08-052r6

Proposal for SAS 2.x Specification to Enable Support for Active Cables

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Introduction

Inclusion of active cable interconnect option into the SAS specification would be beneficial in that it enables active copper and optical interconnects, to support longer reaches, lighter cable, etc.

It is proposed that active cable support may be enabled in the intermediate SAS-2.x specification by making minimum changes to the SAS-2 spec and inserting a section on power supply option.
A proposal for such changes and a stating point for the text of specification is presented.

Change Log

Changes Since 01/08/2008

- Removed the 1.2V power supply option – the proposal now has a single 3.3V supply.
- Added a section on capacitive coupling.

Changes Since 02/12/2008

- Added a sections, tables and figures for keying of active cable: prevents active cable from plugging into a passive port, while allowing passive cable to plug into an active port.

Changes Since 03/07/2008

- Fixed typos:
  - *Title of Table 60: Added the word "Mini" in front of "SAS"*
  - *In Section* **5.2.7.3.2 Power consumption** *replaced "per an interface" with "per cable"; the section now reads:" The voltage and current requirements are such as to enable support for active cable assemblies with power consumption at 3.3 V of up to 2 W per cable with four functioning links."*
  - *In Section* **5.2.7.3.2 Power consumption** *replaced "per an interface" with "per cable"; the section now reads:" The voltage and current requirements are such as to enable support for active cable assemblies with power consumption at 3.3 V of up to 2 W per cable with four functioning links."*

Changes Since 05/02/2008

- *Modified Section* **5.2.7.3.6 Short Circuit Protection** *to read: "The active cable power supply shall have protection against the connection of the Vcc pin to ground, and shall limit short circuit current to below 25 mA when equivalent load resistance is less than 1 Ohm."*

Changes Since 05/15/2008

- *Collapsed the sections* ***5.2.7.3.2 - 5.2.7.3.2*** *into a single section* ***5.2.7.3.2*** **Power Supply Requirements,** *and summarized the numbers in a table (Table 61).*
- *Inserted the word "capacitors" in the last sentence of section* ***5.2.7.3.6*** **Bypassing.**
- *Modified Section* **5.2.7.3.6 Short Circuit Protection** *to read: "The active cable power supply shall have protection against the connection of the Vcc pin to ground or over-current loading, and shall limit the output current when the equivalent load resistance is less than 1 Ohm".*
- *Added a change of wording to section* **6.7.5 Phy reset sequence after devices are attached.**

Changes Since 06/05/2008

- *Added a proposed Informative Annex M for power supply logic reference design.*

List of Proposed Modifications to SAS 2.0 to Enable Active Cables

- The title of section 5.2 “Passive Interconnect” shall be changed to read “Interconnect Characteristics”.
- The title of subsection 5.2.4 “Cable assemblies” shall be changed to read “Passive Cable assemblies”.
- The title of subsection 5.2.6 “Cable assembly and backplane specifications” shall be changed to read “Passive cable assembly and backplane specifications”.
- A subsection 5.2.7 titled “Active Cables” shall be inserted with text as per pages 3-7 of this document.
- The table numbering in section 5.3 and onwards shall be changed so that Table 57 becomes Table 62, etc.
- The figure numbering in section 5.3 and onwards shall be changed so that Figure 98 becomes Figure 99, etc.
- Section 6.7.5 shall be reworded to read:

6.7.5 Phy reset sequence after devices are attached

Since it is not always possible to detect physical mating of a cable, every time a phy reset sequence is originated:

a) expander phys that are enabled but not active shall originate a new phy reset sequence repeatedly,
with no more than a hot-plug timeout (see table 94 in 6.7.1) between each attempt, until a speed negotiation sequence completes successfully;

b) SAS initiator phys should originate a new phy reset sequence after every hot-plug timeout; and

c) SAS target phys should not originate a new phy reset sequence after their first attempt

5.2.7 Active cables

5.2.7.1 Active cable overview

The standard provides support for the cable assemblies which incorporate active circuitry. This includes but is not limited to cables with built-in drivers, repeaters, equalizers, as well as copper cable substitutes which incorporate electro-optical converters and optical transceivers.

