

PCI Express Based SSD Test Methodologies

Aug 22, 2012

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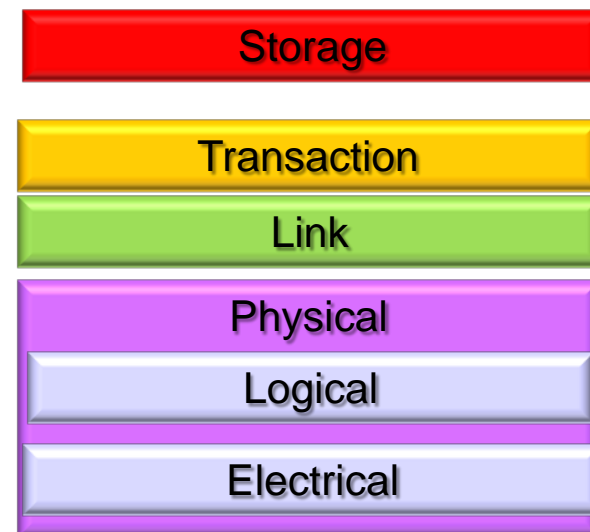
Product Marketing Manager



PCIe SSDs Require New Testing Methodologies



- PCIe SSDs combine various storage protocol layers on top of the PCI Express electrical, link and transaction layers.
- New tools and testing methodologies are required to meet the challenges of high performance SSDs.



