

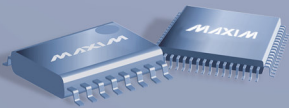


Reference Receiver Solutions for SAS-2 Compliance Testing

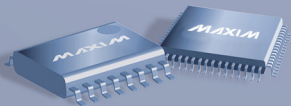
08-330r4

Kevin Witt

10-14-08



- **SAS-2 specification compliance test are based on an eye opening after a reference DFE receiver**
 - “StatEye or Equivalent” processing
- **The SAS-2 user community needs a reference receiver software solution based on captured waveform data**
 - **Tx Compliance**
 - Table 61 Ref Rx output (required 84mV x 0.5UI)
 - **Stressed Rx Compliance ISI generator Calibration**
 - Table 72 (required LDP 13dB)
- **Goal**
 - Investigate if these compliance test can be based on SASWDP 08-345v0
- **Proposal**
 - Provides processed synthesized and measured waveforms
 - Dry run the compliance test with test equipment
 - Proposed changes for Spec
 - Suggestions for enhancements of SASWDP code



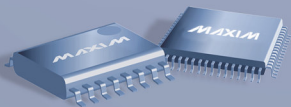
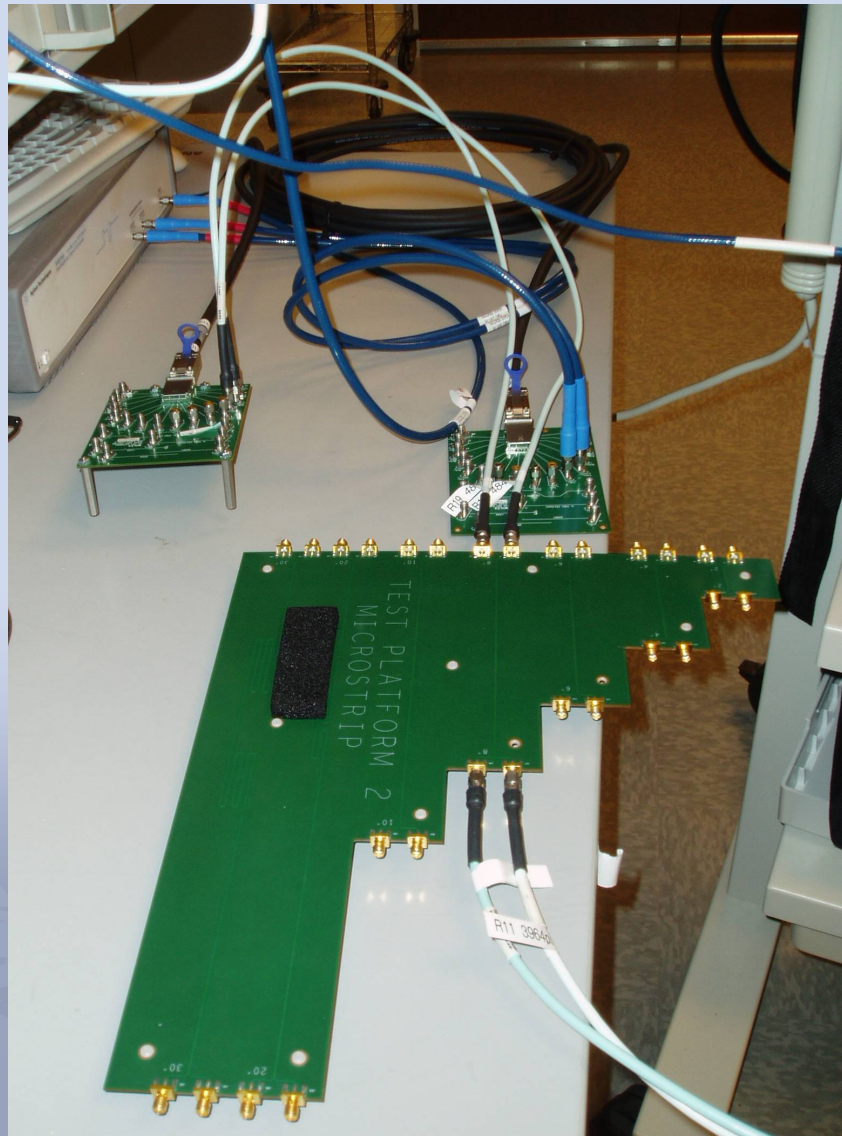


Test Channel

De-Emphasis
Generator

10m MiniSAS

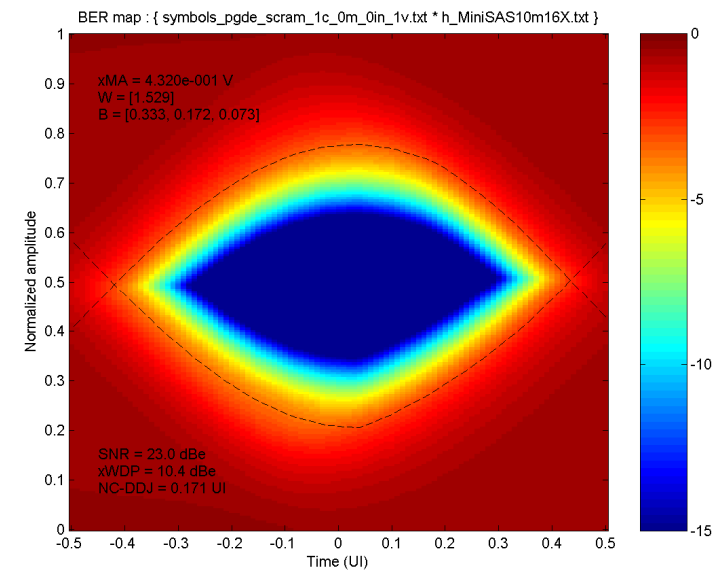
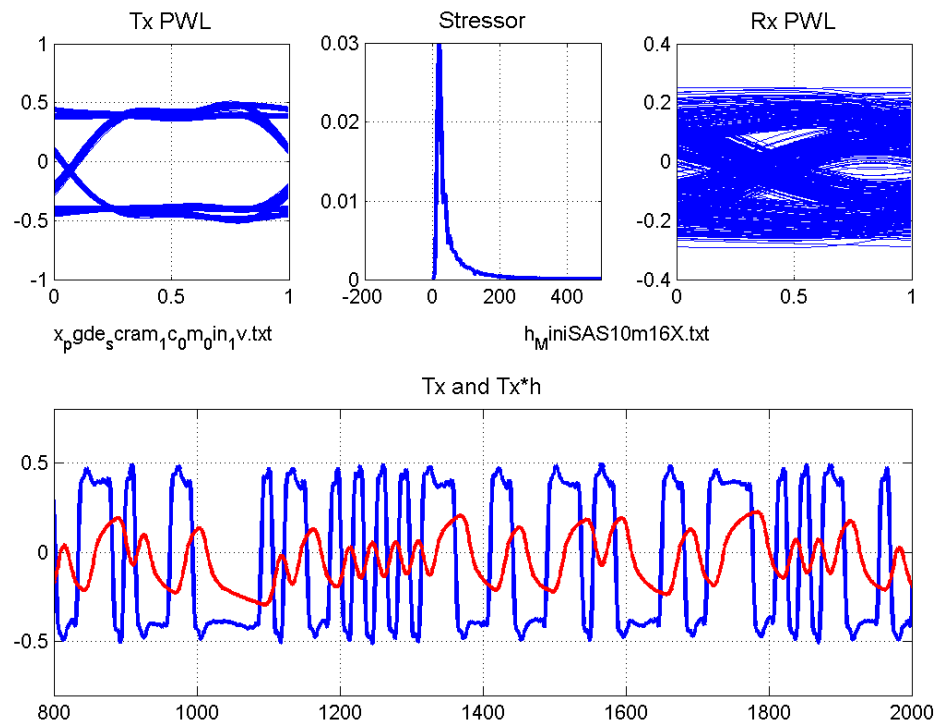
FR-4 Micro Strip
Test Board



