End to End NAND Flash Solution Selection and Configuration

Minimizing The Challenge of Embedded NAND SSD Implementations

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Multiple challenges arise with the implementation of Embedded SSD projects. Potential problems involve usage model variance and untraditional usage models. Another issue is the longevity and reliability of SSD under dynamic change given the various applications of SSDs. Furthermore, mistakes commonly occur in solution selection, which can be easily avoided. To combat these complications, ATP focuses on three areas of solution selection: NAND configuration, firmware/setting configuration, and host setting configuration.

1.0 Challenges of Embedded SSD Implementation

1.1 Usage Model Variance

Embedded SSD projects all have variations in the file read/write requirements, such as the file size. Static versus dynamic data is also taken into consideration. For example, a boot device is read only, whereas data logging is cyclic and has a small file write. Other differences in usage models are in their intended environmental conditions: some are meant to be operated or stored in gradient/cycling temperatures, some can only withstand certain ranges of humidity or vibration/shock, and others have specific cold starts. Usage Models can also have differing OS/File systems (they are often custom-made). Finally, they have various application requirements, such as fixed versus removal form factors and the frequency/manner of insertion, power-cycling requirements, and bandwidth/performance requirements.

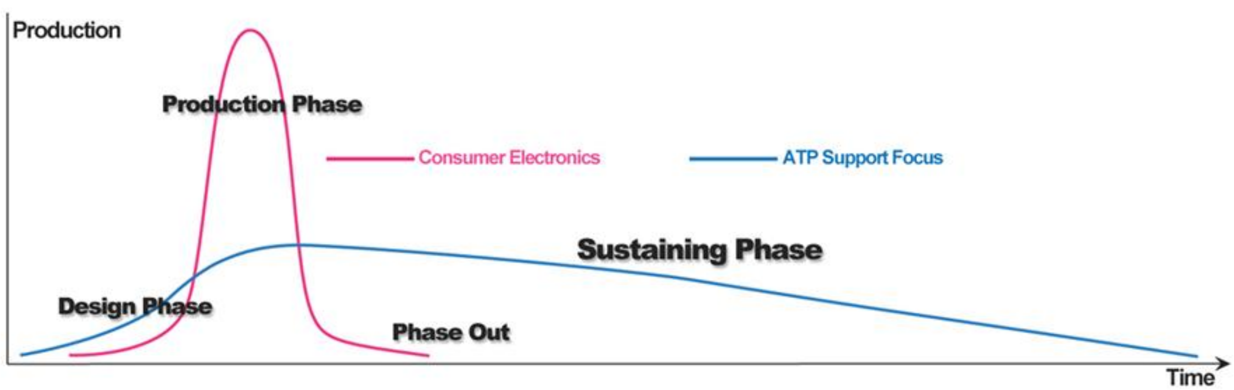
1.2 Untraditional Usage Models

Untraditional usage models can be problematic for embedded SSD implementations. Untraditional usage for NAND has certain requirements for SLC, and density/cost requirements of MLC. For example, there are endurance requirements between MLC/eMLC, but there is also a high requirement for data retention. Another untraditional usage model regarding industry standards involves form factors and protocol schemes, which have been developed for customer usage. A specific example of an untraditional usage model is in-vehicle infotainment and navigation data, where removability is required for future map updates. This usage model has mostly read with very little to no write; small amounts of data are commonly read and the remaining data is intermittently read. This model focuses on reliability under long-term data retention over a wide temperature range.

1.3 Longevity/Reliability Under Dynamic Change

Given that the NAND/DRAM industry is fast moving, IC architecture and the manufacturing process are continuously evolving. Embedded and industrial applications typically involve longer term, more costly validation/qualification requirements as well as increased sensitivity to stability and control on BOM (Bill of Materials) as seen in Figure 1. The ATP support focus includes a long sustaining phase for increased customer support. These applications also require increased liability and strict requirements for DPM (Defects per Million) failure rate.

Figure 1



1.4 Common Mistakes in Solution Selection

The solution selection process is often riddled with mistakes such as one-dimensional cost evaluation (commonly cost per density/GB). The TCO (Total Cost of Ownership) of a solution should include the cost per TBW (Total Bytes Written)/endurance, re-qualification costs, and the AFR (Annual Failure Rate). The re-evaluation of solutions under die changes is insufficient if the solution/density evaluations are only under new product introductions. Often, sustaining-level qualifications are simplified/inadequate, or if densities and the solution itself have to change upon die revision. Another common mistake in solution selection is incorrect timing of BOM planning. BOMs are often selected with recommended cost/availability timing during early new product introductions, but they are not ideal for mass production. This may result in redundant multiple qualifications during introduction of the product or even during mass production ramp up.

