Beyond 12Gb/s SAS

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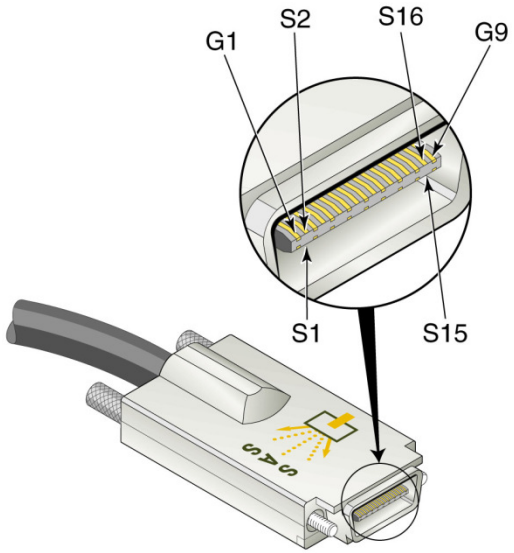
Overview

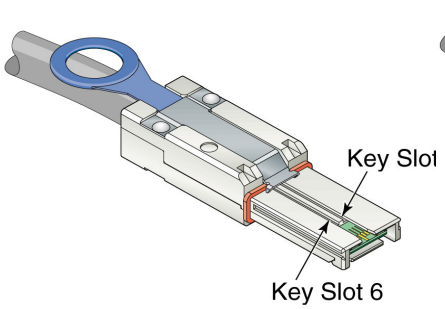
- Today
  - External and Internal interconnect
- 24Gb/s SAS MRD
- 24 Gb/s SAS Solutions?

