Standardized Testing for SSD's

Performance and Reliability

Flash Memory Summit

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Tony Lavia, PhD
Flexstar Technology
tlavia@flexstar.com
www.flexstar.com

Performance & Reliability Testing

- Why Test
- What is Standardized Testing
- Performance & Reliability Testing
- Device Specific Reliability Tests
- Storage Test Evolution

- **Engineering Verification**
  - EVT DVT etc
  - Development debug
- **OEM Qualification**
  - Systems qualification
  - Performance evaluation
  - Reliability gauge
- **Device Manufacturing**
  - Meet specifications
  - Reliability / early life failures
  - Fast failure analysis
  - ORT
- **Field**
  - Failure analysis
  - RMA confirmation

A problem has been detected and Windows has been shut down to prevent damage to your computer.

The problem seems to be caused by the following file: aries.sys

PAGE_FAULT_IN_NONPAGED_AREA

If this is the first time you've seen this Stop error screen, restart your computer. If this screen appears again, follow these steps:

Check to make sure any new hardware or software is properly installed. If this is a new installation, ask your hardware or software manufacturer for any Windows updates you might need.

If problems continue, disable or remove any newly installed hardware or software. Disable BIOS memory options such as caching or shadowing. If you need to use Safe Mode to remove or disable components, restart your computer, press F8 to select Advanced Startup Options, and then select Safe Mode.

Technical information:

*** STOP: 0x00000050 (0xFFFFFFF8,0x00000000,0xF9CF5C88,0x00000000)

***   aries.sys - Address F9CF5C88 base at F9CF5000, DateStamp 424bb23f

Beginning dump of physical memory
Physical memory dump complete.
Contact your system administrator or technical support group for further assistance.

- **Engineering Verification**
  - EVT DVT etc
  - Development debug
- **OEM Qualification**
  - Systems qualification
  - Comparative analysis
  - Performance evaluation
  - Reliability gauge
- **Device Manufacturing**
  - Meet specifications
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Key Features of Standardized Testing

- Accuracy
- Repeatability
  - Ability to reliably recreate same test conditions <u>globally</u>
- Tight control over test conditions
  - Environmental
  - Test tool environment
- Scripting Based Tests
  - Suits individual product requirements
  - Easily sharable
- Ability to debug in place
  - Interrogate / Trace failure conditions
  - Remote testing/debugging
- Provides Data Collection & Correlation
 - Consistency across the industry
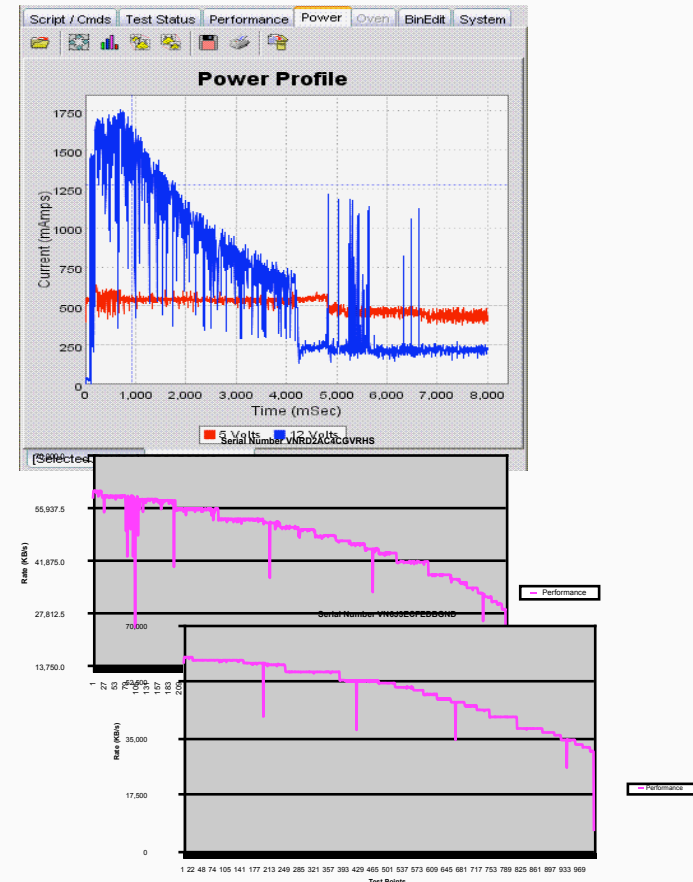
The benefits of standardized, independent test systems

