HITACHI
Inspire the Next

Feature Set Description

# Hitachi Deskstar 7K400

## Ultra ATA/133 Hard disk drive

Models HDS724040KLAT80

## Introduction

The Deskstar 7K400 was designed for a variety of capacity intensive applications. At launch time it is the highest capacity drive available, with performance to match any 3.5-inch ATA drive. This document describes various features that make it suitable for a diverse group of applications. Those interested in implementation details should reference the Deskstar 7K400 Hard Disk Drive Specification (Publication Number 2870).
Additional details on some features are described in 'white papers' available on the Hitachi GST web site, www.hitachigst.com.

### Drive Specification Summary

| | |
|---|---|
| Capacity | 400 GB |
| Spin rate | 7200 rpm |
| Seek time | 8.5 ms |
| Data transfer rate | |
| - Max sustained | 61.4 MB/s |
| Areal density | 61.7 Gb/sq in |
| TPI | 90 K |
| BPI | 686 K |
| Acoustics (idle) | 3.1 bels |
| Power (idle) | 9.6 W SATA |
| | 9.0 W PATA |
| Non-operational shock | 225 G |
| Interface | ATA-7 |
| Disks / Heads | 5 / 10 |

# Features

## 1.0 Acoustic and Power Management

## 2.0 ATA-7 Compliant

- SMART Selective Self Test
- World Wide Name

## 3.0 ATA-7 AV Streaming Command Set (Parallel interface only)

## 4.0 Mechanical Enhancements

## 5.0 Rotational Vibration Safeguard

## 6.0 Load / Unload

---

The Deskstar can be configured to reduce audible noise and reduce power demands beyond its leading specifications. Whenever the system is located near the user, low acoustics are important. Low noise levels can also be important in audio / video production environments.

Power savings are important in all applications. Reducing drive power requirements benefits the system in several ways.

- Reduces demand for cooling
- Enables less costly power supplies
- Enhances reliability for all components

The following details describe Hitachi's Deskstar 7K400.

## 1.0 Acoustics Management

The Deskstar drives can be configured to the silent seek mode. With this mode enabled, drive acoustics during seeking drops from 3.5 to 3.3 Bels. This improvement not only makes for a quieter environment for the user, there is also a power benefit. The drive's power requirement drops significantly during seeking, from 13 watts to only 11 watts.

See Section 10.15 of the HDD Specification for details on advanced acoustic management.

### Power Management

PC systems and other single-drive configurations will realize benefits by utilizing the Deskstar power management capabilities. The hard drive can be under utilized in many single user applications. In these cases, the system can switch the drive to one or more of the power saving modes described below.

In addition, ATA 3.5-inch drives are increasing being used in multi-drive configurations. One typical application is nearline storage, where the drives may remain idle for extended periods of time. In such environments, the system can benefit from a key feature of the Deskstar drives, advanced power management. These drives have four stages of readiness and each level has power and cooling benefits for the system. The accompanying table shows percentage of savings and recovery time for each mode.

**Online**
In the normal ready mode, the drives respond immediately to system requests for data. The Deskstar drives, in the standard configuration, lead the industry for low power requirements. This leading low power enables lower cost power supplies and less cooling than required for other ATA drives. Deskstar drives achieve this integration benefit (lower power) while providing industry-leading performance.

**Unload**
The heads can be sent to the ramp if the drive is idle for several minute intervals. This mode reduces power, since the servo circuit is disabled. Power is also reduced due to lower aerodynamic drag from the heads and actator arms. 24% less power is required than in the online mode. With a request for data, the drive quickly returns to the online mode for rapid access.

**Low RPM**
When longer periods of non use occur, additional power saving is possible. In this mode, in addition to head unload from the media, the spindle motor can be slowed to a lower spin rate (approximately 60% of normal). This action further reduces the power needed for the drive, 27% less than the unload mode. In less than seven seconds, the drive can be restored to ready mode for data access.

