Sun T10000 Tape Drive and Industry Tape Futures

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Introducing the T10000 Enterprise Tape Drive: The Next Generation in Capacity Storage

Highest Throughput at 120 MB/s
500 GB Cartridge can be re-used at 1 TB with next Generation Drive
Introducing T10000 Enterprise Tape Media …

StorageTek T10000 media combines high-capacity, performance, and reliability in an aggressive cost-per-gigabyte solution, without compromising data integrity.

- **T10000 Data Cartridge**
  - 500 GB native for maximum capacity
  - 62 second average access time*

- **T10000 Cleaning Cartridge**

- **T10000 VolSafe Cartridge**
  - Secure Media Technology (WORM)

- **T10000 Sport Cartridge**
  - 120 GB native short length for fast access
  - 28 second average access time*

*Includes load and thread times
Technology Introduction

- Higher areal density

<table>
<thead>
<tr>
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<th>9940B</th>
<th>T10000</th>
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</thead>
<tbody>
<tr>
<td>Areal Density (Mbits/inch²)</td>
<td>241</td>
<td>400</td>
</tr>
<tr>
<td>Number of tracks</td>
<td>576</td>
<td>768</td>
</tr>
<tr>
<td>Linear bit density (Kbits/inch)</td>
<td>157</td>
<td>214</td>
</tr>
</tbody>
</table>

- Introduce New Media
  > Move to advanced MP media
  > Smaller magnetic particle size
  > Support higher areal densities

- Key New Drive Technologies
  > SafeGuide™ Tape Guiding System
  > Dual Head Technology – 32 Channel head
T10000: a look under the covers

- Enclosed take-up reel
- New buckler design, no leader pin or block
- Media passes 1 meter drop test, RFID for MIR redundancy
- Cartridge loader designed to 9310/SL8500 specs
- Dual 16 channel R/W Heads (Under Plate)
- Dual speed motor & 256MB buffer to deliver high and low throughput operation
- Dual fan airflow design keeps electronics cool without flowing through the tape path
- 5 roller tape guiding on the back of the media
Mechanical View
Tape Path and Leaders
T10000 Dual 16 Channel Heads

- Reduces required tape velocity needed to achieve high data rates
  > Better servo control
  > Architecture that is easily extendable to higher transfer rates

- Reduces the number of passes to fill a tape
  > Less wear on tape and drive

- Improved Error Correction Capability
  > Spreading data block over a larger area yielding higher data reliability
T10000 Recording Head

- Dual 16 parallel channel MR read / write head
  - Write track width of 12.8 microns
  - Read track width of 6.8 microns
  - Read head fabricated on write head with shared shield
T10000 Technology - Media

- Employing latest media technology (MP3+)
  - Smaller particle size (45 nm)
  - Higher coercivity (2500 Oe)
  - 6.50 micron media thickness (0.12 micron magnetic thickness)
- Cartridge/media is demonstrated to support 1 TB capacity
New Media Cartridge

- Over 900 meters (1/2 mile) of tape in cartridge
- RFID memory (4 kB) located in cartridge
- Leader used to load tape into drive
- Interface with library grippers and vision systems
NEW Unique Cartridge Hub Locking System

• Hub Lock Technology
  > Media is locked from rotation and wobble inside the cartridge when not in use
  > The hub can be turned by the drive or with a tool

• Benefits
  > Reduced edge damage to the media
  > Increased media reliability
T10000 Tape Path

- **Unique backside media guiding**
  - No guide contact to magnetic recording surface
  - Limits surface wear on media
- **Unique long tape path**
  - 5 flanged and grooved rollers
  - Increased data reliability
T10000 Servo Pattern

- Servo pattern used to accurately place tracks on media
- Timing Based Servo (TBS) servo pattern developed with improved tracking capability
- Magnetic pattern recorded on tape; 5 bands
- Longitudinal position (LP) detection
- Extendable to over 1000 tracks on tape
Data Format on Tape – More detail

- Each of the two recording heads operates in half of the tape
  - Head 0 operates in the Band 0,1 domain.
  - Head 1 operates in the Band 2,3 domain.
Tape Drive Futures: an Industry Perspective
2005 INSIC Tape Roadmap

Roadmap Leadership Team

INSIC: C. Denis Mee, Barry Schechtman, Sharon Rotter, Paul Frank
Applications Section: Gary Francis (InflectionPoint Strategies)
Technology Section: Bob Raymond (Sun Microsystems)
  Heads: John Moore (Certance, now Quantum)
  Media: Mike Sharrock (Imation)
  Channel: Scharmin Dorostkar (Quantum)
  Drive: Paul Poorman (Hewlett-Packard)
  Helical Scan: Jeff Laughlin (Sony)
2005 INSIC Tape Roadmap

