HIGH DATA RATE
OPTICAL TAPE RECORDING

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LOTS TECHNOLOGY CHARTER

DEVELOP AND PRODUCE A FAMILY OF HIGH PERFORMANCE LINEAR OPTICAL TAPE DRIVES FOR THE DATA STORAGE AND VIDEO INDUSTRIES

BASED ON 3480 & DUAL REEL (DTF) Sized MEDIA BIDIRECTIONAL SERPENTINE FORMAT

USE PROPRIETARY TECHNOLOGY TO ESTABLISH POSITION IN HIGH END MARKET:

1) MULTI BEAM OPTICAL WRITING
2) FAST TAPE TRANSPORT

HIGH DATA RATE: 25 - 200+ Megabytes/s.
HIGH MEDIA CAPACITY: 1 TB Mono Reel, 2 TB Dual Reel
REQUIREMENT

- IMPROVE ALL SYSTEM PARAMETERS

- Standards
- Reliability
- Technology Stability
WHY OPTICAL TAPE?

• **Lower Costs, Much Higher Capacity/Media Unit**

  = Less Media, Smaller Robots, Autoloader < 10TB.

• **Faster Data Access**

  Due to Higher Data Density: Fast Fwd. @ 30 GB/Sec.

• **Higher Data Rates**

  Due to Higher Data Density & Faster Tape

• **Archival** Media Now > 100 yr., **Rewritable** Media Later

• **Non Contact Recording** = Better Reliability

  No Head Wear, Very Low Media Wear

• **Longer Lived Hardware** Due to Fewer Media Mounts
Basic Multi-beam System

Beamforming Hologram, 8xN Beams in 2D array

Objective Lens & Focus Track Actuator

8xN Simultaneous Tracks per Group, & Multiple Groups Across Media Width

Moving Media

532 nm Laser

8xN Modulator Array

8xN Data Detectors

Focus & Track Servo

8xN Simultaneous Tracks per Group, & Multiple Groups Across Media Width

Moving Media
Optical Implementation

Laser
Focus & Track Actuator
Beamforming Hologram N x 8 Beam Array
Reflective Spatial Light Modulator - N X 8 Array
Tape Media
Beamsplitters
Focus & Track Detector
Data Detector

Optical Elements

Writing Beam
Focus & Track and Data Beams
BEAMFORMING HOLOGRAM

Single Collimated Beam Input, Multiple Collimated Outputs.

- All Beams Diffraction Limited
- Two Dimensional Fan
- 8xN Beams, e.g. for N = 4

All Beams Focus In Same Plane
Beam Forming Pattern
8 x 8 Array = 64 Beams

8x8 Array @ 12.5 Mb/s. User Data Rate per bit Track (PPM) = 800 Mb/sec. for Group

TAPE MOTION

- 0.8 micron
- 56.2 microns
- 2.5 microns
- 7.125 degrees
Modulator Pattern
8 x 8 Array = 64 Beams

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<th>1,2</th>
<th>1,8</th>
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~ 2mm

20%

80%

HR Coating
Optical Modulation @ 12MHz allows writing PPM data at 16.7 Mbits/sec. per track, e.g. 64 tracks = 1069 Mbits/sec. ⇔ 800 Mbit/sec. User Data Rate.
LOTS High Speed Tape Transport & Optical Servo System;
- Provides Sub-Micron Tracking at 10 m/Sec.
160T FORMAT

200 BOT, 64 data tracks/group, 10 GB each.
Bidirectional Serpentine

Track Group = 64 data bits
64 tracks, 0.8 micron/track
= 51.2 microns/group,
+ 5 micron group spacing,
= 56.2 microns/group
200 Trk. Groups =11.24mm

200 Track Groups across 12.7 mm tape
each of ~ 10 GB
for 650m Length
Media in Cassette
DATA RATES, PPM Encoding

User Data Rate
Mbits/sec.

Data Rate vs. No: Bit Tracks/Group & Tape Speed

Current Design Tape Speed

0 2 4 6 8 10 12 14
TAPE SPEED  m/sec.

0 400 800 1200 1600 2000

128 Bit Trks/Gp.

64 Bit Trks/Gp.
DATA RATE GROWTH

• MAINTAIN BASIC FORMAT FOR COMPATIBILITY

  532 nm Laser & 0.8 Micron Track Spacing

• Increase Bit Track Parallelism, Larger Group

• Increase Media Transport Speed

• Denser Encoding
POTENTIAL DATA RATE - 1 GB/s.?
Using PWM & Higher Tape Speed

User Data Rate
Giga bits/s.

Data Rate vs. No: Bit Tracks/Group & Tape Speed

TAPE SPEED  m/sec.

16
12.8
9.6
6.4
3.2
1.28
0

1 GB/s.

512 Trks/Gp.

256 Trks/Gp.

128 Trks/Gp.

64 Trks/Gp

X
160T Configuration - ‘DTF Cassette’

Loader
Media Transport
Cassette
Front Panel
Air Pump
Optical Head
Laser
Power Supplies
Connectors
Air Filter
PCBs
## Media Parameters vs. Capacity

<table>
<thead>
<tr>
<th>Media Package Size</th>
<th>‘3480’</th>
<th>‘DTF’ (Center Park)</th>
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<tbody>
<tr>
<td>Media Thickness - microns</td>
<td>13</td>
<td>9</td>
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<tr>
<td>Media Length - m</td>
<td>500</td>
<td>720</td>
</tr>
<tr>
<td>Capacity, PPM - TB</td>
<td>1.0</td>
<td>1.4</td>
</tr>
<tr>
<td>Capacity, PWM - TB</td>
<td>1.6</td>
<td>2.3</td>
</tr>
<tr>
<td>Capacity, PRML - TB</td>
<td>2.4</td>
<td>3.4</td>
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<tr>
<td>Time to EOT @15 m/s - s</td>
<td>33.3</td>
<td>48</td>
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PPM Access Rate = 30GB/s; PWM Access Rate = 48 GB/s
CONCLUSIONS

• 0.532 MICRON (GREEN) LASER & ASSUMING
  LARGE TRACK GROUPS > 128 TRACKS
  HIGH SPEED TAPE > 20 m/s
  THIN MEDIA BASE ~ 6 MICRONS

• POTENTIALLY PROVIDES
  DATA RATES > 1GB/s
  CASSETTE CAPACITY > 5 TB

• BEYOND THIS, FAR IN THE FUTURE:
  0.4 MICRON --- 1.33X DATA RATE & 1.75X CAPACITY
  PRML ---- 1.5X DATA RATE & 1.5 X CAPACITY

• COMBINING ALL FACTORS, Data Rate > 2GB/s & Capacity > 10 TB