To: T10 Technical Committee  
From: Barry Olawsky, HP (barry.olawsky@hp.com)  
Date: 13 January 2005  
Subject: T10/05-025r1 SFF8470 Crosstalk Study

Revision History
Revision 0 (5 January 2005) First revision  
Revision 1 (13 January 2005) Second revision – Further clarify the problem and solution.

Related Documents
sas1r07 - Serial Attached SCSI 1.1 revision 7  
T10/05-007r0 - SAS-1.1 External Cable Electrical Specification

Overview
Provide technical data (electrical) to evaluate the feasibility of proposal 05-007r0. Specifically, demonstrate crosstalk summation and provide analysis to support necessary changes.

Reference Information
Included below
SSF8470 Crosstalk Study

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January, 2005
Topics

- Demonstrate multi-lane SFF8470 near-end crosstalk is additive
- Review crosstalk spec in proposal 05-007r0
- Effects of crosstalk with spectral content above fundamental
- Proposed levels
Multi-Aggressor Crosstalk Assertion

• Near-end inductively coupled crosstalk is additive. At a frequency of interest, crosstalk magnitude at the victim is a summation of the amplitude due to each aggressor. The phase offset of the two aggressors, observed at the victim, is a parameter in the summation.
Near-End Crosstalk Model
Multi-Aggressor Near-End Crosstalk Model

\[ \text{Aggressor} \#1 \text{ Launch} \quad L_M \quad L_M \quad L_M \quad L_M \quad \text{Termination} \]

\[ \text{Victim} \quad L_M \quad L_M \quad L_M \quad L_M \quad \text{Termination} \]

\[ \text{Aggressor} \#2 \text{ Launch} \quad L_M \quad L_M \quad L_M \quad L_M \quad \text{Termination} \]
Differential NEXT Test Fixture Setup

D3186
clkin
Dout(+/-)
clkout

Adapter

Adapter

SFF8470 Crosstalk Test Fixture

SCOPE

Internal Clock Source

BERT with Adjustable Trombone Delay

Lossy Cable (Length selected to establish edge rate)

D10.2 used. BERT varies phase offset between aggressors.
NEXT at Victim
(Aggressor edge rare of 120ps), UI: 333ps

Aggressor 1: 26mV
Aggressor 2: 22mV
In-phase Summation: 42mV
NEXT at Victim
(Aggressor edge rare of 60ps), UI: 167ps

Aggressor 1: 44mV
Aggressor 2: 45mV
In-phase Summation: 88mV
Multi-Aggressor Crosstalk Amplitude vs. Aggressor Pair Skew, UI: 333ps, ER: 120ps
Multi-Aggressor Crosstalk Amplitude vs. Aggressor Pair Skew, UI: 167ps, ER: 60ps
Summary of Test Results

- Screen captures show additive property of multi-aggressor NEXT using D10.2 pattern at the above documented edge and data rates.
- Amplitude variation with respect to aggressor skew is further evidence of additive property.
Review of 05-007r0

- Proposal specifies NEXT of -30dB (3.2%) for single pair from 10 to 4500MHz.
- Combining crosstalk from different pairs could yield value that is much larger than 5%.
- Previous sample measurements have demonstrated NEXT amplitudes in excess of 3.2% above 2GHz for most samples tested.
Proposed Changes to 05-007r0

- Consider reducing allowable crosstalk at fundamental such that multi-aggressor sum is less than or near 5%
- Crosstalk isolation required above the fundamental may possibly be reduced. Crosstalk of energy at harmonics must be appropriately accounted for in crosstalk budgeting.
Spectral Content and Edge Rate

- For 3Gbit signaling, all spectral components above 1.5GHz are harmonics.
- Both pattern type and edge rate affect the spectral content.
- Can crosstalk isolation be reduced at some point above 1.5GHz? Consider 2.25GHz.
D10.2 Spectral Content vs. Edge Rate

0ps
67ps
137ps
K28.5+/K28.5- Spectral Content vs. Edge Rate

0ps
67ps
137ps
Spectral Content Summary

• Reduction in harmonic amplitude at 4.5GHz less than 6dB. However, reduction at slowest edge rate is dramatic!
• Variation in reduction based on pattern type
• 2.25GHz appears to be feasible point for shift in crosstalk isolation spec
Sample Adjacent Pair Crosstalk Plots

MHz

dB

0.00
-10.00
-20.00
-30.00
-40.00
-50.00
-60.00

0 750 1500 2250 3000 3750 4500 5250 6000

Typical
Best
Worst
Proposed Changes Below 2.25GHz

- Proposal based on samples from several industry suppliers
- 30dB isolation for pairs offset by 1 position (adjacent)
- 36dB isolation for pairs offset by 2 positions
- 40dB isolation for all other pairs
Proposed Changes From 2.25 to 4.5GHz

- Shift spec by 6dB for offsets of 1 and 2 positions
- 24dB isolation for pairs offset by 1 position (adjacent)
- 30dB isolation for pairs offset by 2 positions
- 40dB isolation for all other pairs
Summary

• Industry suppliers have difficulty meeting 30dB (10 .. 4500MHz) isolation spec
• At fundamental, 30dB isolation is insufficient
• Proposal attempts to offer a compromise of those two conflicting objectives