**Standby**
One final mode enables the greatest power saving state. In this case, as above, the heads are moved to the ramp. In standby mode, power is removed from the disks. Stopping the disks results in 38% savings over the Low RPM mode or 87% less than when online. In this mode, only a few key circuits remain active, thus significantly reducing the power requirement. The active circuits enable the drive to accept commands and quickly return to online mode.

The standby drive can be quickly brought to the online mode; if for example, one of the active drives is removed from the system. This mode is especially useful in RAID environments where one drive may serve as a spare.

Each of these modes can be enabled by the Set Feature commands. They are described in the Advanced Power Management section of the product Hard Disk Drive Specification.

Figure 1 : Power Modes

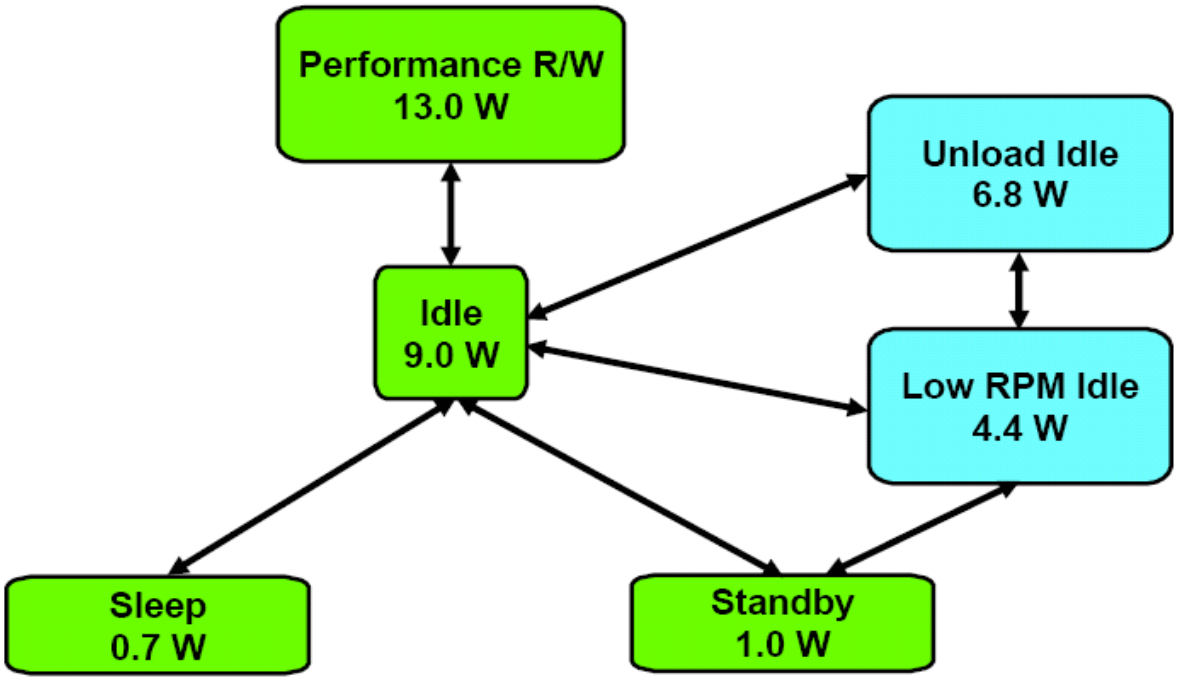


Table 1: Deskstar 7K400 Power States

| Power Mode | Power Savings (%) | Recovery Time (sec) |
|---|---|---|
| Normal | 0 | 0 |
| Unload | 30 | 0.7 |
| Low RPM | 49 | 7.0 |
| Standby | 64 | 15.0 |

See Section 10.14 of the HDD Specification for details on advanced power management.

## 2.0 ATA-7 Compliant

- **SMART Selective Self Test** - The device provides the self-test features which are initiated by SMART Execute Off-line Immediate command. The self-test checks the fault of the device, reports the test status in Device Attributes Data, and stores the test result in the SMART self-test log sector as described in the SMART self-test log data structure.

