Intel®440MX AC’97 Power/Performance Applications Note

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1. INTRODUCTION

This application note highlights and explains the benefits of Intel’s AC’97 soft technology solution while using the integrated AC’97 link interface in the Intel ® 440MX mobile chipset. The 440MX is the first Intel mobile chipset to support the AC’97 link interface. To really illustrate the benefits of the AC’97 soft technology solution, we have done several benchmarks while comparing the traditional PCI hardware audio/modem solution with the AC’97 soft technology solution.

The block diagrams in Figure 1 below show the architecture difference between these two solutions. The block diagram on the left shows the current PCI hardware solution. A PCI hardware solution contains a dedicated controller engine to do data modulation and demodulation for modem or/and data sampling rate conversion for audio, plus the additional PCI interface logic and CODEC for analog-to-digital data conversion. The block diagram on the right represents the AC’97 soft technology solution.

The idea is to utilize the data processing power of host CPU to do the data modulation and/or data sampling rate conversion. Intel’s soft technology solution also integrates the AC’97 link interface logic into the core logic chipset: the 440MX. This basically eliminates the need for a dedicated hardware controller engine (or DSP) and PCI interface logic on the traditional PCI hardware solution. With the reduction of total chip count and real estate for audio and/or modem subsystems, we have reduced the total cost of platform as compared to PCI hardware implementation.

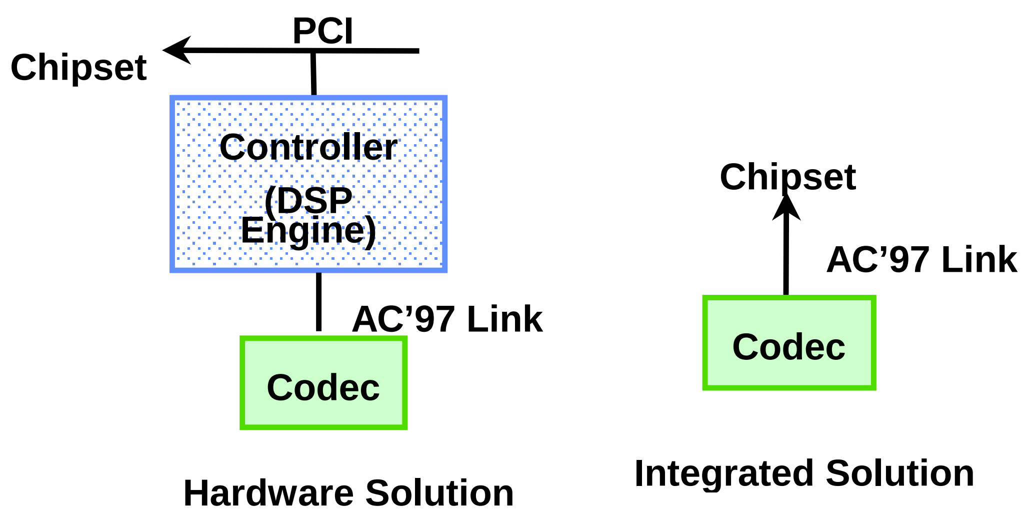

Figure 1. Current PCI Hardware Solution (Left) vs. AC’97 Soft Technology Solution (Right)

In additional to cost-saving, one of the biggest benefits here is the reduction of overall system power consumption. A collection of power measurements for both the PCI hardware solution and the AC’97 soft technology solution are included later in this document.

Another major concern has been raised from users and OEMs regarding the impact on the host CPU performance. The AC’97 soft technology solution relies on host CPU to do additional data processing, as compared to the current PCI hardware solution, which has a dedicated hardware controller. To demonstrate that the impact on the host CPU performance is very minimal, we have also collected and analyzed the benchmark results later in this document.

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2. BACKGROUND INFORMATION

Intel ® 440MX AC’97 interface:

AC '97 defines a high quality audio and modem architecture for the 1999 mobile platforms and beyond. AC’97 soft technology provides a low-cost soft audio/modem solution. Intel ® 440MX is the first mobile chipset that supports the AC’97 link interface. For further details on AC’97 architecture, please refer to the AC’97 Specification Revision 2.1, which is posted on the Intel developer website. The URL is: **http://developer.intel.com/pc-supp/platform/ac97/.**

V.90*:

V.90 is the official designator for the International Telecommunications Union' (ITU) draft recommendation for 56K modems. Known previously as V.pcm*, the V.90 draft was approved in February 1998, clearing the way for universal compatibility among various 56K modems.