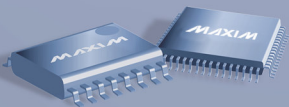


Tx Compliance SASWDP

- PG-DE: Scrambler Output : 1024 Averages, 2536 Symbols



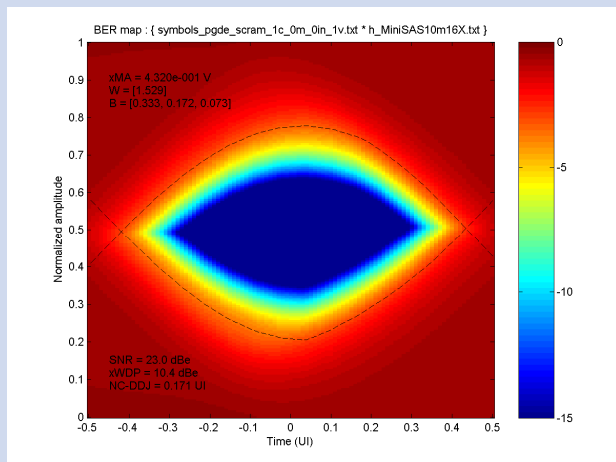
xWDP = 10.4 dB
NC-DDJ = 0.171



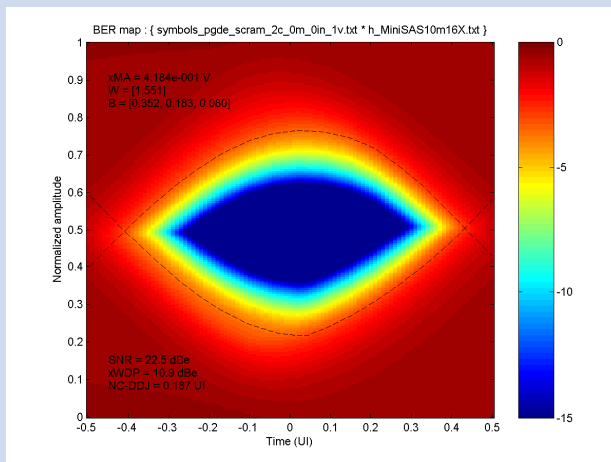


Tx Compliance (simulated 10m Cable & Scrambler Output)

