

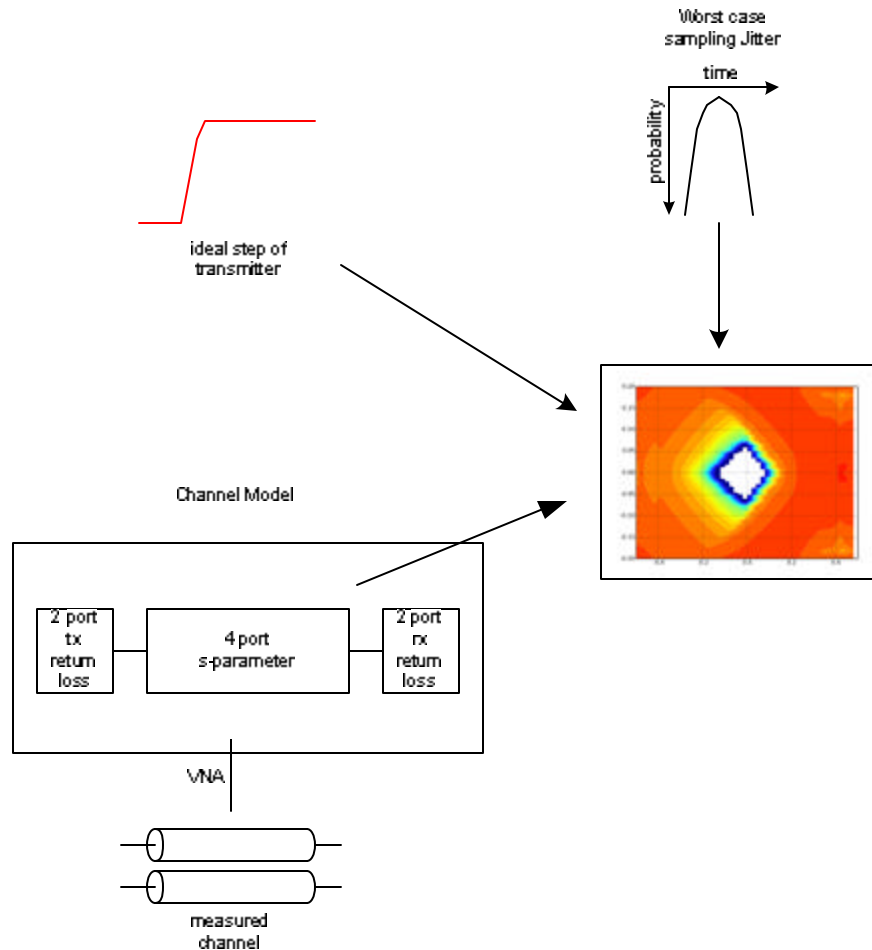
SAS-2 Application of StatEye v5

Anthony Sanders
Harvey Newman
Monday, 05 Nov 07
T10/07-491r1



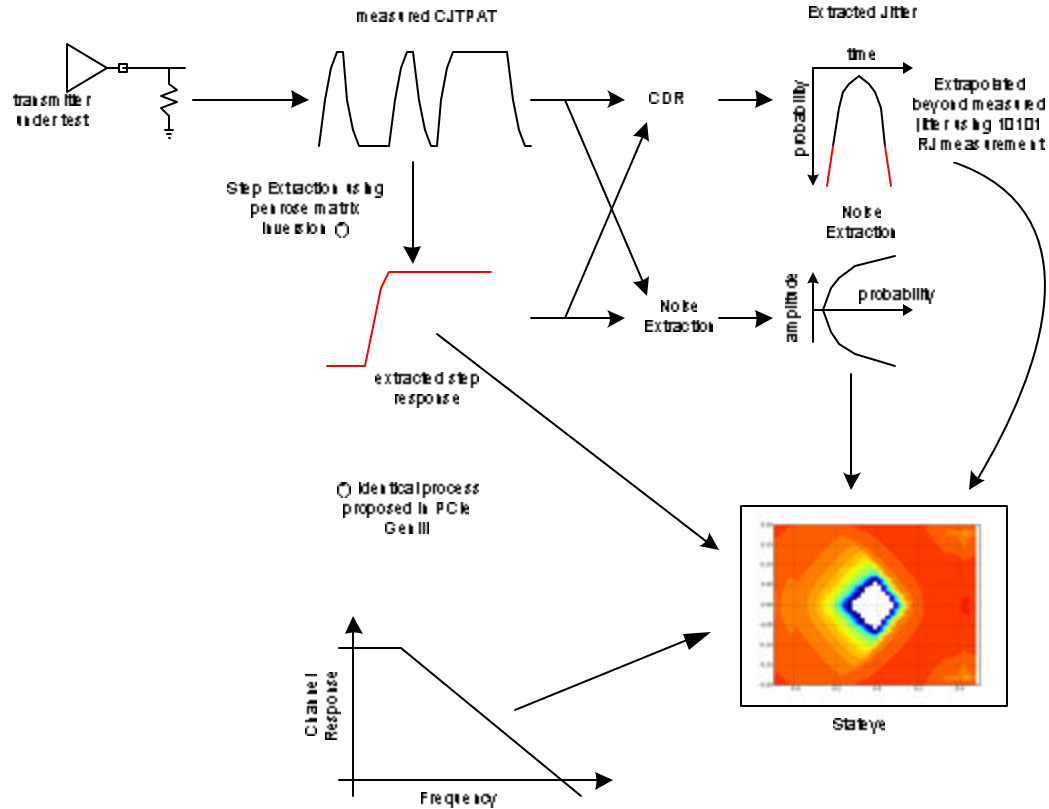
Never stop thinking

Channel Compliance



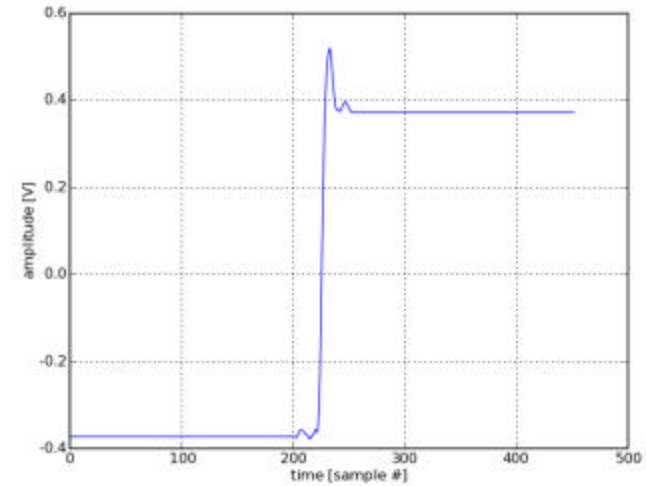
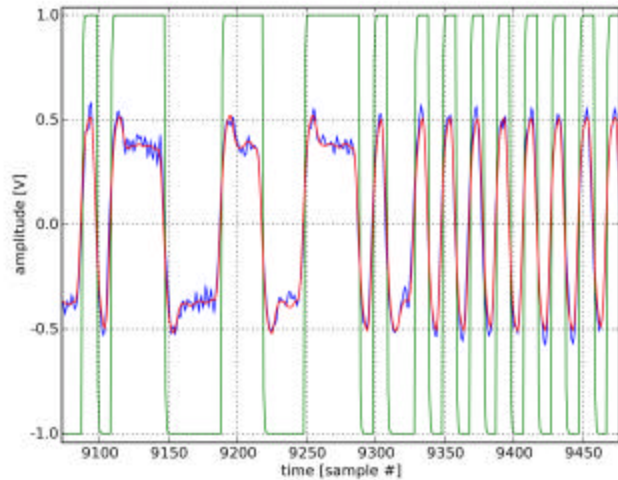
- Channel compliance is the classic usage model of stateeye, with a measured channel being cascaded with reference return loss models of the transmitter and receiver
- In combination with a worst case transmit jitter and ideal step response, the channel capability with a given equalisation de-emphasis and DFE can be tested
- A GUI Wizard is currently in development

Transmitter Compliance



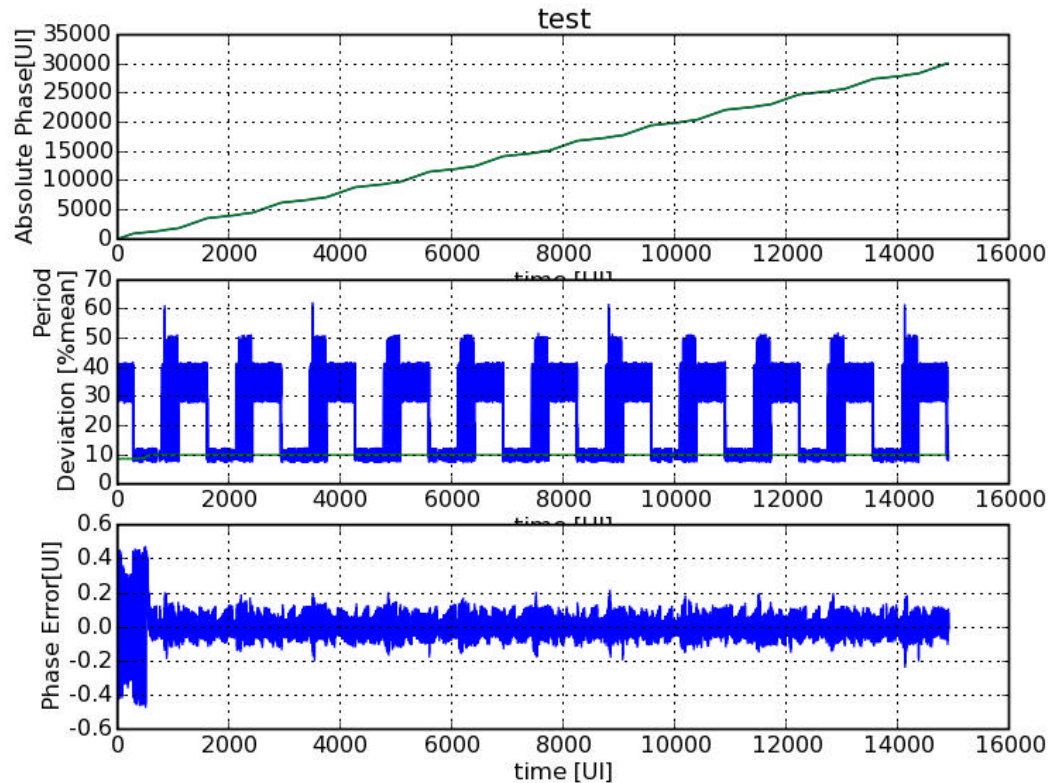
- Transmitter with CJTPAT is measured into a test load
- From signal the step response is extracted
- Using a CDR and Amplitude Noise Extraction function the timing jitter and amplitude noise is extracted
- These fundamental descriptions of the transmitter in combination with the test channel is then used to generate a Stateye which can be tested against the compliance requirements

Silicon Correlation using real silicon Step Extraction



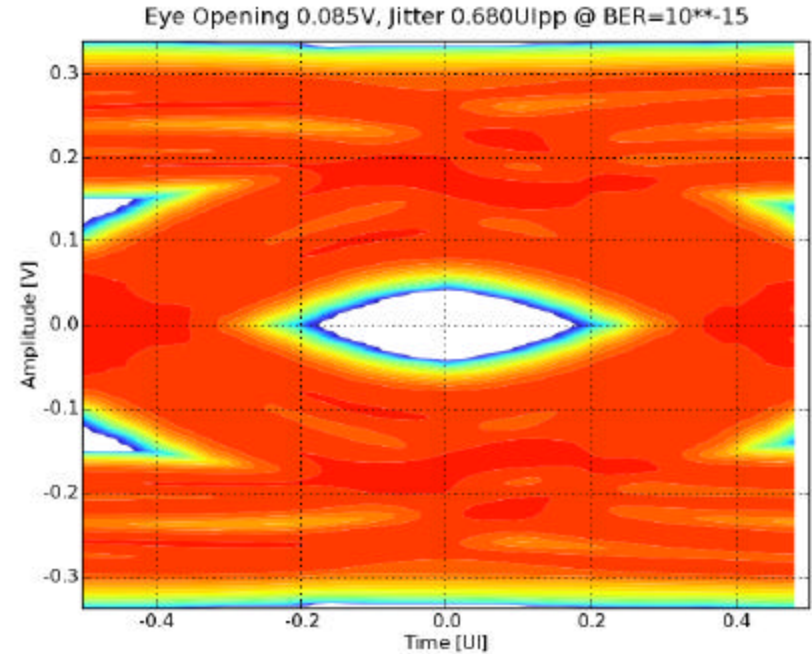
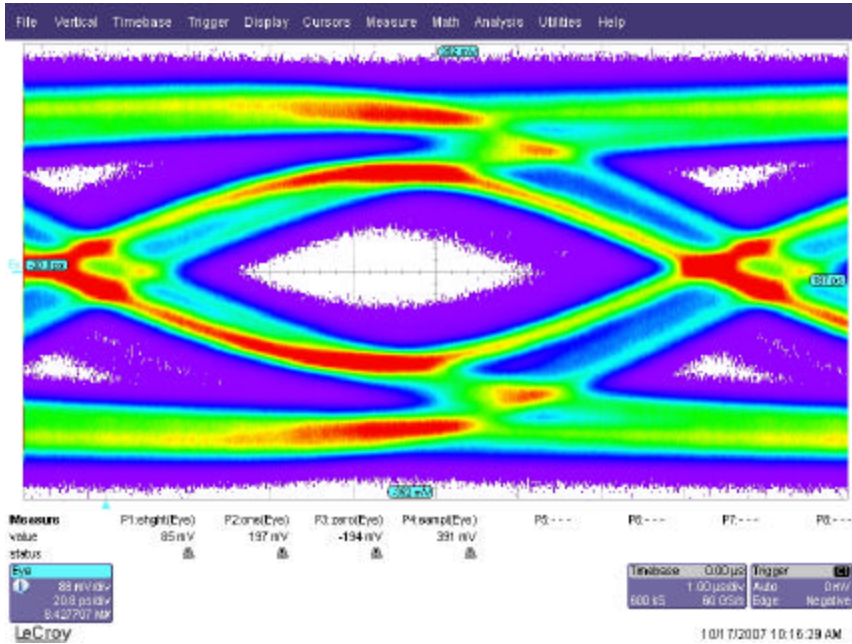
- From a measured CJTPAT signal (blue left) the equivalent step response (right) can be extracted by utilizing a penrose matrix inversion
- The accuracy of the step response is demonstrated by reconstructing the signal (red) using a fundamental transmit signal (green left).
- This fundamental transmit signal (green left) contains the true timing jitter of the transmitter and is then further used for the high frequency sampling jitter extraction
- This method is very similar to currently discussed transmitter compliance testing in PCIe Gen III

