The Case for SATA Storage in Tablets

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The emerging tablet market is quickly shifting from single-application devices like e-readers to multi-purpose devices with more stringent operating requirements. One of the most exciting opportunities is business-focused "Productivity Tablets" being developed by many major manufacturers.

Next-generation tablets built for this market need to be able to run multiple applications at the same time and quickly switch between them, as well as offer more PC-like features such as web browsing. They must also provide higher storage capacity with faster access to accommodate large spreadsheets, presentations and databases. Storage performance is critical if OEMs don't want tablet performance to degrade as more applications are opened. And, of course, every subsystem in the tablet must intelligently manage power consumption to maximize battery operating life.

For applications like these, a high performance, full-featured storage interface like SATA (Serial Advanced Technology Attachment) is required. SATA is the de facto PC storage interface, with more than 98% market share. In addition, with its >30% share of the Enterprise storage market, SATA is the dominant storage interface worldwide.

Due in part to its aggressive approach to power and size minimization, SATA has also become ubiquitous in the battery-operated notebook computer market. The same features make SATA a natural fit for the emerging tablet market, and are leading to its increasing penetration across the entire mobile space.

SATA for Tablets

Tablets typically utilize solid state storage (SSD) rather than traditional hard disk drive (HDD) storage due to space and power considerations. The SATA specification was designed to provide a low cost, low power storage interface for desktop and mobile environments. Recent innovations in SATA technology provide not only an efficient way to manage SSDs, but also enable tablet OEMs to differentiate their products from their competition:

- **Small Size:** SATA devices are available in a variety of standardized small form factors appropriate for tablets. This ensures that OEMs and consumers have access to a wide selection of storage options at a lower cost because of economies of scale.
- **Increased Battery Life:** SATA's flexible approach to power management enables developers to optimize tablet operating life while balancing performance and responsiveness.

- **High Performance:** With transfer speeds up to 6 Gbps, SATA outperforms other interface technologies currently being used in tablet architectures. This higher performance is critical to meeting the stringent requirements of business users.

Flexible Small Form Factor

SATA is a mature technology that has been extensively field-tested across many industries, applications and operating environments. The specification defines connectors and pin layouts, and utilizes four form factors ideally suited for tablet applications where board real estate and device profile are limited:

- **Micro SATA Connector:** Designed to provide an extremely low profile to keep product thickness to a minimum, this connector enables the use of 5 mm high 1.8 inch SATA SSDs or HDDs. Figure 1 shows a 1.8 inch drive.

Figure 1. 1.8-inch Form Factor

- **mSATA/mSATA mini:** This interface allows a storage module the size of a business card to be plugged into existing mini-PCIe connectors on motherboards. Cards based on mini-PCIe were originally intended to add functions such as Wi-Fi to laptops and are designed to plug in with an orientation parallel to the motherboard. An additional signal added to the connector specification automatically detects if the card is mSATA or PCIe, thereby eliminating the need for a dedicated mSATA connector. For more tightly-constrained designs, mSATA mini has half the depth of an mSATA card (see Figure 2).

Figure 2. mSATA and mSATA mini SSDs

- **SATA microSSD:** The SATA microSSD is completely self-contained within a single BGA package. SATA microSSD devices can be mounted directly onto a motherboard to provide a low profile of less than 1.5 mm (see Figure 3). Standardization of the signal/ball layout and use of a JEDEC standard BGA package ensures that products from different manufacturers are interchangeable.

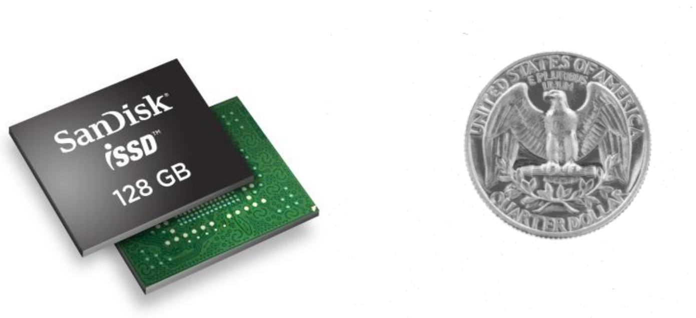

Figure 3. microSSD

Form Factor	Dimensions (rounded)	Specification Availability
1.8-inch drive with Micro SATA	54 x 78 x 5 mm	In SATA rev 3.1
mSATA card	51 x 30 x 4 mm	In SATA rev 3.1
mSATA mini card	26 x 30 x 4 mm	In SATA rev 3.1
SATA microSSD BGA	16 x 20 x 1.5 mm	Available to SATA-IO members Will be in SATA rev 3.2

Table 1. SATA small form factors ideal for tablets

Tablet designs vary greatly in size and storage capacity requirements. The availability of several form factor options gives designers flexibility in balancing device size, capacity and cost while providing superior performance and excellent power efficiency.

For example, the SATA microSSD form factor, because it is placed directly on the motherboard, offers the lowest profile since the drive is the same height as other chips on the motherboard. For applications that can tolerate a larger profile, a 1.8-inch form factor drive with a Micro SATA connector provides the highest capacity.