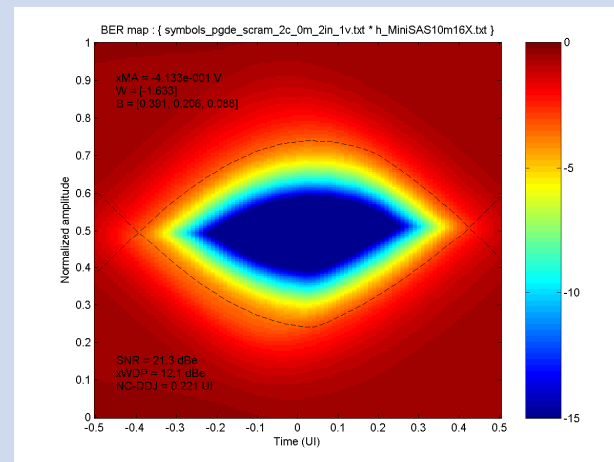
1 Cables + 10m MiniSAS



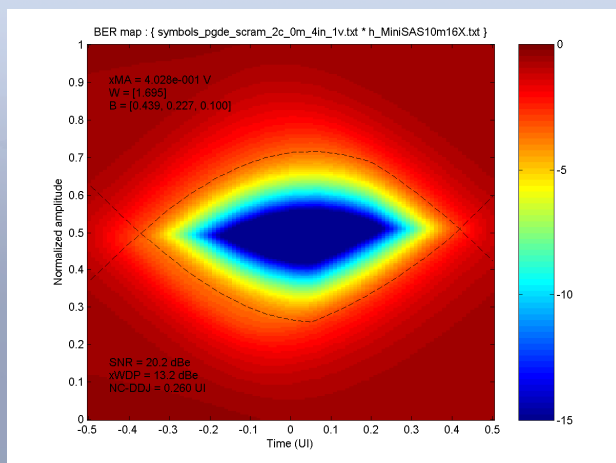
2 Cables + 10m MiniSAS



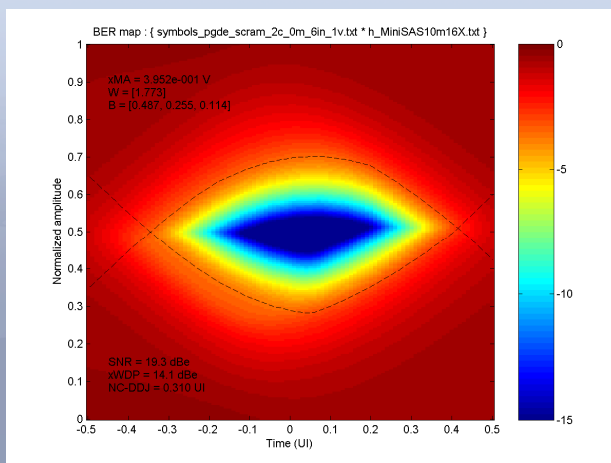
2 Cables + 10m MiniSAS + 2"FR4



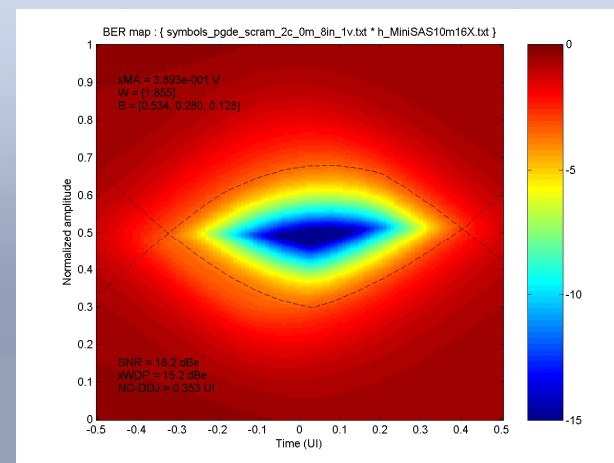
2 Cables + 10m MiniSAS + 4"FR4



2 Cables + 10m MiniSAS + 6"FR4



2 Cables + 10m MiniSAS + 8"FR4

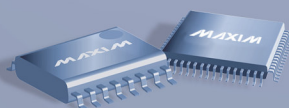
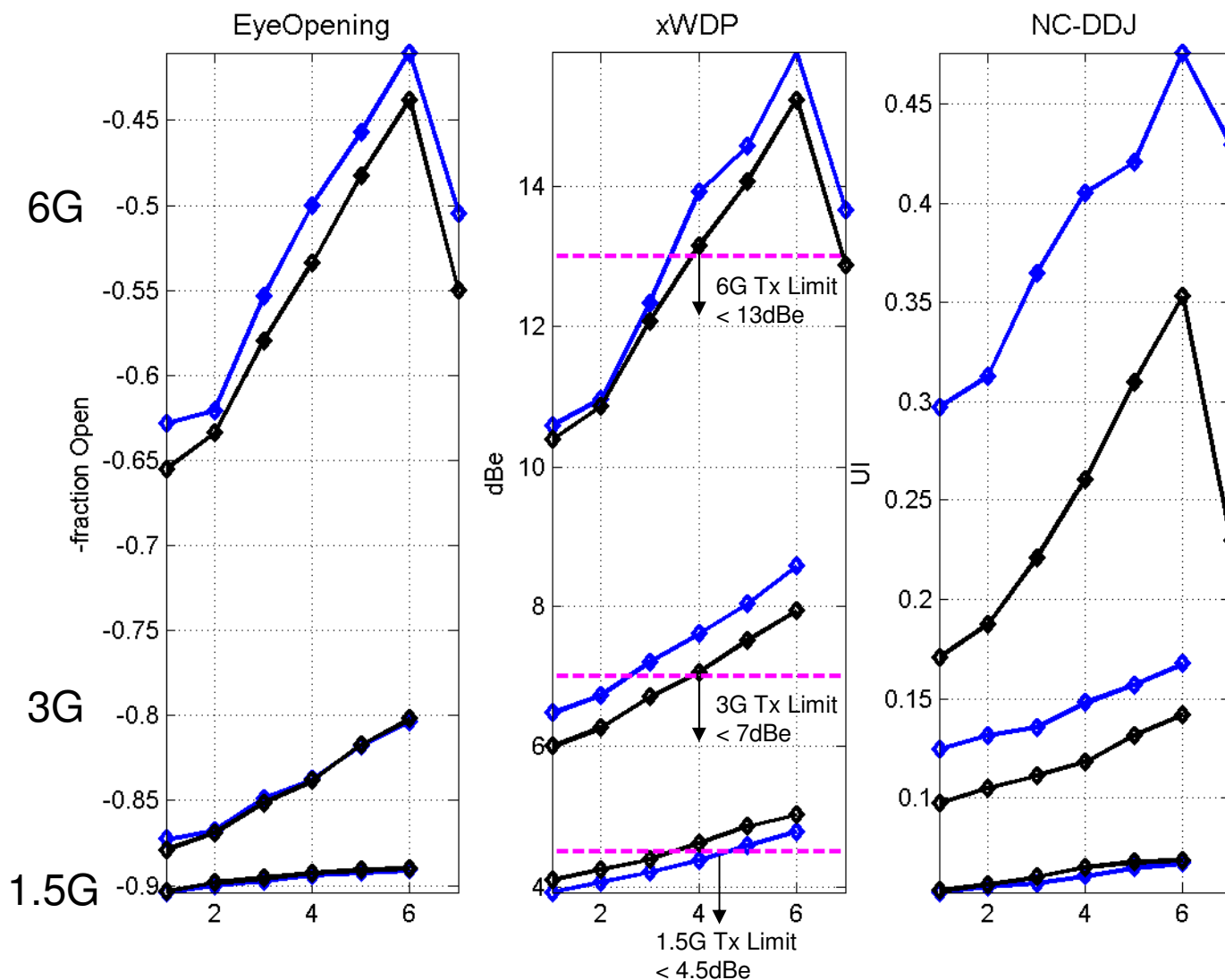




Summary of Tx Compliance Test Results

- Test
1. PG-DE (1 Cable)
 2. PG-DE (2 Cables)
 3. PG-DE (2 Cables)
+ 2" FR-4
 4. PG-DE (2 Cables)
+ 4" FR-4
 5. PG-DE (2 Cables)
+ 6" FR-4
 6. PG-DE (2 Cables)
+ 8" FR-4
 7. PG-DE (2 Cables)
+ 8" FR-4 and re-
optimized DE

- Test
- Blue = PRBS
 - Black = Scramble





Proposed Changes for Tx Compliance Comment Resolution

Changes

1. Remove eye opening specification
2. Add a 6G xWDP : <13 dBc
3. Add a 3G xWDP : <7 dBc
4. Add a 1.5G xWDP : <4.5 dBc
5. Change Pattern to zero seed scrambler output
6. Add data collection note (h):
 - Collected with zero length test load (5.4.2.2)
 - Sufficient number of averages to minimize RJ
 - Pattern length (2536 bits min)

Table 60 — Transmitter device signal output characteristics for trained 1.5 Gbps, 3 Gbps, and 6 Gbps at IT and CT

Signal characteristic	Units	Minimum	Nominal	Maximum
Peak to peak voltage if SATA is not supported ^a	mV(P-P)	850		1 200
Transmitter device off voltage ^b	mV(P-P)			50
Withstanding voltage (non-operational)	mV(P-P)	2 000		
Rise/fall time ^c	UI	0.25 ^d		
Reference differential impedance ^e	ohm		100	
Reference common mode impedance ^e	ohm		25	
Common mode voltage limit (rms) ^f	mV			30
Random jitter (RJ) ^{g, i}	UI			0.15 ^h
Minimum eye opening (i.e. 2 × 71 in figure 127) ^k				

^a See 5.4.6.4.5 for measurement method.

^b The transmitter device off voltage is the maximum A.C. voltage measured at compliance points IT and CT when the transmitter is unpowered or transmitting D.C. idle (e.g., during idle time of an OOB signal).

^c Rise/fall times are measured from 20 % to 80 % of the transition with a repeating 01b or 10b pattern (e.g., D10.2 or D21.5)(see table 237 in 10.2.9.2) on the physical link.

^d 0.25 UI is 41.6 ps at 6 Gbps.

^e For transmitter device S-parameters characteristics, see 5.4.6.4.2.

^f This is a broadband limit. For additional limits on spectral content, see figure 131 and table 61.

^g RJ is 14 times the RJ 1 sigma value, based on a BER of 10⁻¹². This test shall be performed with a repeating 01b or 10b pattern (e.g., D10.2 or D21.5)(see table 237 in 10.2.9.2) on the physical link. If the transmitter device supports SSC, then this measurement shall be performed with both SSC enabled and SSC disabled. For simulations based on a BER of 10⁻¹⁵, the RJ specified is 17 times the RJ 1 sigma value.

^h 0.15 UI is 25 ps at 6 Gbps.

ⁱ 0.30 UI is 50 ps at 6 Gbps.

^j See 5.4.5.2 for JMD requirements.

^k This value is obtained by simulation. It represents the resulting signal output within the reference receiver device (see 5.4.7.4.3) after equalization, when the transmitter device output signal of **zero seed** is transmitted through the reference transmitter test load (see 5.4.2.5). The specific simulation program used (e.g., StatEye from <http://www.stateye.org>) is not specified by this standard.

