Considerations for Active Copper Cables for SAS-2 and Beyond

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01-14-2008

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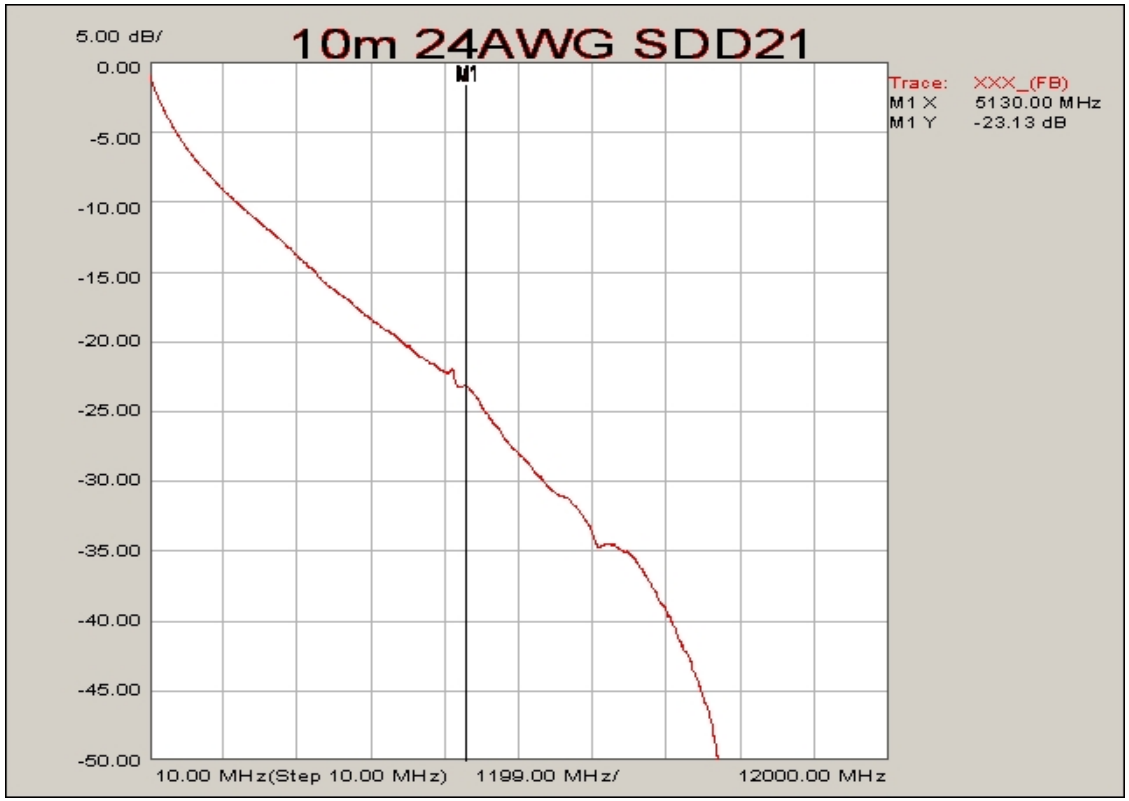
Background

