To: T10 Technical Committee
From: Barry Olawsky, HP (barry.olawsky@hp.com)
Date: 7 March 2005
Subject: T10/04-079r2 SAS-1.1 Minimum XR/IR Receiver Signal Level for 3Gb SATA Mode

Revision History
Revision 0 (22 February 2005) first revision
Revision 1 (23 February 2005) add suggested number to replace TBDs
Revision 2 (7 March 2005) provided data supporting lower loss TCTF model and SATA "X" levels

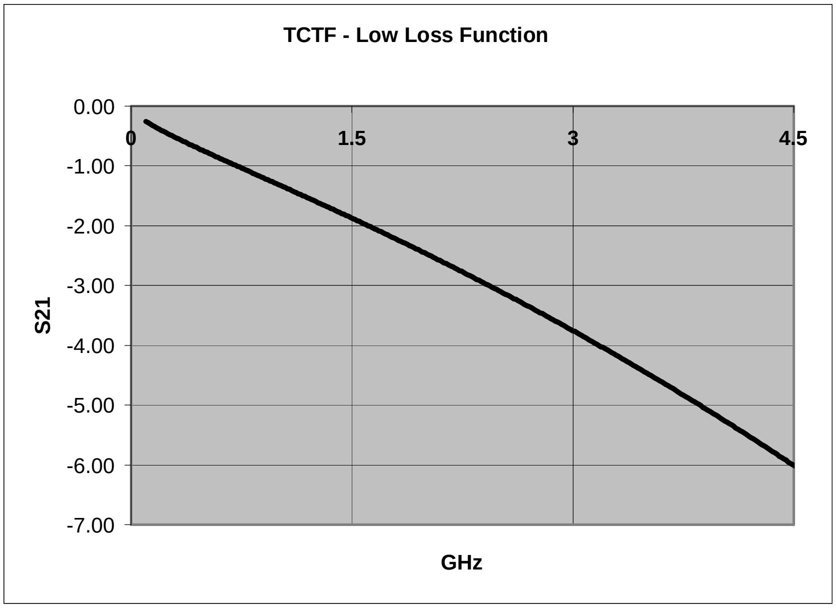
Related Documents
sas1r05 - Serial Attached SCSI 1.1 revision 5
03-240r1 - SAS-1.1 Merge IT and IR with XT and XR (Rob Elliott, Hewlett Packard)

Overview
Determine expander/initiator receiver threshold requirements when using SATA II compliant 3Gb devices. If proposed receiver specifications are not feasible, define a lower loss TCTF for use with SATA devices.

Proposed Changes
Modify the minimum XR/IR receiver signal level specified for 3Gb SATA mode. Change TBD ~~SATA 3Gb column to 125mV in tables 33 and 35.~~ entry in the "Receiver device signal tolerance characteristics" table to allow three implementation options:

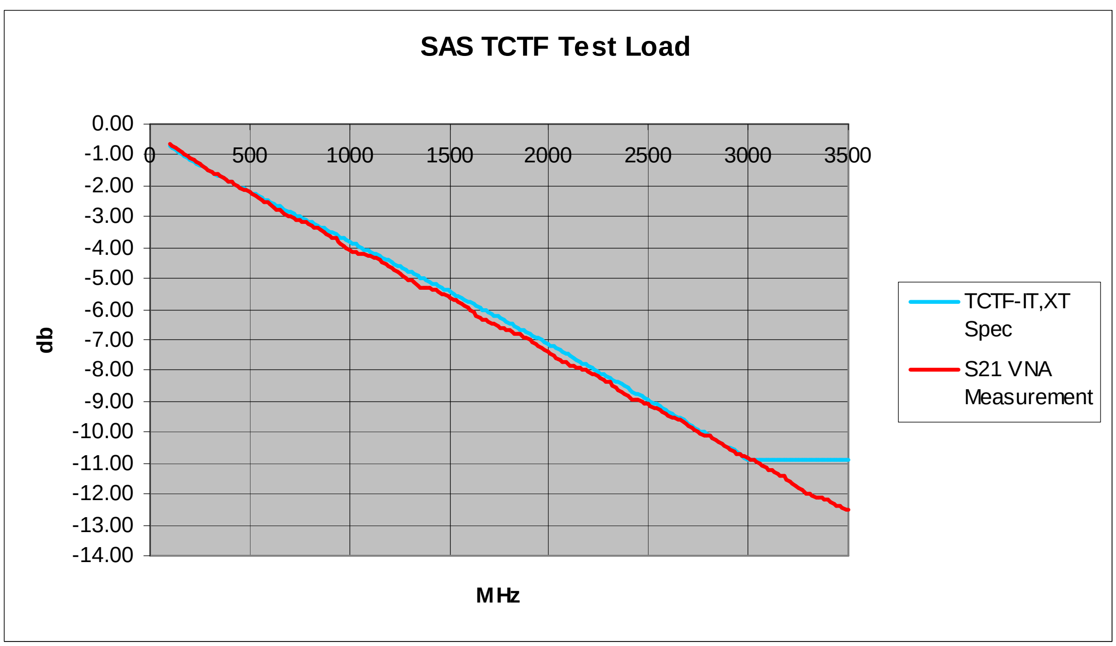
1) When attached to a SATA drive complying with gen2i transmit signaling levels through an interconnect with less insertion loss than the TCTF - LOW LOSS function (as described below) the SAS receiver "minimum eye opening" specification shall be 275mV.
2) When attached to a SATA drive complying with gen2i transmit signaling levels through an interconnect with more insertion loss than the TCTF – LOW LOSS function and less insertion loss than the TCTF-IT function the SAS receiver "minimum eye opening" specification shall be 125mV.
3) When attached to a SATA drive complying with the gen2x transmit signaling levels the SAS receiver "minimum eye opening" spec shall be 275mV.

Add a subsection to "media specifications" defining the insertion loss characteristics of the low loss TCTF. The subsection shall include an insertion loss equation and graph that applies to 3Gb SATA gen2i transmitter devices ONLY. The below equation is obtained by scaling the 3Gb TCTF-IT equation such that 6dB insertion loss is obtained at 4.5GHz. The proposed graph is:



Supporting Information Only (NOT part of SAS-1.1 proposal):