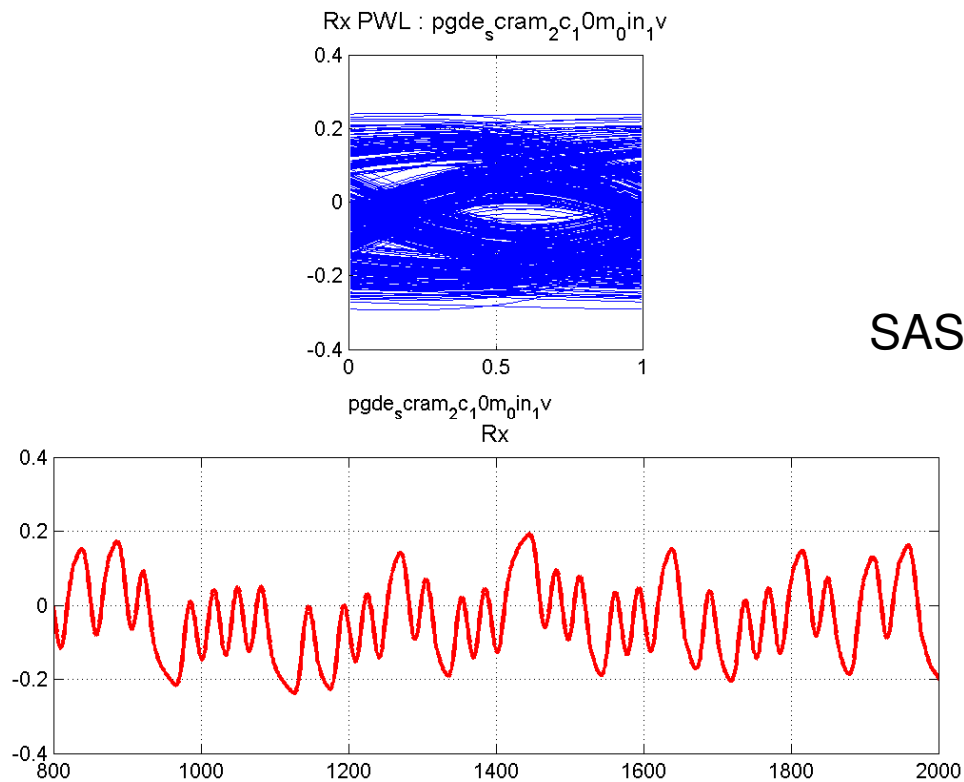
zero seed scrambler output

WDP calculation like saswdp

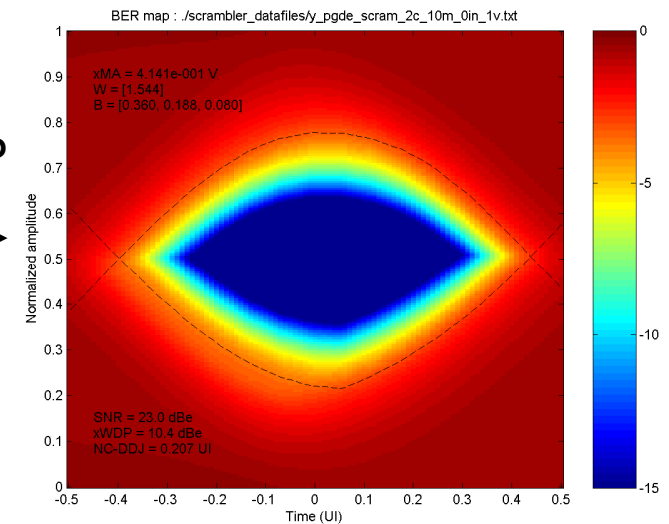


ISI Generator Calibration w/ Scrambler Output

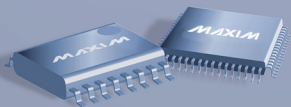
- Capture Receiver Device Input Signal



SASWDP



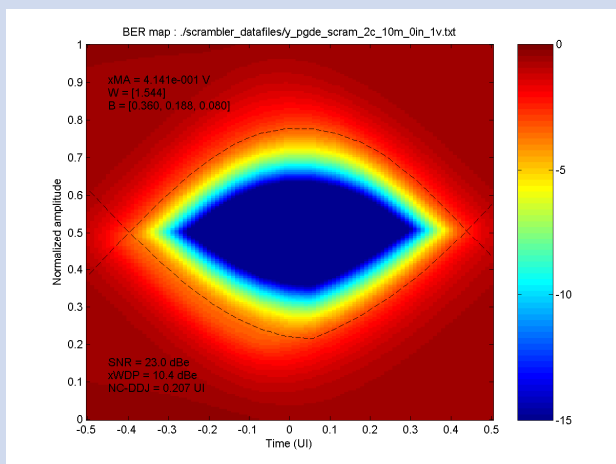
xWDP = 10.4 dB
NC-DDJ = 0.207



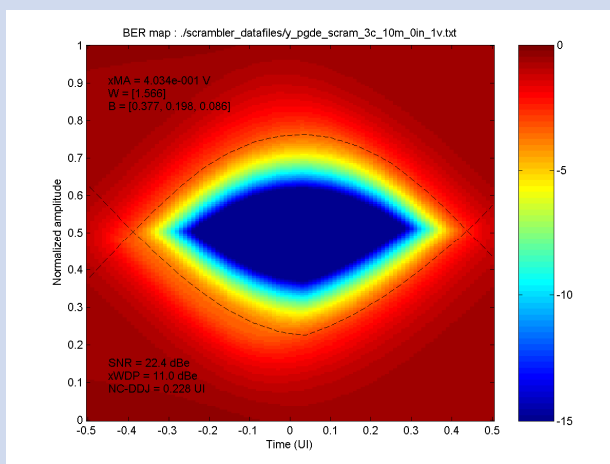


Stressed Receiver Device Compliance Test Calibration Examples 10m & Incremental FR-4 PG/DE (Scrambler)

