To: T10 Technical Committee
From: Steven Fairchild, HP (steve.Fairchild@hp.com)
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Subject: SAS Signal Class Proposal

The purpose for this proposal is to define a mechanism for allowing a system designer to provide a hint to a SAS device about the type of losses expected in the transport medium between the system and the SAS device. The primary focus of this proposal is on a link to target devices (i.e. disk drives), but the mechanism could be extended to any link in the SAS domain. In investigating the usage models for disk drives in the SAS domain, there is enough variability in the transport media (backplanes, cables, etc.) that a hint to the disk drive would allow it to adjust the transceiver characteristics to accommodate the transport media and ultimately improve signal margin.

The proposal assumes that the transport media does not introduce catastrophic losses in the link, but may introduce sufficient losses to reduce signal integrity margin and affect link error rates. It is further assumed that any change to a device signal class is only done through system initialization code provided by the system manufacturer that fully understands, and has tested, the interconnect topology.

The suggested approach is to define the 3 classes of links shown in Figure 1. Each class has some basic assumptions about the physical transport media (see Table 1).

Table 1: Signal Class Characteristics

Class 0	**Unknown Interconnect**
	• The system is not providing any hint of the transport characteristics
Class 1	**Direct Cable**
	• Recommended no more than 2 interconnects (controller – cable – drive) • Maximum of 2.3 dB loss @ 1.5 GHz • Maximum of 4.5 dB loss @ 3.0 GHz
Class 2	**Typical Backplane and Cable**
	• Recommended no more than 3 interconnects (controller – cable – backplane – drive) • Maximum of 3.8 dB loss @ 1.5 GHz • Maximum of 7.5 dB loss @ 3.0 GHz
Class 3	**Lossy Backplane and Media**
	• 3 or more interconnects • Maximum of 5.4 dB loss @ 1.5 GHz • Maximum of 10.9 dB loss @ 3.0 GHz • Additional transitions through lossy interconnects