In order to enable the operation of devices inside the active cable assemblies, 3.3 V power supply option is made available in the connectors.

The powered ports (receptacles) defined in this standard are required to function when passive cables are plugged into them. This means that they must be able to handle the condition where their power supply pins are shorted to ground for any arbitrary length of time. Therefore, voltage sense pins are used to enable the switching of power in these ports.

Active cable assemblies defined in this standard, when plugged into SAS 2.0 (unpowered) ports will not function.

All active cables defined in this standard are external cable assemblies, and they may be SAS 4x – to – SAS 4x; Mini SAS – to – Mini SAS; and SAS 4x – to – Mini SAS, similarly to passive assemblies defined in 5.2.4.2, except that active connectors defined in 5.2.7.2 with corresponding sense and power pin assignments are used.

Because of a wide range of implementations, technologies and transmission media available for the design of active cables, the specification of high-speed data transmission performance of these cables is beyond the scope of this standard. It is understood that the design of active cables shall be such as to provide operation with the transmitter and receiver defined in section 5.3 of this standard.

5.2.7.2 Active connectors

5.2.7.2.1 SAS 4x active connectors

5.2.7.2.1.1 SAS 4x active plug connector

The SAS 4x active cable plug connector is the same as the passive connector defined in 5.2.3.3.1.1) and shown in figure 74.

5.2.7.2.1.2 SAS 4x active receptacle connector

The SAS 4x active receptacle connector is the same as the passive connector defined in 5.2.3.3.1.1 and shown in figure 75

5.2.7.2.1.3 SAS 4x active connector pin assignments

Table 57 defines the pin assignments for SAS 4x cable plug connectors (see 5.2.7.2.1.1)

and SAS 4x receptacle connectors (see 5.2.7.2.1.2) for applications using one, two, three, or four of the physical links.

Table 57 — SAS 4x active connector pin assignments and physical link usage

Signal	Pin usage based on number of physical links supported by the cable assembly [a]			
	One	Two	Three	Four
Rx 0+	S1	S1	S1	S1
Rx 0-	S2	S2	S2	S2
Rx 1+	N/C	S3	S3	S3
Rx 1-	N/C	S4	S4	S4
Rx 2+	N/C	N/C	S5	S5
Rx 2-	N/C	N/C	S6	S6
Rx 3+	N/C	N/C	N/C	S7
Rx 3-	N/C	N/C	N/C	S8
Tx 3-	N/C	N/C	N/C	S9
Tx 3+	N/C	N/C	N/C	S10
Tx 2-	N/C	N/C	S11	S11
Tx 2+	N/C	N/C	S12	S12
Tx 1-	N/C	S13	S13	S13
Tx 1+	N/C	S14	S14	S14
Tx 0-	S15	S15	S15	S15
Tx 0+	S16	S16	S16	S16
Sense-3.3V	G7			
Vcc	G8			
SIGNAL GROUND	G1 – G6, G9			
CHASSIS GROUND	Housing			

[a] N/C = not connected

SIGNAL GROUND shall not be connected to CHASSIS GROUND in the connector when used in a cable assembly.

5.2.7.2.2 Mini SAS 4x active connectors

5.2.7.2.2.1 Mini SAS 4x active cable plug connector

The Mini SAS 4x active cable plug connector is the same as the passive connector: the free (plug) 26-circuit Shielded Compact Multilane connector defined in SFF-8088.

In order to ensure that active cables cannot be plugged into legacy (passive) ports, differentiating keying shall be provided by removing all the key slots from the plug connector and all the keys on the receptacle connector. In addition, two triangle icons on each side on the plug connector will be added to the plug connector to distinguish an active cable assembly (Figure 98).

Table 58 defines the icons that shall be placed on or near Mini SAS 4x cable plug connectors and the key slot positions (see SFF-8088) that shall be used by Mini SAS 4x cable plug connectors.