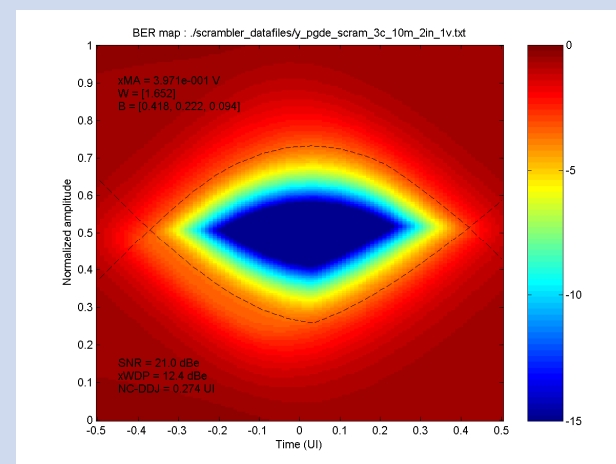
2Cables + 10m MiniSAS



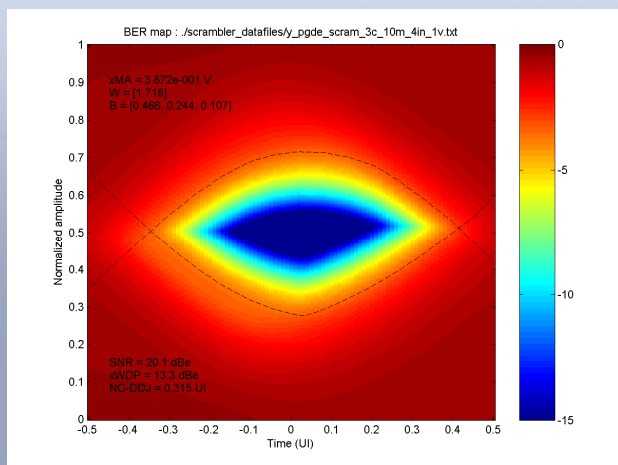
3Cables + 10m MiniSAS



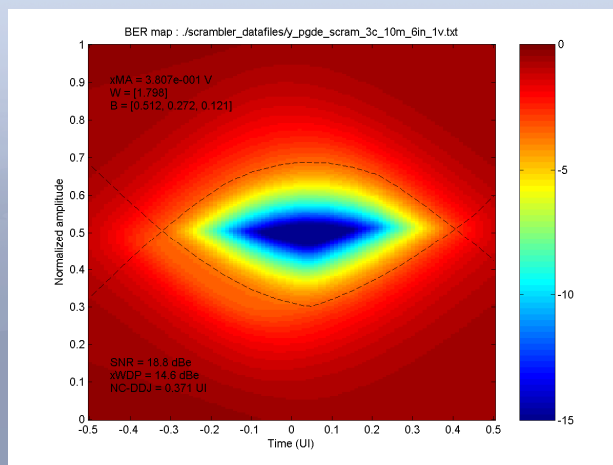
3Cables + 10m MiniSAS + 2"FR4



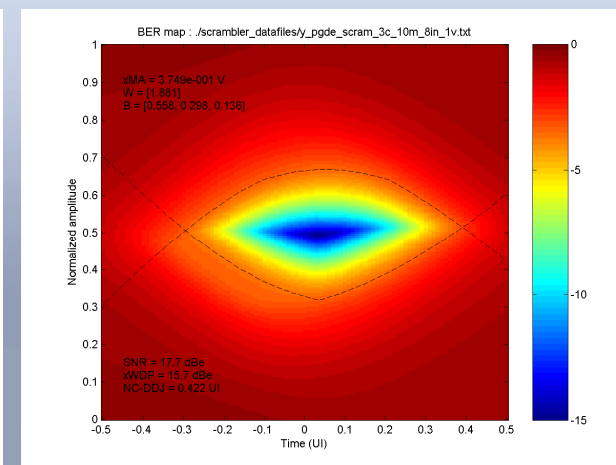
3Cables + 10m MiniSAS + 4"FR4



3Cables + 10m MiniSAS + 6"FR4



3Cables + 10m MiniSAS + 8"FR4

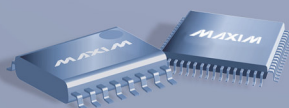
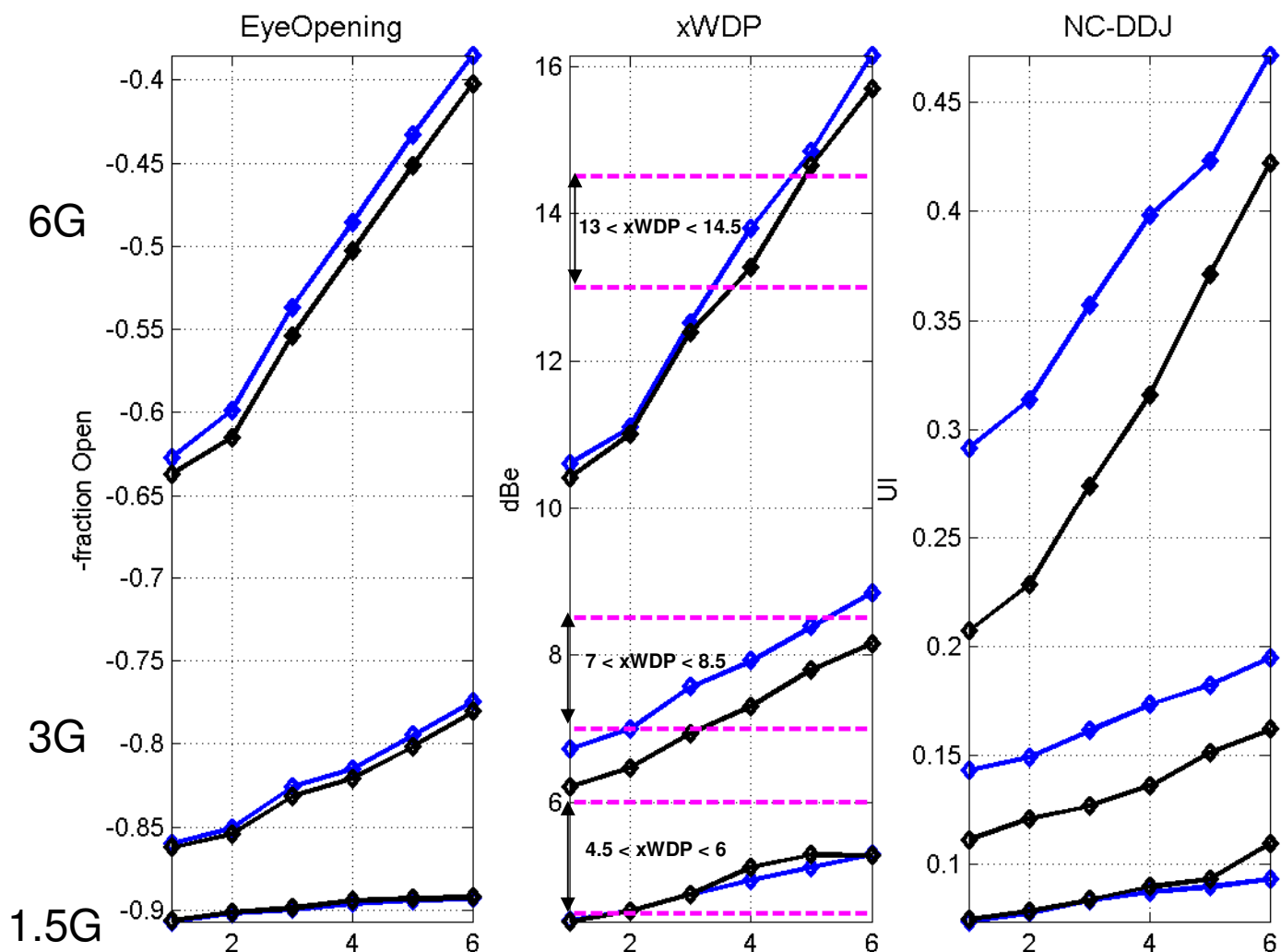




Summary of ISI Compliance Test Results

- Test**
1. PG-DE (1 Cable)
 2. PG-DE (2 Cables)
 3. PG-DE (2 Cables) + 2" FR-4
 4. PG-DE (2 Cables) + 4" FR-4
 5. PG-DE (2 Cables) + 6" FR-4
 6. PG-DE (2 Cables) + 8" FR-4
 7. PG-DE (2 Cables) + 8" FR-4 and re-optimized DE

