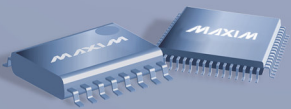




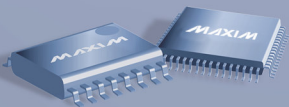
# Reference Receiver Solutions for SAS-2 Compliance Testing 08-330r1

Kevin Witt

9-9-08



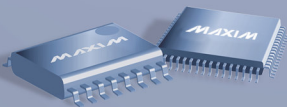
- **SAS-2 specification compliance test are based on an eye opening after a reference DFE receiver**
  - “StatEye or Equivalent” processing
- **The SAS-2 user community needs a reference receiver software solution based on captured waveform data**
  - **Tx Compliance**
    - Table 61 Ref Rx output (required 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
- **Initial investigation**
  - Process synthesized and measured waveforms
  - Dry run the compliance test with test equipment





## References

- Stressed Receiver Device Sensitivity Proposal
  - 07-380r1 SAS-2 Comprehensive Stressed Receiver Sensitivity Test  
Kevin Witt, Maxim, Sept 18 2007
- DFEEYE Software
  - T11/07-550v0 Introduction to DFEEYE, Adam Healey, LSI, Sept 2007
- SASWDP Software
  - 08-345v0 SASWDP, Mike Jenkins, LSI, August 2008
- Channels & Data Files (Included in 07-380r0)
  - h\_MiniSASp5m1000mV2dBDEPRBS716X.txt, T10/05-401r0
  - h\_MiniSAS6m1000mV2dBDEPRBS716X.txt, T10/05-404r0
  - h\_MiniSAS10m1000mV2dBDEPRBS716X.txt, T10/07-193r1
  - DFEEYE\_stressor\_iPass\_10m\_h0Table\_6g0\_16X.txt, T11/07-550v0
  - SAS\_CJTPAT\_samples.txt, T11/07-550v0
  - SAS\_CJTPAT\_symbols.txt, T11/07-550v0



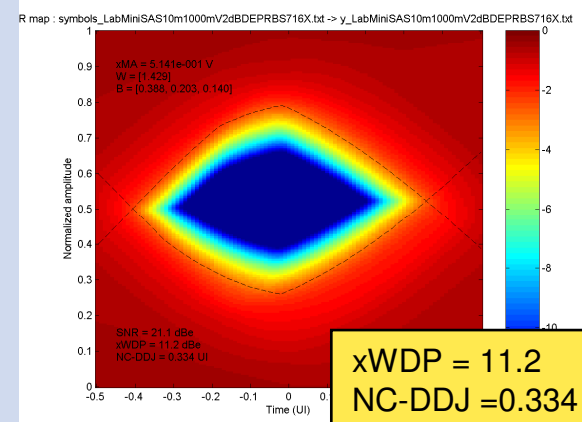
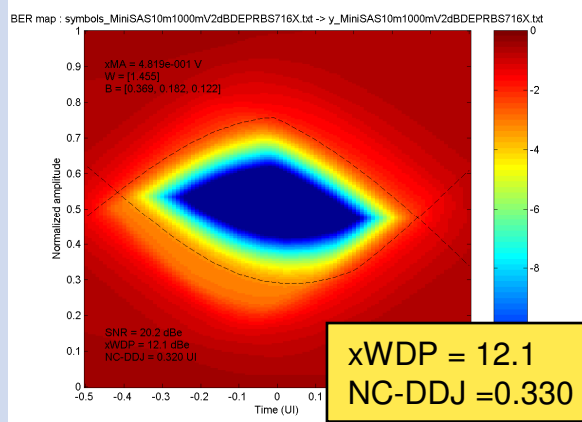


# SASWDP Processing of PRBS-7 Data

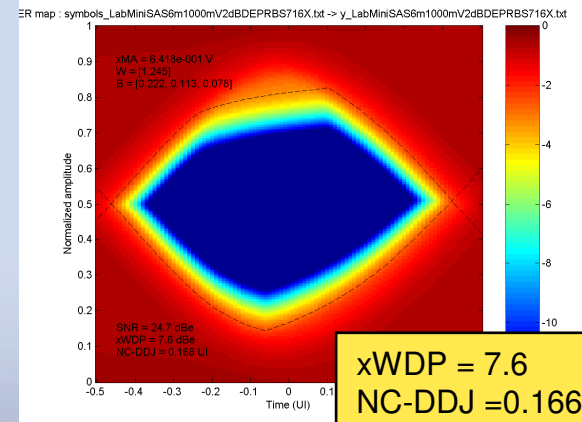
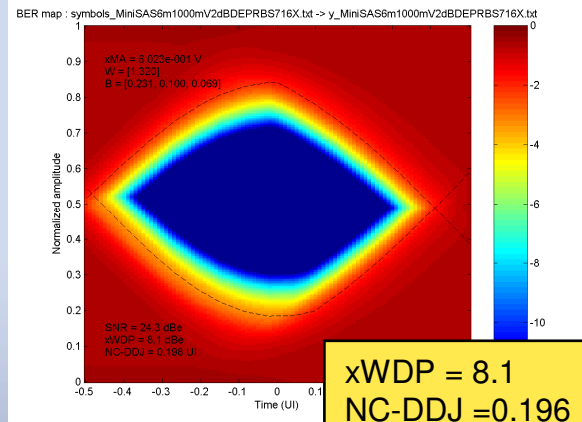
## Synthesized Waveform Based

## Measured Lab Waveform Based

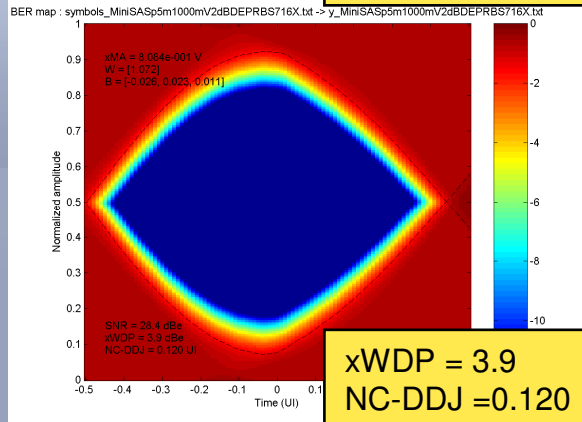
10m prbs7



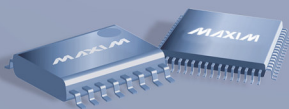
6m prbs-7



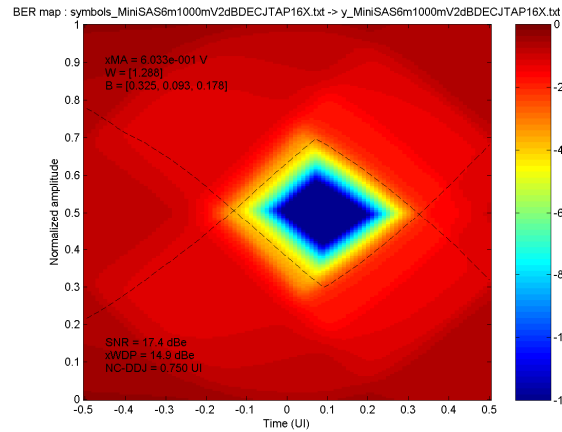
0.5m prbs7



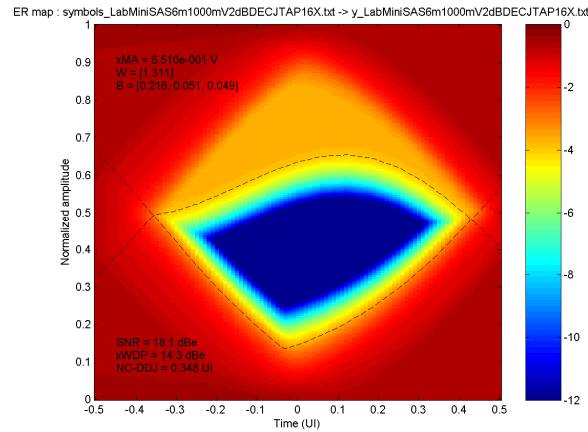
**Encouraging results from synthesized and measured waveform files w/ PRBS-7**