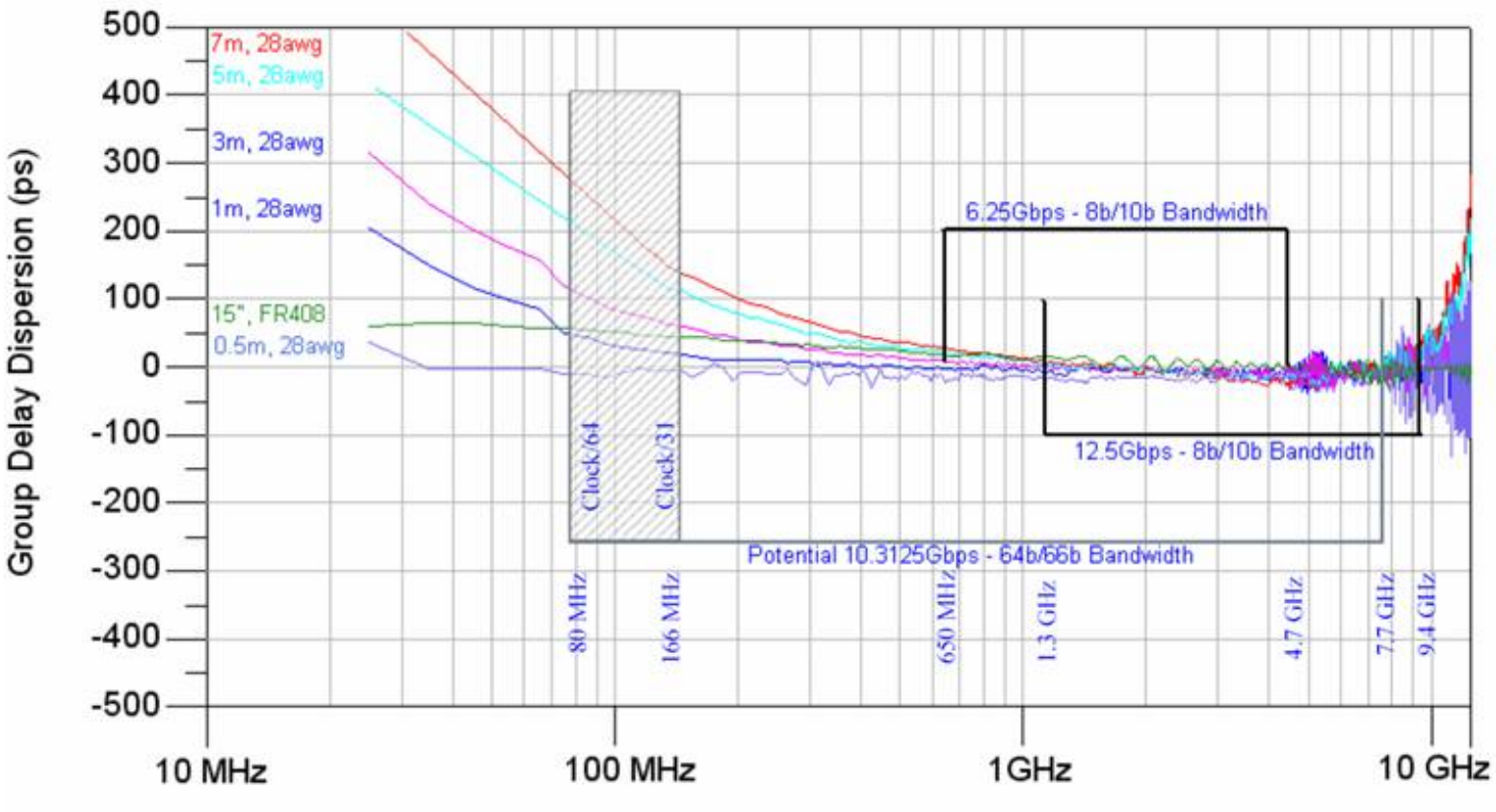
- System designers need the flexibility to implement longer cable reaches (<10 meters), while using thinner cable gauges – to reduce cable weight, improve cable management, increase airflow in the data centers.
- Active cables have proven to be an economical, low-power, low-latency and high-performance option to support longer reaches and thinner wire gauges.
- Growing use by the industry in the InfiniBand, 10GBASE-CX4, PCIe, QSFP and other applications. Several silicon vendors have products.
- Incorporating active cable option (power supply) will also enable optical solutions.
- Consider the active cable option for SAS-2.x and SAS-3