2.0 Three Areas of Proper Solution Selection

Proper solution selection requires the right NAND controller solution and proper information exchange. With a hardware setup established, controller settings can be optimized and tested by project requirement. In many cases, the host usage model or software configurations are fixed, but just as often there is simply a lack of information exchange on possible ways to optimize the host for more efficient and thus more cost effective usage of the storage device.

2.1 NAND Configuration

Successful NAND configuration calls for proper information exchange. Initially, it is important to establish project reliability and performance requirements. Project usage model details must be communicated to the SSD vendor for analysis on the WAI (write amplification index) efficiency. Project schedule and supply chain windows also need to be established. Finally, it is necessary to evaluate NAND and density options to establish cost effectiveness in terms of cost per GB, cost per Usage/TBW, cost per longevity window, as well as the satisfaction of project reliability and performance hard requirements. Figure 2 indicates the different attribute levels for various NAND flash types.

Figure 2- Attribute Levels for NAND Flash Types

	TLC	cMLC	eMLC	IT MLC	SLC
Cost/GB	✔✔✔✔✔	✔✔✔✔	✔✔	✔✔✔	✔
Cost/TBW	✔	✔✔	✔✔✔✔✔	✔	✔✔✔✔
Data Retention	✔	✔✔	✔	✔✔	✔✔✔✔
tPROG	✔	✔✔	✔	✔✔	✔✔✔
Density Scalability	✔✔✔	✔✔✔✔	✔✔✔	✔✔✔✔	✔✔
Longevity Window	✔	✔✔	✔✔✔	✔✔	✔✔✔✔

2.2 Firmware/Setting Configuration

Many industry standards require support for different interface modes, a “trial and error” scenario must be avoided, and the correct interface mode settings must be established once. Other factors that need to be considered are the density/provisioning settings, such as duplication/content loading environment/requirements and over-provisioning. SSD information access settings must also be configured, including the usage/wear/health status, the SMART command set settings for ATA devices, and special command set settings for other devices. Finally, there are special functions for encryption, serialization/keys, and power cycling recovery. There are also special commands to trigger special SSD functions and application-specific special controller algorithms (e.g. Auto Refresh techniques to combat data retention issues).

2.3 Host Setting Configuration

There are host settings that require configuration, such as file read/write sizes. Page/block sizes continue to grow, but many embedded applications remain at very small file sizes. The NAND flash/controller management unit size, block, and page sizes need to be communicated by BOM to allow for possible host optimization and improvement on the WAI. Additionally, file systems and OS environments are often directly drafted over from a previous implementation on HDD and need to be revisited for SSDs. A third host setting is the host response to SSD health status, which signals the scheme to the server or user based on the SSD health status. The host usage mode response to SSD health status is another setting. Finally, switching over from a discrete NAND implementation to a managed NAND solution often involves ‘deprogramming’ the host from trying to implement its own wear leveling and block level management algorithms – thus second guessing the controller should be avoided.

3.0 Conclusion

With the increasing diversity of NAND options and application-specific controller setting/features, deeper considerations and additional information exchange should be included for the proper selection of an embedded NAND SSD. There are multiple factors that should always be discussed, including usage model details, project longevity requirements and sensitivity/cost to re-qualification, cost metrics (cost per TBW, cost per longevity window, and cost/GB), and project NPI and ramp schedules. Deeper collaboration with your embedded SSD vendor is vital for proper information exchange for every qualification and every die revision. Demand more active feedback from your embedded SSD vendor regarding your specific usage model and the appropriate cost effective solution.

ATP provides Solution Selection Services, such as the project TCO evaluation process (which quantifies several solution options/densities) and the joint validation program (involving joint testing processes at the system level). Multiple information exchange services are available, such as quarterly market updates and embedded SSD technology trends, and NAND Validation/Testing Reports that focus on embedded usage models, various environmental conditions, and their associated NAND bit error rates. Other ATP resources include solution whitepapers on specific failures encountered in industrial and embedded application segments.

About ATP

ATP Electronics is a leading manufacturer of high performance, high quality and durable NAND flash memory solutions and DRAM memory modules. With over twenty years of experience in service based memory products, ATP continues to focus on mission critical applications such as industrial, telecom, medical and enterprise computing where high levels of technical support, performance consistency and wide operating temperature ranges are required. ATP offers unique flash technologies such as PowerProtector, Secure Erase and recently introduced the Elevated Temperature Burn in Testing system to screen for SMT related assembly issues and IC infant mortality. ATP also offers extensive supply chain support with controlled/fixed BOMs and long product life cycles, with components sourced from the Micron's Product Longevity Program with a guaranteed life cycle of up to ten years.

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