Innovative Power Solutions — HiVERT in Hitachi Hard Disk Drives

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Introduction

Driven by the need for mobility and fueled by the integration of traditional desktop computer capabilities, notebook PCs are quickly becoming the primary computing solution for users worldwide. Many of these users require desktop- or even workstation-like performance from their notebook computers while maintaining the portability of mainstream notebooks. Although portability enables the convenience of ubiquitous data access, the proximity to power supply outlets frequently forces users to operate their laptops on battery power.

The hard disk drive is a key element in determining the overall performance of the host system it serves. The problem of delivering high levels of computing performance without increasing power consumption has been a critical design consideration behind the development of Hitachi Global Storage Technologies' 2.5-, 1.8- and 1.0-inch hard disk drives. Since its first implementation of Advanced Battery Life Extender™ (ABLE) in 1995, Hitachi Global Storage Technologies has led the industry in pioneering innovative solutions for lowering power consumption while maintaining the highest levels of hard disk drive performance.

Drawing upon its experience in power reduction technologies, the Hitachi team began modeling a new technique that would compliment what is now its third generation of power management methods integrated under the Enhanced ABLE™ moniker. This development effort resulted in the HiVERT™ invention, short for Hitachi Voltage Efficiency Regulator Technology, a novel power-saving technology that works in conjunction with Enhanced ABLE to significantly reduce power consumption by the hard disk drive without sacrificing performance characteristics of the base design. Test data shows that when coupled with Enhanced ABLE, HiVERT enables Hitachi Travelstar® 2.5- and 1.8-inch hard disk drives which operate at very high performance levels to consume comparable or even lower amounts of power than 4200, 5400 and more recently, 7200 RPM offerings from other suppliers.

Hard Disk Drive Measured	Capacity	Average Power
★ Travelstar 7K100 – 100	100 GB	0.96 Watts
★ Travelstar 7K100 – 80	80 GB	0.93 Watts
Vendor B – 7200 RPM	100 GB	1.42 Watts
★ Travelstar 5K100 – 100	100 GB	0.77 Watts
★ Travelstar 5K100 – 80	80 GB	0.76 Watts
Vendor A – 5400 RPM	100 GB	0.93 Watts
Vendor A – 5400 RPM	80 GB	1.31 Watts
Vendor B – 5400 RPM	160 GB	1.14 Watts
Vendor B – 5400 RPM	100 GB	1.42 Watts
Vendor C – 5400 RPM	100 GB	1.32 Watts
Vendor C – 5400 RPM	80 GB	1.27 Watts
Vendor D – 5400 RPM	80 GB	1.44 Watts
Vendor E – 5400 RPM	80 GB	1.18 Watts
★ Travelstar 4K120 – 120	120 GB	0.59 Watts
Vendor A – 4200 RPM	120 GB	1.04 Watts
Vendor B – 4200 RPM	100 GB	1.42 Watts
Vendor C – 5400 RPM	60 GB	1.00 Watts

Figure 1: Test results indicate average power consumption run over four hours using MobileMark 2002 with Patch 2.

Power management within the hard disk drive

Hard disk drives draw the highest power during various modes of operation: Spin Up, when the drive is first powered on and the spindle motor starts rotating the magnetic platters inside the drive, as well as Read and Write, when data is being read or written from the magnetic disks. Increasing the power efficiency of the hard disk drive during these modes was the objective behind the HiVERT development effort.

Power is supplied to 2.5-inch, or "mobile" hard disk drives through a single 5 volt (5V) supply line. This 5V level is required to operate the spindle motor, the voice coil motor (VCM), which positions the read/write heads over the magnetic disks, and the Pre-Amp Integrated Circuit, also known as the arm electronics, which amplifies the electronic signals sensed by the recording heads before being routed to the printed circuit board assembly. Other electri-

cal functions within the hard disk drive operate on voltages lower than 5V and therefore must be "stepped down" to the appropriate voltage level or levels. These include the main controller and logic microprocessor, buffer memory and read/write channel electronics, which require 3.3V while various other channel functions operate on 1.5V power. The method used to "step down" the power supply from 5V to 1.5V largely determines the overall power efficiency of the hard disk drive. It was this area that was the focus of improvement by the engineers developing the technology behind HiVERT.

