Fast Just Got Faster: SATA 6Gb/s
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Abstract

The new Serial ATA Revision 3.0 specification from the Serial ATA International Organization (SATA-IO) increases throughput for the world's most popular storage interface from 3 to 6Gb/s. This whitepaper provides an overview of the benefits and applications enabled by SATA 6Gb/s and will be of interest to enterprise IT managers, CIOs, "prosumers," and anyone interested in SATA technology. For a detailed look at the protocol and PHY differences between SATA Revision 2.6 and SATA Revision 3.0, please refer to the complementary whitepaper, "The Path from 3Gb/s to SATA 6Gb/s: How to Migrate Current Designs to the SATA Revision 3.0 Specification."

The world's most popular storage interface just got faster. The Serial ATA (SATA) interface is evolving to meet the need for speed. Now that the Serial ATA International Organization (SATA-IO) has released the Serial ATA Revision 3.0 specification, developers, manufacturers, and end-users of SATA equipment can look forward to substantially increasing throughput to 6Gb/s for a wide variety of storage, enterprise, and PC applications.

Since its introduction in 2001, SATA has become the primary internal storage interconnect for desktop and mobile PCs. With more than 1 billion SATA hard disk drives shipped, SATA has also achieved a significant presence in enterprise applications by enabling the integration of higher capacity, more cost-effective storage. In addition, external SATA (eSATA) extends SATA technology outside the PC, offering the highest performance of any mainstream external storage interface.

With its high transfer rate and efficient protocol, SATA technology appeals to manufacturers and end-users alike for its ease-of-use. Designed to facilitate easy configuration and simplified upgrading of devices, the Serial ATA Revision 3.0 specification promises to enable a wider array of next-generation storage applications while still maintaining low-cost connectivity.

Leveraging SATA 6Gb/s

Network administrators and computer equipment manufacturers moving from SATA 3 Gb/s to SATA 6Gb/s will see immediate benefit. Doubling the data rate, by itself, means that data can be transferred in half the time it used to require. Service providers, as well as end-users, will be excited at the resulting increased responsiveness, especially for on-demand services. With the increasing availability of

commercial content and the rising tide of personal photos, videos, music, and other data files, basic transfer rates have become a primary purchasing consideration.

The lower latency of SATA 6Gb/s translates to higher performance across an extensive range of other key applications, including:

Hard disk drive caching: Today's hard disk drives (HDDs) use techniques such as caching and larger block sizes to buffer throughput from the latencies inherent in rotating media (i.e., getting to speed and moving the drive head). Data transfer speeds from a cache are not limited by the electro-mechanical latencies of the HDD, and thus can take full advantage of a faster interface. Newer HDDs are already being introduced which have stalled at the performance edge of SATA 3Gb/s, in the range of 270-290 MB/s. At 6Gb/s, SATA technology enables faster transfers of short bursts of data from drive caches. Next-generation HDDs have already been shown to operate at over 580 MB/s when connected with SATA 6Gb/s, thus eliminating storage devices as a system bottleneck.

Solid State Drives (SSDs): One of the major market needs SATA 6Gb/s addresses is the throughput bottleneck facing solid state drives (SSDs). SSDs provide faster data access and are more robust and reliable than standard HDDs because they do not incur the latency associated with rotating media. SSDs are used in a variety of applications but one of the most exciting is two-tier, hybrid drive systems for PCs. The SSD serves as short-term and immediate storage, leveraging its lower latency to speed boot time and disk heap access while a HDD, with its lower cost per MB, provides efficient long-term storage. With SATA 3Gb/s, SSDs are already approaching the performance wall with sustained throughput rates of 250-260 MB/s. Next-generation SSDs are expected to require 6Gb/s connectivity to allow networks to take full advantage of the higher levels of throughput these devices can achieve.

Entry-Level Enterprise: Emerging enterprise environments increasingly support mixed SAS and SATA interfaces both operating at 6Gb/s. Such architecture gives users the flexibility to implement SAS drives with full management capabilities built in for high-end servers or to utilize more cost-effective SATA-based drives for entry-level applications.

Faster Network Backup: The reduced latency of SATA 6Gb/s provides an immediate improvement in RAID performance, particularly for RAID0 (performance striping) and RAID1 (mirroring). Individual users will also see increased performance by being able to back up laptops and PCs in substantially less time.

Workstations: In addition to reducing downloading times for database, video, and image file access, the lower latency of SATA 6Gb/s can have a significant impact on application performance and responsiveness.

Multiple Stream Support: The number of data streams a storage area network (SAN) drive can support is dependent upon the available bandwidth. At SATA 6Gb/s, storage applications can support more data streams/users per drive, increasing overall efficiency and density of the storage network.

Superior Link Utilization: Today, an average hard drive operating off its rotating media (not its cache) might sustain 80 MB/s, a figure much lower than the theoretical maximum throughput of ~600 MB/s offered by SATA 6Gb/s. With support for up to 15 drives, SATA's unique port multiplier capabilities enable users to aggregate multiple drives behind a single SATA port in order to fully utilize host link capacity. In this way, data across several drives appears as a single logical bank of data. Port multipliers help to relieve storage bottlenecks, especially in applications such as entry-level servers and high-bandwidth applications like video post-production.

Designing a Cost-Effective, High-Speed Interface

A key concern for the designers of the SATA Revision 3.0 specification was minimizing the impact on cost when moving to 6Gb/s. When standards move to higher data rates, new functionality – such as training or more advanced preemphasis and equalization – is often required to help maintain signal integrity. Any changes to the protocol, PHY, connector, and cabling, however, percolate throughout the design and supply chain, often resulting in significant implementation cost increases.