- **World Wide Name** - The 7K400 incorporates the new naming standard for product identification, as described here in Table 2.

Table 2: World Wide Naming Standard

| | |
|---|---|
| Organization | Hitachi Global Storage Technologies |
| Manufacturing Site | Prachiburi, Thailand |
| Product | Deskstar 7K400 |
| OUI | 000CCAh |
| SHBU Block Assignment | 200h |
| Port / Node ID | 11b |

## 3.0 ATA-7 Streaming Command Set

The ATA standards committee has developed a method of enabling system builders to control a drive's error handling process. This capability is desirable in audio / video processing in order to ensure storage of long data streams. Control of error processing is also desirable in some enterprise applications.

AV systems play and record streams of data. If the stream is interrupted, the interrupt may result in missing audio or video information. There is no advantage to streaming data faster than the AV device requires. Data must be delivered consistently at the rate required.

In AV applications, it may be better to have some small segment of incorrect data delivered in the stream than to have a long delay. Short delays may result in the loss of only a few pixels. A long delay in the data stream would result in the loss of a larger block of data, which would be noticeable to a viewer. A new Streaming Command Set has been developed for ATA drives, and is introduced with the Deskstar 7K400. This feature allows AV products to change drive behavior to meet AV system requirements.

**Disk Drive Behavior**
When a disk drive detects an error, the correction process involves a multi-step process.

The delays are multiples of a revolution time. The drive can detect an error in the data read using the error correcting code at the end of each sector. If the data is not correct, the drive will automatically wait for the disk to go around again and re-read the data. If the drive is unable to successfully write or read data to a particular sector, an alternate is assigned.

The procedure for recovering from a data error can be many revolutions long, using techniques such as micro-stepping off track. For computer systems where the data integrity is the highest requirement, the time delay is acceptable; but for AV systems, a long delay to get perfect data is not required, nor the preferred behavior.

**AV Normal Behavior**
The ATA Streaming Command Set includes a set of tables that describes the normal drive performance. With this information, an AV system can estimate the time it will take to reach a track and the time required to read or write the data.

**AV Error Recovery Procedure Controls**
In computer applications, drives may go into time consuming error recovery procedures to maximize the likelihood of returning correct data. In AV systems, data that is delayed is as useless as bad data. If the buffer runs empty there will be visible defects or a loss of signal. The Streaming Command Set provides controls to set a time limit to stop error recovery. AV systems, using the performance data and the buffer capacity, determine how much time can be allotted to each command. By setting a time limit for each command, the AV system can ensure that any error can be handled quickly, causing minimal visual or audible defects in the AV stream.

It is important to allow drives some error recovery time. At least three revolution times (3 x 8.34 ms) plus the data transfer time is recommended.

**Read and Write Continuous**
The Streaming Read/Write commands support the Read Continuous (RC) bit or Write Continuous (WC) bit. When a stream command is issued with RC or WC bit set, the drive will transfer the best data it can during error conditions, while completing the command within the time limit.

If read data is transferred that is not completely correct, an entry is placed in the Read Stream Error Log. Logging the data performs two functions. An AV system can find the defective data in a stream by looking in the log. During RC operations, the Error bit is not used. Some operating systems go into a long error recovery procedure when they see the Error bit so it is suppressed during RC operations.

WC operations are also supported. There is a much lower probability of detecting an error during writing; but WC is useful in that a command will complete within the time limit by skipping inaccessible sectors and logging the write errors in the Write Stream Error Log.

