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White Paper
Introducing Serial ATA
November 7, 2000



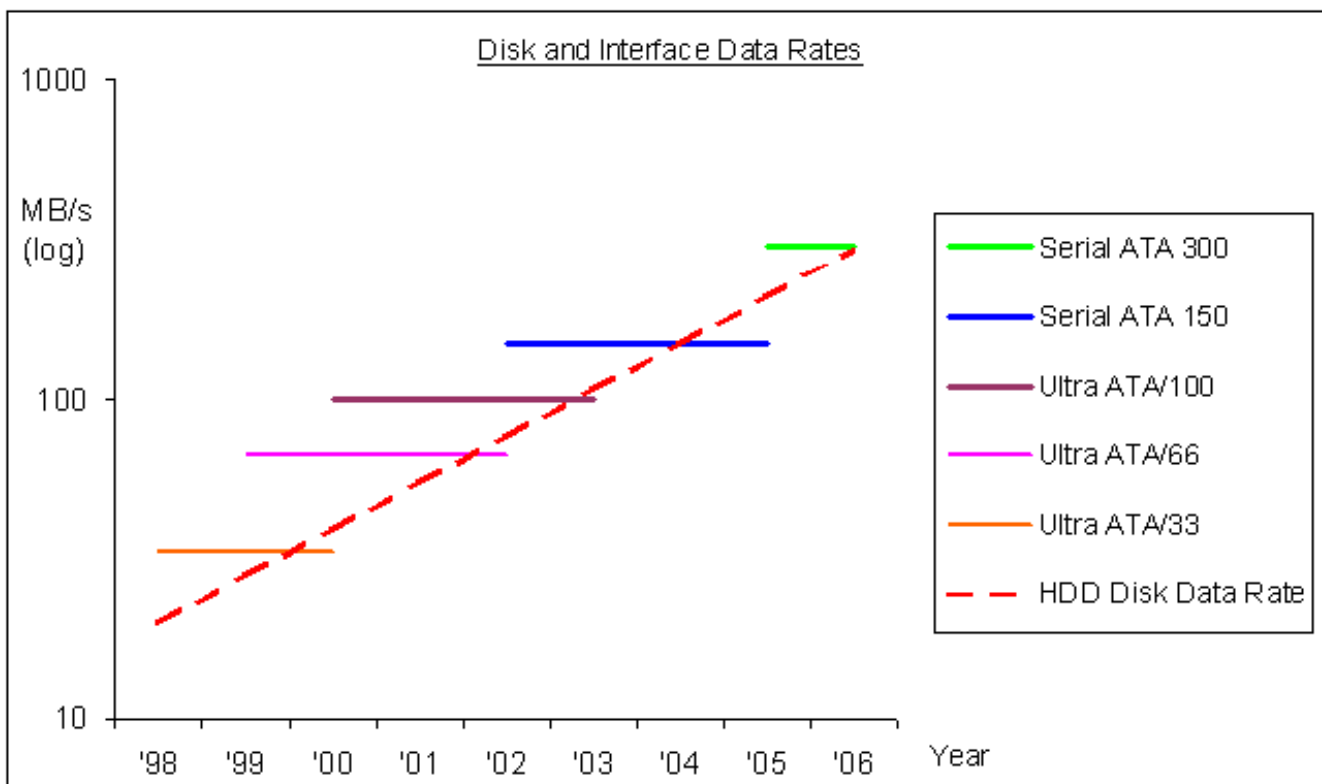
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How Can I Benefit from Serial ATA?

Serial ATA is the next generation personal computer (PC) storage interface. It will replace the Ultra ATA/100 interface used to connect most PCs to their primary storage, which is projected to become a bottleneck within two years. This paper describes the primary benefit of the Serial ATA interface, the increase in data rate. Other features and benefits are also outlined, together with a comparison to alternative storage interfaces. The current development program, the promoters and Quantum's role are discussed. This introduction to Serial ATA will prepare PC and storage manufacturers to maximize the advantages of this revolution in the personal storage industry.