## SASWDP

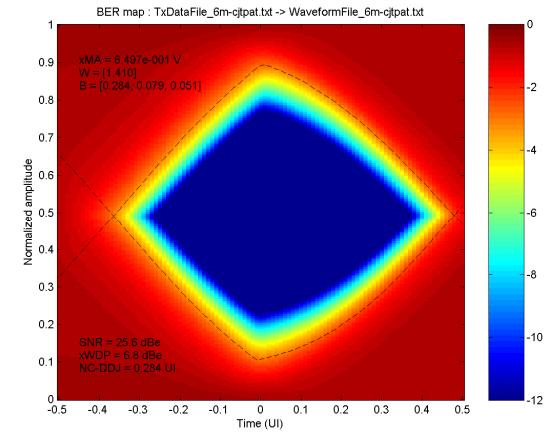


Synthesized



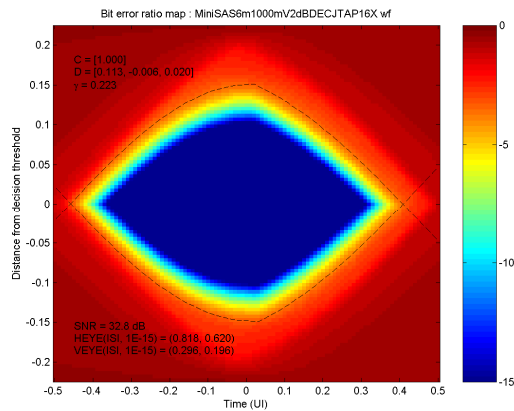
Measured

## 08-345r0

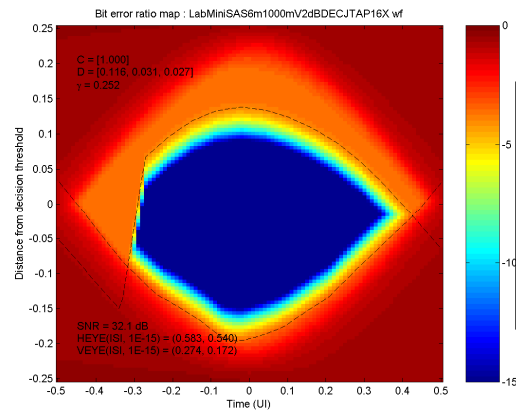


Synthesized?

## DFE\_EYE rev 1.0



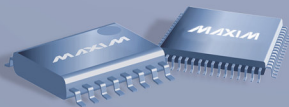
Synthesized



Measured

**These SAS CJTPAT files leading to an issue not seen with DFE\_EYE**

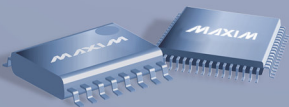
**Input files issue or DFE\_EYE solver is more robust, TBD**





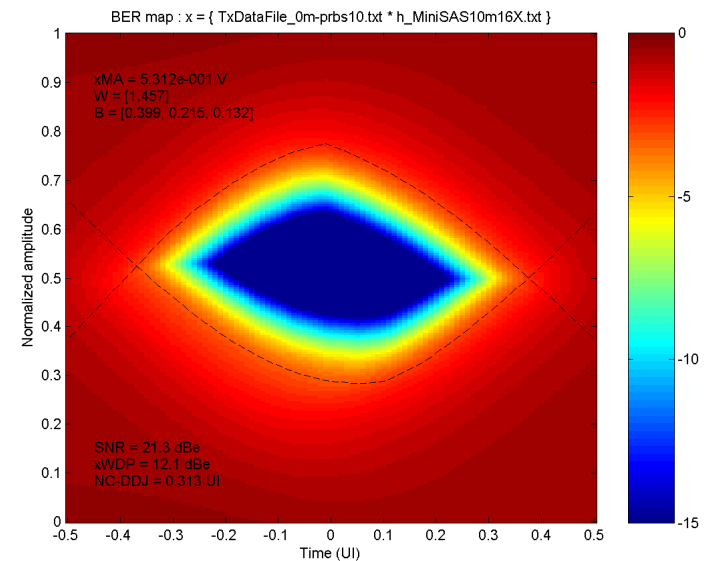
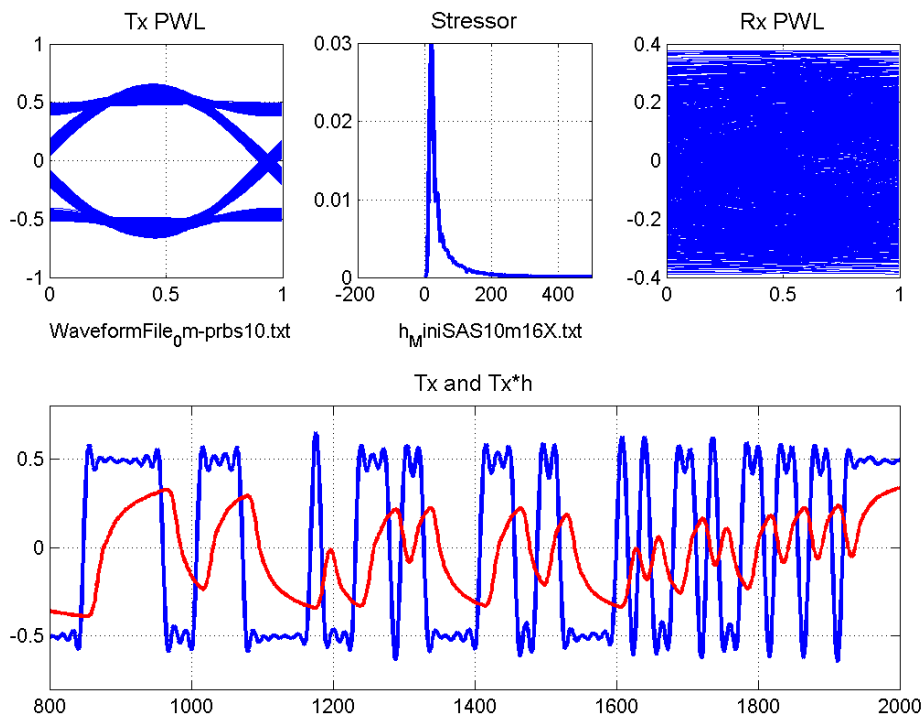
## Tx Compliance

- **Compliance based on Table 61**
  - Tx Swing, rise/fall and RJ based on traditional measurement techniques
  - Need a reference Rx for 84mV x 0.5UI eye opening specification
- **Straw-man SASWDP Based Method**
  - Set Up Tx based on Table 61 and 64 (swing, DE, tr/f ...)
  - Collect near end Tx pwl waveform for SAS CJTPAT
    - Use a sufficient # averages (16) to minimize RJ
    - Convolve pwl with reference channel impulse response
      - Example h\_MiniSAS10m1000mV0dBDECJTAP16X.txt from 08-330r0
    - Process with SASWDP to see eye opening with ref Rx
    - Confirm xWDP < 13dBe (TBC)
    - Jitter spec based on NC-DDJ < xx UI (TBC)



