Microdrive: High Capacity Storage for the Handheld Revolution

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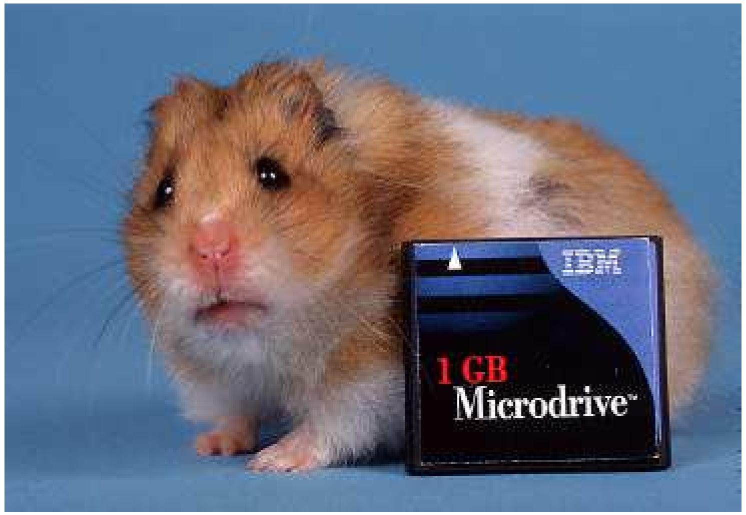
Recent History

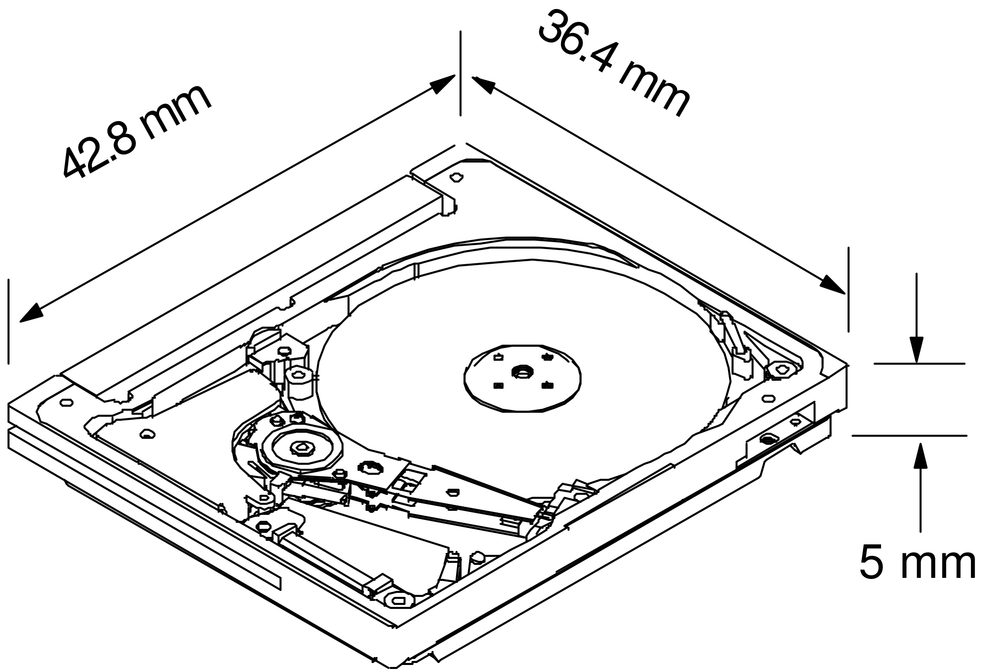
Autumn 1998
Technology
Introduction

June 1999
Gen 1 Product



June 2000
Gen 2 Product

CompactFlash Type II Form Factor

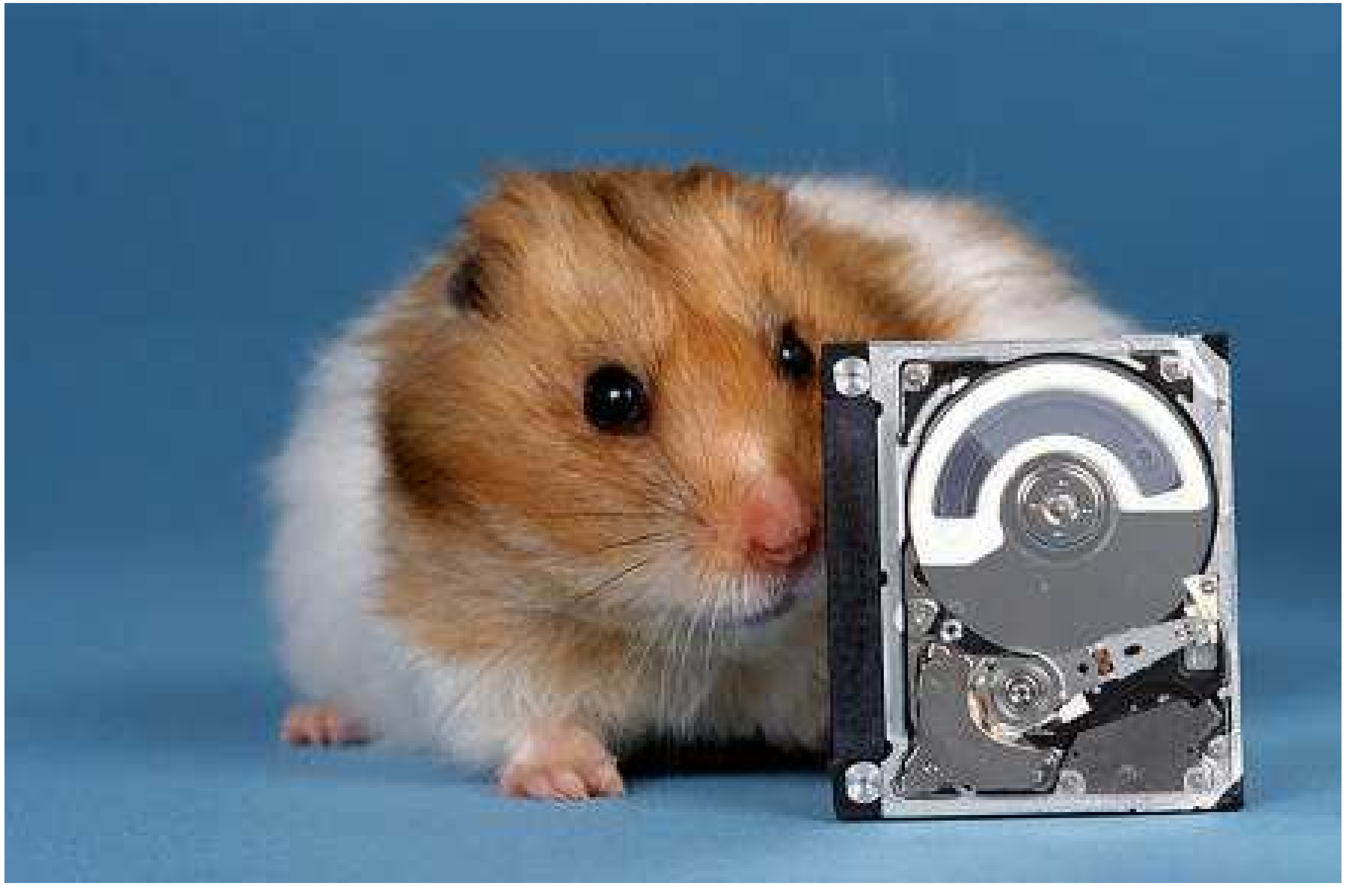


- CompactFlash type I already established as leading storage form factor for cameras, hand-held PCs
- Type II (introduced by CFA 12/98) is identical to Type I except height increased from 3.3 mm to 5 mm
- Microdrive brings high capacity HDD storage to hand-held devices