Vtune:

Vtune is a performance analyzer application developed by Intel to help users to measure the performance of the applications. Vtune allow users to run a non-intrusive monitoring session along with the rest of the software running on the systems, analyze its performance, and display the performance bottlenecks in your application.

CPUmark*:

CPUmark is part of Winbench*98 and 99. It includes CPUmark32* for 32-bit window applications and CPUmark16* for 16-bit applications. It is designed with the performance potential for running either 16-bit or 32-bit applications. It focuses on testing the performance of CPU, cache, and main memory subsystems. CPUmark runs on Windows*95, Windows*98, and Windows NT* systems.

MDC:

MDC stands for mobile audio/modem daughter card. MDC defines a common standard interface connector and mechanical form factor for adding a low-cost soft modem and/or audio solution on mobile form factors. By placing the sensitive analog components on a riser, higher audio quality and easier modem certification are enabled. The MDC specification is publicly available and can be downloaded from the Intel developer website. The URL is **http://developer.intel.com/design/mobile/mdcspec/**

Audio Winbench*99:

Audio WinBench 99 is a new ZD benchmark that focuses on the audio subsystem of a PC. Its tests give you both an overall comparative measure and a subjective measure of a PC's audio subsystem's performance. As a result, Audio WinBench 99 contains a mix of automated tests and interactive tests. The tests are all 32-bit and run only on Windows 95, Windows 98, and Windows NT systems.

3. POWER/PERFORMANCE COMPARISON

In this section, we will describe in detail two major benefits that can be obtained by using integrated AC’97 soft technology with the Intel® 440MX mobile chipset. The first benefit is that AC’97 soft technology delivers an equivalent performance to that of the current PCI hardware solution, while maintaining a low CPU utilization. The second benefit is the reduction of overall system power consumption. We will also describe how we do the testing, and finally we will analyze the testing results. Since the applications are very different for audio and modem subsystems, we have chosen different PCI hardware, and have used different benchmark programs, to measure the performance respectively for audio and modem subsystems.

3.1 Low CPU Utilization of AC’97 Soft Technology

As we said earlier, the implementation of AC’97 soft technology has raised a concern to users that this technology may drain too much of the host CPU power, leaving no time for other devices or applications. Fortunately, with today’s high-performance CPUs, this load is small enough to make its presence nearly undetectable. We have chosen the Intel Celeron™ processor for the host CPU for all our benchmarks, and the results of benchmark data show only a small increase in the percentage of CPU utilization, going from the hardware solution to the software solution. The CPU utilization benchmark is divided into two different tests: one for audio and one for modem. Each uses a specific testing methodology.

3.1.1 V.34 SOFT MODEM TESTING

Traditionally, a hardware modem includes a controller processor to perform the data compression and a DSP chip to perform the data modulation. Today, most of the PCI hardware modems have eliminated the controller processor, but still are implemented with a dedicated DSP chip to perform the data modulation task. As we move from the PCI controllerless hardware solution to the integrated AC’97 soft modem solution, and to illustrate that the extra load added to the host CPU is very minimum, we have chosen an ESS Technology ES336* V.34 PCI modem and a Motorola SM56 soft modem for comparison. The Motorola SM56* is the AC’97 software-based solution. The ESS Technology ES336 PCI modem is a controllerless DSP modem card.

The test is done by connecting two computers via modem connection and TAS* emulator. TAS emulator simulates telephone network conditions. One computer acts as a client, which is a 333MHz Intel Celeron™ 440MX platform, and the other acts as a remote server. After the client establishes the connection with the server, the client starts to download a data file with the V.34 modem connection speed. In the meantime, to measure the CPU loading, we also started the Vtune program before the beginning of the data transfer. Finally, we repeated the same tests for both hardware and software solutions.