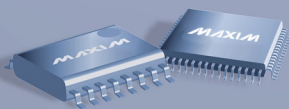
## Tx Compliance Example

- Test equipment: pattern generator & de-emphasis generator



xWDP = 12.1  
Veye ~200/1.4  
NC-DDJ = 0.313

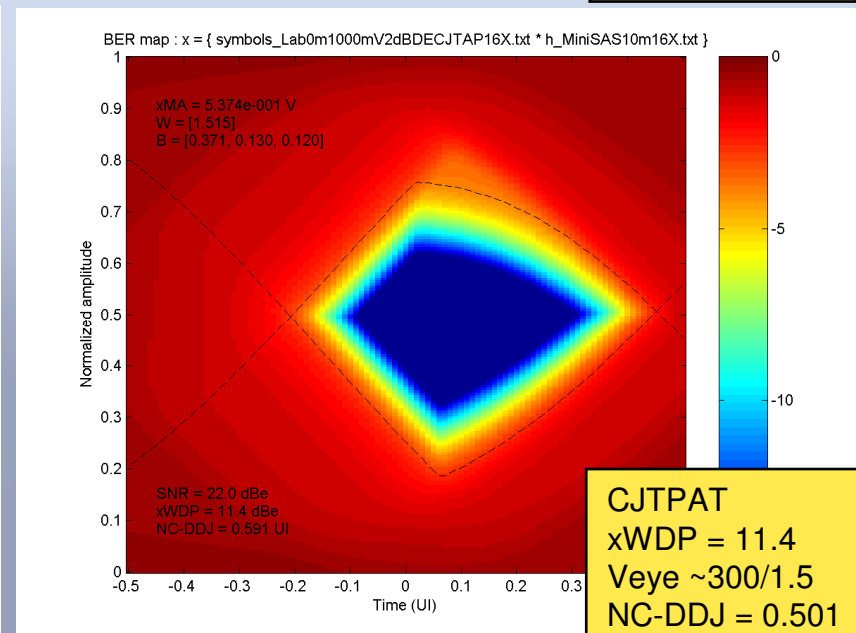
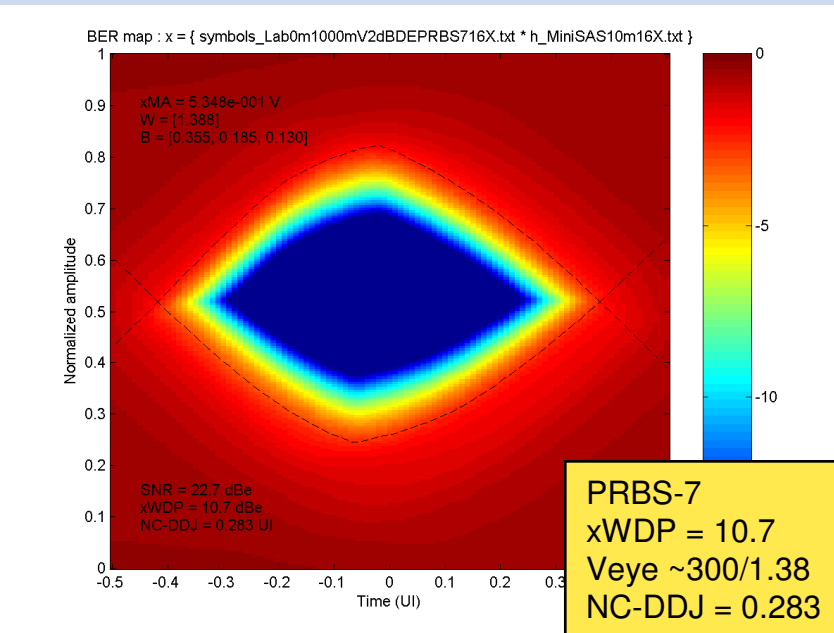
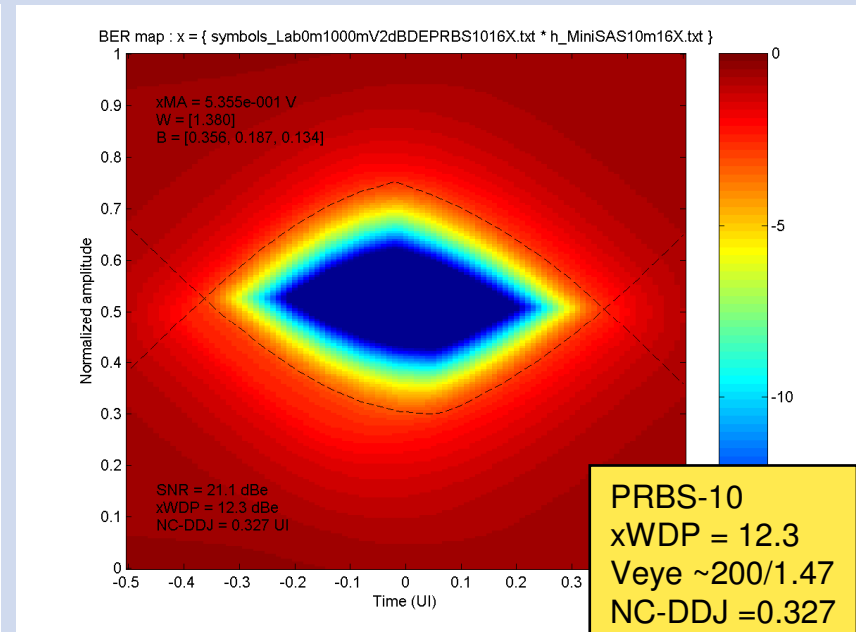
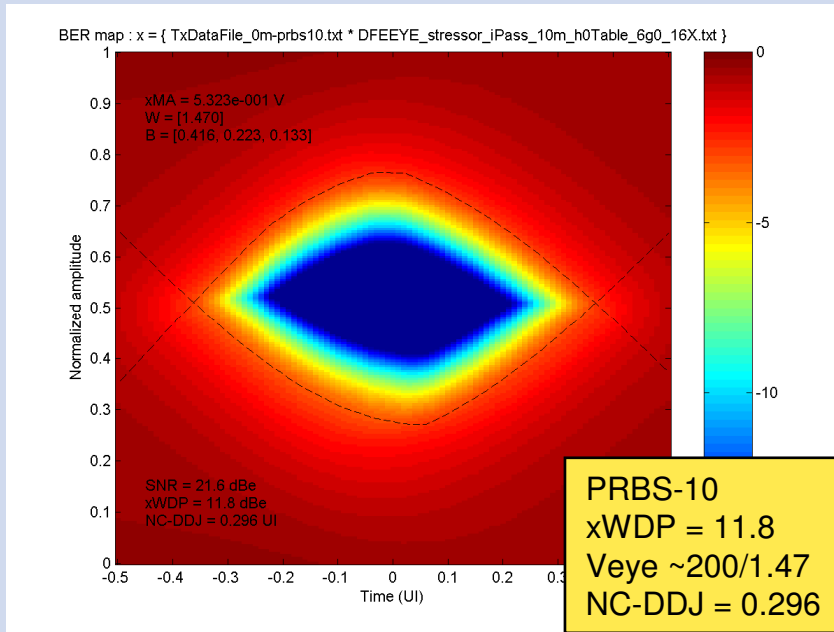
Working with PRBS-10  
Will need to use a xWDP or eye opening  
measurements







# Tx Compliance Examples

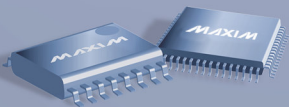






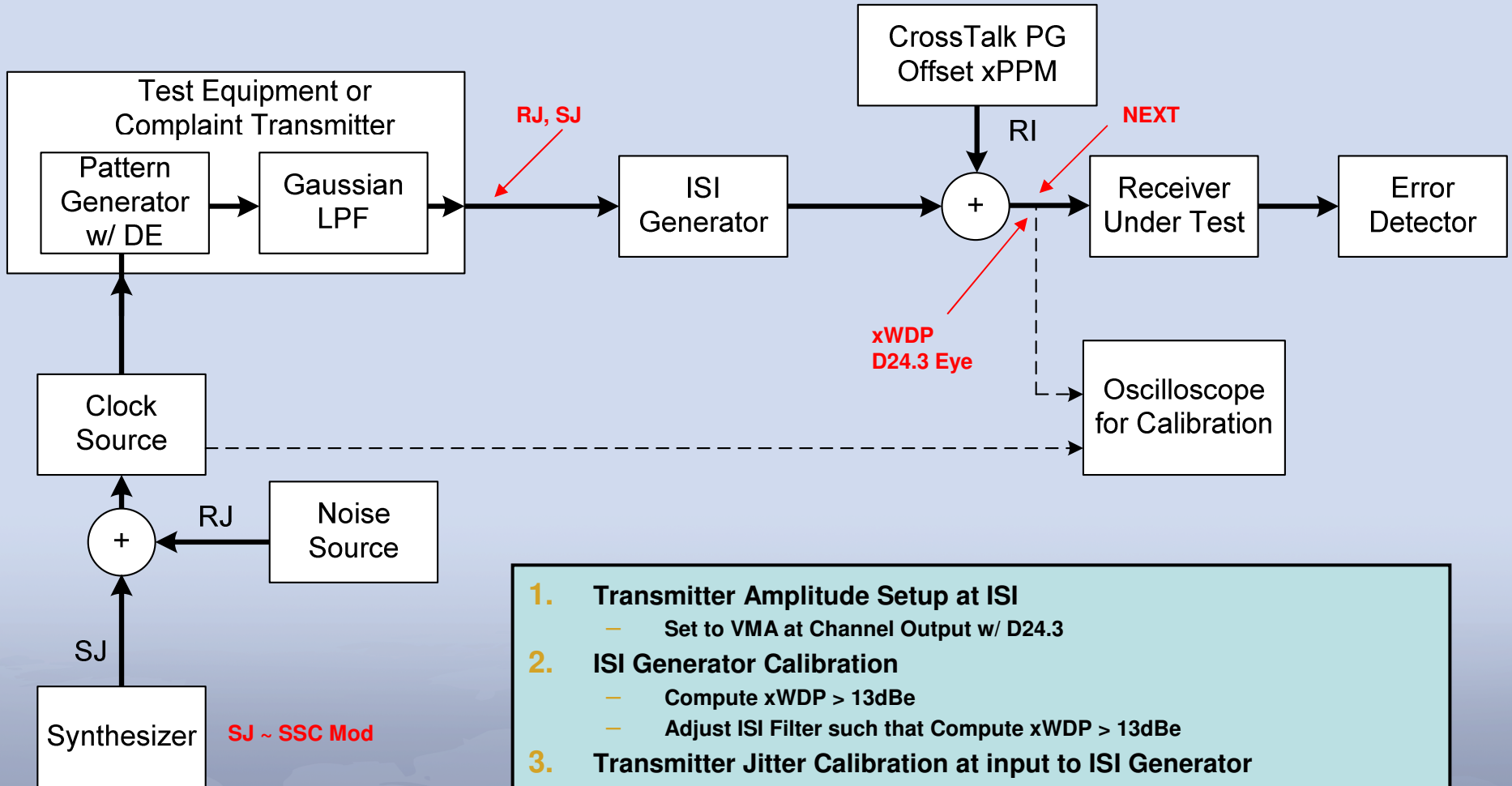
## Rx ISI Generator Compliance

- **Compliance based on Table 72**
  - Need a reference Rx for ISI Generator Calibration
- **Straw-man SASWDP Based Method**
  - Set Up ISI generator without jitter or crosstalk, Table 72 and Figure 133
  - Collect near end Rx pwl waveform for SAS CJTPAT
    - Use a sufficient # averages (16) to minimize RJ
    - Process with SASWDP to compute  $xWDP > 13$  dBc ?
  - Calibrate NEXT, RJ and SJ at the receiver device interface

