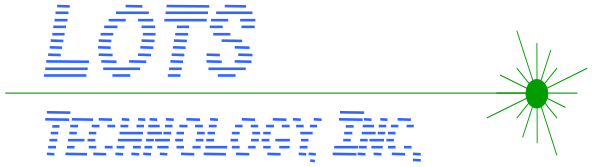
Optical Head Design for an Optical Tape Drive of 1 Tera-Byte Capacity

Presented by

Mahdad Manavi

LOTS Technology, Inc.



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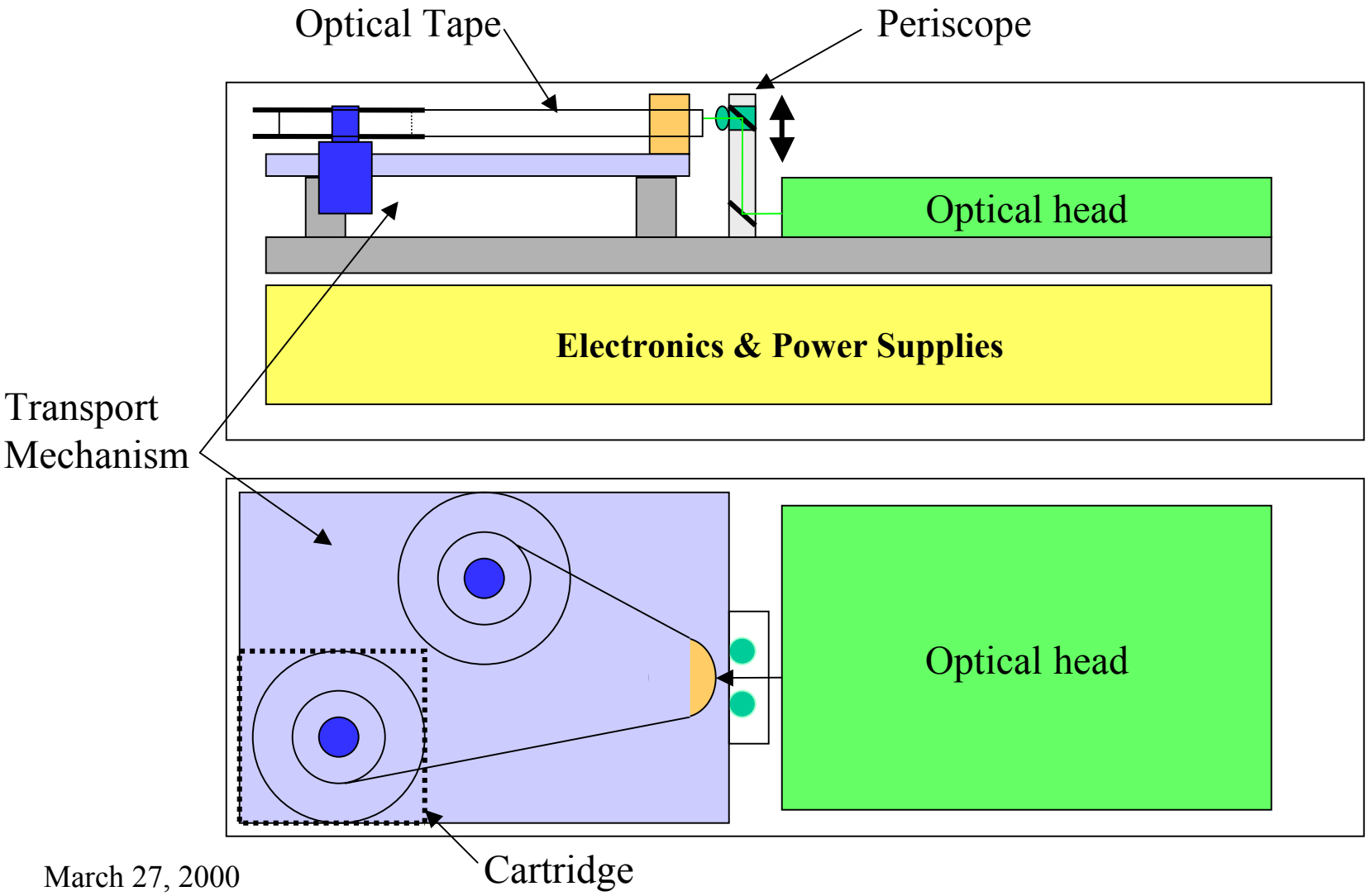
Special Thanks to:

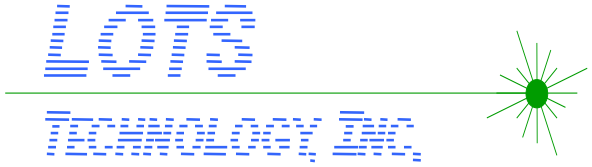
Dan Soo, William Oakley

Drive Specification

- 25 MB/sec. user data transfer rate for both read and write operations
- 1 TB user data capacity in a 3480 sized cartridge
- Robotic compatible
- Write once archival media
- Low wear, rapid access linear transport
- Guaranteed tape interchange capability