The mSATA form factor enables developers to not only offer greater storage capacity than SATA microSSD but also supports manufacturer-removable storage. The availability and removability of the mSATA mini form factor enables OEMs to create a single tablet design with multiple storage options to address different price points in the market, while maintaining a very small form factor.

Both the Micro SATA and mSATA specifications are public with storage products on the market. The SATA microSSD interface standard is available now to SATA-IO members. It will be made public with the 3.2 version of the SATA standard anticipated to be released in late 2012. Storage products utilizing the SATA microSSD interface are already available to fill the slots being implemented in new designs.

Higher Power Efficiency = Longer Operating Life

Traditionally, the selection of data storage components has focused on capacity, performance and cost. However, power efficiency is an important consideration alongside these other factors in the design of tablets and other mobile devices as it directly impacts battery life.

The power efficiency of a storage device is determined primarily by its active power consumption and power management capabilities. SATA offers several low power operating modes for managing power consumption by both the storage device and interface. Through intelligent powering down of parts of the system by removing or reducing power to circuitry that is not currently in use, higher overall power efficiency can be achieved.

However, lower power modes require longer recovery times for the device to become fully operational and recovery time must be managed to avoid unnecessary impacts on system responsiveness.

The power management capabilities of SATA are extremely battery-friendly. To address time-to-wake issues and provide the most flexibility and efficiency, SATA provides a range of host and device controlled power management options. SATA also defines two distinct areas of power management: within the SATA device and on the SATA interface. By allowing the interface to be managed separately from the storage device, designers can achieve higher overall power efficiency.

For storage device power management, SATA supports four modes: active, idle, standby and sleep. These modes can be initiated by either the host or the SATA device to give developers the flexibility to optimize power management according to the application currently in use. For example, a storage device may use a standby timer, programmed by the host, to put itself into standby mode after a predetermined period of inactivity. The actual power consumed in each mode is dependent upon the type of storage being used and how it is implemented.

In terms of the SATA interface, the PHY is the primary consumer of power. SATA offers five interface operating modes (see Figure 5) that are available across all applications SATA supports.

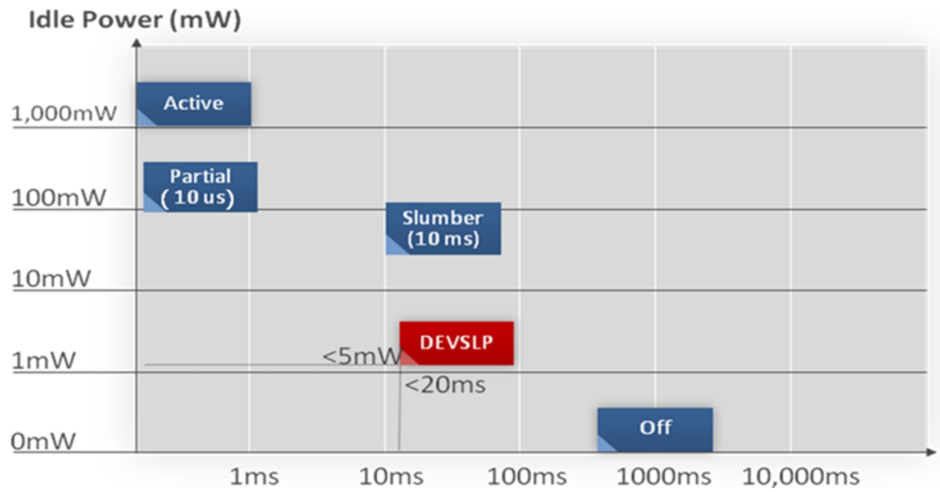

Figure 5. SATA PHY Power Management Modes

For all but DevSleep, these time-to-wake figures represent the maximum time allowed by the SATA specification. For DevSleep, it is the typical time for a device to enter PHY Ready mode after receiving a wake-up request. Recovery time may be different for a particular product, depending upon how the interface is implemented.

DevSleep is a new interface power mode recently introduced to the SATA standard that improves power efficiency by enabling the interface PHY to be completely powered down. With Partial and Slumber modes (see Figure 6a), the need for in-band signaling to send commands over the SATA bus means the PHY must remain partially powered even when the system knows no data is being sent to storage.

DevSleep overcomes this issue through the use of a side-band signal (DEVSLP) to direct the SATA device to completely remove power from the SATA PHY (see Figure 6b). This enables the PHY to be powered down below Slumber levels while maintaining a reasonable recovery time. Given that the PHY is one of the major power consumers in the storage subsystem, this results in significant power savings.