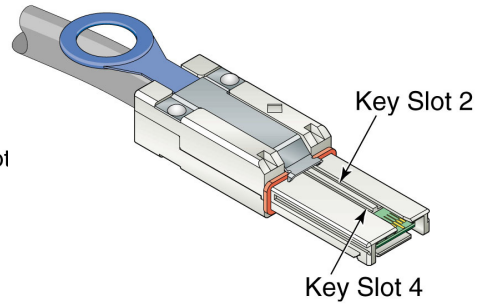
Today's SAS 1 / 2 4x Connectors

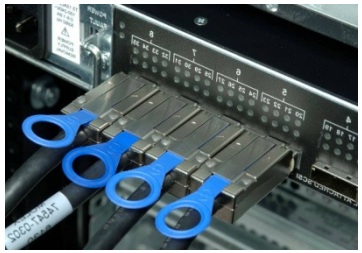
SFF-8470



External Mini-SAS

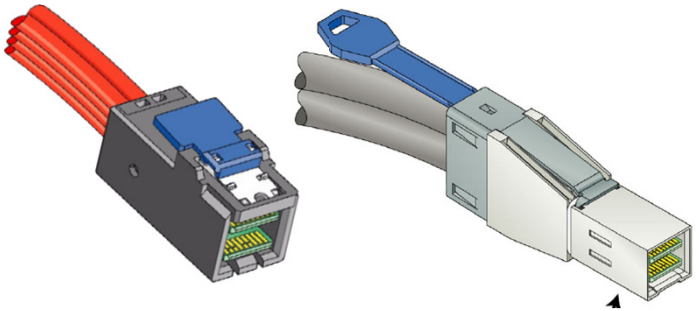




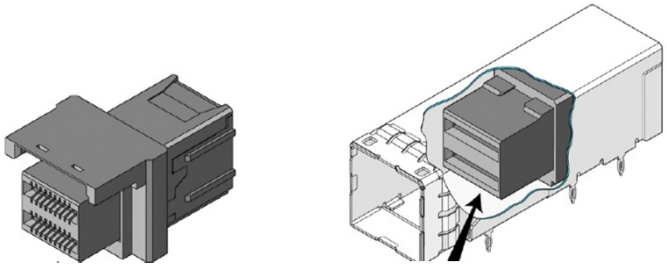


12Gb/s SAS External Interconnect

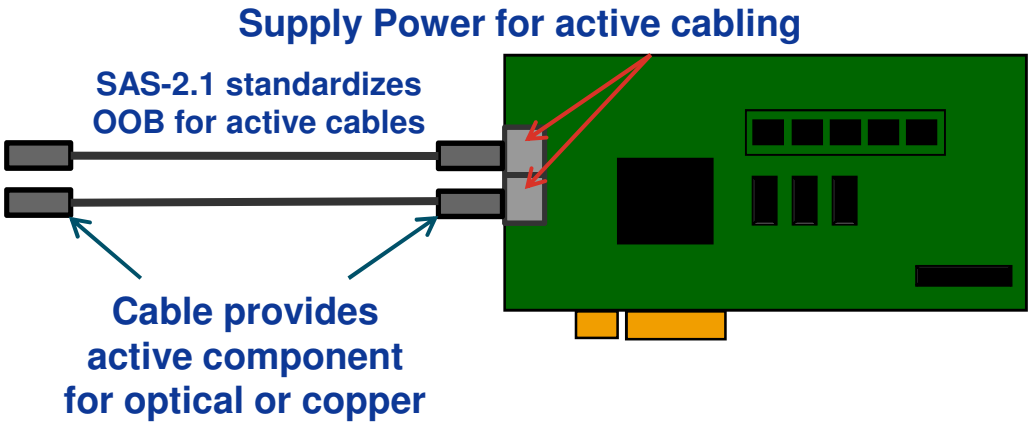
- Drive market consistency
- Simplified cable & connector options
- 2X density improvement
- Passive copper to 7m
- Active copper solution to 20m
- Active Optical (AOC) solution to 100m
- Managed connectivity standards



Internal similar to External



Passive, Active Copper, or Optical use same connector

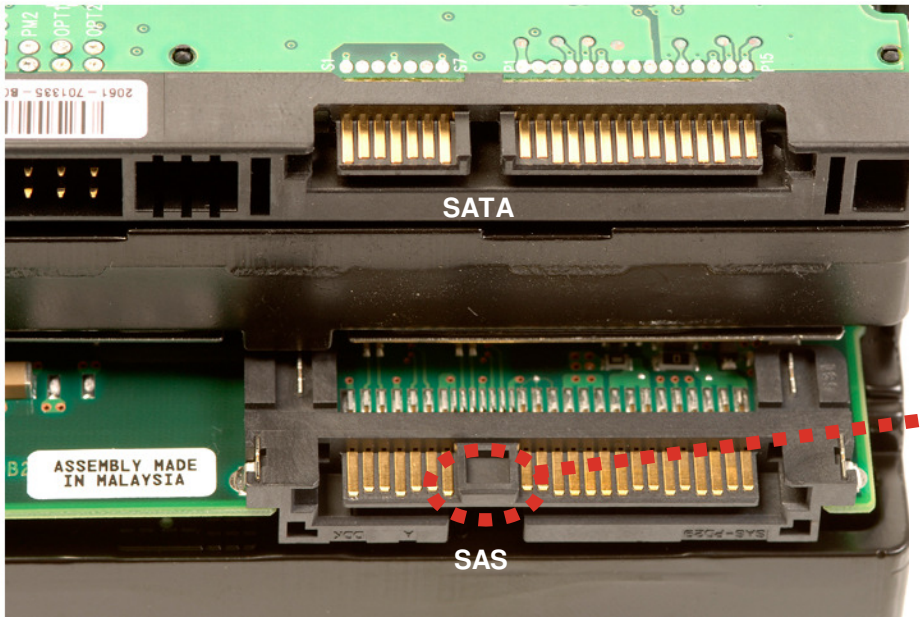


Managed Cable System

- New to SAS
- OoB (Out of Band) method of controlling the interface
- Every pluggable device has an EEPROM or microprocessor that communicates with the system via a low speed, two wire interface.
- Allows each port to support short passive copper cables to 100m active optical cables