Protocol Analysis with the SFF-8639 Interposer

Link Speed Frame/OOB



PCIe Protocol Analyzer



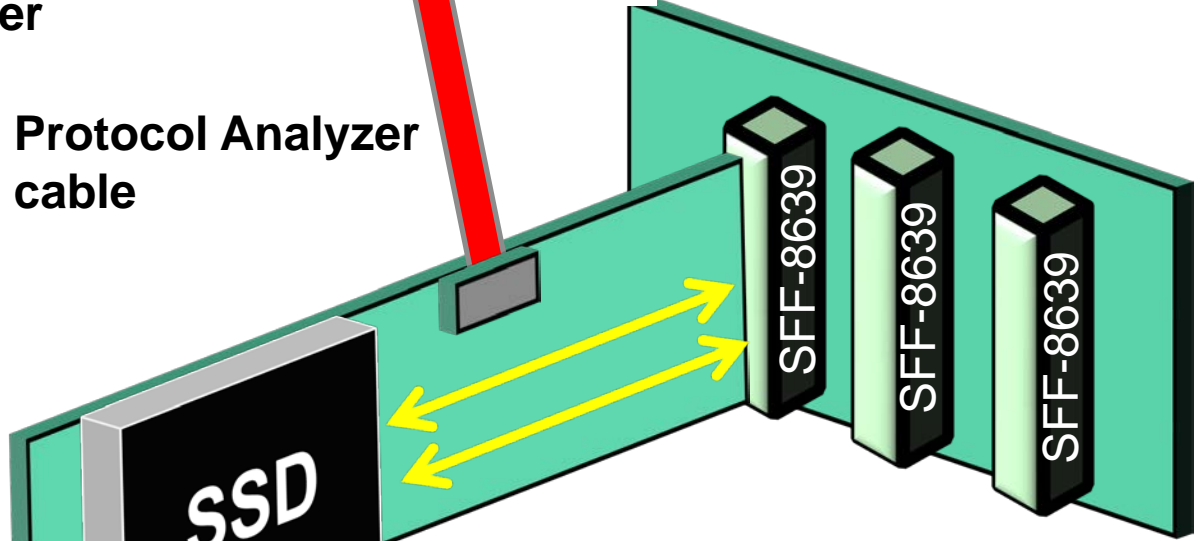
Right Angle Plug



Vertical Receptacle

SFF-8639

Protocol Analyzer cable



SFF-8639 Interposer

Testing PCIe SSD and Systems

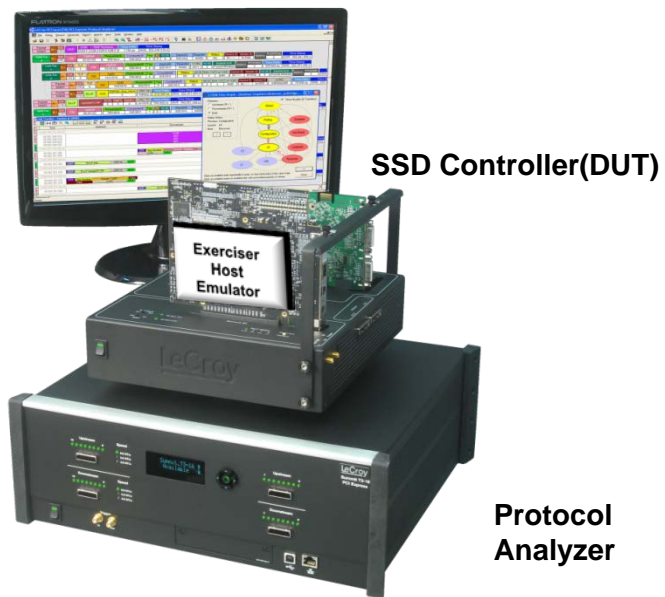
- Supports the Windows 7 NVMe Driver
- Emulates all NVMe Registers
- Admin Commands
- NVM Commands
 - Write
 - Read
 - Compare
 - Extensible for Vendor Specific Commands
- Queue Management
- Come up in Device Manager
- Extensible Vendor Specific Features (for Get/Set Features)
- Complete commands via fused Commands (i.e. Compare & Write)