The chart in Figure 2 below shows the testing results of CPU utilization. As indicated by the chart, with the performance of the 333MHz Intel Celeron™ processor, the AC’97 soft modem solution is using 15.4 % of CPU resource, and the PCI hardware controllerless solution is using about 9.5% of CPU resource. The increased usage of CPU resource is to handle data pump, echo cancellation, and data modulation, which are being done by the dedicated DSP chip in the case of the ESS 336 PCI modem card.

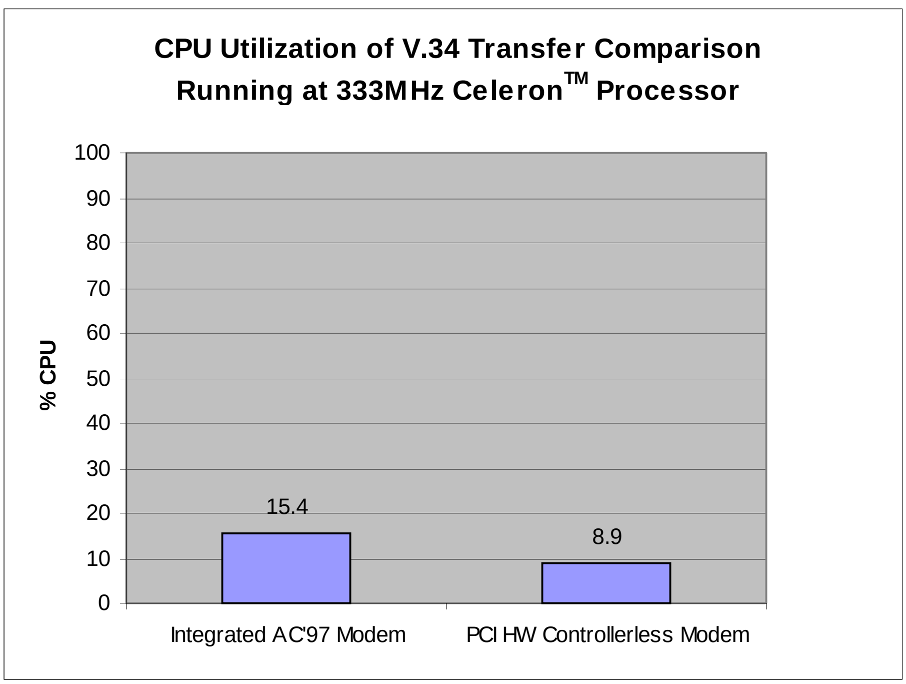

Figure 2. CPU Utilization of V.34 Transfer Running with Intel Celeron™ at 333MHz

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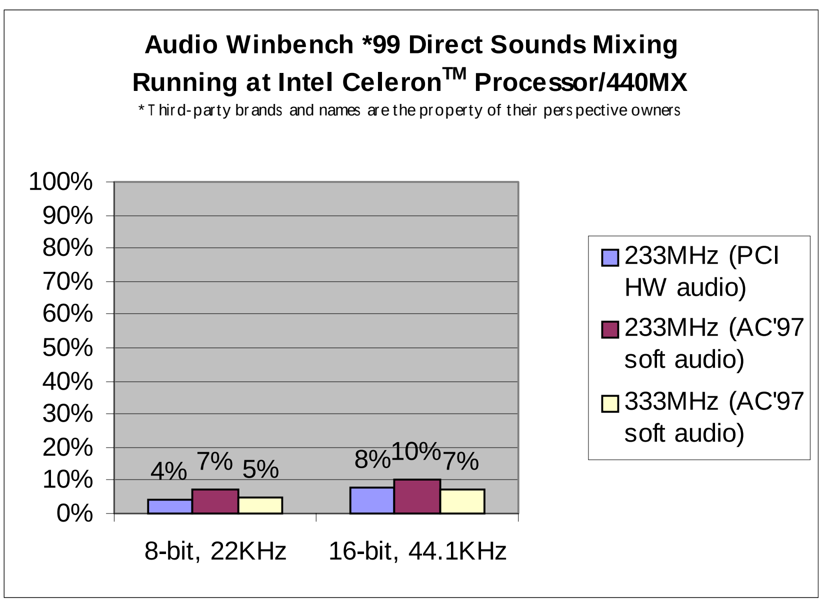
3.1.2 V.90 SOFT MODEM TESTING

For soft modem technology, data pump and modulation are the major tasks that are being handled by the host CPU. The maximum data transfer rate of V.90 is higher than V.34 (56K vs. 34K), which potentially needs more CPU resource for data pumping. However, the V.90 has a simpler data modulation method, the overall CPU utilization for V.90 transfer is believed to be the same as the V.34 transfer. Currently, the actual testing data is not available at the time this document is being published.

