

Solutions for Implementing SD Express into Your Products Public Webinar

February 2023

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SD Express Public Webinar





Introduction

Yosi Pinto, Chairman and Technical Committee Chair, SD Association

Senior Technologist at Technology & Strategy Division in Western Digital (formerly SanDisk) and Chairman of the Board and the Technical Committee chair at the SD Association





Disclaimer

During our meeting today SDA members will present some of their products or plans.

Anything presented today, on slides or verbally, by those companies is under the responsibility of the presenting company. SDA do not take any responsibility either on the content presented nor on any consequences of potential implementations of the presented solutions.

Forward-Looking Statements

During our meeting today we may provide forward-looking statements.

Any statement that refers to expectations, projections or other characterizations of future events or circumstances is a forward-looking statement, including those relating to industry trends, standardization plans and any SD Association's related plans. Actual results may differ materially from those expressed in these forward-looking statements due to various factors. We undertake no obligation to realize these forward-looking statements, which speak only as of the date hereof.

Agenda of the Webinar



□ Introduction – Yosi Pinto (Chairman of SDA)

□ SD Express Bridging Solutions by the Following SDA Member Companies:

- Bayhub Toshi Akagi (Senior Engineering Manager)
- Genesys Logic Sean Chen (Product Marketing, Deputy Manager)
- JMicron Gordon Chang (Technical Marketing Manager)
- Realtek Jim Shiau (System Designer)
- □ SD Express and microSD Express Connector Solutions by Amphenol Robin Aw (Sr FAE)
- □ SD Express Testing Solution by Prodigy Technologies Godfree Coelho (Founder and CEO)
- □ Q&A Session

SD Association



□ 20+ years creating innovative specifications meeting industry and consumer needs

- □ Strategically maintains the relevance and value of industry-leading SD memory cards for consumer and industrial uses
 - Approximately 800 members related to removable cards eco-system (cards, connectors, memory devices and host vendors)
 - A unique structure with Technical, Marketing and Compliance capabilities all working together to meet industry needs

SD Express Card – What is it?

- The fastest SD[™] and microSD[™] memory cards with backward compatibility
- □ Supporting the following interfaces:
 - NVMe[™] + PCle[®] interface up to PCle 4.0 x2
 - SD interface (UHS-I up to 105MB/s)



2000

500

1000

1500

HIC

2500

3000

ant Bat

Bandwidth (MB/s)

4800

4500

3500



Uses the same, well known form-factors

 $32.0 \times 24.0 \times 2.1$ mm

 $15.0 \times 11.0 \times 1.0$ mm

SD Card Specifications Evolution





* Source: Estimation using news published by SanDisk in 2015 ("2 Billion microSD cards sold by 2015") + TrendForce's report from 2019 ("total of ~3 billion cards sold within 2016-2019") and report from Futuresource of total of ~1.1B sold between 2020-2022

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Technology and Market Evolution





Evolving technology trends push memory interface requirements to higher sequential and random performance levels

Evolving removable memory devices with higher performance enables new usage models and market opportunities

SD Express: Running Towards New Horizons



PCIe[®] and NVMe[™] Memory Card Interfaces

Delivers performance and advanced protocol required for the next generation of memory-intensive high-performance applications



SD Express - Applications





SD Express Card – Features



□ Initiate either directly from the PCIe/NVMe or SD

- Fully compatible to PCIe/NVMe standards Identifies itself as a standard NVMe Memory
- ESD protection up to 4KV on all pads (Same as legacy SD card requirements)
- □ Hot Plug-In/Removal support
- □ Boot, TCG and RPMB (SD9) may be supported by the SD interface as well
- □ Working on New Speed Classes over NVMe (1)

		642036200	
Base Class	Sub-Class	Programming Interface	Neuring
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		301	ATA controller with ADMA interface: - controller operation (see Note 2)
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	35k	0091	Universe Fredh Statege (UFB) contrater - vendar- specific intertace
		0.00	Universal Fisch Storage (UFS) controller - Universal Plant Storage High Controller Interface (UFSHC) (or Web 5)

⁽¹⁾ Forward-looking statement: SDA undertakes no obligation to realize these forward-looking statements, which speak only as of the date hereof.

