Intel® 82801FR I/O Controller Hub 6 R (ICH6R) and Advanced Host Controller Interface

Performance Brief

October 2004

Document Number: 302648-002

Contents

Revision History

Revision Number	Description	Revision Date
-001	• Initial public release	June 2004
-002	• Updated to reflect product support change	October 2004

1 Introduction

Serial ATA (SATA) is the next-generation internal storage interconnect designed to replace parallel ATA technology. Serial ATA is the proactive evolution of the ATA interface from a parallel bus to a serial bus architecture. This architecture overcomes the electrical constraints that are increasing the difficulty of continued speed enhancements for the classic parallel ATA bus. Serial ATA has been introduced at 1.5 Gbps (150 Mbytes/sec), with a roadmap already planned to incorporate several speed doublings to support up to 10 years of storage evolution based on historical trends. Though Serial ATA will not be able to directly interface with legacy Ultra ATA hardware, it supports the ATA command protocols and thus is compatible with legacy software. Serial ATA specifications can be obtained at http://www.sata-io.org. Serial ATA was introduced into Intel's desktop chipsets in 2003, along with the support of Serial ATA RAID. Intel 82801FR I/O Controller Hub 6 R (ICH6R) continue support for RAID and will help further adoption of RAID in the desktop market. The ICH6R introduce new RAID capabilities along with some new Serial ATA specific features.

This performance brief introduces the ICH6R Advanced Host Controller Interface (AHCI) along with describing the new RAID capabilities that have been included in the chipset since the introduction of the Intel 82801ER (ICH5R). The Intel® Matrix Storage Technology enabled by Intel® Application Accelerator 4.0 (IAA 4.0) software supports both the AHCI and RAID capabilities within the chipset. In the following sections, this document will outline what the new capabilities are within the chipset and how the software enables these features. While Intel Application Accelerator 4.0 is not required for the ICH6R chipsets to function properly, the software does enable advanced RAID and AHCI features.

1.1 Intel® 82801FR (ICH6R) Advanced Host Controller Interface

AHCI is an industry-defined specification for SATA host controller registers and command operations. It addresses limitations of existing host controller interfaces such as proprietary power management solutions, software intensive command delivery and interrupt overhead, and limited device count support (two devices per channel, four total devices per controller with Parallel ATA). ICH6R AHCI support allows standardized host controller support for new SATA features such as Native Command Queuing (NCQ) and hot plug. NCQ is an important feature within the ICH6R AHCI implementation that improves performance for the storage interface.

Intel's ICH6R implement the AHCI controller supported under the 1.0 specification revision. It is supported through software by the Intel Application Accelerator software. The features and advantages of the AHCI controller in ICH6R will also be enabled while the chipset is configured for RAID operation (e.g., NCQ). Intel Application Accelerator supports operation for use in Microsoft Windows* XP and Microsoft Windows* 2000 operating systems, and Microsoft Windows* Server 2003.

1.1.1 Native Command Queuing

One of the AHCI features that addresses performance is Native Command Queuing (NCQ). Command queuing is a mechanism where drives are issued multiple commands at the same time and are allowed to complete them in arbitrary order. Intelligent reordering of commands within the drive's internal command queue helps improve performance of workloads by minimizing mechanical positioning (both seek and rotational) latencies on the drive. Command queuing has been used in SCSI drives for more than a decade to deliver enhanced performance for random I/O, but there has not been an efficient and high performance command queuing scheme developed for ATA drives over that same period. Native Command Queuing, as defined in Serial ATA, has addressed this important feature for Serial ATA drives. Intel has brought NCQ benefits to the desktop segment with AHCI in ICH6R.

ICH6R's AHCI implementation enables software to efficiently issue up to 32 commands to a drive by providing a command list. Software can build all 32 commands at the same time and the host will automatically issue these commands to the disk drive in order to minimize software overhead and decrease latency. ICH6R's hardware automatically processes requests from the drive to transfer data without software intervention, including selecting the appropriate DMA engine context for the transfer. ICH6R is capable of reporting multiple command completions at the same time, enabling additional software overhead/interrupt reduction. Software is able to dynamically add commands to the list as command slots are freed by previous command completions. NCQ must also be supported by the hard drive to take advantage of the feature.

Native Command Queuing is not supported in the drivers included with current Windows operating systems (Windows XP and Windows 2000 operating systems). This new feature can be enabled on the ICH6R through the use of IAA 4.0 and the AHCI interface.

1.1.2 Intel® 82801FR (ICH6R) RAID

The introduction of RAID into the desktop chipset in the ICH5R included support for both RAID 0 and RAID 1. The ICH6R in combination with the IAA 4.0 software will introduce the following additional capabilities:

- Support for up to two RAID volumes on a single, two- hard drive RAID array
- Support for two, two-hard drive RAID arrays on any of four Serial ATA ports
- Support for Serial ATA ATAPI devices
- Support for RAID spares and automatic rebuild
- Support for AHCI on RAID arrays, including NCQ and native hot plug.

