

RTE, Client JFMEA

GSF Customer Collaboration

Surveillance ECA4 15-Bay JMEA

ST10000VX0004

ST8000VX0022

RenJie / Samuel Ho /Desmond Ng

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Agenda

- ❑ System GSF ECA Setup/configuration Spec
- ❑ Product to assess: 10TB Skyhawk
- ❑ Scope of the assessment for this GSF ECA System include :
 - Temperature, Workload, Power Consumption of HDD, In System Performance, Vibration (Resonance)
 - Setup and Test Objective
 - Observation / Result
- ❑ Abnormal usage simulation assessment
 - Beeper / Alarm trigger assessment
- ❑ Summary of the assessment
 - ❑ What went well / Not went well



Summary of Assessment

GSF ECA4 Surveillance System → Product 10 TB HDD (15 units)

Result / Observation → Assessment (STX 10000VX0004)

- ✓ In System Characterization
 - ✓ Temperature Characterization at room / Projection
 - ✓ Within recommended sustaining HDD Spec when projected to 40C environment usage
- ✓ In System Performance (ISP) →
 - ✓ Greater than 90% throughput performance (*** very good performance)
 - ✓ ISV / ISP with Fan on / off / Fan MAX Characterization
 - ✓ No major impact with FAN impact (outlet fan default/ max fan speed)
 - ✓ Map Chassis Resonance frequency with respect to product spec
 - ✓ Higher RV energy is observed when target drive is performing random write operation
- ✓ In System Power Consumption
 - ✓ HDD current draw during operation
 - ✓ No major concern as overall still within System power supply margin/spec
- ✓ Abnormal usage condition(Beeper/Alarm) sound simulation
- ✓ Centre beeper has some impact to HDD performance
- ✓ Mitigation path → Turn off beeper and use cloud connected feature to monitor the health of the HDD

- ✓ In System Performance (ISP) → 8TB Drive (STX8000VX0022)
 - ✓ Greater than 95% throughput performance (**** very good performance)



GSF ECA4 System Information

GSF ECA4

Specification:

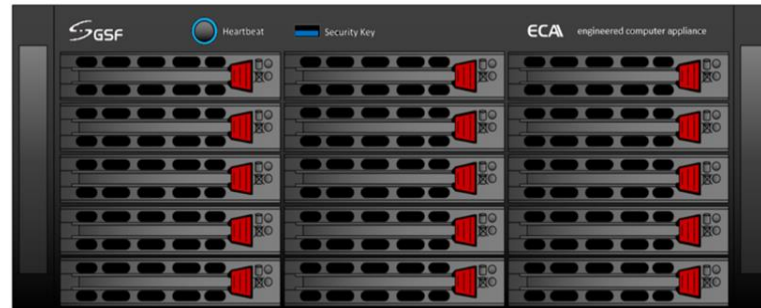
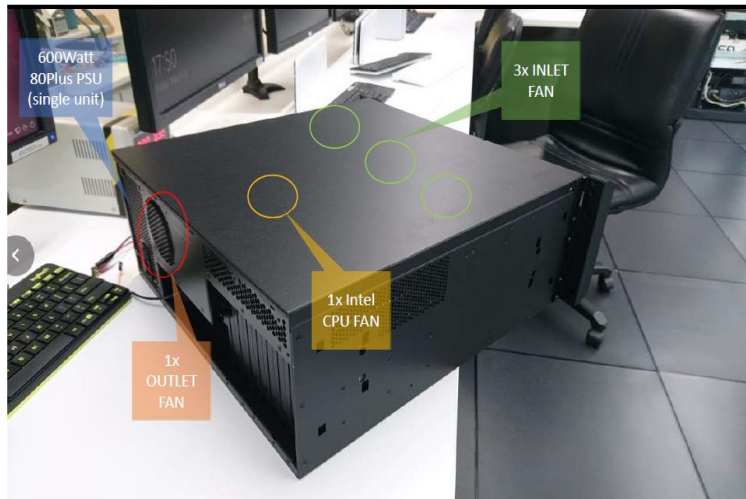
- Intel Xeon E3
- DDR4 ECC 16GB
- Windows 10 Enterprise x64bit OS
- Heartbeat 2 cloud connected microcontroller.
- 4U Rack Mount
- 600Watt 80Plus certified PSU. (single psu)

Surveillance Performance (Storage)

- 100CH of videos
- 3Mb/sec bit rate FULL HD each CH
- 300Mbit/sec real time work load in total
- 150TB RAW HDD (10TB x 15unit)
- 30days of 247 continuous live videos
- Dual Parity Storage Redundancy (by Microsoft StorageSpace).
- Dual Fall-Back Drive
- Dual SSD Cache for Video Data.

GSF new Engineered Computer Appliance (ECA) Gen-4

Standard 19" 4U Rack Mount.
445mm Depth



Highlights of the New GSF ECA System + Test Scope & Objectives

What is Launching?

New GSF ECA4. 19" 4U Rack Mount System with 15 bays, hot swap, RAID/JBOD, HDD SMART monitoring, capable of supporting up to 100 channels.

Objective of the Engagement with Seagate

To have Seagate support the testing of the new GSF ECA4 for assurance on the compatibility with Seagate Skyhawk.

Set-up Required:

- 15 units of Seagate SkyHawk 10TB (installed)
- configured in Microsoft Storage Space Dual Parity.

The Scope of the Testing to Include:

- Vibration and Resonance
- Power consumption for each HDDs and for all the combined 15*HDDs.
- Temperature monitoring for each HDDs and overall internal chassis temperature, plus CPU temperature
- Test environment with a holding temperature between 30-40 Celsius – if required, will need to simulate a non-air conditioned environment
- Propose that all tests to be stressed for a minimum of 24 hours



Thermal characterization test

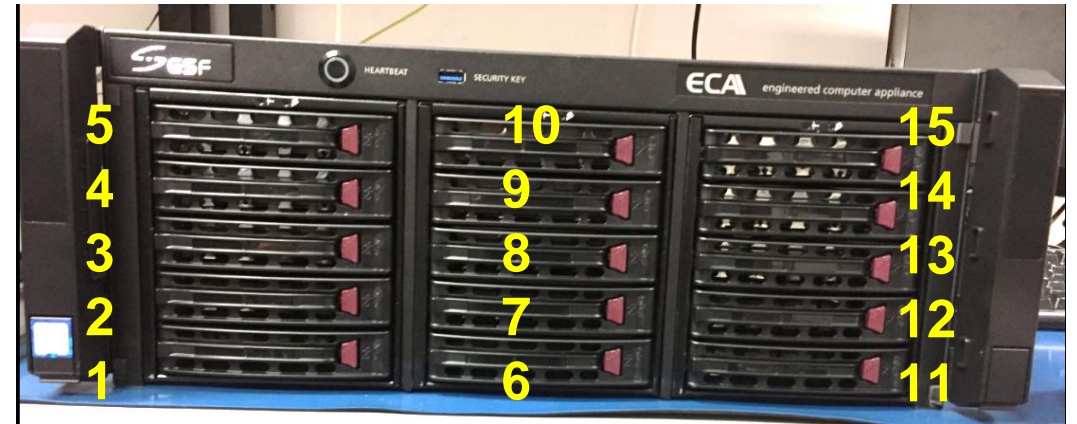
Objective: To measure the temperature of the HDD / In System temperature to assess if it within the recommend temperature ($< 55^{\circ}\text{C}$)

Testing condition / Setup

- ❑ Test software: Macula video recording simulator
- ❑ System storage setup: Windows storage space 5 pools, 3 x 10TB HDDs per pool. 1 partition per pool.
- ❑ Test channels: 100 (20 channels recording per pools)
- ❑ Ambient temperature: $\sim 19^{\circ}\text{C} - 25^{\circ}\text{C}$
- ❑ Projection to 40°C ambient usage
- ❑ Test duration: ~ 93 hours(4 days)

Test Summary:

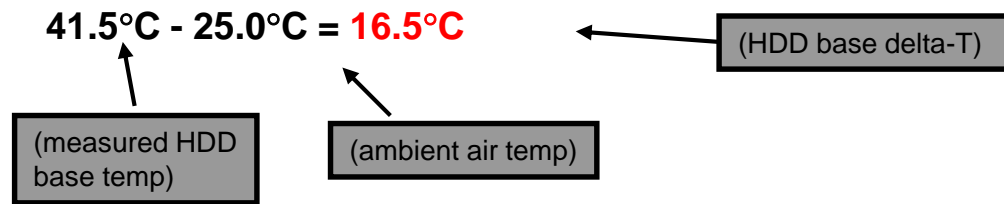
- ❑ Hottest HDD recorded: HDD 3
- ❑ Coolest HDD recorded: HDD 6
- ❑ Projected temperature for HDD at slot 3 under ambient temperature (40°C) : 50.4°C
- ❑ Projected temperature for HDD at slot 6 under ambient temperature (40°C) : 46.9°C
- ❑ Assumed max operation temperature is 40°C , all HDDs are expected to work within product's temperature specification.
- ❑ Post test pack read pass for all 15 HDDs.