SD Express Cards Pinout



=1st row: conventional SD in SD mode or PCIe side band (PERST#, CLKREQ#, REFCLK+/-) in PCIe mode

- =2nd row: PCle 1st lane differential IO's in PCle mode SD 7.X
- =3rd row: PCIe 2nd lane differential IO's in PCIe mode SD8.0



Allowed Power States (Max Power)



 Max Current for each power rail depends on the bus mode

 Supported power states are defined according to the card type

Power State	(Max Power)

Card Type						
G3L1	G3L2 / G4L1	G4L2				
		4.0W				
		3.2W				
	2.8W	2.8W				
	2.5W	2.5W				
1.8W	1.8W	1.8W				
1.44W	1.44W	1.44W				
0.72W	0.72W	0.72W				

SD7.x → 0.72 through 1.8W (same power levels as legacy SD spec) SD8.0 → 2.5W through 4.0W

* PCIe interface supports low power sub-states

PCIe and NVMe Interfaces – Test Advantages

Many Bus Analyzers, Protocol Analyzers, Test Suites are in the market*...

- □ SD Express Test Fixtures for SD7.x & SD8.0
- Enables Host and Card vendors to test their SD Express's PCIe interface using standard test equipment
- The set is available for borrow by our members at our approved labs (GRL and Allion)
- In parallel, there are new lower-cost SD Express card dedicated testers available or under development







SerialTek

JDSU

OakGate Technology





How To Implement SD Express Host



As described in SDA publication: <u>SD Express Host Implementation Guideline</u>



SD Express Host - other possible methods





SD Express Host - other possible methods









- □ SD Express Card includes PCIe/NVMe interface in addition to the SD UHS-I
- The SD Express card introduces itself as NVMe Standard Memory device standard PCIe/NVMe drivers may be used to access the PCIe interface
- □ The high speed PCIe interface pads are independent while the side band and RefCLK are muxed with DAT lines of the SD interface
- □ SD Express Host may be implemented either as a built-in SD host design update as the example provided by SDA or using an off-the-shelf bridge solution available in the market



SD Express Bridging Solutions







BayHub SD Express Controller Solution

Katsutoshi Akagi, Host-TG Co-Chair, SD Association

Senior Engineering Manager at BayHub Technology SD Association IO-WG Chair, Host-TG Co-Chair

BayHub Technology



- www.bayhubtech.com
- □ Bridge IC and SD host controller leading company
- □ Strong expertise in SD, eMMC, PCIe, USB, SATA, Hi-speed I/O, etc.
- □ Worldwide offices to support customers
- □ Strong partnership in SD eco-system
 - □ SD card vendors, card controller vendors, testing companies, etc.
- □ Strong partnership with platform companies
 - □ Intel, AMD, Google, etc.
- □ Strong partnership with SD host products companies
 - □ PC, High-End Camera, Game, etc.



□ SD host products have strong motivation for larger and faster removable media

- SD Express has the best positioning to support the trend
- □ SD Express eco-system is ready
 - □ SD Express host controller, SD Express card, SD Express card controller

□ BayHub offers SD Express host controllers for above all SD host products

Why SD Express? - worldwide IP traffic trend --



- □ Worldwide IP traffic increased from 100EB (2016) to 270EB (2021)
- □ Consumer devices drive IP traffic explosion
- More data stream increase the demand for larger and faster storage
 Exabyte/month
 Exabyte/month



2016 2021





Why SD Express for Camera?