Background: Attenuation in Cable Assemblies



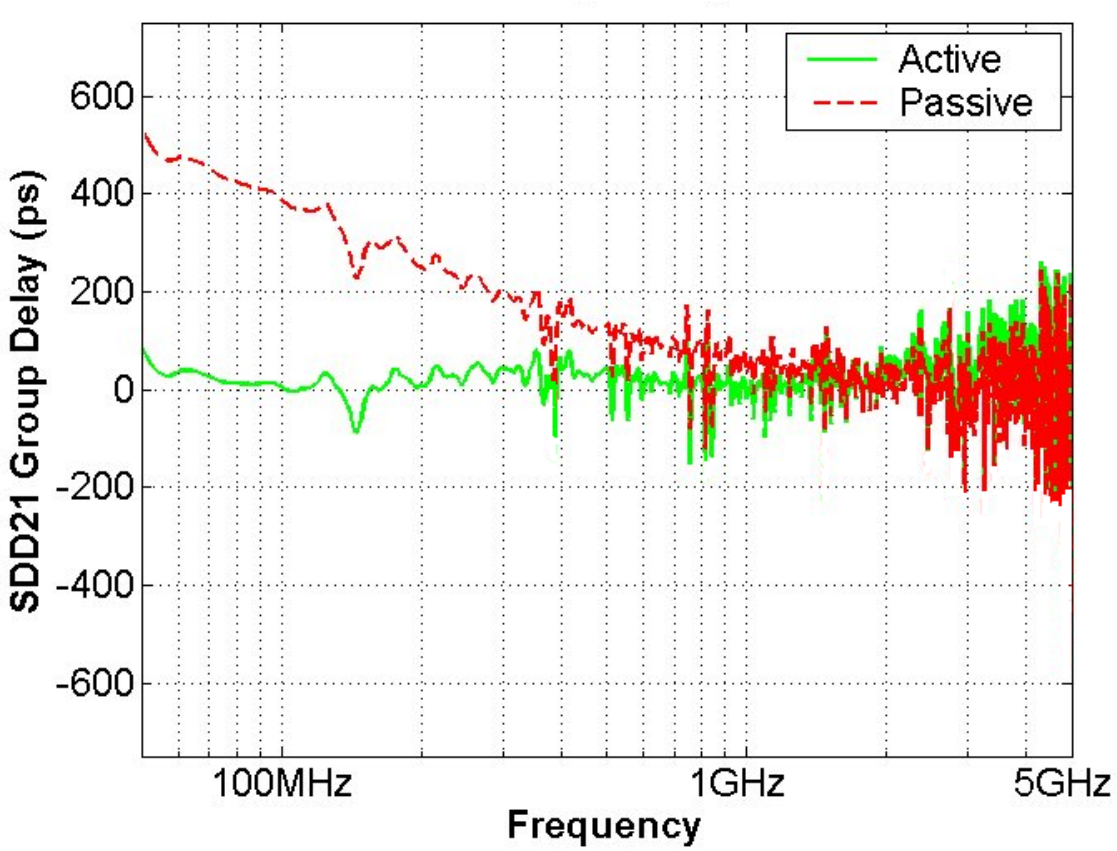
- 10M of 24-26AWG cable assemblies can be made to match the 10GBASE-KR channel model for 10 Gbps 64b/66b operation, anything longer and/or thinner will be difficult (SDD21 for a 10M 24AWGQSFP assembly shown). So, SAS-3 will be challenging