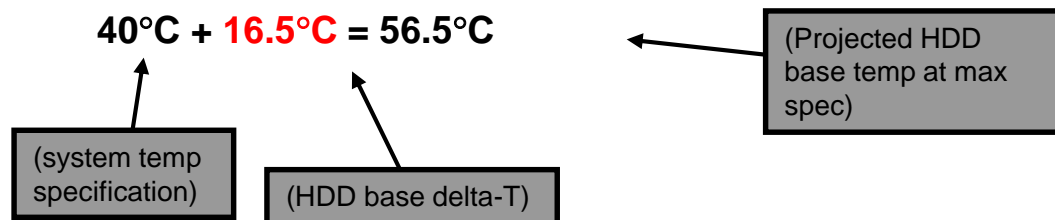
HDD temperature projection method

Temperature point 1 (HDD base) - Temperature point 2 (ambient air) = delta-T (temperature difference)

Example:



Projection : Assume usage at 40 °C



Seagate recommended system designer to project and monitor the HDD case temperature during system operations. Stretching beyond the hard drive design spec or limit will result in reducing the useful life of the product.

STX Guide for Environment Temperature

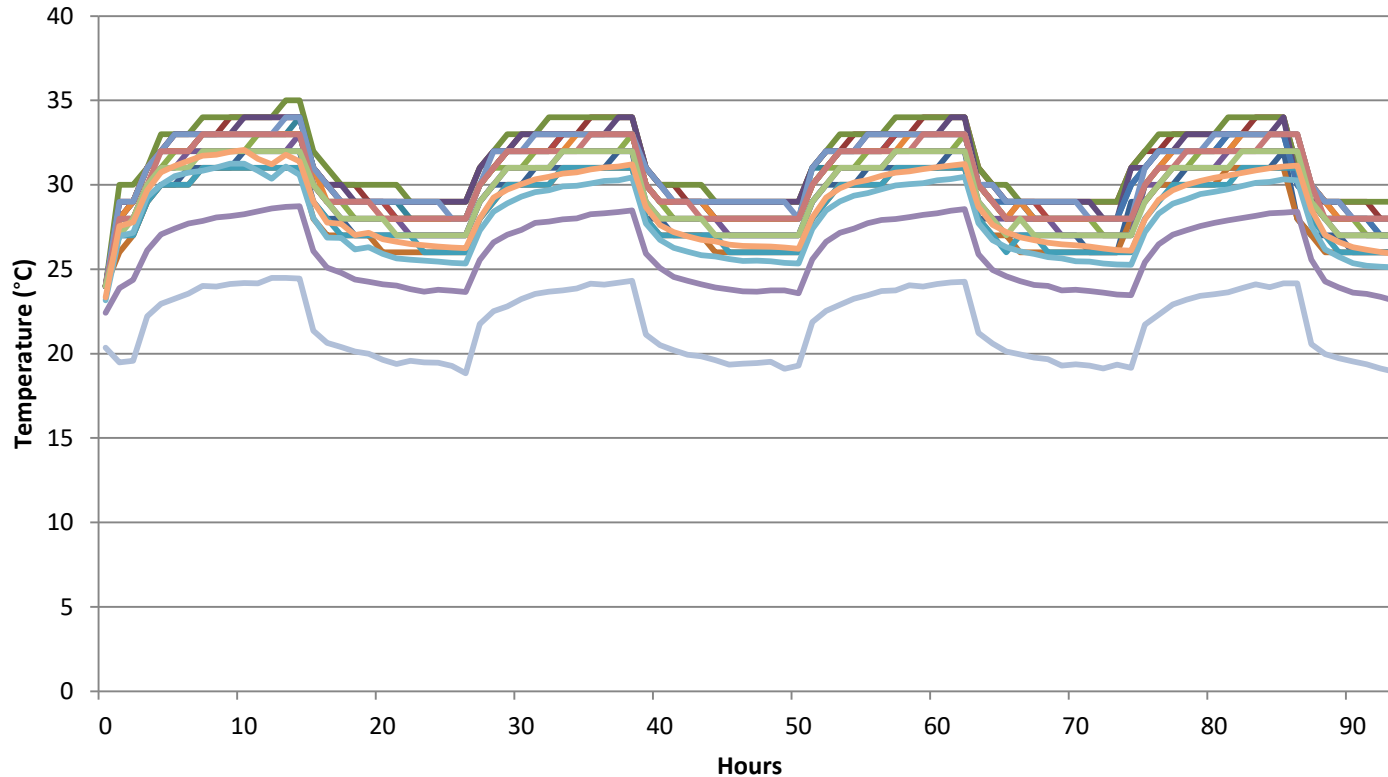
Using temperature projection method to estimate HDDs temperature at varies operating temperature.

During system operation:

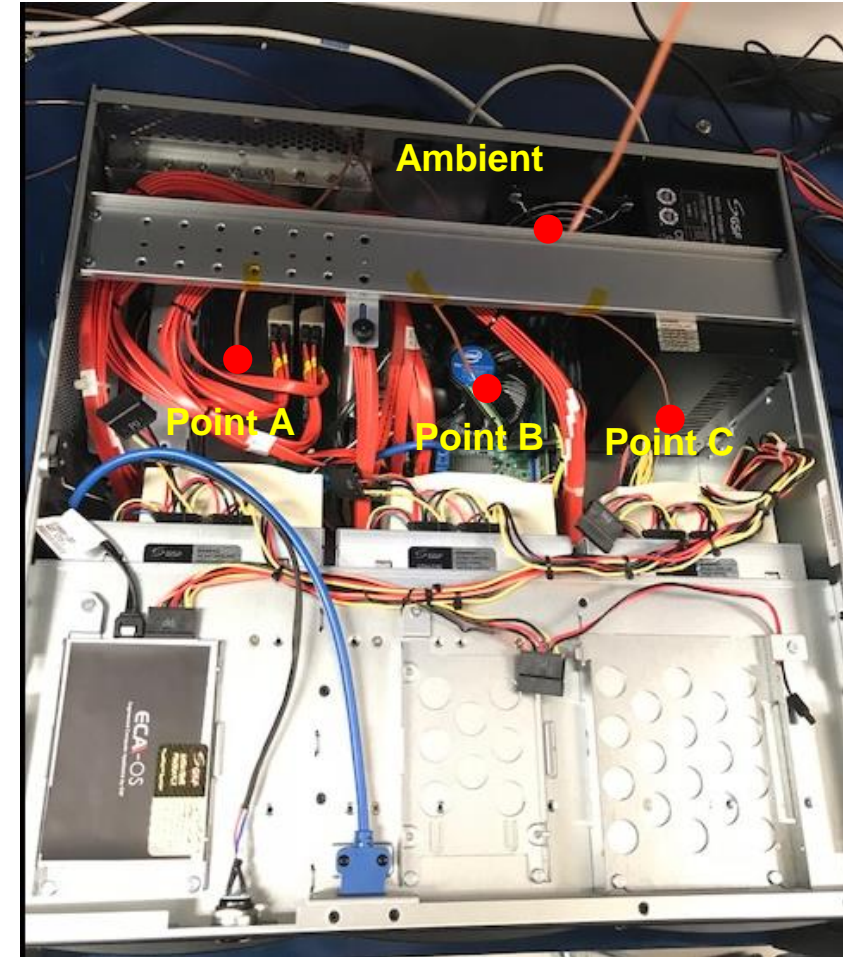
- Ideal if HDDs temperature are $> 5^{\circ}\text{C}$ to $< 55^{\circ}\text{C}$.
- If HDDs temperature $< 0^{\circ}\text{C}$
System required heater to warm up the HDD
- If HDDs temperature $> 55^{\circ}\text{C}$
Thermal control method may required to introduce to system design to enhance heat transfer.

Thermal Characterization

Thermal characterization



- HDD 1
- HDD 2
- HDD 3
- HDD 4
- HDD 5
- HDD 6
- HDD 7
- HDD 8
- HDD 9
- HDD 10
- HDD 11
- HDD 12
- HDD 13
- HDD 14
- HDD 15
- Point A
- Point B
- Point C
- ambient



	Hottest HDD	Coolest HDD
Slot position	HDD 3 (ZA201Y5C)	HDD6 (ZA21D8YW)
Ambient temperature at ~18.8°C	29°C	26
Ambient temperature at ~24.5°C	35°C	31
Avg Delta between HDD and ambient temperature	10.4°C	6.9
Projected HDD temperature (ambient = 40°C)	50.4°C	46.9°C

- HDD temperature from SMART
- Point A-C and ambient temperature measured using J type thermocouple and data logger.



Workload projection

Objective: To estimate the read/write usage of the HDD in one year per the simulated usage scenario

Test setup:

1. Video recording simulator software was installed in the system.
2. HDDs (total of 15 HDDs) were divided in groups of 3 to form storage pools.
3. 1 partition per pool was created.
4. System was configured to simulate 100 channels recording. 20 channels carter to each pool of storage.
5. All channels of the system will start recording a pre recorded video stored in C: (SSD) of the system.
6. All channels were set to record video at 1920 x 1080 resolution.