- Known test hardware
- Unbiased and fair
- Repeatable test solutions
- Common test scripts
- Industry standard interfaces
- Correlation between manufactures and OEM's
- Speeds failure analysis
- Investment protection through upgradability

SSD Design & Manufacturing

- – Design Verification
- – Reliability Demonstrations
- – Performance tuning
- – Firmware tuning, etc.
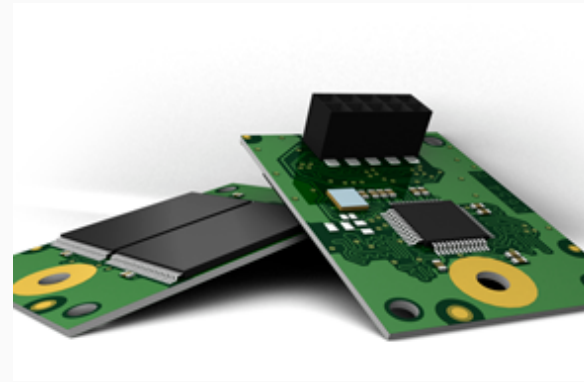
QualificationTesting

- – Full HDD equivalence
- – Multi vendor comparisons

Note: There is a dramatically different test focus between existing HDD and SSD devices……except in the qualification cycle!

Design & Manufacturing

Within each test environment (qualification or DVT) multiple views are evaluated.

Field & Reliability

HDD design verification / qualification
(rotational media)

Root Cause

– Design/Components/DRAM

– Component Failures / i.e.
red phosphourous

– Head/Media instability

– Design margin

Test Process

⇒ Pattern reads/writes/verify

⇒ Power cycling

⇒ Extended test at temperature

⇒ Voltage margining

⇒ Temperature Cycling

⇒ Voltage margining & 4 corner

HDD field reliability

(variable factors in rotational media)

Root Cause

- Contamination
- Handling, head laps
- Lube issues
- Motor bearings
- Growing defect lists

Test Process

⇒ Multiple full media R/W.

⇒ Head/Surface defects

⇒ W/R adjacent tracks

⇒ Dwell at elevated temperature

SSD design verification / qualification

Root Cause

– Endurance

– Performance-mfg. variability

– Bit failures / Data Retention

– Component Failures

– Write splice

– Metadata corruption

– Write performance

– Erase failures

– Design Margin

Test Process

⇒ Multiple writes

⇒ Performance verification

⇒ Disturb testing / pattern writes

⇒ Temperature Cycling

⇒ Voltage margining & 4 corner

⇒ Power cycling mid writes

⇒ Random I/O w/ power cycling

⇒ Cold write

⇒ Margined erase

⇒ Four Corners

SSD testing for field reliability

Root Cause

– Wear leveling performance

– Data Retention

– Reallocation errors

Test Process

⇒ Fragmentation tests

⇒ Temperature & power cycling

⇒ RW tests w/ power cycling

⇒ Write splice, cold writes

- What Tests should I run?
  - Should cover Functional capabilities of DUT
    - Which Commands Sets supported?
  - Exercise DUT in modes likely to cause problems

1. Read / Write Commands
2. Power Management Commands
3. Automatic Acoustic Management commands
4. 28 Bit Addressing
5. 48 Bit Addressing
6. Queued Commands
7. SMART commands
8. Packet commands
9. CFA commands
10. Security commands
11. Removable Media commands
12. Device Configuration Overlay commands
13. Streaming Commands
14. Media Card Pass Through commands
15. General Purpose Logging commands
16. Host Protected Area commands.

What the Customer Expects

(in a world of tests developed by key OEMs)

- Complete functional equivalence and independence.

- Interface testing

- Reliability demonstration

- Performance demonstrations

- Endurance demonstration

- Power on / spin-up / sleep / resume from sleep compliance.