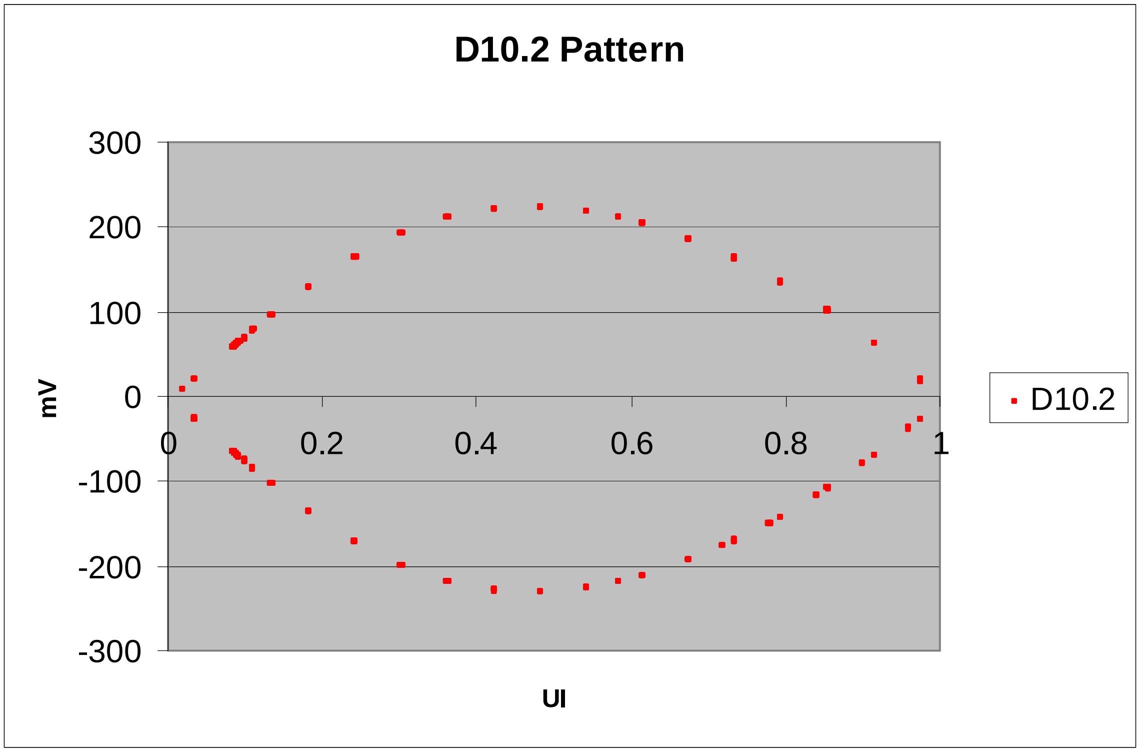
To evaluate the existing SATA mode receive output level specification, a TCTF test load for IT/XT was constructed. A network analyzer was then used to measure the insertion loss and return loss of the TCTF test load as shown below.



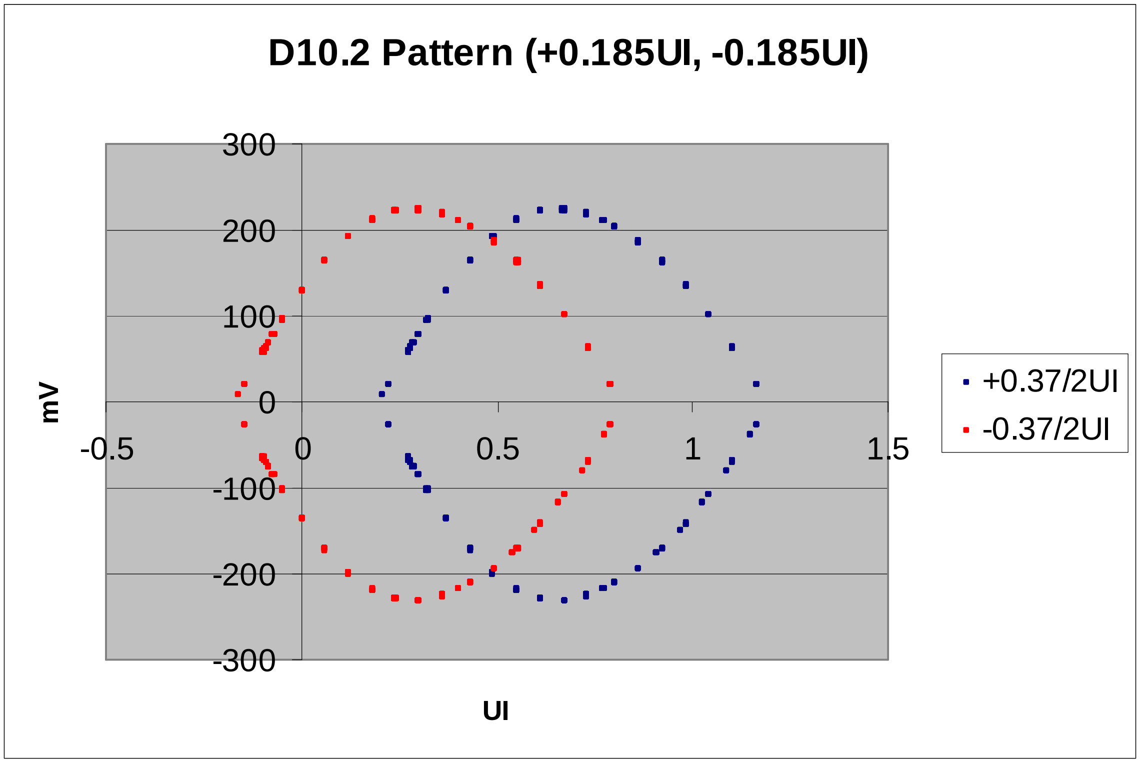
Touchtone files were obtained from the VNA and used in HSpice simulations for the following eye diagrams.

Simulation Results

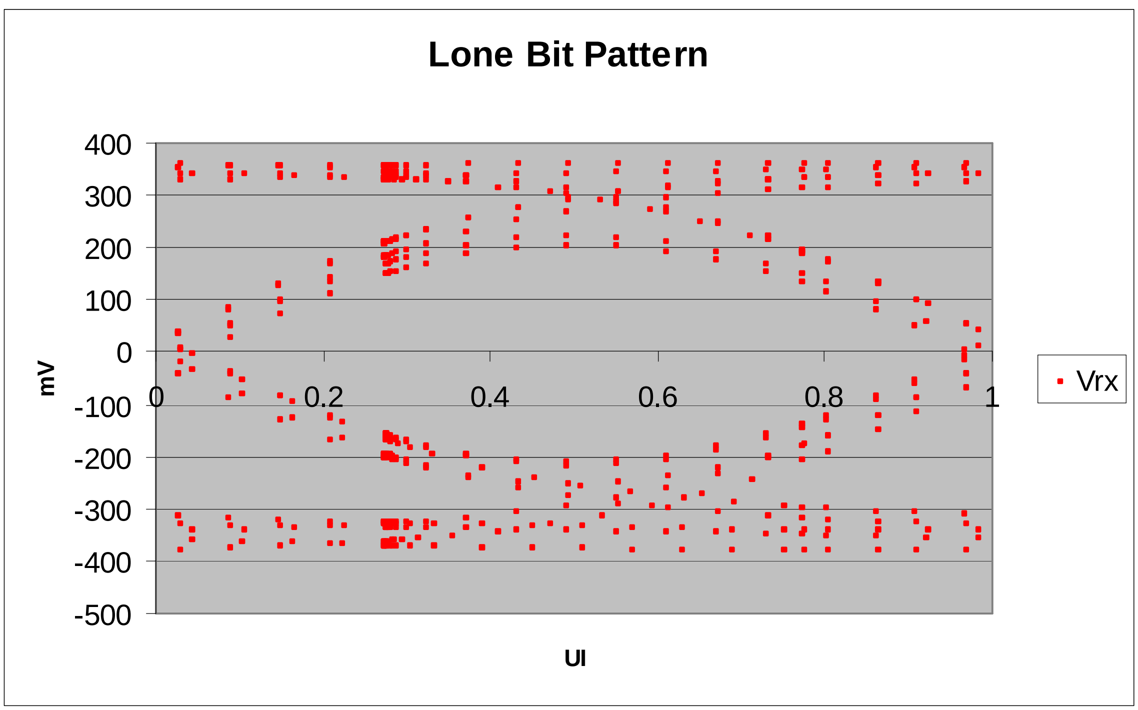
Simulation results of D10.2, K28.5 and the lone-bit patterns are included below. The transmitter amplitude is set to 400mVpp. Rise/fall time of the transmitter is 136ps.