Typical Drive Layout





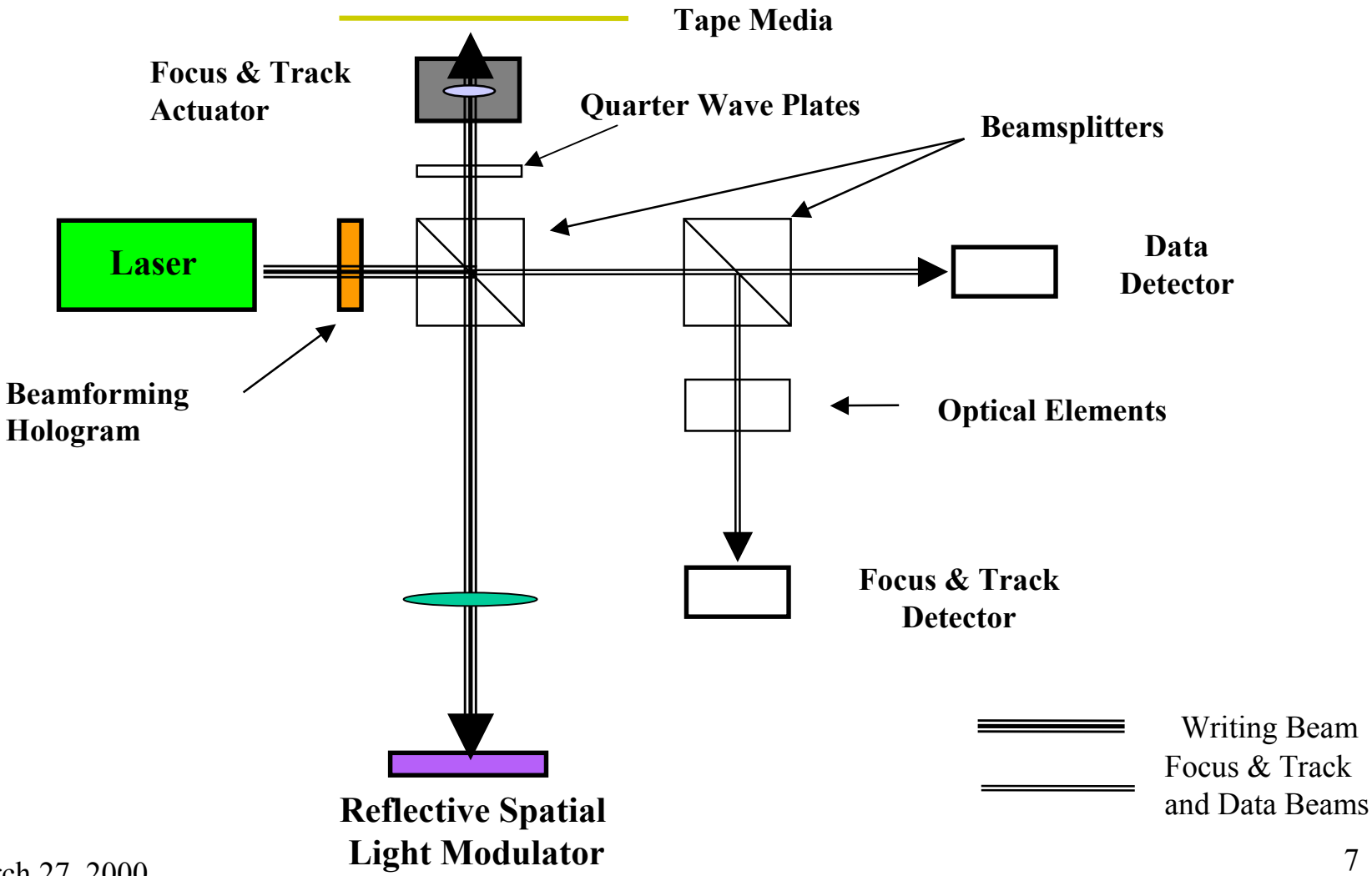
Why Optical Tape - 1

- Much higher capacity per removable media unit than any storage device in the market
- Archival Media: greater than 30 years life
- Non-contact recording and read-back, results in zero head wear and minimal tape wear

Why Optical Tape - 2

- Minimal contact between transport and tape further enhances tape operational lifetime
- High tape capacity results in fewer media mounts, thus causing less wear on robotics and cartridge

Optical Head Layout

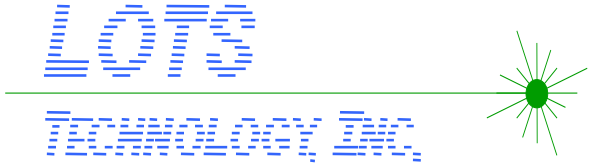


Main Advantage of Approach

- Single laser and hologram generates a beam array
- Each beam acts as a read/write head
- Each beam independently modulated by electro-optic modulator to record data on tape
- We do not use a laser diode array to generate multiple beams.

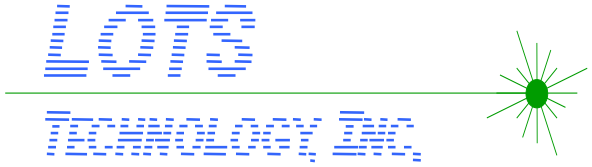
Laser

- Doubled YAG ~ 532 nm
- Small size package
- Wavelength evolution avoided: ensures backward compatibility so far as optical tape optimization and tape interchange issues are concerned



Beam-Array Former - 1

- Use of hologram with Nd:YAG laser wavelength stability insures controlled spot array magnification at the tape plane
  - A controlled spot array magnification subsequently insures tape interchangeability.
- Much lower cost approach than laser diode array



Beam-Array Former - 2

- Additional advantage of this design approach:
  - Very high data transfer rates readily available at a given tape speed by increasing number of laser beams
    - i.e. a new hologram with a larger beam array and matching modulator