- Test**
- Blue = PRBS
 - Black = Scramble



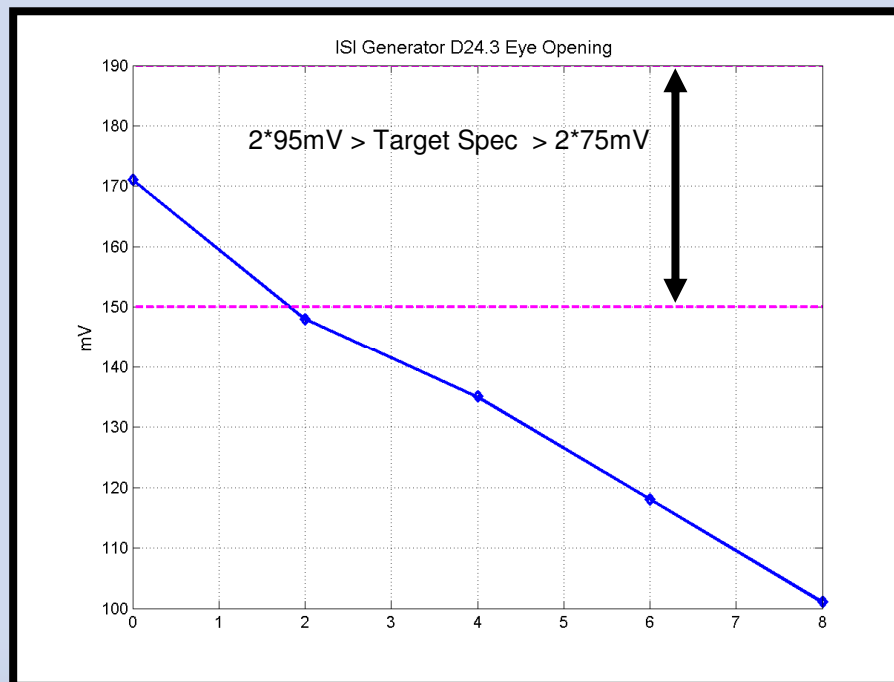


D24d3 ISI Calibration

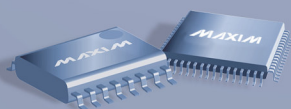
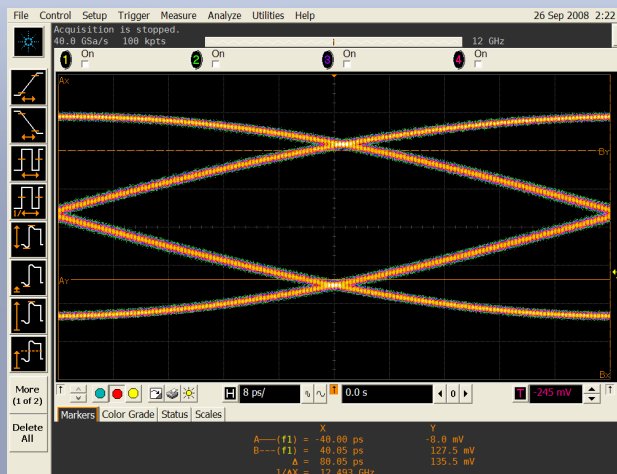
- **D24d3 vs. FR-4 Adder**
 - 800mV 2dB Tx
 - 900mV 2dB TX
 - ➔ 150mV

Test

1. PG-DE (2 Cables) + 10m MiniSAS
2. PG-DE (3 Cables) + 10m MiniSAS
3. PG-DE (3 Cables) + 10m MiniSAS + 2" FR-4
4. PG-DE (3 Cables) + 10m MiniSAS + 4" FR-4
5. PG-DE (3 Cables) + 10m MiniSAS + 6" FR-4
6. PG-DE (3 Cables) + 10m MiniSAS + 8" FR-4



Far End 10m + 4" FR4



Spec Typo

- Figure 123 was not updated to match Table 71

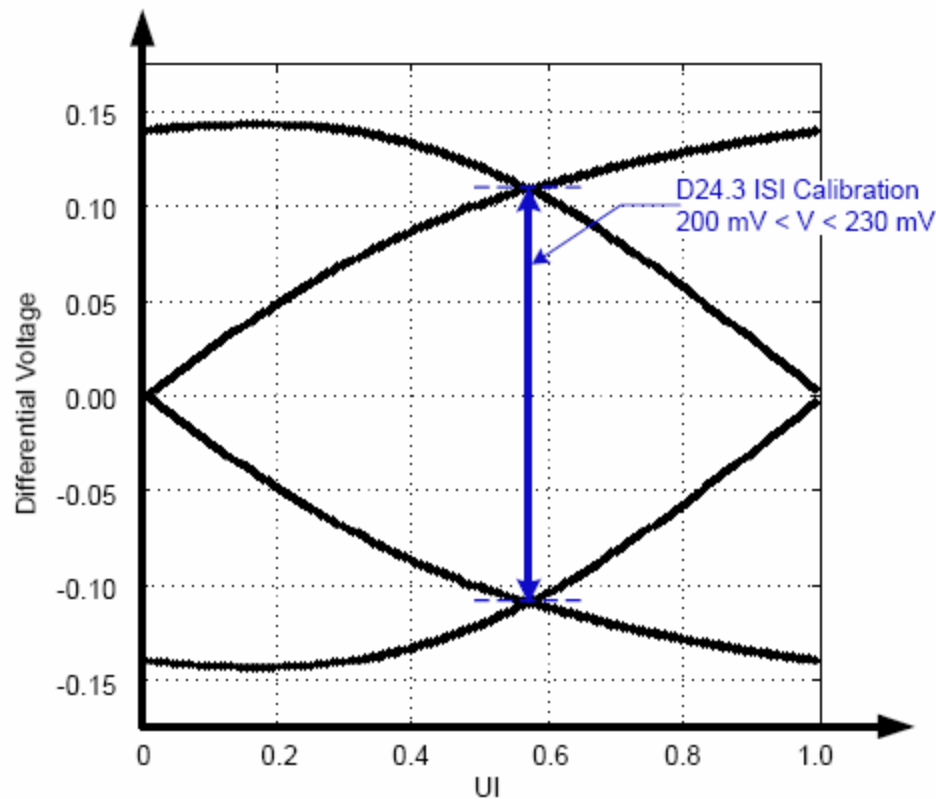
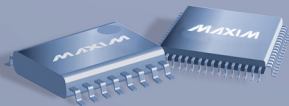


Figure 123 — Reference transmitter test load D24.3 response

This should be 150 → 190mV
Per: Table 71 in SAS2r14e





Spec Changes to Resolve Comments

1. Change Pattern to Scrambler (see table 223)
2. Include SASWDP Code as Appendix
3. Rename LDP to WDP, add 3 frequencies
 - 6G: 13 min, 14.5 max
 - 3G: 7 min, 8.5 max
 - 1.5G: 4.5 min, 6 max

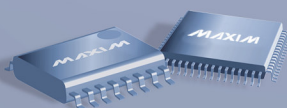
This is obsolete

Table 71 — Stressed receiver device sensitivity test characteristics

Characteristic	Units	Minimum	Typical	Maximum	Reference
Tx data pattern		Scrambler with Zero Seed			Annex A
Tx peak to peak voltage	mV(P-P)			800	5.4.6.4.1
Tx minimum rise/fall time	UI	0.24 ^a			5.4.6.4.1
Transmitter equalization	dB			2	5.4.6.4.5
Tx RJ	UI	0.15 ^b			5.4.6.4.1
Tx bounded uncorrelated jitter	UI	0.000 22 ^c			
Waveform Dispersion Penalty	dB	13		15	5.4.7.4.4.8
D24.3 delivered eye opening ($\angle 1$) ^d	mV	75		95	5.4.5.4
NEXT offset frequency ^e	ppm	20			
Total crosstalk amplitude ^{e, f}	mV _{rms}	4			

^a 0.24 UI is 41.6 ps at 6 Gbps.
^b 0.15 UI is 25 ps at 6 Gbps.
^c 0.000 22 UI is 0.036 ps at 6 Gbps.
^d Link dispersion penalty is the WDP of the delivered signal computed with Pallocc = 15.4 dB.
^e This specification pertains to the delivered signal at IR or CR during the receiver device compliance test. All adjacent phys in the receiver device shall be active with representative traffic with their maximum amplitude and maximum frequency of operation. Additional pseudo-random crosstalk shall be added, if needed, to meet the total crosstalk amplitude specification.
^f Observed with a histogram of at least 1 000 hits.

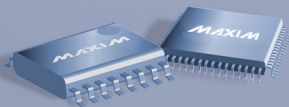
Editor's Note 2: Numerous changes are piled up for that table, awaiting work on SASWDP to complete. See 08-202, 08-330, 08-345.