These features can provide improved performance, data protection, and new capabilities to desktop systems.

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2 System Requirements

The system requirements for the Intel 82801FR (ICH6R) and RAID and AHCI interfaces for the testing outlined in this document are as follows.

2.1 Hardware

- The system must be an ICH6R-based desktop system (Intel 82801FR I/O Controller Hub)
  - Intel® 925x Express chipset, Intel® 915G/915GV/915P or Intel® 910GL Express chipsets are examples of Express chipsets that may include the 82801FR I/O Controller Hubs
- Intel® Pentium® 4 processor
- 1 GB of memory
- Maxtor MaXLine* III hard drive

2.2 Software

- Microsoft Windows* XP operating system
- Intel® Application Accelerator v4.0
- PCMark* 04 (latest version and updates at http://www.futuremark.com)

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3 Performance Summary

3.1 Benchmarks

3.1.1 PCMark 04

PCMark 04 is the latest version of the popular PCMark benchmark series from FutureMark Corporation. According to FutureMark, PCMark04 measures component and system level performance with a usage profile targeting typical home usage. PCMark04 runs a series of test suites that measure the overall system performance as well as the CPU, memory, graphics and hard disk drive. The CPU test suite is a subset of the test suites included in the overall system score and consists of tests that measure the performance of the CPU.

3.2 Test Configurations

For the testing on ICH6R we looked at the Maxtor MaXLine III hard drive model in several configurations. This hard drive does support Native Command Queuing (NCQ).

For the testing, three configurations were used in comparisons done with PCMark 04:

- ICH6R Serial ATA (using the native Microsoft driver in the operating system which does not support AHCI or NCQ)
- ICH6R Serial ATA single drive “RAID ready” (includes support for AHCI and NCQ on a single hard drive)
- ICH6R Serial ATA RAID Level 0 (includes support for AHCI and NCQ on two hard drives)

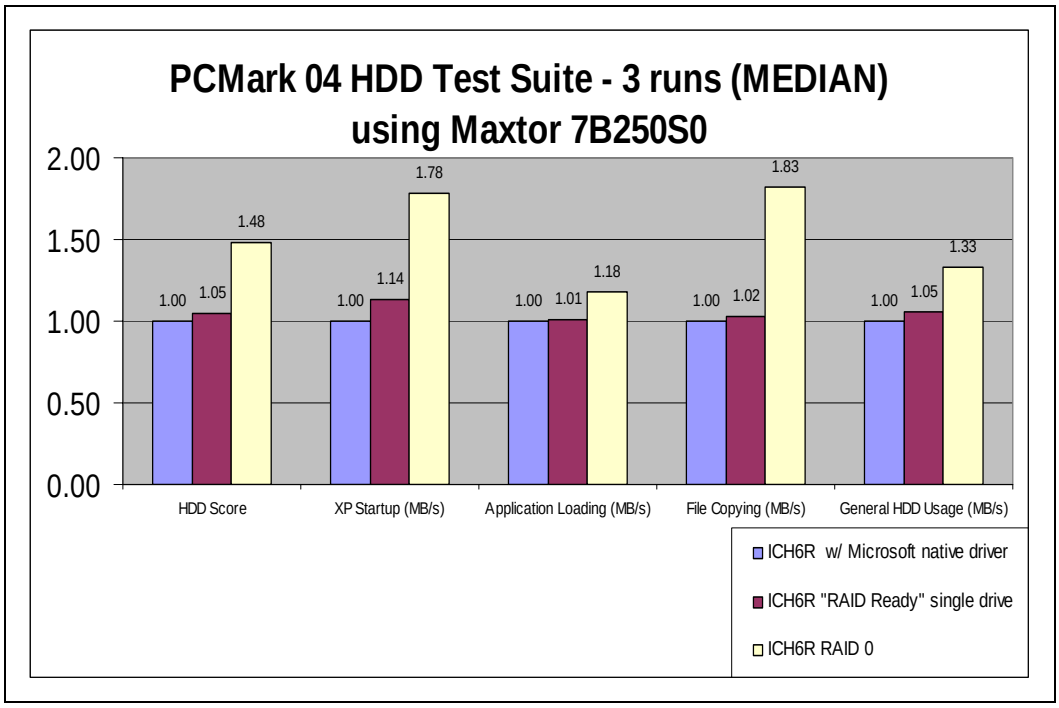
Serial ATA drive model	Drive Information
Maxtor 7B250S0	MaXLine III (250GB, 7200 rpm, 16 MB cache)

3.3 Results Analysis

This results analysis is solely based on the data collected and included in this document (see below). System configuration details are located in the Appendix.

3.4 PCMark* 04 Results

Note: Each test was run a total of three times and recorded, then the MEDIAN of the three runs was calculated for each configuration. The MEDIAN values have been normalized to the results of the ICH6R Serial ATA IDE configuration in the charts below.