Silicon Correlation using real silicon CDR and Jitter Exactration



- The jitter on the fundamental transmit signal is passed through a compliance CDR transfer function, to extract the high frequency sampling jitter.
- This step is fundamentally important, as the measured signal cannot be used directly for compliance testing as the jitter and data are correlated and only represent a single possible case

Silicon Correlation using real silicon

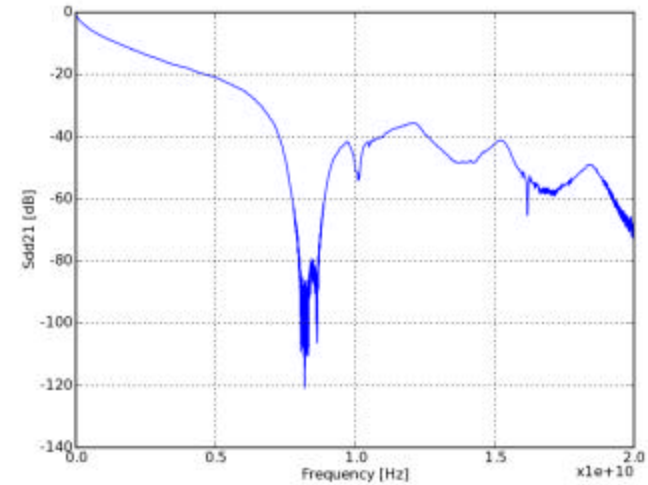
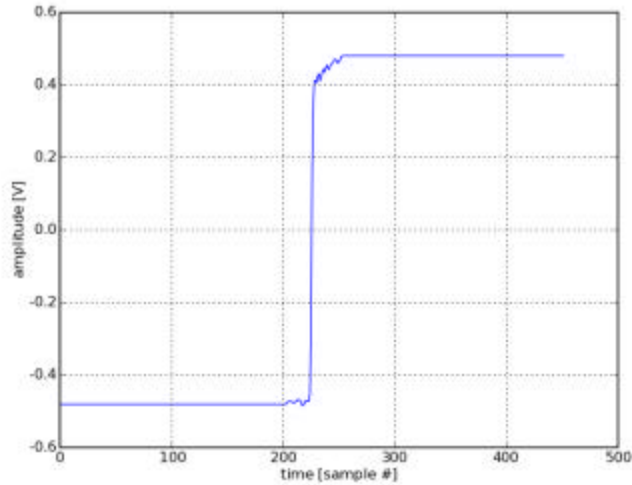


- Using measurements from LeCroy, Tek, and Agilent Real Time and Equivalent Time Scopes a state eye is generated for the output signal of a TCTF channel for no receiver equalization
- When comparing these eye to a measured eye with 0.62UI jitter and 85mV opening, good correction can be seen
- The larger jitter seen with Stateye is clearly a function of the lower sampling population of the RT scope, however, the amplitude shows good correction as the data pattern used has limited statistical content, i.e. 8b10b

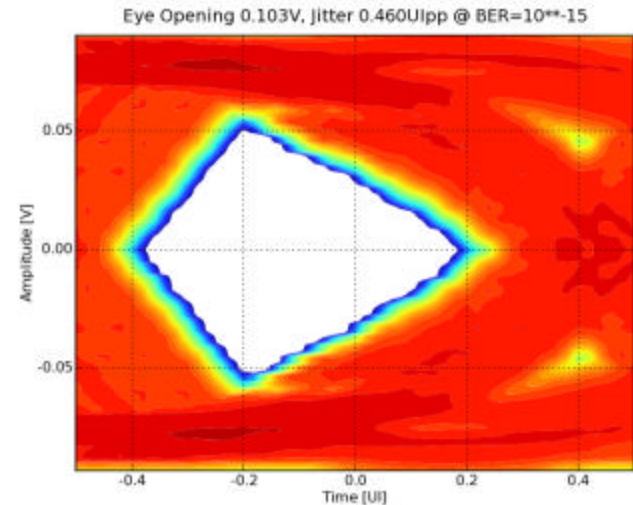
Specification Proposal

- Effective Transmit Jitter ; $DJ=0.15UI_{pp}$, $RJ=0.15UI_{pp}@1e-12$
 - measured with de-emphasis turned on, but measured at virtual test point in transmitter using penrose inversion
- Transmit amplitude ; 1Vppdiff max
- Transmit de-emphasis ; 2dB
- Channel ; Cascaded SAS10m and Transmit/Receiver Reference
- Receiver Equalization ; 3 tap DFE
- Receiver Sensitivity ; 100mVppdiff
- Receiver Jitter ; $0.55UI_{pp}@1e-15$

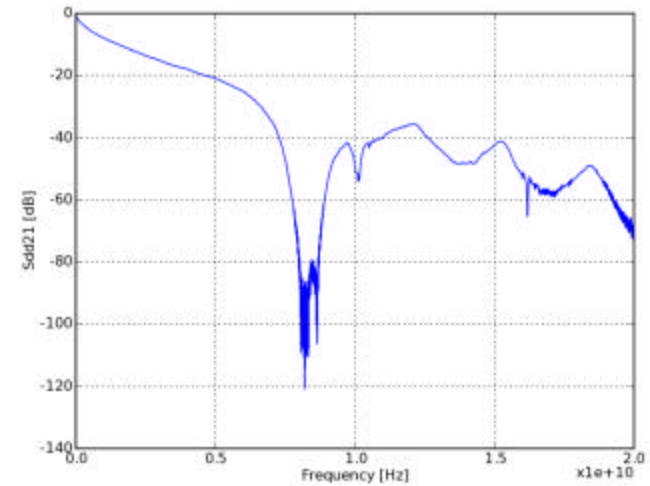
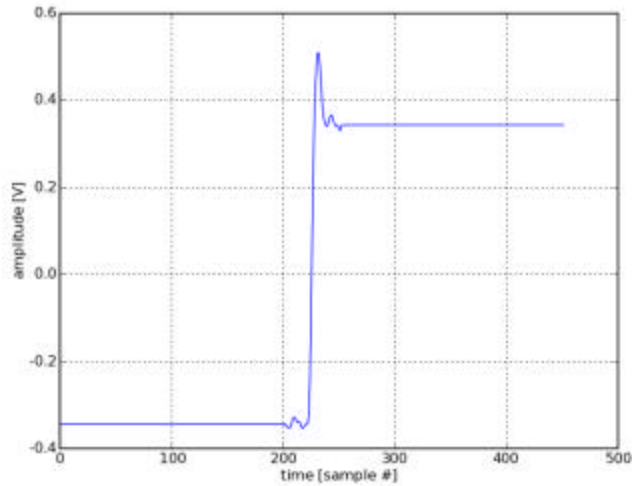
Proof of Specification Proposal Measured BERT with maximum jitter



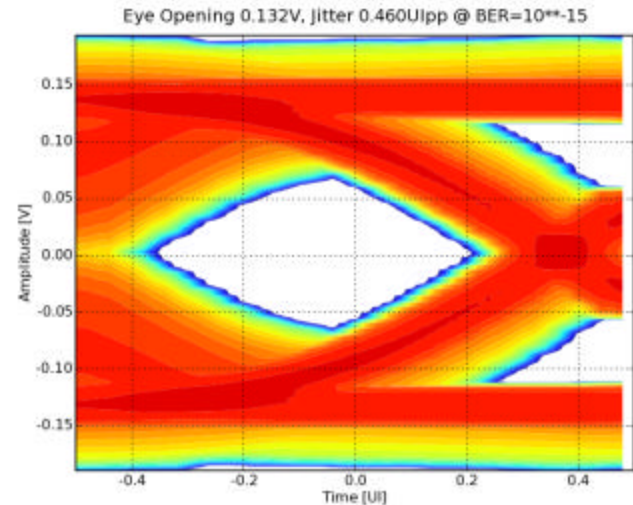
- RT Scope measurement of BERT output is used as basis for step response extraction
- De-emphasis is introduced using Stateye
- SAS 10m cable is used, cascaded with transmitter and receiver return loss model



Proof of Specification Proposal Measured Transmitter with measured jitter



- RT Scope measurement of PHY silicon with de-emphasis turned on is used for step response extraction and jitter extraction
- Good silicon correction was seen with this step response and the TCTF channel
- Resulting eye opening is within compliance requirement



Conclusion

- Stateye v5 has been seen to correlate against silicon measurement
- Stateye v5 has been shown to be able to compliance test a silicon transmitter based on generally available test equipment
- Propose Stateye v5 as
 - a means for transmitter compliance testing of SAS Gen III transmitters
 - a means for channel compliance testing of SAS Gen III cables
- Propose transmit jitter, transmit amplitude, transmit de-emphasis, reference receiver equalization, and post equalisation receiver tolerance specification as seen on pp.7
- Propose crosstalk is dealt with using a “real” channel, in a similar fashion to Stateye v4

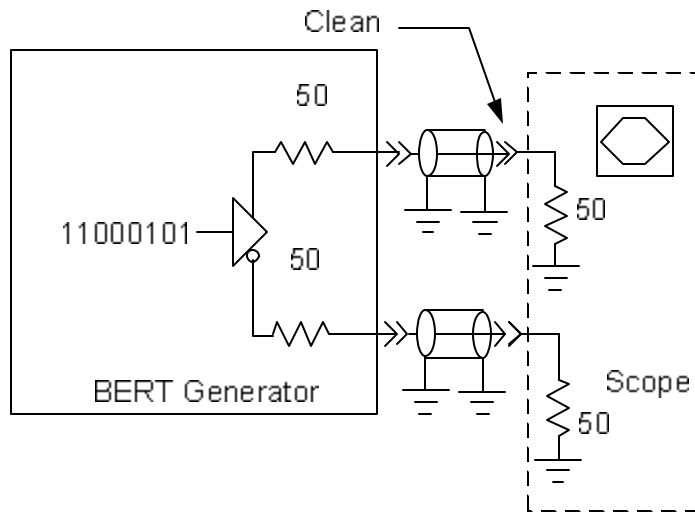
Timescale for final release

- GUI and Wizard for Channel Compliance
 - Edotronik is currently engaged in technical discussion for upgrading the GUI and XML parser to support v5
 - Currently targeting End of December for useable beta release
- Transmit compliance
 - Necessary API for measurement equipment tested for all major instrumentation companies
 - 1st integration of v5 into instrumentation to commence mid November
 - Release date being discussed with Instrumentation companies

Measurements

- Supplemental measurement section

Clean interface

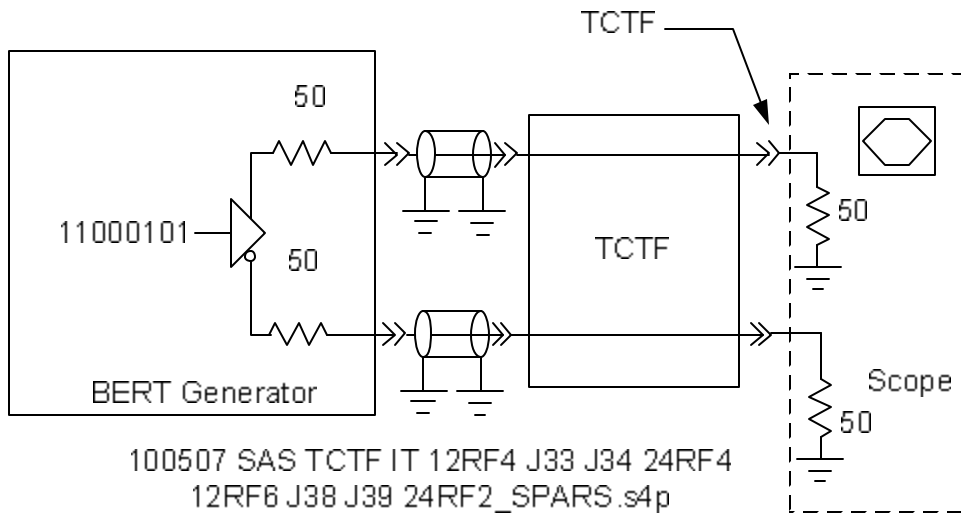


Export, CSV format:
Waveform, TJ, RJ,
Noise, Eye

Screen capture:
Waveform, Eye &
Measurements

Capture:
CJTPAT (2640 bits)