For example, even the addition of a single pin to a connector requires IC designers to redesign major portions of their chips to accommodate wider buses. Adapter manufacturers have to reroute boards and backplanes as well as work with completely new connectors. End-users also feel the impact when they have to purchase all new cabling.

SATA Revision 3.0 was designed to facilitate a much more elegant – and cost effective – migration to higher data rates. Rather than completely redefining the spec, SATA Revision 3.0 achieves its data rate increase by faster signal switching. While this has resulted in changes to the PHY, modifications to the protocol have been kept to a minimum. In addition, SATA Revision 3.0 is backward compatible so that the same connectors and cabling used for SATA 3 Gb/s under SATA Revision 2.6 can be used for SATA 6Gb/s.

This decision not only enables end-users to retain their existing investment in cabling when moving to SATA 6Gb/s, it also enables silicon manufacturers to maintain much of their existing IP. Except for the doubling of the data rate, SATA Revision 3.0 is no more complex than SATA Revision 2.6 from an electrical perspective, and no heroics are required to implement the technology at 6Gb/s speeds.

The end result is that moving from SATA 3Gb/s to SATA 6Gb/s data rates provides double the throughput without adding undue complexity or cost. SATA 6Gb/s also maintains its exceptional efficiency by not introducing additional overhead to the SATA protocol. This magnifies the value proposition of SATA 6Gb/s compared to SATA 3Gb/s, a factor that is sure to accelerate the migration to SATA 6Gb/s in the market place.

SATA 6Gb/s Cabling

The same cables and connectors used for current SATA implementations can be used to connect SATA 6Gb/s devices. SATA-IO recommends utilizing quality components to ensure data integrity and robust operation at the fast 6Gb/s transfer rate. Cables already at the threshold of 3Gb/s operating margins may experience lower performance than expected at 6Gb/s due to an increased number of resends.

The SATA Revision 3.0 spec addresses this issue by defining the Compliance Interconnect Channel (CIC). The CIC is outlined as a mathematical model of a compliant channel as well as an insertion/return loss plot defining the most extreme losses the system can sustain and still be compliant. Note that the CIC does not specify the components to be used in a system but rather the overall performance and quality the system must exhibit.

Cable vendors will want to consider removing any question of quality by marking their packaging to explicitly state a product's 6Gb/s CIC compliance. Vendors can also have their cables added to the Integrators List on the SATA-IO web site. End-users, for their part, will want to consult the Integrators List – this list is available to the public – before buying new cabling.

Test Considerations

Early on in the development of the SATA Revision 3.0 specification, SATA-IO collaborated with test equipment companies to review the SATA Revision 2.6 testing

parameters as defined in the Unified Test Definition Specification (UTD) and modify them to reflect changes in the spec. Specifically, SATA-IO wanted to focus and refine the testing process to simplify testing and certification of cables at 6Gb/s. While there are multiple ways to verify particular characteristics of a system, some methods are more difficult than others to implement. By working directly with test equipment vendors, SATA-IO was able to design tests that exploit the capabilities of testing platforms, not only removing ambiguities from the testing process but also improving testing efficiency through the elimination of certain parameters that tended to complicate testing. By simplifying the creation – and automation – of comprehensive test benches, equipment vendors will be able to speed development and troubleshooting.

Developers and end-users will also need to consider how to introduce testing equipment without adversely impacting signal integrity. For example, when test equipment is inserted in-line, electrical discontinuities in the signal path can induce both jitter and attenuation. Test setups operating at the margin for SATA 3Gb/s will more than likely fail if they are not updated to meet SATA 6Gb/s requirements. By first verifying the CIC of a cable, users can be more confident that any problems uncovered are with the device under test rather than the test setup. Users also need to be aware of the numerous connection methods available and how each reduces or compensates for added jitter and attenuation.

Other important considerations include:
- Co-locating test equipment with devices under test to reduce cable lengths
- Using high-quality shielded cables that shield the entire cable, not just the individual conductors
- Selecting cables and connectors that are certified and on the SATA-IO Integrators List when purchasing new cabling
- Pre-testing existing 3Gb/s cables to avoid the possibility of introducing phantom signal integrity issues
- Eliminating all but necessary discontinuities – including connectors, splices, and adapters – wherever possible to avoid introducing undesirable reflections and signal attenuation
- Using the shortest reasonable cable to keep attenuation at a minimum

By respecting the tighter signal integrity tolerances imposed at 6Gb/s and ensuring that cables meet SATA 6Gb/s CIC specifications, developers can substantially accelerate development by avoiding many of the problems caused by low-quality cabling. For a comprehensive discussion on this topic, see the whitepaper entitled "Successful SATA 6Gb/s Equipment Design and Development" which is available on the SATA-IO web site. An FAQ document is also available.

Summary

SATA Revision 3.0, in addition to providing immediate performance and efficiency benefits in existing systems, enables a wide range of new, high-speed storage applications. By doubling the potential throughput, SATA 6Gb/s increases drive burst performance and eliminates storage as a system bottleneck. Finally, by maintaining backward compatibility, the SATA-IO has kept the cost of moving from 3Gb/s to 6Gb/s at a minimum, thereby ensuring the continued dominance of SATA technology in the PC and storage industries.

About SATA-IO

The SATA Revision 3.0 specification was developed by the Serial ATA International Organization (SATA-IO), an independent, non-profit consortium dedicated to sustaining the quality, integrity, and dissemination of SATA technology. With this latest release of the SATA storage interface, SATA-IO continues its commitment to create future interface technology and specifications that will meet the evolving needs of the storage industry and carry it into the next decade.

Founded in 2004, SATA-IO is comprised of more than 200 member companies representing the entire storage industry, including hard drive manufacturers, silicon vendors, software developers, test tool manufacturers, and service providers. For more information about SATA technology, SATA-IO, and membership, visit www.sata-io.org.