The focus on the results for this storage comparison will be on the HDD Test Suite for the PCMark 04 benchmark. The HDD Test Suite has four, separate sub-tests within the suite along with a calculated overall score (HDD Score).

The first subtest, XP Startup, is a trace of the disk activity occurring at operating system start-up. The results from this test show NCQ outperforming the native driver by 14%. RAID 0 with NCQ is showing a benefit of 78% on this test.

Application Loading is the second subtest which contains application disk activity during the opening and closing of files. NCQ has a minimal impact on the performance during this workload, but RAID 0 is showing an improvement of 18%.

The third test, File Copying, contains disk activity during file copies within the operating system. Native Command Queuing is showing a benefit of 2%, while RAID 0 is providing 83% better scores.

The final test, General HDD Usage, contains disk activities from using several common applications including but not limited to the playback of media files, virus scanning, and file compression. NCQ is showing a benefit of 5% on this sub-test. RAID 0 is adding a 33% benefit over the native driver in the operating system.

The results in this testing show that the Maxtor MaXLine 7B250SO hard drive with NCQ support in combination with the Intel Application Accelerator software outperforms the current standard native driver configurations. This is seen both in the single drive (“RAID ready”), with a 5% improvement in the HDD Score, and RAID 0 configuration, with a 48% improvement in the HDD Score. This Maxtor SATA hard drive model will be one of the first desktop drives to incorporate this new Native Command Queuing feature. We expect other hard disk drive vendors will adopt Serial ATA Native Command Queuing in future products as well.

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Appendix A – System Configuration

A.1 Platform Configuration

Processor - Name and ID# or stepping	Intel® Pentium® 4-E-T (PSC-E)
Processor - Core Frequency	3600
Processor - Bus Frequency	800
Processor - L1 Cache	16 K + 12 K
Processor - L2 Cache	1 MB
Processor - L3 Cache	N/A
Platform - Vendor & Model number	Pre-production Intel® D925xCV AA 303
Platform - Motherboard Chipset	Intel® 925X Express Chipset
Platform - Bios Name & Version	CV92510A.86A.0159.2004.0527.1516
Platform - BIOS settings	default BIOS settings
Platform - Additional BIOS settings if apply	N/A
Memory - Vendor & Model number	Micron MT16HTF6464AG-53EB2 PC2-4300U-44410-B0 (512MB/DDRII/533/CL4/DS)
Memory - Type (PC1066, PC2100, PC2700 or PC3200)	PC2-4300 (DDRII 533)
Memory - Timing (i.e., CL 3-3-3)	default BIOS at CL 4-4-4-12
Memory - Size (number of stick memory/Total memory)	1 GB total (2 x 512 MB)
Memory - Channel (i.e,. Dual-channel, Single-channel)	stick in channel 1 and 1 in channel 2 for dual channel operation
Hard Disk - Vendor and Model number	Maxtor MaXLine* III 7B250S0 reference hard drive
Hard Disk - Size (GB)	250 GB
Hard Disk - Buffer Size (2 MB or 8 MB)	16 MB

Hard Disk - Rotating speed (RPM)	7200
Hard Disk - Type (SATA-1 or PATA-100)	Serial ATA (SATA)
Hard Disk - Controller (SATA or PATA)	Integrated SATA controller
Operating System - Type & Version	Microsoft Windows* XP Professional
Operating System - Build Number	Build 2600
Operating System - Service Pack	SP1
Operating System - File Partition	NTFS
Operating System - Kernel (Control Panel - Hardware - Computer)	ACPI Multiprocessor PC
AGP Graphics - Graphic card vendor and Model number	ATI Radeon X600 Series RV380 Reference PCIe-16
AGP Graphics - Type (AGP 4x or AGP 8x)	PCIe-16
AGP Graphics - Memory Size/Type	256 MB GDDR3
AGP Graphics - Resolution/Color	1024/768 32-bit Color
AGP Graphics - Driver: Windows* XP operating system	ATI 6.14.10.6458 (8.03)
System Driver - Microsoft DirectX* API	DX 9.0b
System Driver - Chipset Installation File (INF)	Windows* XP: Intel chipset software installation file (INF): 6.0.0.1014
System Driver - Hard Disk Driver	Microsoft default / Intel® Application Accelerator 4.0.0.6211 (RAID ready & RAID)
Sound Card - Vendor and Model number (set to MUTE for Mobile platform)	Intel® Integrated Realtek HD Audio (for 925x/915x)
Sound Card - Driver version	Driver version Audio 5.10.0.5024
Network Card - Vendor and Model number	Marvell Yukon Gigabit Ethernet 10/100/1000Base-T Adapter
Network Card - Driver version	Windows* XP driver: 7.6.1.0
Monitor - Type and Refresh rate	Plug and Play @ 75Hz.

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