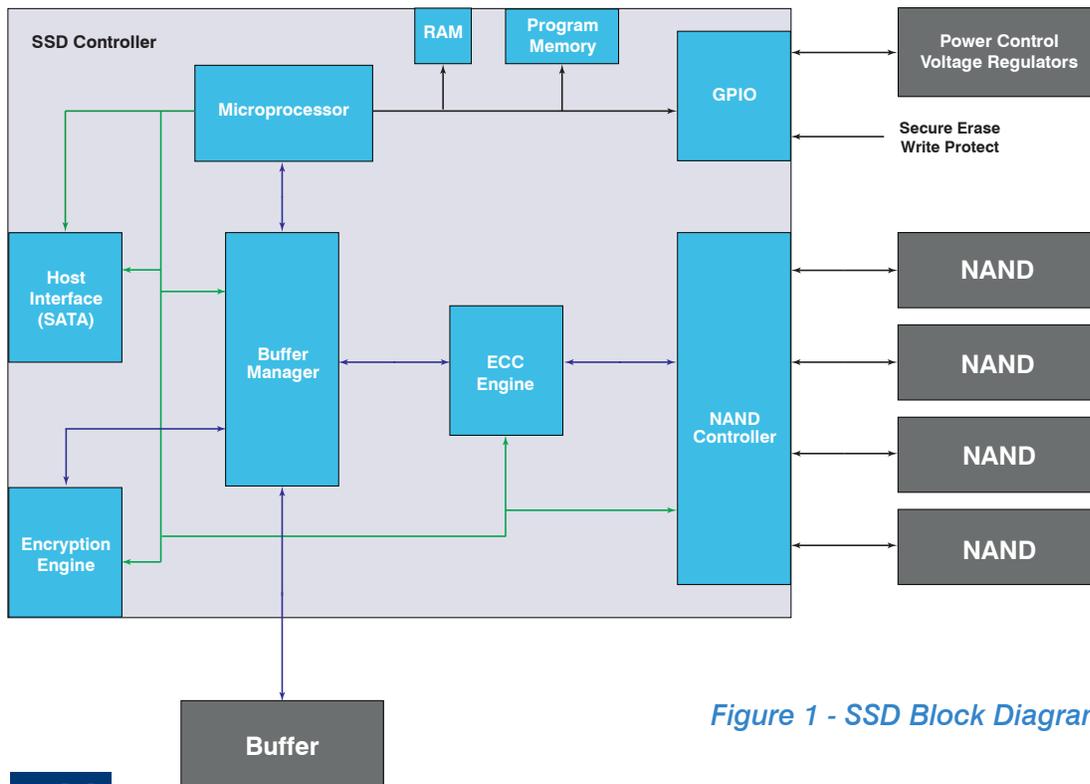


Figure 1 - SSD Block Diagram

What are the Benefits?

Obsolescence

One of the key functions of an SSD controller is to control the NAND flash memory that provides the storage for user data. Modern flash is undergoing very rapid technology advancement, which is driving the dramatic increase in capacities and decrease in cost. Flash generations are occurring every 18 months and there is pressure to end production of earlier generations due to limited fab capacity and the insatiable demand for the latest flash technology in the commercial and consumer markets.

Commercial SSD controller vendors see that same pressure to be on the leading edge of speed, capacity and performance. Many of these companies are startups and they want to devote their precious limited resources, both design and manufacturing, to producing the latest and greatest.

There is also a lot of consolidation taking place in the SSD industry. This happened previously in the hard disk drive industry, which went from over 200 manufacturers in 1980s to just 3 today (Toshiba, Seagate and Western Digital). The SSD market is expected to go through a similar consolidation in the coming decade, but at an even faster pace. In many cases, the acquired companies are bought by larger storage companies to obtain access to technology which may then become available only through that company. This consolidation is very disruptive to the defense market, as shown in Table 1.