**AV Optimizations**
The Streaming Command Set has features that allow an AV system to get maximum performance from a disk drive. The Configure Stream command allows the system to tell the disk drive how many simultaneous streams will be used and if they are read or write streams. This information allows the disk drive to optimize its buffer management.
**Handle Stream Error**
An additional optimization provided by the Streaming Command Set is the Handle Stream Error or HSE bit. AV applications may need data that must be correct, like computer system data, for software or file information, etc. The HSE bit allows an AV system to do full error recovery in steps, with other stream commands between attempts to do error recovery. If a command times out, the system can retry the command with the HSE bit set to 1. This causes the command to try again, starting at the

level of error recovery that was reached at the previous try. For example, a system may be running several streams of AV data and also need computer quality data. If an error occurs during the computer data read and the time limit is reached, the data is not returned. The system then services the AV streams, to keep the buffers full, and then retries the computer data command with HSE set to 1. The drive starts where it left off and continues until the data is accurately recovered or the time limit is reached. The system can continue this process until the computer data is recovered, without causing an interruption in the AV streams.

**Summary**
The new Streaming Command Set included in the ATA/ATAPI-7 standard provides a comprehensive set of tools for Audio/ Video disk drive applications.

**The ATA Streaming Command Set Includes:**

- Streaming Performance Log (to describe normal drive performance)
- Error Recovery Time Limits (to prevent long delays for error recovery)
- Continuous Read/Write Controls (to return/use partially correct data)
- Streaming Error Logs (to reduce time delays for system error processing)
- Configure Stream Command (to allow optimum drive buffer management)

Section 10.18 of the HDD specification provides details on the streaming feature set.

# 4.0 Mechanical Enhancements

Hitachi continues the long tradition of enhancing each generation of disk drive. The newest drive, Deskstar 7K400, contains several mechanical enhancements. These design improvements help to protect customer data, while enabling increased capacity and performance. Several of the enhancements were added to reduce air turbulence within the enclosure. Stable air flow is important as areal density continues to increase.

The new enhancements include:

- Mechanical actuator latch system
- Rotational Vibration Safeguard
- Spindle motor

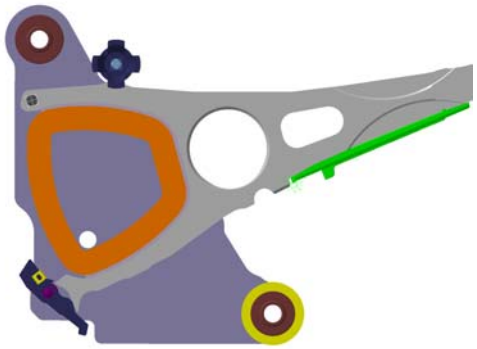
How will these changes benefit the owner of this new drive? All enhancements work to provide fast and accurate access to user data, as well as protecting user data.

**Mechanical Actuator Latch System**
This new feature was first utilized with the Travelstar and Ultrastar designs. The latch helps protect user data in two key ways.

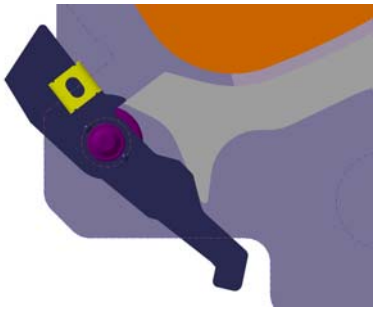
1. The latch enables the heads to be kept on the ramp during non-operation. This protects user data in the event of a severe shock, which might otherwise knock the heads off of the ramp and onto the data area.
2. The data area is also protected during operation. In the event of accidental power down, the heads are prevented from rebounding onto the media after landing on the ramp. This action thus keeps the heads from bouncing on the disks and possibly damaging user data.

Figure 2 : Mechanical Actuator Latch System

Actuator Arm



Close up of Latch



## 5.0 Rotational Vibration Safeguard

Excessive external disturbances (vibration) can cause a disk drive head to move unexpectedly off track. When this situation occurs, the drive's performance is impaired, since the head must reposition itself before reading or writing can resume. Excessive vibration can frequently occur in multi-drive configurations, especially with more than three drives.