- 10 year roadmap.
- Consensus of over 80 researchers (up from 40 for 2002 roadmap)
  - Representing virtually every large tape drive manufacturer, tape media and substrate supplier, many of the leading research universities.
- Primarily focused on linear tape (helical scan section by Sony).
- Focus on smallest unit of storage
  - Tape cartridge (1/2” form-factor)
  - Hard disk drive (3.5” single-platter form-factor)
- Goal to remain competitive with disk ($/MB) and be technically feasible.
  - Assume:
    - Disk capacity growth will be 30%/year
    - Disk data rate growth will be 15%/year
- Define pre-competitive research
Capacity and Data Rates

\[ \text{Capacity} \sim (tpi)(bpi)WL\varepsilon \]

\[ \text{DataRate} \sim n(bpi)v\varepsilon \]

\( tpi = \text{track density}, \ bpi = \text{bit density}, \ L = \text{length of tape}, \)

\( W = \text{width of tape}, \ \varepsilon = \text{efficiency}, \ n = \text{number of channels}, \)

\( v = \text{tape speed} \)
INSIC International Magnetic Tape Storage Roadmap 2005

Three Scenarios for Tape Technology Evolution

**Scenario 1:** High Bit Density

**Scenario 2:** High Track Density

**Scenario 3:** Wide Tape 12.7mm ->18mm
# INSIC International Magnetic Tape Storage Roadmap 2005

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<tbody>
<tr>
<td>Capacity (TB)*</td>
<td>0.4</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>8</td>
<td>16</td>
<td>41% per year</td>
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<tr>
<td>Data rate per channel MB/sec**</td>
<td>5</td>
<td>7.3</td>
<td>10</td>
<td>14</td>
<td>19</td>
<td>26</td>
<td>17 % per year</td>
</tr>
<tr>
<td>Total data rate MB/sec</td>
<td>40-80</td>
<td>120</td>
<td>195</td>
<td>316</td>
<td>513</td>
<td>832</td>
<td>27% per year</td>
</tr>
<tr>
<td>Number of channels</td>
<td>16</td>
<td>16</td>
<td>19</td>
<td>23</td>
<td>27</td>
<td>32</td>
<td></td>
</tr>
<tr>
<td>Tape thickness (µm)</td>
<td>8</td>
<td>6.86</td>
<td>6.06</td>
<td>5.36</td>
<td>5.00</td>
<td>5.00</td>
<td>-5% per year (2007-2013)</td>
</tr>
<tr>
<td>Tape length (meters)</td>
<td>680</td>
<td>772</td>
<td>874</td>
<td>989</td>
<td>1060</td>
<td>1060</td>
<td>5% per year (2007-2013)</td>
</tr>
<tr>
<td>Linear track density (TPI)</td>
<td>1776</td>
<td>2777</td>
<td>3889</td>
<td>5446</td>
<td>8058</td>
<td>12771</td>
<td>21% per year</td>
</tr>
<tr>
<td>Linear bit density (KBPI)</td>
<td>245</td>
<td>314</td>
<td>394</td>
<td>494</td>
<td>620</td>
<td>777</td>
<td>12% per year</td>
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<tr>
<td>Areal density (Gb/inch²)</td>
<td>0.435</td>
<td>0.87</td>
<td>1.53</td>
<td>2.69</td>
<td>4.99</td>
<td>9.93</td>
<td>36% per year</td>
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<tr>
<td>Tape speed (meters/sec)</td>
<td>5.4</td>
<td>6.7</td>
<td>7.3</td>
<td>8.0</td>
<td>8.7</td>
<td>9.6</td>
<td>5% per year</td>
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</tbody>
</table>

* User capacity excludes 15% servo/track layout and 29% ECC and formatting overhead
** 29% ECC and formatting overhead
*** Calculated to meet minimum requirement of 260 full media passes

**Roadmap Scenario 1. Scenario 1 pushes the linear bit density to a critical point to reduce track density risk.**
Capacity Trends

IBM/Fuji 2006 demo
2005 INSIC Roadmap

Linear Tape
Helical Tape
Data Rate Trends

- Linear Tape
- Helical Tape
- 2005 INSIC Roadmap
Linear Bit Density Trends

Year

Kbpi


IBM/Fuji 2006 demo

High bpi scenario

High tpi scenario

2005 INSIC Roadmap

Linear Tape

Helical Tape
Track Density Trends

- High TPI Scenario
- IBM/Fuji 2006 demo
- High bpi scenario
- 2005 INSIC
- Linear Tape
- Helical Tape


TPI: 100, 1000, 10000, 100000
Channel Trends

Sun T10000
32 channel dual head

2005
INSIC

Year


Number of channels

1.0 10.0 100.0

Thank You!
HDD Areal Density Trends

- Longitudinal demos
- Perpendicular demos
- Products

Areal Density (Gbits per square inch)

Year


Historical demos
1999 demos
190 %/yr

1999 demos
190 %/yr

2000-2 demos
40 %/yr

Recent demos
30 %/yr

Recent products
30 %/yr

Products 1998-2002
100 %/yr

Products 1998-2002
100 %/yr