Table 58 — Mini SAS 4x active cable plug connector icons and key slot positions

Use	Icon	Key slot positions	Reference
End of a SAS external cable that attaches to an end device, or an enclosure universal port	2 Triangles	None	Figure 98

Figure 98 shows an active mini SAS 4x cable plug connector that attaches to an enclosure universal port:

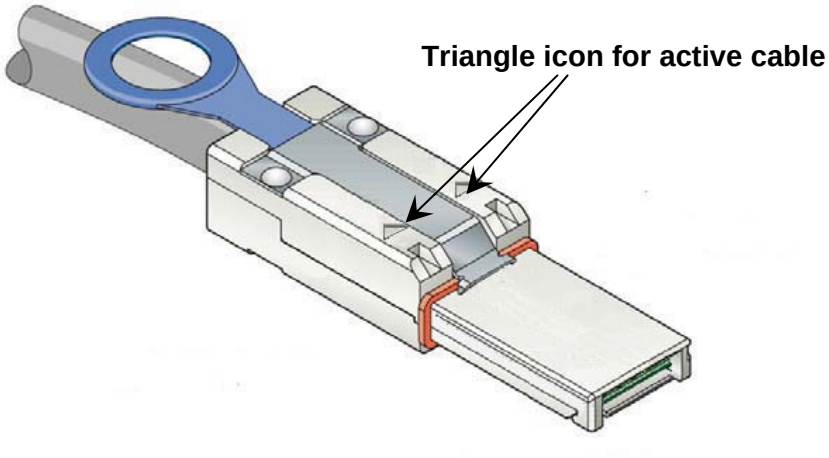

Figure 98 — Mini SAS 4x cable plug connector that attaches to an enclosure universal port

5.2.7.2.2.2 Mini SAS 4x active receptacle connector

The Mini SAS 4x active receptacle connector is the fixed (receptacle) 26-circuit Shielded Compact Multilane connector defined in SFF-8088 and shown in figure 79.

In order to ensure that active cables cannot be plugged into legacy (passive) ports, differentiating keying shall be provided by removing all the key slots from the plug connector and all the keys on the receptacle connector. In addition, two triangle icons shall be placed near the receptacle to identify active receptacle connectors.

Table 59 defines the icons that shall be placed on or near Mini SAS 4x receptacle connectors and the key positions (see SFF-8088) that shall be used by active Mini SAS 4x receptacle connectors.

Table 59 — Mini SAS 4x active cable receptacle connector icons and key slot positions

Use	Icon	Key positions
End device or enclosure universal port	2 Triangles	None

5.2.7.2.2.3 Mini SAS 4x active connector pin assignments

Table 60 defines the pin assignments for Mini SAS 4x cable plug connectors (see 5.2.7.2.2.1) and Mini SAS 4x receptacle connectors (see 5.2.7.2.2.2) for applications using one, two, three, or four of the physical links.

Table 60 — Mini SAS 4x active connector pin assignments and physical link usage

Signal	Pin usage based on number of physical links supported by the cable assembly [a]				Mating level
	One	Two	Three	Four	
Rx 0+	A2	A2	A2	A2	Third
Rx 0-	A3	A3	A3	A3	
Rx 1+	N/C	A5	A5	A5	
Rx 1-	N/C	A6	A6	A6	
Rx 2+	N/C	N/C	A8	A8	
Rx 2-	N/C	N/C	A9	A9	
Rx 3+	N/C	N/C	N/C	A11	
Rx 3-	N/C	N/C	N/C	A12	
Tx 0+	B2	B2	B2	B2	
Tx 0-	B3	B3	B3	B3	
Tx 1+	N/C	B5	B5	B5	
Tx 1-	N/C	B6	B6	B6	
Tx 2+	N/C	N/C	B8	B8	
Tx 2-	N/C	N/C	B9	B9	
Tx 3+	N/C	N/C	N/C	B11	
Tx 3-	N/C	N/C	N/C	B12	
Sense 3.3 V	B10				First
Vcc	B13				
SIGNAL GROUND	A1, A4, A7, A10, A13, B1, B4, B7				
CHASSIS GROUND	Housing				
[a] N/C = not connected					N/A

SIGNAL GROUND shall not be connected to CHASSIS GROUND in the connector when used in a cable assembly.

5.2.7.3 Active cable power requirements

5.2.7.3.1 Active cable power overview

Active SAS 4x and Mini SAS 4x cables may contain integrated active devices such as drivers, repeaters, equalizers, as well as electro-optical converters and optical transceivers for fiber-optic assemblies. In order to enable the operation of these devices, 3.3 V power supply is provided.