Microdrive: Selected Specs

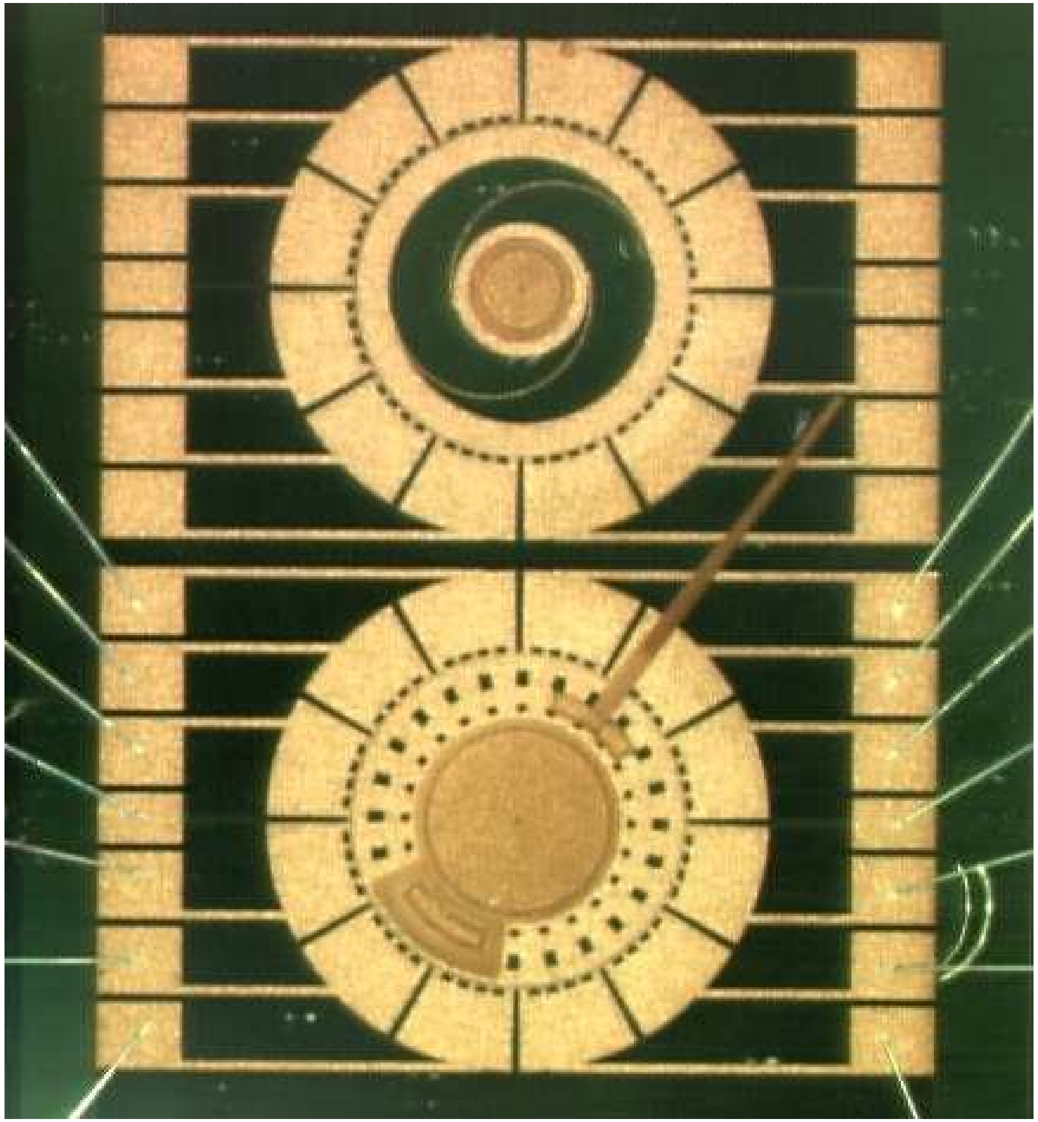
Specification	Gen 1 (340 MB)	Gen 2 (1.0 GB)
Dimensions	42.8 x 36.4 x 5.0 mm	42.8 x 36.4 x 5.0 mm
Capacity	340 / 170 MB	340 / 512 MB/ 1.0 GB
Disk diameter	27.4 mm	27.4 mm
Areal Density (Gb/sq.in.)	5.04 (Max)	15.2 (Max)
Avg Seek Time	15ms	12ms
Data Rate (MB/s)	3.2 (Max)	4.2 (Max)
Rotational Speed (RPM)	4500	3600
Power Requirements	+3.3 v, 5.0 v + / - 5%	+3.3 v, 5.0 v + / - 5%
- Spin Up	260mA	260mA
- Read/Write	300mA	250mA
- Idle	220mA	140mA
- Standby	65mA	20mA
Shock: - Non-OP	1000 G	1500 G
- Operating	150 G	175 G
Weight	16g	16 g
Interface	CF (ATA)	CF (ATA)

Microdrive Technology



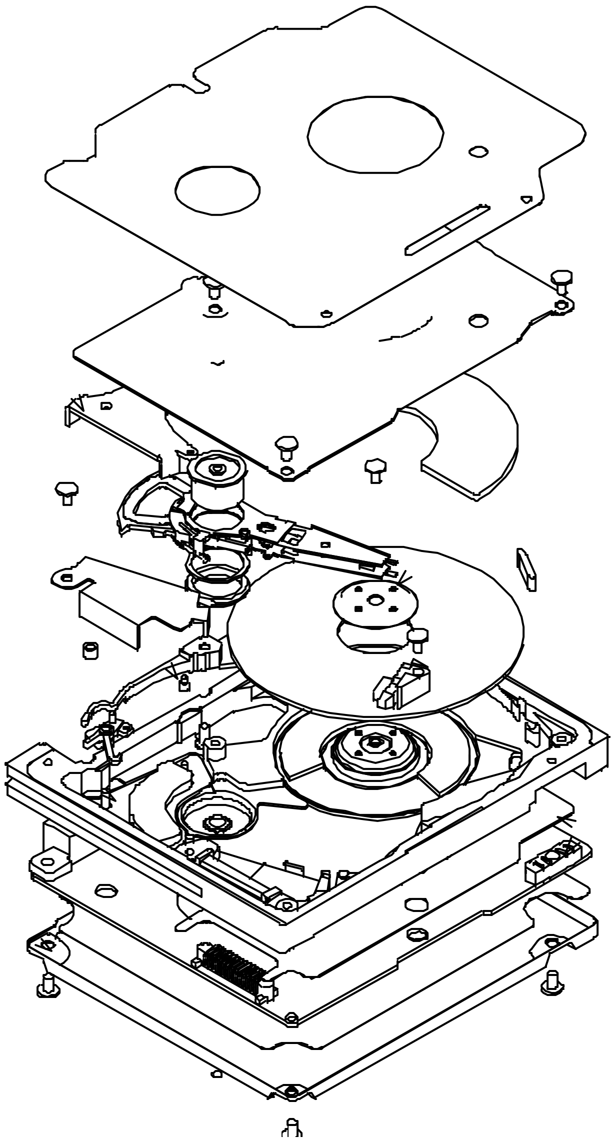
Are micromechanics required to make a microdrive?