HDD	HDD s/n	Hours	Read LBA	Write LBA	Total (GB)	Average per hour (GB)	Projected workload 1 year (TB)	
1	ZA21DG7P	93	737621152	2353253786	1473.844022	15.84778518	135.5728498	
2	ZA21D9TE	93	743839048	2352100426	1476.258981	15.87375248	135.7949919	
3	ZA201Y5C	93	860045045	810830235	796.7354202	8.567047529	73.28841441	
4	ZA21D9Q1	93	850379459	811959311	792.6648951	8.523278441	72.91398354	
5	ZA21DHMQ	93	743931979	2351674370	1476.100134	15.87204446	135.7803803	
6	ZA21D8YW	93	741407441	2351830412	1474.970747	15.85990051	135.6764926	
7	ZA21PZXB	93	762822946	2380834770	1499.012812	16.11841733	137.8880233	
8	ZA21D9H2	93	812940748	2381799455	1523.37084	16.38033161	140.1286181	
9	ZA21D4WQ	93	892386888	827670751	820.1873965	8.819219317	75.44566526	
10	ZA21DHA6	93	823699587	2400617509	1537.474201	16.53198066	141.4259283	
11	ZA21DGQN	93	902034940	834510856	828.0495625	8.903758736	76.16887356	
12	ZA21DADS	93	835773895	2400994329	1543.411362	16.59582109	141.9720633	
13	ZA2207JX	93	815129634	2359868109	1513.956901	16.27910646	139.2626686	
14	ZA2207F6	93	917925201	819412957	828.4273901	8.907821399	76.20362837	
15	ZA21DE9A	93	797169081	2358655635	1504.814489	16.18080096	138.4216957	
							117.0629518	Average
							72.91398354	Min
							141.9720633	Max

Summary:

- ❑ Test based on the 5 x pools, 1 partition per pool Windows storage space configuration setting, and 20 Channels per pool HD video recording simulation.
- ❑ The estimated average workload per HDD is **~117TB/year**, which is within 180TB/year workload spec for consumer HDD.



HDD power measurement

Objective: To measure the HDD current in a worst case power consumption scenario and assess the total power consumption(watt)

Hardware:

- GSF ECA4 – Windows 10
- 2 x current probes setup
- 2 x voltage probe
- 1 x Oscilloscope

Software:

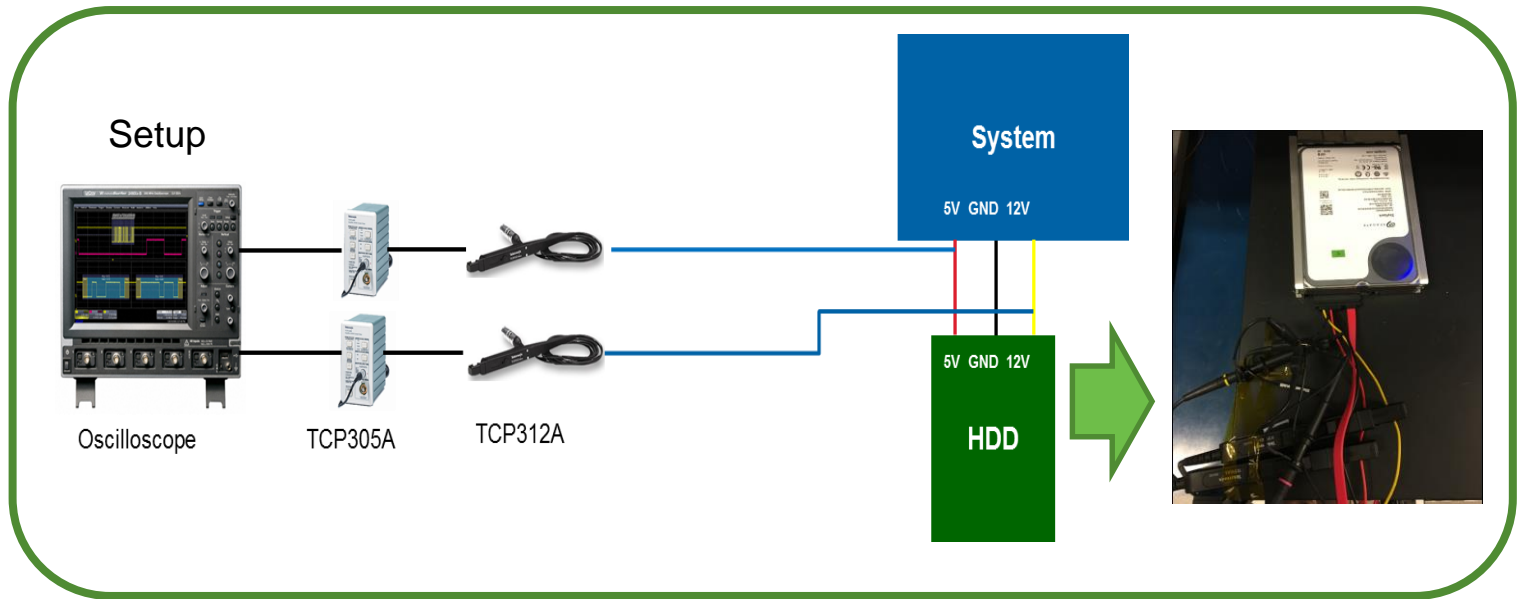
- IOmeter

IOmeter profile:

- 128K8Q Sequence Write
- 4K8Q random Write

Test:

1. Measure voltage and current both 12V and 5V line for each test scenario.
2. Calculate the wattage.

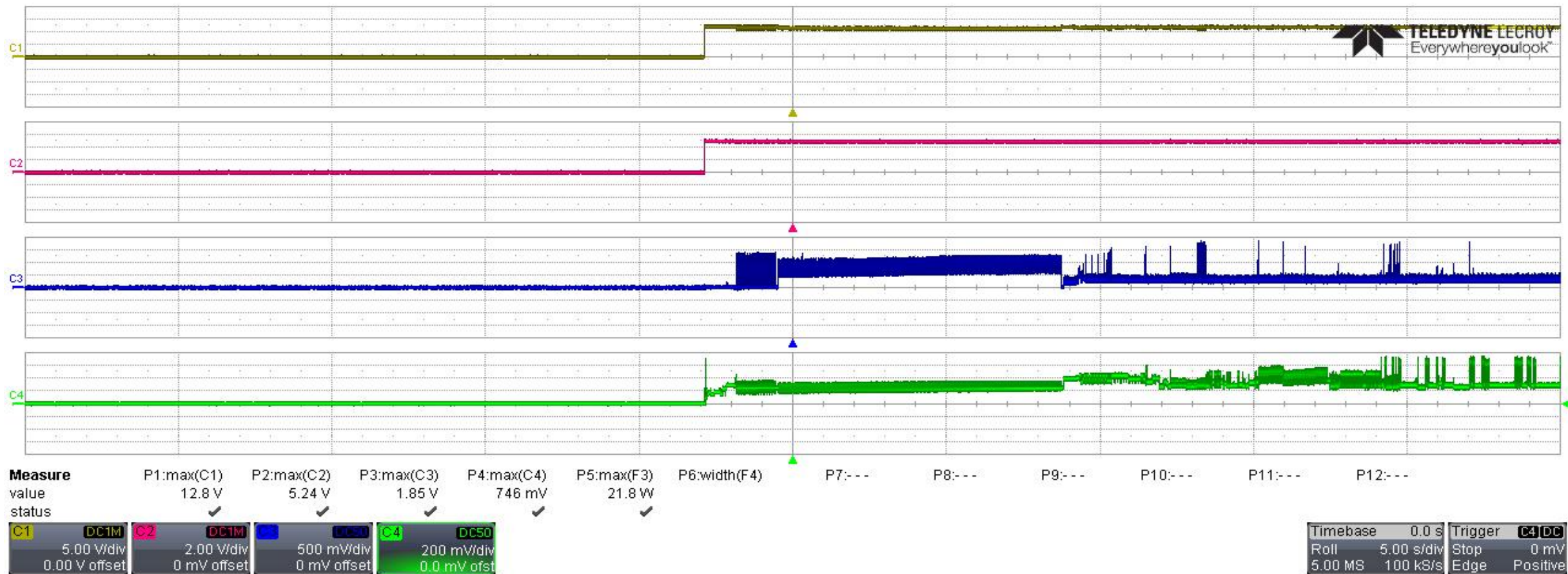


Test scenario	Power (max peak)	Estimated power needed for 15 x HDDs (*worst case)
HDD start up	27.589W	413.84W
IOmeter 128K8Q Sequence Write	12.4W	243.1W
4K8Q random Write	20.5W	372.8W

*All test scenarios are assumption of worst case situation, that might not be the real representative of the real world application.