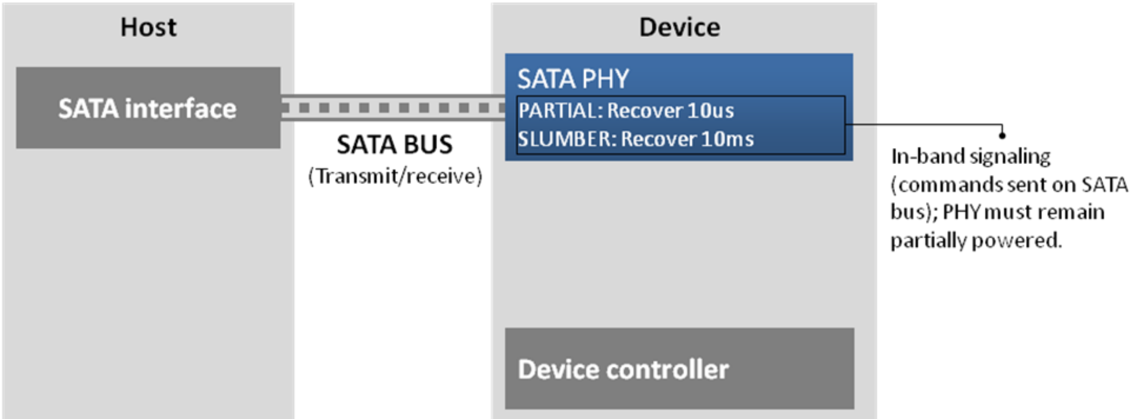

Figure 6a. Power Management without DevSleep

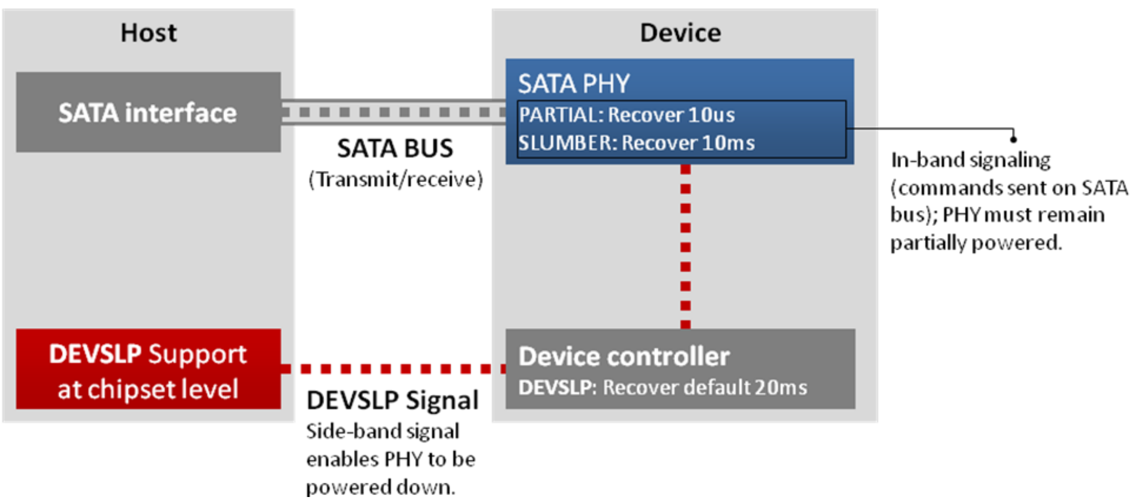

Figure 6b. Power Management with DevSleep

To take advantage of DevSleep, both the host and storage device must support the in-band signal in hardware. The DevSleep specification is completed and available to SATA-IO members. Many storage device vendors are already designing DevSleep into their next-generation devices and have plans to introduce DevSleep capabilities between regular product updates.

By defining several reduced power modes for both the interface and device, SATA gives designers maximum flexibility in intelligently balancing the trade-off between power consumption and recovery time for both the storage device and interface.

Next-Generation Performance

SATA outperforms current storage interfaces for mobile devices with transfer rates up to 600 MB/sec. By comparison, eMMC, today's most popular mobile storage interface, has a maximum transfer rate of 200 MB/sec. In addition, SATA offers Native Command Queuing (NCQ), a technology that allows the host to send additional commands while the current command is being completed. With a non-queued interface, the host must wait for a command to finish before issuing another. In a device like a tablet where the system may be accessing data for multiple applications, this could cause undesirable delays in commands being processed.

NCQ also gives developers the ability to ensure the reliable delivery of data in the multitasking environment of tablets. For example, the real-time streaming capabilities of NCQ increase the quality of delivery for high bandwidth applications, such as audio and video that utilize timing-sensitive isochronous data transfers. In these applications, a delay can result in an impact visible to users, such as a glitch in video playback or audio dropping out of sync with video.

The lower latency enabled by NCQ results in a more immediate response to storage requests. Effective throughput is higher as well since the storage device does not need to wait between transfers for the next command to arrive; since commands are already queued up, the storage device can proceed immediately to the next transfer.

Summary

Next-generation productivity tablets are demanding applications that need an interface that delivers performance and power efficiency. SATA offers battery-friendly intelligent power management, multiple small form factors, high performance, fast response time and large storage capacity. With its flexibility and extensive field-testing, SATA is the ideal storage interface not only for tablets, but for a wide range of other mobile devices, as well.

SATA-IO is the organization behind the SATA interface standard with nearly 200 members representing all aspects of the storage industry – SSD, HDD, controllers, components, cables, connectors, sub-systems and test labs. For more information, visit www.sata-io.org.