• Microdrive project started with goal of using MEMS to make a disk drive....



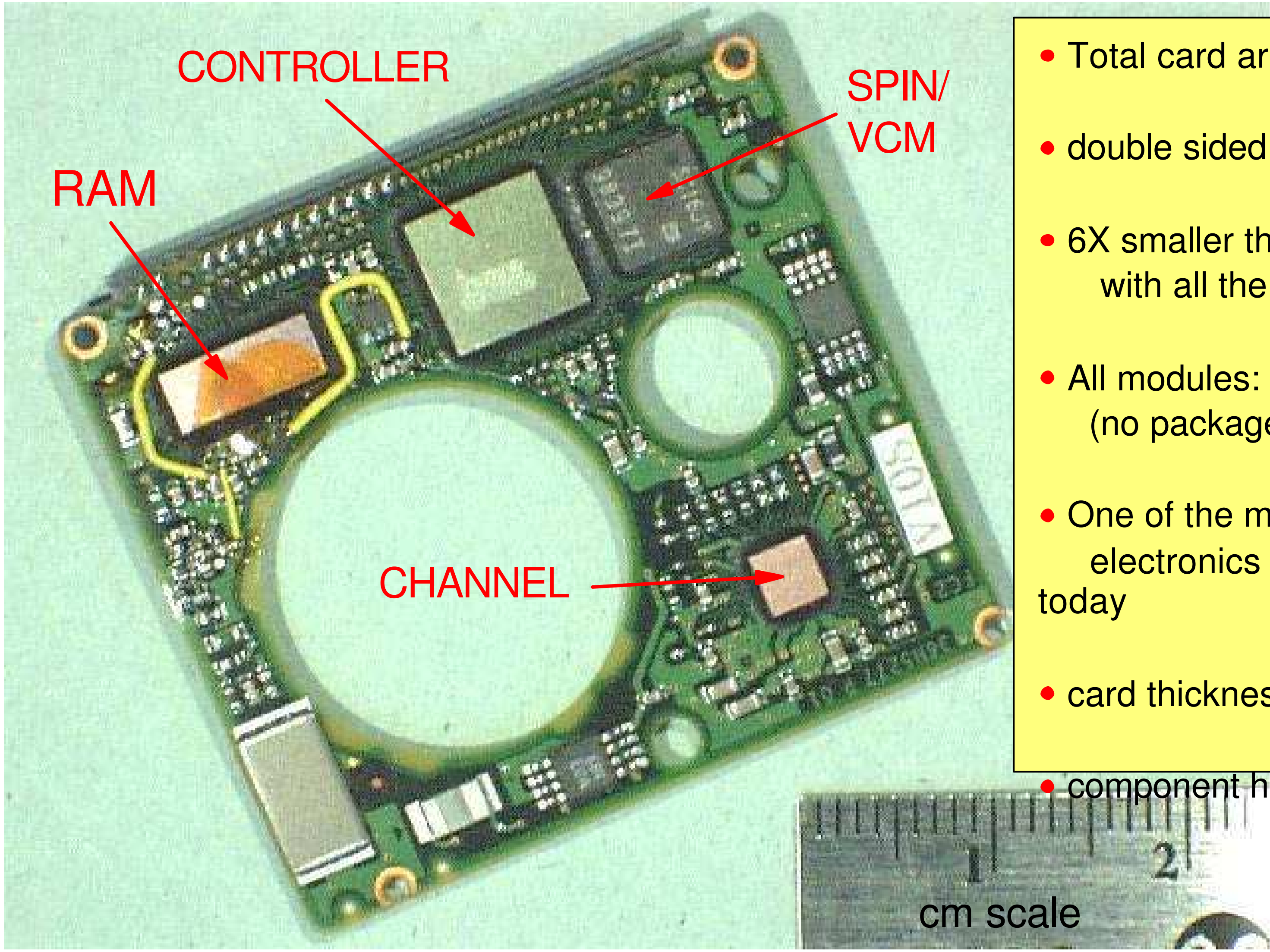
(L.S. Fan)

Microdrive: Intelligently Scaled Conventional Design



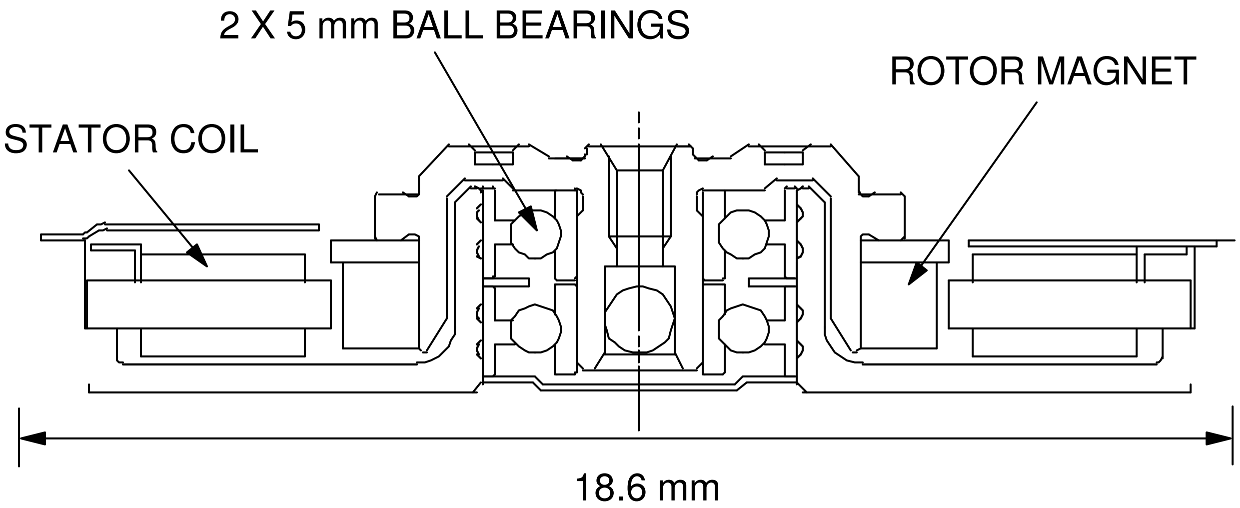
- Properly scaled conventional designs turned out to be a cheaper and better approach.
- MEMS technology is not ready to replace most components yet:
  - bearings (lubrication and life)
  - motors (available torque)
  - expense (too high)