3.1.3 AC’97 SOFT AUDIO DIRECT SOUNDS TESTING

For audio application, we have performed the tests while running the Audio Winbench*99 from Ziff-Davis**. Also for the purpose of new and old technology comparison, we have selected the ESS Maestro-2EM sound card for PCI hardware audio solution and the ADI 1881 codec with ADI SoundMAX* driver for soft audio solution. The “Audio CPU Utilization Test” under the Audio Winbench*99 includes 8-bit 22KHz and 16-bit 44KHz Direct Sound tests. All these tests measure the amount of host CPU that the sound subsystem uses for common operations, such as playing different voice sounds concurrently, and mixing different sounds together. Every measurement number shown below is an average of three repeated tests for 8, 16, and 32 voices of Direct Sound respectively. For the PCI hardware sound card, the audio mixing task is done by the hardware. So, the “Audio CPU Utilization Test” allows us to compare the performance of sound cards. It determines how much work playing the sounds is adding to the processor, so that we know how much CPU is available for other tasks.

As indicated by the chart shown in **Error! Reference source not found.** below, while running a 233MHz Intel Celeron™ processor, there is only about
2 ~ 3% CPU utilization more as we move from the ESS Maestro-2EM* hardware audio solution to the AC’97 soft audio solution. This additional load for the host CPU from soft technology is to handle voice mixing and conversion, which is done by the dedicated DSP chip on the ESS sound card. Also, as the processor speed increases from 233MHz to 333MHz, the CPU utilization percentage decreases from 10% to 7% for the 16-bit, 44.1 KHz case test, and from 7% to 5% for the 8-bit, 22KHz scenario. Therefore, we can conclude that the CPU utilization is less noticeable while moving to higher-



performing processors (this is also indicated in the chart).

Figure 3. Soft Audio CPU Utilization Comparison with Direct Sounds*

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3.2 Overall System Power Consumption Comparison

The second major benefit of AC’97 soft technology is the reduction of overall system power consumption. With the elimination of digital controller and PCI interface logic, plus the integration of AC97 link interface into the core logic chipset, a certain amount of power reduction is foreseen. On the other hand, because of the shift of additional data processing load to the host CPU, a small amount of power consumption for the host CPU has been increased. While doing the power measurement and comparison, we often compare the power consumption for the overall system. In the following section, we will present and analyze the lab measurement results between hardware solutions and soft technology solutions.

The power measurements have been divided into two separate tests: one for modem, and one for audio. The same PCI hardware cards and soft solutions used for CPU utilization testing were also used for power consumption measurement. Refer Appendix A for details on system configuration.

Before we analyze the data from the lab measurement, we provide a brief discussion of power measurement methodology.

3.2.1 POWER MEASUREMENT METHODOLOGY

The block diagram shown in Figure 4 below represents the basic concept of power measurement methodology. First, connect the specific voltage source or voltage regulator for the subsystem or components on the 440MX platform to the data acquisition unit via a 0.02ohm resistor, as illustrated in the block diagram. The subsystem can be the PCI audio hardware card, AC’97 audio, host CPU, main system memory, hard disk, or graphics. The data acquisition unit then feeds the data back to the host system for further data processing or manipulation. For example, on the modem testing, we monitored and recorded power consumption numbers from the beginning to the end of V.34 data transfer. Then, the host PC processes the data and generates the final averaging power consumption number over the whole period of data transfer. The data acquisition unit that we used is Fluke NetDAQ 2645*.