SASWDP Enhancements

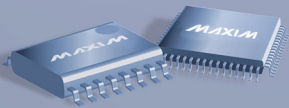
- Change Q0=7.9419; % for BER = $10^{(-15)}$
- Normalize Eye for no AGC eye opening, W = 1, like DFEEYE
- Return vertical and horizontal eye opening, like DFEEYE
 - 1e-15
 - ISI only (eye lid)
- Change hard coded baud rate in specification to variable
- Small robustness enhancements
 - min(find(...
 - Enable row or column vectors as inputs
- NC_DDJ (sum of both sides vs. 2 x 1 side?)
- More Robustness to waveform dependencies and length
 - SAS CJTPAT vs. PRBS-7, PRBS-10 (see T10/08-330r0/1/2)





Summary

- Dry run of SASWDP based Tx compliance test results presented
- Changes proposed to results Table 61 & 71 comments
- Early look at ISI calibration results provided





EYE_OPENING & SASWDP Results

- | | Test |
|----|---|
| 1. | PG-DE (2 Cables) + 10m MiniSAS |
| 2. | PG-DE (3 Cables) + 10m MiniSAS |
| 3. | PG-DE (3 Cables) + 10m MiniSAS + 2" FR-4 |
| 4. | PG-DE (3 Cables) + 10m MiniSAS + 4" FR-4 |
| 5. | PG-DE (3 Cables) + 10m MiniSAS + 6" FR-4 |
| 6. | PG-DE (3 Cables) + 10m MiniSAS + 8" FR-4 |

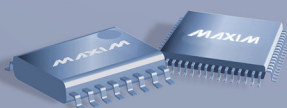
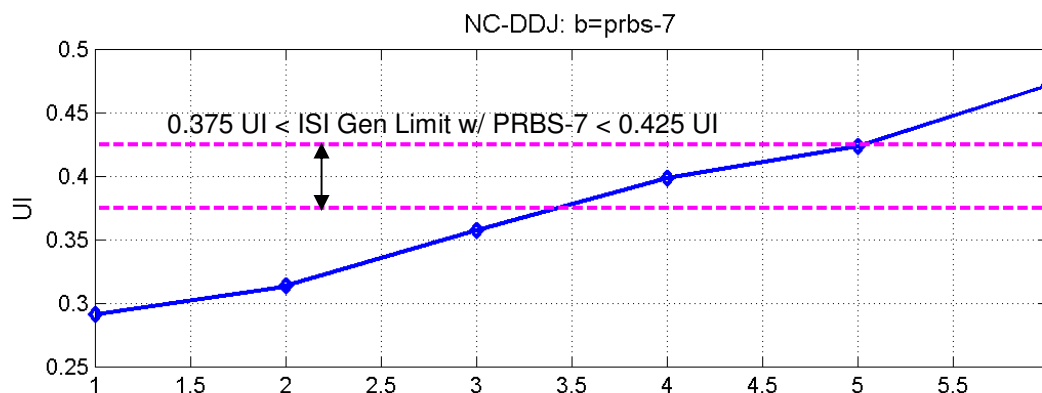
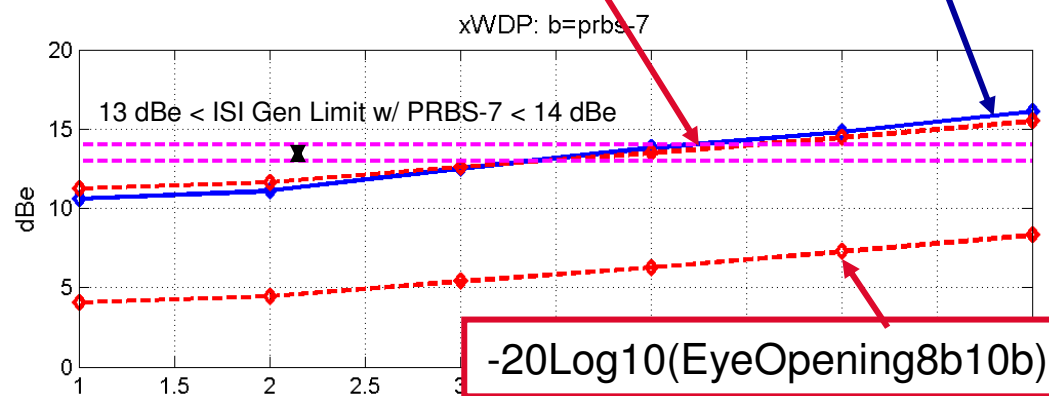
Observation

