Considerations for Active Copper Cables for SAS-2 and Beyond

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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 Cables

Max Data Rate (Gbps)

Cable Reach (meters)

Passive Cables
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:

![Diagram showing Cable Crosstalk and Connector NEXT]

- 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

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

miniSAS (I-Pass)

SAS (SFF-8470)

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)

<table>
<thead>
<tr>
<th>Signal</th>
<th>Pin</th>
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<tbody>
<tr>
<td>Rx 0+</td>
<td>S1</td>
</tr>
<tr>
<td>Rx 0-</td>
<td>S2</td>
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<tr>
<td>Rx 1+</td>
<td>S3</td>
</tr>
<tr>
<td>Rx 1-</td>
<td>S4</td>
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<td>Rx 3-</td>
<td>S8</td>
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<tr>
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<td>S10</td>
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<td>S11</td>
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<tr>
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<tr>
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<tr>
<td>SIGNAL GND</td>
<td>G1 – G6</td>
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<tr>
<td>CHASSIS GND</td>
<td>Housing</td>
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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 and 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!