To: T10 Technical Committee
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Subject: 06-463r2 SAS-2 OOB transmission requirements

Related document
sas2r06 - Serial Attached SCSI - 2 (SAS-2) revision 6

Overview
When Serial Attached SCSI was first implemented, some disk drives could not transmit OOB signals at 1,5 Gbps if the other port had already negotiated a speed of 3,0 Gbps. The OOB specification was written to allow this situation and extended the concept to future generations such that the ALIGN (0) primitive used for the OOB signal may be transmitted at the lowest supported transmission rate. Increasing the allowed OOB signal frequency, especially beyond G2, increasingly complicates the OOB detection circuitry requirements.

SATA allows the transmission of D24.3 characters at 1,5 Gbps as an alternative to the ALIGN primitive at 1,5 Gbps during OOB. The D24.3 pattern provides better signal frequency content for detection and can be generated rather easily by higher-speed transmitter by simply doubling bits as required to match the timing of the repeating 1100 pattern at 1,5 Gbps.

This proposal changes SAS-2 OOB transmission requirements to restrict it to a G1 rate (1,5 Gbps) and to allow the D24.3 character pattern as an alternative to ALIGN (0) for easier implementation of both the transmitter device and OOB detection circuitry as the lowest supported rate increases in future generations. The requirement for the receiver to detect the OOB signal of ALIGN (0)’s at G2 rates (3 Gbps) is specifically included for backwards compatibility with SAS-1.1.

Suggested changes:

5.3.7.1 Receiver device characteristics overview

(Table 57: Delete the present note f and replace with note g. Change reference to note g with a reference to note f.)

Table 57 — Delivered signal characteristics as measured with the zero length test load at receiver device compliance points IR and CR (part 2 of 2)

Signal characteristic	Units	IR		CR	
		1,5 Gbps	3 Gbps	1,5 Gbps	3 Gbps
Jitter tolerance (see figure 114 in 5.3.5.4) [a]	N/A	See table 59 in 5.3.7.4			
Half of maximum jitter (i.e., X1 in figure 113) [b]	UI	0,275			
Center of bit time (i.e., X2 in figure 113)	UI	0,50			
Maximum intra-pair skew [c]	ps	80	75	80	75
Maximum voltage (non-operational)	mV(P-P)	2 000			
Minimum OOB burst amplitude [d], if SATA is not supported	mV(P-P)	240 [f]			
Minimum OOB burst amplitude [d], if SATA is supported	mV(P-P)	225 [g]		N/A	

[a] The value for X1 applies at a total jitter probability of 10^{-12}. At this level of probability direct visual comparison between the mask and actual signals is not a valid method for determining compliance with the jitter requirements.

[b] The value for X1 shall be half the value given for TJ in table 58. The test or analysis shall include the effects of a single pole high-pass frequency-weighting function that progressively attenuates jitter at 20 dB/decade below a frequency of ((bit rate) / 1 667).

[c] The intra-pair skew measurement shall be made at the midpoint of the transition with a repeating 0101b pattern (see table 201 in 10.2.9.1) on the physical link. The same stable trigger, coherent to the data stream, shall be used for both the Rx+ and Rx- signals. Intra-pair skew is defined as the time difference between the means of the midpoint crossing times of the Rx+ signal and the Rx- signal at the probe points.

[d] With a measurement bandwidth of 1,5 times the highest supported baud rate (e.g., 4,5 GHz for 3 Gbps), to be detected as an OOB burst, each signal level during the OOB burst shall exceed the specified minimum differential amplitude before transitioning to the opposite bit value or before termination of the OOB burst.

[e] Amplitude measurement methodologies of SATA and this standard differ. Under conditions of maximum rise/fall time and jitter, eye diagram methodologies used in this standard may indicate less signal amplitude than the technique specified by SATAII-PHY. Implementors of designs supporting attachment to SATA devices are required to ensure interoperability and should perform additional system characterization with an eye diagram methodology using SATA devices.

[f] The OOB burst is comprised of either 1,5 Gbps ALIGN (0) primitives or 3 Gbps ALIGN (0) primitives (see 6.6).

[g] The OOB burst is comprised of either 1,5 Gbps D24.3 characters, 1,5 Gbps ALIGN (0) primitives, or 3 Gbps ALIGN 0) primitives (see 6.6 and SATAII-PHY).

6.6.2 Transmitting OOB signals

To transmit an OOB signal, the transmitter device shall repeat these steps six times:

1) transmit D.C. idle for an idle time; and
2) transmit an OOB burst consisting of D24.3 characters with either starting disparity or ALIGN (0) primitives for a burst time.

The transmitter device shall then transmit D.C. idle for an OOB signal negation time.

The transmitter device shall use signal output levels during burst time and idle time as described in 5.3.6.5.

The D24.3 characters or ALIGN (0) primitives used in OOB signals ~~should~~ shall be transmitted at 1,5 Gbps (e.g., the ~~generation 1 (~~G1~~)~~ physical link rate ~~(i.e., 1,5 Gbps~~). The OOB signals ~~ALIGN (0) primitives~~ are only required to generate an envelope for the detection circuitry, as required for any signaling that may be A.C. coupled. ~~If G2 ALIGN (0) primitives are used, the number of ALIGN (0) primitives doubles compared with G1 ALIGN (0) primitives.~~ A burst of D24.3 characters at 1,5 Gbps is equivalent to a square wave pattern that has a one (see 6.3.3) for 2 OOBI and a zero (see 6.3.3) for 2 OOBI. A transmitter may use this square wave pattern for the OOB signal. The start of the pattern may be one or zero. The signal rise and fall times:

a) may be greater than or equal to the minimum rise and fall times allowed by the fastest supported rate of the transmitter device; and
b) shall be less than or equal to the maximum rise and fall times allowed by the G1 physical link rate (see Table 64).

~~When transmitting an OOB burst, if the phy supports SATA, the transmitter device shall transmit ALIGN (0) primitives at G1. If the phy does not support SATA, the transmitter device:~~

~~a) should transmit ALIGN (0) primitives at G1;~~
~~b) may transmit ALIGN (0) primitives at its lowest supported physical link rate if it is not able to transmit at G1; and~~
~~c) shall not transmit ALIGN (0) primitives at a physical link rate faster than its lowest supported physical link rate.~~

6.6.3 Receiving OOB signals

~~A SAS receiver device shall detect OOB bursts comprised of ALIGN (0) primitives transmitted at any rate up to its highest supported physical link rate. This includes physical link rates below its lowest supported physical link rate (e.g., a SAS receiver device supporting only 3 Gbps detects 1,5 Gbps based ALIGN (0) primitives, providing interoperability with a SAS transmitter device supporting both 1,5 Gbps and 3 Gbps).~~

A SAS receiver device shall detect OOB bursts comprised of any of the following:

a) D24.3 characters at 1,5 Gbps;
b) ALIGN (0) primitives at 1,5 Gbps; or
c) ALIGN (0) primitives at 3 Gbps.

NOTE: ALIGN (0) primitives at 3 Gbps provides interoperability with transmitters compliant with previous versions of this standard.

~~NOTE 21 - SAS transmitter devices compliant with future versions of this standard may not support transmitting OOB signals using the G1 physical link rate.~~

~~A SAS receiver device that supports SATA shall also detect OOB bursts comprised of D24.3 characters transmitted at 1,5 Gbps (see SATAII-PHY).~~

~~A SAS receiver device shall not check the characters used to form the OOB burst; only the frequency content of the burst matters.~~

A SAS receiver device shall not qualify the OOB burst based on the characters received.