08-103r1

Active Copper Cables for SAS-2.x

(supporting presentation for 08-052r1 proposal)

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MORE SIGNAL | LESS NOISE

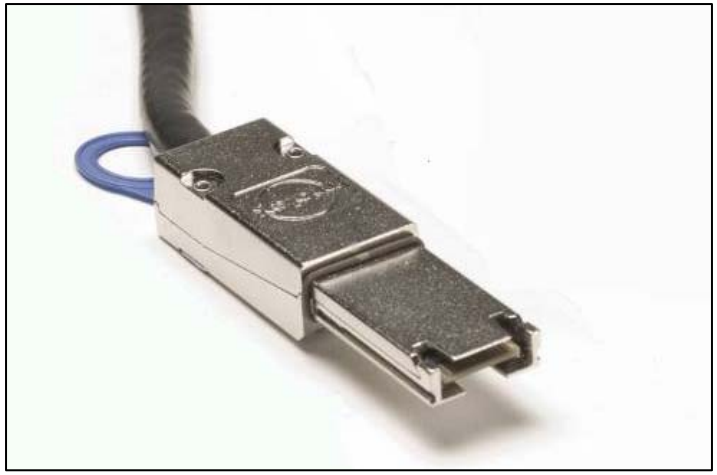
Background

- System designers need the flexibility to implement longer cable interconnects.
- A 20 meter reach is a desired target, allowing to wire a vast majority of connections in a typical datacenter.
- 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

Interconnect Options For Active Cable

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

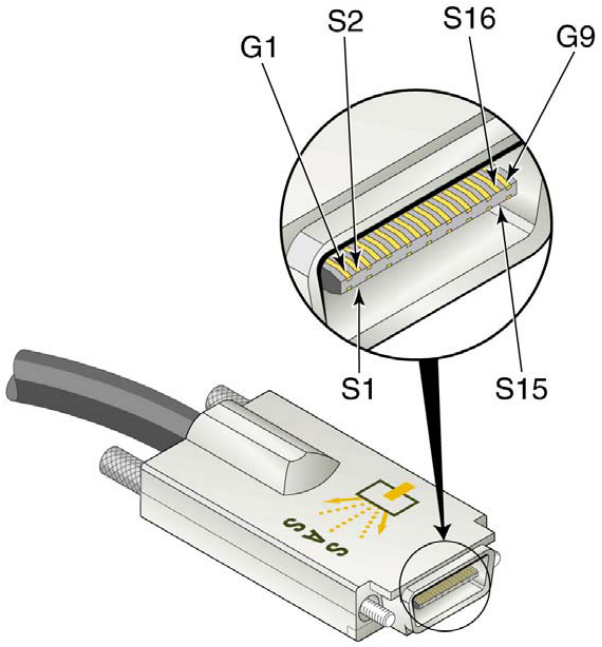
SAS (SFF-8470)



miniSAS (I-Pass)