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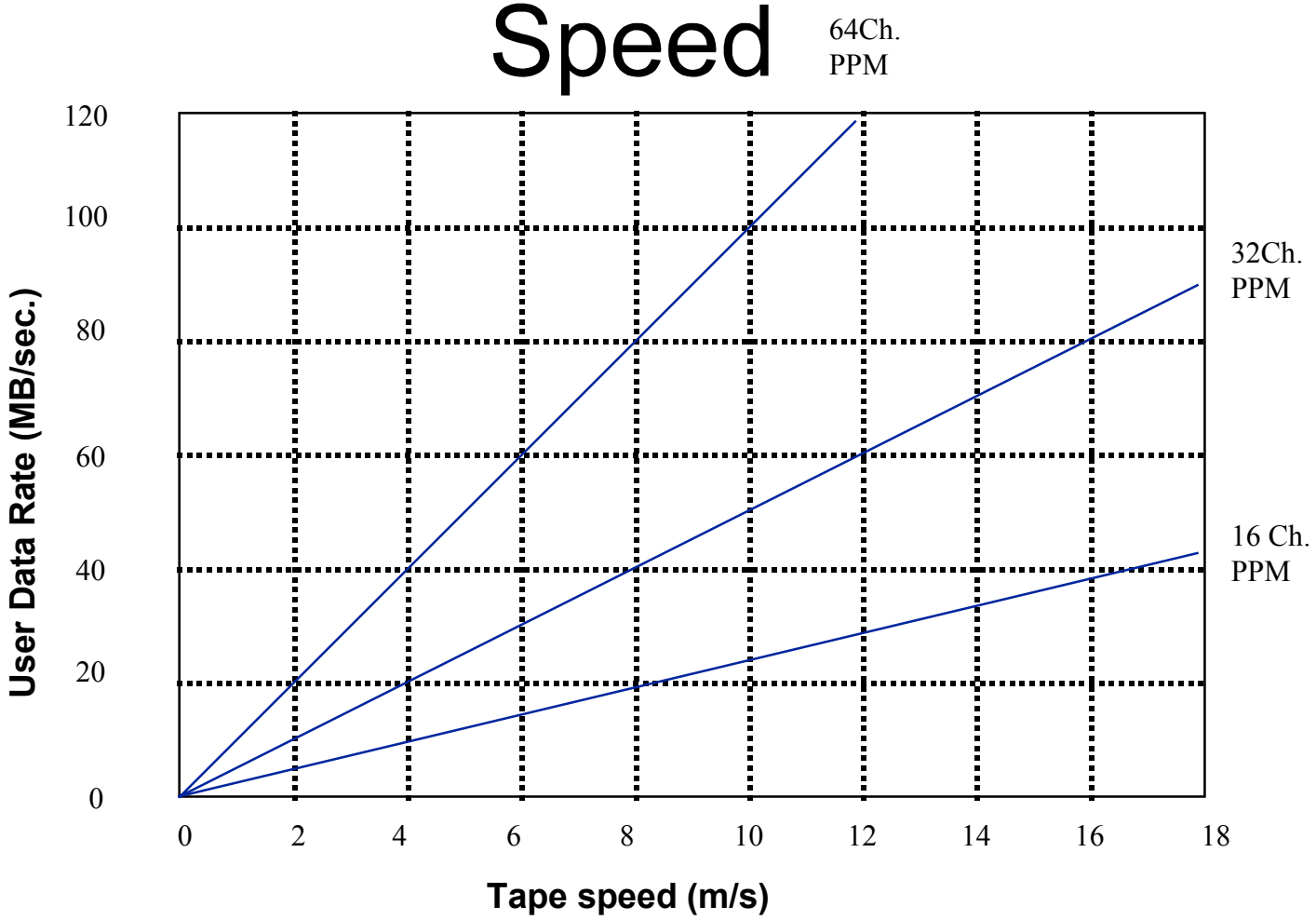
Data Transfer Rate Vs. Tape Speed



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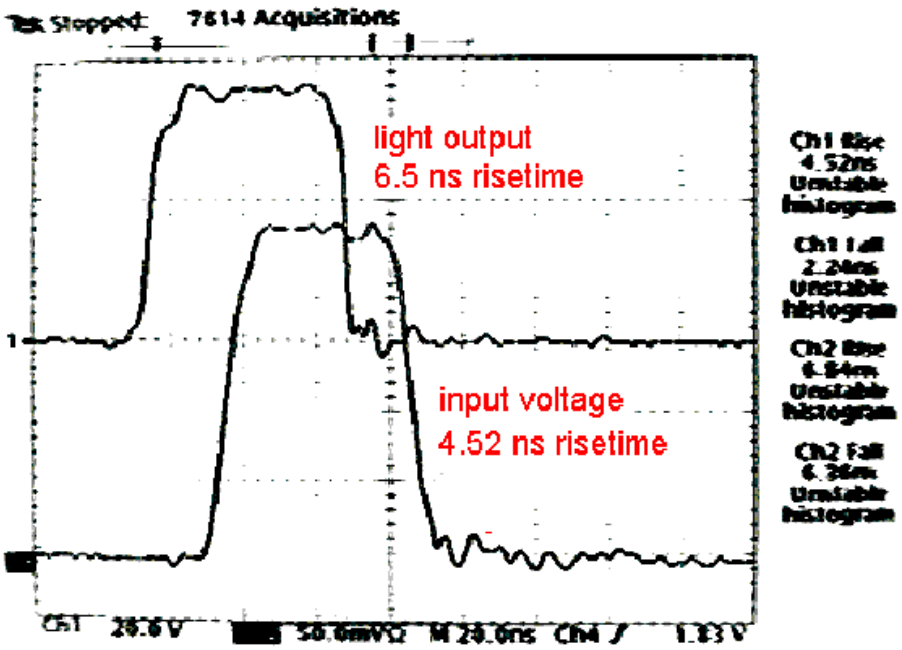
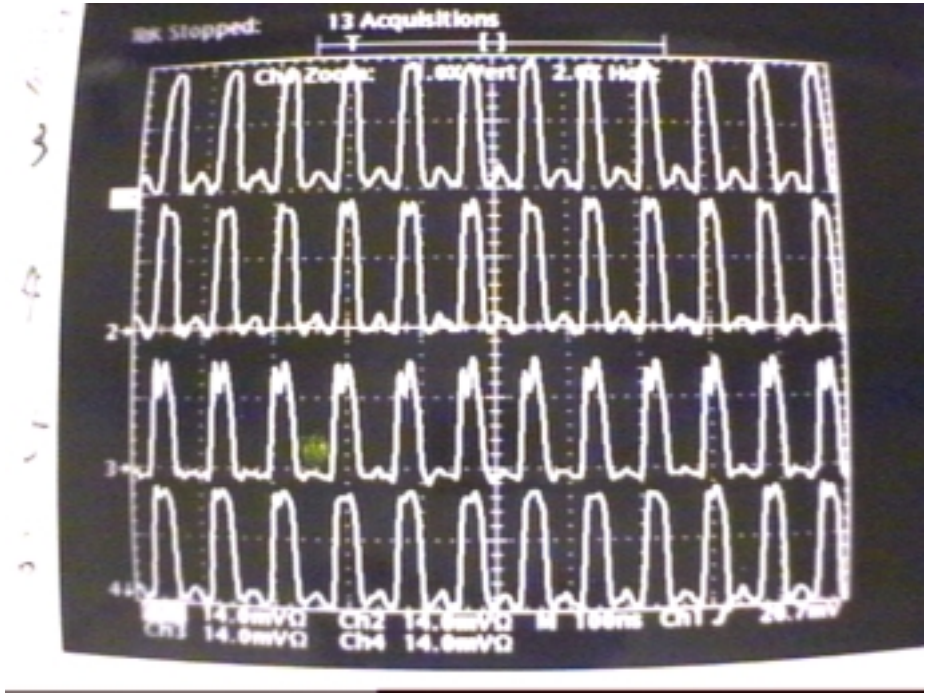
Electro-Optic Modulator

- Design proprietary to LOTS Technology
- The laser beam-array is imaged onto the electro-optic modulator array
- Polarization of each beam is modulated according to the write channel data stream
- With polarization selection, write beams that reach the optical tape plane form a mark.