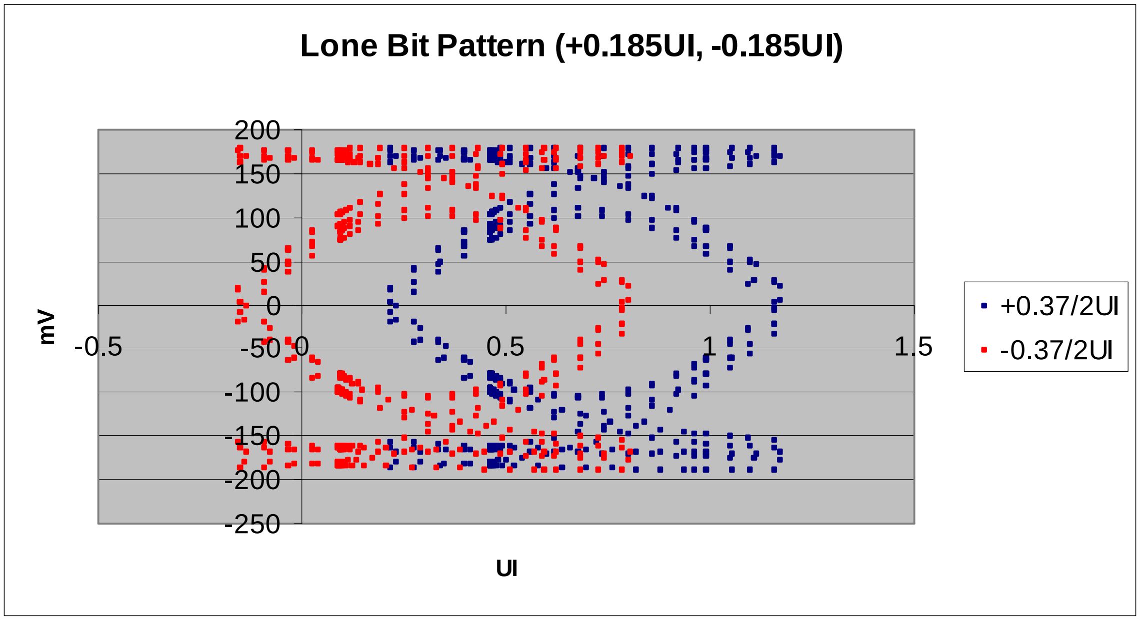
D10.2 amplitude with no transmitter jitter: 227mV



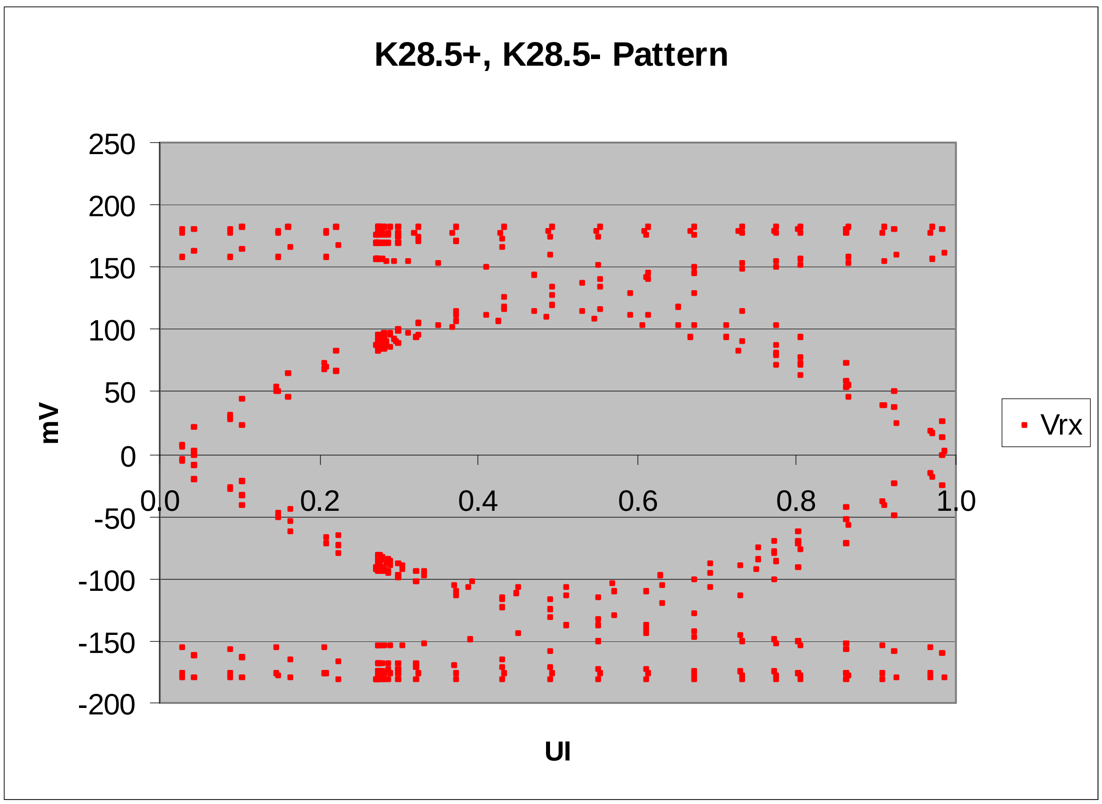
D10.2 amplitude with 0.37UI transmitter jitter: 190mv