QSFP

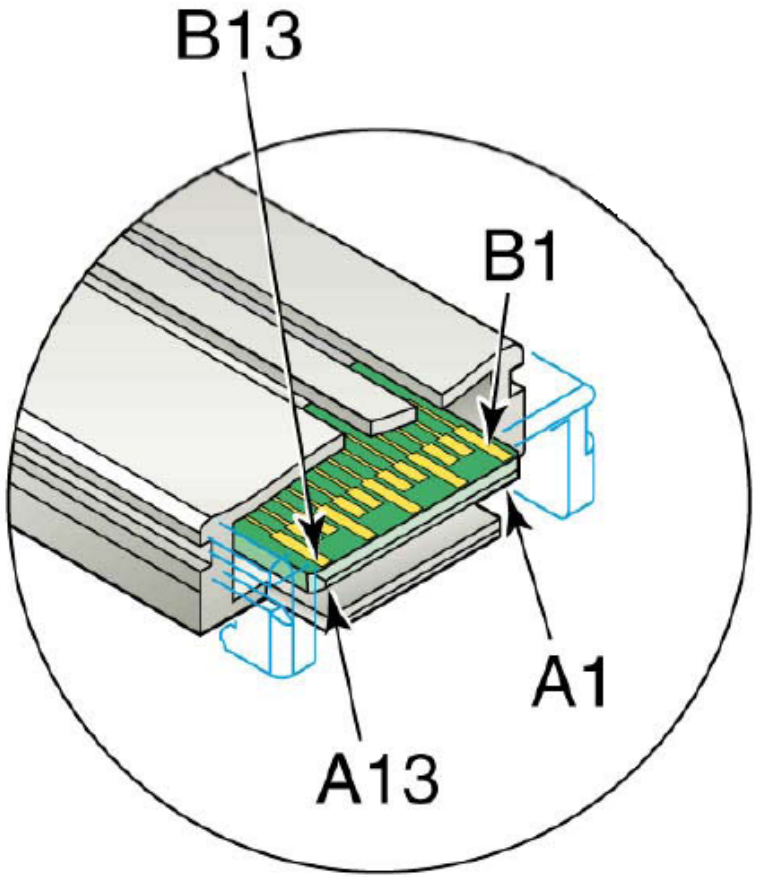
Active Cable with SAS Connectors



- Already done in InfiniBand (and used for 10GBASE-CX4)
- A total of 8 GND tabs
- GND7: Voltage sense pin
- GND8: Power (3.3V)

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
Vcc	G8
SIGNAL GND	G1 – G6, G9
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. B13) as 3.3V power
- Use another GND pin (e.g. B10) as voltage detection for an active cable
- A/C couple those pins to ground to preserve signal integrity.

Issues We Need to Address

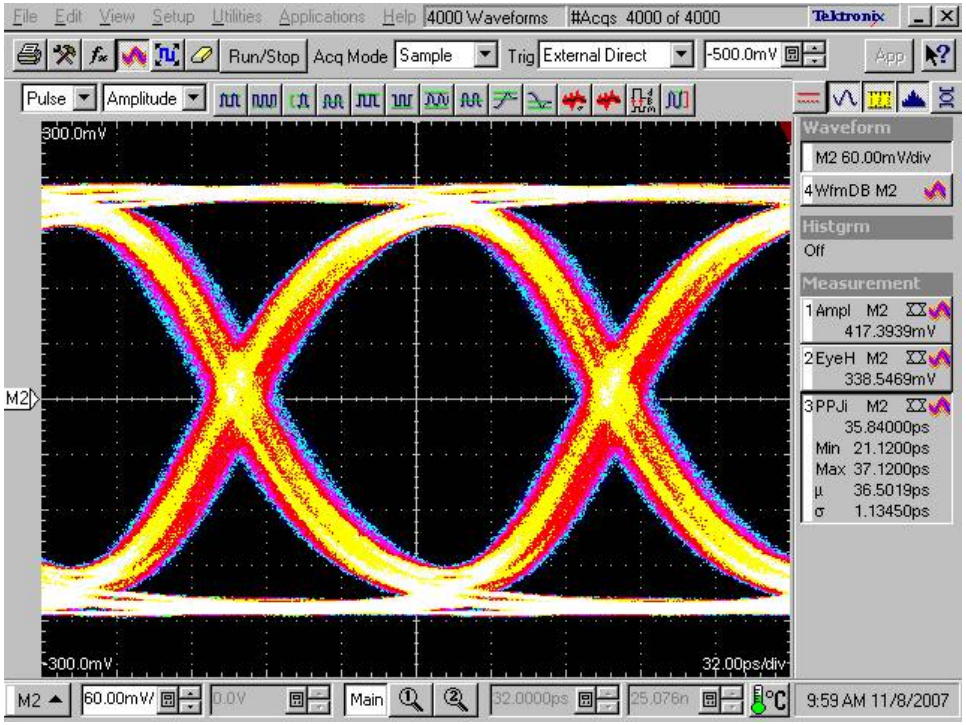
- Performance:
  - Can the 20 meter reach target be achieved with active cables?
  - Can SAS protocol features be supported with active cables?
- Power Delivery:
  - Will using some of the ground pins for power and sense affect signal integrity (crosstalk)?
- Backward Compatibility
  - Will passive cables work on active ports? Active cables on passive ports?
  - Is keying needed?