Electro-Optic Modulator



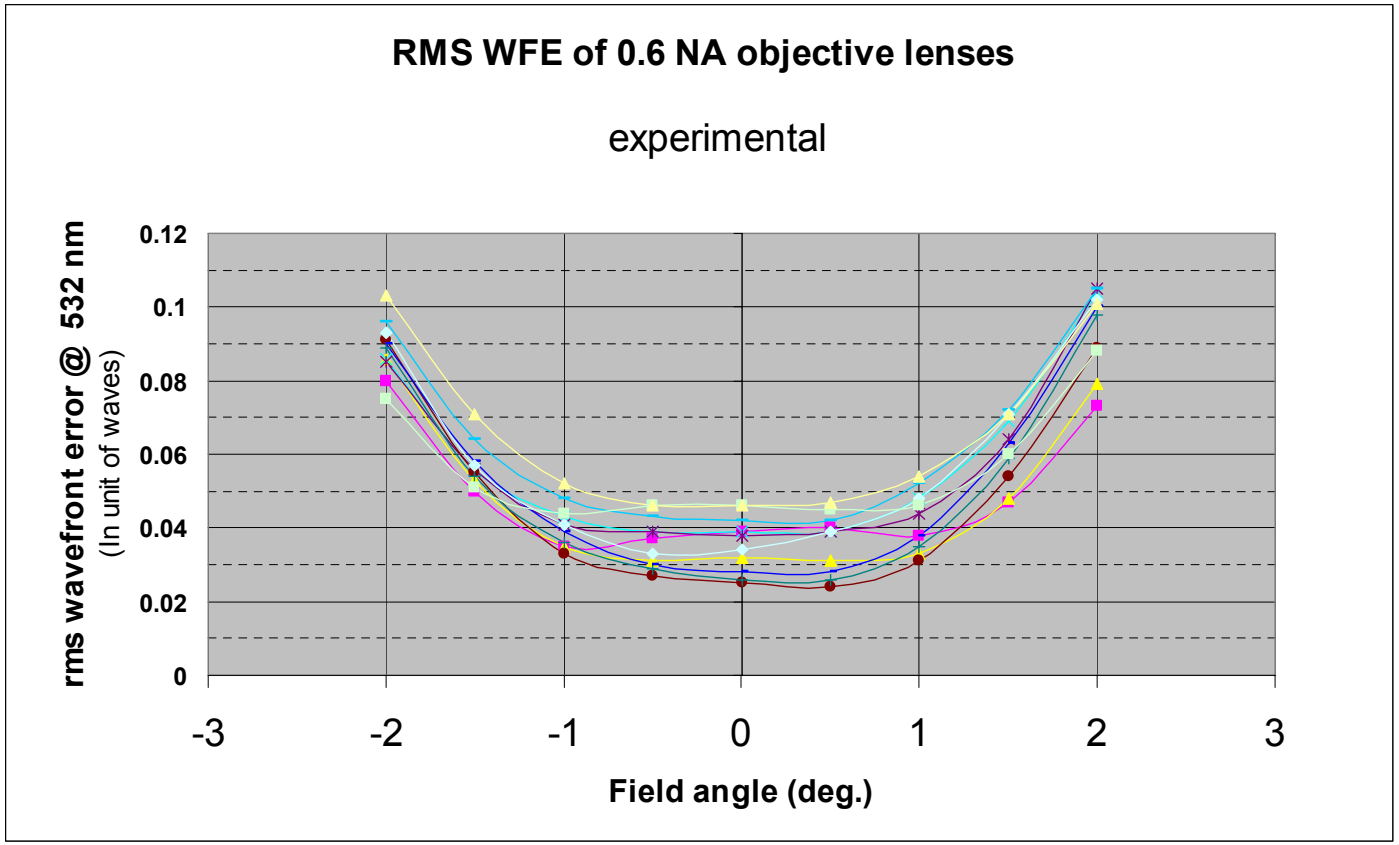


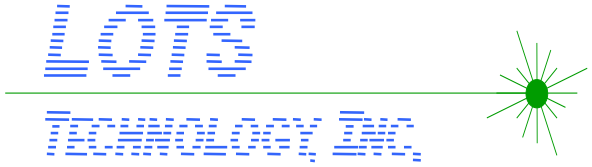
- Required per channel modulation is 11.47 MHz.

Objective Lens

- Single element
  - easy to fabricate
  - simple alignment
  - low mass (i.e. usable in a focus actuator)
- 0.6 NA
  - sub-micron diffraction limited spot
- Flat field to ± 1 degree
  - all beams in a large array, focus on a flat plane (tape plane)

Objective Lens



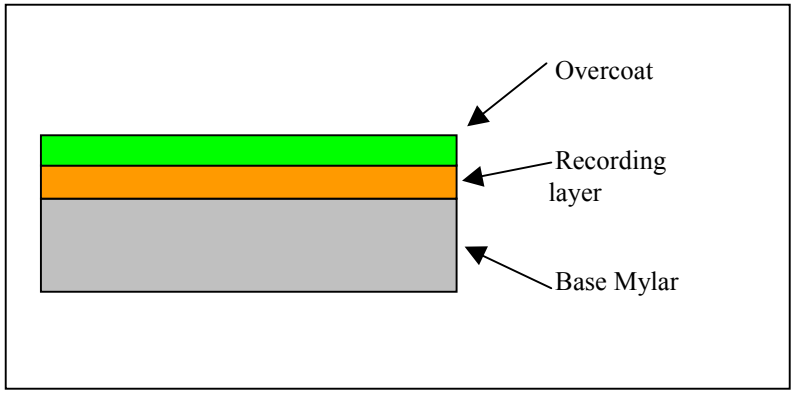


Media Structure

- Media is WORM type
  - Media is archival with greater than 30 years life span
- Active material is a Kodak proprietary vacuum deposited amorphous thin film of SbSnIn (Antimony,Tin,Indium) alloy.
- Crystallization near instantaneous when alloy heated to about 250 degrees C.