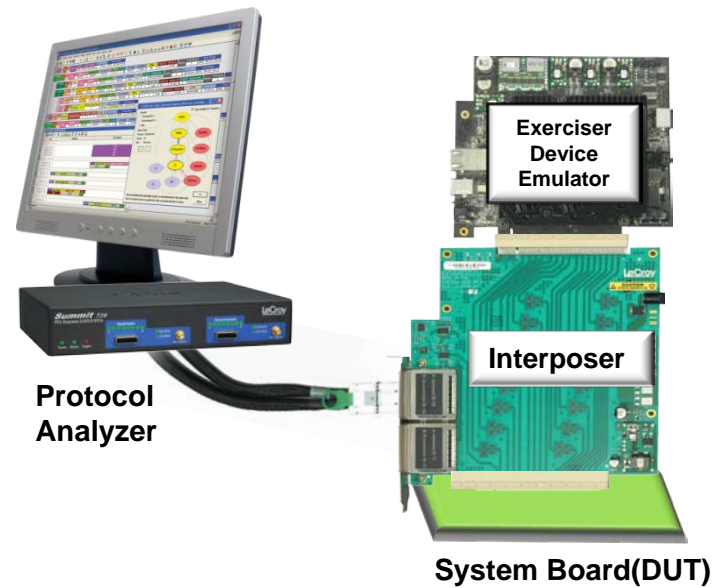
Summit Z3-16 Protocol Exerciser

SSD Test Setup

SSD Device Controller Test



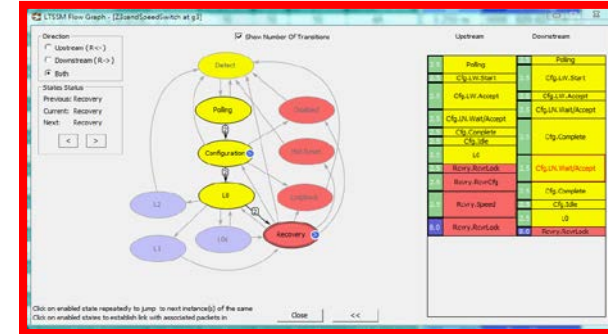
SSD Driver Host Test



PCI Express Performance Tools

■ Measure and monitor PCIe SSD performance details

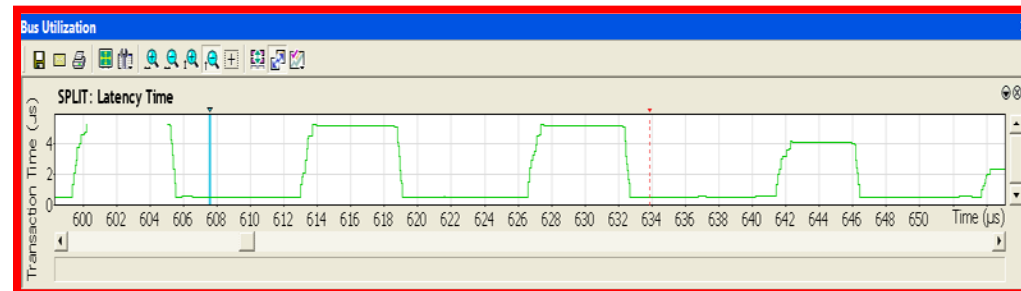
- PCIe Packet Metrics
- Timing Calculator- Bandwidth, Link Utilization
- Post Capture Bus Utilization Graph Tool
 - Latency, Throughput Views
- Real Time Statistics Graph Tool



■ Understand link behaviors and improve SSD performance

- Flow Control View
- Link Tracker
- LTSSM State View

Bus Utilization		
	Upstream	Downstream
Link Utilization	45.127 %	44.546 %
Time Coverage	45.072 %	44.493 %
Bandwidth	9025.43 Mb/s	8909.10 Mb/s
Data Throughput	592.29 MB/s	598.72 MB/s
Packets/second	19696168.45	24833612.81



Tools for PCIe SSD Technologies



SSD Protocols	Analyzer	Exerciser
PCI Express	Summit T3-16 Summit T3-8 Summit T28	Summit Z3-16 <i>Host/Device Emulation</i>
NVM Express	Summit T3-16/ T3-8/ T28 <i>SSD Decoding</i>	Summit Z3-16 <i>NVMe Host/Device Emulation</i>
SCSI Express(SOP/PQI)	Summit T3-16/ T3-8/ T28 <i>SSD Decoding</i>	Summit Z3-16 <i>SCSI Express Host Emulation</i>
SATA Express (AHCI/PCIe)	Summit T3-16/ T3-8/ T28 <i>SSD Decoding</i>	Summit Z3-16 <i>SATA Express Host Emulation</i>



NVM Express 1.0c Analysis Decode



IO Transfer

Completion



NVM	RequesterID	CompleterID	IO Cmd	OPC	FUSE	CID	NSID	MPTR Hi	MPTR Low	PRP1 Hi	PRP1 Low	PRP2 Hi	PRP2 Low	SLBA	LR	FUA	PRINFO
195	008:00:0	000:00:0	Read	b00	0x0000	0x00000001	0x00000000	0x00000000	0x00000000	0x00000001	0xEED31000	0x00000000	0x00000000	0x00000000:00000000	0	0	0x0

NLM	DSM	Incompressible	SR	AL	AF	EILBRT	ELBAT	ELBATM	Time Delta	Time Stamp
0x0000		0	0	None	None	0x00000000	0x0000	0x0000	163.968 μs	0079.553228928 s

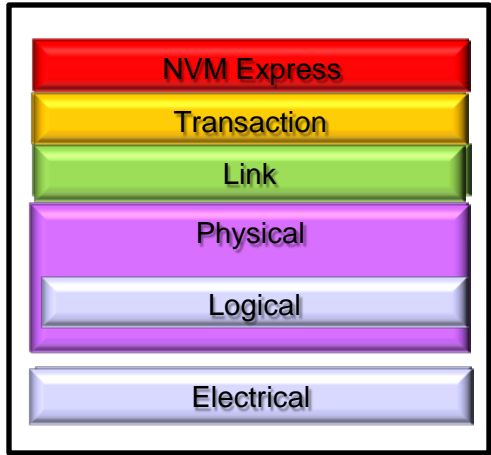
NVM	RequesterID	Command	Addr Hi	Addr Lo	Data Len	Data	Time Delta	Time Stamp
196	008:00:0	CMD PRP	0x00000001	0xEED31000	0x00000200	127 quadlets	313.872 μs	0079.553392896 s