HDD power measurement



HDD start up

C1 -> 12V line voltage (max): 12.8V

C2 -> 5V line voltage (max): 5.24V

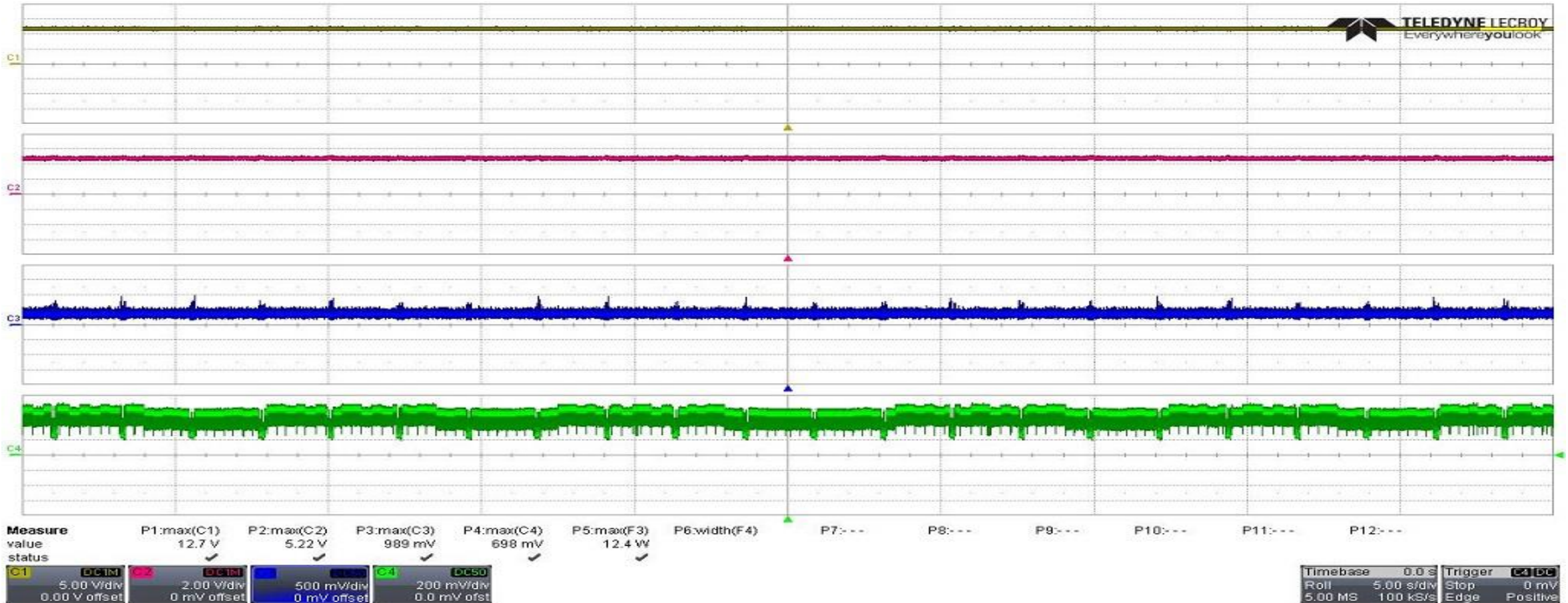
C3 -> 12V line current (max peak): 1.85A

C4 -> 5V line current (max peak): 0.746A

Total wattage (max peak): 27.589W



HDD power measurement



HDD 128K8Q sequence write

C1 -> 12V line voltage (max): 12.7V

C2 -> 5V line voltage (max): 5.22V

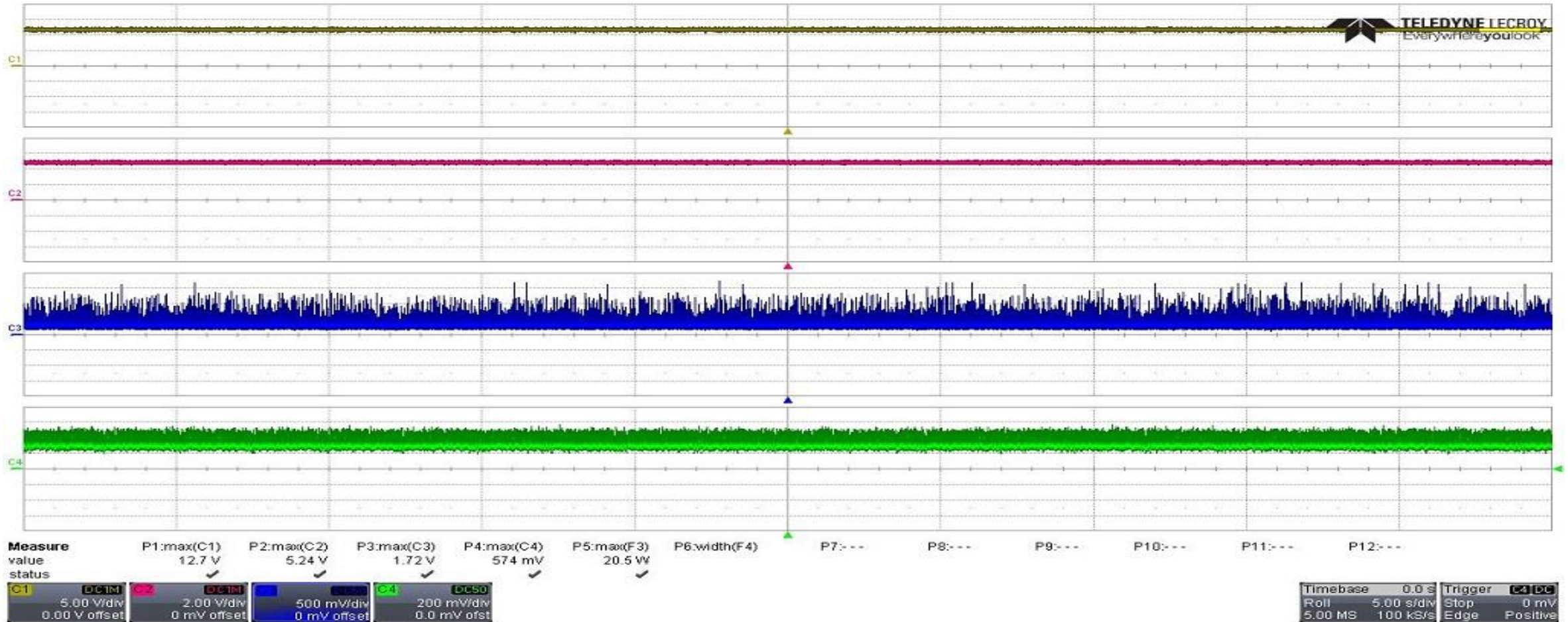
C3 -> 12V line current (max peak): 0.989A

C4 -> 5V line current (max peak): 0.698A

Total wattage (max peak): 16.2W



HDD power measurement



HDD 4K8Q random write

C1 -> 12V line voltage (max): 12.7V

C2 -> 5V line voltage (max): 5.24V

C3 -> 12V line current (max peak): 1.72A

C4 -> 5V line current (max peak): 0.574A

Total wattage (max peak): 24.86W



In-System Performance (ISP) Test Setup & condition

Objective: To assess individual drive/ slot performance during actual operating usage

Test Method:

Hard drive vibration was measured under following conditions:

Test Pre-condition:

- IO scripts are directed to individual drives.
- Target drive instrumented with RV accelerometers
- Target Drive I/O
 - Random Write:
 - Transfer length: 4kB
 - Cache: write-cache-disabled
 - Queue: Queue depth 8
 - Sequential Write:
 - Transfer length: 128kB
 - Cache: write-cache-disabled
 - Queue: Queue depth 8
- Adjacent Drive I/O
 - Random Read
 - Transfer length: 4kB
(aligned to 4k sector boundary if 4k Native)
 - Queue: Queue depth 1

Grading Criteria

Score	Minimum observed throughput	Description
★★★★	>95%	Excellent throughput.
★★★	>90%	Very good throughput.
★★	>80%	Marginal throughput. May be acceptable, application dependent
★	<80%	Atypical low throughput. May be acceptable, especially if the test condition is unlikely to occur in field use
	<15%	Unacceptable low throughput. Risk of system time-out events

In System Performance Test:

- Baseline:
 - Measure the baseline throughput of the target drive
- Random Write:
 - Enable system fan
 - Execute I/O test on all 15 HDDs (1 target, 14 adjacent drives)
 - Move target drive to next drive bay and repeat measurement, repeat In-System I/O performance measurement
- Sequential Write:
 - Enable system fan
 - Execute I/O test on all 15 HDDs (1 target, 14 adjacent drives)
 - Move target drive to next drive bay and repeat measurement, repeat In-System I/O performance measurement
 -
- Compute I/O throughput percentage for each drive
 - Random Write Throughput
 - $RW = (In\text{-}System\ iops / Baseline\ iops) * 100\%$
 - Sequential Write Throughput
 - $SW = (In\text{-}System\ MB/s / Baseline\ MB/s) * 100\%$



In-System Performance (ISP)