The HiVERT innovation in voltage handling

Previous generation Enhanced ABLE products from Hitachi, employed a series of two linear regulators to step the voltage down from 5V to 1.5V levels. One linear regulator, incorporated into the combined spindle motor/voice coil motor driver (Combo) module, stepped the input voltage down from 5V to a 3.3V level. The resulting 3.3V output was then fed into a single module which integrated three important disk drive functions ñ the Head Disk Controller (HDC), Multi-Processor Unit (MPU) and Read Channel. Another linear regulator incorporated in this chip steps the 3.3V power supply down to the 1.5V level required by the various electronic read/write channel functions.

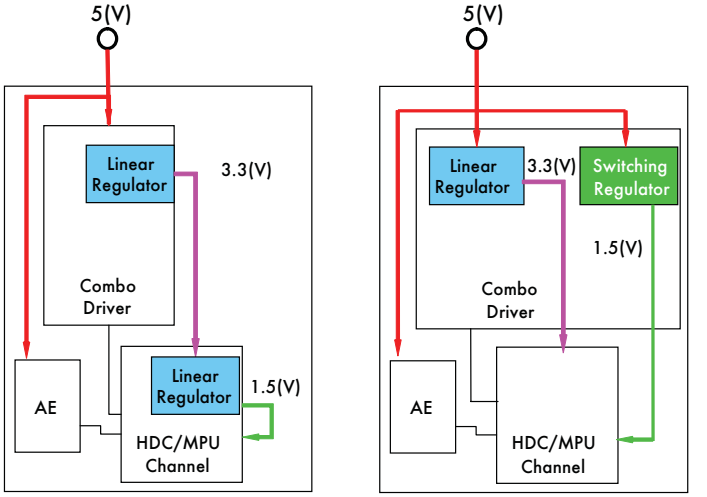

Figure 2. The HiVERT embedded switching regulator compared against conventional power conversion implementations

The largest power efficiency losses occur during the voltage conversion processes as routed through these two sequential linear regulators to produce a usable 1.5V power supply. Targeting this area, the HiVERT engineers streamlined the conversion process by circumventing both linear regulator step processes and inserting a "switching" regulator into the circuit, which stepped the power supply from its 5V input directly to the 1.5V level. During testing in the Hitachi laboratories, the power efficiency utilization realized from the HiVERT "switching-based" regulator solution is 90%, a dramatic increase when compared to the 30% efficiency level realized from traditional linear regulator implementations. Concern over the potential of additional noise on the voltage line which directly feeds into the read/write was mitigated with the addition of an external FET, diode, capacitor and coil, that further improved the quality of the 1.5V line supplied from HiVERT-based switching regulator solutions.

HiVERT implementation history

HiVERT technology was first introduced in the Serial ATA interface models in the 2.5-inch Travelstar 5K100 product line. This was quickly followed by a second generation implementation in May 2005, which was incorporated in both the Parallel and Serial ATA versions of the Travelstar 7K100, 7200 RPM disk drive series. The design used a discrete switching regulator, a separate component from the spindle motor/VCM driver module, which performed the voltage step-down function by converting the 5V input power to the 3.3V supply level. A linear regulator incorporated in the integrated Hard Disk Controller and Micro-Processing Unit (HDC/MPU) module performed the 3.3V to 1.5V step-down process.

More recent HiVERT implementations such as that represented in the Travelstar 4K120 line of 4200 RPM hard disk drives embed the switching regulator into the spindle motor/VCM driver module, allowing for a more direct step-down of the 5V input to 1.5V, further improving the power efficiency of the overall drive. The power savings realized by this second-generation HiVERT design has been significant. In comparing the power consumption of Hitachi's 5400 RPM hard disk drive offerings against other suppliers not using the technology, laboratory testing found that the power savings realized from Hitachi's HiVERT-enabled drives during Read and Write operations is as much as 25 percent.