1m Cable ~0.5 dBe

2" FR-4 Micro strip ~ 1dBe

Matched Means

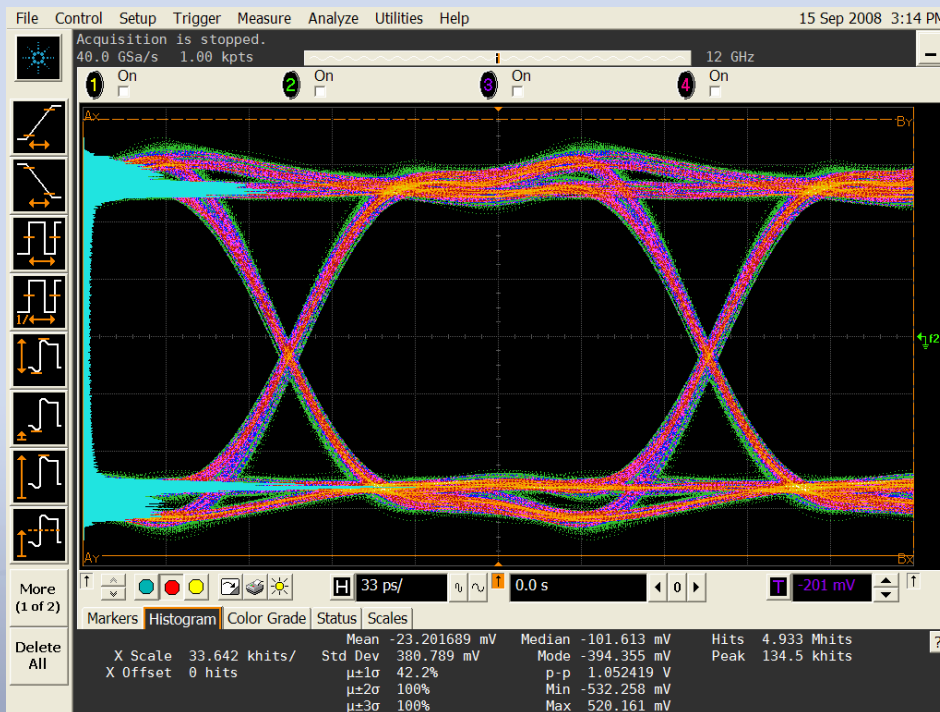
SASWDP



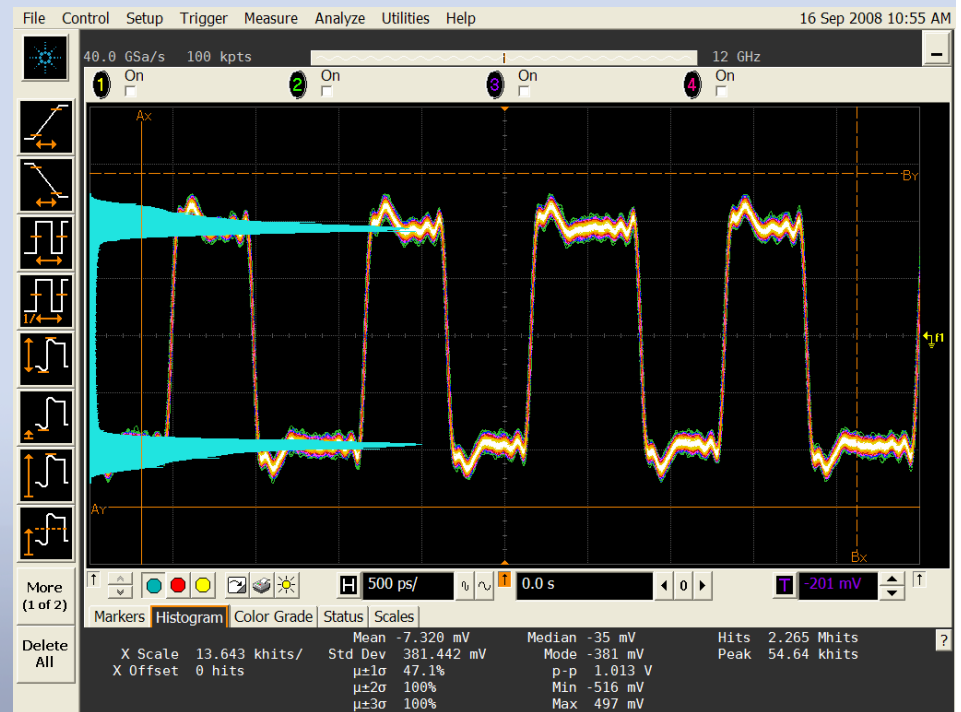


PG w/ DE Box

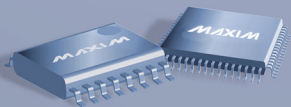
- 1000mV pk-pk
- 2.2dB DE
- 6Gpbs

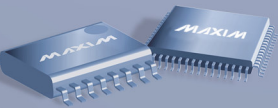


PRBS-7



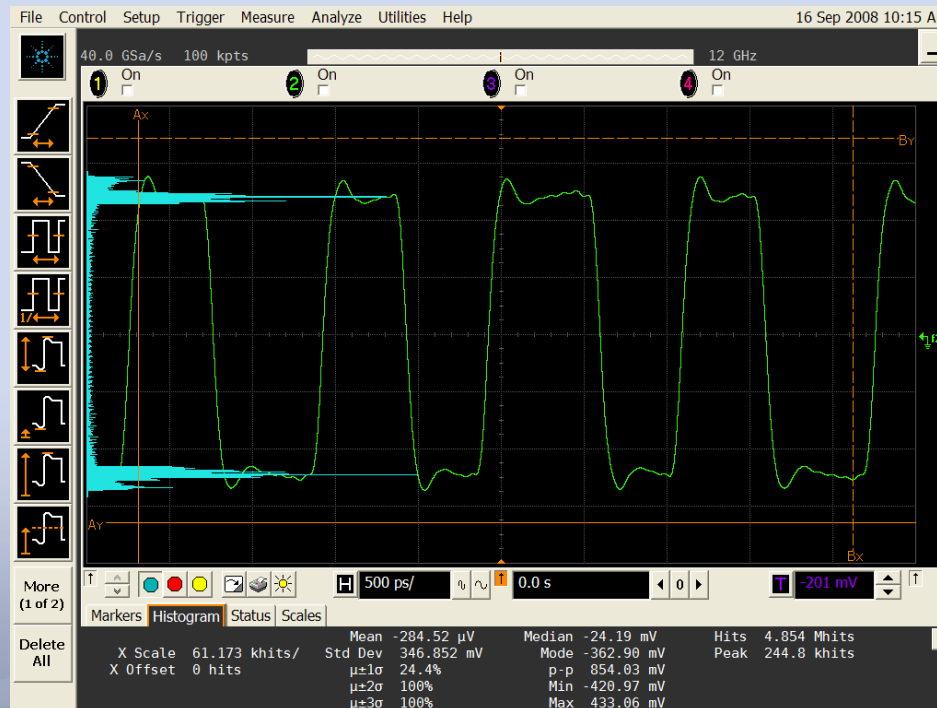
D30.3
w/ pattern
trigger





Averaging Example

- **Measure the average of the differential signal with a pattern trigger**
- **RJ is virtually eliminated**

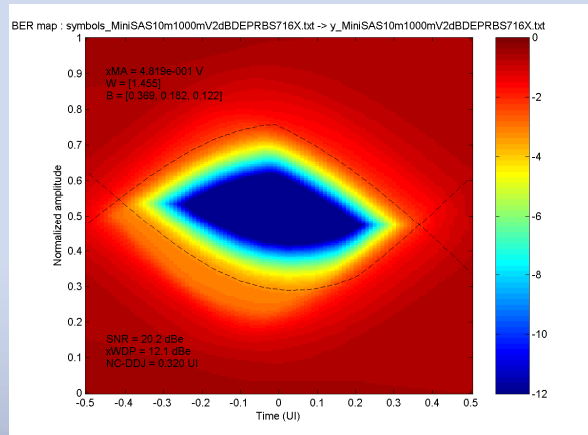


D30.3
1024 Averages w/ pattern
trigger

Correlation Runs

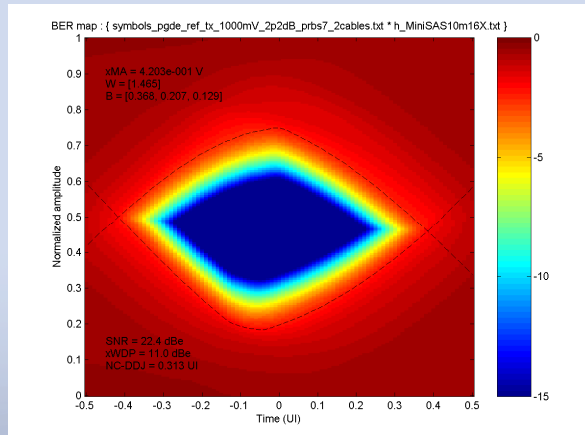
- PRBS-7

Synthesized Waveforms
SASWDP(TX_est*h_est)



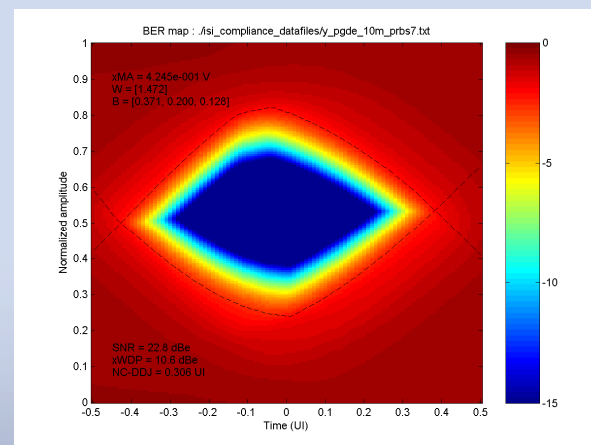
xWDP = 12.1
NC-DDJ = 0.320

Tx Compliance Test (#1)
SASWDP(TX_lab*h_est)



xWDP = 11.0
NC-DDJ = 0.313

ISI Gen Compliance
SASWDP(RX_lab)



xWDP = 10.6
NC-DDJ = 0.306