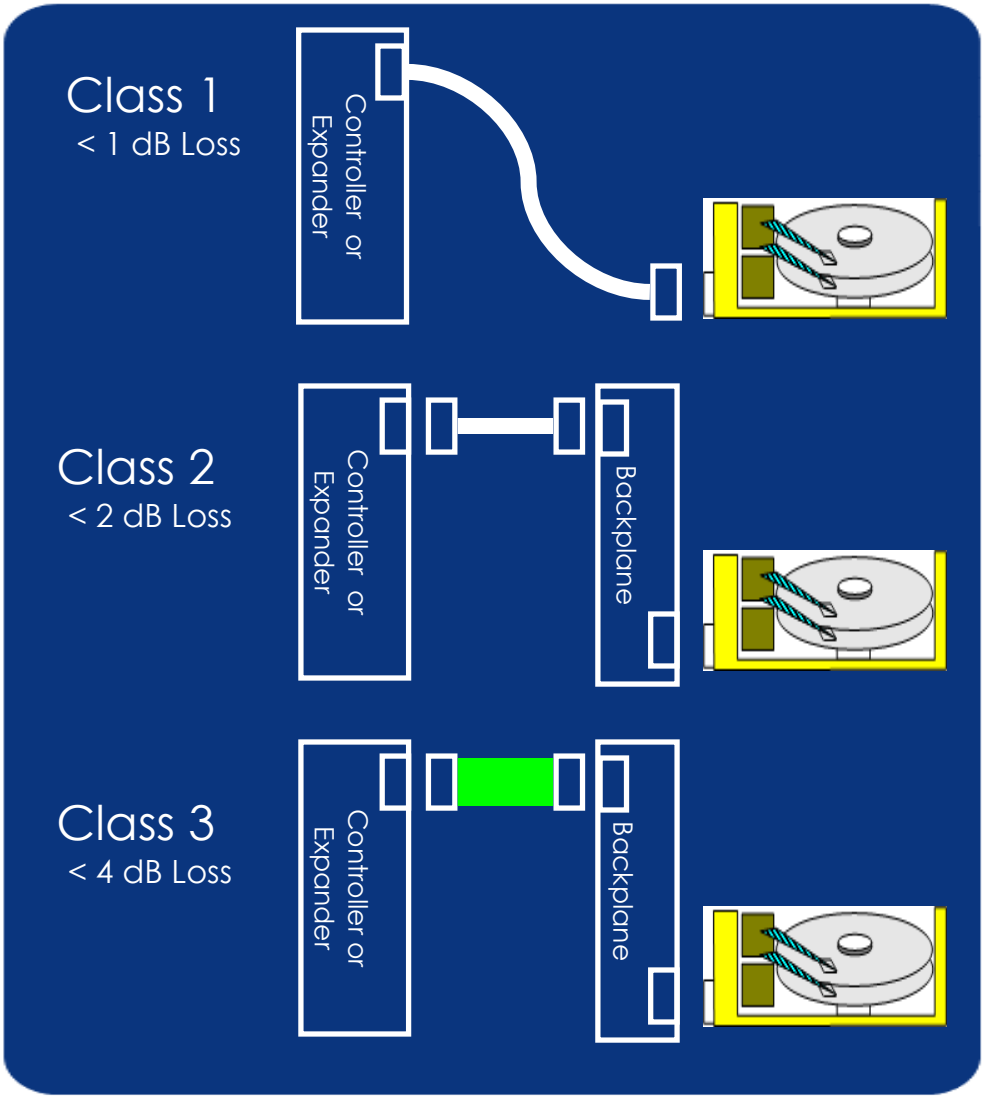

Figure 1: Link Classes

To implement the class concept both sides of the link must make modifications.

For initiators and expanders, this proposal requires a modification to the Identify Address Frame they originate. The change is to redefine a reserved field in byte 21 to support a Signal Class field in byte 21. The Identify Address Frame change is shown in Table 2. The system design engineer would use this field to indicate to the class of transport media after making the appropriate electrical characterizations.

Table 2: Identify Address Frame

Bit Byte	7	6	5	4	3	2	1	0
0	Restricted	Device Type			Address Frame Type (0h)			
1	Restricted							
2	Reserved				SSP Initiator Port	STP Initiator Port	SMP Initiator Port	Restricted
3	Reserved				SSP Target Port	STP Target Port	SMP Target Port	Restricted
4 - 11	Restricted							
12 - 19	SAS Address							
20	Phy Identifier							
21	Reserved				Signal Class			
22 - 27	Reserved							
28 - 31	CRC							

For target devices, this proposal requires that they recognize the modification to the Identify Address Frame they receive. The target device would adjust its transceiver characteristics to match the characteristics of the value specified in the Signal Class field. The target device must also have a means of reporting and optionally setting its transceiver characteristics through a Protocol-Specific Port Mode Page and a sub-page code of Signal Class to facilitate qualification efforts.

The transceiver characteristic reporting method is based on an application sending a MODE SELECT with the Protocol-Specific Port Mode Page and a sub-page code of Signal Class. The definition of the Signal Class sub-page and the resulting behavior is described below.

1 Initiator and Expander Role

The role of the initiator or expander in the Signal Class model is to provide a hint of the loss characteristics of the transport media to the target device. The goal of this hint is to allow the target to adjust its transceiver characteristics and improve the signal margin of the link with an opportunity to improve link error rates. There is an assumption that the target device communicates sufficiently through the transport media to complete the Phy Reset Sequence as described in the SAS specification. The initiator or expander provides the hint in the Signal Class field of the Identify Address Frame that it provides to the target as part of the Phy Reset Sequence. The Signal Class field is changeable. The class designation of 0 to 3 is determined during the qualification effort of a system or enclosure. The classification should be based on the signal characteristics of the transport media that will connect the initiator or expander to the target. It should not be based on the characteristics of the target.

The Signal Class settings are:

- Signal Class 0 will be the default setting, indicating that the initiator or expander is not aware of the transport media characteristics.
- Signal Class 1 indicates that the system designer expects a cable or low loss backplane without enclosure services to be used as the transport media.
- Signal Class 2 indicates that the system designer expects a “typical” backplane with enclosure services to be used as the transport media.
- Signal Class 3 indicates that the system designer expects a “lossy” backplane with enclosure services to be used as the transport media.

The Signal Class may be dependent on the link rate. For example an enclosure designed for 3 Gb/s with a class 2 designation may be a class 3 designation at 6 Gb/s.

1.1 Signal Class Setting and Qualification

Representative samples of each Signal Class transport media will be provided to target designers, as they become available during the qualification.

2 Target Role

The role of the target in the Signal Class model is to use the hint provided by the initiator or expander to adjust the targets transceiver characteristics. The target device should power up with Signal Class 0 characteristics. Following a successful Phy Reset Sequence, the target should inspect the Signal Class field of the Identify Address Frame and adjust its transceiver characteristics to match the class requested. The target is not expected to use the Signal Class mechanisms to compensate for the inability to complete a Phy Reset Sequences at a specific link rate. The target is not required to retain the signal class information across initiator or expander originated Phy Reset Sequences. To avoid link errors when adjusting the transceiver characteristics, a target may choose to originate a Phy Reset Sequence as part of the transceiver characteristic change. The transceiver characteristics should be retained across the target originated Phy Reset Sequence. The target should not retain the signal class information across Phy Hard Reset Sequences.

