



Beyond 12Gb/s SAS

Greg McSorley
Vice President, SCSI Trade Association
Business Development Manager, Amphenol

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STA' s 24Gb/s SAS MRD



- ◆ Preserve existing SAS architecture
- ◆ Continue 6Gb/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

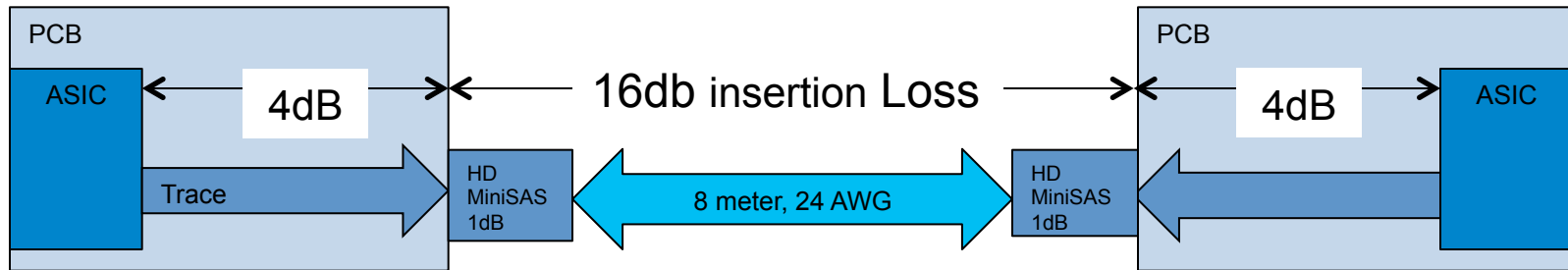
What might it take?



- ◆ Distance -- Target same distance as 12Gb/s SAS
 - ◆ 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

