NON-VOLATILE
SOLID STATE RECORDING

Doyle Johnson
Mountain Optech Inc.
4775 Walnut St, Suite A
Boulder CO 80301
Phone: +1-303-444-2851; FAX: +1-303-444-4431
doyle@mt-optec.com
Presented at the THIC Meeting in Marriott Denver Southeast
July 22, 1997
Mountain Optech Designs, Manufactures and Markets Rugged Mass Memory Solutions
COMPANY BACKGROUND

• Founded in 1985
• Located: Boulder, Colorado
• Products: Mass Memory Systems
• Specialty: Rugged COTS Products
  • Optical MO & CD-ROM
  • Magnetic Hard Drives
  • Solid State
• Subsidiary of Phillips Service Industries, Inc.
• General Manager: Dennis Sauerbrey
DEVELOPMENT

• MOUNTAIN OPTECH INC., MID 1994
• “WE NEED A HIGH CAPACITY NON-VOLATILE SOLID STATE DATA STORAGE PRODUCT”
WHY FLASH SOLID STATE

• Extremely Durable Under Harsh Conditions
  – Wide Temperature Range - 40 to +75 C
  – No Rotating Media / No Moving Parts

• Fast Data Accesses
  – Microseconds Instead of Milliseconds
  – No Latency

• Secure Data
  – Non-Volatile
WHAT IS MASS STORAGE
FLASH

• Custom Boards With Captive Memory Chips
  – EEPROM, NOR, DINOR
  – New Design Required For Upgrade

• Socketed Flash (Intel, AMD, Micron)
  – Bulk/Sected/Boot Block (64K Blocks)
  – Requires Driver or FTL (Flash Translation Layer)

• Hard Disk Emulation FLASH Modules - 512 Byte Sectors With IDE/ATA Interface
  – SanDisk, Hitachi, Mitsubishi, Smart Modular
SOLID STATE MINIMUM REQUIREMENTS

- SCSI II, 1553, RS-422, RS-232 Inputs
  - Special Bus Alternatives
- 8 Megabytes DRAM Cache Memory
- 16 Megabytes to 1 Gigabyte Non-Volatile Flash Memory
- Multi-Processing Operating System
- 1 Megabyte Sustained Write Rate (Channel Speed Burst)
- 2 Megabyte + Sustained Read Rate
- 810 D Environmental Performance
  - 6 Grms Vibration
  - 30 G Shock
  - -40 to 75 Degrees C Temperatures
DEVELOPMENT OBJECTIVE

• Non-Volatile Solid State Read/Write Data Storage Product
  – Requirements
    • Fast Write/Read Data Rate
    • High Capacity
    • Reliable
    • Long Product/Technology Life
    • Reasonable Cost
    • Versatile
    • Easily Upgradable
    • Growth Path - Building Block Design
• Review of Existing Technology - 1995
  – Technology was not yet ready for High Capacity
    • Write Rate too Slow
    • Too Costly

• How Can We Be Ready With the Technology?
  – We Needed a Standard Bus Interface Controller
  – We Need a Device Interface to the Solid State Device
INTERFACE CONTROLLER

- Fall 1994 MOI Awarded Phase II SBIR for Development of an Optical Recorder for Use on V22
- Development Requirement:
  - Intelligent Interface Controller
FIRST BUILDING BLOCK

- **Intelligent Interface Controller**
  - Multiple Input Interfaces - SCSI, 1553, RS 232, RS422
  - Booch Object Oriented C++ Software
  - CPU Power for the Future - Intel 80CF960
  - Multi Processing Real Time OS - pSOS
  - Expandable and Up-dateable ROM - Captive FLASH
  - Data Buffering - 8 MB EDO RAM
  - Standard Device Output - SCSI, PCMCIA-ATA
# HARDWARE COMPONENTS

<table>
<thead>
<tr>
<th>Component</th>
<th>Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPU</td>
<td>Intel 80CF960-33</td>
</tr>
<tr>
<td>SCSI Host Interface</td>
<td>NCR 53C720</td>
</tr>
<tr>
<td>FLASH Module</td>
<td>Intel 28F016</td>
</tr>
<tr>
<td>DRAM</td>
<td>Micron 50ns EDO</td>
</tr>
<tr>
<td>DRAM Controller</td>
<td>Xilinx 4005E</td>
</tr>
<tr>
<td>Serial Interfaces RS422</td>
<td>National VL16C550</td>
</tr>
<tr>
<td>Device Controller</td>
<td>Xilinx 4005E</td>
</tr>
<tr>
<td>Device Interface</td>
<td>Mod PCMCIA-ATA</td>
</tr>
</tbody>
</table>
SECOND BUILDING BLOCK

• Industrial Standard PCMCIA-ATA Interface
  – PCMCIA-ATA Compatible
  – Replaceable Module Design
    • Easy Maintenance
    • Easily Upgradeable
  – Customized for Maximum Multi-Operating OS Usage
  – Each Device Addressable Simultaneously
    • Each Device a Master
  – Variable and Expandable Number of Devices
    • 4 to 20 SS Modules
SANDISK PCMCIA-ATA
FLASH DISK MODULES

• SanDisk Is The Leader In FLASH Disk Technology - Worlds Largest Manufacturer of Data Storage FLASH Products