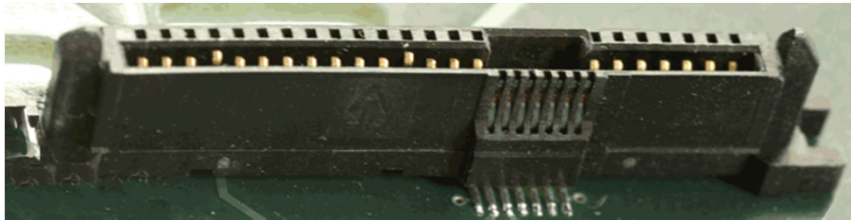
SAS / SATA Drive Connectors

Disk Drive Connectors

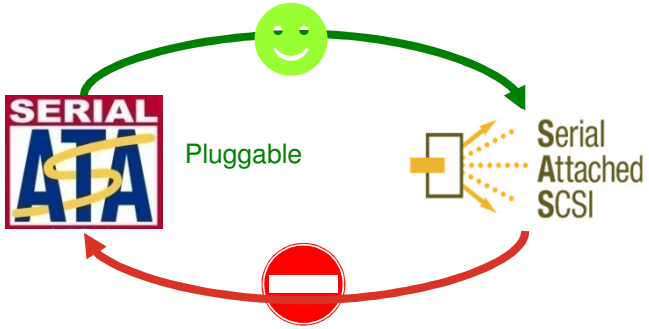


SAS Connector Flip Side

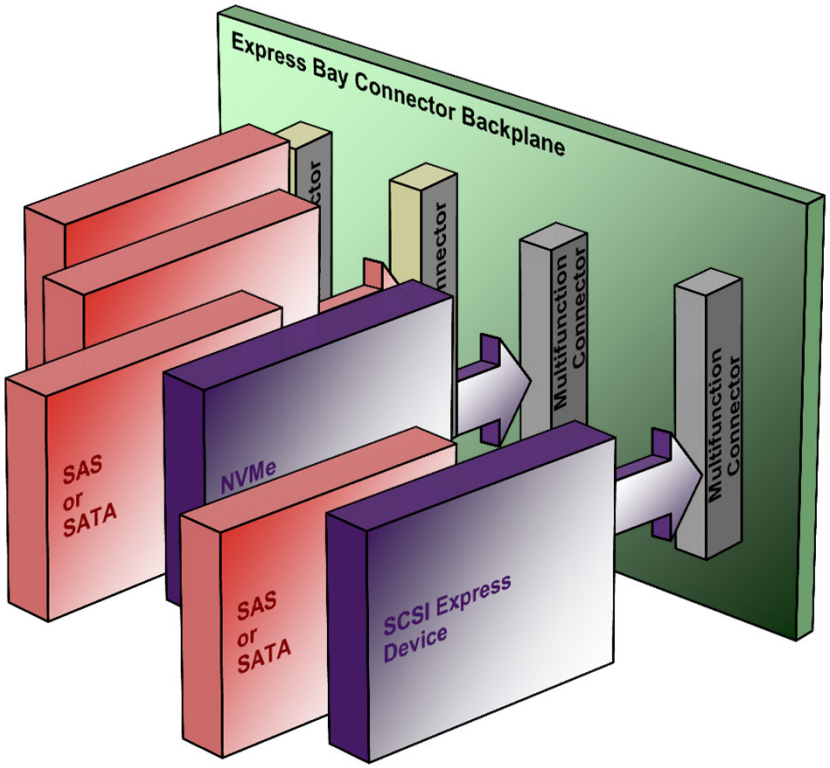
SAS Backplane Connector



Accommodates both SAS & SATA Drives

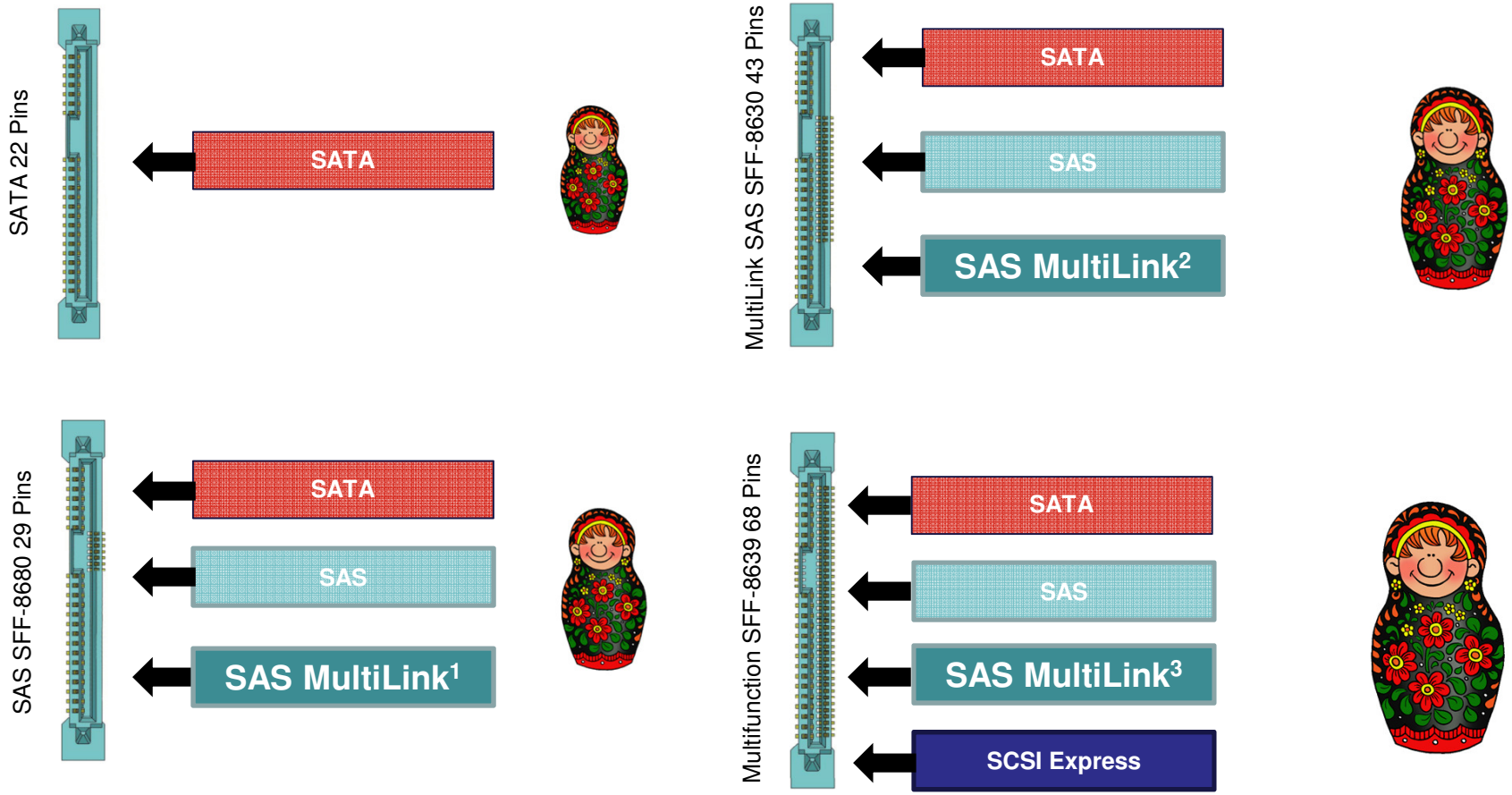


Express Bay



- Express Bay
  - Up to 25 Watts
  - SFF-8639 connector
  - PCI-SIG electrical specification
- Objectives
  - Preserve the enterprise storage experience for PCI Express storage
  - Meet SSD performance demands
  - Serviceable, hot-pluggable Express Bay opens up new possibilities…

SAS Connector Compatibility



[1] Max two links operate
[2] Four links operational
[3] Two or four links operation depending on host provisioning

http://www.scsita.org/

STA 24Gb/s SAS MRD

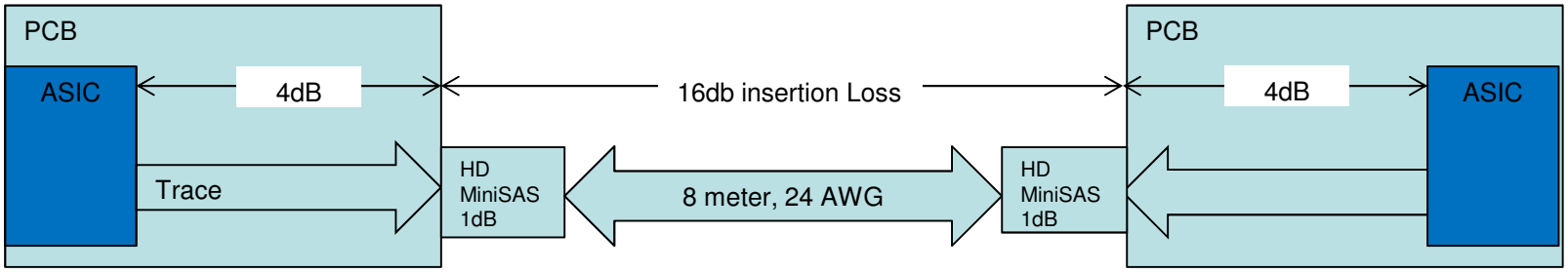
- Preserve existing SAS architecture
- Continue 6 Gb/s SATA compatibility
- Maintain and Support SAS backward compatibility
  - Must be backward compatible 2 generations: 6Gb/s SAS and 12Gb/s SAS
- Maximize link utilization when using devices operating at less than 24Gb/s
- Encourage improved storage system RAS attributes
- Double the transfer rate

What Might it Take to Get to 24Gb/s?

- Distance -- Target same distance as 12Gb/s
  - Better materials
    - Cables and boards
  - May need more efficient encoding scheme
  - Forward error correction
- Connectors
  - Higher density with active and optical options
  - Highly desirable for drive connectors to remain compatible
    - Improvements (magic) may be needed
  - Highly desirable for internal and external connectors to remain compatible with Connectivity Roadmap