TCTF Measurement

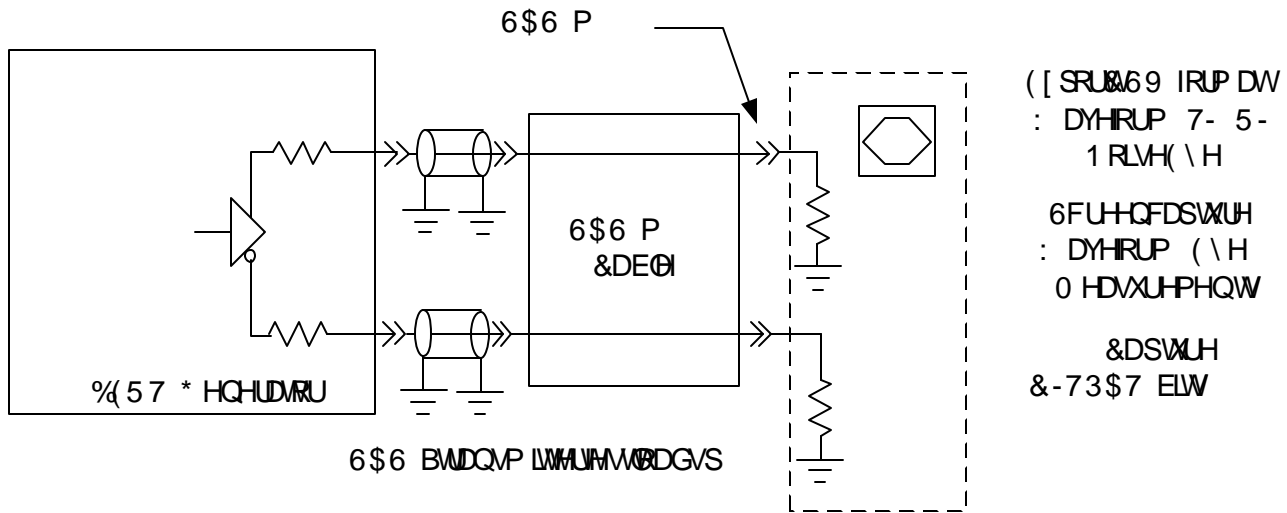


Export, CSV format:
Waveform, TJ, RJ,
Noise, Eye

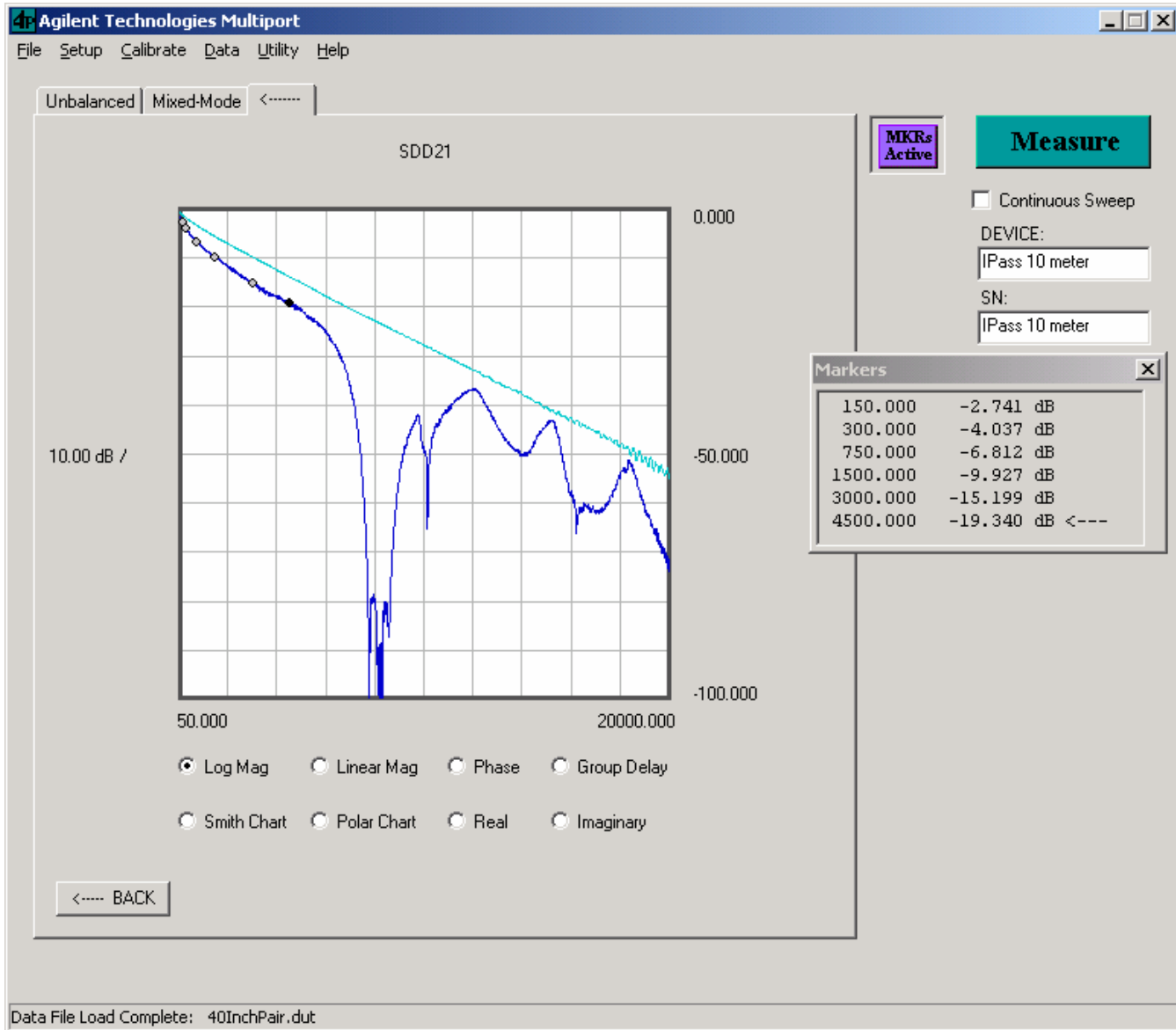
Screen capture:
Waveform, Eye &
Measurements

Capture:
CJTPAT (2640 bits)

SAS 10 m Measurement



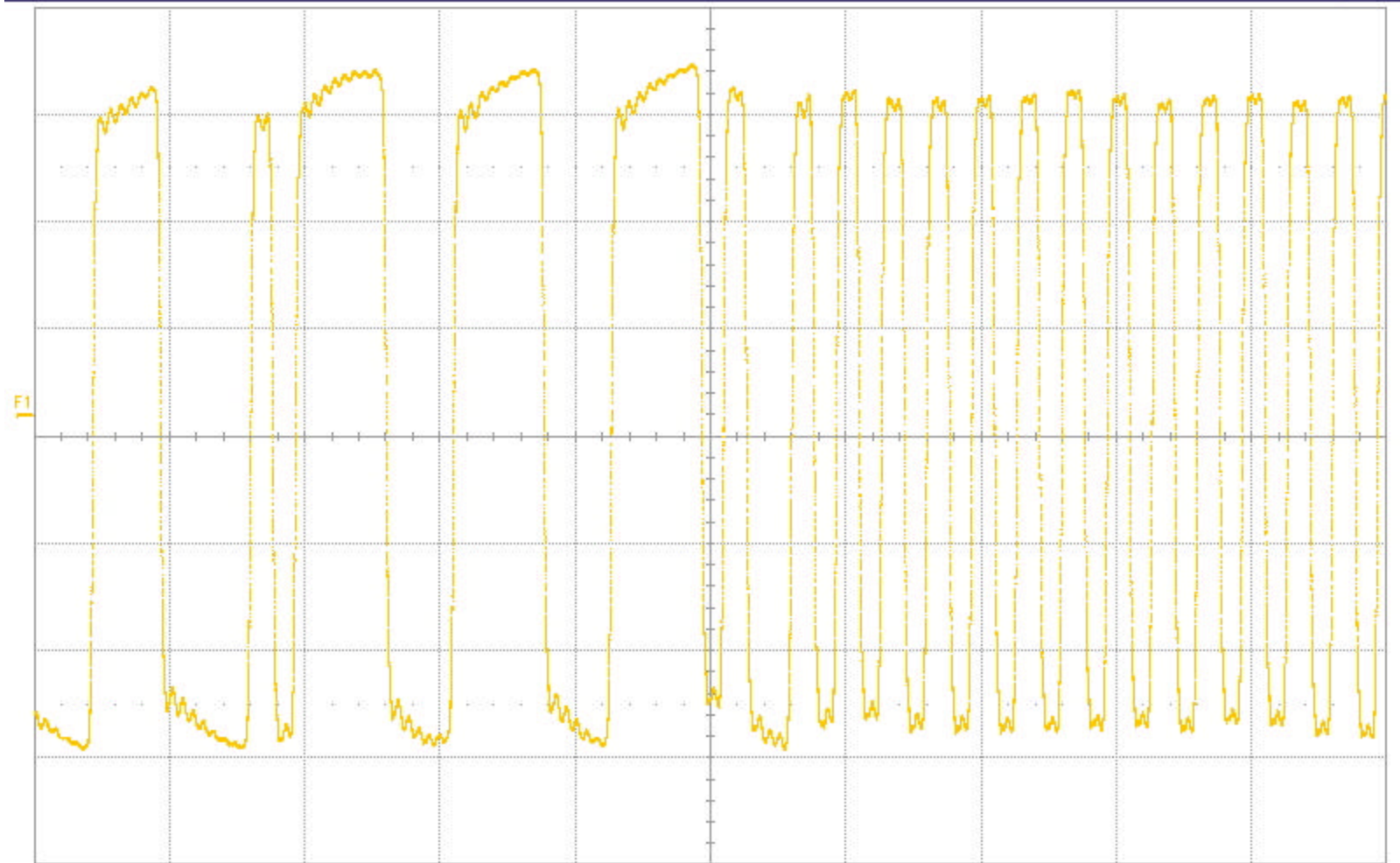
TCTF and SAS 10m



Equivalent Time bert_cjtpat_clean_wfm



File Vertical Timebase Trigger Display Cursors Measure Math Analysis Utilities Help Zoom Undo



F1 (C1-C2)
151 mV/div
1.00 ns/div

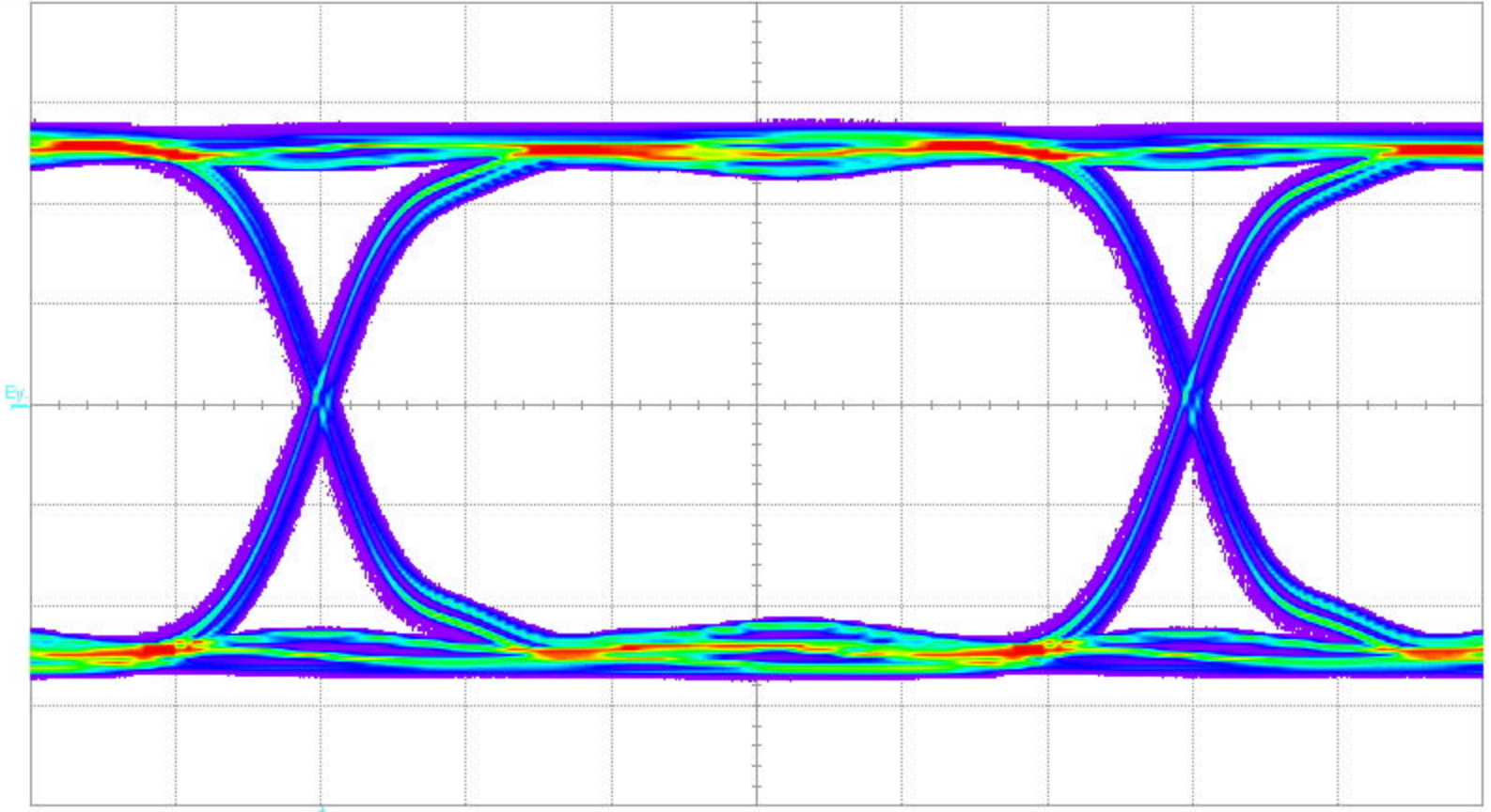
Timebase -24 ns
CIS 100 ns/div
12.3 MS 81 fs/S
Trigger Prescaler
Stop
Edge

LeCroy

10/17/2007 11:34:59 AM

Equivalent Time bert_cjtpat_clean_eye

File Vertical Timebase Trigger Display Cursors Measure Math Analysis Utilities Help



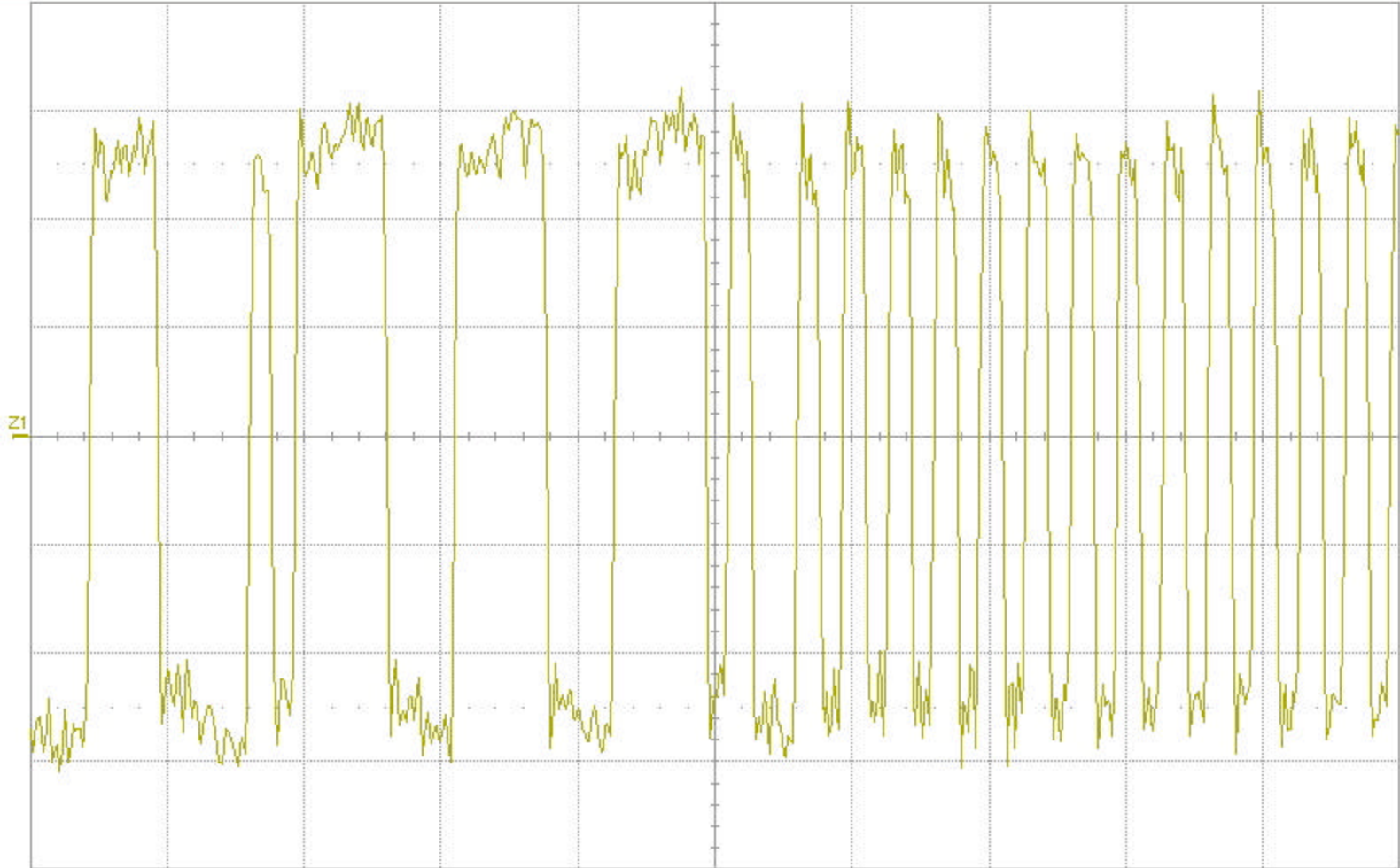
Eye Measure	P1:ehght(Eye)	P2:one(Eye)	P3:zero(Eye)	P4:eamp(Eye)	P5:---	P6:---	P7:---	P8:---
value	731 mV	440 mV	-427 mV	868 mV				
status	✓	✓	✓	✓				