The Need for Change

The Advanced Technology Attachment (ATA) interface, previously called Integrated Drive Electronics (IDE), has existed in substantially the same form since 1989, and has become the highest-volume disk drive interface in production. Quantum, in its role as the patent owner, has led continuous improvements to parallel ATA that extended its data transfer rate from 3.3 Megabytes per second (MB/s) to 100 MB/s, with only one cable change. As PC processor performance has increased, so have the read/write data rates of hard disk drive (HDD) heads and media. This disk rate is projected to exceed today's 100 MB/s interface bandwidth by 2003. Parallel ATA has kept pace in the past, but is nearing its limit, becoming a performance bottleneck. Serial ATA will eliminate this bottleneck by initially offering 150 MB/s and in the future it will provide significant headroom for future improvements.



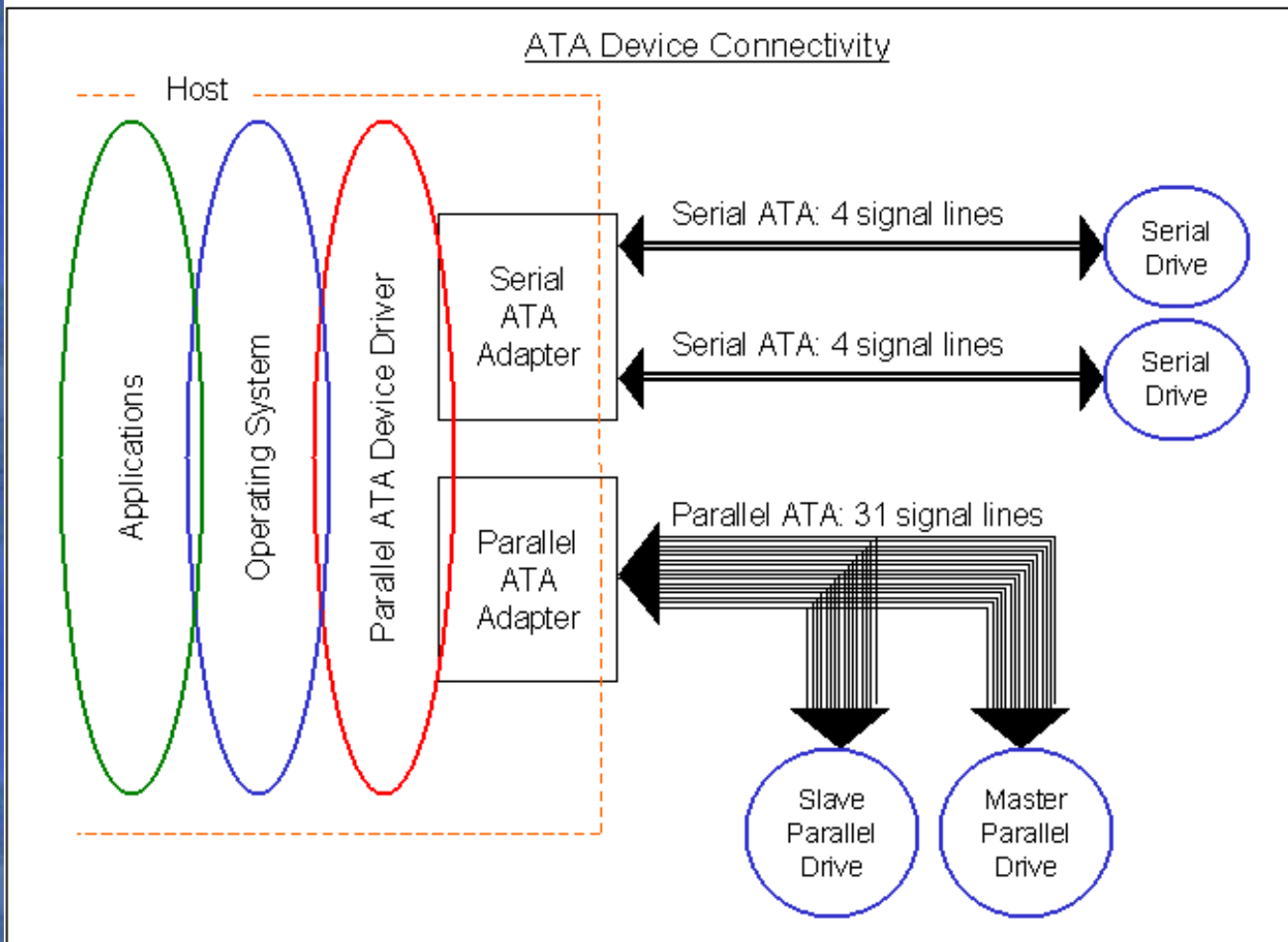
Desktop Storage Interfaces

Interface	Parallel ATA	Universal Serial Bus (USB)	IEEE 1394 (FireWire or i.LINK)	Serial ATA
Target Market	INTERNAL storage devices	EXTERNAL consumer devices, (printer, scanner keyboard, mouse)	EXTERNAL removable storage devices	INTERNAL storage devices
Cost	Low	> Parallel	> Parallel Requires Royalty	= Parallel
Speed in Year 2000 (MB/s)	100	1.5 (USB 1.1)	50	N/A
Projected Speed in Year 2002 (MB/s)	100	60 (USB 2.0)	50	150 Generation 1
Projected Speed in Year 2005 (MB/s)	100	60	200	300 Generation 2
Cable Length (m)	0.45	6.0 per link	4.5 per link	1.0
OS Driver Support	Established parallel	USB	New 1394 specific	Use current parallel
Bootable	Yes	No	No	Yes
Integrated on PC Motherboard	Yes	Yes	No	Yes
Hot Plug	No	Yes	Yes	Yes

ATA Device Connectivity

Parallel ATA allows up to two devices to be connected to a single port using a master / slave communication technique. Both devices are daisy-chained together via one ribbon cable that is an unterminated multidrop bus.

The standard parallel ATA software and device driver access the Serial ATA subsystem in exactly the same manner as parallel ATA and will function correctly. For Serial ATA however, the software views the two devices as if they were masters on two separate ports. The drive interface section of the host adapter uses a new design that converts the normal operations of the software into a serial data / control stream. The Serial ATA structure connects each of the two drives with individual cables in a point-to-point fashion.