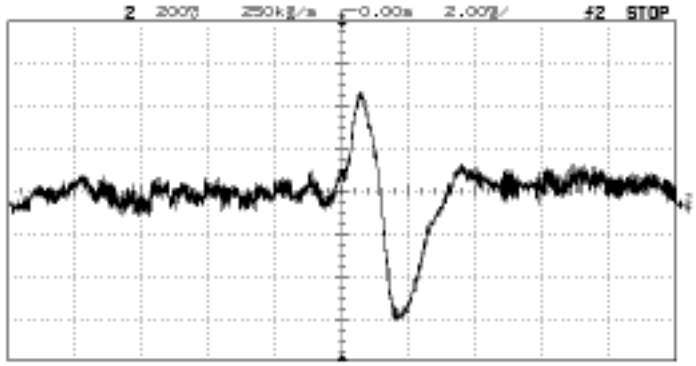
Media Structure

- Overcoat layer thickness optimized for:
  - tracking error signal amplitude
  - data signals amplitude
  - required write power

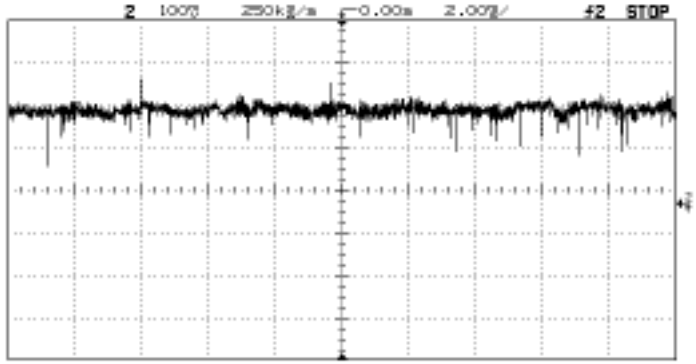


Tape Handling

- Residual focus error 0.1 µm, p-p at 10 m/s tape speed.
- Depth of focus, 0.8 µm p-p.



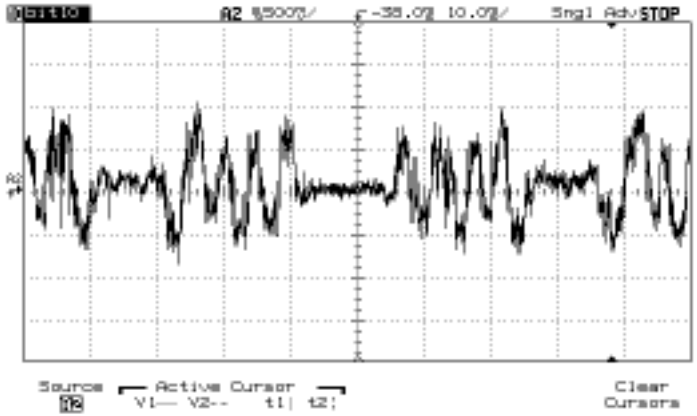
FES S-curve



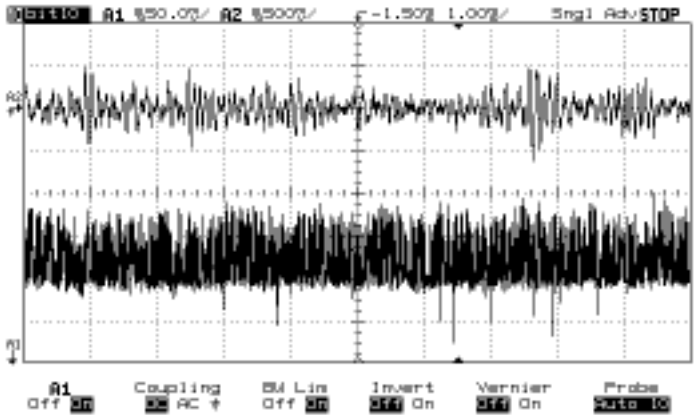
Closed focus loop (700 Hz BW) with tape at 10 m/s

Tape Handling

- Residual track error 0.07 µm 0-p at 10 m/s tape speed.
- Track spacing ~ 0.8 µm.