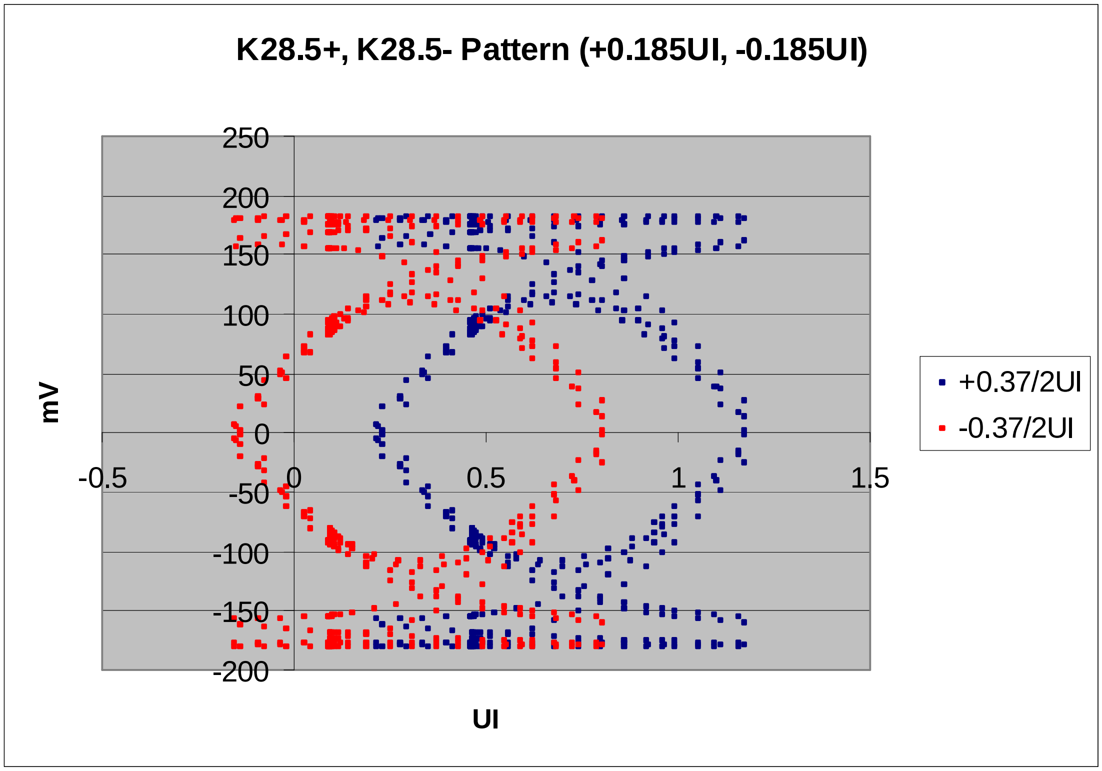
Lone-bit pattern amplitude with no transmitter jitter: 206mV



Lone-bit pattern amplitude with 0.37UI transmitter jitter: 173mV



K28.5 pattern amplitude with no transmitter jitter: 215mV



K28.5 pattern amplitude with 0.37UI transmitter jitter: 179mV

Initial Conclusions:

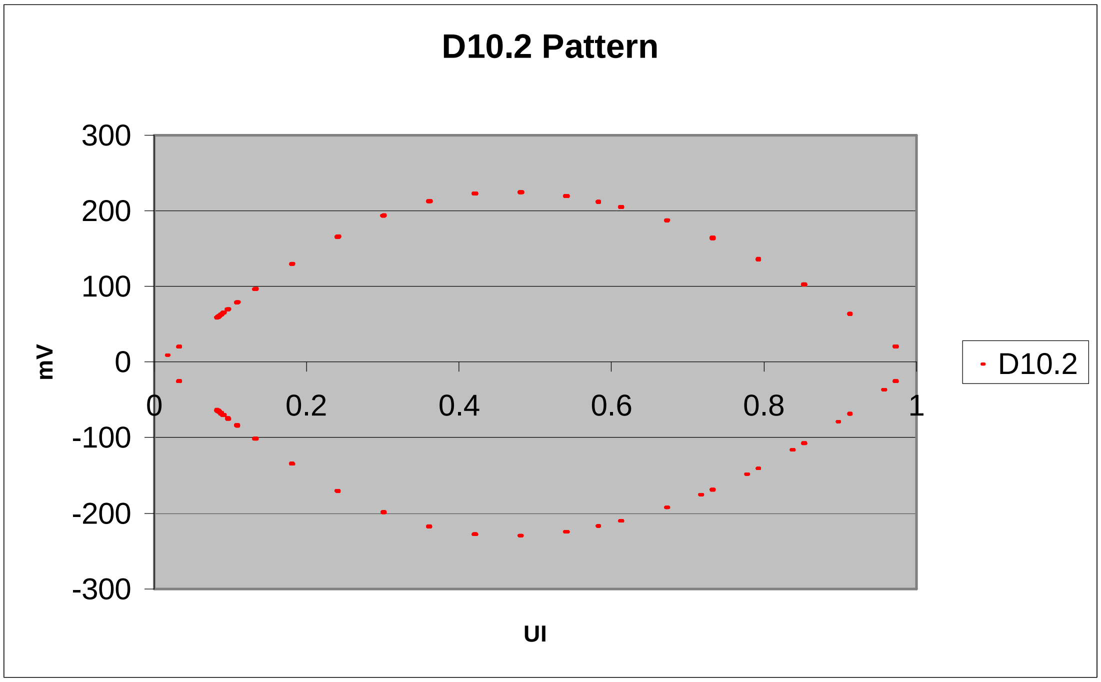
Based on the above data, a receiver would be required to operate correctly with a signal level below 173mV. A value of 150mV would provide a small margin but a value of 125mV would be a more conservative estimate. Are these values feasible with existing receiver technologies?

The below supporting information was added during the revision 2 edit:

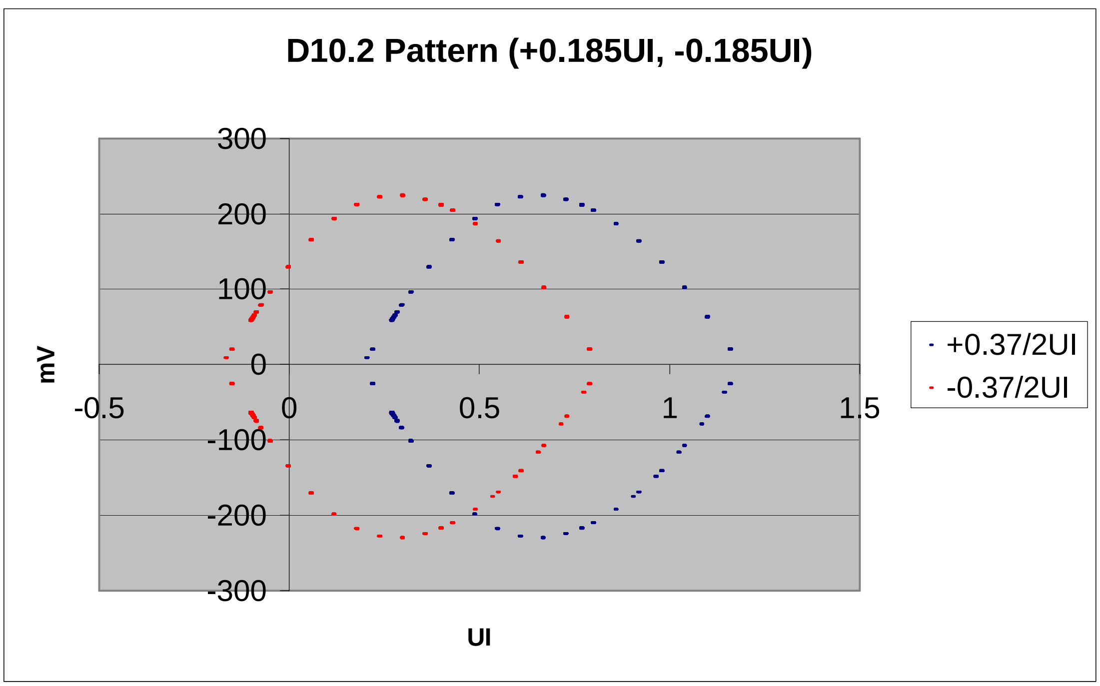
Two additional approaches can be considered. If a 3Gb SATA drive is available that can drive Gen2-x levels, the signal amplitude may be adequate for a TCTF-IT/XT loss environment. Also, the insertion loss of some applications is far less than the TCTF-IT/XT. For that case, a SATA drive with Gen2-i levels may be a suitable choice. Both options are elaborated below.

SATA Gen2-X Signal Levels

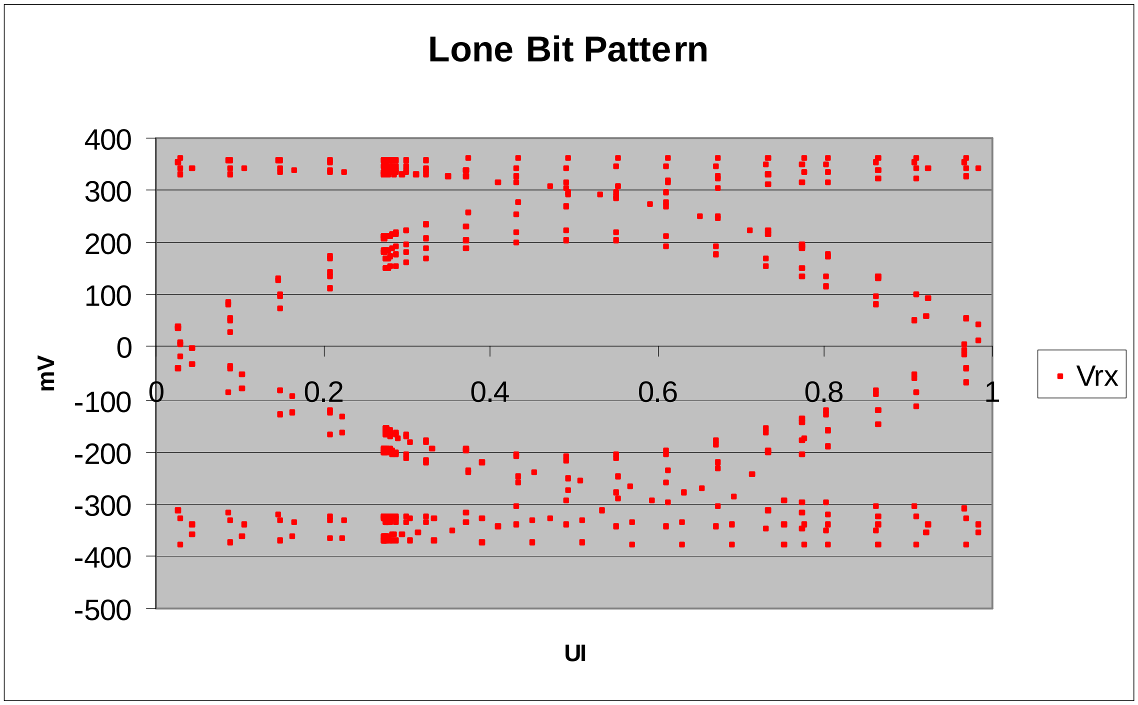
Using SATA Gen2-x signaling levels (800mVpp differential) and the TCTF-IT/XT insertion loss model shown at the beginning of this document, the previous simulations are repeated with a higher transmitter output level. Rise/fall time of the transmitter is 136ps.



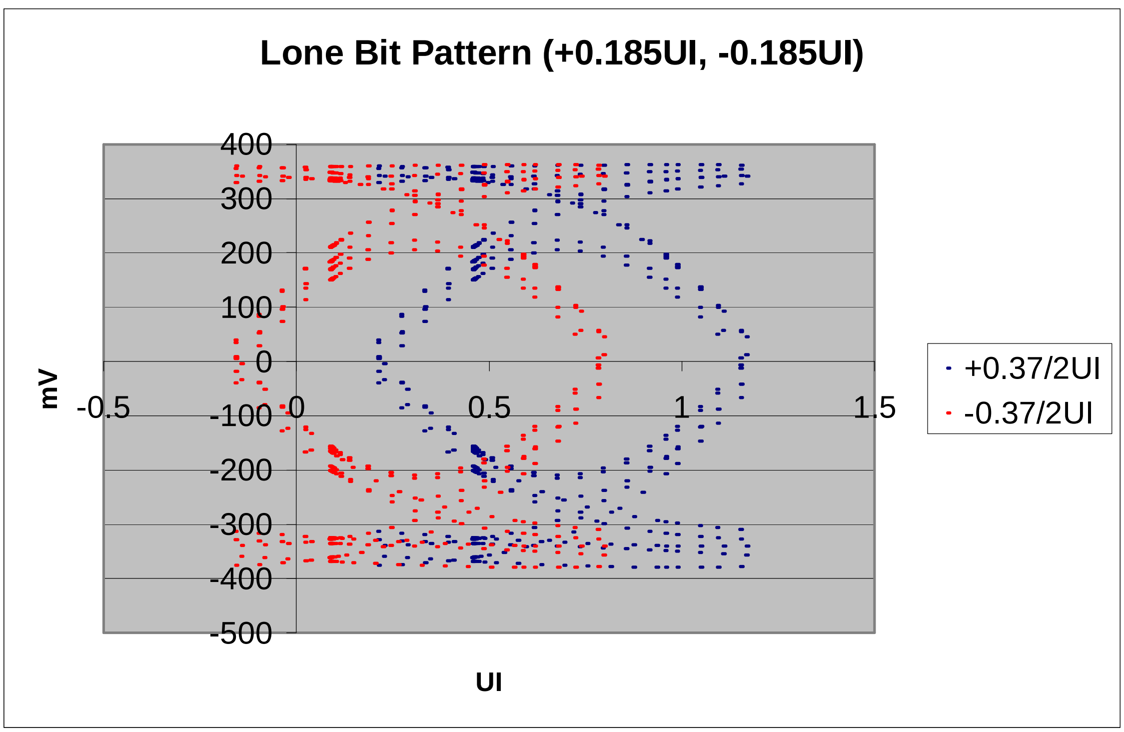
D10.2 amplitude with no transmitter jitter: 454mV