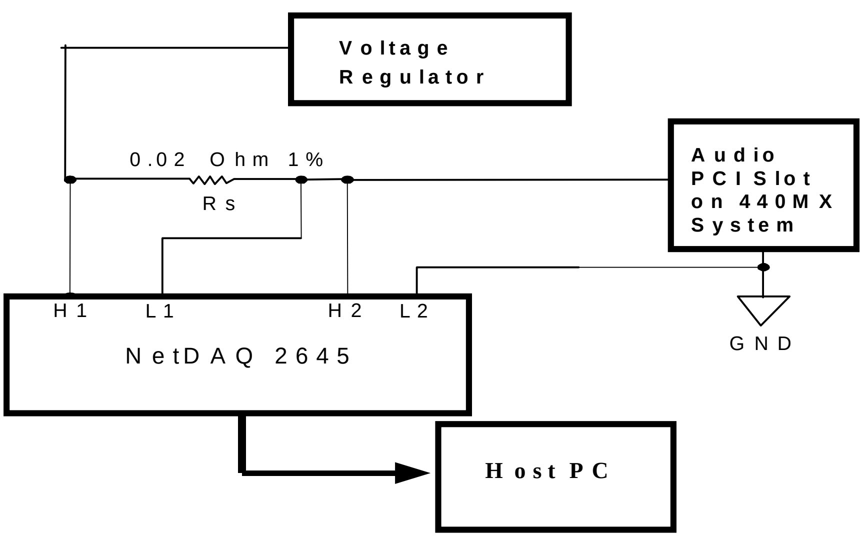

Figure 4. Power Measurement Methodology

3.2.2 SOFT MODEM POWER CONSUMPTION

As indicated from the chart shown in Figure 5, the power consumption for the modem subsystem has been reduced from 1.38W to 0.25W, while moving from PCI hardware to the AC’97 soft modem solution. This is mainly due to the elimination of the dedicated DSP chip. On the other hand, the CPU power consumption has slightly increased from 0.74 W to 1.11 W. This is due to the additional demand for host CPU to handle the data modulation, data pump, and echo cancellation for the soft modem solution. The power consumption for the rest of the other subsystems (chipset, memory, graphics, and hard drive) stays the same. So, while comparing the overall system power consumption, the number has been reduced from 6.05W to 5.15W, which is about a 15% power reduction from hardware to soft technology solutions.

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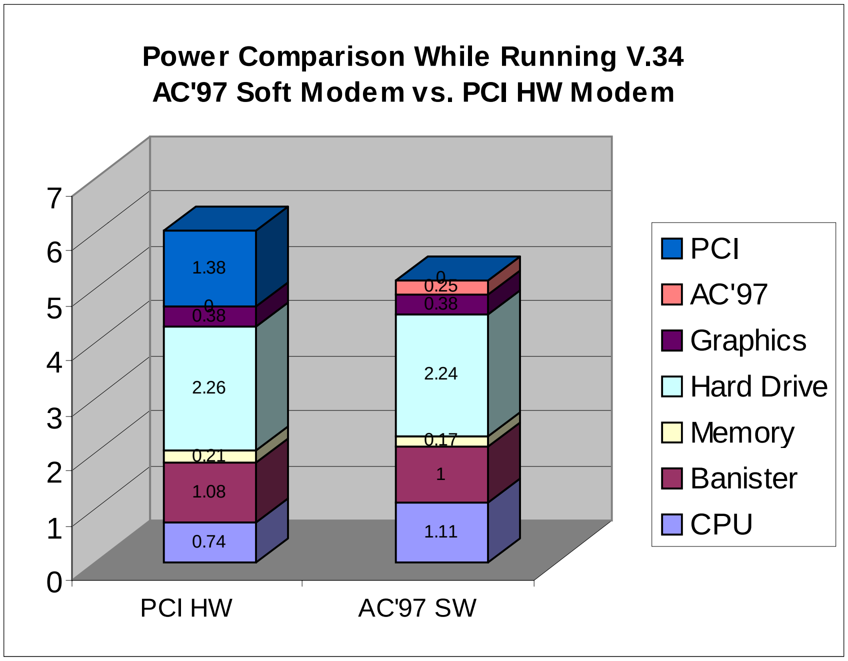