Eye
176 mV/div
27.8 ps/div
12.28800 M#

Timebase -24 ns
CIS 100 ns/div
12.3 MS 81 fs/S
Trigger Prescaler
Stop
Edge

Real Time Bert_CJTPAT_Clean_wfm

File Vertical Timebase Trigger Display Cursors Measure Math Analysis Utilities Help



Z1 zoom(C1)
170 mV/div
1.00 ns/div

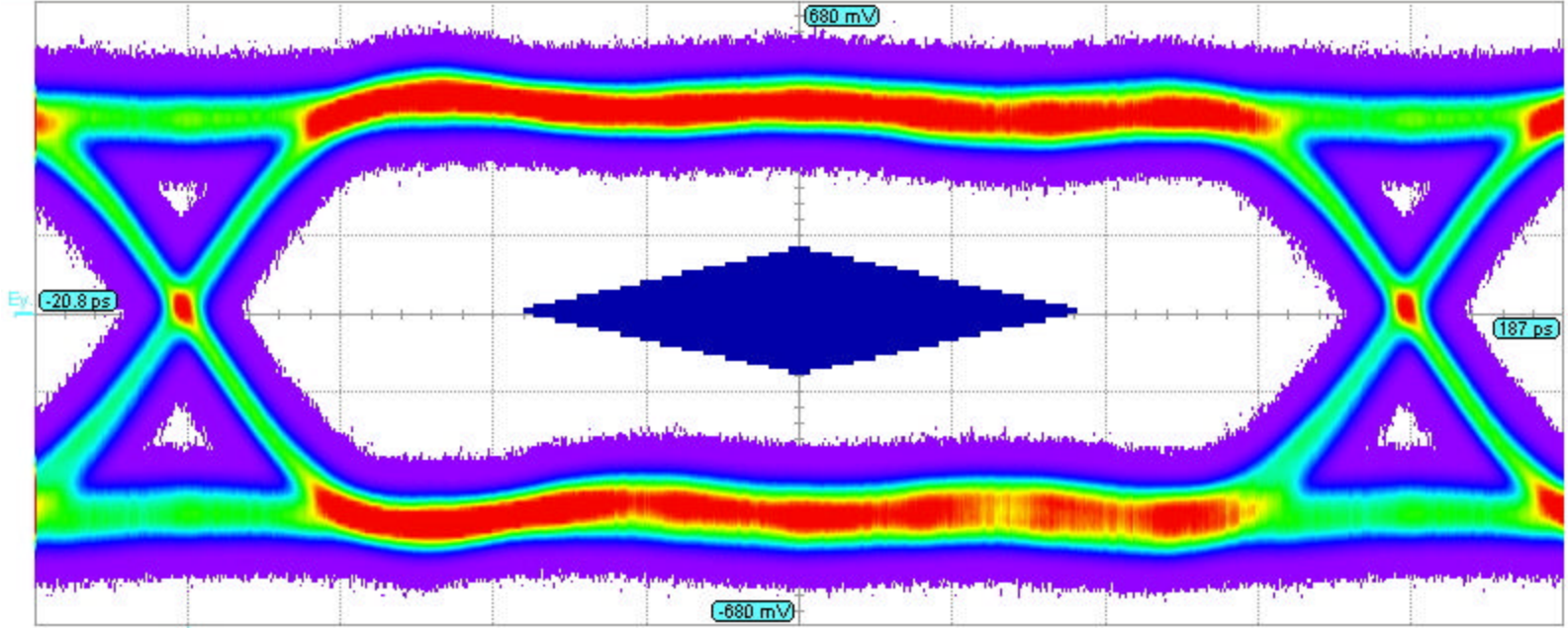
Timebase	0.00 μ s	Trigger	C1
	1.00 μ s/div	Stop	0 mV
600 kS	60 GS/s	Edge	Negative

LeCroy

10/17/2007 7:49:57 AM

Bert_CJTPAT_Clean_Eye

File Vertical Timebase Trigger Display Cursors Measure Math Analysis Utilities Help



Measure	P1:ehght(Eye)	P2:one(Eye)	P3:zero(Eye)	P4:eamp1(Eye)	P5:---	P6:---	P7:---	P8:---
value	669 mV	453 mV	-439 mV	892 mV				
mean	669.0 mV	453.0 mV	-438.7 mV	891.7 mV				
min	669 mV	453 mV	-439 mV	892 mV				
max	669 mV	453 mV	-439 mV	892 mV				
sdev	---	---	---	---				
num	1	1	1	1				
status	✓	✓	✓	✓				
histo	----- ----- ----- ----- ----- ----- ----- -----							

Eye
 170 mV/div
 20.8 ps/div
 19.37266 M#

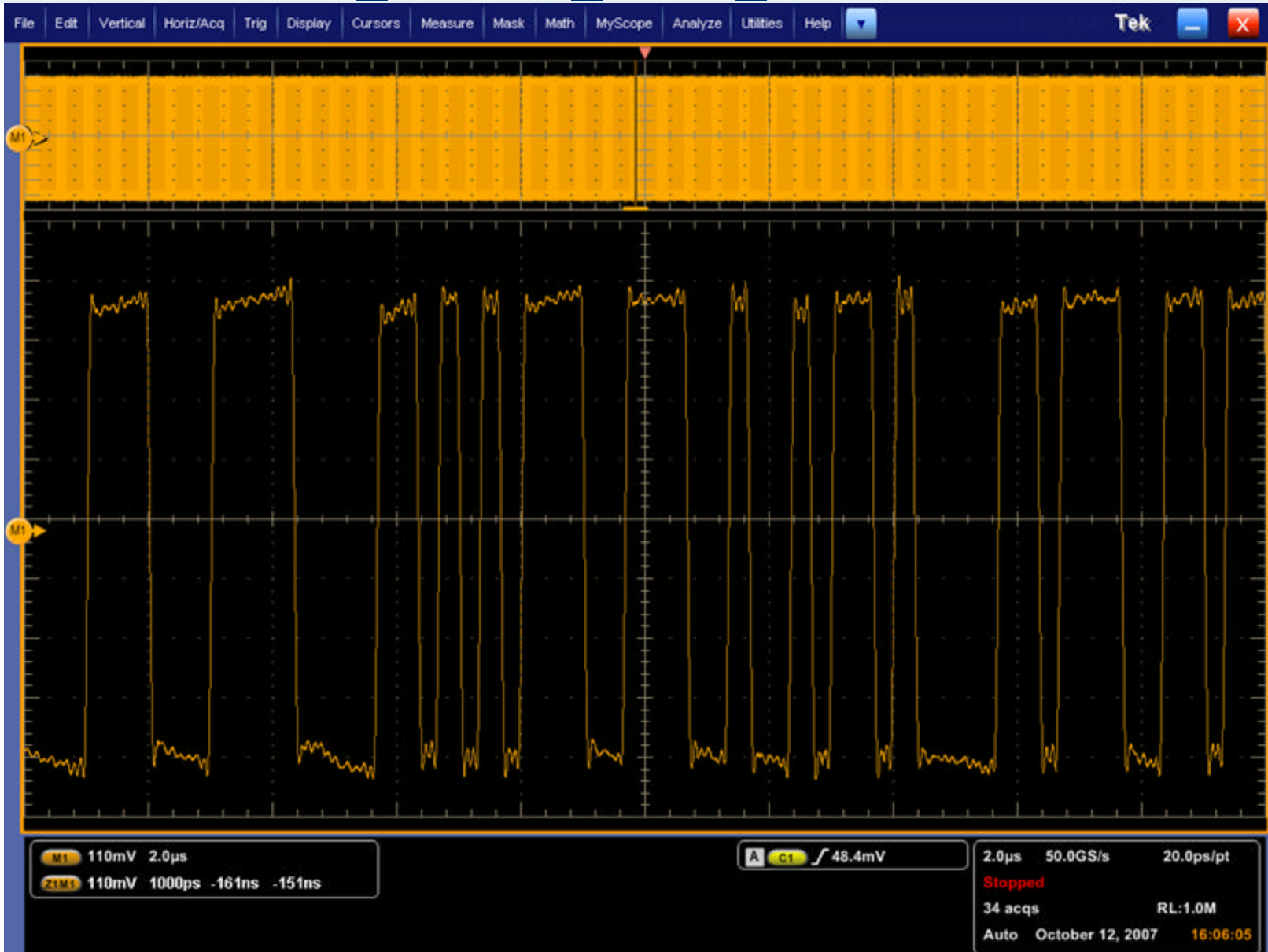
Timebase 0.00 μ s
 1.00 μ s/div
 600 kS
 60 GS/s

Trigger C1
 Stop 0 mV
 Edge Negative

LeCroy

10/17/2007 7:39:38 AM

Real Time BERT_CJTPAT_clean_6G



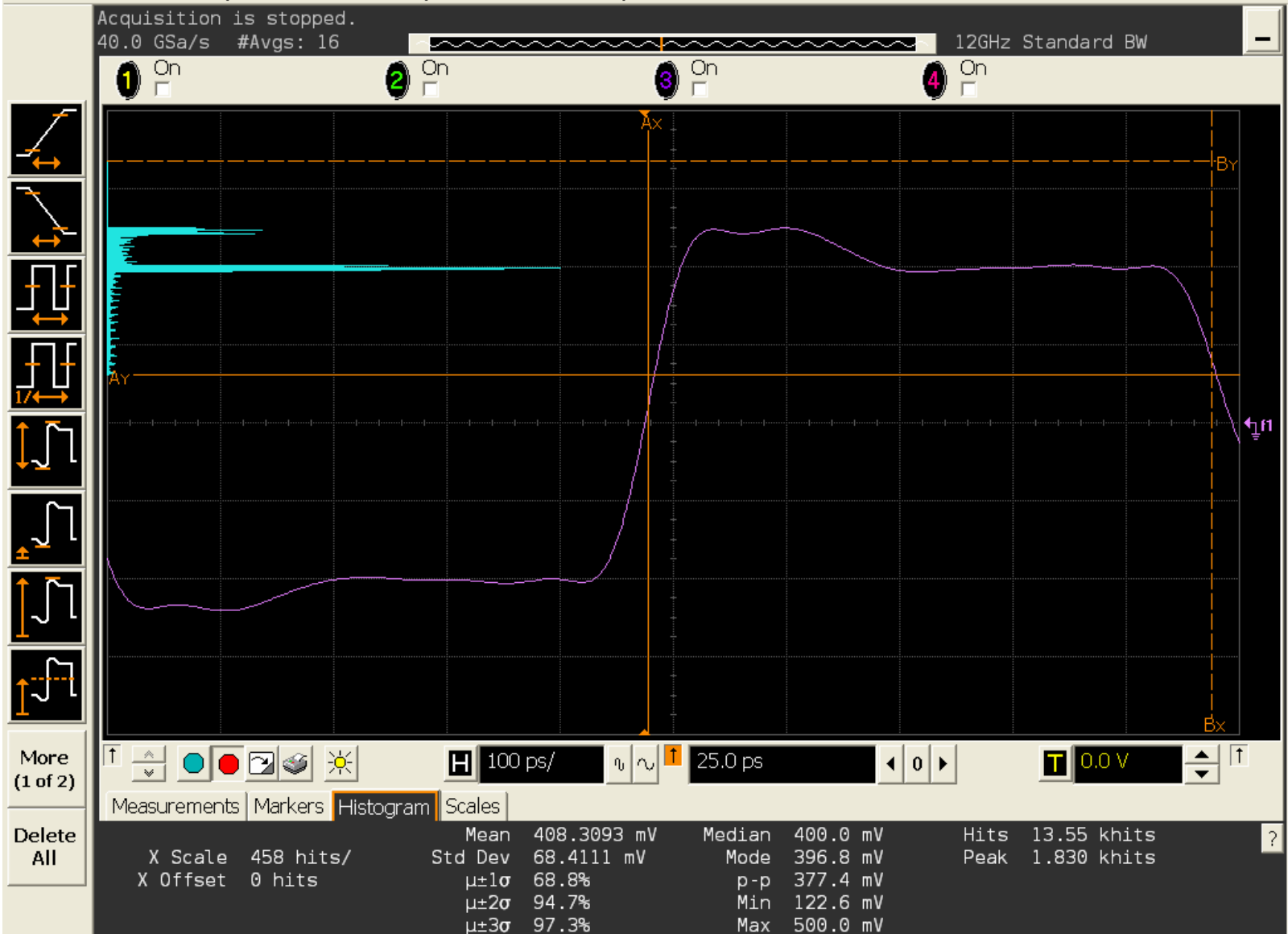
Agilent data used de-emphasis

- All Agilent data used a different signal source.
- Rise time filters were used to show rise times to SAS levels.
- De-emphasis module used to set 2dB.
- Peek to peek amplitude adjusted to 1000mVppd