NVM	RequesterID	Command Completion	QHD	SQID	CID	P	ST	SC	SCT	M	DR	Time Delta	Time Stamp
197	008:00:0	0x00000000	0x0001	0x0010	0x0000	1		0x0000	0x00	0	0	26.720 μs	0079.553706768 s

Physical Region Page

Commands or Data

- NVMe is a standardized high performance queuing interface and command set optimized for PCIe SSDs
- NVMe is scalable from client to enterprise applications



Courtesy SanDisk 2012

NVMe Compliance and Interoperability Testing

- UNH-IOL(University Of New Hampshire IOL) and the NVM Express Promoters Group are collaborating to create an interop and conformance test program centered at UNH-IOL.
- They will be creating a multi-vendor test bed to help products prove interoperability, and conformance test services to prove that products follow the NVMe specification correctly.
- Targeting Fall 2012.



University of New Hampshire
**InterOperability
Laboratory**

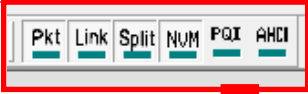


Teledyne LeCroy Summit Z3-16 NVMe Emulator
Demo in Booth #706

SCSI Express SOP Analysis Decode

Link Speed Frame/OOB

Advancing Producer in Inbound Queue



PQI	Req	Len	RequesterID	Index	Time Delta	Time Stamp																
55	R→	x1	000:00:0	0x0001	21.304 μs	0140 . 113 039 492 s																
56	R→	x1	010:00:0	000:00:0																		
			SOP IU	IT	CF	IU LEN	ROQID	WA	Req ID	Data Dir	PARTIAL	DATA LEN	SCSI CDB	OP Code	SA	CDB Info	LBA	CDB Info	LEN	CDB Info	CONTROL	
			0x10	0x00	0x003C	0x0003	0x0000	0x0000	0x0007	3	0	0x00000010	0x00	0xA0	0x0	0x0	0x00000000	0x00001000	0x00000000	0x00	0x00000000	
			DB DWs	DB DWs	DB DWs	DB DWs	DB DWs	DB DWs	DB DWs	DB DWs	DB DWs	DB DWs	DB DWs	DB DWs	DB DWs	DB DWs	DB DWs	DB DWs	DB DWs	DB DWs	DB DWs	DB DWs
			0x14281120	0x00000000	0x00000010	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000

Advancing Consumer in Inbound Queue

PQI	Req	Len	RequesterID	Index	Time Delta	Time Stamp											
57	R→	x1	010:00:0	0x0001	490.879 ms	0140 . 113 162 956 s											
9610	R→	x1	TLP	MsgD	Msg Routing	Length	RequesterID	Tag	Message Code	VID	Data	VC ID	Explicit ACK	Metrics	# Packets	Time Delta	Time Stamp
			851	011:10011	Broadcast	1	000:00:0	0	Vendor_Defined_Type1	0x8086	1 dword	0	Packet #18600		2	135.073 ms	0140 . 604 041 748 s

Advancing Producer in Outbound Queue

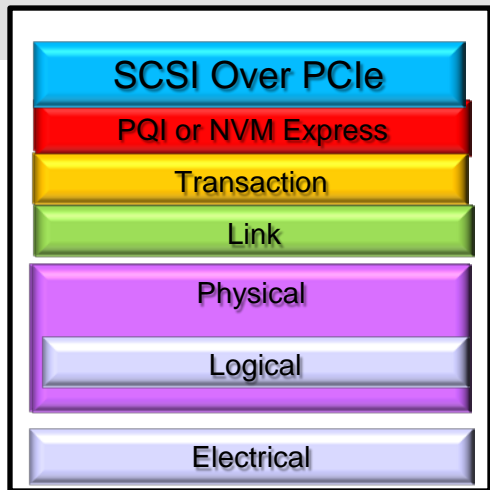
PQI	Req	Len	RequesterID	SOP IU	IT	CF	IU LEN	ROQID	WA	Req ID	NEXUS ID	Time Delta	Time Stamp
58	R→	x1	010:00:0	0x90	0x00	0x000C	0x0003	0x0000	0x0000	0x0007	0x0007	23.096 μs	0140 . 919 210 444 s