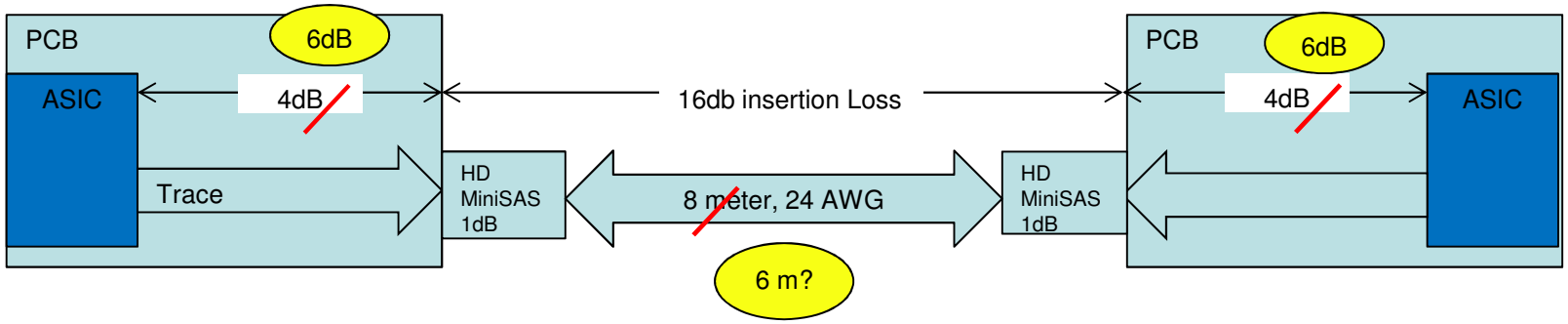
Basic Link Budgets

SAS 3.0 Total Insertion Loss = 24dB



Higher Frequency = more Insertion Loss

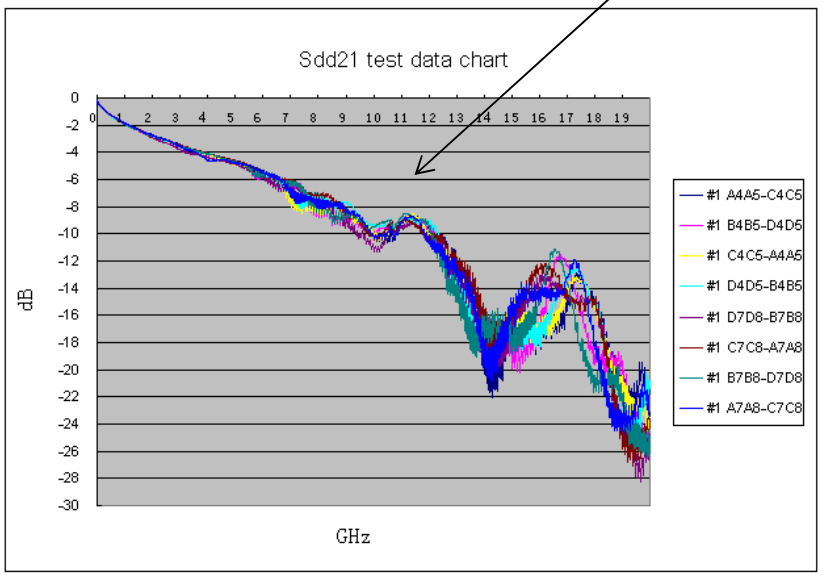
SAS 4.0 Total Insertion Loss = 28dB

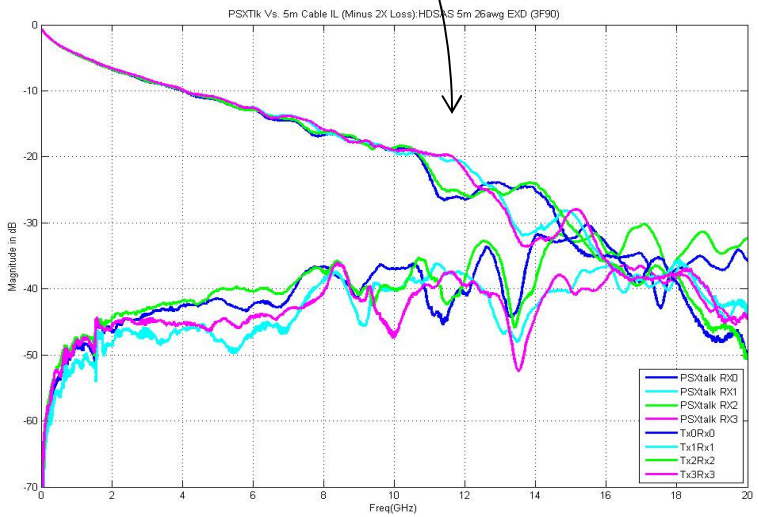


Connector Improvements

Today's miniSAS HD