Background: Group Velocity Dispersion



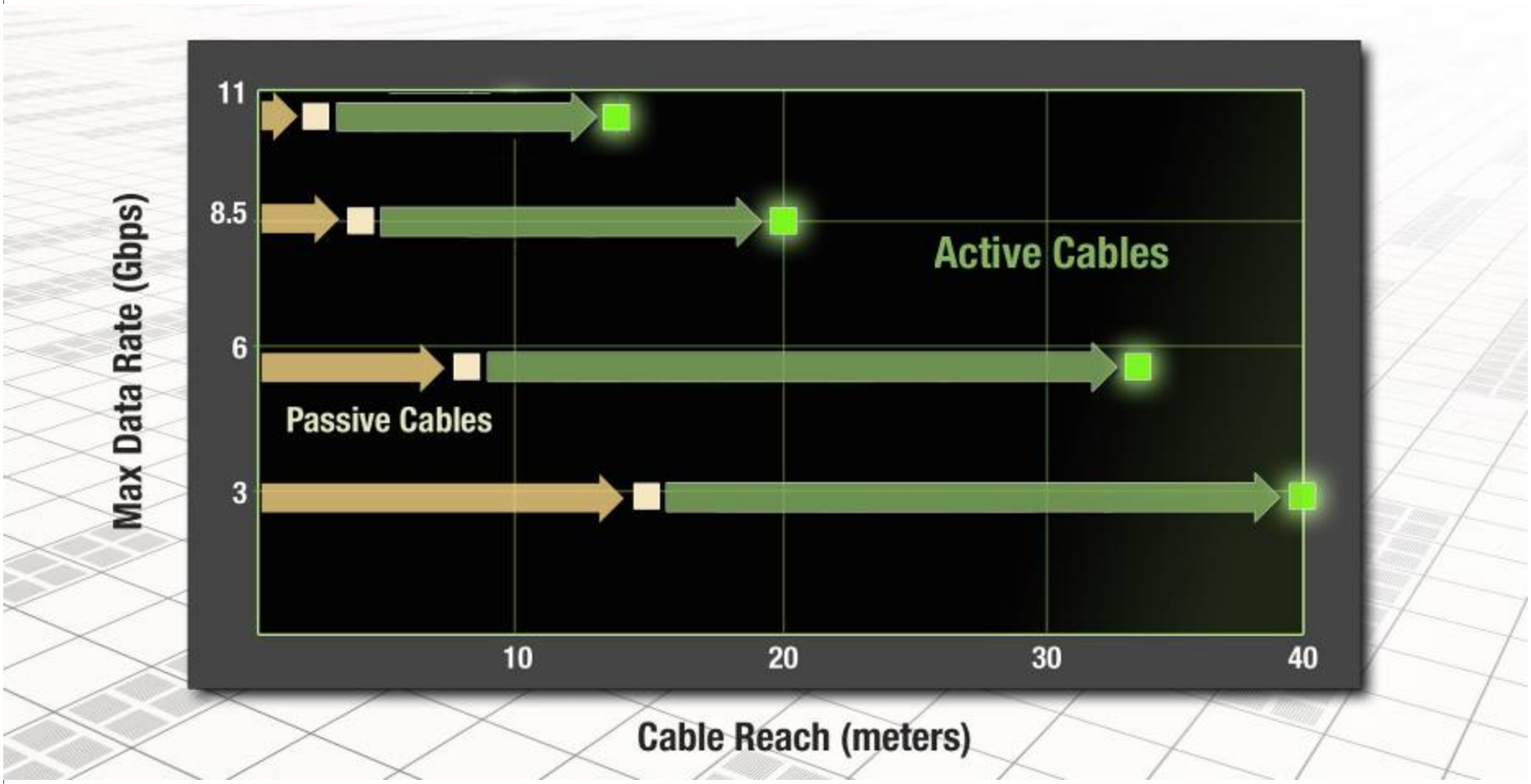
- Matching Attenuation is not enough: adapting 10GBASE-KR signaling (64b/66b) to cable assemblies will run into the Group Velocity Dispersion Issue (graph courtesy of Patrick Casher, Molex)

Background: Group Velocity Dispersion



- A well designed active cable can help mitigate the Group Velocity Dispersion problem.
- Example: 10m 30 AWG Cable: Group velocity dispersion compensated down to 20 MHz (plot courtesy of Andrew Kim, Quellan).