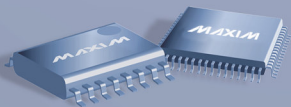




## Receiver Device Stressed Sensitivity Test (based on 07-380r1)



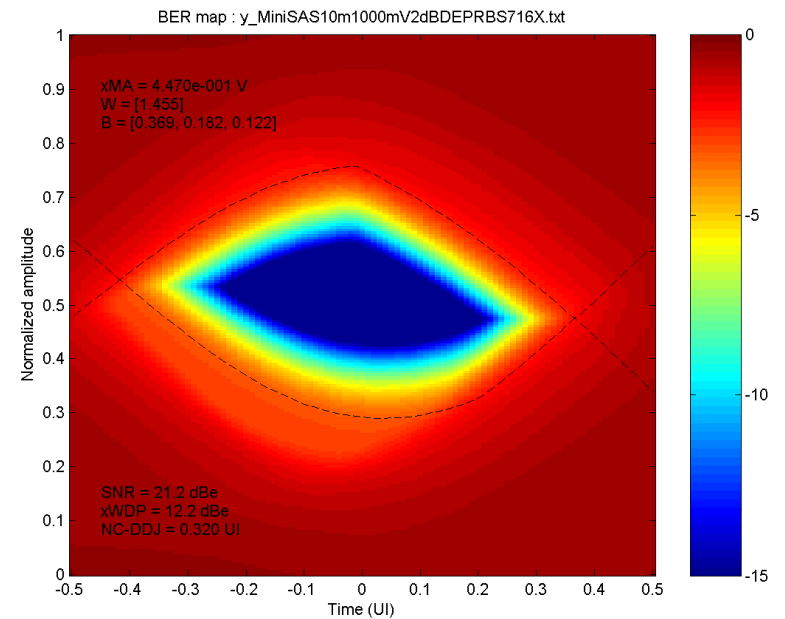
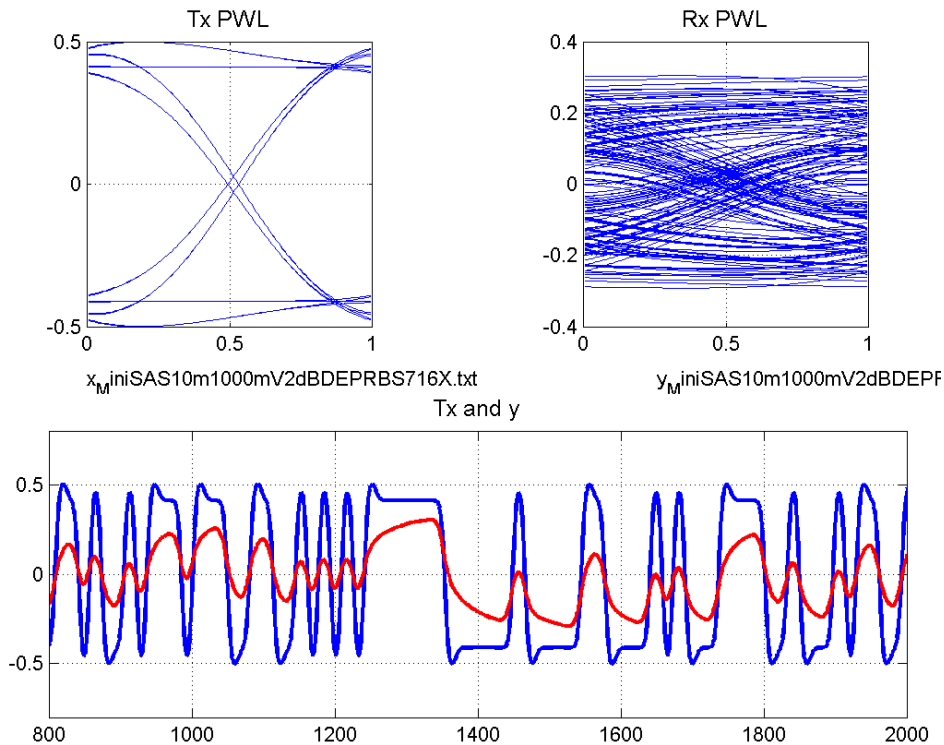
- 1. Transmitter Amplitude Setup at ISI**
  - Set to VMA at Channel Output w/ D24.3
- 2. ISI Generator Calibration**
  - Compute xWDP > 13dBe
  - Adjust ISI Filter such that Compute xWDP > 13dBe
- 3. Transmitter Jitter Calibration at input to ISI Generator**
- 4. Crosstalk**
  - Use Bounded Crosstalk Source and Adjust Amplitude to 4mV rms
- 5. Test – Confirm BER < 1e-12**



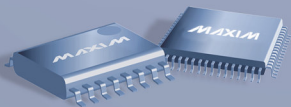


## ISI Generator Compliance Example

- Synthesized 10m MiniSAS cable response
- PWL processes for xWDP estimate



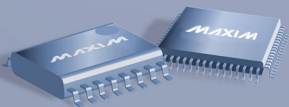
PRBS-7  
xWDP = 12.2 dB  
Veye ~200/1.4  
NC-DDJ = 0.32





## SASWDP Enhancements

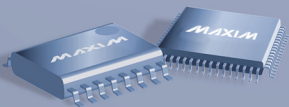
- **Change Q0=7.9419; % for BER =  $10^{-15}$**
- **Normalize eye output, no AGC eye opening, W = 1, like DFEEYE**
- **Return vertical and horizontal eye opening, like DFEEYE**
  - 1e-15
  - ISI only (eye lid)
- **Change hard coded baud rate in specification to variable**
- **Small robustness enhancements**
  - min(find(...
  - Enable row or column vectors as inputs data vectors





## Thoughts / Proposal

- **Tx Compliance**
  - Switch Compliance from eye opening to max xWDP < 13 dBe (TBC)
  - Add NC-DDJ Specification ?
- **Rx ISI Calibration**
  - Leave Compliance ISI generator to xWDP > 13 dBe (TBC)
  - Add NC-DDJ Specification?
- **Incorporate modified SASWDP into as an appendix describing the xWDP algorithm**



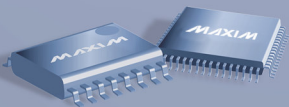


## Next Step

- **Need to determine SAS CJTPAT differences**
- **Need to understand how to model RJ and DJ specs in Tx compliance test.**
- **Need more users trying this code with real hardware**

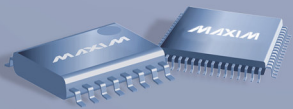
## Summary

- **Initial runs complete and a few issues observed**
- **With some work this code can serve as a Reference Rx.**
- **With this code and some specification changes we might be able to wrap up the open technical SAS-2 compliance test Issues/ comments**