Because active SAS 4x and Mini SAS 4x receptacle connectors must be intermateable with legacy passive cables, there will be times when the power supply pins will be shorted to ground. Sense pins are therefore defined (see Tables 57 and 60) in order to enable the power circuitry to supply power only when an active cable assembly is plugged in, and to remain in the default “off” state when a passive cable or no cable is plugged in.

5.2.7.3.2 Power supply requirements

The voltage and current requirements for the power supply are such as to enable support for active cable assemblies with power consumption at 3.3 V of up to 1 W per each end of the cable with four functioning links. These requirements are summarized in Table 61.

Table 61 — Active cable power supply requirements

Characteristic	Units	Minimum	Nominal	Maximum
Supply Voltage	V	3.135[a]	3.3	3.465[b]
Supply Current	mA	319.4[c]		600
Current Consumption	mA			288.6[d]
Power Consumption	mW			1000[d,e]

[a] At maximum current
[b] The power supply shall not exceed this value at any current
[c] The power supply shall be able to deliver at least this amount of current at the minimum voltage of 3.135 V.
[d] Maximum consumption for each end of the active cable assembly.
[e] This is a derivative quantity obtained from: (maximum supply voltage) x (maximum current consumption)

5.2.7.3.3 Voltage Sense

The active cable assembly shall provide a connection of the Sense pin to ground via a 5 kOhm (±5%) resistor.

The active cable power supply circuitry shall enable power to the receptacle connector only when the presence of the Sense resistor is detected, and it shall be disabled if the Sense pin is open (no cable plugged in) or shorted to ground (passive cable).

5.2.7.3.4 Short Circuit Protection

The active cable power supply shall have protection against the connection of the Vcc pin to ground or over-current loading, and shall limit the output current when the equivalent load resistance is less than 1 Ohm.

5.2.7.3.5 Hot-pluggable operation

In order to support hot plugging, the active cable power supply circuitry shall be able to detect the Sense resistor value and provide full current within 50 milliseconds of cable connection.

5.2.7.3.6 Bypassing

The active cable power pins (Vcc and Sense) shall be coupled to ground via bypass capacitors in such a way as to have low impedance to ground from 100 MHz to 1.5 times the fundamental frequency of the maximum baud rate supported by the port. These bypassing capacitors shall be present both in the receptacle and the plug.

5.2.7.3.7 Capacitive coupling

In addition to bypassing, the system designers shall ensure that the power planes of the system (on the receptacle side) are sufficiently coupled to ground.

5.2.7.3.8 Voltage Converters (DC-to-DC)

In specific implementations where the active circuitry in the cable requires voltages other than the provided 3.3 V, local voltage regulators may be used. These regulators shall be located within the active cable assembly.

Annex M
(informative)

Active Cable Power Supply and Voltage Detection Circuitry

Due to the fact that powered mini-SAS equipment supporting active cables needs to be able operate with passive cables which have the Vcc pin tied to ground, there needs to be a mechanism that turns on the power to the port only when an active cable is plugged, to avoid shorting the power supply. A voltage sense pin is implemented to detect if an active cable is in operation. This can also be used to detect the status a specific port, or implement other features within a switch device.

The following is a reference design utilizing a dual comparator to determine from the sense pin on the cable if an active cable is in operation on a specific port. The circuit then supplies power based upon whether there is an active cable connected to the specific port.