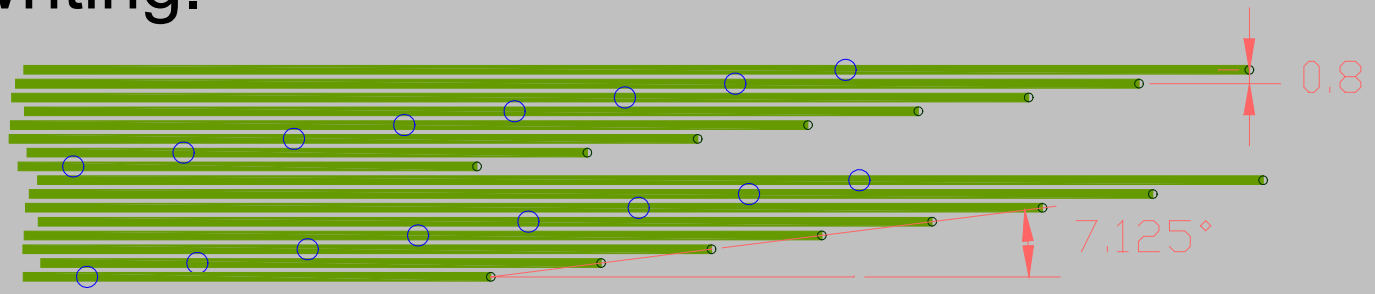
TES S-curve



Closed loop tracking (3 KHz BW) with tape at 10 m/s

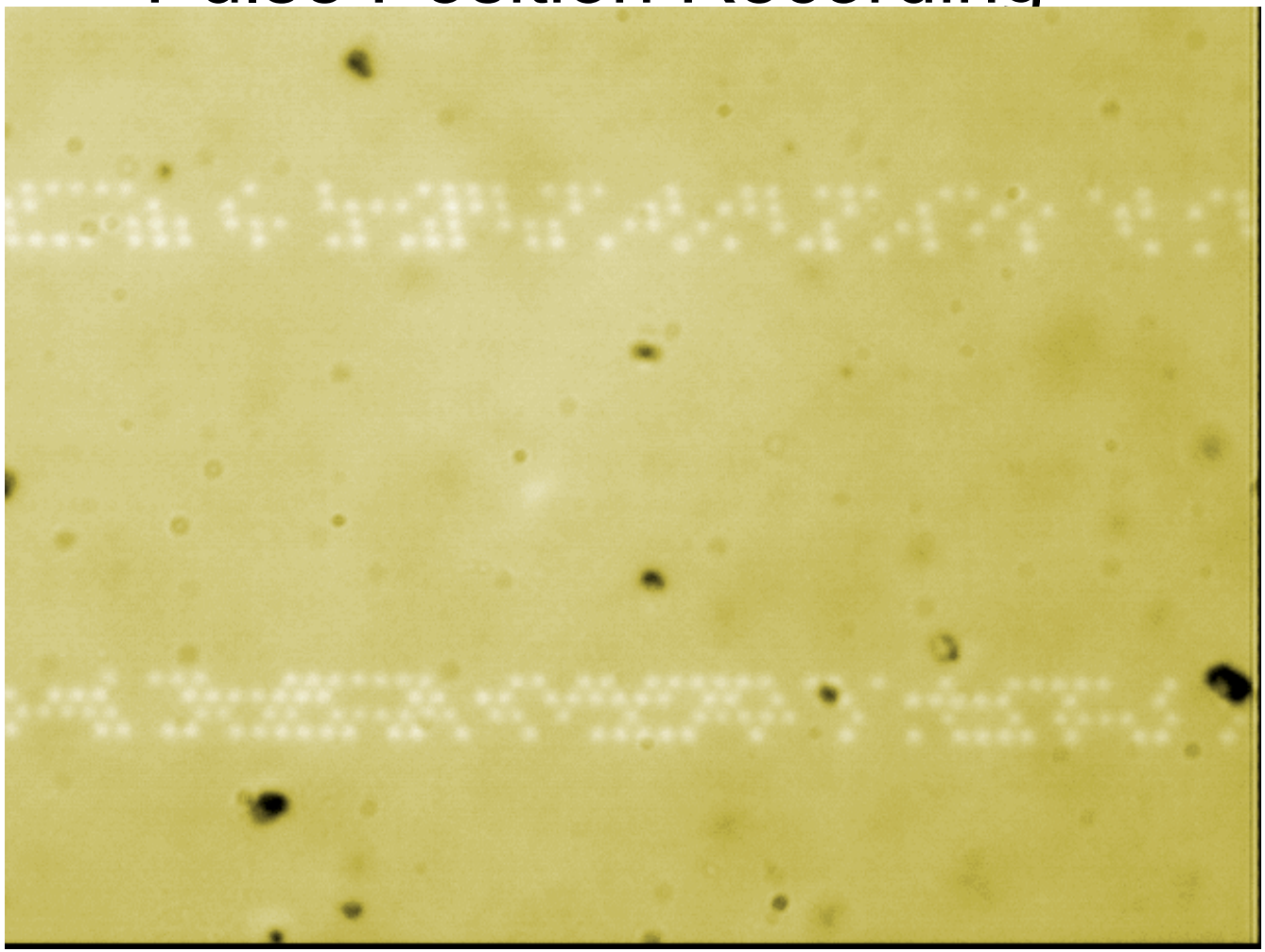
Optical Head Skew Angle

- The optical head must be skewed relative to the tape to insure equal track spacing while writing.