Electronics Card



- Total card area: 10 cm^2
- double sided (most on one side)
- 6X smaller than 2.5" HDD card, with all the same functions
- All modules: direct chip attach (no package, no wire bonding)
- One of the most compact electronics cards in industry today
- card thickness: 0.4 mm (4 layer)
- component height: 0.9 mm

Spindle Motor

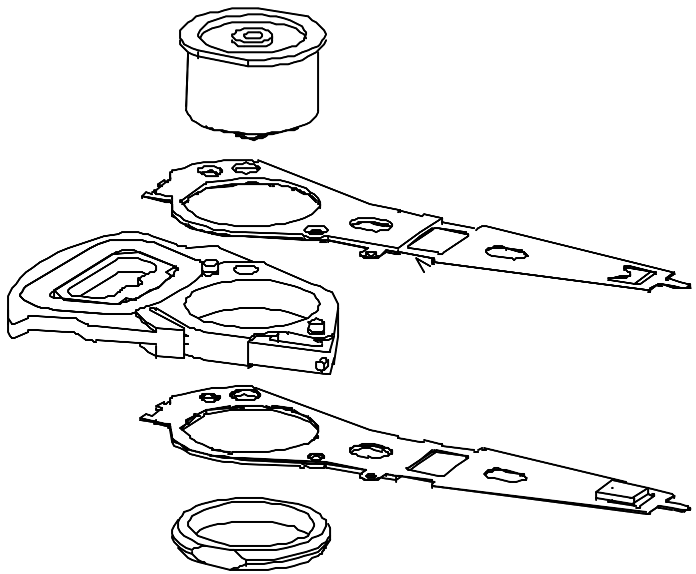


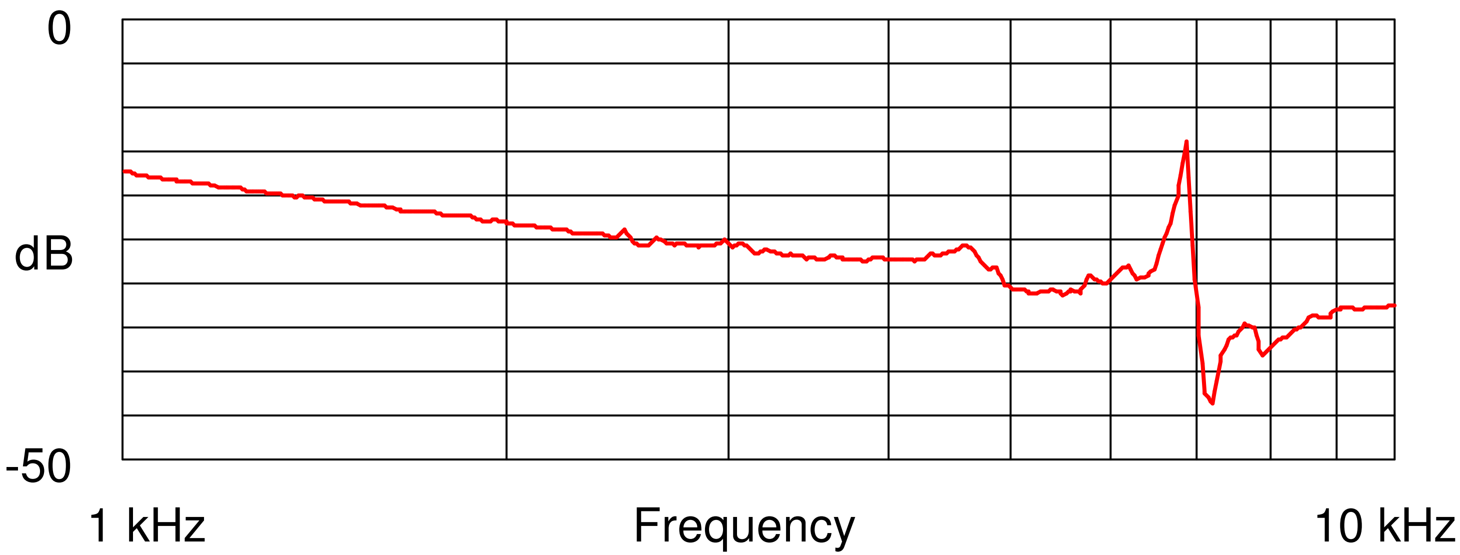
INNER ROTOR DESIGN

- rotating mass dominated by spindle rotor, not disk (unlike most drives)
- oversize (not scaled) bearings (for manufacturability, shock resistance)
- reduced mass (increased resistance to linear shock)
- reduced rotational inertia (spin up time ~ 0.5 sec)
- reduced tilt inertia (increased resistance to rotational shock)
- increased Kt (more room for windings)
- 12-pole 9-slot design; $K_t = 0.0025$ Nm/A
- future: fluid dynamic bearing (higher track dens, better acoustics, better shock)

Actuator

- transfer function clean out to ~ 7 kHz
- similar to moving-suspension secondary actuators in larger drives
- may achieve dual-stage performance without second stage





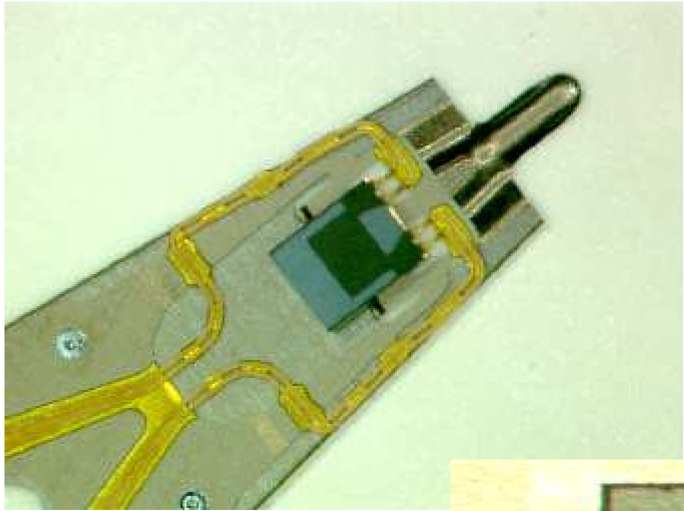
- 127 turn coil
- overmolded plastic carriage
- integrated lead suspension
- $K_t \sim 0.002$ Nm/A
- $I \sim 0.1$ g cm^2

Air Bearing

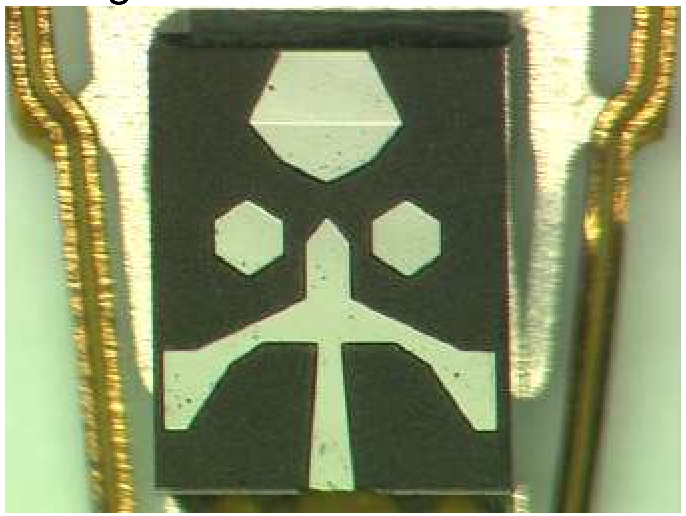
Can a conventional ABS work in
a microdrive?