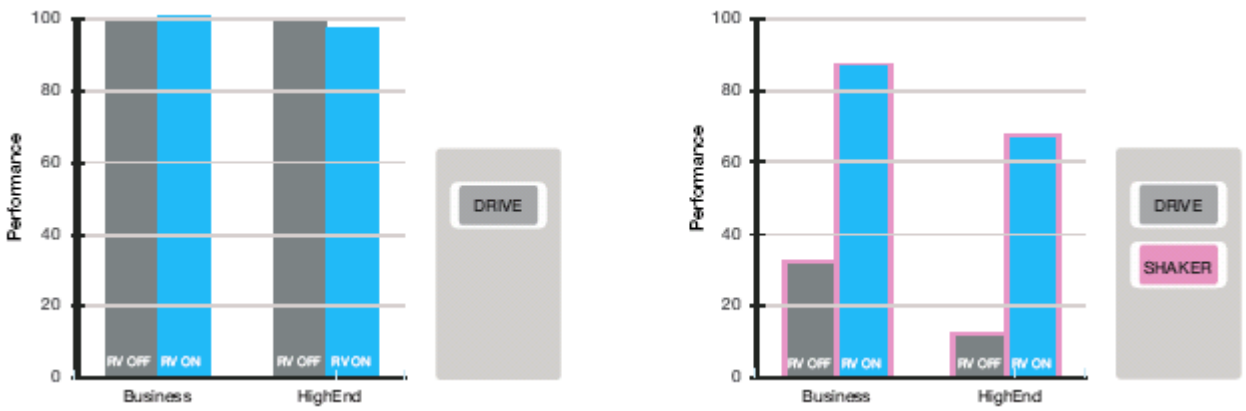
Rotational Vibration Safeguard (RVS) protects the drive from excessive rotational vibration. Two sensors are mounted to the circuit board. Motion detected by these sensors generates electrical signals that are fed to the servo control circuit. By anticipating potential off-track conditions, the drive is better able to adjust so that the heads remain on track. In this way, the effects of external vibration are minimized, providing optimum performance.

Figure 3 illustrates the benefit of RVS. The target drive was tested in two configurations:

- Mounted to an aluminum plate, non-vibrating environment and
- Mounted in a system with a second drive loosely mounted, simulating vibration environment.

The loosely mounted second drive, by actively seeking, served to induce vibration into the target drive. When the RVS is active, performance is restored as proven in each benchmark test.