Advancing Consumer in Outbound Queue

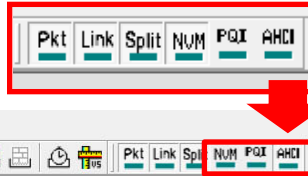
PQI	Req	Len	RequesterID	Index	Time Delta	Time Stamp				
59	R→	x1	010:00:0	0x0001	10.6 μs	0140 . 919 244 204 s				
9614	R→	x1	TLP	Mem	MWrr(32)	Len	RequesterID	Index	Time Delta <td>Time Stamp</td>	Time Stamp
			571	010:00000			000:00:0	0x00000001	9.702 ms	0140 . 919 249 844 s

Courtesy SanDisk 2012

- SCSI Express is based on the SCSI over PCIe (SOP) host interface specification which enables SCSI initiators communicating to SCSI targets over PCIe through the PQI transfer layer



SATA Express Analysis Decode

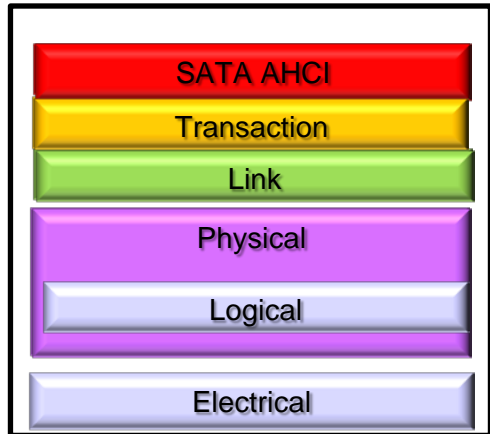


AHCI	RequesterID	CompleterID	PxCMD	ICC	ASP	ALPE	DLAE	ATAPI	APSTE	FBSCP	ESP	CPD	MPSP	HPCP	PMA	CPS	CR	FR	MPSS	CCS	FRE	CLO	POD	SUD	ST	Time Delta	Time Stamp
AHCI 203	R→	5.0	RequesterID	000:00:0	No-Op / Idle	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0	0	1.520 μs	0010 . 002 648 088 s
AHCI 204	R→	5.0	RequesterID	000:00:0	CompleterID	004:00:0	No-Op / Idle	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	812.776 μs	0010 . 002 649 608 s
AHCI 205	R→	5.0	RequesterID	000:00:0	CompleterID	004:00:0	No-Op / Idle	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1.688 μs	0010 . 003 462 384 s
AHCI 206	R→	5.0	RequesterID	000:00:0	CompleterID	004:00:0	No-Op / Idle	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	8.113 ms	0010 . 003 464 072 s
AHCI 207	R→	5.0	RequesterID	000:00:0	CompleterID	004:00:0	PxCLBU	CLBU	0x00000000	Time Delta	1.768 μs	Time Stamp	0010 . 011 577 456 s														
AHCI 208	R→	5.0	RequesterID	000:00:0	CompleterID	004:00:0	PxCLB	CLB	0x0000D100	Time Delta	1.496 μs	Time Stamp	0010 . 011 579 224 s														
AHCI 209	R→	5.0	RequesterID	000:00:0	CompleterID	004:00:0	PxCLB	CLB	0x0009D100	Time Delta	2.328 μs	Time Stamp	0010 . 011 580 720 s														
AHCI 210	R→	5.0	RequesterID	000:00:0	CompleterID	004:00:0	PxFBU	FB	0x00000000	Time Delta	1.648 μs	Time Stamp	0010 . 011 583 048 s														
AHCI 211	R→	5.0	RequesterID	000:00:0	CompleterID	004:00:0	PxFB	FB	0x0009D140	Time Delta	1.712 μs	Time Stamp	0010 . 011 584 696 s														
AHCI 212	R→	5.0	RequesterID	000:00:0	CompleterID	004:00:0	PxFB	FB	0x0009D140	Time Delta	2.304 μs	Time Stamp	0010 . 011 586 408 s														

