Reference Receiver Solutions for SAS-2 Compliance Testing

08-330r3

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10-2-08
Overview

• 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
PG w/ DE Box

- 1000mV pk-pk
- 2.2dB DE

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)

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

ISI Gen Compliance
SASWDP(RX_lab)

xWDP = 12.1
NC-DDJ = 0.320

xWDP = 11.0
NC-DDJ = 0.313

xWDP = 10.6
NC-DDJ = 0.306
Tx Compliance
SASWDP

- PG-DE: PRBS-7 : 1024 Averages, 256 Symbols

**xWDP = 10.8 dBe**
**NC-DDJ = 0.306**
Tx Compliance
SASWDP

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

xWDP = 10.4 dBe
NC-DDJ = 0.171
MAXIM

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

<table>
<thead>
<tr>
<th>Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. PG-DE (1 Cable)</td>
</tr>
<tr>
<td>2. PG-DE (2 Cables)</td>
</tr>
<tr>
<td>3. PG-DE (2 Cables) + 2” FR-4</td>
</tr>
<tr>
<td>4. PG-DE (2 Cables) + 4” FR-4</td>
</tr>
<tr>
<td>5. PG-DE (2 Cables) + 6” FR-4</td>
</tr>
<tr>
<td>6. PG-DE (2 Cables) + 8” FR-4</td>
</tr>
<tr>
<td>7. PG-DE (2 Cables) + 8” FR-4 and re-optimized DE</td>
</tr>
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- **Tx Limit w/ PRBS-7 < 13dBe**
- **Tx Limit w/ PRBS-7 < 0.4UI**
Summary of Tx Compliance Test Results
SASWDP & EYEOPENING

- Test
- PG-DE (1 Cable)
- PG-DE (2 Cables)
- PG-DE (2 Cables) + 2” FR-4
- PG-DE (2 Cables) + 4” FR-4
- PG-DE (2 Cables) + 6” FR-4
- PG-DE (2 Cables) + 8” FR-4
- PG-DE (2 Cables) + 8” FR-4 and re-optimized DE

Blue = prbs-7
Red = SAS CJTPAT
Black = scrambler output
Proposed Changes for Tx Compliance Comment Resolution

Changes

1. Remove eye opening specification
2. Add a maximum 13 dBe xWDP
3. Add a maximum 0.4 UI NC-DDJ (TBC)
4. Change Pattern to zero seed scrambler output
5. 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)
6. Add Post Processing Note (i)
   - Convolve with impulse response of transmitter test load (5.4.2.5)
   - Extract Data bits
   - Process with SASWDP code
7. Add Appendices for SASWDP code
8. Add Appendices for Impulse response
9. ?

WDP calculation like saswdp

zero seed scrambler output
ISI Generator Calibration w/ Scrambler Output

- Capture Receiver Device Input Signal

\[ xWDP = 10.4 \text{ dBe} \]
\[ \text{NC-DDJ} = 0.207 \]
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 Stressed Receiver Device Compliance Test Calibration

## Examples with Increasing Stressor

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<td>4. PG-DE (3 Cables) + 10m MiniSAS + 4” FR-4</td>
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<td>6. PG-DE (3 Cables) + 10m MiniSAS + 8” FR-4</td>
</tr>
</tbody>
</table>

**Observation**

- 1m Cable ~0.5 dBe
- 2” FR-4 Micro strip ~ 1dBe

![Graphs showing dB and UI limits with dashed and solid lines for scrambled data](image)
Summary of ISI Compliance Test Results
SASWDP & EYEOPENING

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
D24d3 ISI Calibration

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

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</table>

2*95mV > Target Spec > 2*75mV
Spec Typo

- Figure 123 was not updated to match Table 71

This should be $150 \rightarrow 190\text{mV}$
Per: Table 71 in SAS2r14e
Spec Changes to Resolve Comments

1. Change Pattern to Scrambler (see table 223)
2. Rename LDP to WDP 13 min, 15 max
3. Include SASWDP Code as Appendix

Table 71 — Stressed receiver device sensitivity test characteristics

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Units</th>
<th>Minimum</th>
<th>Typical</th>
<th>Maximum</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tx data pattern</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Annex A</td>
</tr>
<tr>
<td>Tx peak to peak voltage</td>
<td>mV(P-P)</td>
<td></td>
<td></td>
<td></td>
<td>5.4.6.4.1</td>
</tr>
<tr>
<td>Tx minimum rise/fall time</td>
<td>UI</td>
<td>0.24 a</td>
<td></td>
<td>800</td>
<td>5.4.6.4.1</td>
</tr>
<tr>
<td>Transmitter equalization</td>
<td>dB</td>
<td></td>
<td></td>
<td>2</td>
<td>5.4.6.4.5</td>
</tr>
<tr>
<td>Tx RJ</td>
<td>UI</td>
<td>0.15 b</td>
<td></td>
<td></td>
<td>5.4.6.4.1</td>
</tr>
<tr>
<td>Tx bounded uncorrelated jitter</td>
<td>UI</td>
<td>0.000 22 c</td>
<td></td>
<td>15</td>
<td>5.4.7.4.4.8</td>
</tr>
<tr>
<td>NEXT offset frequency</td>
<td>ppm</td>
<td></td>
<td>20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total crosstalk amplitude</td>
<td>mV rms</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

This is obsolete

Scrambler with Zero Seed

Waveform Dispersion Penalty

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
  - 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
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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 ~ 1 dBe

Matched Means

SASWDP

-20Log10(EyeOpening8b10b)

13 dBe < ISI Gen Limit w/ PRBS-7 < 14 dBe
0.375 UI < ISI Gen Limit w/ PRBS-7 < 0.425 UI