Real Time SAS_LFTP_VMA_VMax_Histogram

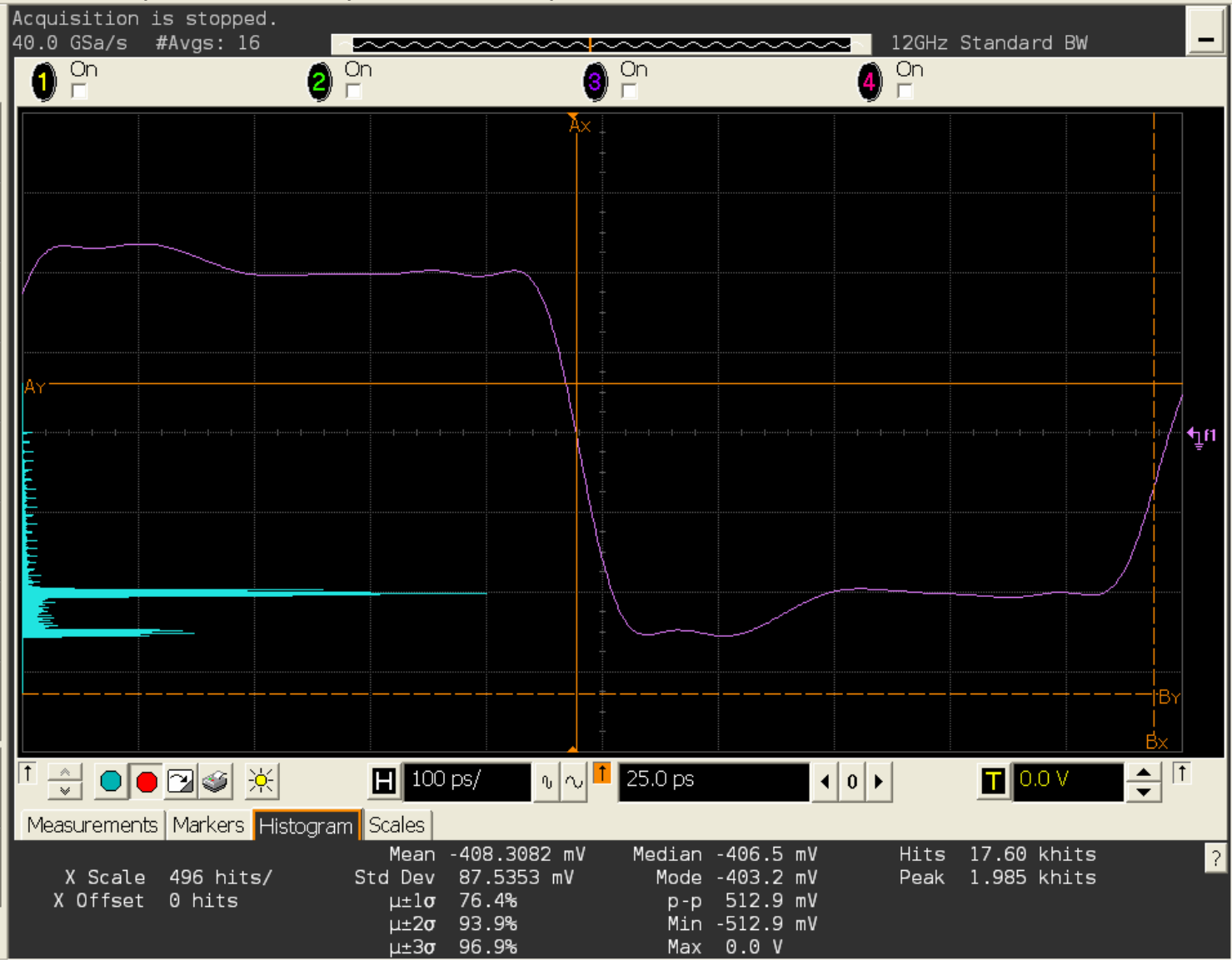
File Control Setup Measure Analyze Utilities Help

10:24 AM

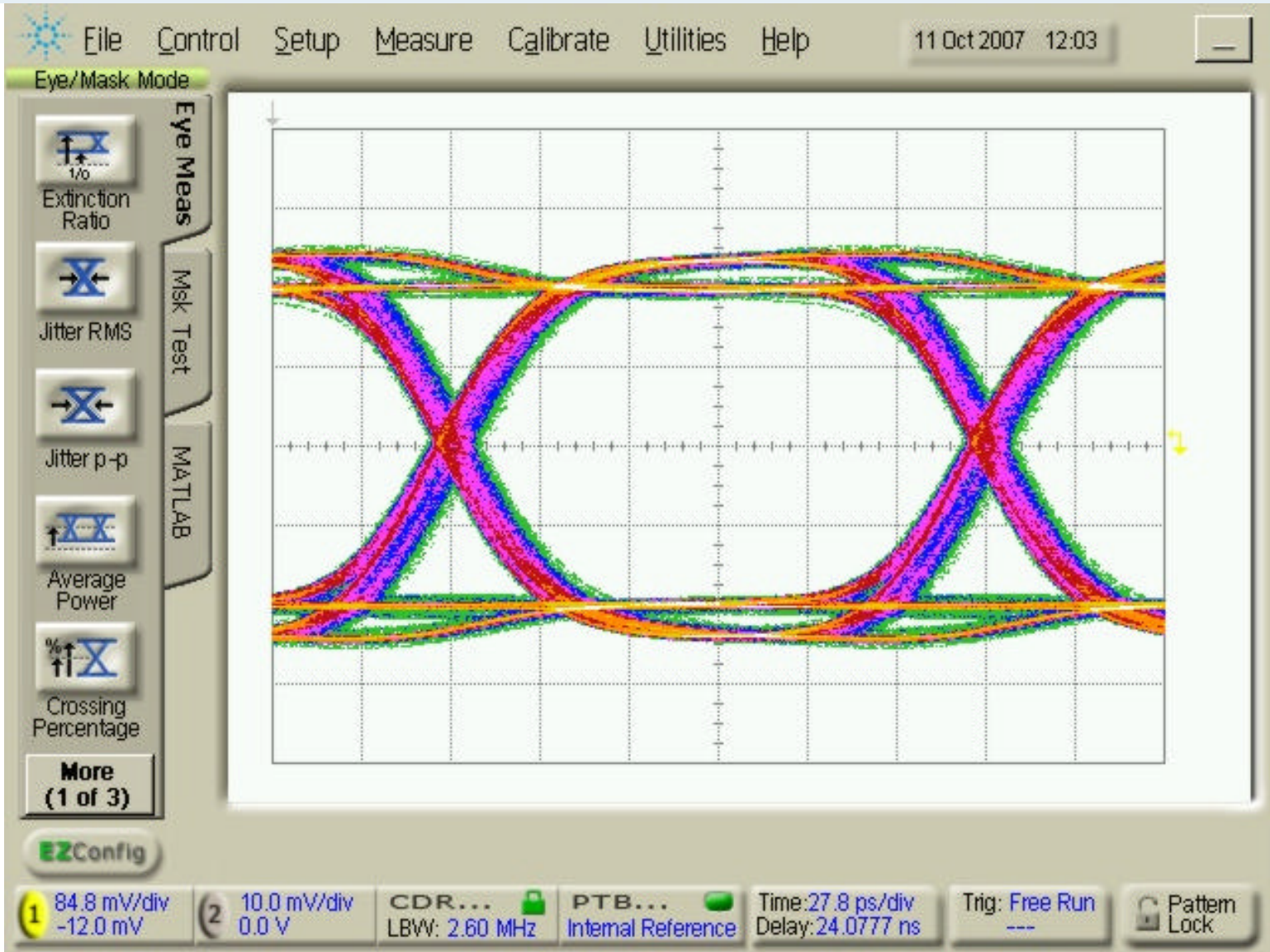


Real Time SAS_LFTP_VMA_VMin_Histogram

File Control Setup Measure Analyze Utilities Help 10:26 AM



BERT CJTPAT Clean EYE

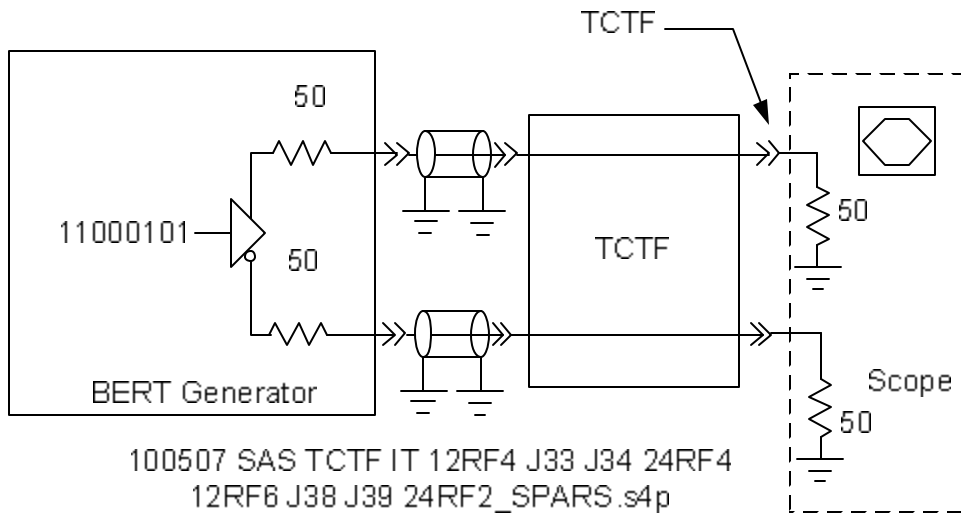


Agilent Real Time SAS_CJTPAT_Clean_Eye

File Control Setup Measure Analyze Utilities Help 11:09 AM



TCTF Measurement

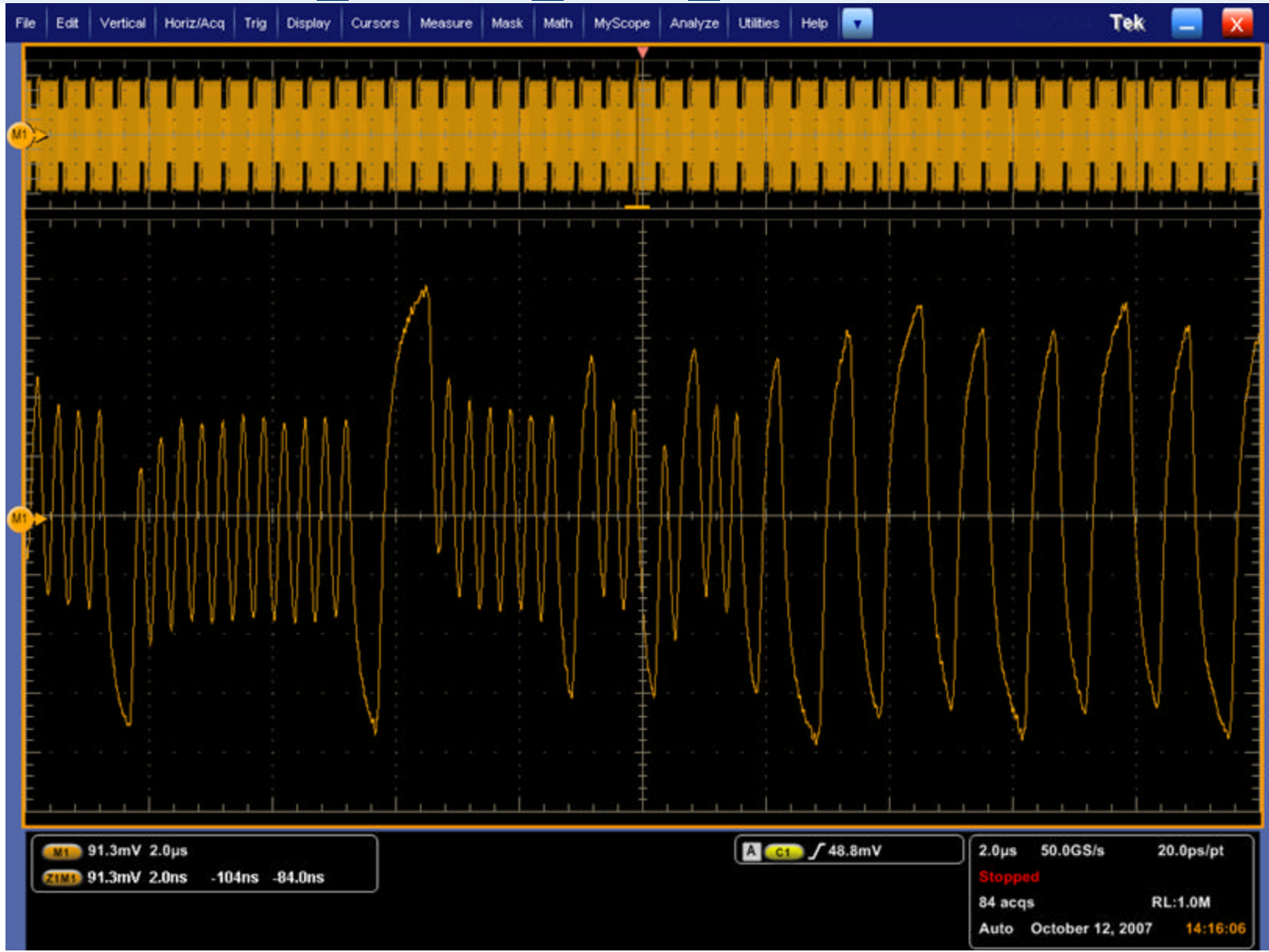


Export, CSV format:
Waveform, TJ, RJ,
Noise, Eye

Screen capture:
Waveform, Eye &
Measurements

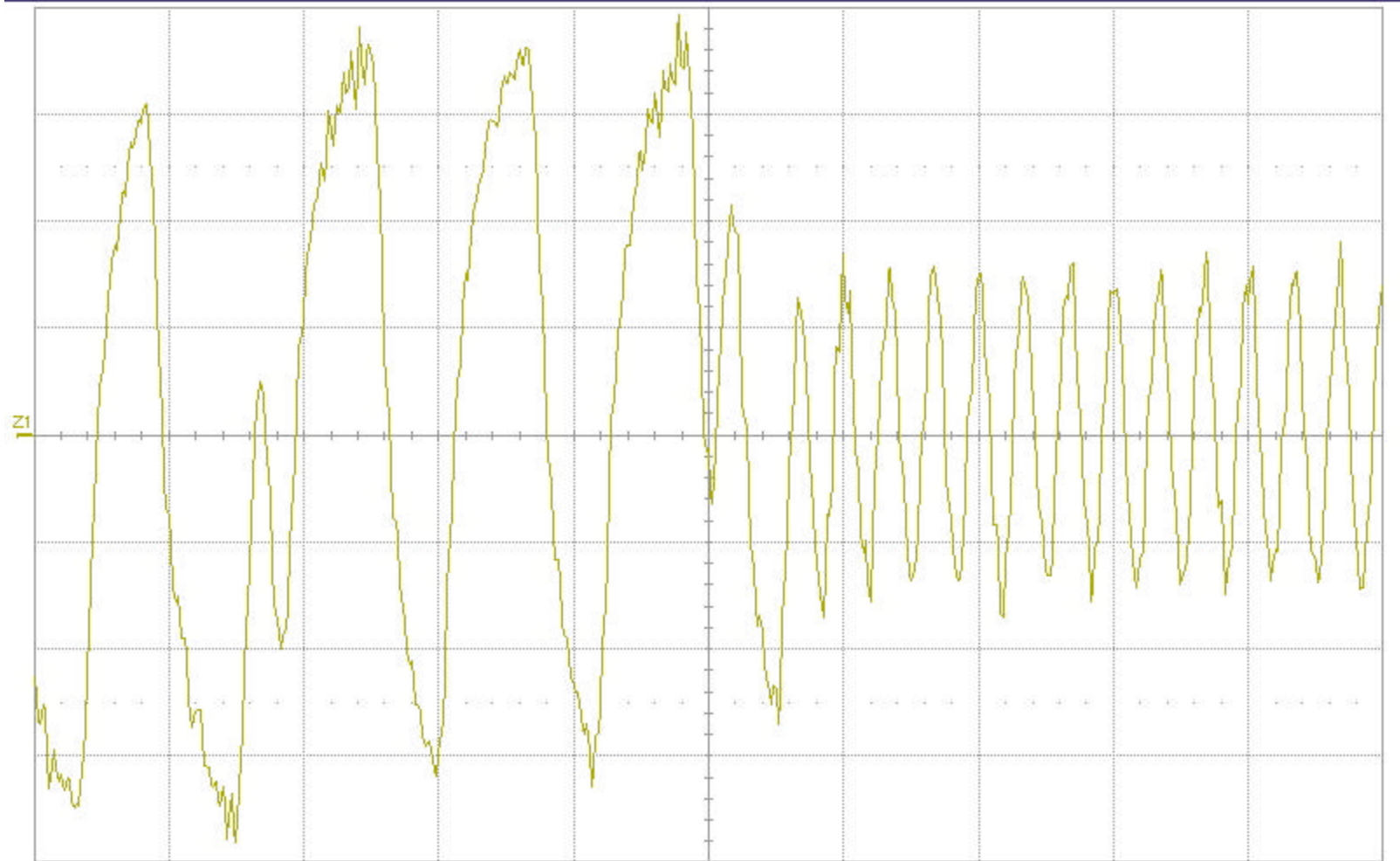
Capture:
CJTPAT (2640 bits)