Suck out at or near the Nyquist frequency reduces the max. link length

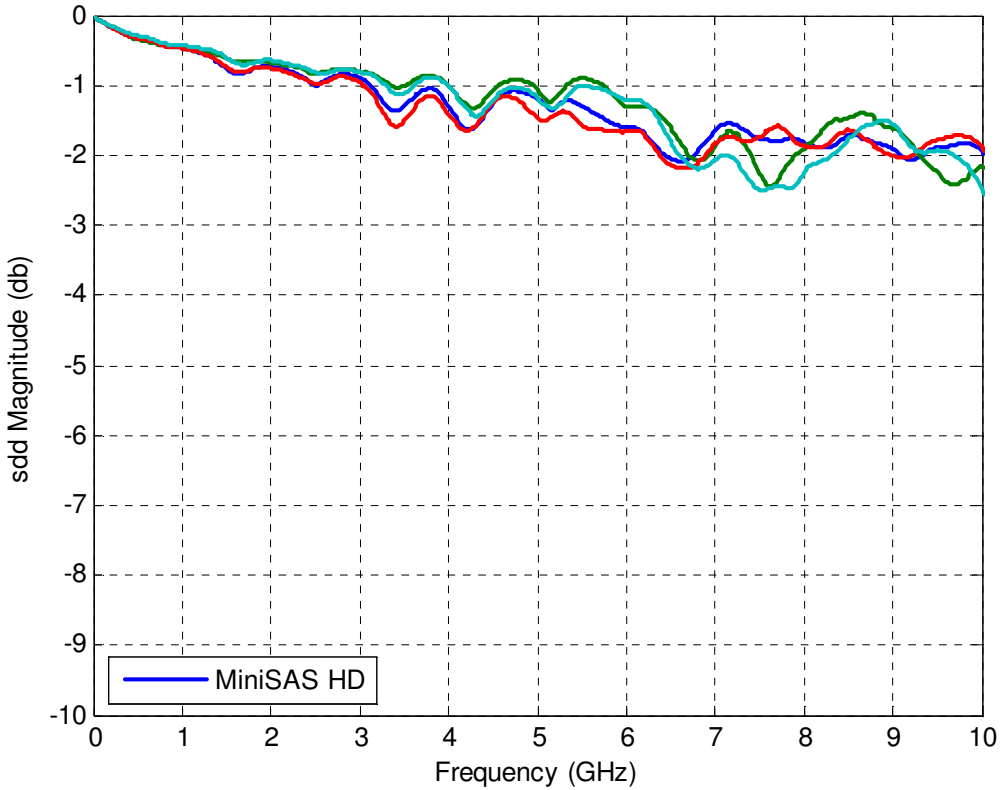




External connector

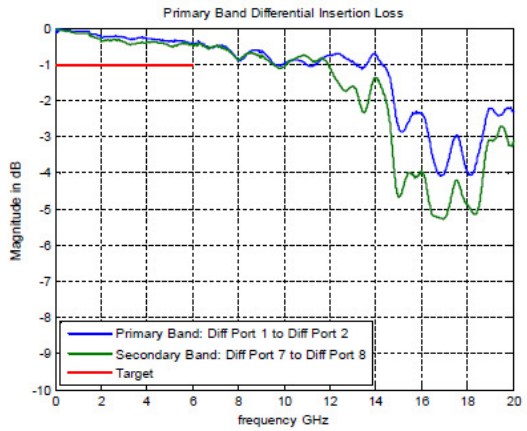
Internal connector

Improved miniSAS HD

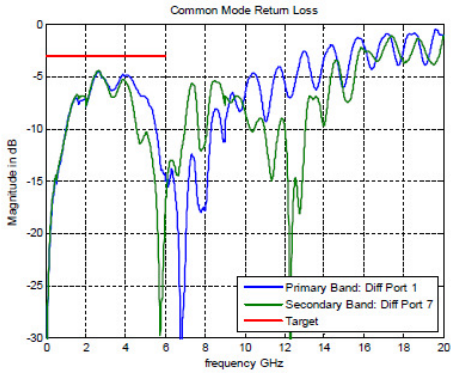


12Gb/s SAS Drive Connector

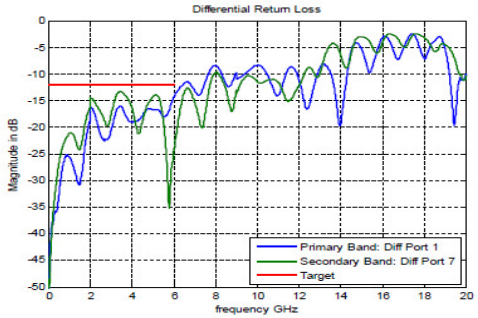