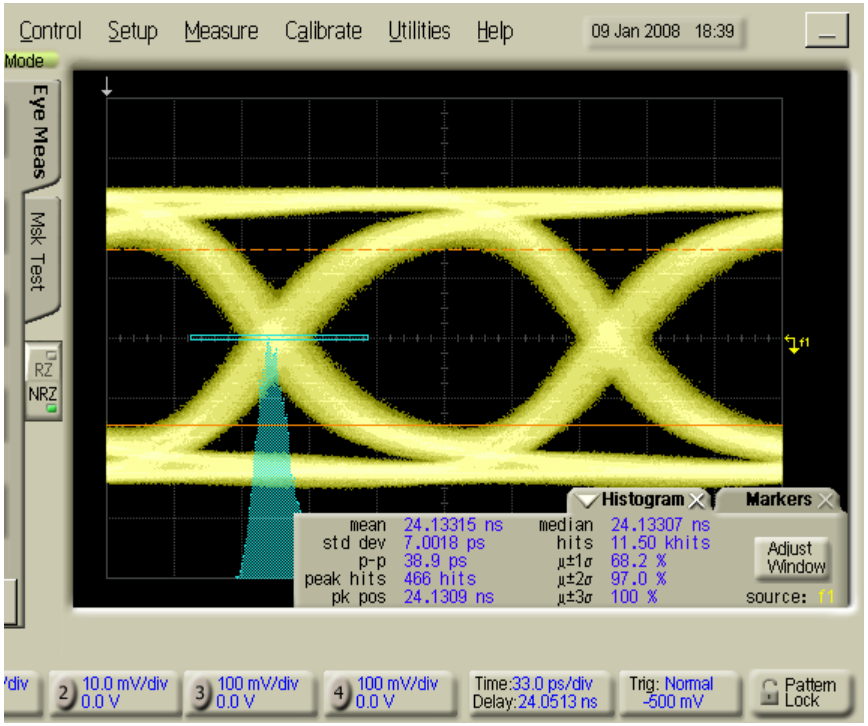
Performance:

For the purposes of this presentation, Quellan's active copper cables with receive-only equalization were used. Other implementations can be used, including adding TX-side EQ for PCB losses, as well as non-copper (optical) solutions. Spec should not restrict implementation.

- Eye diagrams at ~6 Gbps for both SFF-8470 (20m) and I-Pass cables (25 meters are shown). The Output TJ in both cases is better than 0.25 UI (the limit required by other standards that support active cables)

Performance (*continued*):





20m SFF-8470 Cable, 6.25 Gbps

25m I-Pass Cable, 6 Gbps

(graph courtesy of Molex)

Performance (*continued*):

- Active cables can be designed to ensure support for SAS protocol features. OOB signaling is particularly important:
  - OOB signals would require the active cable to support DC idle (muting) with tight constraints on the response time
  - COMWAKE (the tightest OOB signal): 106.6ns duration for both burst and idle; for a minimally compliant receiver, bursts 100 ns or shorter and idles shorter than 101.3 ns may not be detected.
  - So, if an active cable has a difference between idle-to-burst and burst-to-idle response times tighter than 5.3 ns, the OOB features will be supported.
  - Example: Quellan active cables based on the QLx4600 series equalizer are held tighter than 5 ns.

Power Delivery:

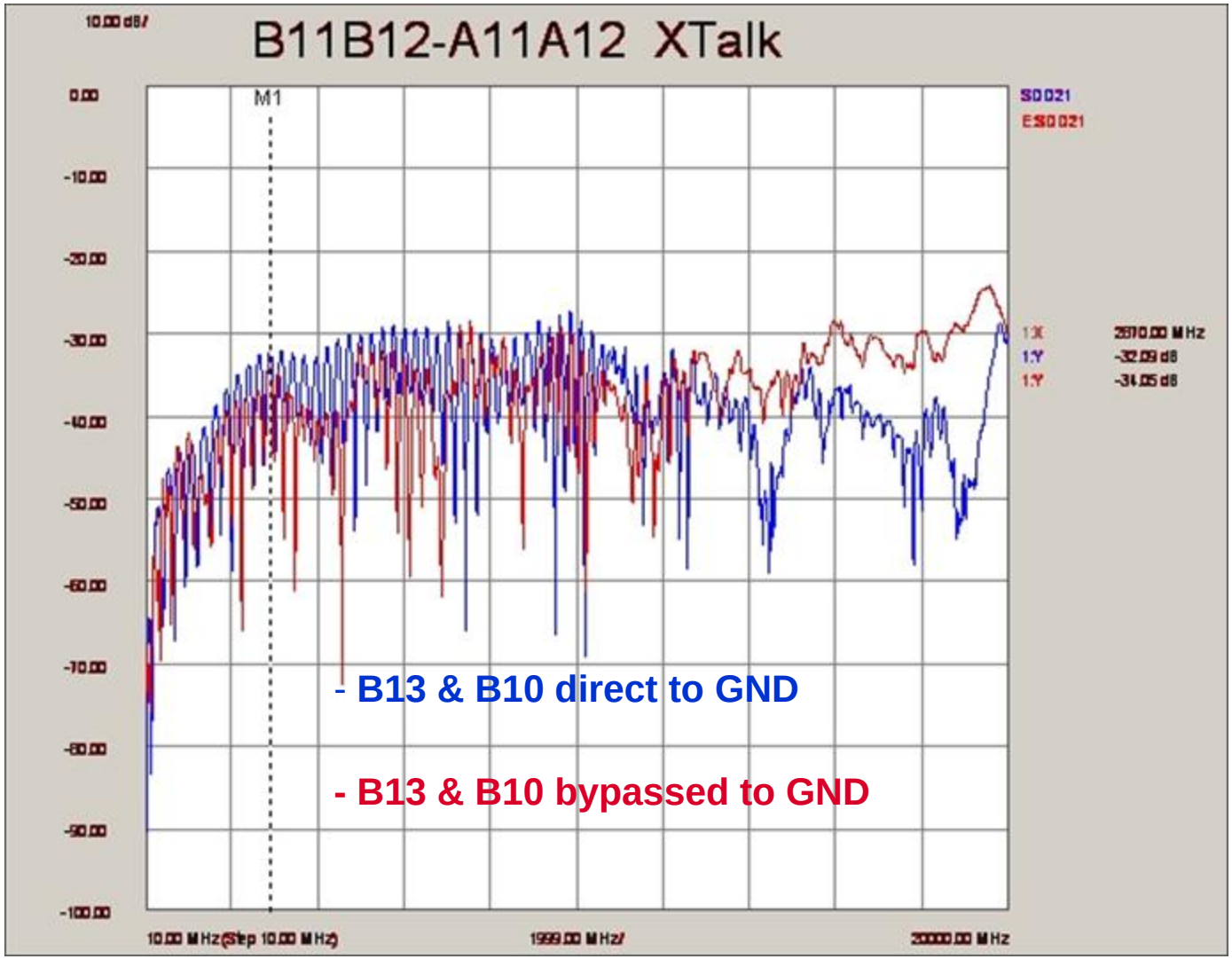
- A concern is sometimes voiced that using ground pins for power may undermine crosstalk performance, in particular when a passive legacy cable is used on an active port.

- Experience from other standards suggest that bypassing the ground pins (with ~ 10nF chip capacitors) combined with capacitive coupling of the power planes and the ground planes on the system side relieves this concern.

Power Delivery *(continued):*

- To confirm, the following test has been done:
  - B13 and B10 ground pins were lifted of a mini-SAS SMA test board, then reconnected through 10nF 0603 caps.
  - A 1m mini-SAS cable assembly was connected, with another SMA board terminated to 50 Ohm at the far end.
  - Worst-case NEXT (between B11B12 and A11A12 pairs) was measured with an Agilent VNA, before and after the modification.
  - No change other than caused by PCB variations was observed (if anything, bypassing brought the ringing down).

Power Delivery *(continued):*



Backward Compatibility:

shall not operate

shall operate

Keying may be added to allow passive (legacy) cables to plug into an active port, but not the other way round, if the group so desires.

Thank You!