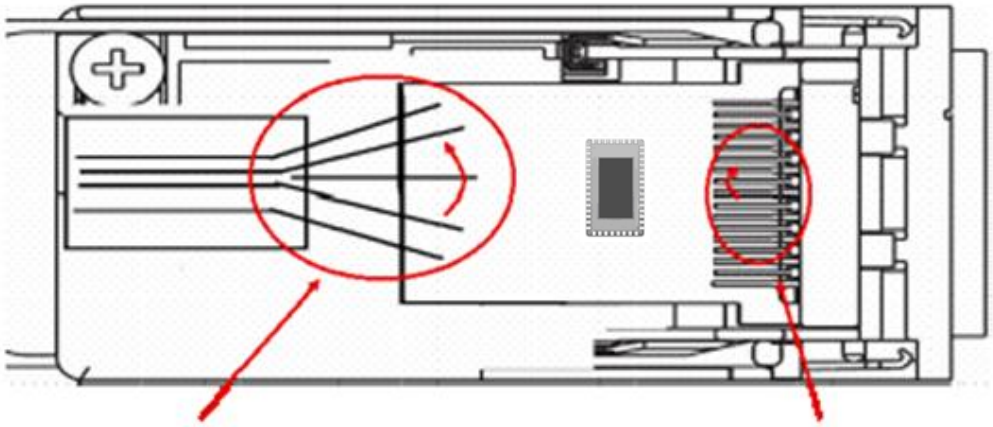
Active Cable Overview



Active Cable Reach Extension

Active Cable Overview

- How active cables improve the channel (Two-Fold Improvement of SNR):
  - Boost received signal
  - Reduce Crosstalk (NEXT) impact by placing the equalizer inside the cable assembly:



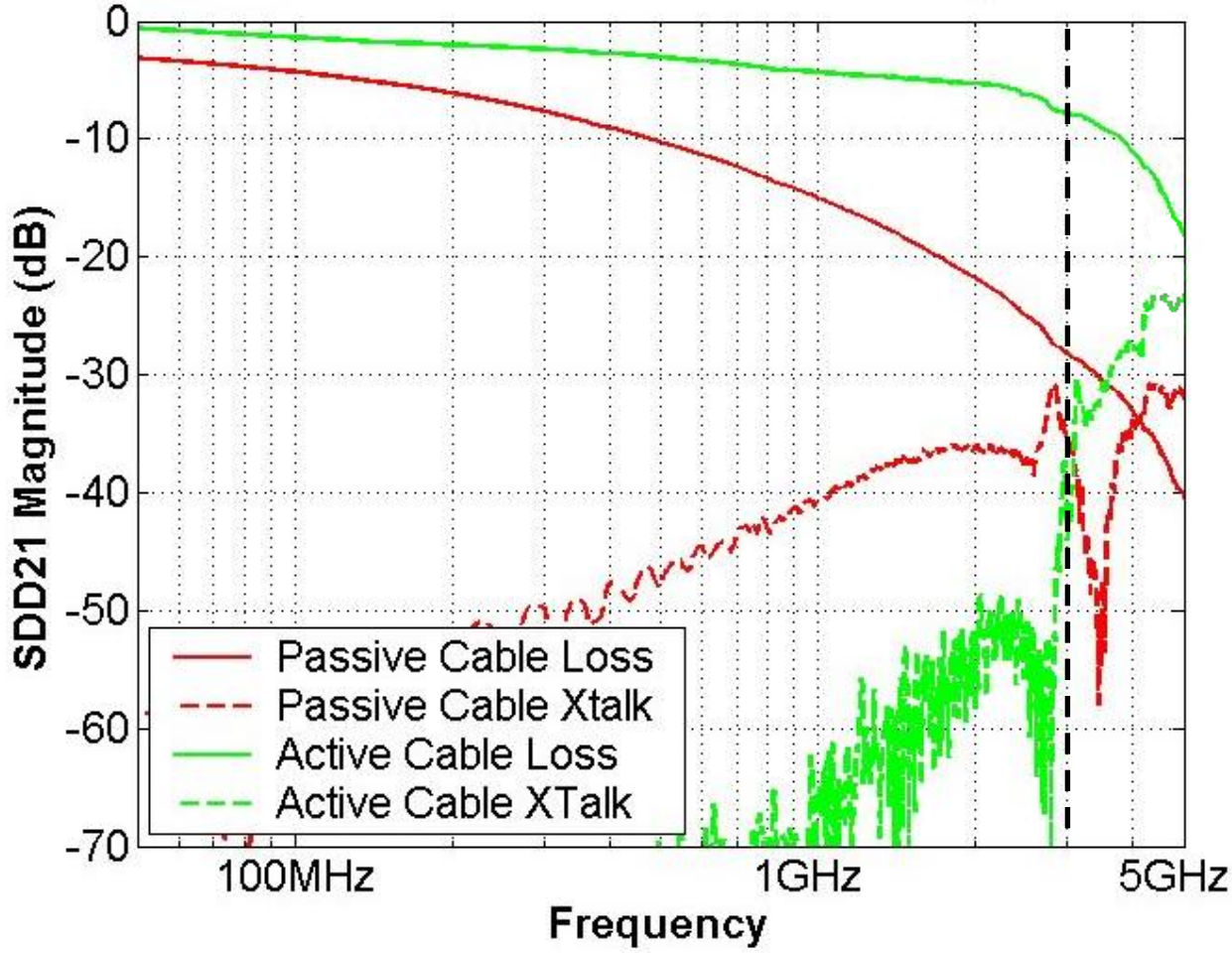
Cable Crosstalk

(generally small)

Connector NEXT

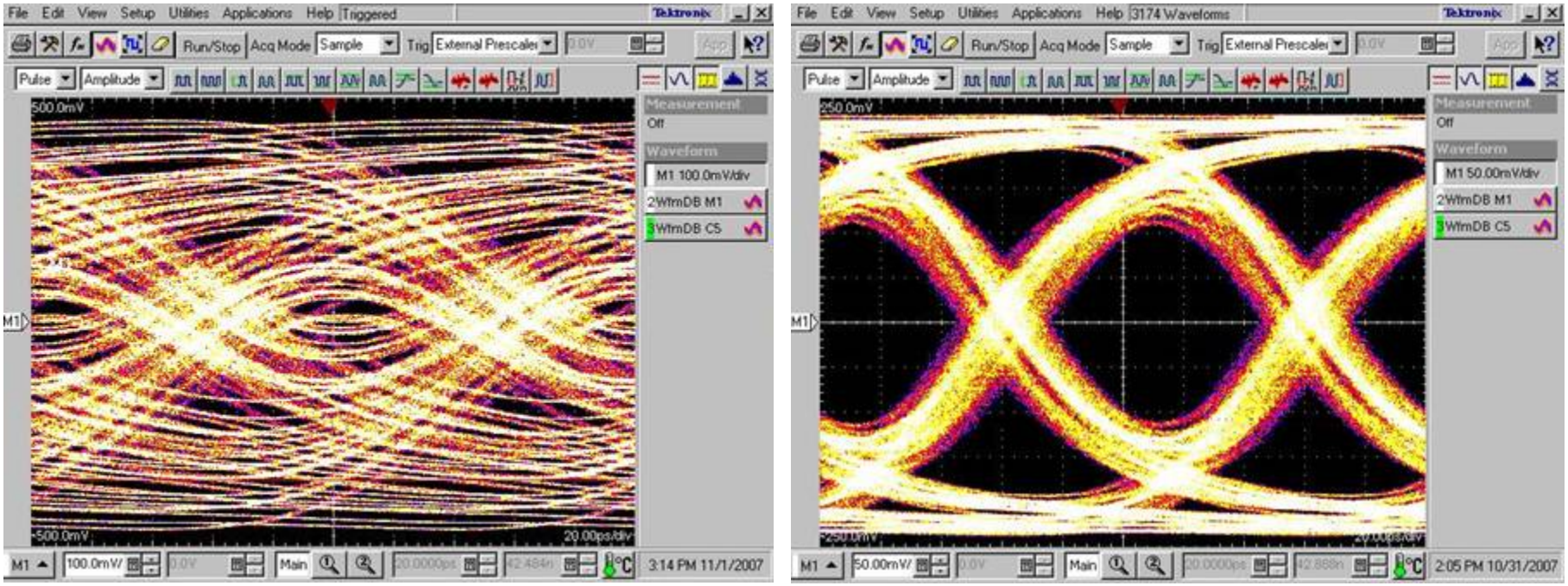
(minimized in active cables)