## Backup Material

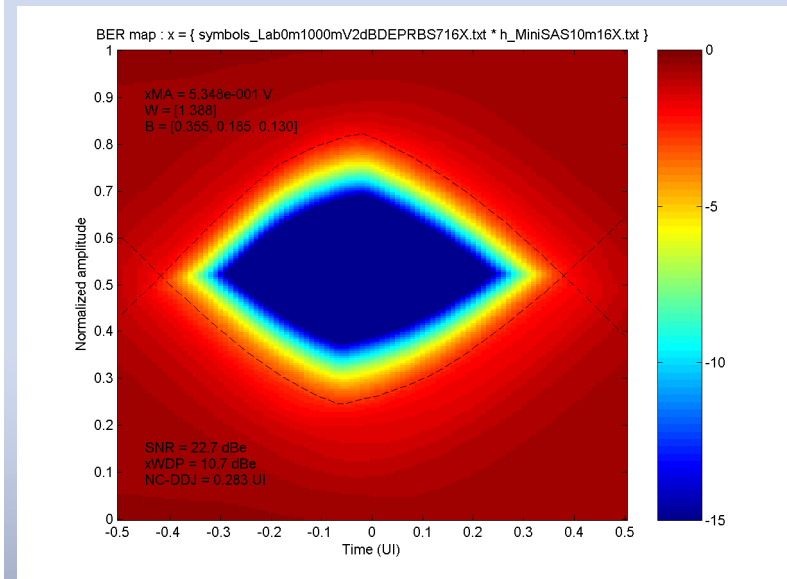
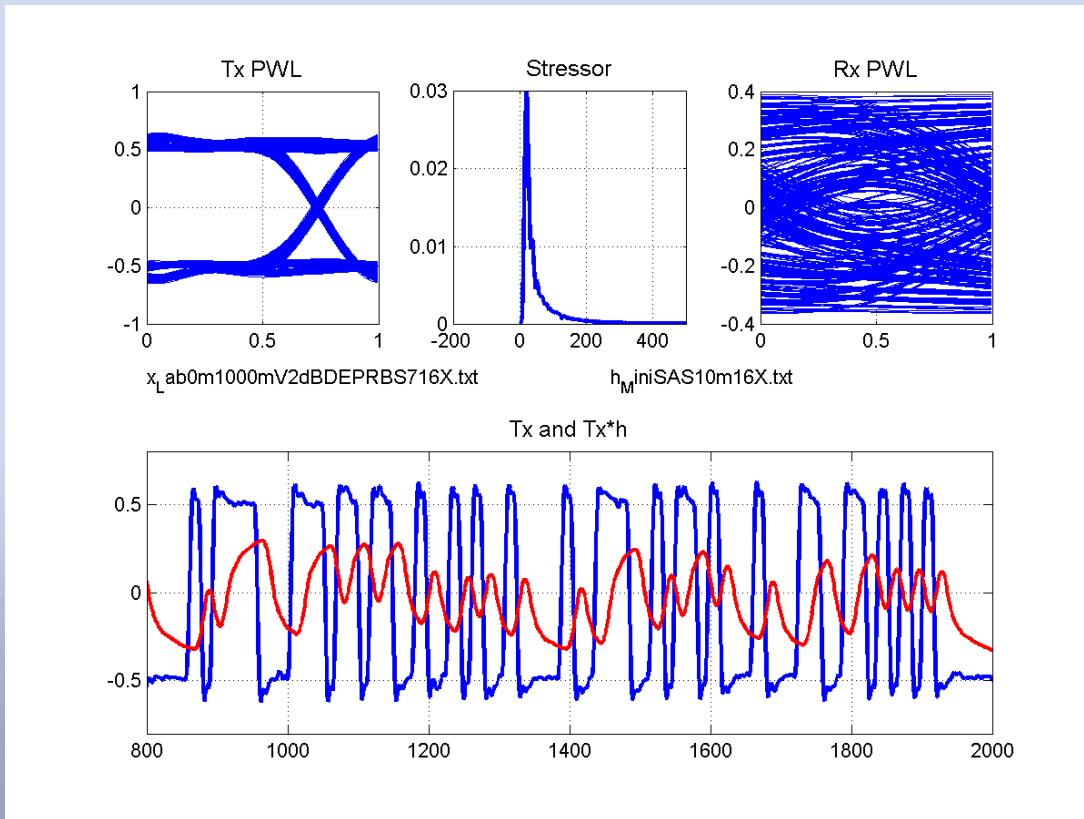




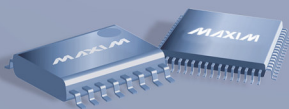


## ISI Generator Compliance Example #2

- Test equipment: pattern generator, de-emphasis generator, 10m Cable



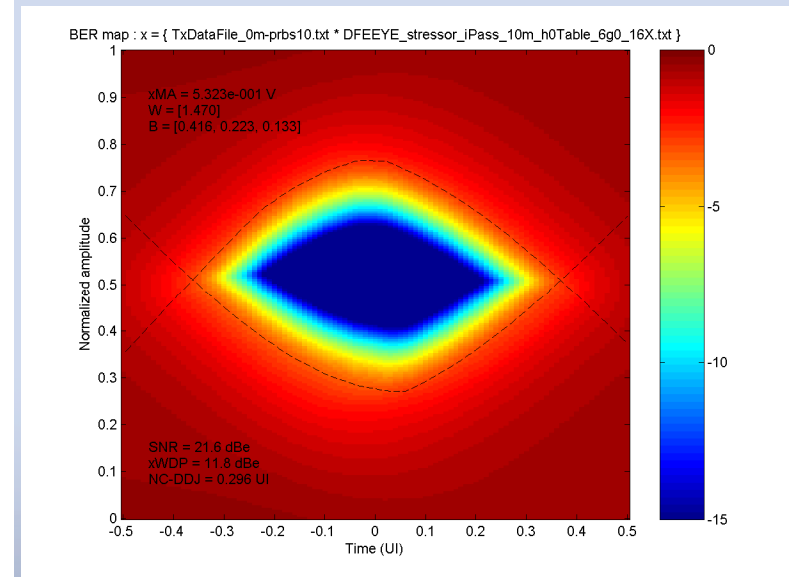
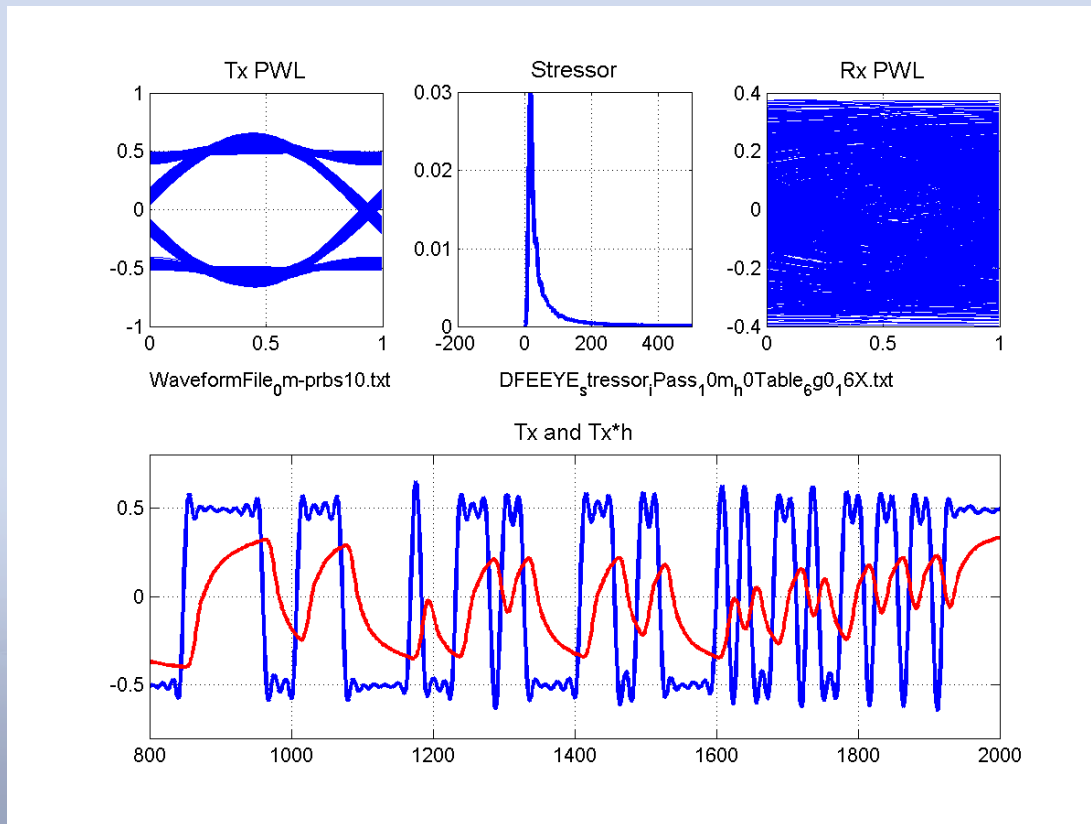
SNR = 22.7  
xWDP = 10.7  
Veye ~300/1.38  
NC-DDJ = 283