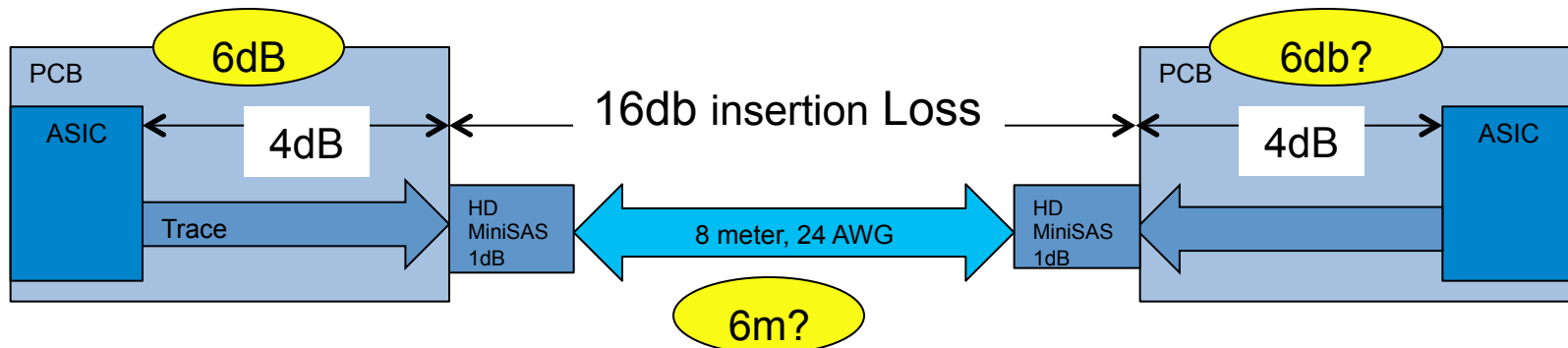
Basic Link Budgets

SAS 3.0 Total Insertion Loss = 24dB



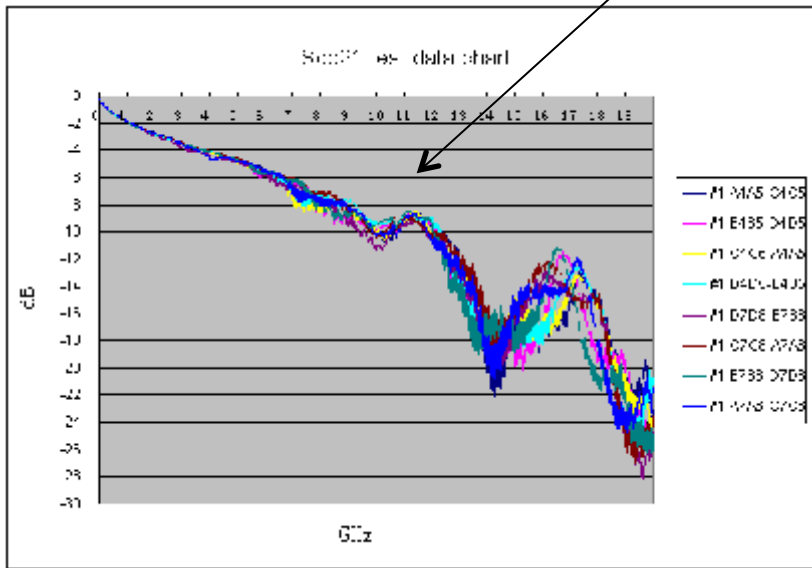
Higher Frequency = more Insertion Loss

SAS 4.0 Total Insertion Loss = 28dB

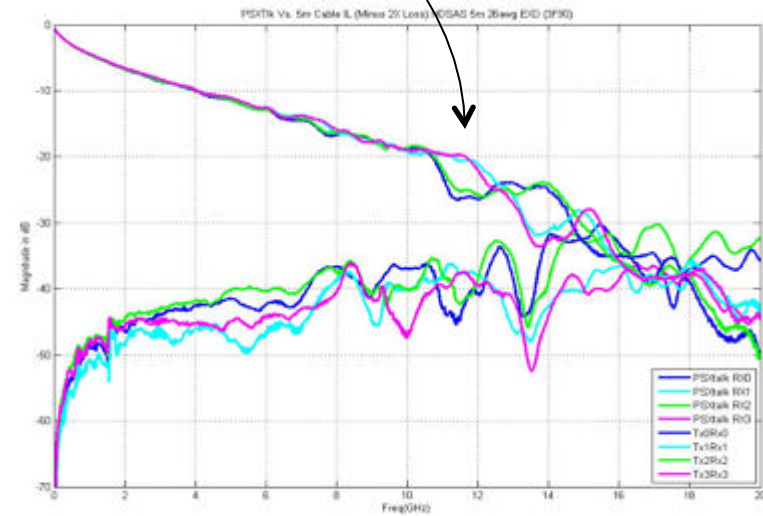


Today's 12Gb/s HD miniSAS

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



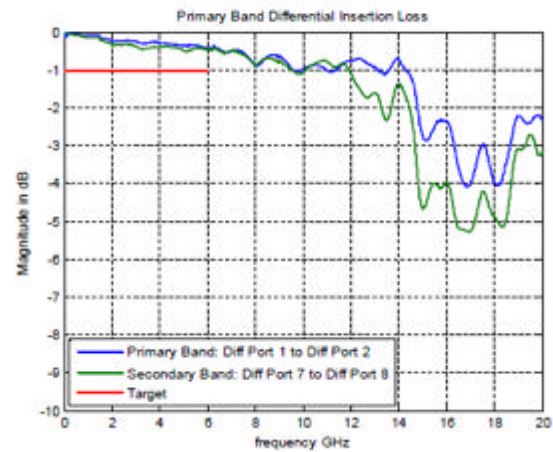
External connector



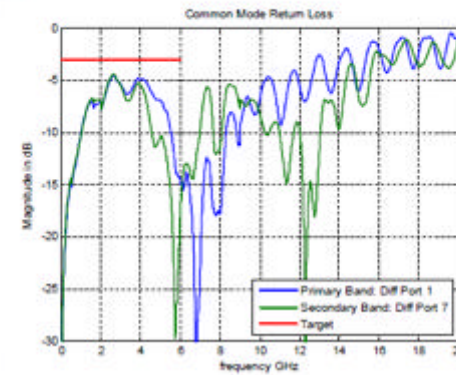
Internal connector

Today's Drive connector

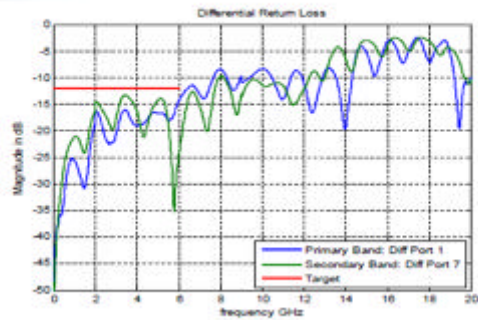
Differential Insertion Loss



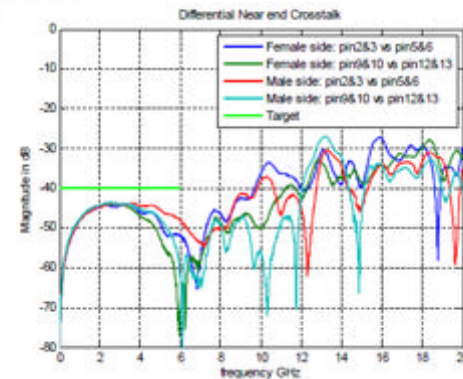
Common Mode Return Loss



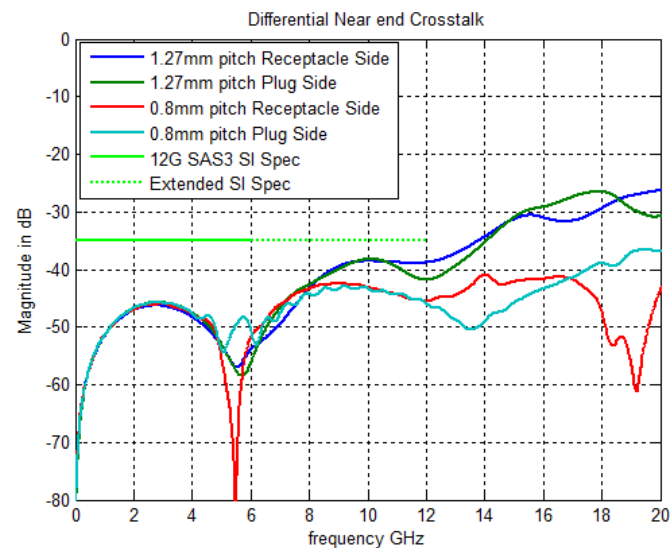
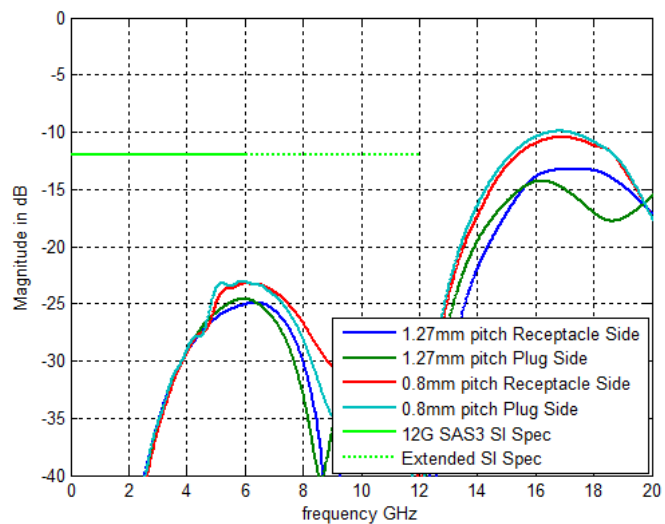
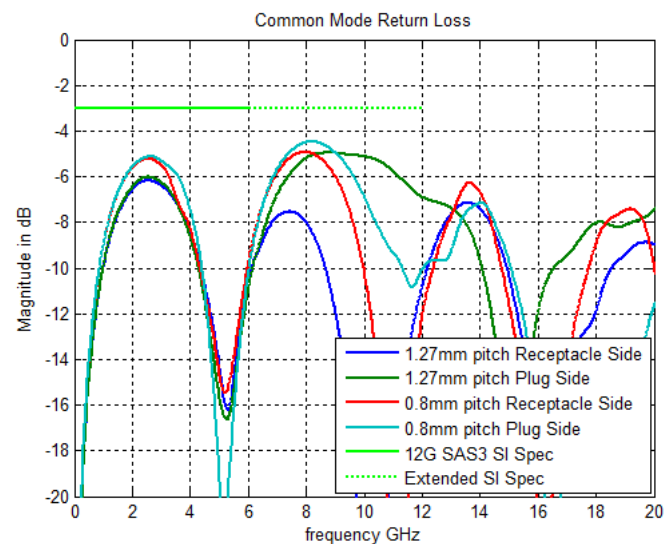
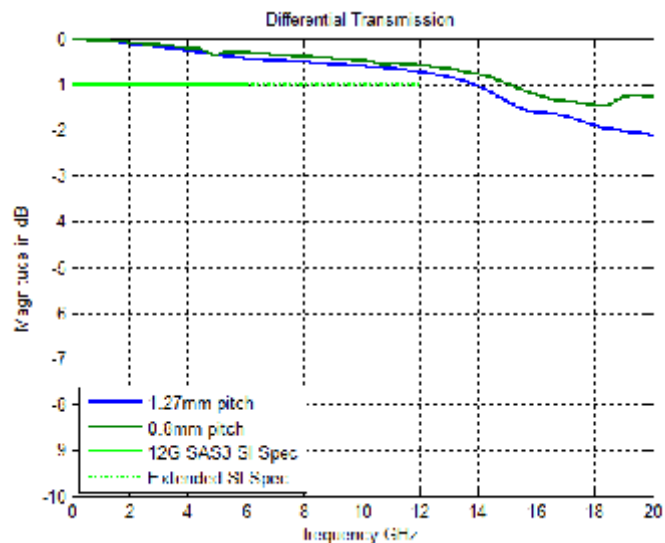
Differential Return Loss



Differential NEXT



New Multiport Drive connector



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



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

¹Raw data throughput of 19.2Gb/s.

²SI gain is addition IL that the system can tolerate (~2x the FEC gain at the slicer)

³Assumes 1e-15 as a target BER.

⁴Additional latency imposed by use of FEC

⁵Differential encoding and BCH algorithm for FEC.

⁶Reed-Solomon algorithm with T=4 for FEC.

Differing Dielectric Materials Can Help



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 Cable¹	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 SAS is definitely feasible
- ◆ Will need more efficient encoding
- ◆ Probably need FEC
- ◆ Better board materials can help
- ◆ Drive connectors shipping Q1 2014