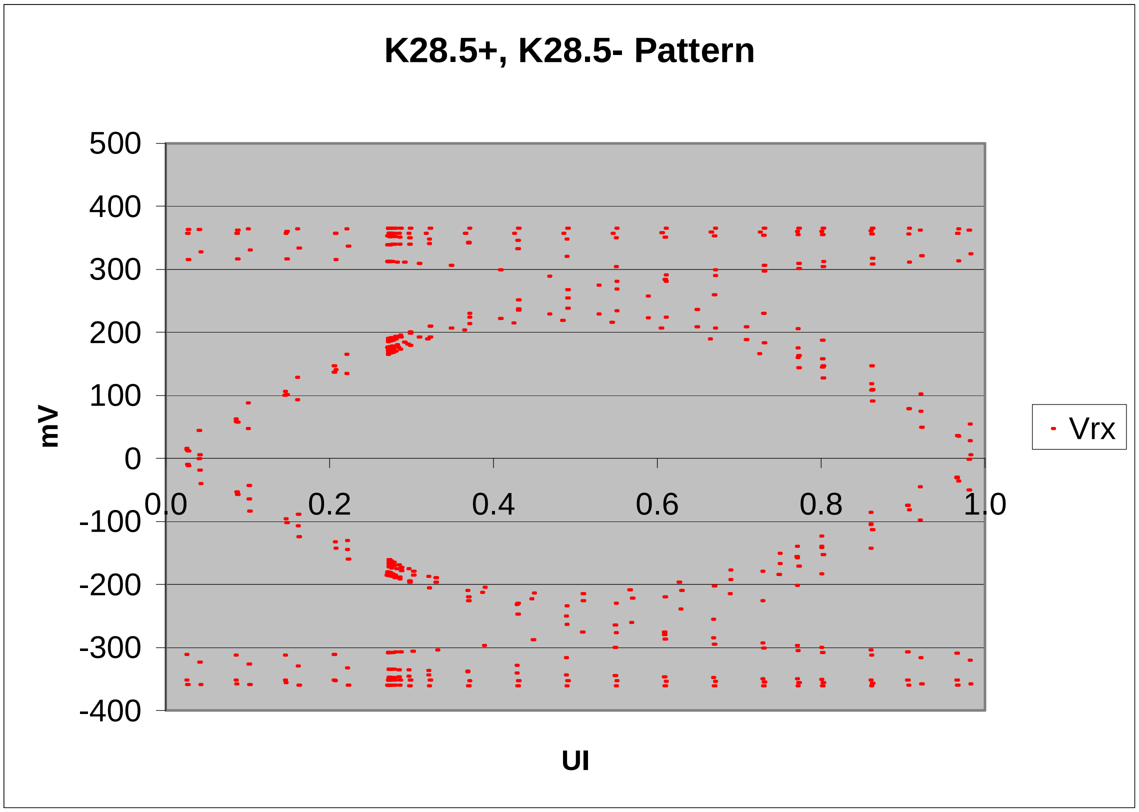
D10.2 amplitude with 0.37UI transmitter jitter: 380mv



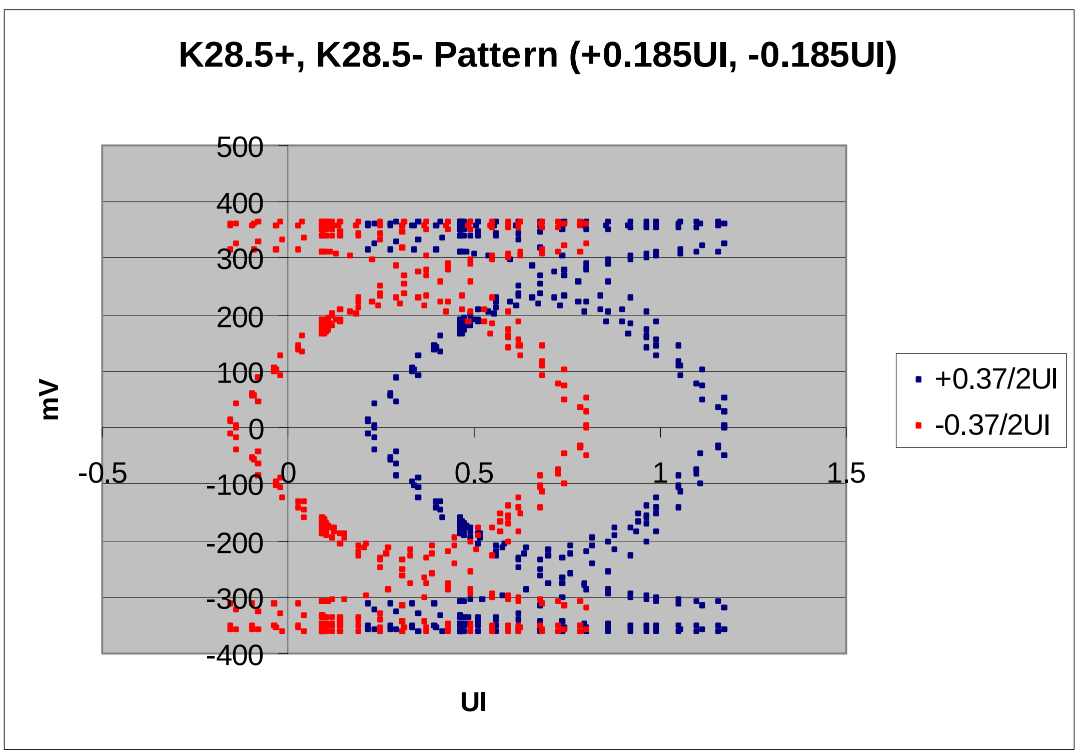
Lone-bit pattern amplitude with no transmitter jitter: 412mV