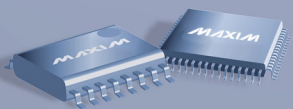


## PRBS-7 Tx Compliance Example #1b

- Test equipment: pattern generator & de-emphasis generator



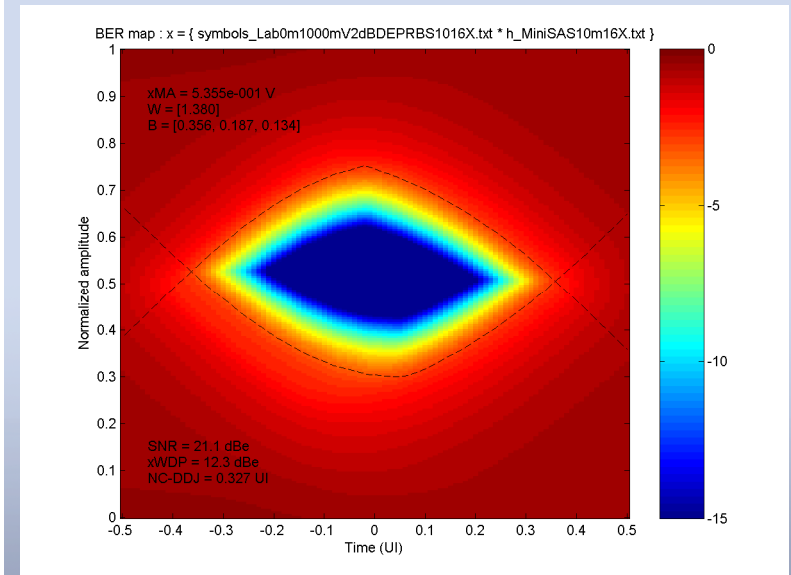
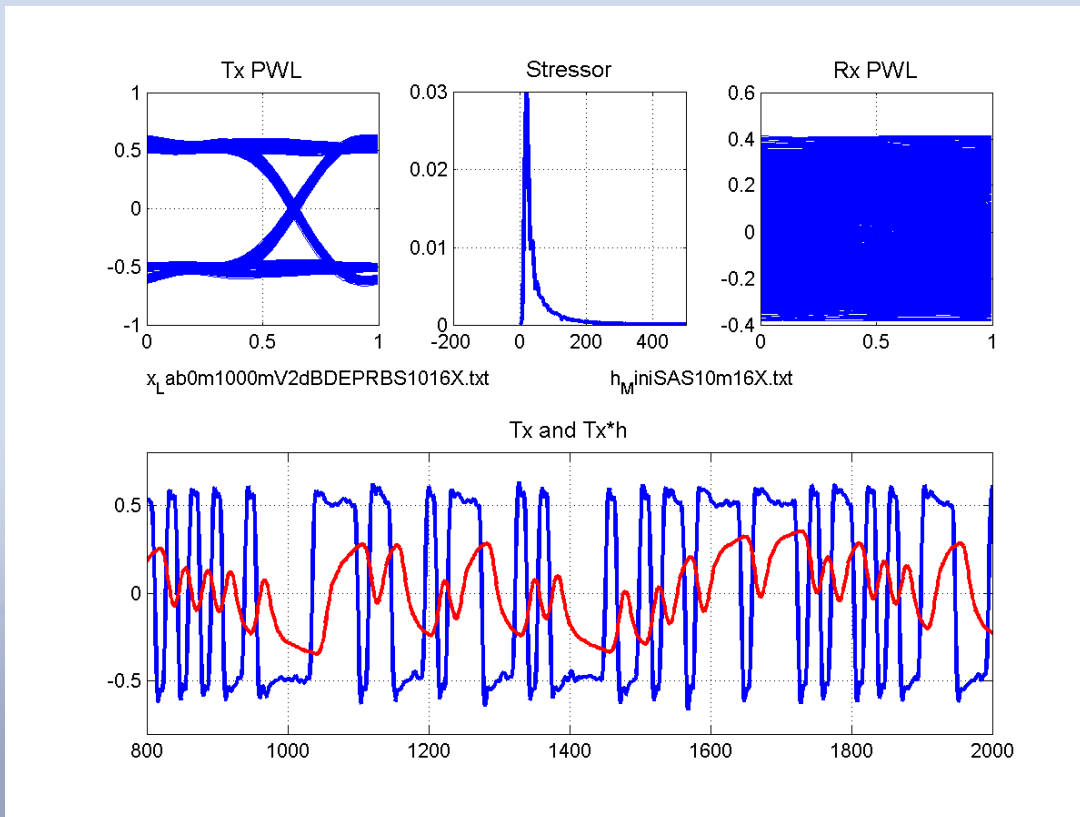
SNR = 21.6  
xWDP = 11.8  
Veye ~200/1.47



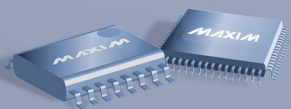


## SAS CJTPAT Tx Compliance Example #3

- Test equipment: pattern generator & de-emphasis generator



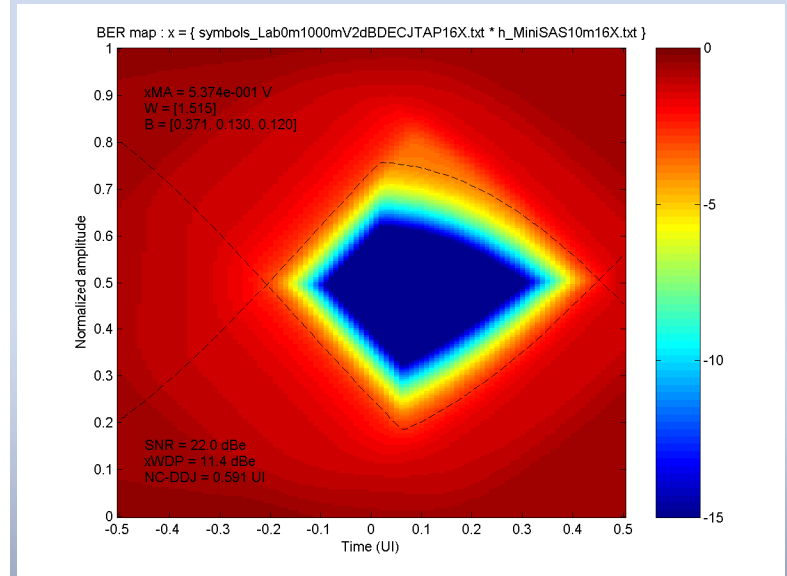
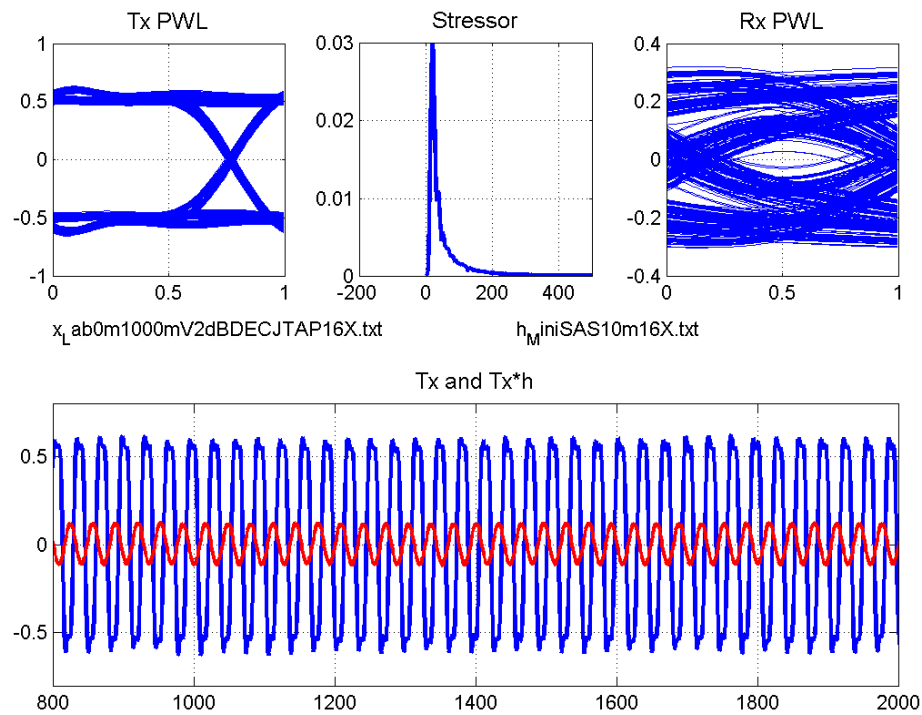
SNR = 22.7  
xWDP = 10.7  
Veye ~300/1.38  
NC-DDJ = 0.327