ST10000VX0004



System Outlet Fan
 Default(10%): ~3350rpm
 Max(80%): ~5300rpm

* ISP test are performed with HDD write cache disabled

HDD Slot	HDD S/N	4kB Random Write;Queue depth 8; unit:IOPS					128kB Seq. Write;Queue depth 8; unit:MB/s				
		Baseline	System Fan Default 10%	Percentage = default fan / Baseline(without fan)	System Fan Max 80%	Percentage = Max Fan / Baseline(without fan)	Baseline	System Fan Default 10%	Percentage = default fan / Baseline(without fan)	System Fan Max 80%	Percentage = Max Fan / Baseline(without fan)
1	ZA21DG7P	104.9	102.9	98.1	102.5	97.7	231.6	228.9	98.8	227.9	98.4
2	ZA21D9TE	104.9	103.8	99.0	102.9	98.1	241.9	238.9	98.8	238.3	98.5
3	ZA201Y5C	103.5	101.7	98.3	100.9	97.5	227.8	226.5	99.4	223.2	98.0
4	ZA21D9Q1	105.0	103.7	98.8	103.8	98.9	227.7	226.1	99.3	225.3	98.9
5	ZA21DHMQ	108.5	103.7	95.6	103.6	95.5	249.5	236.0	94.6	235.2	94.3
6	ZA21D8YW	108.4	103.3	95.3	102.8	94.8	246.4	233.5	94.8	232.9	94.5
7	ZA21PZXB	109.0	103.3	94.8	104.4	95.8	241.6	228.4	94.5	228.9	94.7
8	ZA21D9H2	109.7	107.5	98.0	107.2	97.8	245.8	242.2	98.5	241.7	98.3
9	ZA21D4WQ	109.2	107.3	98.3	106.7	97.7	243.7	239.6	98.3	239.7	98.4
10	ZA21DHA6	109.4	106.7	97.5	106.7	97.5	241.3	237.5	98.4	237.5	98.4
11	ZA21DGQN	108.6	105.4	97.1	106.1	97.7	244.8	241.5	98.7	240.1	98.1
12	ZA21DADS	108.3	106.6	98.4	107.3	99.1	245.2	241.7	98.6	240.5	98.1
13	ZA2207JX	109.4	106.4	97.3	106.1	97.0	239.0	235.2	98.4	235.0	98.3
14	ZA2207F6	108.8	106.1	97.5	106.3	97.7	253.2	248.7	98.2	248.7	98.2
15	ZA21DE9A	108.5	106.2	97.9	105.8	97.5	237.6	233.8	98.4	233.8	98.4
		Min		94.8	Min	94.8		Min	94.5	Min	94.3
		Max		99.0	Max	99.1		Max	99.4	Max	98.9
		Avg		97.4	Avg	97.3		Avg	97.8	Avg	97.6

Summary

- ❑ Overall, in-system performance for all slots measure > 90% (according to performance grading criteria ★★★)
- ❑ Slot 5,6,7 have lower throughput performance compared to the rest and are selected for analysis



In-System Performance (ISP)

ST8000VX0022



System Outlet Fan
 Default(10%): ~3350rpm
 Max(80%): ~5300rpm

* ISP test are performed with HDD write cache disabled

HDD: Makaraplus (8TB, Surveillance)

HDD Slot	HDD S/N	4kB Random Write;Queue depth 8; unit:IOPS					128kB Seq. Write;Queue depth 8; unit:MB/s				
		Baseline	System Fan Default 10%	Percentage = default fan / Baseline(without fan)	System Fan Max 80%	Percentage = Max Fan / Baseline(without fan)	Baseline	System Fan Default 10%	Percentage = default fan / Baseline(without fan)	System Fan Max 80%	Percentage = Max Fan / Baseline(without fan)
1	ZA14VJ7B	208.9	209.7	100.4	209.3	100.2	244.5	243.7	99.7	244.1	99.8
2	ZA14VHW0	210.3	209.1	99.5	209.7	99.7	242.3	242.4	100.0	242.4	100.0
3	ZA12W0LT	210.6	208.0	98.8	209.3	99.4	235.9	235.4	99.8	235.6	99.9
4	ZA14VJAY	208.7	209.8	100.5	209.2	100.3	233.7	233.5	99.9	233.6	99.9
5	ZA14VJ6N	210.3	209.8	99.8	210.1	99.9	239.7	240.4	100.3	240.1	100.1
6	ZA13VTKT	207.5	209.3	100.9	208.4	100.4	248.5	245.4	98.7	246.9	99.4
7	ZA14VJ23	209.3	208.9	99.8	209.1	99.9	238.5	241.1	101.1	239.8	100.5
8	ZA14VJ2W	206.7	211.0	102.1	208.8	101.0	234.3	238.3	101.7	236.3	100.9
9	ZA14GC5L	209.8	209.1	99.7	209.4	99.8	234.7	235.7	100.4	235.2	100.2
10	ZA13W31C	203.6	208.3	102.3	206.0	101.2	235.2	237.5	101.0	236.4	100.5
11	ZA14VHWJ	209.8	213.0	101.5	211.4	100.8	242.3	243.0	100.3	242.6	100.1
12	ZA14VJ12	208.9	212.4	101.7	210.7	100.8	235.6	233.7	99.2	234.6	99.6
13	ZA14WHFZ	208.0	213.4	102.6	210.7	101.3	231.4	233.6	100.9	232.5	100.5
14	ZA14VW5R	205.6	210.0	102.2	207.8	101.1	241.7	243.4	100.7	242.6	100.3
15	ZA14VHYE	211.4	210.2	99.4	210.8	99.7	232.8	233.8	100.4	233.3	100.2
			Min	98.8	Min	99.4		Min	98.7	Min	99.4
			Max	102.6	Max	101.3		Max	101.7	Max	100.9
			Avg	100.7	Avg	100.4		Avg	100.3	Avg	100.1

CPU Fan - 2528rpm

Outlet Fan - 3358rpm (10% Default)

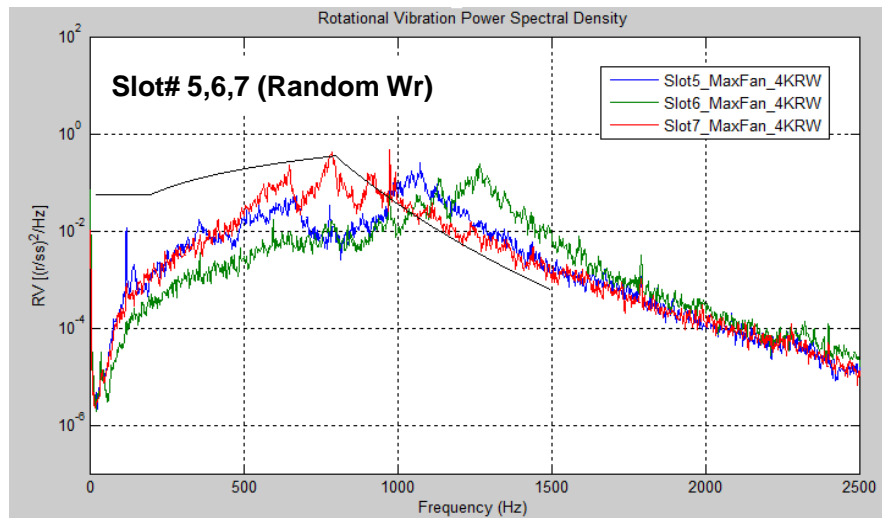
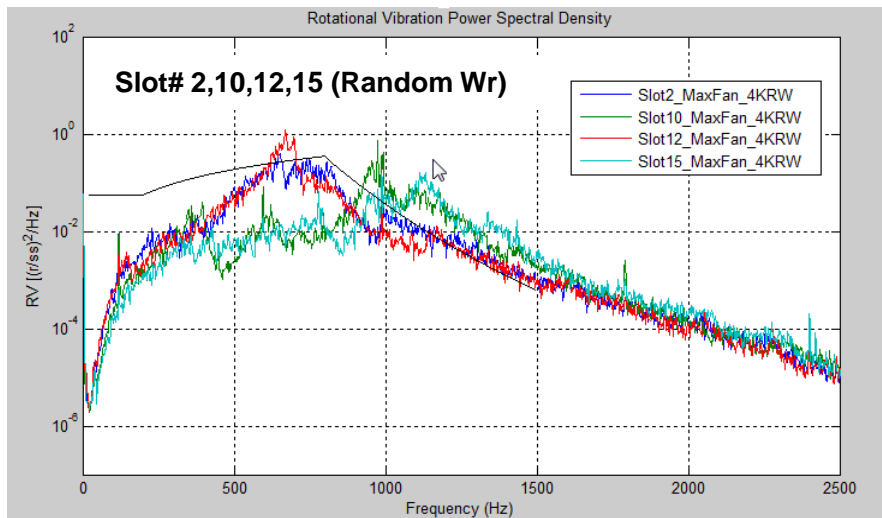
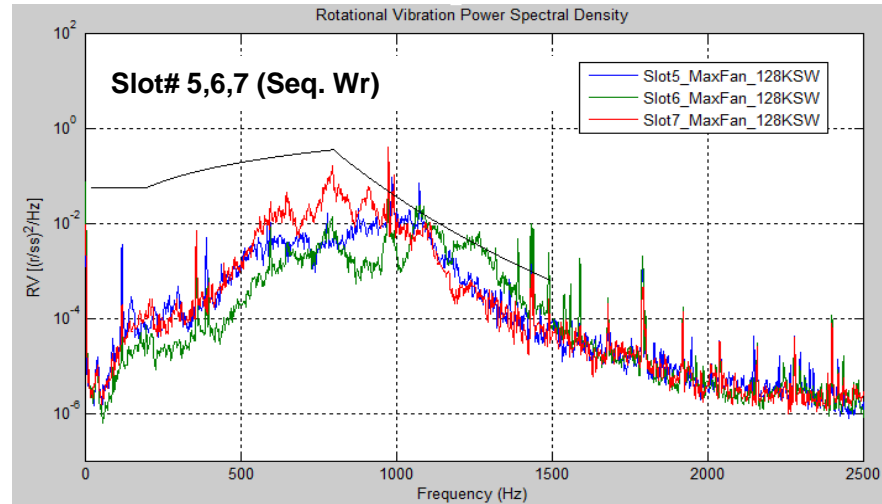
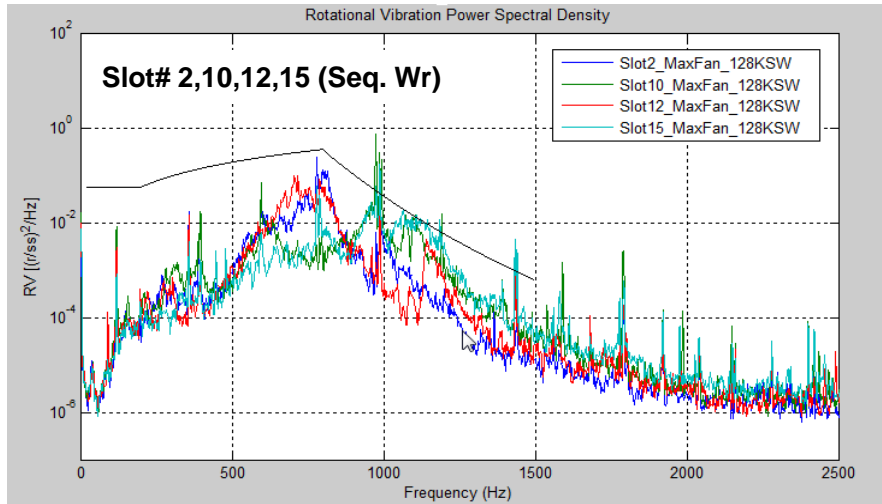
Outlet Fan - 5357rpm (80% max)