Requirements:

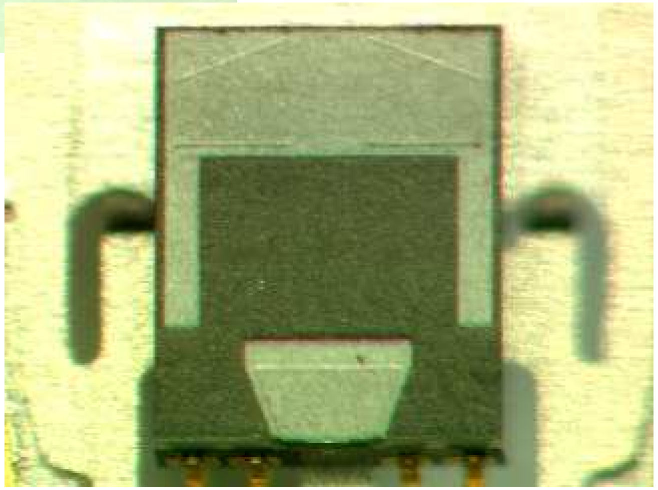
- 2.2 - 4.2 m/sec linear velocity
- sub 1 microinch FH
- good tolerances



ILS suspension
with pico slider



nano ABS from early prototype



pico subambient pad ABS
used in product

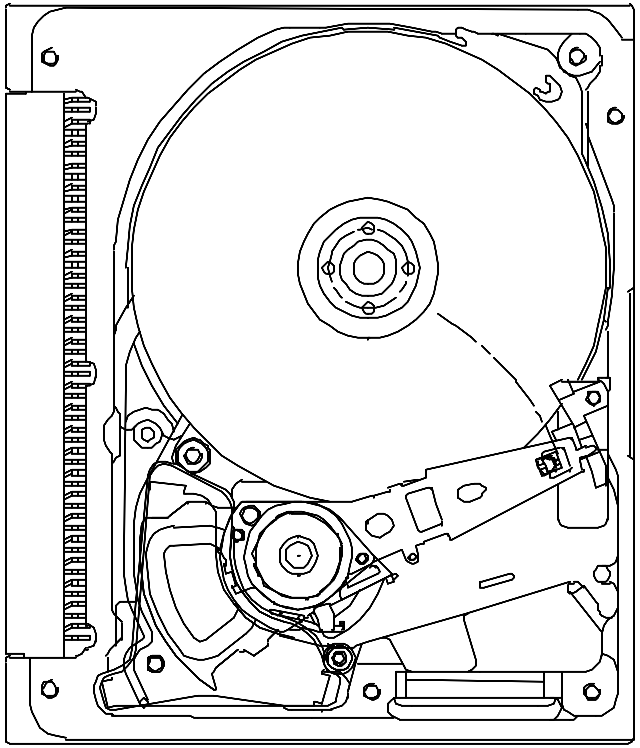
Load/Unload

SPINDLE TORQUE TOO LOW FOR CONTACT START-STOP

- limited coil winding space
- CompactFlash requires 3.3 V operation, limits K_t
- oversize bearing (not scaled) results in disproportionately high drag

OTHER ADVANTAGES OF L/UL

- increased nonoperating shock resistance (eliminates head slap)
- elimination of stiction/wear failures
- reduced power consumption (unlimited start/stops for aggressive power savings)
- increased areal density (smooth disk for low noise, low flying height)
- ease of assembly (no head merge operation)



Design Considerations for SHOCK

- Microdrive has 1500 G nonop shock spec (industry best)

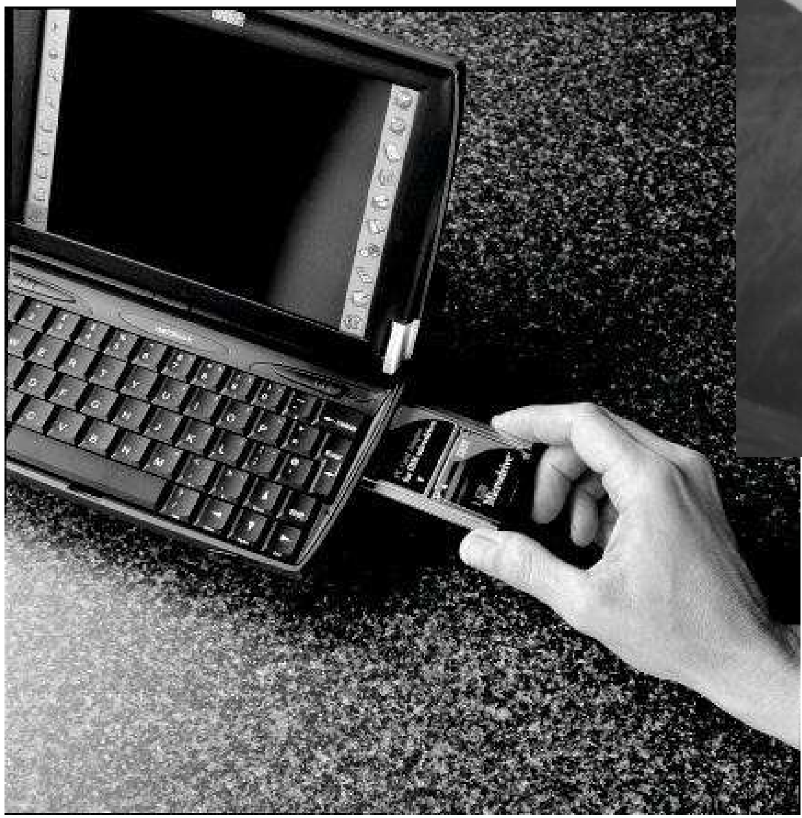
- Contributing factors:

  - Load/Unload (eliminate head slap)
  - Oversize spindle and actuator bearings (higher brinaling threshold)
  - Suspension limiters (prevent gimbal damage, slider-slider contact)
  - Inertia latch (keep actuator reliably parked)
  - "True Track" super-harmonic servo (allows for some disk slip)