□ High-End Camera application needs larger/faster memory card more and more

- □ Image sensor technology (Pixel count ~100M -> 500M in 2025)
- □ RAW data recording
- □ High demand for # of continuous shooting frames
- □ Best shot selection among multiple frames
- □ High resolution (~4K/8K)/Long time movie recording
- □ Many intelligent features require larger capacity and faster speed for local storage
- □ Larger and faster storage is a MUST trend and SD Express can fit such demand

BayHub SD7/4/3 Host Controller



- □ BH770GG7 PCIe to SD7/SD4/SD3 Bridge IC
- □ Supports PCIe Gen3 (8Gbps) speed
- □ Supports SD7.x (SD Express), SD4.x (UHS-II), SD3.x (UHS-I)
- □ Target Application: High-End Camera (DSLR, Mirror-Less)
 - □ Perfect solution for high speed/large capacity





SD Express Bridging Solutions





GL9767 PCI Express to SD Express Card Reader Controller

Sean Chen, Product Marketing, Genesys Logic Inc.

Product Marketing Manager from Storage Product Team in Genesys Logic.





- The major applications of GL9767 are the internal SD Express card reader of laptop, mini PC, Server system, professional camera, game console and drone devices that demand the high speed of SD storage or the second SSD-like storage for the real memory expansion.
- The support of SD Express interface can be up to SD 8.0 SD Express (PCIe Gen.4 x 2).
- GL9767 is the first SD Express card reader controller which can backward support SD 4.0 UHS-II speed mode and SD 3.0 UHS-I speed mode. The existing devices support UHS-II card slot use GL9767 in the next generation product not only upgrade the speed of SD storage also retain the fully support of UHS-II card.
- For power saving, GL9767 support PCI Express ASPM, L1 sub-states (L1.1 and L1.2) and RTD3 (Runtime D3 Hot/Cold), Modern Standby and S0ix.
- The supported OS are Windows, Chrome OS and Linux
- GL9767 is available in QFN32 5mmx5mm

GL9767 is the only SVP for both SD Express and UHS-II





Source: https://penang.graniteriverlabs.com/svplist

Controller Block Diagram – GL9767





The block in red (not include sideband signal mux and 3.3V/1.2V LDO for SD VDD3) operate as a SD 4.0 card reader

When the SD Express card inserted, the card will directly connect to PCIe root complex and the in-box NVME driver will be loaded







System Requirement :

The PCIe root port need to enable PCIe hot-plug function to support SD7 card plug and un-plug

When the non-SD Express card inserted, the card will be initialized by the internal SD host controller and the vendor driver will be loaded









Benchmark Test with SD7 & SD4 & SD3 cards









Support 2-lane SD8 card by a specific system design





Benchmark Test use GL9767 2-Iane EVB + PCIe G4 SSD



All	1 ~ 8GiB ~ E: 0% (1/4	466GiB)
	Read (MB/s)	Write (MB/s)
SEQ1M Q8T1	3556. 88	3458.49
SEQ1M Q1T1	2833.87	3083 .99
RND4K Q32T1	512.43	<mark>36</mark> 8.88
RND4K	84.68	196.15



GL9767 MP schedule



- □ Engineering sample is available now
- □ Customer sample will be available in March
- □ Will release to mass production in May

□ The design kit is available now for customer to have an early evaluation.



SD Express Bridging Solutions





JMS581SD – USB 3.2 Gen2 to SD7.x

Gordon Chang, Technical Marketing Manager Technical Marketing Manager at JMicron Technology Corporation



The World's 1st USB 10Gb/s to SD Express Card Reader Solution





JMS581SD Demo Board

□ JMS581SD is a system-on-chip solution which embedded with USB 3.2 Gen 2 to SD7.1/8.0 interfaces

□ Its upstream port is USB 10Gbps and its downstream port supports UHS-I and SD8.0 memory cards

 Supports the latest SD Ultra Capacity (SDUC) card specification which enables max capacity of 128TB, plus it is also backward compatible with the legacy SD card specification

□ In mass production since July 2020
JMicron JMS581SD – Product Specification

- Comply with USB 3.2 Gen 1 and Gen 2
 Specification
- Comply with USB Mass Storage Class, Bulk-Only Transport Specification (Revision 1.0)
- Comply with USB Attached SCSI Protocol (UASP) Specification (Revision 4)
- Integrate with USB Type-C multiplexer & configuration channel (CC) logic
- □ Support SD3.01 UHS-I
- □ Support SD8.0 (PCle Gen3x2 NVMe 1.3)