Figure 5. Power Consumption While Running V.34 AC’97 Soft Modem vs. PCI Hardware Modem

3.2.3 SOFT AUDIO POWER CONSUMPTION

Two applications have been used to measure the audio power consumption. One is the Mixman Studio*, which is an application that allows users to create and play a mix of CD quality music. The other is the popular 3D video game: Quake II*. As indicated from the chart shown in Figure 6 below, similar to the modem testing, the power consumption for the audio subsystem has been reduced from 1.13 W to about 0.2W for Mixman Studio, and from 1.1 W to 0.2W for Quake II, while moving from the hardware solution to the soft technology solution. The power consumption increases slightly for CPU on both applications. However, the overall power consumption has been reduced from the PCI hardware solution to the AC’97 soft technology solution. For Mixman Studio, it is about a 6% reduction, and for Quake II, it is about a 13% reduction.

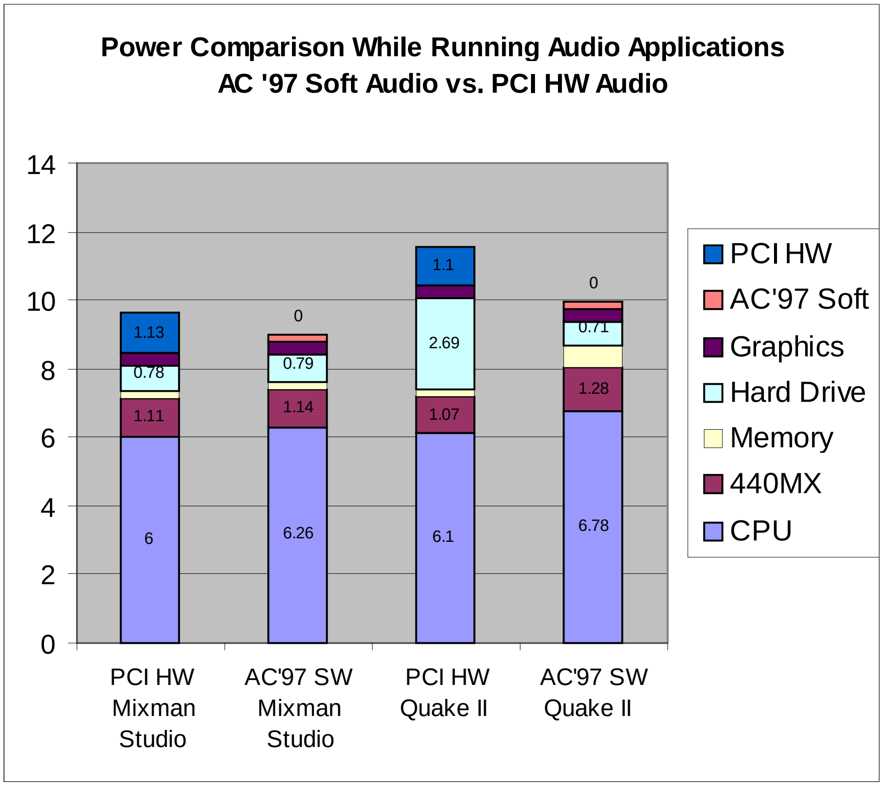

Figure 6. Power Comparison While Running Audio Applications – AC’97 Soft Audio vs. PCI Hardware Audio

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APPENDIX A. SYSTEM CONFIGURATION

Processor	Intel Celeron™ processor 333MHz (or 233MHz)
Motherboard	Intel internal 440MX platform (Llama board)
BIOS	Phoenix* 3/4/99 with default setting for CPU utilization
Graphics	ATI Rage II*
Hard Drive	Toshiba* MK2103 IDE driver running at DMA mode 2
System memory	66MHz 64MB SDRAM
AC’97 Soft Audio	ADI 1881 CODEC with ADI SoundMax driver (version 4.10.2111)
AC’97 Soft Modem	ADI 1882 CODEC with Motorola* driver (version 4.01.63)
Operating System	Windows* 98 (version 4.10.1998)
PCI Hardware Audio	ESS Maestro-2EM*
PCI Hardware Modem	ESS ES336 V.34 PCI controllerless modem

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