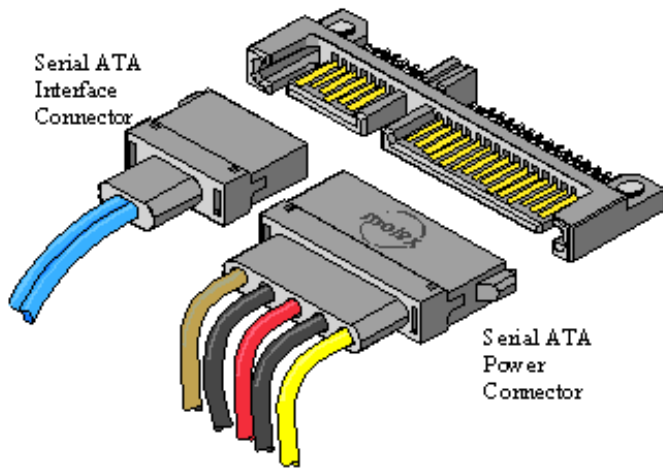
Benefits of Serial ATA

Serial ATA is a high-speed serial link replacement for the parallel ATA attachment of primary internal storage devices. The table below lists some of the features and benefits of Serial ATA.

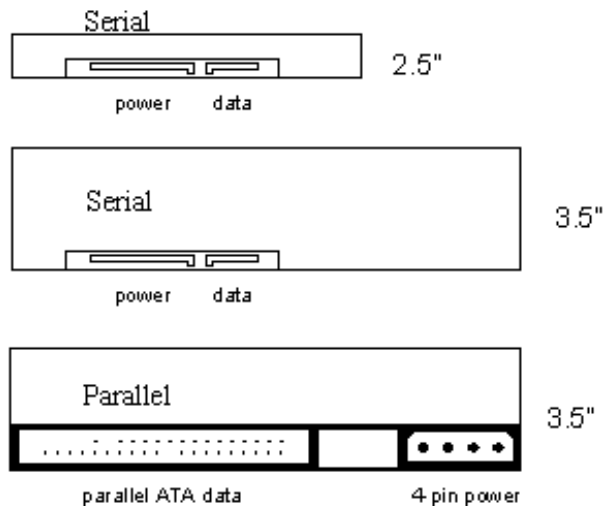
Feature	Benefit
Designed for future speed enhancements	Future-proof with a predicted roadmap spanning at least 10 years to minimize disruption to the PC industry.
150 MB/s interface data transfer rate	Introduced at 150 MB/s to stay ahead of disk data transfer rate and to remove bottleneck that may occur with 100 MB/s parallel ATA.
Low cost	Cost competitive with equivalent parallel ATA solution at introduction.
Primary internal storage interface	Design optimized for internal storage. No trade-off for compatibility with low-speed external devices. A complementary interface to USB.
Point-to-point host to device connection	Easy installation and configuration. No jumper setting or external termination required, reducing integration time and end-user service requests. Eliminates master/slave initialization failures and increases fault isolation. Both devices can transfer data in parallel.
Low voltages	Eliminates 5V tolerant I/O signals to ease hardware design and reduce cost and power.
Low ASIC pin count	Enables future ASIC die-shrinks, which improves cost-effectiveness on both devices and hosts.
Interface power control features	Power management and power consumption suitable for mobile use.
Completely software and driver transparent with parallel ATA	Uses current parallel ATA device driver to ease the transition.
Command optimization	Low overhead and performance features, including command queuing and overlap, enable target market to include entry-level server and RAID systems.
First party DMA	A new feature that gives the device access to host memory, reducing the command and status overhead for the host processor.
Cables and connectors	These are discussed in the next section.