Active Cable Overview



Comparison of SNR for passive (red) and active (green) 10m 30AWG cable assemblies

Active Cable Overview



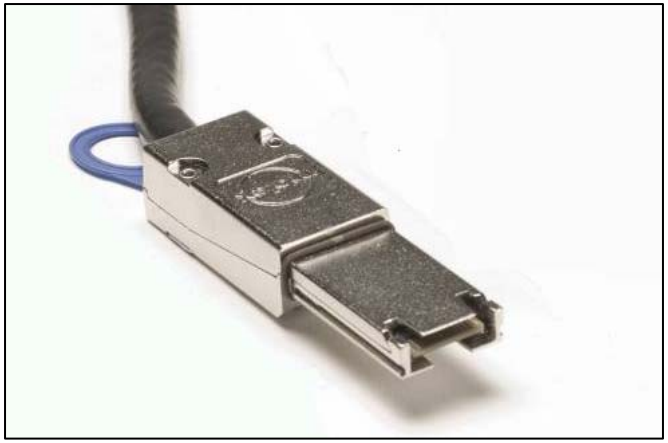
(a) **(b)**

Comparison of 10 Gbps eye diagrams of passive (a) and active (b) 24AWG QSFP cable assemblies

Interconnect Options For Active Cable

- Need power delivery to the plug
- A twin-ax type cable

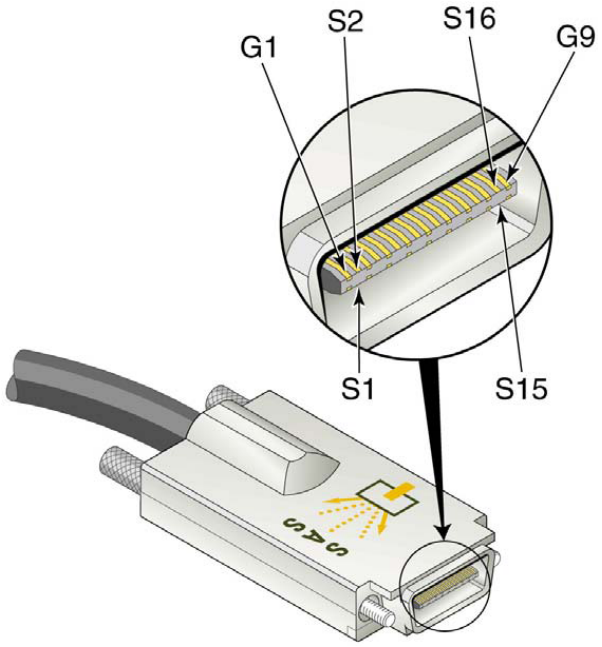
SAS (SFF-8470)



miniSAS (I-Pass)