Differential Insertion Loss



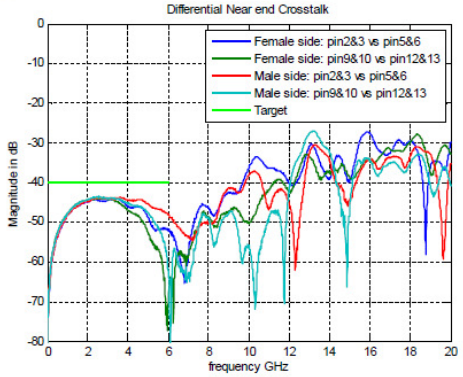
Common Mode Return Loss



Differential Return Loss



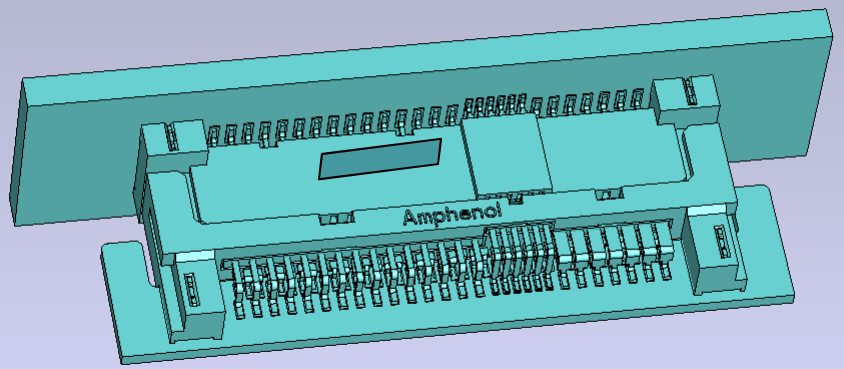
Differential NEXT



SAS / Express Bay Connector

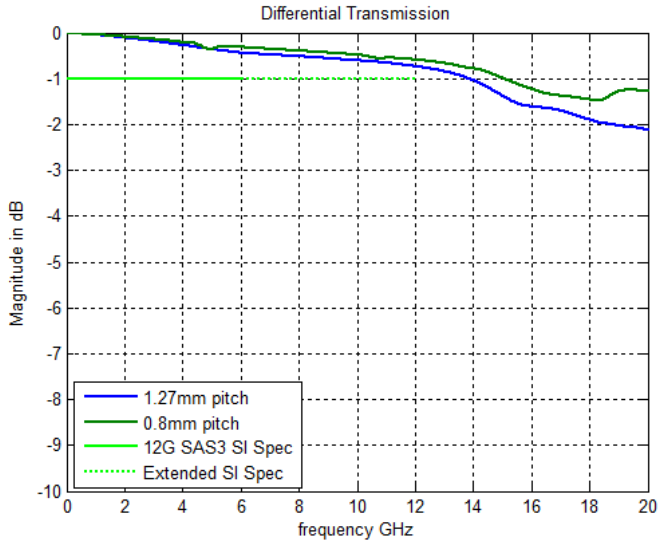
- SFF-8639 Multifunction 12 Gb/s SAS 6X Unshielded Connector