Port control setup address of Command list

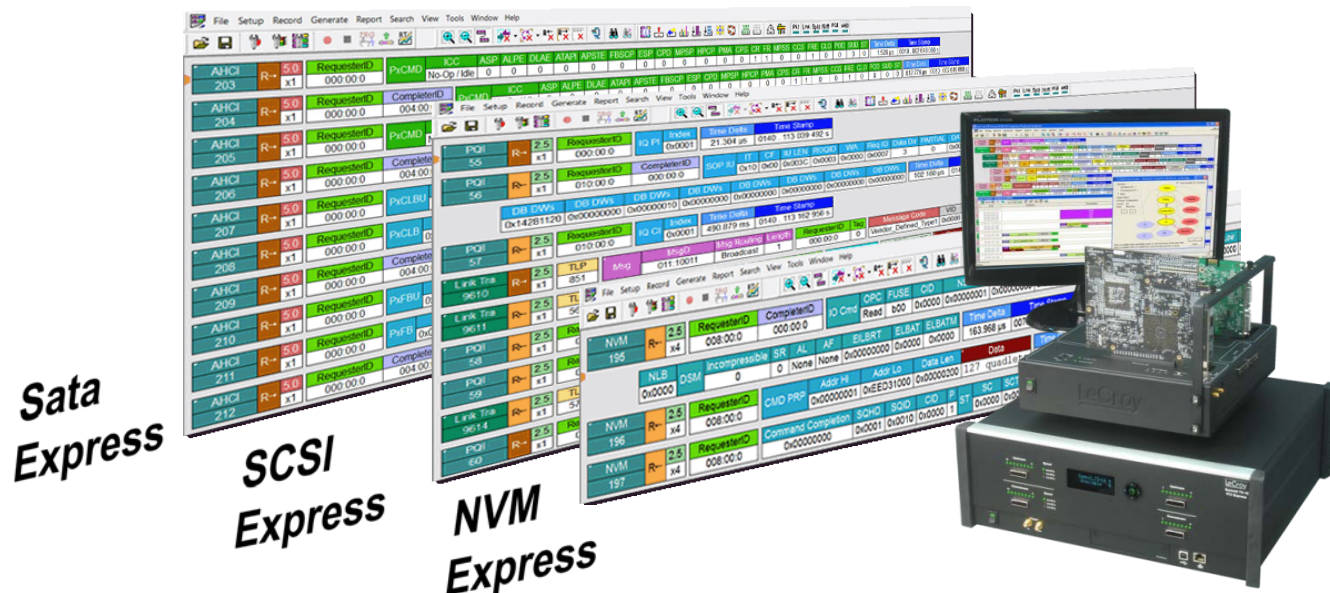
Port control setup address of FIS

- SATA Express enables new devices to be developed that utilize the faster PCIe interface and maintain compatibility with a broad base of existing SATA applications.



Conclusion

- New testing methodologies are needed for NVM Express, SCSI Express and SATA
- Protocol analysis tools can show developers useful details about PCIe SSD transactions between the storage host and controller.
- Host and device emulation can discover performance, error handling and protocol issues that affect the quality of products.



Contact LeCroy PSG



Summit T3-16
Analyzer

Summit T3-8
Analyzer

Summit T28
Analyzer

Summit Z3-16
Exerciser with
Test Platform

Fax(Sales&Service): 845-578-5985

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