Connectors and Cables

Appearance of Serial ATA Connectors (Drawing courtesy of Molex)



Device Connector Sizes and Locations



Feature	Benefit
The interface cable consists of: <ul style="list-style-type: none"> ▪ Transmit signal differential pair ▪ Receive signal differential pair ▪ Three ground connections 	The use of differential signals improves tolerance to electrical noise.
The power cable consists of: <ul style="list-style-type: none"> ▪ +12 V ▪ +5 V ▪ +3.3 V ▪ Two ground connections 	+3.3 V power enables this connector to be used for future low power systems, particularly in the mobile market.
Small connector design with a common location for both 3.5 inch and 2.5 inch drives	The same interface and power connector can be used on both 3.5 inch and 2.5 inch form factor products. This simplifies PC integration tooling and chassis design. It reduces part counts and therefore costs, and enables interchange of form factors in the same chassis.
Thin flexible cable	The Serial ATA cable is easier to route inside a PC. The trend is towards small footprint PCs that will make this more important. These PCs are often fanless for quiet operating environments and smaller-diameter cables will improve airflow and cooling.
1.0 m maximum cable length	The increased cable length provides more flexibility in PCB layout and opportunities for RAID systems with larger chassis.
Reduced pin count, one-sided blade and beam design with keyed connector	The one-sided design reduces costs. The reduced pin count connector with a key assists blind mating, making it easier to install and reducing the risk of integration damage.
Extended ground pins on connector	The primary goal of Serial ATA is rapid and orderly adoption. This feature is included to enable future hot-plug capabilities.

Quantum's Role in the Development of Serial ATA

Seven key promoters have worked together to develop Serial ATA: APT, Dell, IBM, Intel, Maxtor, Quantum and Seagate. Of these, Intel has been the leading player on the host side, with Quantum taking a key role on the device side.

All of the promoters are recognized leaders in their respective areas. They are collaborating to leverage their experience with previous

interface implementations to ensure that Serial ATA is successfully adopted by the computer industry.

A major thrust of the development is to create a cost-effective solution for primary storage. An example of how Quantum has led this development occurred in October 2000, with Quantum's proposed change in the physical layer communication protocol that will provide a projected overall cost-saving to end-users of \$80 million in the year 2003.

The original specification called for a transmit and receive frequency tolerance of 150 ppm achievable only by using crystal oscillators costing around \$0.50 each. The host already uses these oscillators. Some devices make use of cost-effective ceramic resonators costing around \$0.10 each. The tolerance of these parts, however, is as large as 6,000 ppm.