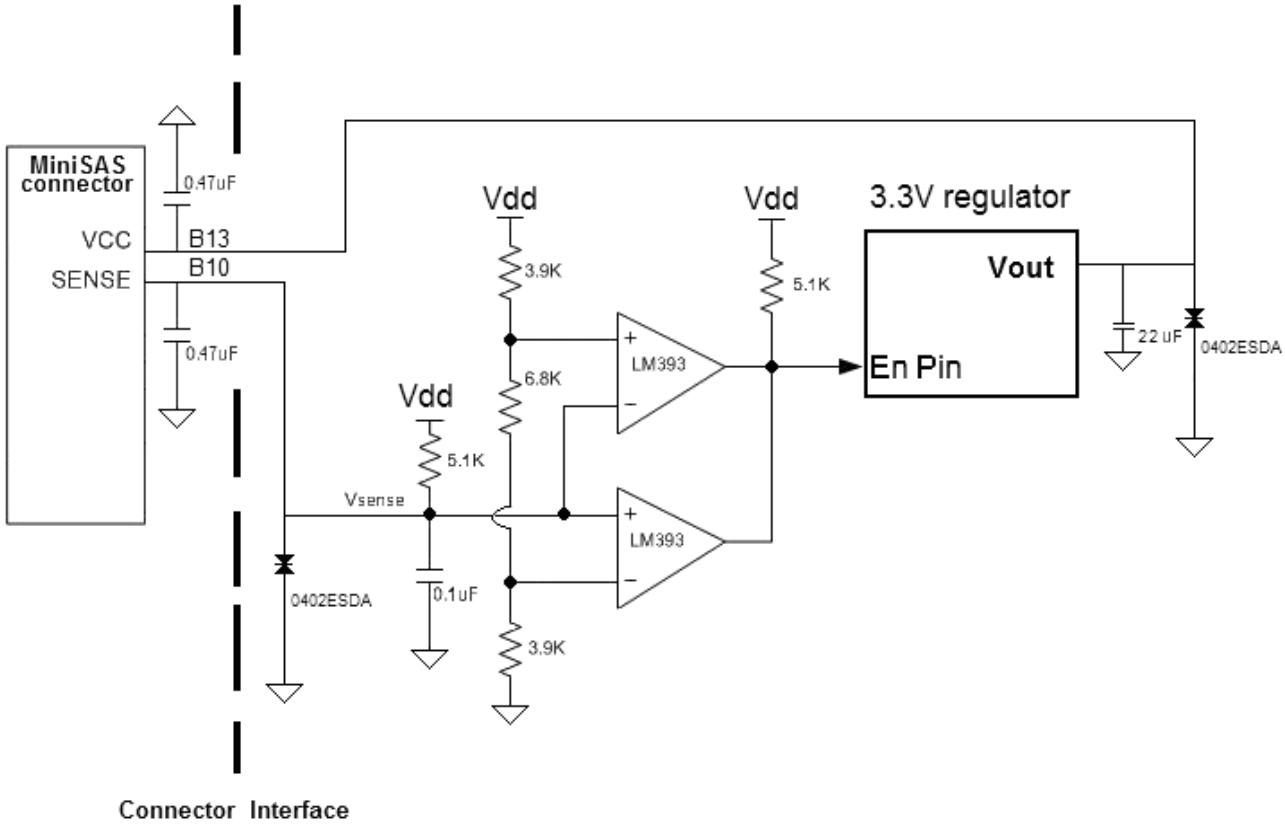

Figure M.1 — Dual comparator design for active cable detection

Table M.1 is a suggested list of components to use to implement the voltage sense circuit functionality in a switch or line card application. The overall power consumption of the circuit is less than 1A.

Table M.1 — Parts list for voltage sense circuitry design in Figure M.1

Item	Qty	Part	Distributor	Device	Vendor
1	2	0.47uF	Digikey 399-4899-1-ND	Capacitor 0402	Kemet
1	1	0.1uF	Digikey 399-3026-1-ND	Capacitor 0402	Kemet
2	1	22uF	Digikey 445-1373-1-ND	Capacitor 0802	TDK
3	1	6.8k ohm	Digikey 2312 275 16802-ND	Resistor 0402	BC components
4	1	5.1k ohm	Digikey 2312 275 15102-ND	Resistor 0402	BC components
5	2	3.9k ohm	Digikey 2312 275 13902-ND	Resistor 0402	BC components
6	1	51.1k ohm	Digikey 2312 275 15113-ND	Resistor 0402	BC components
7	2	LM393	Digikey LM393NNS-ND	Dual comparator	National Semiconductor
8	2	0402ESDA	Digikey 283-2792-1-ND	ESD Protection Diode	Cooper Bussmann

The power supply needs to provide power to each active mini-SAS receptacle with characteristics specified in Table 61. The type of power delivery device can be either a switching or linear regulator. Recommendations for a specific power supply cannot be made without prior knowledge of the number of active cables utilized in a given design.