Inlet Fan - 2840rpm (Unable to vary speed)


❑ Overall, in-system performance for all slots measure > 95% (according to performance grading criteria ★★★★★)



In System Vibration – Drive RV



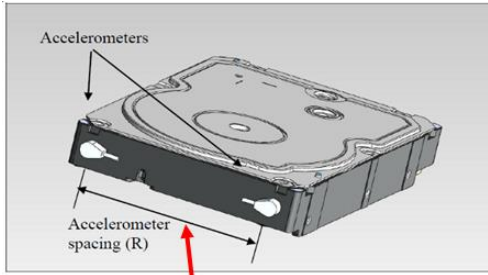
- No significant difference observed between the RV data for high and low performance slots
- Higher RV energy is observed when target drive is performing random write operation compared to sequential



In-system Vibration (Drive RV)
 Vibration sources such as HDD seek operations (rotational vibration) and cooling fan (linear and rotational vibration) may degrade HDD I/O performance.

Target Drive I/O and Adjacent Drive

- Target Drive - Random Write
- Adjacent Drive - Random Read
- Transfer length: 4kB ,same
- Cache: write-cache-disabled ,same



Measure the spacing between two single accelerometer (Left side & Right side)

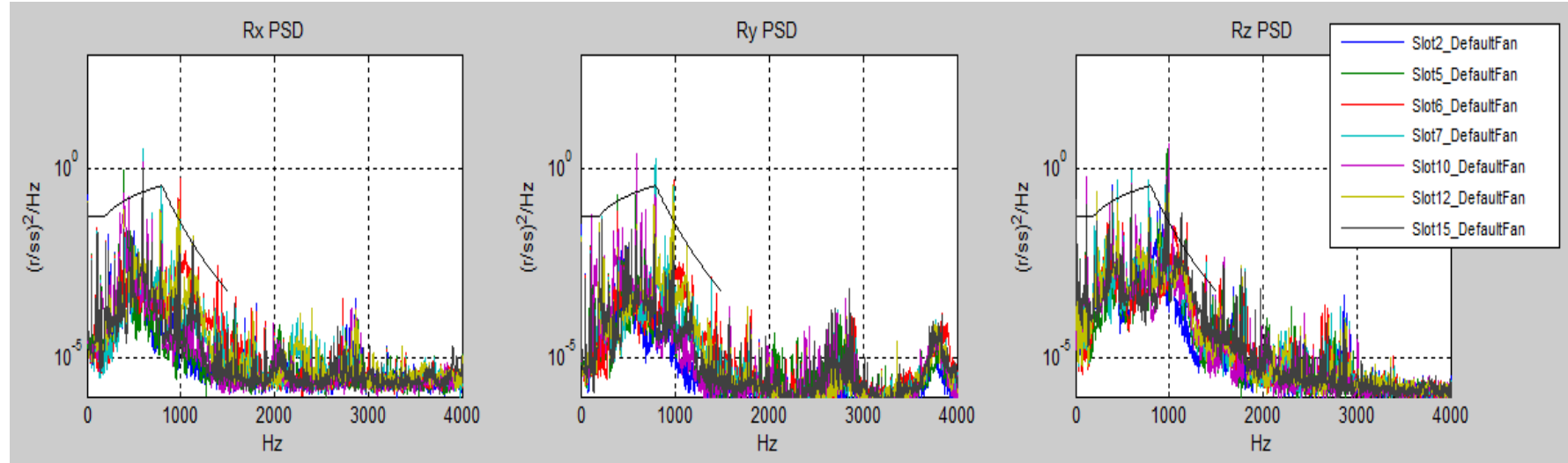
Drive RV → Include Drive self Induce RV, System FAN and adjacent drives vibration

Drive RV

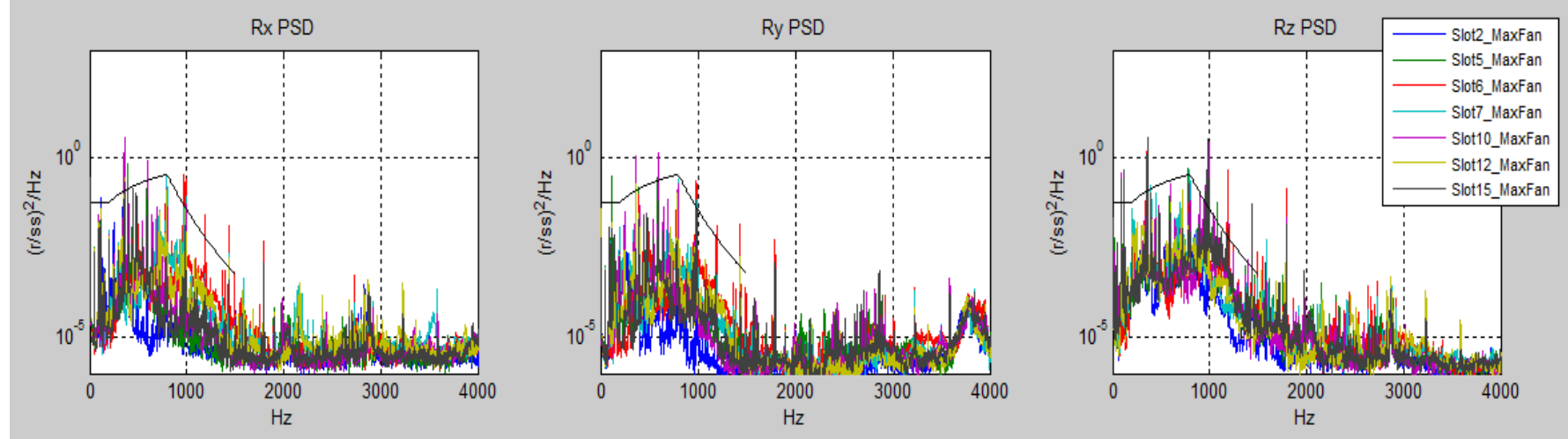


In System Vibration – Surrogate ISV

Default Fan condition



Max Fan condition



- ❑ No significant difference observed between ISV plot for default & max fan condition
- ❑ In this case, system outlet fan speed does not have significant impact on slot RV

In-system Vibration (Fan RV)

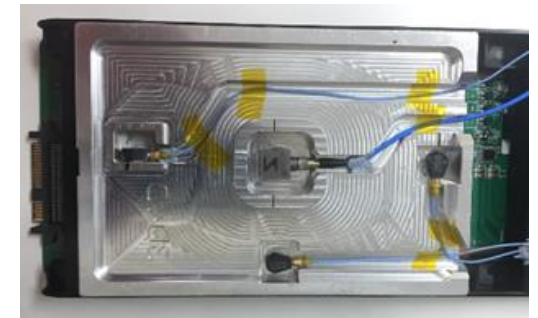


Surrogate (AL block, non-operating), we are able to isolate the RV effect contributed by external cooling fan and adjacent drives.