Lower power consumed at the disk drive level equates to longer battery life as well as a reduction in the heat dissipated by the hard drive itself. With the addition of HiVERT, our research shows that Hitachi hard disk drives operate from 3 to 5 degrees Celsius cooler than other drives operating at the same spindle rotational speed. Hitachi's research indicates that a 10-degree Celsius drop in the case temperature of the hard disk drive can double the service life of the drive. Depending on the configuration of the host system, today's HiVERT-enabled hard disk drives could contribute to an extension in the service life of the product incorporating the Hitachi drive by as much as 50 percent.

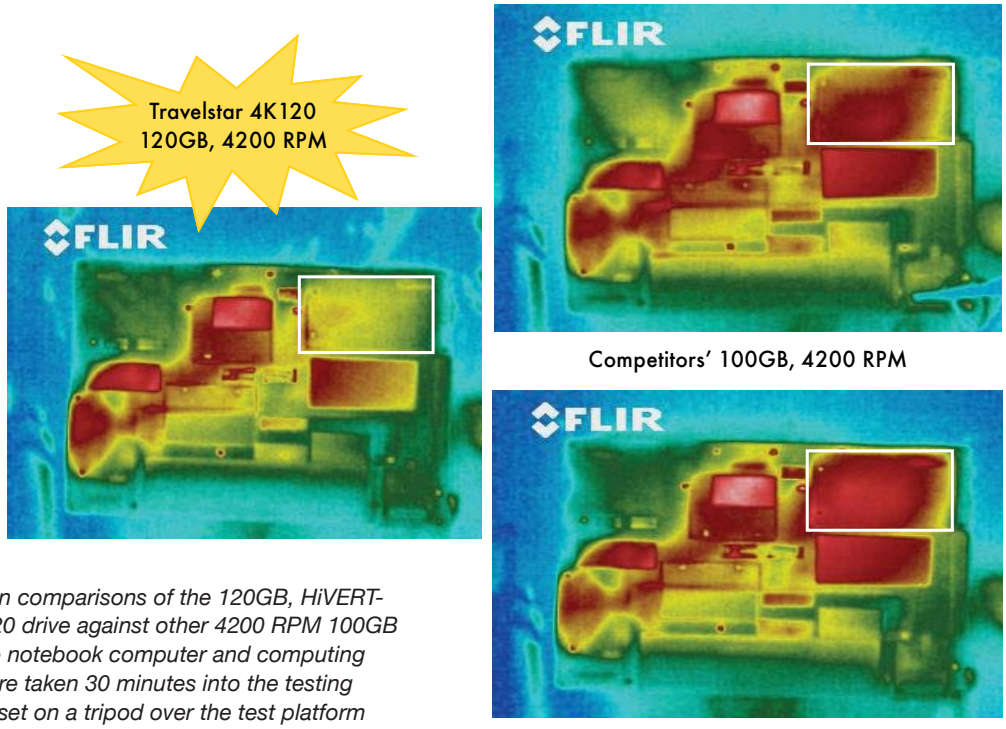

Figure 3. Heat dissipation comparisons of the 120GB, HiVERT-enabled, Travelstar 4K120 drive against other 4200 RPM 100GB offerings using the same notebook computer and computing workload. All images were taken 30 minutes into the testing with an infrared camera set on a tripod over the test platform

Summary

Since the introduction of its first 2.5-inch hard disk drive in 1991, Hitachi has continued to lead the market in solutions for mobile and portable hard disk drives that provide performance, low power consumption as well as durability features which can prolong the overall service life of the host system. In 2005, the invention of HiVERT and its introduction in the Travelstar 7K100 and 4K120 products, established unprecedented levels of power efficiency for 2.5-inch hard disk drives. The decrease in power consumption can directly result in longer battery usage times as well as cooler operating environments for HiVERT-enabled hard disk drives. As users migrate to notebook computers for their primary workstation, the demands on the hard disk drive for higher performance with lower power consumption will continue to increase. Innovations such as HiVERT and Enhanced ABLE ensure that today's users of Hitachi hard disk drives will derive the benefits of greater performance and portability in computing solutions that are designed to go the distance.

References and additional reading

1. Enhanced Adaptive Battery Life Extender by Dr. William Heybruck, Senior Storage Engineer.

2. Ramp Load/unload Technology by Patricia Kim, Product Marketing Manager and Mike Suk, Senior Technology Staff Member.

These documents can be found under White Papers in our Technical Library at http://www.hitachigst.com/support.

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