Lone-bit pattern amplitude with 0.37UI transmitter jitter: 346mV



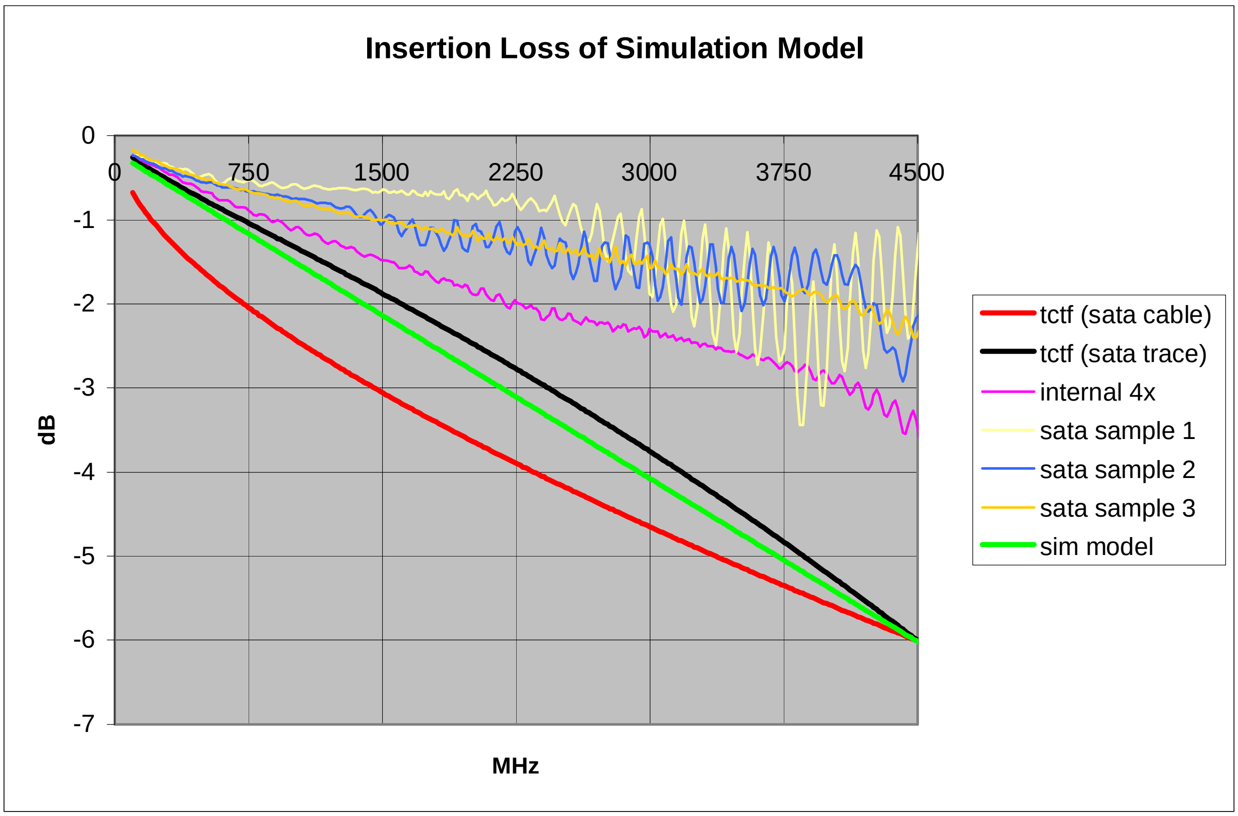
K28.5 pattern amplitude with no transmitter jitter: 430mV



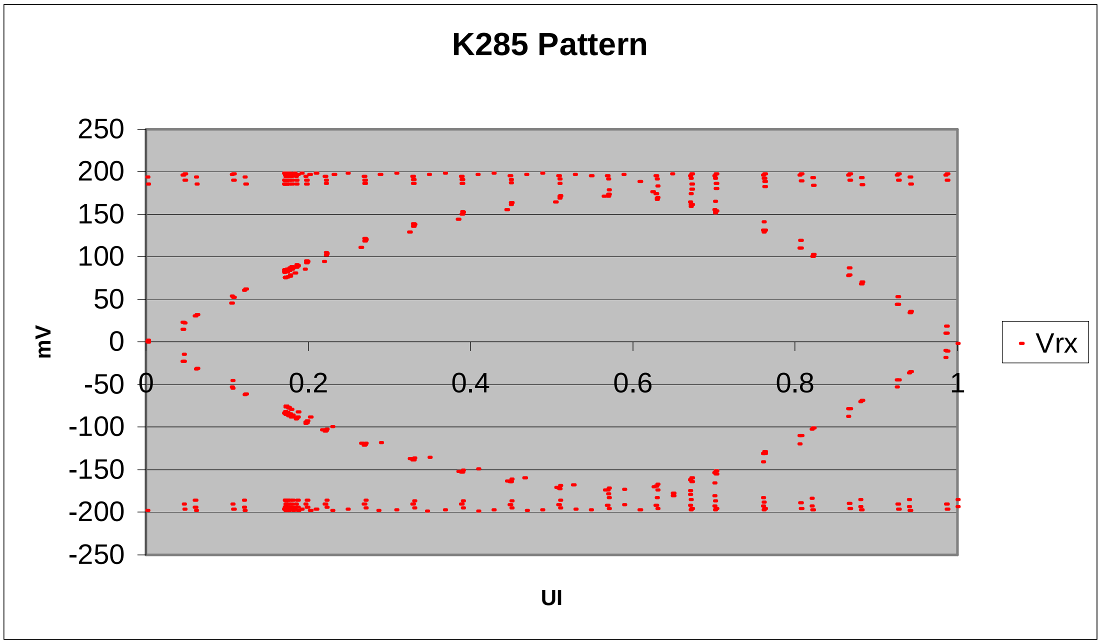
K28.5 pattern amplitude with 0.37UI transmitter jitter: 358mV

Low Insertion Loss Interconnect

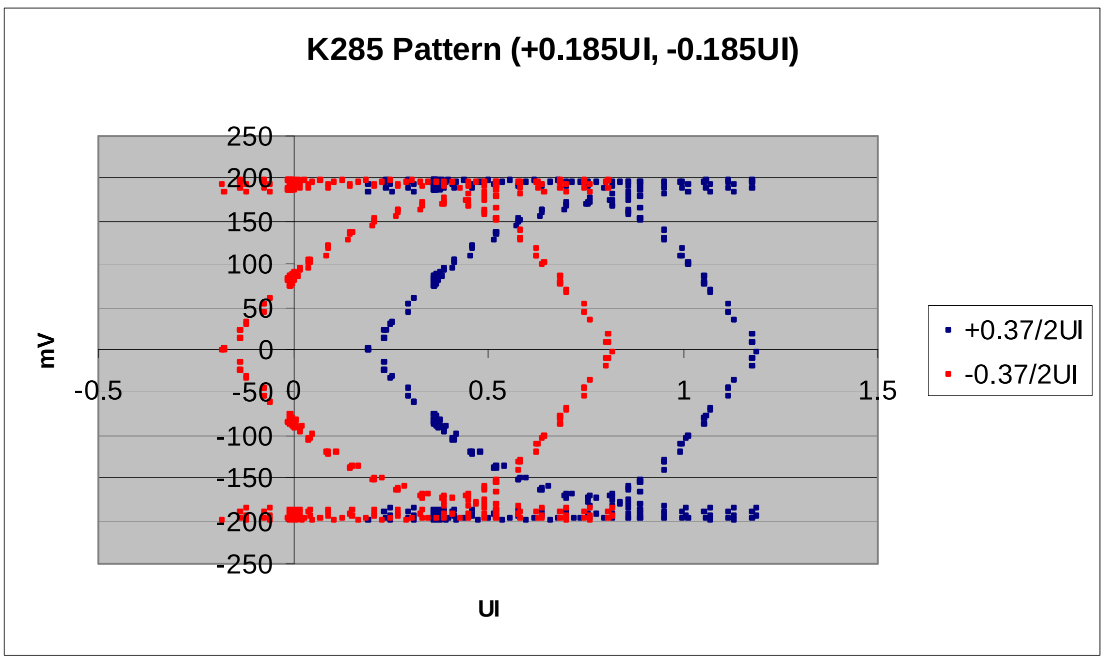
Using the Serial ATA specification as a guide, can we obtain a TCTF model of the 1 meter cable? The specification calls out a maximum insertion loss of 6dB up to 4.5GHz. However, 1 meter of 26AWG twinax has far less insertion loss. The remainder of the loss budget is reserved for the two connector interfaces … not just for attenuation but for the resonances that are created by less than perfect impedance control. A first attempt at a low loss compliance channel would be to scale TCTF-CTA and TCTF-IT/XT. Also pictured below are insertion loss plots of various SATA cables.