Fan Speeds →
On(Default) , On (Max)



Fan RV measurements:
All HDD idle (powered on, no iops) Surrogate drive instrumented with accelerometers



Surrogate → System FAN and adjacent drives vibration (idle and spinning)

Surrogate RV

System Outlet Fan

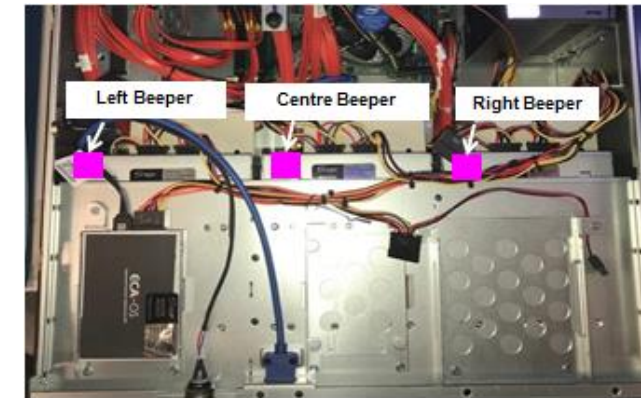
Default(10%): ~3350rpm
Max(80%): ~5300rpm



System beepers Characterization - ISP

* ISP test are performed with HDD write cache disabled

HDD Slot	HDD S/N	4kB Random Write;Queue depth 8; unit:IOPS			128kB Seq. Write;Queue depth 8; unit:MB/s		
		Baseline	System Fan Default + (3 x Beepers "On")	Percentage = Beeper "On" / Baseline (without fan)	Baseline	System Fan Default + (3 x Beepers "On")	Percentage = Beeper "On" / Baseline (without fan)
1	ZA21DG7P	104.9	101.9	97.1	231.6	224.0	96.7
2	ZA21D9TE	104.9			241.9		
3	ZA201Y5C	103.5	100.5	97.1	227.8	209.8	92.1
4	ZA21D9Q1	105.0			227.7		
5	ZA21DHMQ	108.5	102.4	94.4	249.5	233.6	93.6
6	ZA21D8YW	108.4	100.9	93.1	246.4	221.3	89.8
7	ZA21PZXB	109.0			241.6		
8	ZA21D9H2	109.7	101.0	92.1	245.8	218.3	88.8
9	ZA21D4WQ	109.2			243.7		
10	ZA21DHA6	109.4	96.5	88.2	241.3	136.4	56.5
11	ZA21DGQN	108.6	104.8	96.5	244.8	239.5	97.8
12	ZA21DADS	108.3			245.2		
13	ZA2207JX	109.4	104.3	95.3	239.0	232.2	97.2
14	ZA2207F6	108.8			253.2		
15	ZA21DE9A	108.5	102.8	94.7	237.6	216.0	90.9



*pink – refers to beeper location

Slot-10 assessment (isolate primary beeper that cause performance drop)

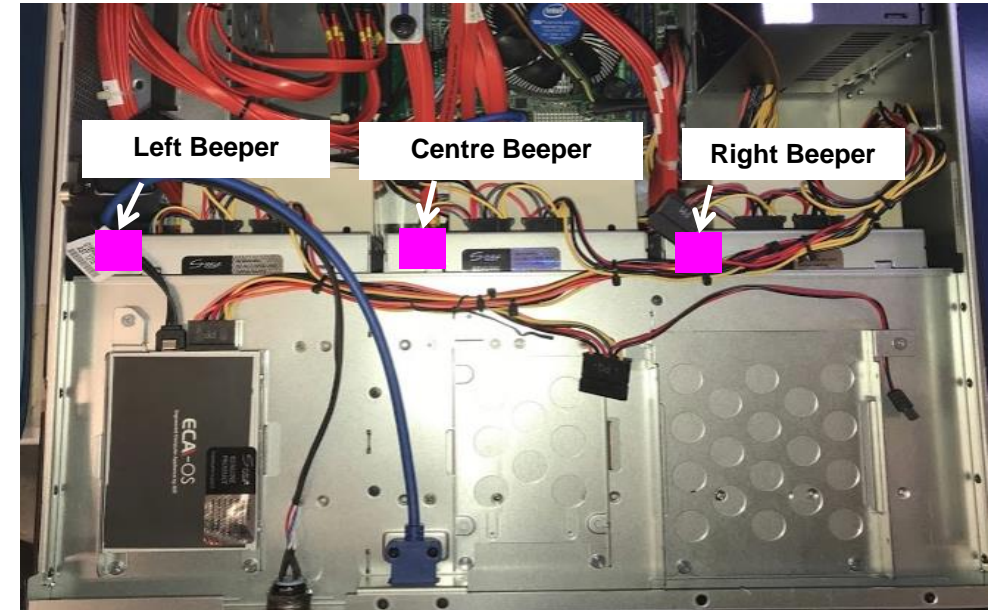
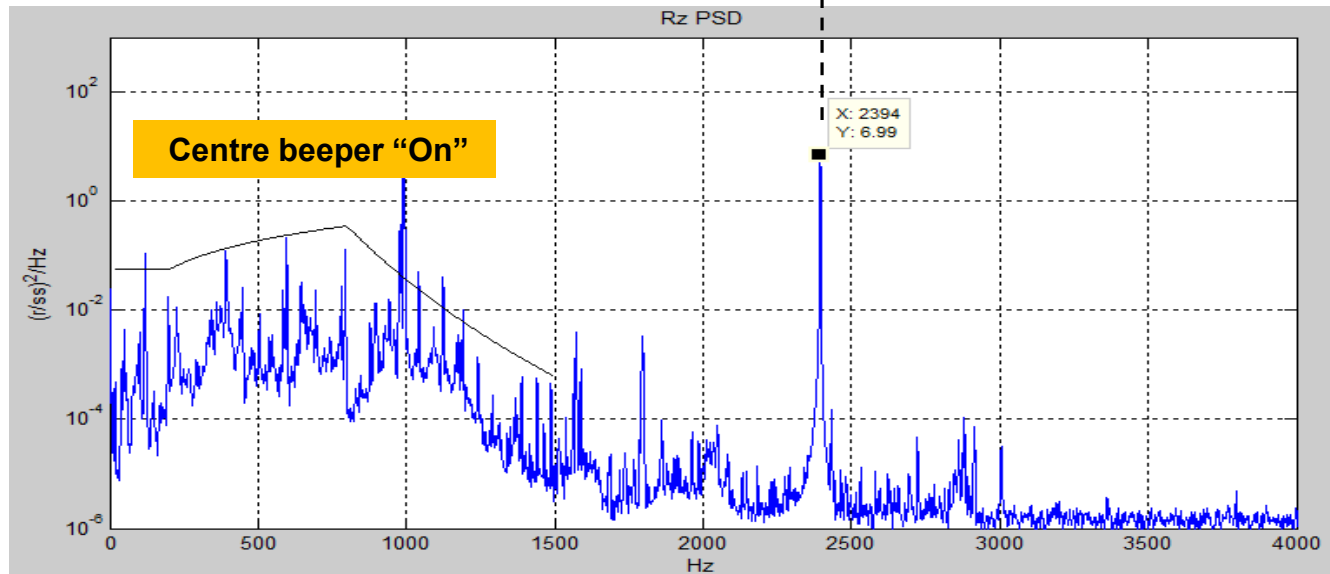
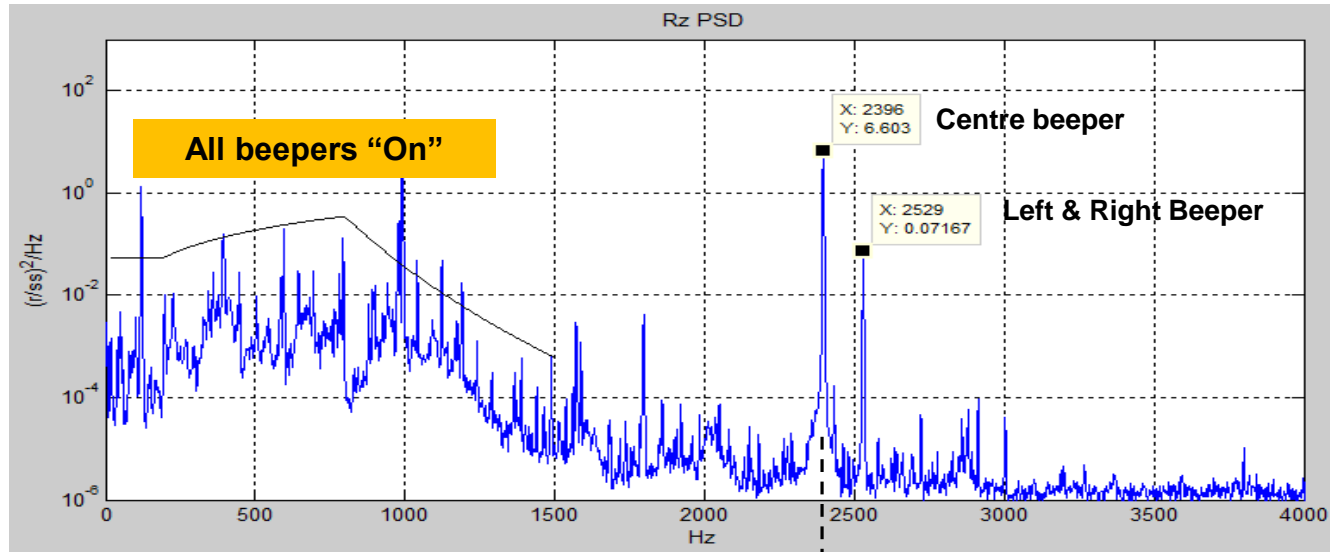
HDD Slot	Configuration	HDD S/N	128kB Seq. Write;Queue depth 8; unit:MB/s					Remarks (based on surrogate RV)	
			Baseline	Throughput #1	Throughput #2	Throughput #3	Average		Percentage %
10	All Beeper On	ZA21DHA6	241.3	168.6	166.6	73.9	136.4	56.5	observe 2.4khz + 2.5khz
10	Only Centre Beeper On	ZA21DHA6	241.3	84.5	138.8	104.4	109.2	35.0	~2.4Khz
10	Only Adjacent (Left & Right) Beeper On	ZA21DHA6	241.3	236.5	236.9	235.0	236.1	98.0	~2.5Khz