Thank You

Tony Lavia, Flexstar Technology

For additional questions, please feel free to follow up with me in booth #202

Test Type	Test Name	HDD	SSD	DVR	DVD	CD
• Buffer Test (Cache)	BufferE8-E4.P25	✔	✔	✔	✔	✔
• Command Overhead (Knee)	Mult-Wrt-Rd.p2e	✔	✔	✔		
• Command Queuing	SSD2.p2e	✔	✔	✔		
• Command Time Measurements	CMD-Times.p2e	✔	✔	✔	✔	✔
• Complete Identify Device	IdDec.class	✔	✔	✔	✔	✔
• Contact Start Stop	10K-CSS.p2e	✔		✔		
• Continuous seeks	Placeholder.?	✔		✔	✔	✔
• DOD Wipe	DOD-Wipe.p2e	✔	✔	✔		
• Generic Smart Commands	Smart.p2e	✔	✔	✔	?	?
• Lube Test	Lub-Tst.p2e	✔		✔		
• Multi stream performance (DVR sim)	DVRsim	✔	?	✔		
• Pattern Test ATE Read through	TestPat.p2e	✔	✔	✔		
• Power Management Profiling	PwrMgtPrf.p2e	✔	✔	✔	✔	✔
• Power up / down	Placeholder-?	✔	✔	✔	✔	✔
• Radial Perf/Memory Scan	RadialPerf.p2e	✔	✔	✔		
• RW entire drive (multipass option)	Rw-multpass.p2e	✔	✔	✔		
• Seek Performance	Simple.p2e	✔		✔		
• Streaming	DVRsim	?	?	✔		
• Surface/Media Scan	SurfScan.p2e	✔	✔	✔		
• Time to Ready Sleep/wake	SleepProfile.p2e	✔	✔	✔	✔	✔
• Voltage Margining Test	48HrUpDn.p2e	✔	✔	✔		
• Voltage Margining to failure	Placeholder-?	✔	✔	✔	✔	✔
• Wear Leveling (SSD)	Wearlevel.p2e		✔			
• Write Shutoff	Splicer.p2e	✔	✔	✔	✔	✔

✔ = Device Dependant Supported

- This test suite is composed of six SSD-specific P25 test scripts plus two Java Plug-in "class" files that are called from some of the scripts.

- <u>The scripts are examples of tests important to **all** SSD manufacturers and their customers.</u> They are run on a FLEXSTAR test system: the tests include raw performance (transfer rate and NCQ), reliability, power consumption and wear leveling.

- Flexstar encourages the to adopt these test scripts as their standard. These scripts can be modified per manufactures requirements.

FLEXSTAR
T E C H N O L O G Y

- Based upon a leading PC manufacturer's SSD qualification tests.

- The scripts perform various sequential and random write and read tests using a variety of transfer lengths.

- The scripts also perform two different Load/Unload tests plus a SATA NCQ (Native Command Queuing) performance test.

- After an initial sequential write of a data pattern across the entire drive, a sequence of five different timed tests each 12 minutes in duration (one hour total) is performed. "SSD3" repeats the one hour test sequence 96 times (4 days long) whereas "SSDQuick2" only goes through the one hour test sequence once then ends.

- Transfer length is set to 256 sectors and data compare function is turned off. This results in the fastest transfer rate performance.

- Transfer performance is shown graphically on the P25 GUI.

- For brevity, only tests the drive's first 100K sectors.

- Three separate performance tests are performed:
  - Sequential Write
  - Sequential Read
  - Random Write w/ verify

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- This script demonstrates the FLEXSTAR tester's power profiling features.

- Current profiles are taken (2000 samples are taken per profile) on power up, during seek tests and power down. The sampling rates are varied.

- The script runs in "Macro Step" mode so script execution automatically pauses after each current profile has been taken.

- Performs a sequential write and read of the entire disk then performs a timed 24 hour wear-leveling test.

- 75% of the time is spent randomly writing to and reading from only 10% of the disk. 25% of the time is spent sequentially writing to and reading from the entire disk.

- The 10% selected for wear-leveling is chosen randomly. Every four hours a different 10% of the media is selected for wear-leveling testing.

- # Write Shutoff (Write Splice)
  - ## Identify problem of incomplete write operation during a power failure.
    - Simulate condition by turning off the power in a middle of a write operation
      - DUT must successfully complete finish writing the sector even though power was removed in the middle of the write operation.
    - Restart DUT and check data at the exact sector where power failure occurred.

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Your Standardized Testing and Qualification Partner

Thank you!

- Questions

- Next Steps