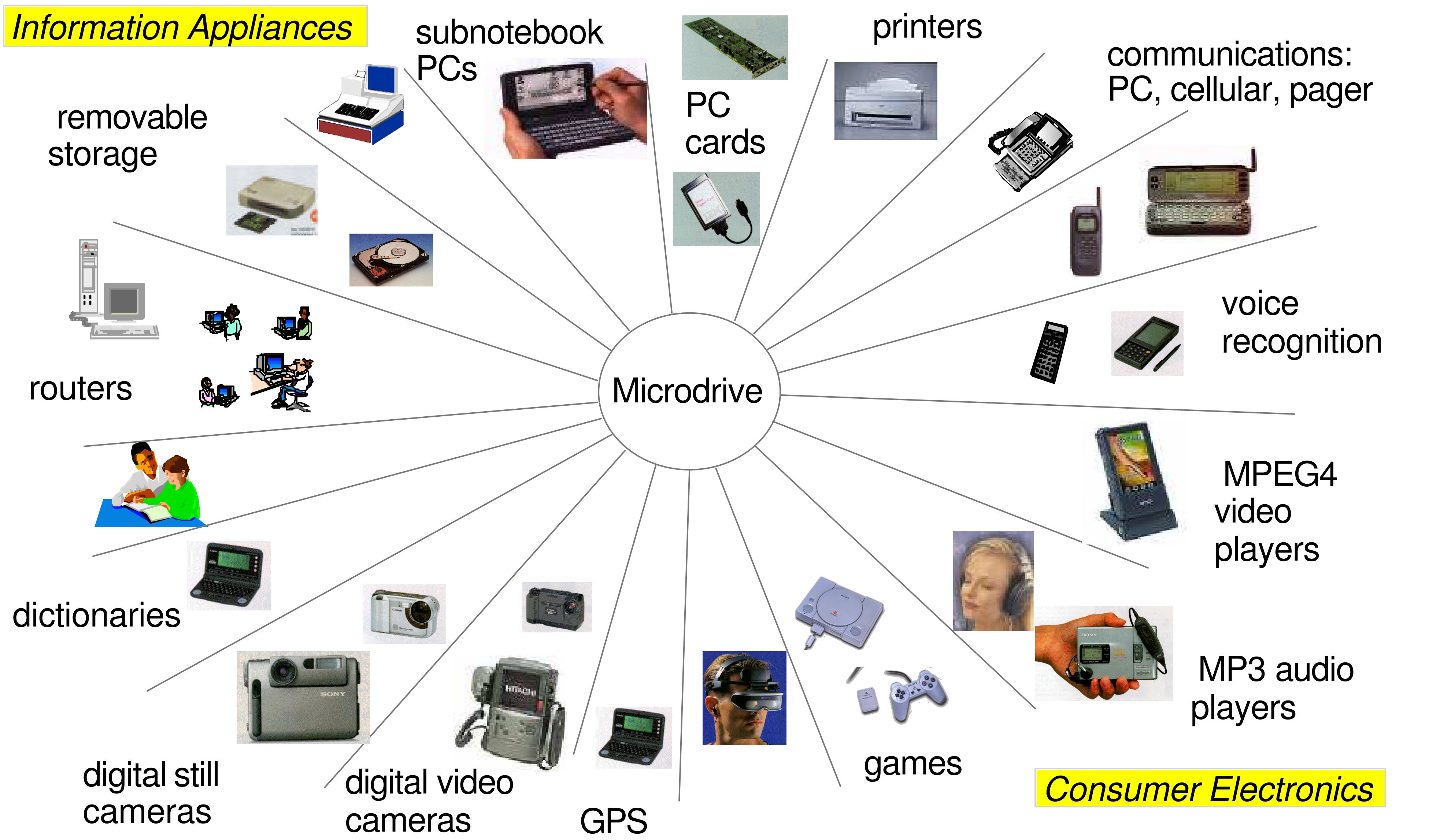
For "throw it against the wall" durability:

Compact shock mounting system from Edapting Solutions

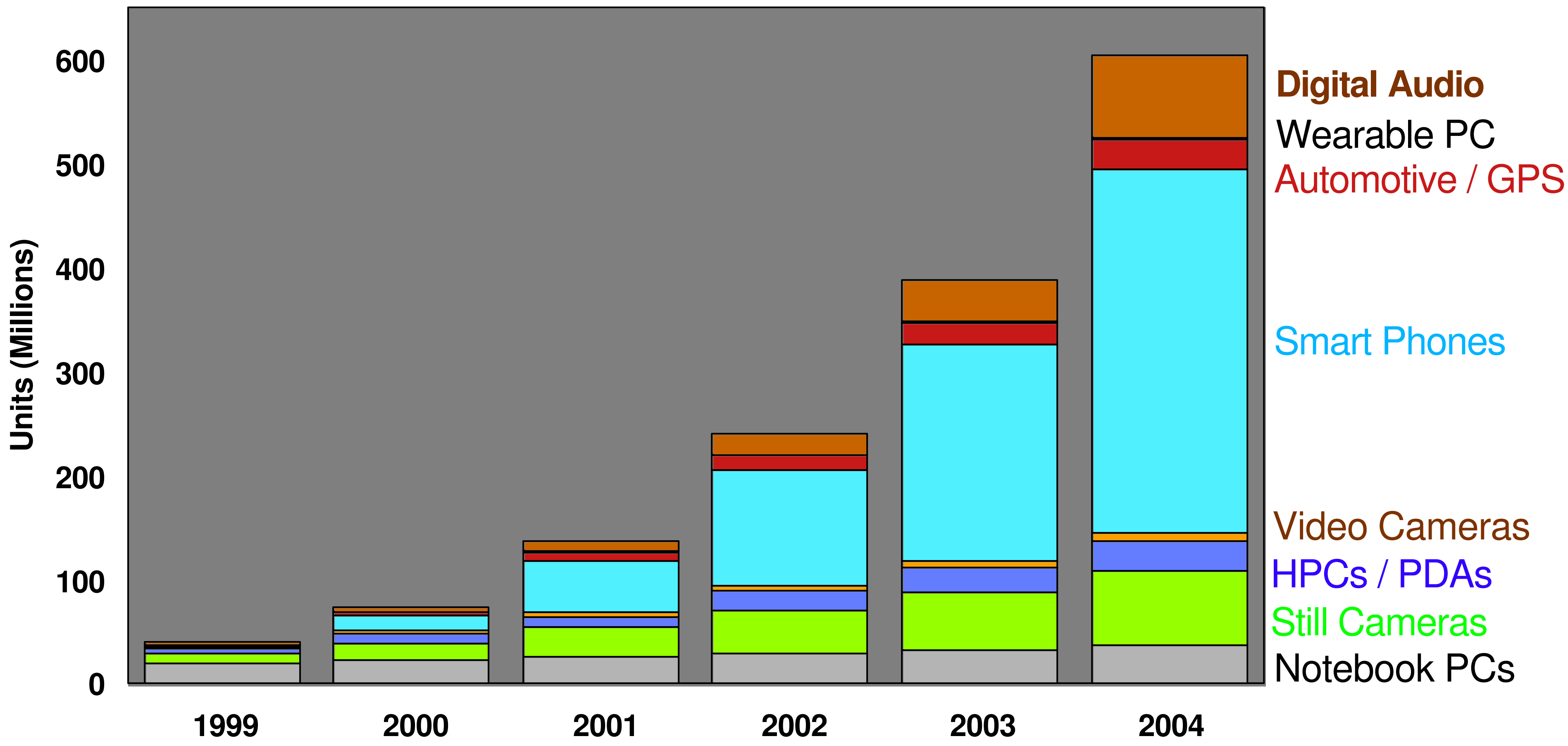
Microdrive Applications



Microdrive Opportunity



Potential Host Devices: Volume Projections



- even a small percentage penetration into these markets represents significant volume

Digital Cameras

(Canon digital camera)