- ❑ ISP test conducted on 9 slots to access any impact on drive performance when all 3 x beepers turn on
- ❑ Slot-10 observe worst throughput performance (~ 56%) when all beepers are turned on
- ❑ Centre beeper is observed to have the most significant impact on the slot-10 performance



System Beepers Characterization - Surrogate ISV

Surrogate ISV Characterization on "Slot-10"

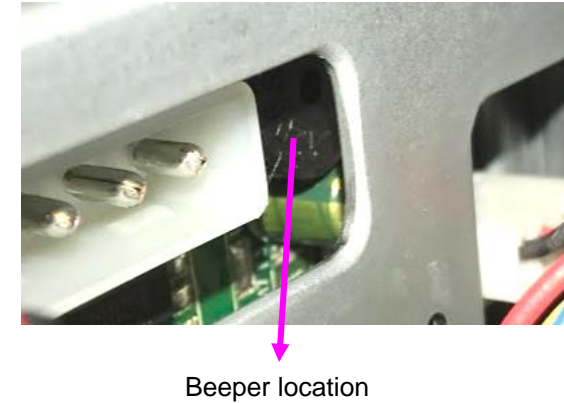


- ❑ System has 3 x beepers which are situated behind the drive slots. Distance of beeper to HDD is ~ 2cm
- ❑ Surrogate ISV measurement observe distinct tone frequency of the beepers:
 - Centre beeper has a freq ~ 2.4 khz
 - Left / Right beeper has freq ~ 2.5 khz

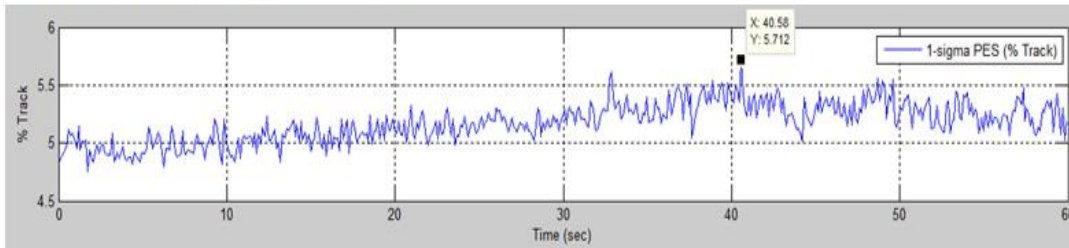


System Beepers Characterization - PES

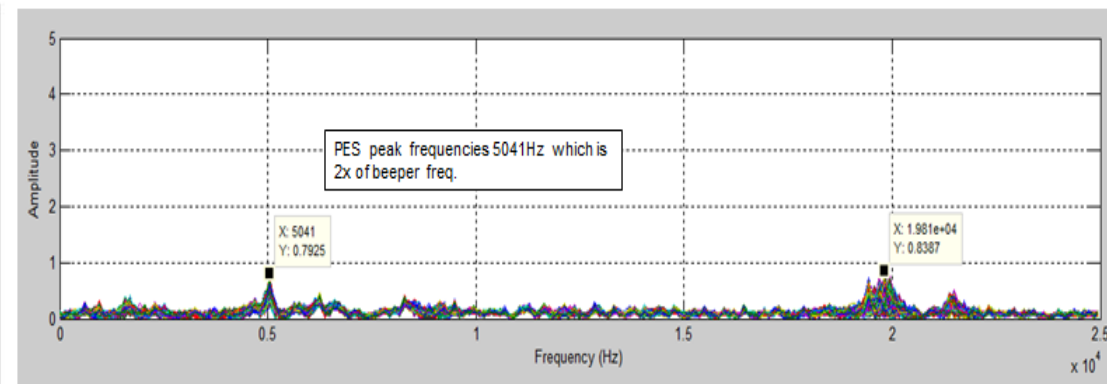
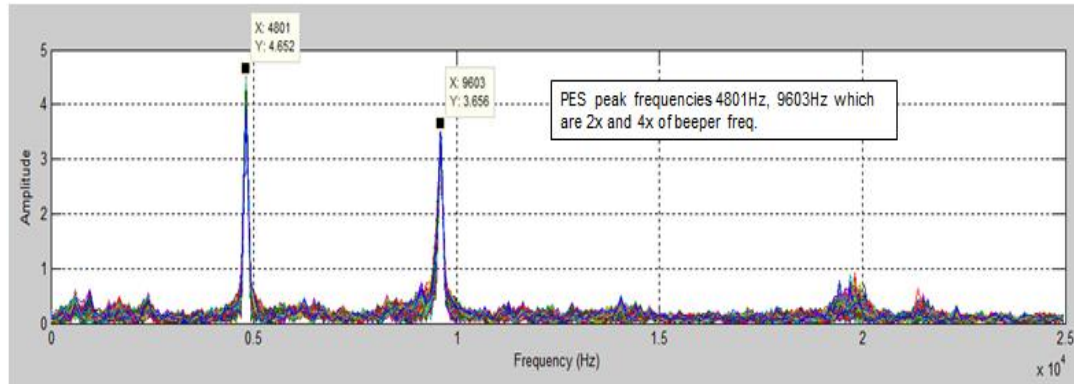
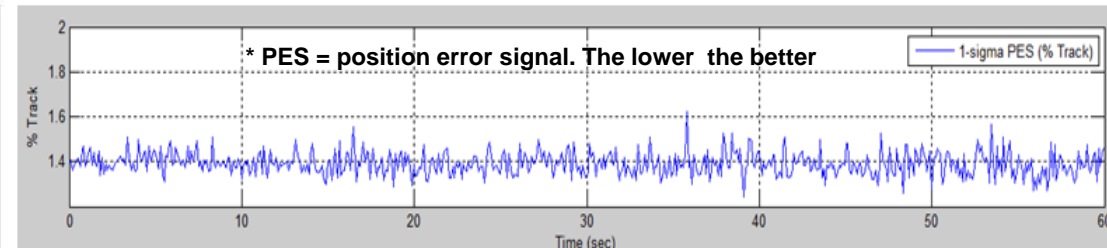
Slot #	Beeper	PES Duration	Peak frequency	1- σ PES
Slot 10	Baseline (All beepers OFF)	60-sec	na	1.2%-1.4%
Slot 10	Centre Beeper "ON"	60-sec	4801Hz, 9603Hz	5.0% - 5.7%
Slot 10	Left / Right Beeper "ON"	60-sec	5041Hz	1.4% - 1.6%
Slot 05	Left Beeper "ON"	60-sec	5041Hz	2.0% - 2.4%
Slot 05	Centre Beeper "ON"	60-sec	4801Hz	1.3% - 1.6%



Slot10 PES >> Centre Beeper 2.4KHz "On"



Slot10 PES >> Left & Right Beeper 2.5KHz "On"



- ❑ Slot 10 drive observe higher PES reading when the center beeper is turned on
- ❑ Peak frequency observed from the PES are 2 x and 4x of the beeper frequency



Thank You



Partnership
Collaboration