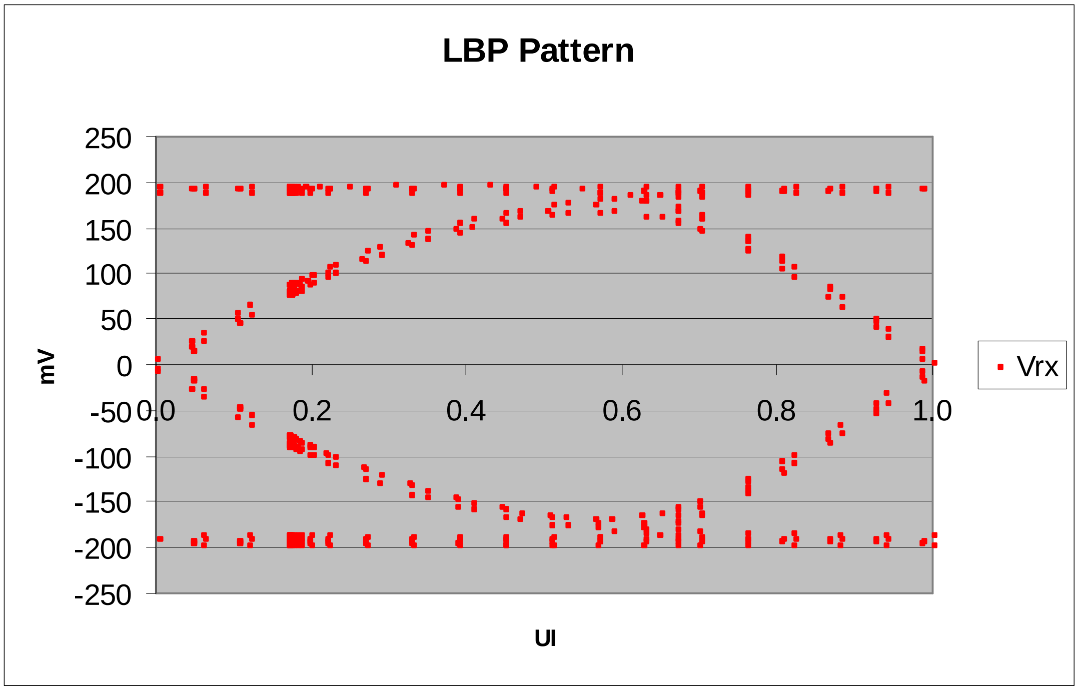
The insertion loss of the cable mode is significantly higher at the fundamental of 1.5GHz. Additional simulations were performed using a loss profile as specified above.



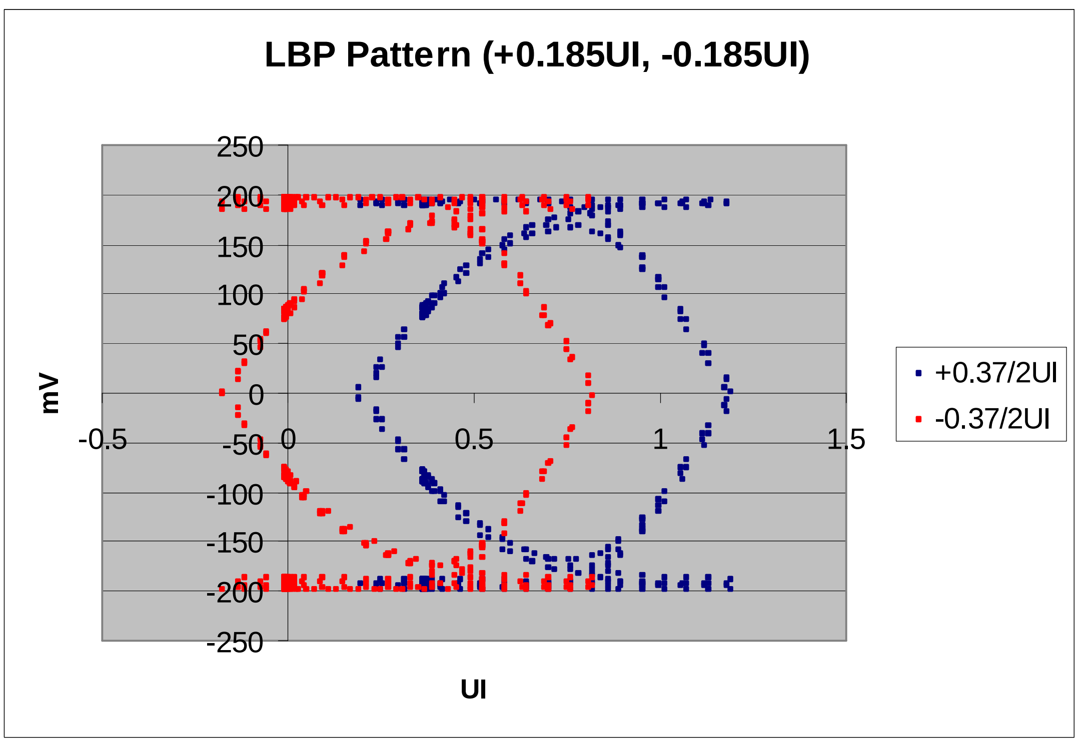
K28.5 pattern amplitude with no transmitter jitter: 332mV



K28.5 pattern amplitude with 0.37UI transmitter jitter: 258mV



Lone-bit pattern amplitude with no transmitter jitter: 337mV



Lone-bit pattern amplitude with 0.37UI transmitter jitter: 276mV

Conclusions:

Since few SATA within SAS applications will be direct cabled, the trace model may be more appropriate. Also, the K28.5 simulation with jitter does violate the minimum eye opening. A model with less insertion loss is necessary.