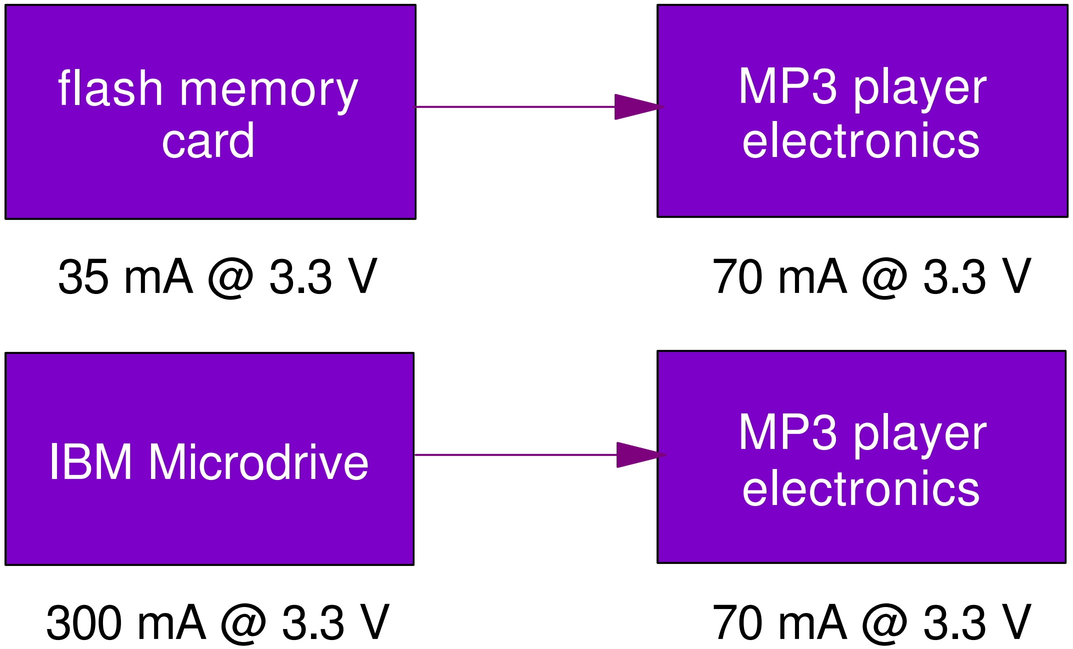
- most popular use of Microdrive
- image capacity for 1 GB:
  - Casio QV3000 camera (3.3 Mpel)
  - compressed:
    - 710 images @ 2048 x 1530 pel
    - 2750 images @ 1024 x 768 pel
  - uncompressed:
    - 100 images @ 2048 x 1530 pel
- uncompressed images:
  - superior quality
  - better for subsequent editing
  - 10 MB per image @ 3.3 MP
  - only practical with Microdrive

MP3 Audio Players

Microdrive-based MP3 Player
designed by e.Digital
(coming to market soon)

- MPEG-1 audio layer 3
- compressed audio
  (16X smaller than CD)
- data rate 128 kb/sec
  (16 KB/sec, ~1 MB/min)
- competition uses solid
  state flash memory
  (typically 32-128 MB)
- flash is not a very good
  solution (too expensive)
- high capacity of Microdrive
  is ideal

Mythical Problem: Microdrive Power Consumption



Total 105 mA @ 3.3 V

Total 370 mA @ 3.3 V

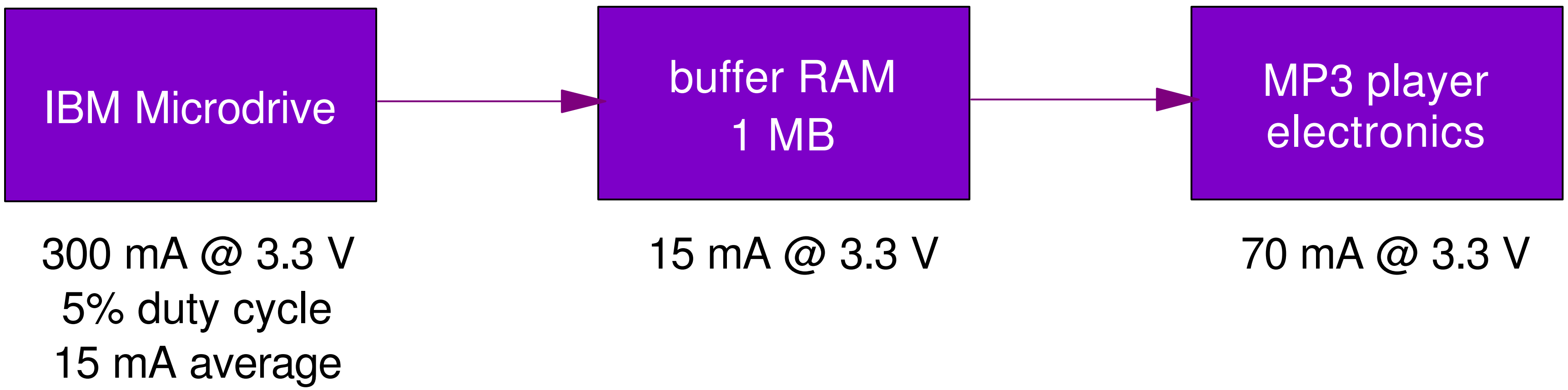
3.6 X more current

more than 5X shorter battery life

There is a better way...

Solution: Add a Data Buffer

- MP3 data rate: 16 KB/sec
- Microdrive minimum sustained data rate: 1.8 MB/sec
- Microdrive is > 100X too fast!



- Microdrive consumes only 15% of total power
- negligible effect on battery life vs. flash memory
- 10-20 hrs battery life with pair of AA batteries