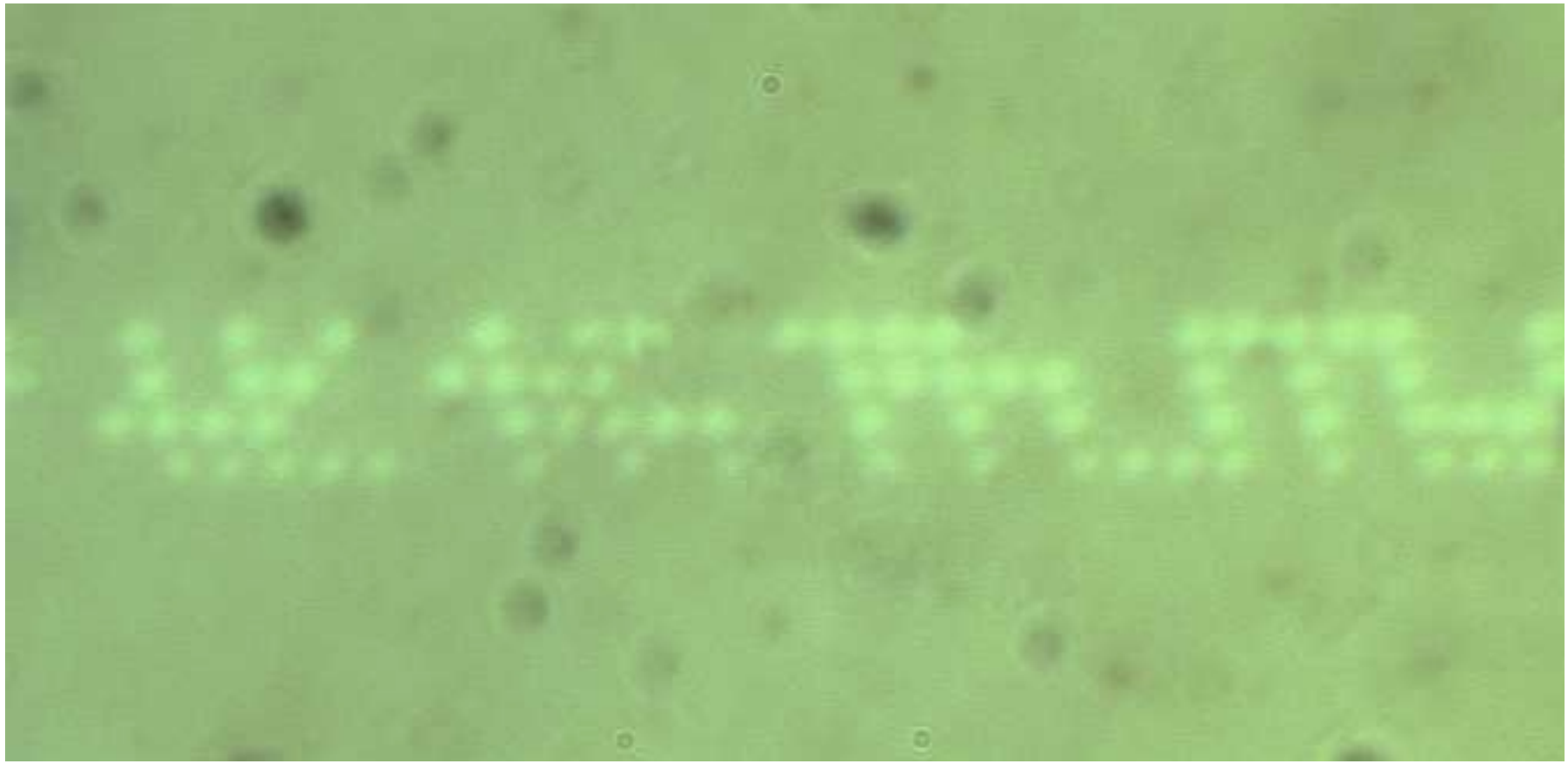


Tape Surface Photo

Pulse Position Recording

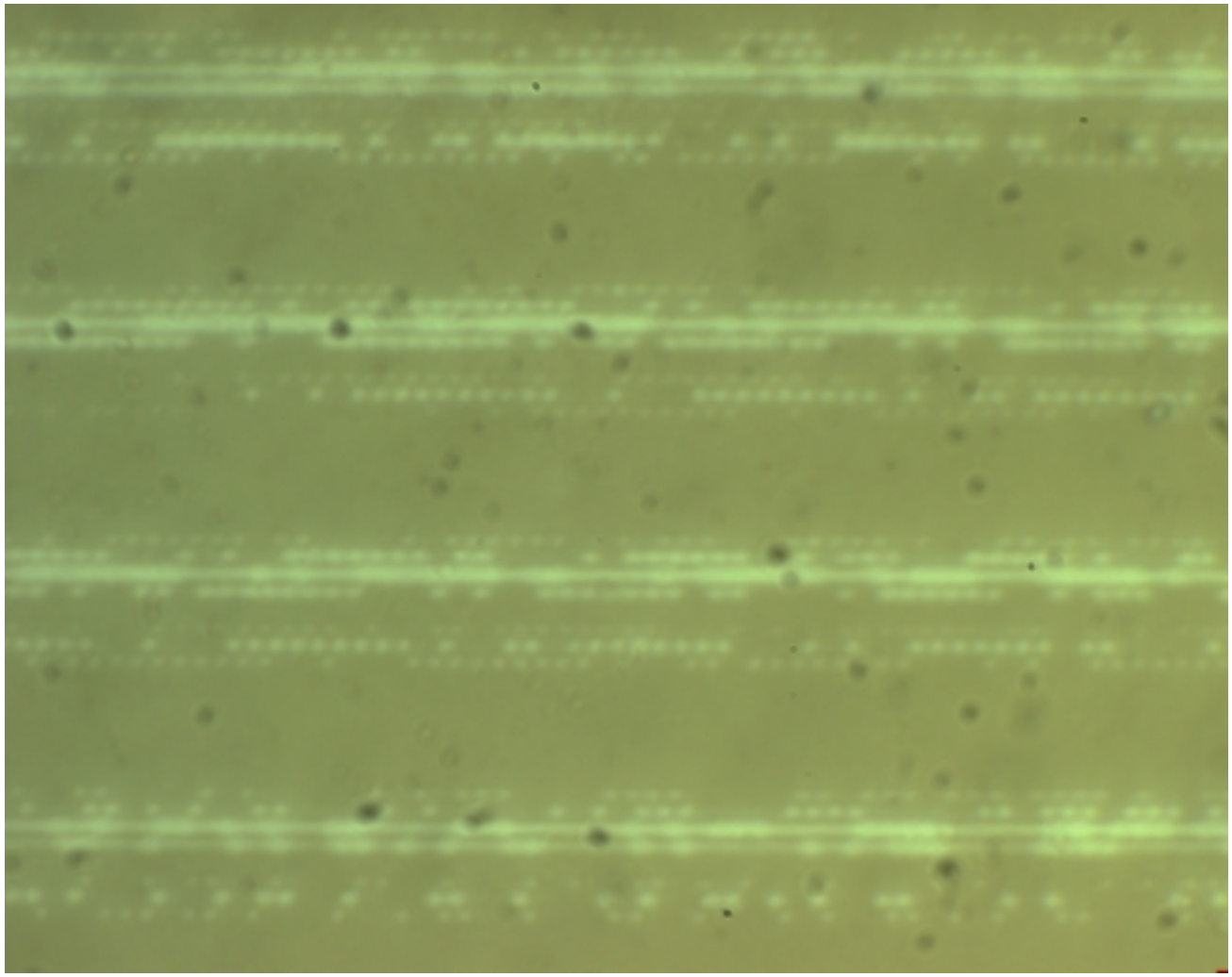


Tape Surface Photo
(Enlarged)