Real Time BERT_CJTPAT_TCTF_6G



Real Time Bert_CJTPAT_tctf_wfm

File Vertical Timebase Trigger Display Cursors Measure Math Analysis Utilities Help

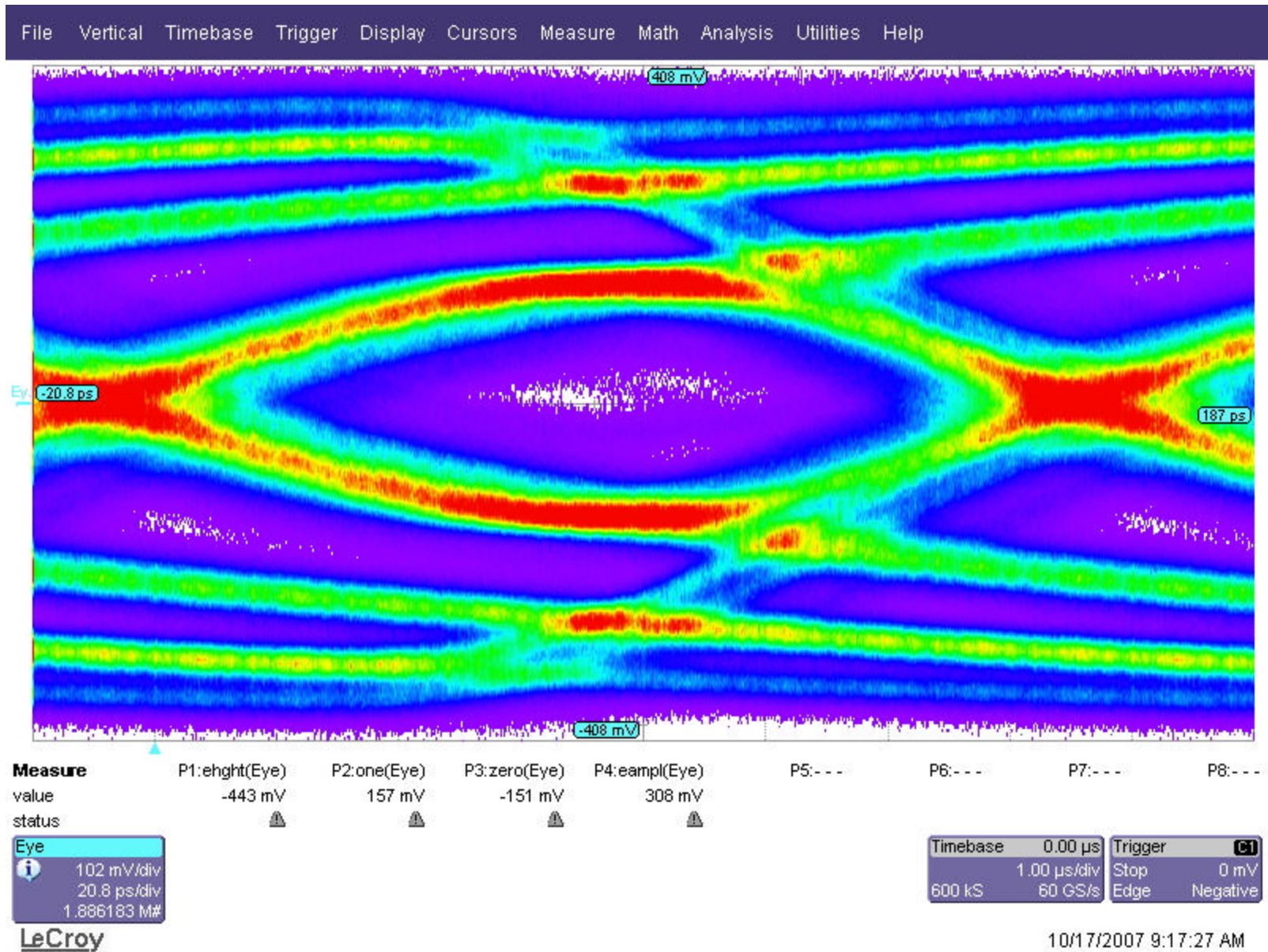


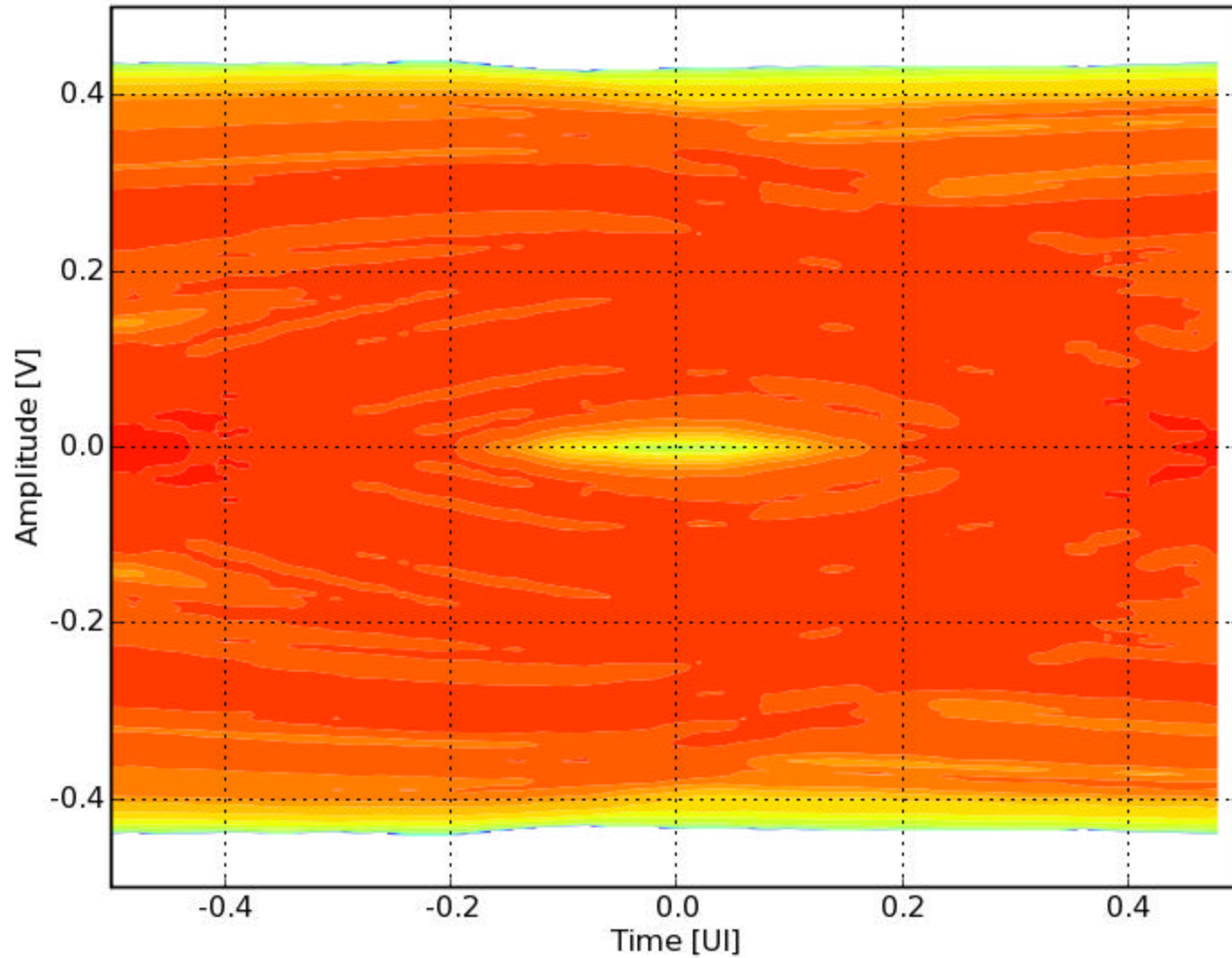
Z1 zoom(C1)
102 mV/div
1.00 ns/div
LeCroy

Timebase	0.00 μ s	Trigger	C1
	1.00 μ s/div	Stop	0 mV
600 kS	60 GS/s	Edge	Negative

10/17/2007 9:19:07 AM

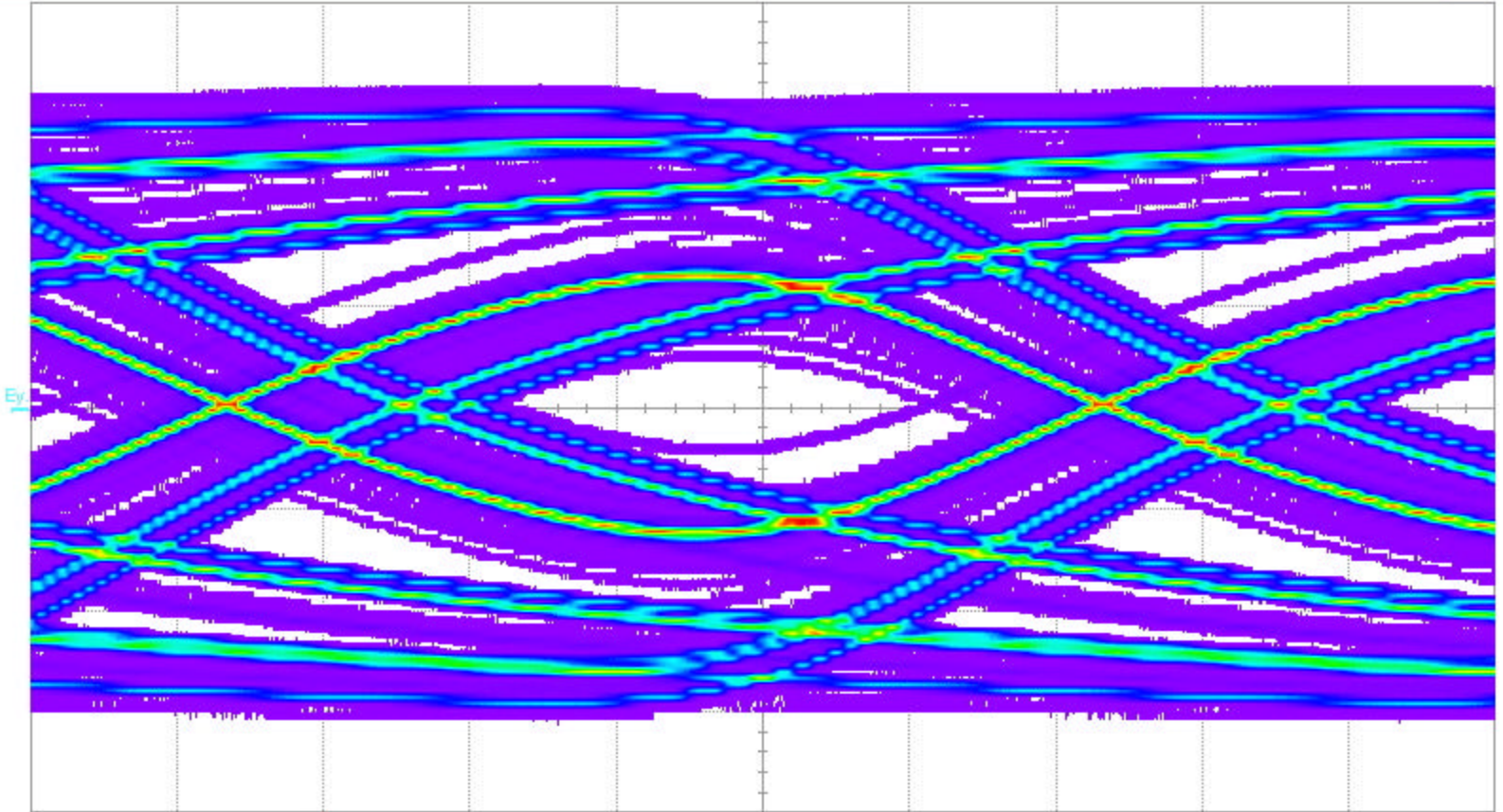
Real Time bert_cjtpat_tctf





Equivalent Time bert_cjtpat_tctf_eye1

File Vertical Timebase Trigger Display Cursors Measure Math Analysis Utilities Help Zoom Undo



Eye Measure	P1:ehght(Eye)	P2:one(Eye)	P3:zero(Eye)	P4:eamp(Eye)	P5:---	P6:---	P7:---	P8:---
value	-55 mV	217 mV	-205 mV	423 mV				
status	✓	✓	✓	✓				