Figure 3 : Performance Advantage of RVS Spindle Motor



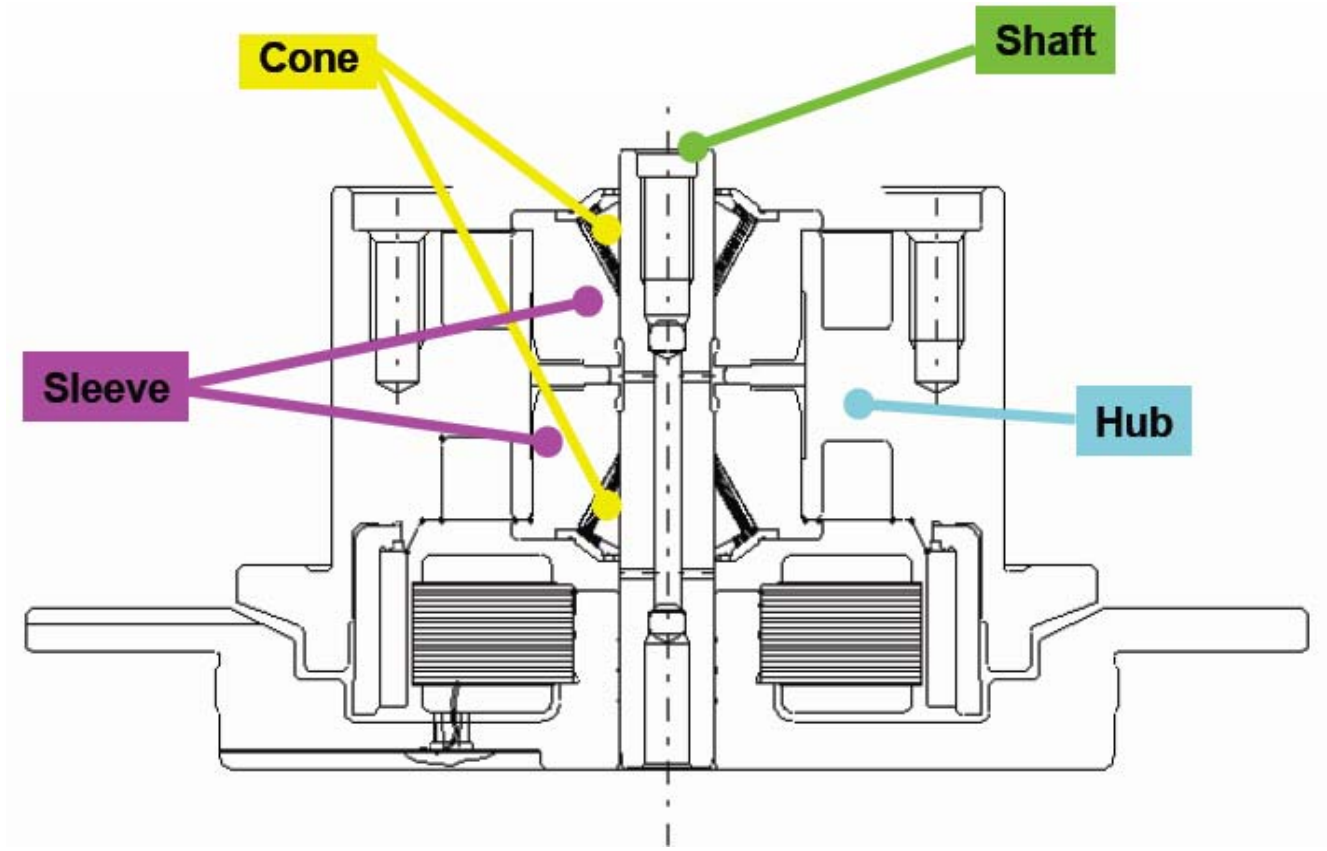

**Spindle Motor**

The new spindle motor for the Deskstar 7K400 was first proven with enterprise or server-class drives. This motor was designed for continuous spin operation. A key concern with spindle motors relates to increases in track density.

The design is optimized for repeatable run-out (RRO) and non-repeatable run-out (NRRO). Thus the heads can track-follow, reducing time to find user data.

This motor also better accommodates the five disks of the 7K400. Like the past several generations, the motor is the fluid bearing type. The fluid bearing provides both quiet operation and better shock protection than steel ball bearings. For added stability, the motor shaft is secured both top and bottom.

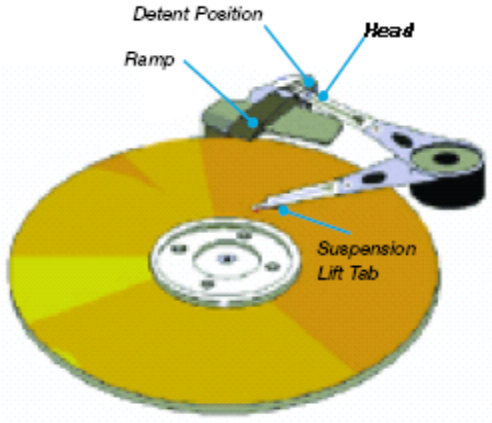
Figure 4 : Spindle Motor Diagram




## 6.0 Head Load / Unload

The 7K400 is now the fifth generation Deskstar to utilize load/unload. The head load/unload mechanism is provided to protect the user data stored on the disks during shipping, movement, or storage. Upon power down, the heads automatically unload from the disk area and the locking mechanism of the head actuator will secure the heads in the unload position.

Figure 5 : Load/Unload Ramp Technology



Hitachi Global Storage Technologies
5600 Cottle Road
San Jose, CA 95193
Produced in the United States

08/04



19 August 2004