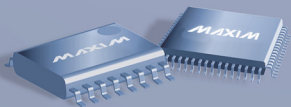


## SAS CJTPAT Tx Compliance Example #4

- Test equipment: pattern generator & de-emphasis generator

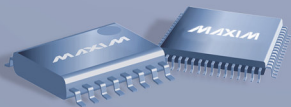
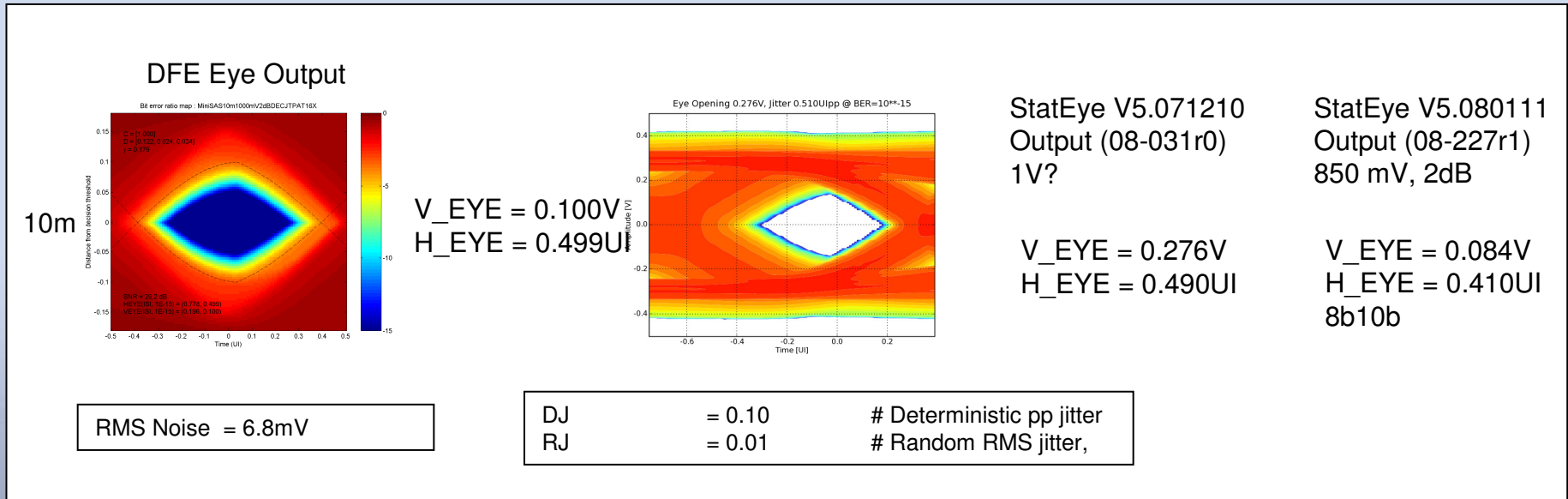


SNR = 22.0  
xWDP = 11.4  
Veye ~300/1.5  
NC-DDJ = 0.501



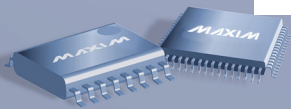
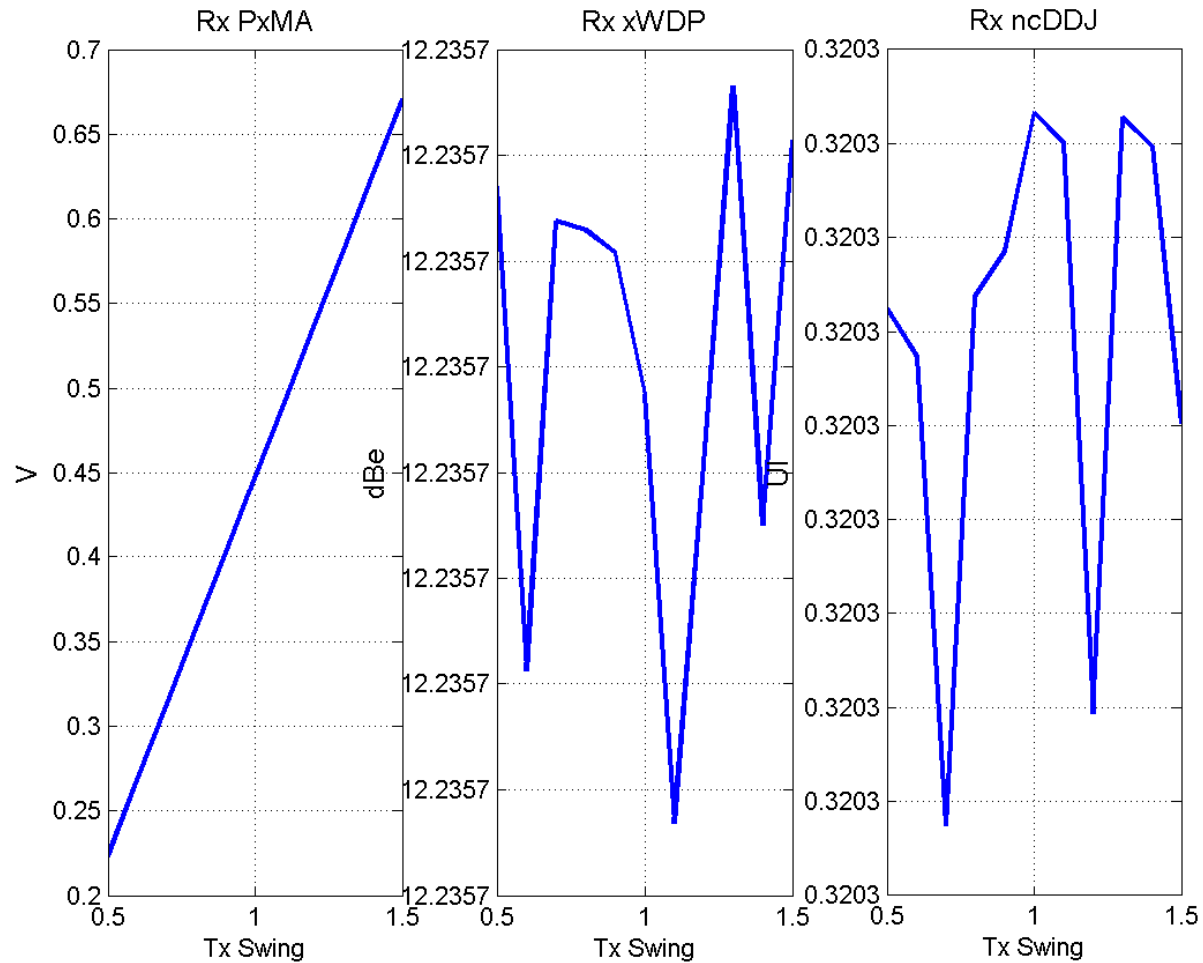
## Fundamental Difference

- **DFE Eye uses input referred noise w/o Tx Jitter**
  - AM to PM causes Jitter
- **StatEye uses jitter w/o input referred noise.**