Eye

- 120 mV/div
- 27.8 ps/div
- 12.28800 M#

Timebase -24 ns

CIS ■ 100 ns/div

12.3 MS 81 fs/S

Trigger Prescaler

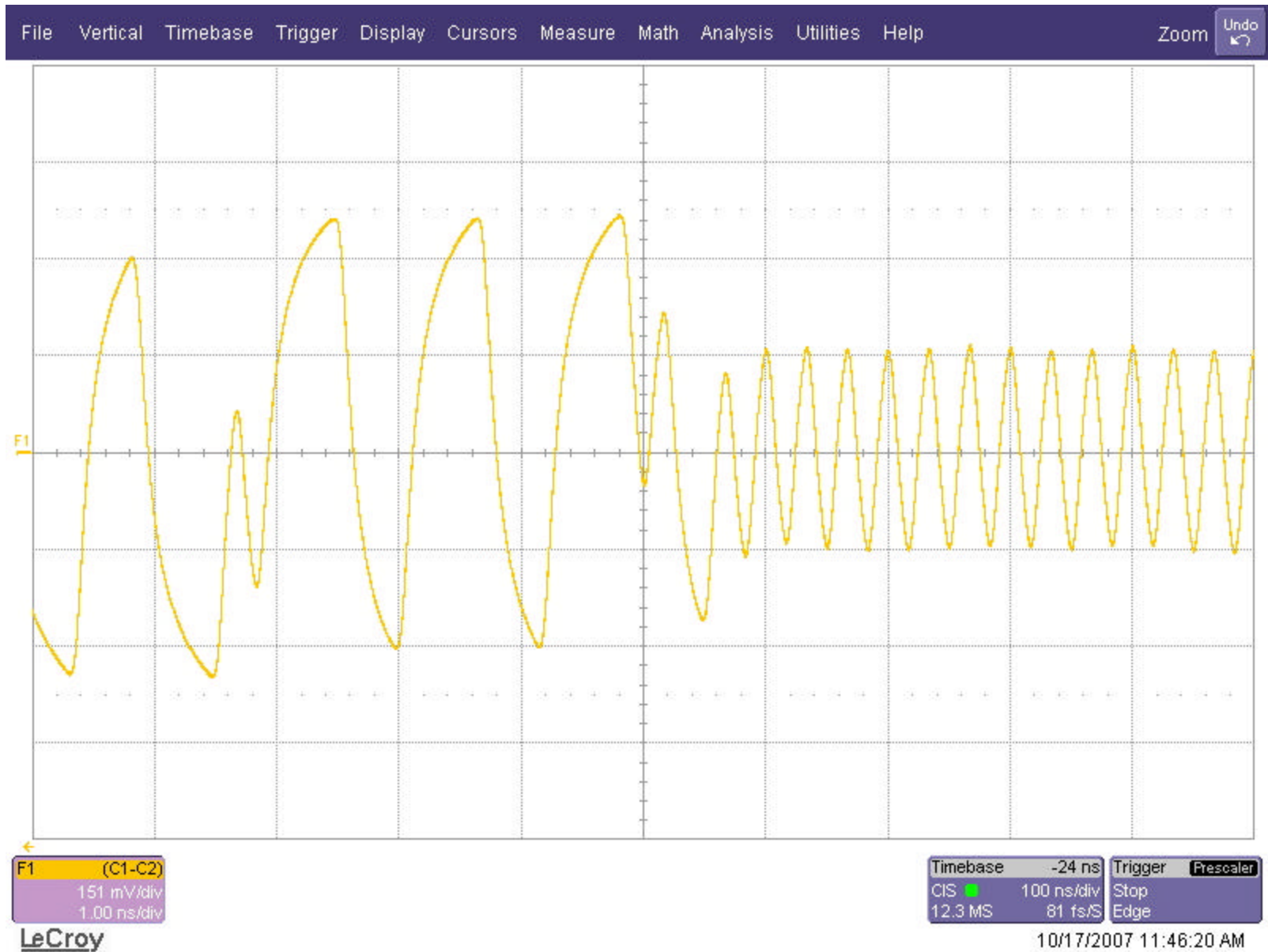
Stop

Edge

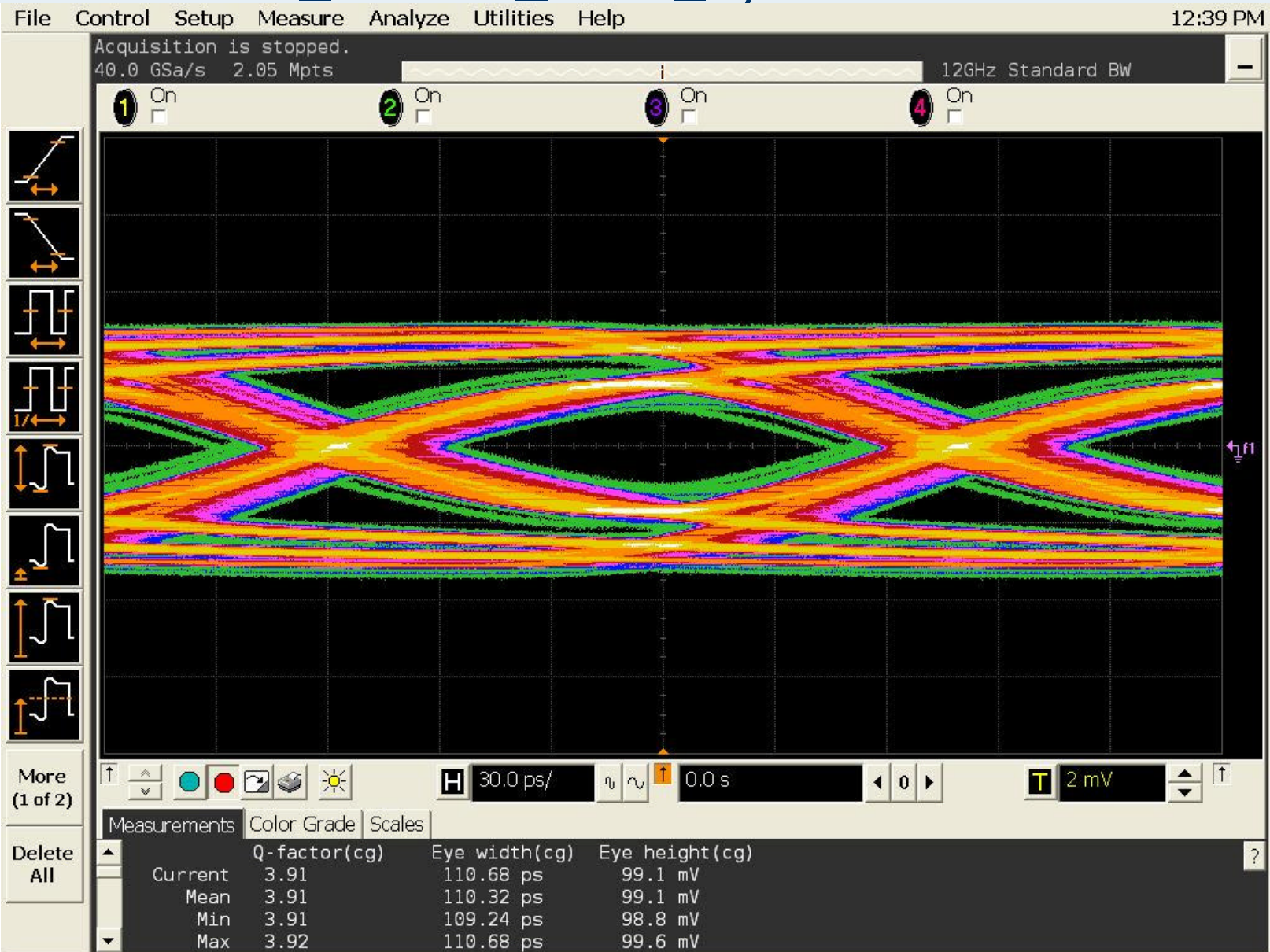
LeCroy

10/17/2007 12:00:55 PM

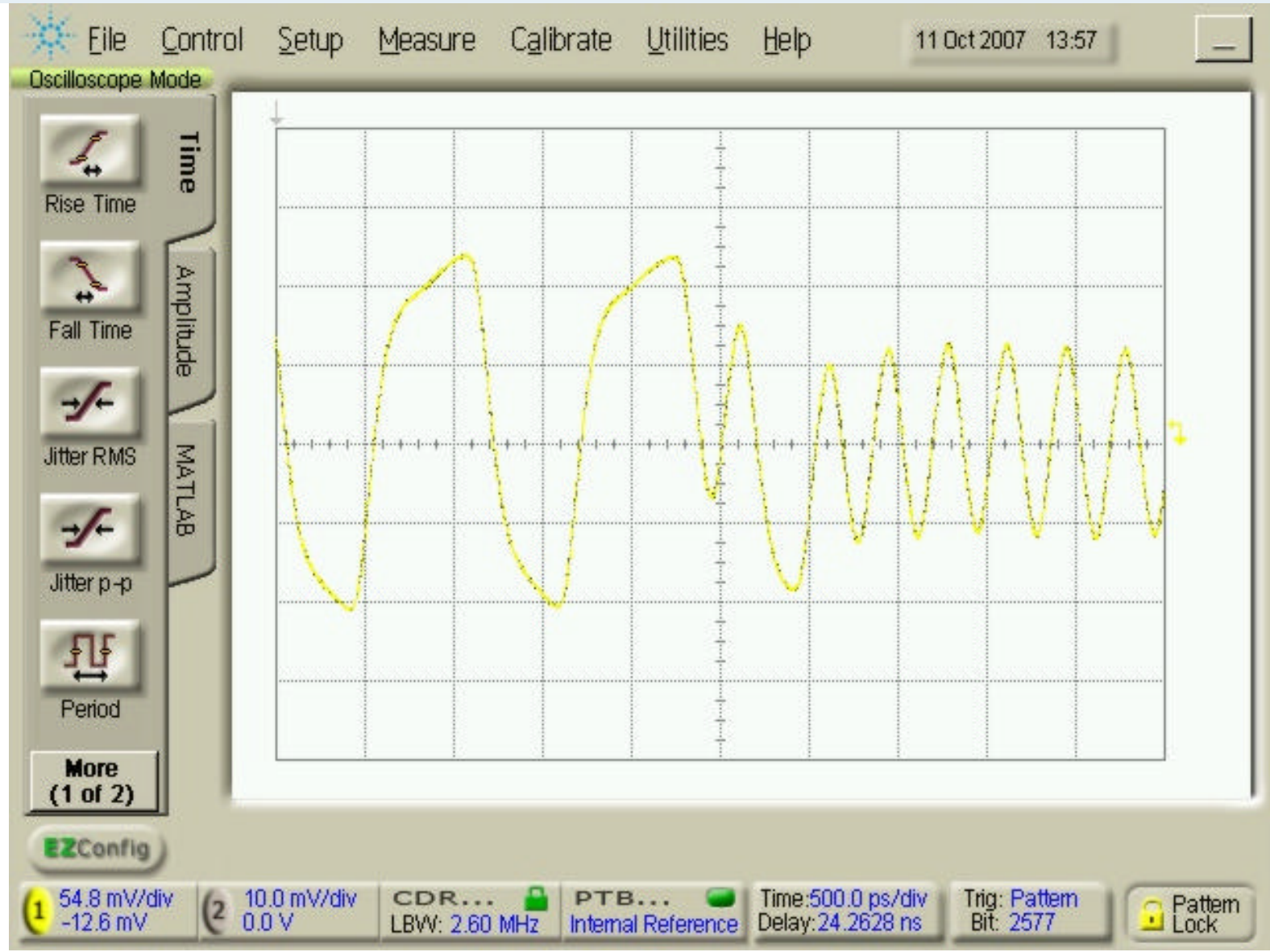
Equivalent Timebert_cjtpat_tctf_wfm1.jpg