JMS581SD Block Diagram



JMicron JMS581SD – Product Application





JMS581SD SD Express Card Reader

□ Blazing Performance

□ Maximum speed up to 985MB/s

□ Broad Compatibility

□ Backward compatible with legacy SD cards

□ Incredible Capacity

Up to 128TB of storage capacity with SDUC cards

JMicron JMS581SD – Performance



Sample A (128GB)

Sample B (480GB)



* Performance will vary between different brands and capacities

PCIe Gen 3x1 + UHS-1



JMS581SD Block Diagram

PCIe Gen 3x2

- □ JMS581LT is an upgraded version of JMS581SD
- □ Upstream: USB 3.2 Gen 2x1
- Downstream: PCle Gen3x2 / SATA
 6Gbps / SD7.1/8.0
- Support SD Express cards, CFexpress cards, CFast cards, /PCIe NVMe SSDs, SATA SSDs, and SATA HDDs

□ In mass production since July 2020



SATA 6Gbps



JMicron JMS581LT – Product Applications





All-In-One Card Reader (SD Express / CFast2.0 / CFexpress)





Storage Extension for NAS / Set-top Box / Smart Router

Docking Station



SD Express Bridging Solutions





REALTEK

Realtek Card Reader

Jim Shiau, Manager, Realtek

Manager at Smart Interconnect Business Group, System Design Department in Realtek Semiconductor Corp.

About Realtek Card Reader



- Realtek is a world leading fabless IC design company that provides a variety of IC products
- □ The Realtek Card Reader product line focuses on high-speed connectivity technology
 - □ SD card reader, USB3.2 HUB, USB type C/PD
- □ Realtek SD card reader are widely adopt by ODM/OEM
 - □ Tight partnership with SD card and host chipset vendor
 - □ Offer a wide choice of SD card reader

SD/Host interface	USB	PCIe			
UHS-I	RTS5176E/RTS5306E/RTS5350	RTS5227S/RTS5228			
UHS-II	RTS5329	RTS5250S			
SD Express	RTL9211DS	RTS5261			

Implement SD Express Reader

REALTEK SD Association

□ Select SD Express reader according your product type and host interface

□ Reader is build-in host system: We suggest to use PCIe interface RTS5261

□ Ex: Laptop, Tablet, Gaming console

□ Reader is detachable device: We suggest to use USB interface RTL9211DS





□ Special notice for PCIe interface implementation

- Host chipset should support PCIe hot plug
- □ Vendor driver needs to install in host system

□ Please use USB interface if you can't meet above requirement

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RTS5261 SD Express Reader Controller





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RTS5261

SD Express Reader Controller

- □ The world's 1st mass-produced PCIe SD Express reader controller
- Widely adopted by laptop makers in gaming, creator, and workstation laptops
- Integrates all power sources for SD/SD Express cards, reduces BOM cost and design effort
- Co-layout with Realtek UHS-I RTS5227S/RTS5228 and UHS-II RTS5250S solution
- Design kit available for SD7.1 or SD8.0 design



RTL9211DS SD Express Reader Controller







RTL9211DS SD Express Reader Controller



REALTEK

- The world's 1st mass-produced USB SD Express reader controller
- □ Support USB3.2 Gen2 10Gbps
- □ Widely adopted by dongle makers
- □ Design kit available for SD7.1 or SD8.0 design

	Super Speed Plus (UASP)					
	Read	Write				
Seq 1M Q8T1	860	736				
Seq 128K Q32T1	858	699				
RND4K Q32T16	184	199				
RND4K Q1T1	29	74				

Customers Implementation FAQ



□ Could SD Express reader support legacy SD card?

□ Yes!

□ Could SD Express reader support USB2.0/USB3.2 Gen1 or PCIe Gen1/2 host interface?

 Yes, reader adjusts to suitable mode automatically, but the SD Express card speed might be limit by host interface





SD Express & microSD Express Connector Solutions



Amphenol

Introduction

Robin Aw, Senior FAE & Design Engineer

Senior FAE & Design Engineer at Amphenol Communications Solutions (Server & Storage IO) and Active member in SD Association Mechanical TG

AMPHENOL: THE BRIDGE





WHY AMPHENOL?