• SanDisk Is The Leader In Disk Emulation
  – IDE/ATA Interface
  – 512 Byte Sectors (Just Like A Hard Drive)
  – Intelligent Controller Handles
    • ECC/Defect Management
    • Retirement of defects At The Bit Level
    • Power Conversion
    • Wear Leveling
FIRST SOLID STATE PRODUCT

- Delivered July 1996
- Performance
  - SCSI II Input
  - 8 MB DRAM Cache Memory
  - 440 Megabytes Capacity
  - 1 Megabyte Sustained Write Rate with 5 Megabyte/Sec
  - 3 Megabytes/Sec Sustained Read Rate
  - Removable 5 1/4” form Factor
  - 810 D Environmental Performance
  - Uses Industry Std PCMCIA-ATA FLASH Modules
INPUT BUS

SCSI II
Input

Intelligent Controller

80960 CF
CPU

pSOS OS

2 MB FLASH
ROM

8 MB RAM
Buffer

RAID 0

SCSI SOLID STATE DISK

SOLID STATE
DRIVE 1

SOLID STATE
DRIVE 2

SOLID STATE
DRIVE 3

SOLID STATE
DRIVE 4

Sandisk
PCMCIA-ATA
Modules
4 to 220 MB

Mountain Optech, Inc.

a subsidiary of phillips service industries
SECTOR STRIPPED RAID 0

- PCMCIA-ATA FLASH Memory Modules
- 4 Modules in Bank / 300KB/Sec per Module
- Write Sequence
  - Interpret SCSI Starting Sector (Simple Modula 4)
  - Issue 512 Byte Write to Drive 0
    - Drive 0 Starts to Write
  - Issue 512 Byte Write to Drive 1 - Burst Buffer Full
    - Drive 1 Starts to Write
  - ETC Drives 3 and 4
  - Repeat Cycle
- Results: 1 Megabyte/Sec Average Write Rate
MultiBanked Solid State Disk

- Up to 5 Banks per Drive
- 4 or 8 Modules Per Bank
- Minimum Configuration
  - 4 Modules at 1.2 Megabytes/Sec Sustained Write
- Maximum Configuration
  - 32 Modules at 4+ Megabytes/Sec Sustained Write
- Compatible with New SanDisk D2 Modules
- Individual LUN Support, Device or Bank
INPUT BUS

SCSI II Input

Intelligent Controller

80960 CPU

pSOS OS

2MB ROM

8MB RAM Buffer

RAID 0

ATA BUS

SCSI SOLID STATE DISK

SOLID STATE DRIVE 1

FPGA DATA MGR

SOLID STATE BANK 2

FPGA DATA MGR

SOLID STATE BANK 3

FPGA DATA MGR

SOLID STATE BANK 4

FPGA DATA MGR

Sandisk PCMCIA-ATA Module
4 to 220 MB Mod
4-8 Modules per BANK

Mountain Optech, Inc.
Ultra HighSpeed Solid State Disk
-Available 1ST QTR 1998

- QuadSpeed SSM MultiBank
  - 1 to 4 Memory Banks per Drive
  - 4 or 8 Modules per Bank
- 1.2 to 1.8 Megabytes/Sec per Bank
  - depending upon # of Modules/bank
- Max Sustained Write Rate = 4 Megabytes/Sec
  - 4 Banks
- Capacities 160 Megabytes to 4.8 Gigabytes
COST EFFICIENT
HIGH CAPACITY SSM

- MultiBank SSM Using SanDisk D2 Modules
  - Multilevel Cell Technology (MLC)
- 200KB to 1 Megabyte/Sec Sustained Write Rate
  - 50 KB Per Module (≈ 100 KB By Mid 1998)
- 1/3 Additional Capacity at Same Cost
- 600 Megabyte to 6 Gigabyte Capacities
- Directly Replaceable with Bi-level Modules
WHAT DOES THE NEW DESIGN MEAN TO YOU

• You Decide The Requirements
  – High Data Rate, Limited Capacity
    • 20 Modules x 40 MB - 4MB/S, 800MB
  – Lower Data Rate, Higher Capacity
    • 10 Modules x 220 MB - 2 MB/S, 2.2GB

• You Decide The Configuration
  – 2 Devices, 2 MB/S
    • 20 Modules, LUN 0, 1
  – 4 Devices, 1 MB/S
    • 20 Modules, LUN 0, 1, 2, 3
CUSTOM INTERFACES FOR INTELLIGENT CONTROLLER

• Mountain Optech Designs Special Application Interfaces To Meet Your Needs
• Eliminates the Need to Convert your Data To a Standard Output
• Does Not Require a Computer to Modify the Data
• Interface Modules To Directly Convert Data Streams to SCSI Storage
  – PCM
  – 16 Bit

Mountain Optech, Inc.
CONVENIENCE

• IT’S YOUR DATA, YOU DECIDE
NEW PRODUCTS FROM MOUNTAIN OPTECH INC.

  - SCSI Solid State Disk
    - 1, 2, and 3 Slot products Depending upon Capacity
  - 1553 Solid State Disk
  - Multi Input RS 422 Solid State Disk

- VME 6U SCSI Hard Drive Product Line
  - 9 Gigabyte Drive on 3 Slot Board
  - 4 Gigabyte Drive on 2 Slot Board