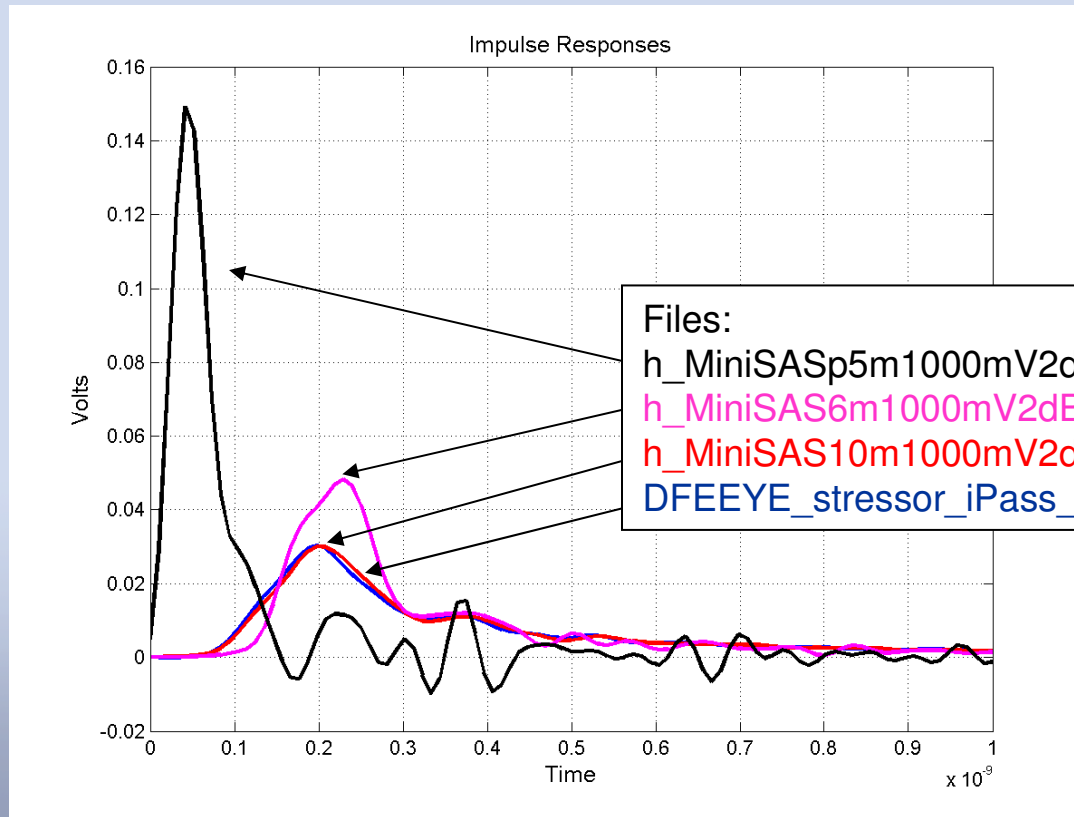
## xWDP vs Tx Swing

- **xWDP Measures ISI and is independent of Tx Swing**

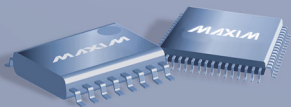


## Channels of Interest

- Channels & Impulse Responses Considered



Note: Noise\_rms = 6.8mV in All Files







## 08-330r0 Post Files

### Matlab Code

DFEEYE\_1p1\_Mod2.m  
 Data files to be located in ./T10\_datafiles  
 Images written to ./T10\_graphics

### Baseline example files

DFEEYE\_stressor\_iPass\_10m\_h0Table\_6g0\_16X.txt  
 SAS\_CJTPAT\_samples.txt  
 SAS\_CJTPAT\_symbols.txt  
 y\_SAS\_CJTPAT.txt ( a waveform generated by DFEEYE)

### Synthesized Impulse Responses

h\_MiniSAS10m1000mV0dBDECJTAP16X.txt  
 h\_MiniSAS6m1000mV0dBDEPRBS716X.txt  
 h\_MiniSASp5m1000mV2dBDECJTAP16X.txt  
 h\_MiniSAS10m1000mV0dBDEPRBS716X.txt  
 h\_MiniSAS6m1000mV2dBDECJTAP16X.txt  
 h\_MiniSASp5m1000mV2dBDEPRBS716X.txt  
 h\_MiniSAS10m1000mV2dBDECJTAP16X.txt  
 h\_MiniSAS6m1000mV2dBDEPRBS716X.txt  
 h\_MiniSAS10m1000mV2dBDEPRBS716X.txt  
 h\_MiniSASp5m1000mV0dBDECJTAP16X.txt  
 h\_MiniSAS6m1000mV0dBDECJTAP16X.txt  
 h\_MiniSASp5m1000mV0dBDEPRBS716X.txt

### Symbol files

symbols\_LabMiniSAS10m1000mV2dBDECJTAP16X.txt  
 symbols\_MiniSAS6m1000mV0dBDEPRBS716X.txt  
 symbols\_LabMiniSAS10m1000mV2dBDEPRBS716X.txt  
 symbols\_MiniSAS6m1000mV2dBDECJTAP16X.txt  
 symbols\_LabMiniSAS6m1000mV2dBDECJTAP16X.txt  
 symbols\_MiniSAS6m1000mV2dBDEPRBS716X.txt  
 symbols\_LabMiniSAS6m1000mV2dBDEPRBS716X.txt  
 symbols\_MiniSASp5m1000mV0dBDECJTAP16X.txt  
 symbols\_MiniSAS10m1000mV0dBDECJTAP16X.txt  
 symbols\_MiniSASp5m1000mV0dBDEPRBS716X.txt  
 symbols\_MiniSAS10m1000mV0dBDEPRBS716X.txt  
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 symbols\_MiniSAS10m1000mV2dBDECJTAP16X.txt  
 symbols\_MiniSASp5m1000mV2dBDEPRBS716X.txt  
 symbols\_MiniSAS10m1000mV2dBDEPRBS716X.txt  
 symbols\_MiniSASp5m1000mV2dBDEPRBS716X.txt  
 symbols\_MiniSAS10m1000mV2dBDEPRBS716X.txt  
 symbols\_MiniSAS6m1000mV0dBDECJTAP16X.txt

### Samples files ( Symbols file at sample rate )

samples\_LabMiniSAS10m1000mV2dBDECJTAP16X.txt  
 samples\_MiniSAS6m1000mV0dBDEPRBS716X.txt  
 samples\_LabMiniSAS10m1000mV2dBDEPRBS716X.txt  
 samples\_MiniSAS6m1000mV2dBDECJTAP16X.txt  
 samples\_LabMiniSAS6m1000mV2dBDECJTAP16X.txt  
 samples\_MiniSAS6m1000mV2dBDEPRBS716X.txt  
 samples\_LabMiniSAS6m1000mV2dBDEPRBS716X.txt  
 samples\_MiniSASp5m1000mV0dBDECJTAP16X.txt  
 samples\_MiniSAS10m1000mV0dBDECJTAP16X.txt  
 samples\_MiniSASp5m1000mV0dBDEPRBS716X.txt  
 samples\_MiniSAS10m1000mV0dBDEPRBS716X.txt  
 samples\_MiniSASp5m1000mV2dBDECJTAP16X.txt  
 samples\_MiniSAS10m1000mV2dBDECJTAP16X.txt  
 samples\_MiniSASp5m1000mV2dBDEPRBS716X.txt  
 samples\_MiniSAS10m1000mV2dBDEPRBS716X.txt  
 samples\_MiniSASp5m1000mV2dBDEPRBS716X.txt  
 samples\_MiniSAS10m1000mV2dBDEPRBS716X.txt  
 samples\_MiniSAS6m1000mV0dBDECJTAP16X.txt

### Channel Output pwl

y\_LabMiniSAS10m1000mV2dBDECJTAP16X.txt  
 y\_MiniSAS6m1000mV0dBDEPRBS716X.txt  
 y\_LabMiniSAS10m1000mV2dBDEPRBS716X.txt  
 y\_MiniSAS6m1000mV2dBDECJTAP16X.txt  
 y\_LabMiniSAS6m1000mV2dBDECJTAP16X.txt  
 y\_MiniSAS6m1000mV2dBDEPRBS716X.txt  
 y\_LabMiniSAS6m1000mV2dBDEPRBS716X.txt  
 y\_MiniSASp5m1000mV0dBDECJTAP16X.txt  
 y\_MiniSAS10m1000mV0dBDECJTAP16X.txt  
 y\_MiniSASp5m1000mV0dBDEPRBS716X.txt  
 y\_MiniSAS10m1000mV0dBDEPRBS716X.txt  
 y\_MiniSASp5m1000mV2dBDECJTAP16X.txt  
 y\_MiniSAS10m1000mV2dBDECJTAP16X.txt  
 y\_MiniSASp5m1000mV2dBDEPRBS716X.txt  
 y\_MiniSAS10m1000mV2dBDEPRBS716X.txt  
 y\_MiniSAS6m1000mV0dBDECJTAP16X.txt

### Channel input pwl

x\_LabMiniSAS10m1000mV2dBDECJTAP16X.txt  
 x\_MiniSAS6m1000mV0dBDEPRBS716X.txt  
 x\_LabMiniSAS10m1000mV2dBDEPRBS716X.txt  
 x\_MiniSAS6m1000mV2dBDECJTAP16X.txt  
 x\_LabMiniSAS6m1000mV2dBDECJTAP16X.txt  
 x\_MiniSAS6m1000mV2dBDEPRBS716X.txt  
 x\_LabMiniSAS6m1000mV2dBDEPRBS716X.txt  
 x\_MiniSASp5m1000mV0dBDECJTAP16X.txt  
 x\_MiniSAS10m1000mV0dBDECJTAP16X.txt  
 x\_MiniSASp5m1000mV0dBDEPRBS716X.txt  
 x\_MiniSAS10m1000mV0dBDEPRBS716X.txt  
 x\_MiniSASp5m1000mV2dBDECJTAP16X.txt  
 x\_MiniSAS10m1000mV2dBDECJTAP16X.txt  
 x\_MiniSASp5m1000mV2dBDEPRBS716X.txt  
 x\_MiniSAS10m1000mV2dBDEPRBS716X.txt  
 x\_MiniSAS6m1000mV0dBDECJTAP16X.txt