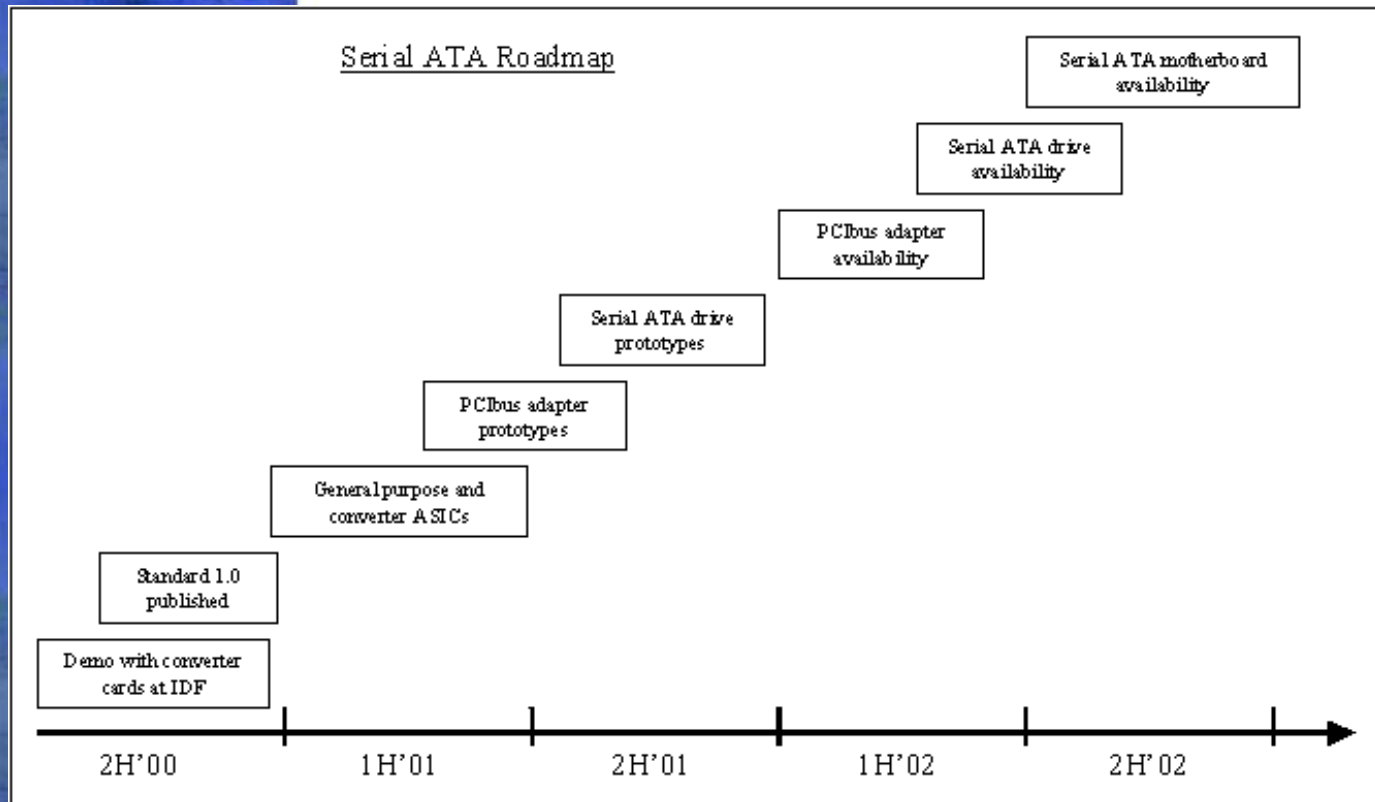
The problem for the ceramic resonator is that the specification requires the device to be the first to transmit critical data at a precise clock frequency. The host uses that data to determine the transfer speed, which will enable the support of future generation products. Quantum recognized the opportunity to provide a lower-cost total solution by redesigning the protocol so that initially the host also provides a constant frequency clock signal, but without data content. The device could then use a ceramic resonator source and phase-lock-loop circuitry to synchronize with and track the host-generated signal. That more accurate source is used to generate the serial clock from the device back to the host.

This Quantum solution has been incorporated into the specification and will enable the Serial ATA system to be more cost effective. In place of the need for two crystal oscillators in a host/device system, only one is called for and the second clock source can be a ceramic resonator, saving \$0.40 per system. At an estimate of more than 200 million systems in 2003, that adds up to over \$80 million in industry savings!

Next Steps

Parallel ATA has succeeded as the primary storage interface for the past 10 years. A team of leaders in the PC and storage industries has recognized that this interface is now approaching its limit. This team has leveraged their experience to develop the storage interface for the next 10 years. The Serial ATA interface is optimized for internal primary storage and provides the capability for future enhancements. Serial ATA is designed for low cost, with ease of adoption in mind.

Projected next steps for the Serial ATA program are shown below. It is expected that drives and PC motherboards incorporating Serial ATA will be available in 2002.



For the latest information on Serial ATA, please visit the website at <http://www.serialata.org/>.