Digital Video Players
Enterprise to Entertainment

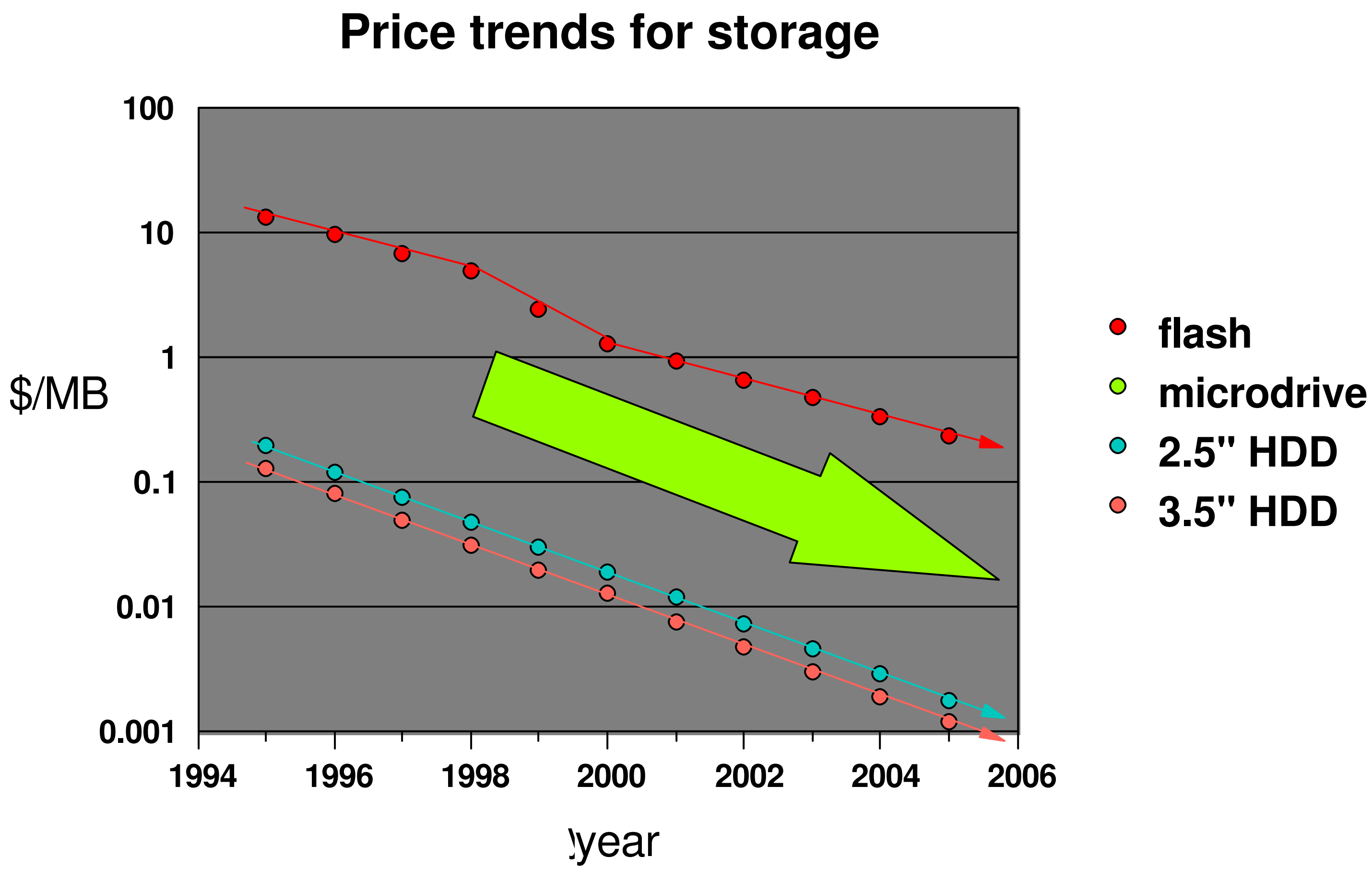
MPEG4 Video with 8 MB buffer

Data Rate	Duty Cycle*	Ave. Current
300 kb/s	3.3%	8 mA
1 Mb/s	10%	25 mA
1.6 Mb/s	15%	38 mA

Assumptions:
- **2 MB/sec sustained data rate**
- **2 seconds overhead per buffer cycle**

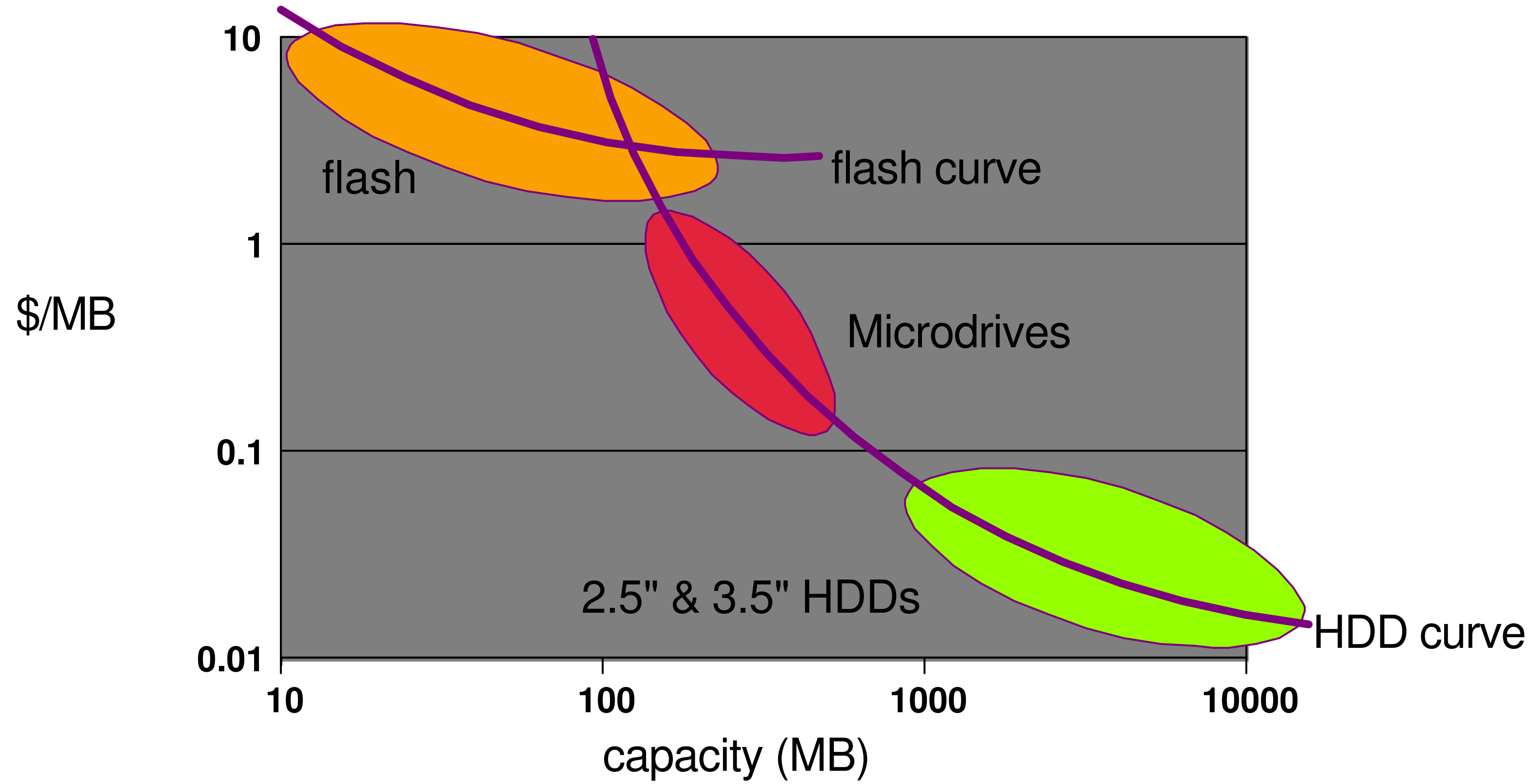
Negligible effect on battery life vs flash memory

1 inch today => 1 cm tomorrow?



Microdrive market occupies widening gap between flash and larger HDDs

1 inch today => 1 cm tomorrow?



Fixed costs of HDDs needs to be reduced before further downward scaling in size (Flash scales down better)

Microdrive: Summary

- World's smallest, lightest HDD
- World's lowest power HDD
- World's most shock resistant HDD
- Based on intelligently scaled conventional design
- Most important applications:
  - digital cameras
  - MP3 audio players
  - MPEG4 video players
- Achieves excellent battery life in sequential access applications (audio, video)