QSFP

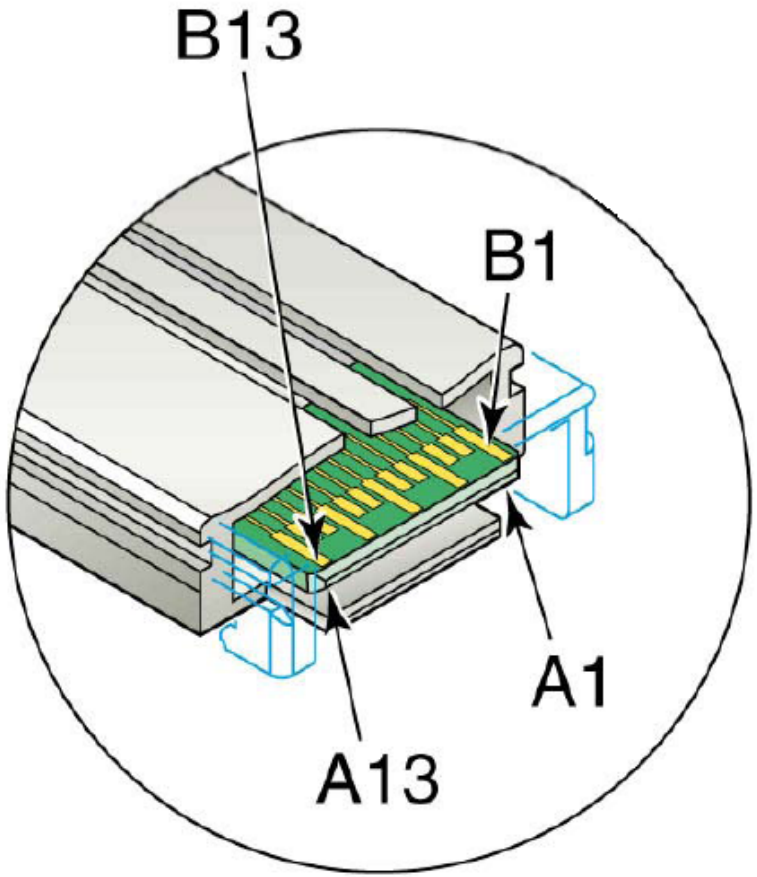
Active Cable with SAS Connectors



- Already done in InfiniBand
- A total of 8 GND tabs
- GND7, GND9: Voltage sense pins
- GND8: Power (3.3V or 1.2V)

Signal	Pin
Rx 0+	S1
Rx 0-	S2
Rx 1+	S3
Rx 1-	S4
Rx 2+	S5
Rx 2-	S6
Rx 3+	S7
Rx 3-	S8
Tx 3-	S9
Tx 3+	S10
Tx 2-	S11
Tx 2+	S12
Tx 1-	S13
Tx 1+	S14
Tx 0-	S15
Tx 0+	S16
Sense-3.3V	G7
Sense-1.2V	G9
Vcc	G8
SIGNAL GND	G1 – G6
CHASSIS GND	Housing

Active Cable with mini-SAS Connectors



- There are 10 GND pads on the Mini-SAS cable
- Use any one of the GND pins (e.g. B1) as 1.2V or 3.3V power
- Use another GND pin (e.g. A1) as voltage detection for an active cable
- A/C couple those pins to ground to preserve signal integrity

Signaling Considerations

- Most NRZ signaling protocols are compatible with active cables
- SAS-1 amd SAS-2 signaling compatible with active cables.
- Line Silence support features (e.g. in Quellan Lane Extenders) support OOB signaling
- The signaling, transmitter and receiver characteristics defined in SAS-2, 10GBASE-KR, etc, should work well with active cables
- Active cables with group velocity dispersion compensation can actually help in improving transmission of stressful (long bit sequence) data patterns, such as 64b/66b of 10GBASE-KR (for SAS-3 extensions)

Summary

- Active cables can be a viable technology to support SAS and mini-SAS copper cabling
- Current growing use in the industry demonstrates the feasibility of active cables for allowing longer reach and smaller wire gauge
- Possible to design active cables using current mini-SAS connectors by using GND pins for power.
- Can be made completely backward compatible to passive cables.
- Suggest an intermediate SAS-2.x specification to enable active cables. Can be made with minimum changes to SAS-2 and an added section on power (see addendum on proposed spec T10/08-052r0)

Thank You!