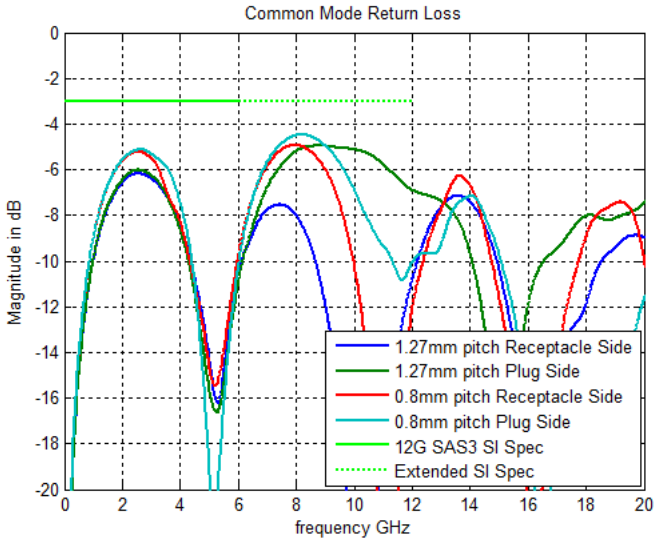
68pin PCIe & SAS Combo Connector

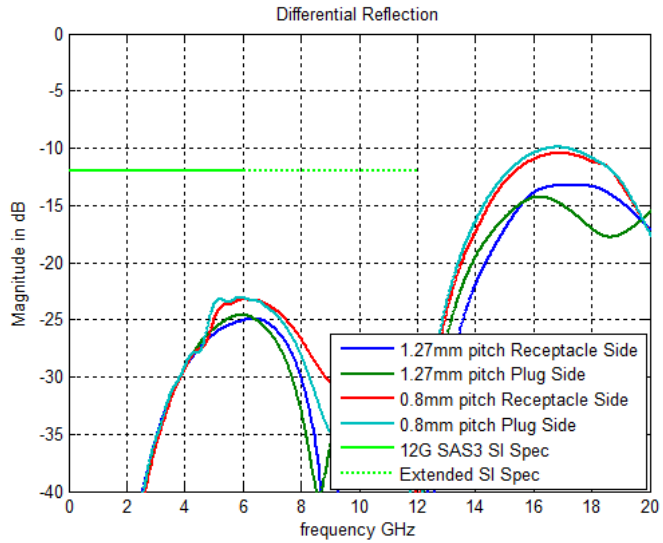


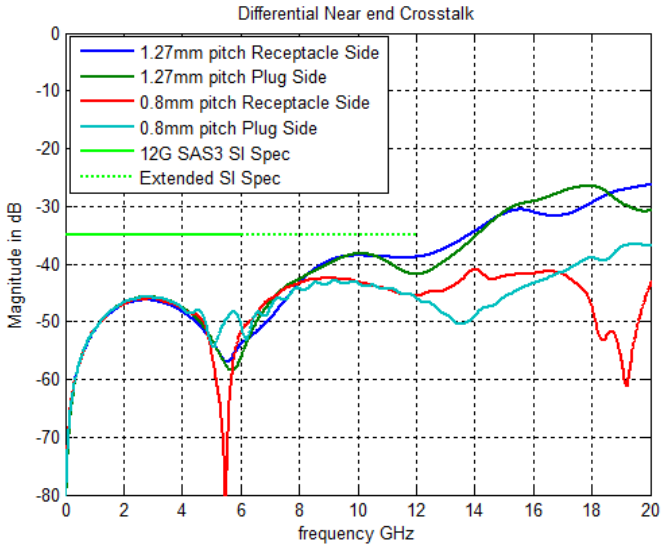
Vertical Receptacle mating R/A Plug

SI 24Gb/s SAS Performance









Transcoding and Forward Error Correction

Transcoding vs. Line Rate

Trans-Coding	Line Rate
8b10b	24.0 Gbps
64b66b	19.8 Gbps
128b130b	19.5 Gbps
256b257b	19.28 Gbps
512b513b	19.24 Gbps
1024b1025b	19.22 Gbps

- Longer transcoding lengths offer similar bandwidth efficiencies and yield minimal reduction in line rate
- Longer transcoding lengths increase buffering requirements and increase protocol handshake latency
- SAS-4 line rate range should be 19.5 Gbps to 24Gbps

Forward Error Correction Performance

Trans-Coding	FEC Bits	Overall coding length (bits)	Line Rate[1]	SI Gain[2] @ BER of 1e-15[3]	FEC Latency Adder[4]
8b10b	0	8b10b	24.0 Gbps	0	0
64b66b	0	64b66b	19.8 Gbps	0	0
128b130b	0	128b130b	19.5 Gbps	0	0
64b66b	14[5]	64b80b	24.0 Gbps	5.8 dB	~2.7 ns
128b130b	16[5]	128b146b	21.9 Gbps	5.8 dB	~5.3 ns
256b257b	18[5]	256b275b	20.63 Gbps	5.6 dB	~10.6 ns
512b513b	20[5]	512b533b	19.99 Gbps	5.6 dB	~21.2 ns
1024b1025b	88[6]	1024b1113b	20.87 Gbps	7.4 dB	~53.2 ns

[1]Raw data throughput of 19.2Gb/s.
[2] SI gain is addition IL that the system can tolerate (~2x the FEC gain at the slicer)
[3]Assumes 1e-15 as a target BER.
[4]Additional latency imposed by use of FEC
[5]Differential encoding and BCH algorithm for FEC.
[6]Reed-Solomon algorithm with T=4 for FEC.

Channel Lengths for a Range of Dielectric Materials

Material	8b10b 24 Gbps	64b66b 19.8 Gbps	64b66B + FEC 24 Gbps	128b130b + FEC 21.9Gbps	256b257b + FEC 20.63 Gbps	512b513b + FEC 19.99 Gbps	1024b1025b + FEC 20.87 Gbps
Megtron6	18.2”	22.1”	25.8”	28.3”	29.7”	30.6”	32.3”
Nelco 4000-13SI	16.4”	19.9”	23.2”	25.5”	26.8”	27.6”	29.2”
Nelco 4000-13	15.6”	18.9”	22.0”	24.1”	25.3”	26.1”	27.6”
Nelco 4000-6	8.3”	10.1”	11.8”	12.9”	13.6”	14.0”	14.8”
FR4 (Nelco 4000)	4.2”	5.1”	5.9”	6.5”	6.8”	7.0”	7.4”
SAS3 Cable	103" (2.6m)	125” (3.2m)	146” (3.7m)	160” (4.1m)	168” (4.3m)	174” (4.4m)	183” (4.7m)
SAS4 Cable[1]	136” (3.5m)	164” (4.2m)	192” (4.9m)	211” (5.4m)	222” (5.6m)	229” (5.8m)	241” (6.1m)
Latency			~2.7 ns	~5.3 ns	~10.6 ns	~21.2 ns	~53.2 ns

Conclusions

- 24Gb/s is definitely feasible
- Will need more efficient encoding
- T10 to investigate forward error correction implications
- Better board materials can help
- Drive connectors shipping Q1 2014