Table 1 – Consolidation examples and their effect on the defense industry

Vendor	Acquired by	Result
SSS manufacturers		
mSystems	SanDisk	Withdrawal from the defense market
Adtron	Smart Modular (later Smart Storage Systems)	Still sells to defense market, but new products focused on enterprise IT market. Smart Storage Systems was itself just acquired by SanDisk. Their plans for the defense market have not been announced.
sTec	Western Digital	Their plans for the defense market have not been announced.
Controller manufacturers		
Indilinx	OCZ	Shutdown of Indilinx in Korea, withdrawal from the merchant controller market in favor of using technology solely in OCZ SSDs
SandForce	LSI	Withdrawal from the defense market due to LSI policies

This rapid pace of technology advancement and manufacturer consolidation can play havoc on defense programs, which favor product stability and long lifetimes. TCS' focus on the defense industry with its own controller technology will allow it to maintain products which provide form-fit-and-function compatibility even as the technology changes. New generations of NAND flash can be incorporated very quickly and with only minor firmware changes, while mechanical and PCB designs remain the same. This will minimize disruption and requalification requirements.

Customization

Most commercial SSD vendors are focused on compatibility with Windows personal computer and server systems as well as robust operation on the storage systems of their larger systems customers. They do not have the staff or desire to support customizations for relatively low volumes in specialized defense systems.

In the past, TCS has customized its designs for customers in order to emulate drives from companies that have exited the defense market. We've also worked through compatibility issues with protocol converters that defense companies have needed to provide longer life to systems based on legacy interfaces such as SCSI. Designing our own controller firmware provides even greater ability to tailor the functionality to specific needs if required. Custom erase algorithms and vendor-specific commands to enhance security or system compatibility are just some of the possibilities.

Having low-level control of the firmware also allows for better optimization of the SSD to meet customer needs. TCS can now modify the level of overprovisioning to optimize the wear-leveling and garbage collection algorithms to balance performance and capacity if required. Speed and power dissipation can now also be balanced both for normal read/write operation and for enhanced erase algorithms.

TCS has also produced custom solid state data recorders with specialized host interfaces where industry standard interfaces were not fast enough or did not have the right features necessary for the customer's application. They have even produced a solid state data recorder that was able to survive a missile explosion with 5000G of pyrotechnic shock.

Robustness

The rapid pace of technology change also hurts product robustness. In the past couple of years, several high-profile large SSD vendors have stumbled in implementing AES-256 encryption and secure military erase protocols. Controller vendors have announced features only to de-commit from them later when they could not get them working and had already moved on to the next generation controller. One controller vendor even found an issue with data loss at moderate altitudes due to radiation effects on the controller.

TCS' controller has been extensively tested with multiple protocol validation suites to ensure that the SSD operates properly both with well-formed and malformed SATA commands and responses. The AES-256 encryption algorithm has been validated by an accredited Cryptographic and Security Testing (CST) Laboratory. Enhanced visibility into the inner workings of the controller also allow for easier troubleshooting and root cause analysis in case of failure, whether caused by hardware issues or protocol incompatibility. This includes the ability to bypass the flash translation layer and read the flash using physical addresses, which improves the ability to demonstrate and validate the correctness of erase algorithms.

Security

Today's interconnected world provides fertile ground for hackers and malware. There has been much speculation in the press recently about theft of data and secrets, even whole aircraft designs. Data on defense and aerospace systems must be secure from prying eyes. There is no room for hidden back doors or sleeping code which can be activated later to allow unauthorized access to data.

TCS' controller hardware and firmware was designed and built in the USA. The firmware has been extensively tested for proper operation under both normal and abnormal conditions to ensure that data is safely stored and, for encrypted drives, only available after proper authentication.

Conclusion

SSDs are one of the hottest things in the commercial storage industry. The pace of change of both technology and of the vendor landscape is staggering. While this rate of change has led to real and rapid advancements in cost and performance, the defense and aerospace industries favor proven robustness and long, stable availability of product.

Ownership of its own controller technology means that TCS can provide even better support to its defense, avionics and aerospace customers. Developed using internal R&D funds, it is evidence of the commitment TCS has made to providing the most robust, rugged and reliable SSD storage to meet the needs of modern, high-tech defense and aerospace systems. It will ensure that TCS can provide the toughest SSDs on the planet for years to come.

TCS Space & Component Technology specializes in high reliability, ruggedized solid state drives for the most demanding environments. With 35 years of industry experience, our team has the knowledge and expertise to provide engineering, manufacturing, quality, and technical services for military, space, and high reliability industrial customers.

If you'd like to know more information about the the importance of SSD controller technology to the defense and avionics industries, contact us!

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