Active Copper Cables for SAS-2.x
(supporting presentation for 08-052r1 proposal)

Gourgen Oganessyan
Quellan

02-13-2008
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

miniSAS (I-Pass)

SAS (SFF-8470)

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)
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?
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.
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.
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):

- B13 & B10 direct to GND
- B13 & B10 bypassed to GND
Backward Compatibility:

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!