2.1 Relationship of the Signal Class sub-page to the Transceiver Control sub-page

The Protocol-Specific Port Mode Page – Signal Class Sub-Page and the Protocol-Specific Port Mode Page – Transceiver Control Sub-Page are related because they both impact the transceiver characteristics. The content of the Signal Class sub-page with the vendor unique values for class 0 to 3 should be considered as the primary source of the transceiver characteristics. The Transceiver Control sub-page should reference the active class values for any adjustment. The Transceiver Control sub-page should not alter the contents of the Signal Class sub-page.

For example, if the target is running in a Class 3 signal class at 3 Gb/s, the Transceiver Control sub-page defaults will be the values for Class 3 operation. Any adjustments through the Transceiver Control sub-page during operation should not affect the Class 3 values on the Signal Class sub-page. This behavior will minimize the opportunity to set improper values during Transceiver testing and prevent a target from initializing.

2.2 Signal Class Setting and Qualification

Prior to a target device entering qualification, the class characteristics for all signal classes should be set to a vendor specific value. During qualification, the necessary signal integrity testing will be performed to determine what the proper setting should be for Signal Class setting 1 to 3. The setting for Signal Class 0 should be a reasonable compromise to ensure the target device can communicate at a link rate of at least 1.5 Gb/s and can complete a Phy Reset Sequence at any supported link rate.

3 Protocol-Specific Port Mode Page - Signal Class Sub-Page (??h)

The Signal Class sub-page of the Protocol-Specific Port mode page is used to report and optionally adjust the signal class transceiver parameters of a phy. The Signal Class sub-page is not returned as part of a MODE SENSE request to return all pages it must specifically be requested. The Signal Class sub-page fields are described below.

Table 3: Signal Class Sub-Page (??h)

Bit / Byte	7	6	5	4	3	2	1	0
0	**PS**	**SPF (1b)**	**Page Code 19h**					
1	Sub-Page Code (??h)							
2-3	Page Length							
4-6	Reserved							
7	Number of Phys							
8	Number of Signal Classes							
9	Number of Link Rates							
10	Reserved							
11	Signal Class Characteristic Length							
12	Signal Class for Phy 0							
	…							
	Signal Class for Phy N (N = Number of Phys – 1)							

3.1 PS, Parameters Savable

The parameters savable field as defined in SPC-3, set to 0.

3.2 SPF

The SPF field shall be set to one to access the long format mode pages.

3.3 Page Code

The value in the Page Code field is a constant defining the Protocol-Specific Port Mode Page. Shall be set to 19h.

3.4 Page Length

The value in the Page Length field is a constant defining the length of the Signal Class Page excluding the Page Code byte. The value shall be established based on the following equation:

Page Length = (4 +
(Number of Phys * Number of Signal Classes *
Number of Link Rates * Signal Class Characteristic Length))

This value is not changeable.

3.5 Number of Phys

The value in the Number of Phys field is a constant defining the number of phys available on this device. The phys are numbered from 0 to N, where N is the value of this field minus one. This value is not changeable.

3.6 Number of Signal Classes

The value in the Number of Signal Classes field is a constant defining the number of signal classes supported by this device. In this proposal this value would be 4, to include reference classes 0 through 3. This value is not changeable.

3.7 Number of Link Rates

The value in the Number of Link Rates field is a constant defining the number of link rates supported on this device. In the first generation of SAS, this value would be 2. This value is not changeable.

3.8 Signal Class Characteristic Length

The value in the Signal Class Characteristic Length field is a constant defining the size of each Signal Class Characteristic field. This value is vendor specific. This value is not changeable.

3.9 Signal Class for Phy X

The value in the Signal Class for Phy X field defines the signal class parameters for each link rate defined. Some elements of the field are changeable, but not savable. See the definition in Table 4.

Table 4: Signal Class for Phy X

Bit / Byte	7	6	5	4	3	2	1	0
	Signal Class for Link Rate, 1.5 Gb/s							
	Signal Class for Link Rate, 3.0 Gb/s							
	…							
	Signal Class for Link Rate, N Gb/s							

3.9.1 Signal Class for Link Rate, X

The value in the Signal Class for Link Rate X field defines the signal characteristics for each signal class. The elements of the field are changeable, but not savable. See the definition in Table 5.

Table 5: Signal Class for Link Rate X

Bit / Byte	7	6	5	4	3	2	1	0
	Signal Characteristics for Class, 1							
	Signal Characteristics for Class, 2							
	…							
	Signal Characteristics for Class, N							

3.9.2 Signal Characteristics for Class, X

The value in the Signal Characteristics for Class X field defines the vendor unique parameters for each signal class. The size of this field and its contents are vendor unique. The elements of this field are changeable, but not savable.