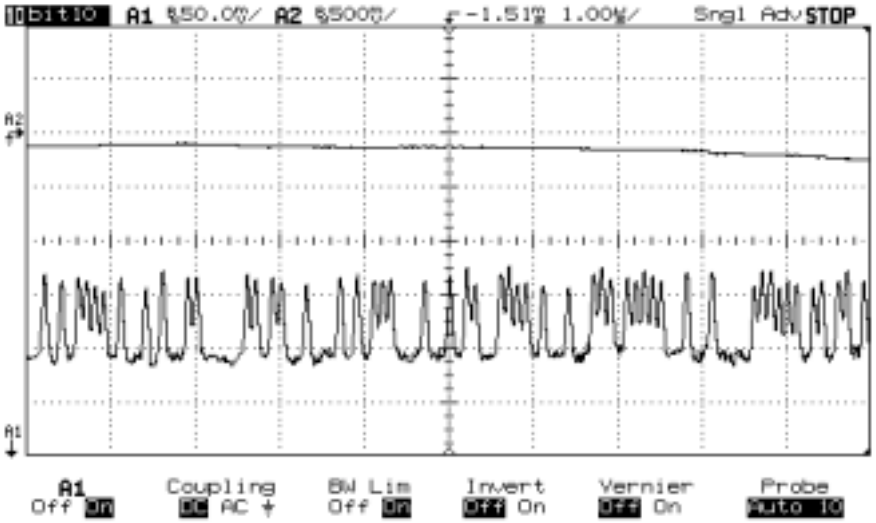


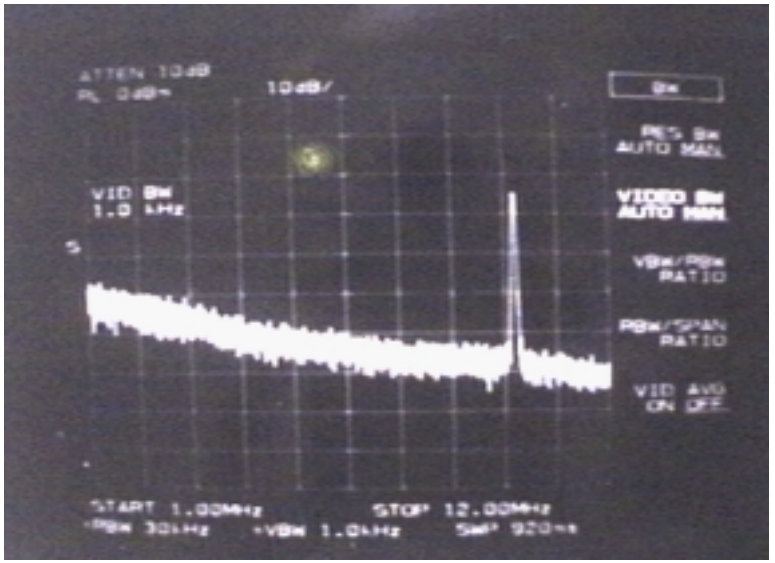
Tape Surface Photo

Write Power Calibration



Data Signal Amplitude

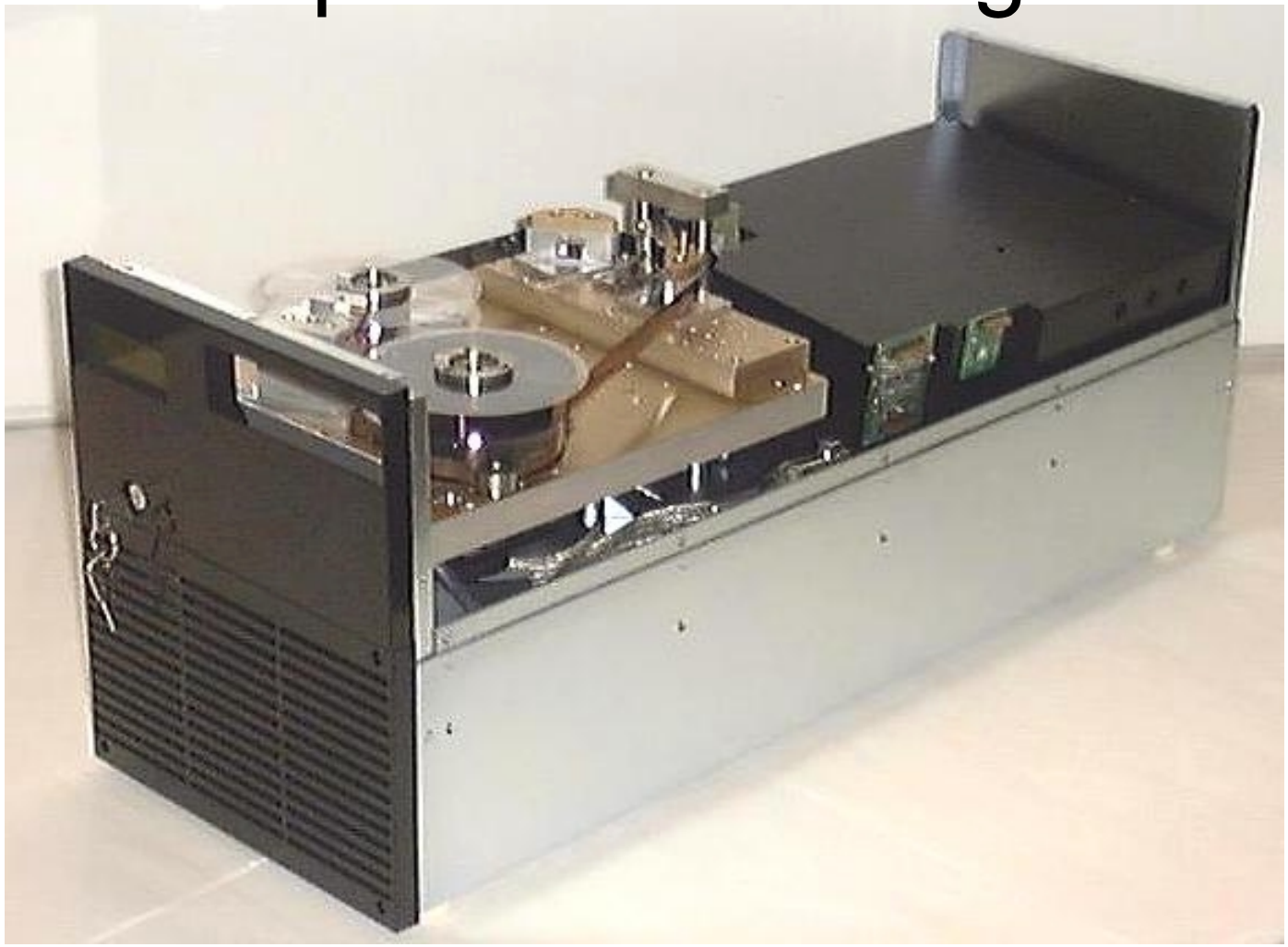


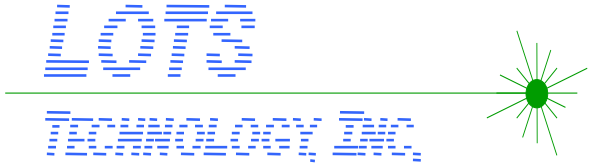


- Data amplitude from pulse position recording
- Residual tracking signal

SNR @ 10 MHz

LaserTape™ 25T Configuration





Conclusion

- Nominal 1 TB user data capacity in a '3480' sized cartridge
- 25 MB/sec. user data transfer rate
- Design approach easily extendable to higher data transfer rate by increasing number of beams
- No head wear, minimal tape wear
- Guaranteed tape interchange
- 30+ years archival tape life