	Amphenol	Competitor
Version	Up to v8.0 sp (Gen 4 x 1 lane)	v1.0-v7.0 _(SD only)
SI report/S-Parameter	Y	N**
Customizable Robustness Requirement	Ŷ	N(TBC)
Customize Capability	Y	N**
Effective Shielding Solution(EMI)	Y	Y
SD Express type	Push Push/ Push Pull	Push Push/ Push Pull
Micro SD express type	Push Push/ Push Pull/ Hinge (developing)	Ν
Backward compatible version	UHS-I / UHS-II (SD + micro-SD)	UHS-I/UHS-II (SD only)



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Connector Evolution with microSD Express







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Connector Evolution with microSD Express





Connector Evolution with microSD Express





microSD Express SD7.1 Connector With UHS II Compatibility





Dimension spec (TBC) L*W*H=14.65*13.50*2.10mm

Mechanical Spec

Durability:5000 cycles(TBD) Mating force: 40N max(TBD) Un-mating force:0.5N-40N(TBD)

Electronic spec

Working current:0.5A Voltage: 100V AC

Various Type Solution

Push Pull (MP)

Limited Samples Available

- Push Push (design stage)
- Hinge type (design stage)

Comprehensive Report Availability

- □ SI/S-Parameter
- □ Shielding Effectiveness (base on customer application requirement)
- Mechanical Robustness Simulation (base on customer requirement)



<u>Full Size</u> SD Express SD7.0 Connector With UHS II Compatibility





Dimension spec L*W*H= 29.40 * 28.35 *3.15mm

Mechanical Spec Durability:5000 cycles (min) Mating force:40N max Un-mating force:0.5N-40N

Electronic spec Working current:0.5A Voltage: 100V AC

S the difference



WE ARE "THE BRIDGE" FOR SD EXPRESS

Do drop us a mail if you have any enquiries

lows.feng@amphenol.com.tw

Thank You!



SD Express Testing Solution







Introduction

Godfree Coelho, Founder and CEO of Prodigy Technovations

He has 30 years of experience in test and measurement companies Tektronix and HP (Keysight). Godfree as founder in Prodigy Technonations involved developing protocol test solutions different standards such as UHS-I, UHS II and SD Express Interface.



Initialization of SD Express card



SD Express Boot Sequence



- SD Express interface has option of booting UHS I interface using CMD0 and CMD8 command.
- Set bits 20 and 21 as '1' in CMD8 to request for PCIe data transfer
- □ If SD card supports PCIe, Card will response with '1' in Response argument to CMD8
- PCIe link initialization starts by sending Line training sequences by TS1 and TS2 packets
- Prodigy make PGY-SSM UHS-I SD Protocol Analyzer
 can be used analyse the UHS- I boot sequence



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SD Express Protocol Analysis



- To Analyzer SD Express Protocol use PGY PCleGen3/4 X4 Protocol Analyzer
- PCIeGen3/4 captures all lines training and data transfer
- □ PCIeGen3/4-PA provides LTSSM Analysis
- □ Protocol decode at PCIe and NVME layer
- SD Express interposer for conveniently probe the
 SD Express interface



PCIeGen3/4 Protocol Analyzer



SD Express interposer

PCIe/SD Express Protocol Decode Results



- Main Window displays the transaction between the Root
 Complex and End Point
 - List the upstream and mainstream packets
 - □ List Order sets and idle
 - Flexibility view each packets
 parameters by right click
- Packet level view of selected packet

LTSSM view

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Question and Answer Session

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After the Webinar



You will receive an email with a link to download the presentation and access to the on-demand recording of the webinar – feel free to share with your colleagues

□ More information on SD Express is available at:

<u>https://www.sdcard.org/developers/sd-standard-overview/bus-speed-default-speed-high-speed-uhs-sd-express/</u>

□ Download our white papers on SD Express and other specifications:

– <u>https://www.sdcard.org/downloads/pls/latest_whitepapers/</u>

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Thank you for attending!

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