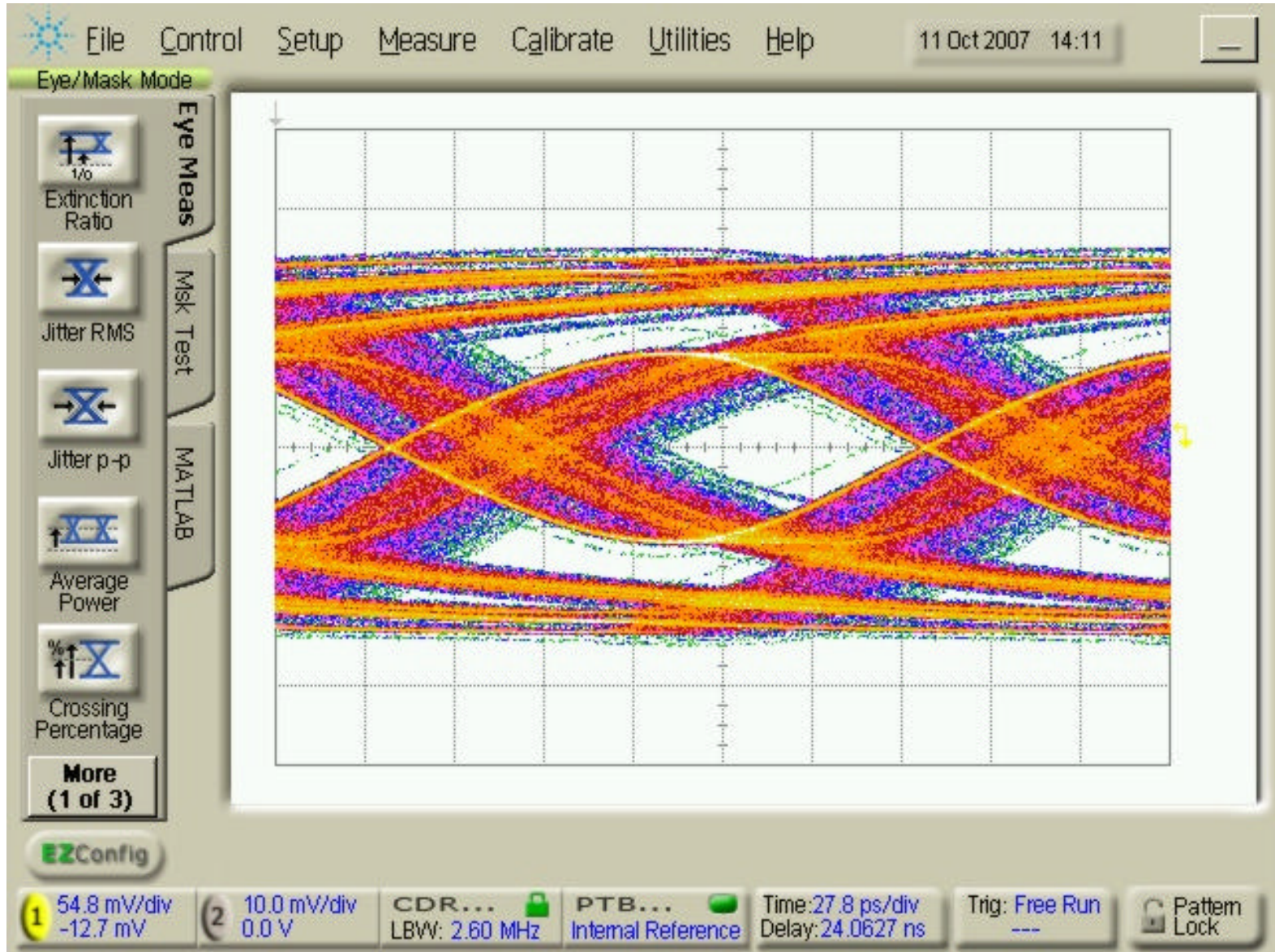
Real Time SAS_CJTPAT_TCTF_Eye



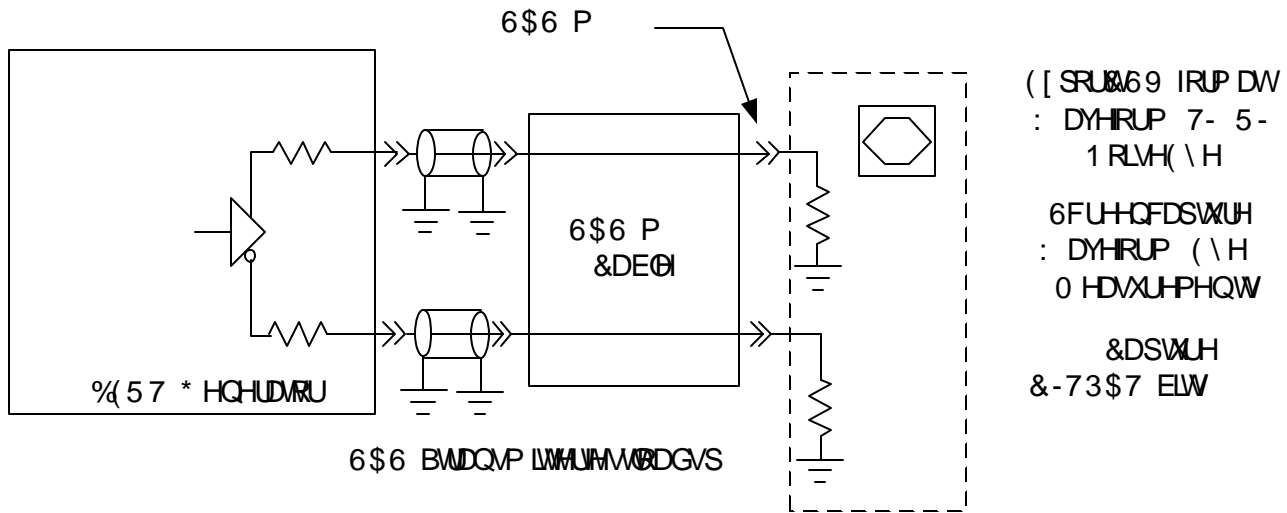
Equivalent Time BERT CJTPAT TCTF Waveform



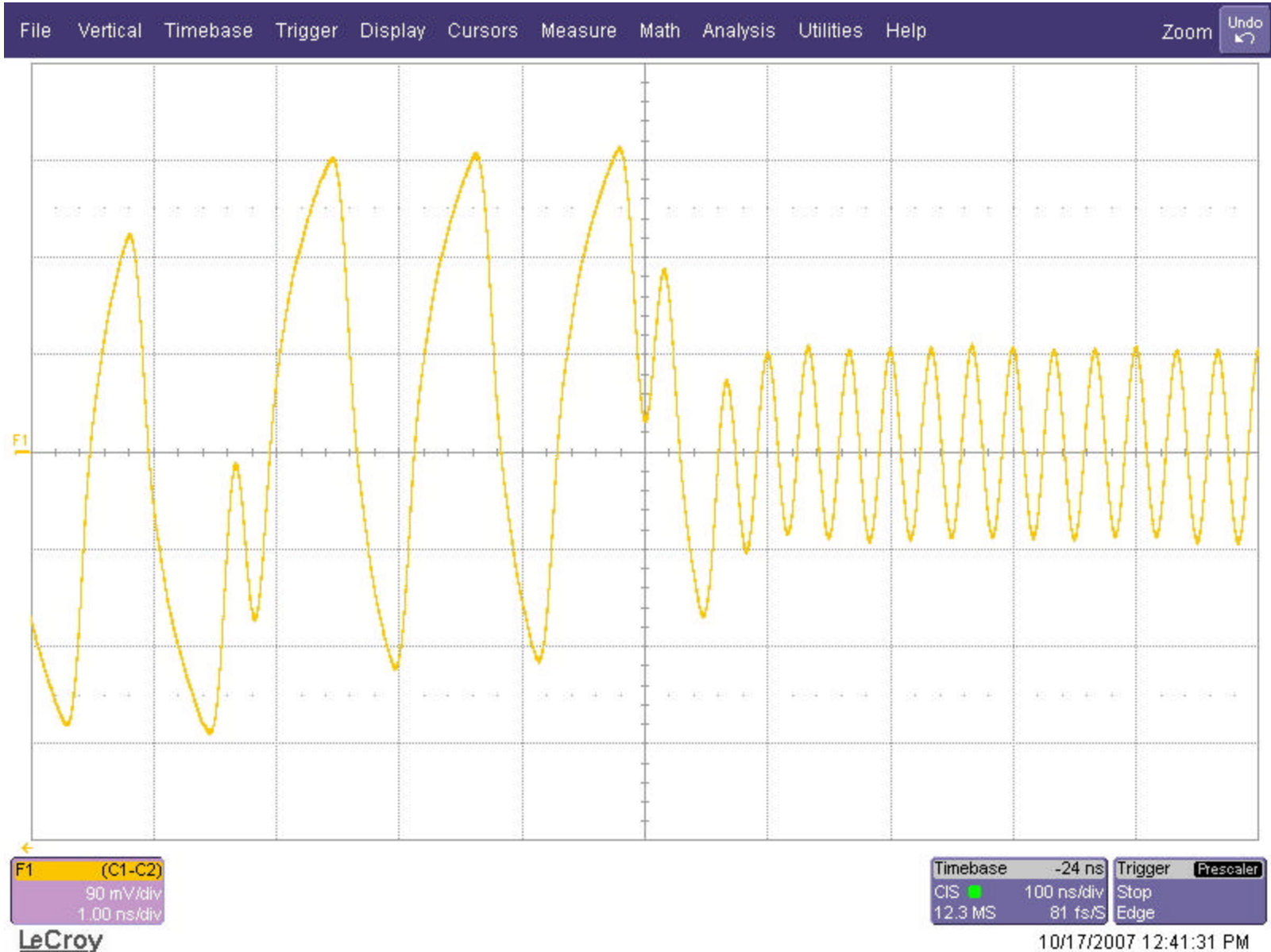
Equivalent Time BERT CJTPAT TCTF EYE_2



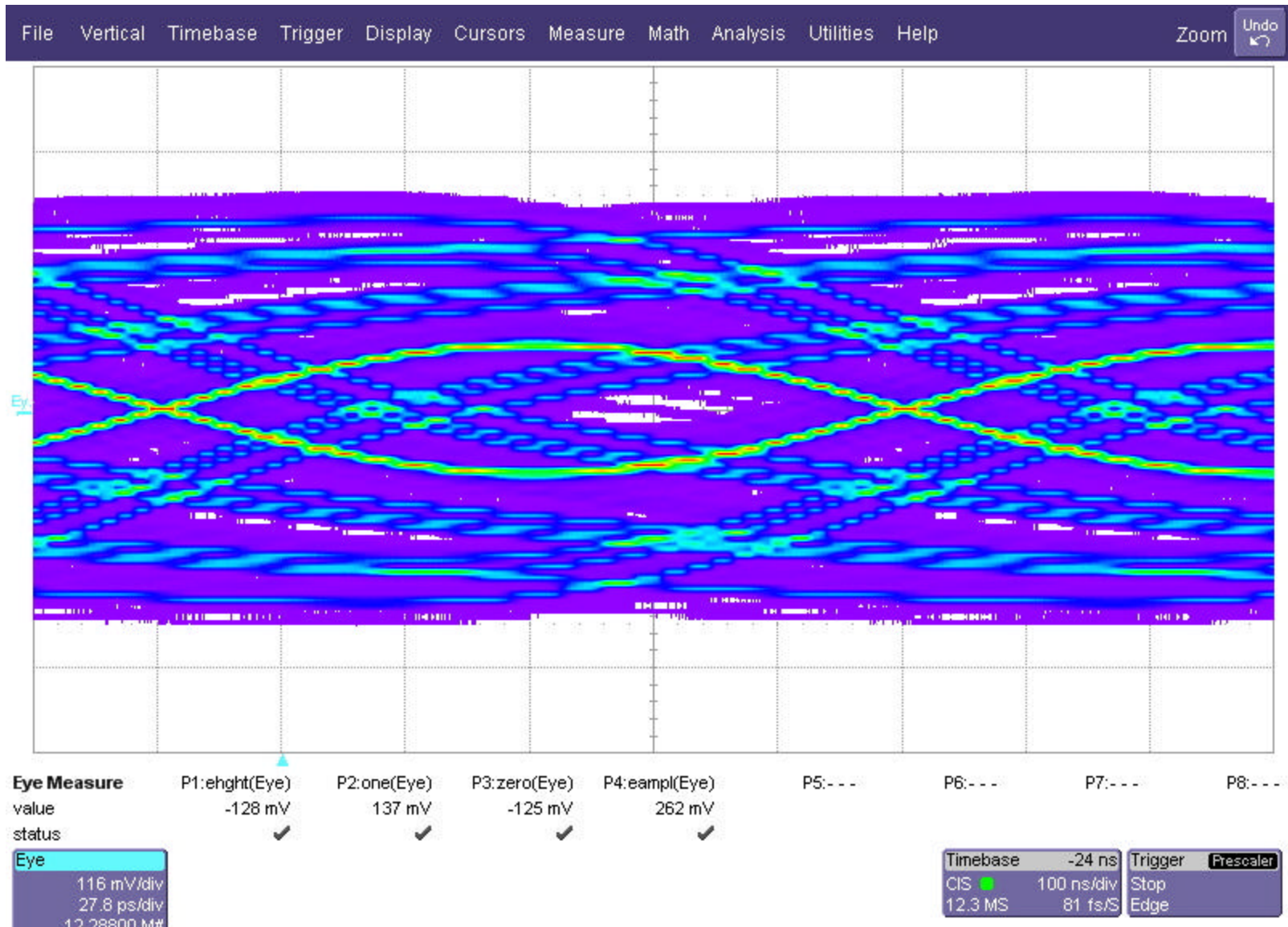
SAS 10 m Measurement



Equivalent Time bert_cjtpat_sas10m_wfm

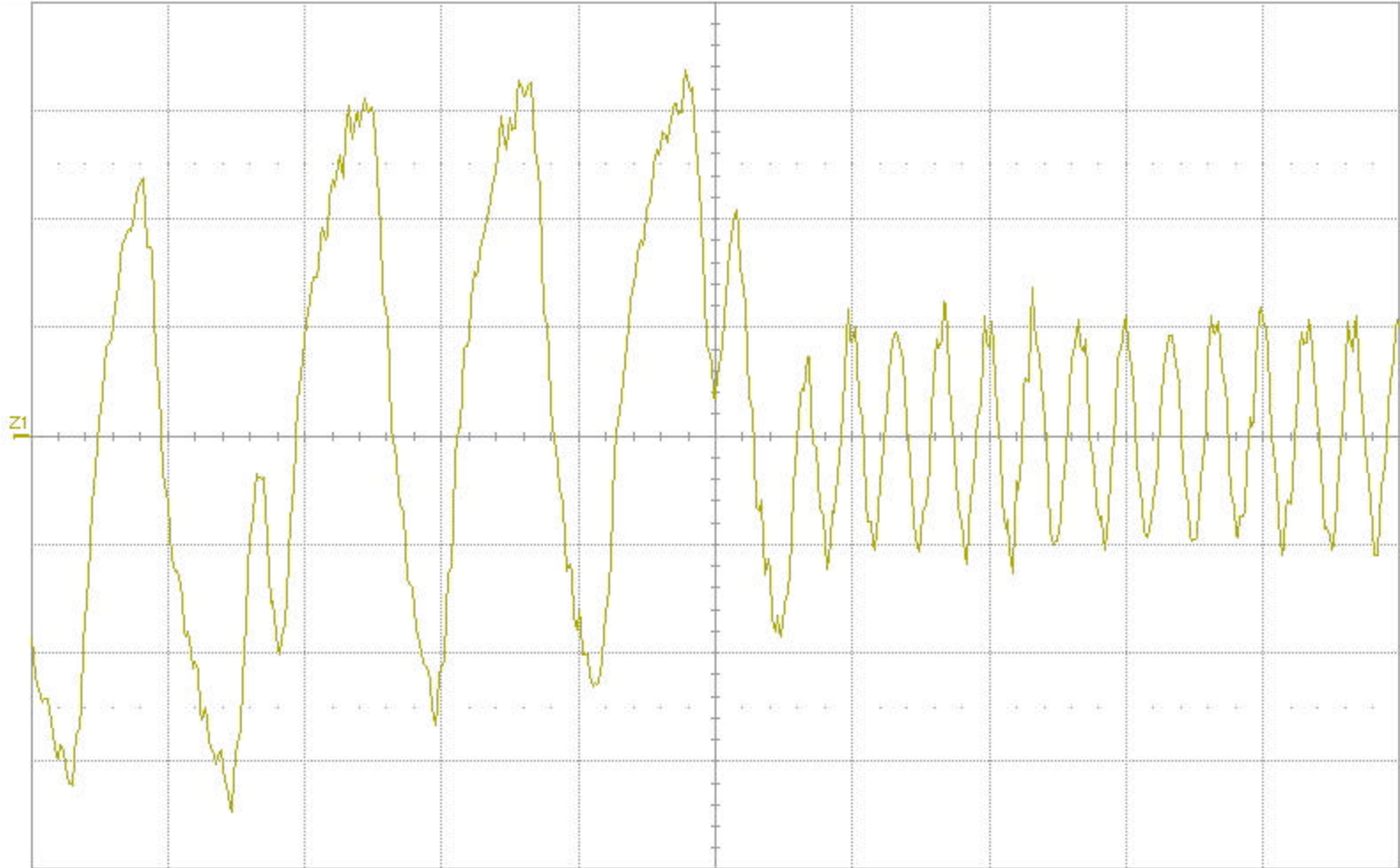


Equivalent Time bert_cjtpat_sas10m_eye



Real Time Bert_CJTPAT_sas10m_wfm

File Vertical Timebase Trigger Display Cursors Measure Math Analysis Utilities Help



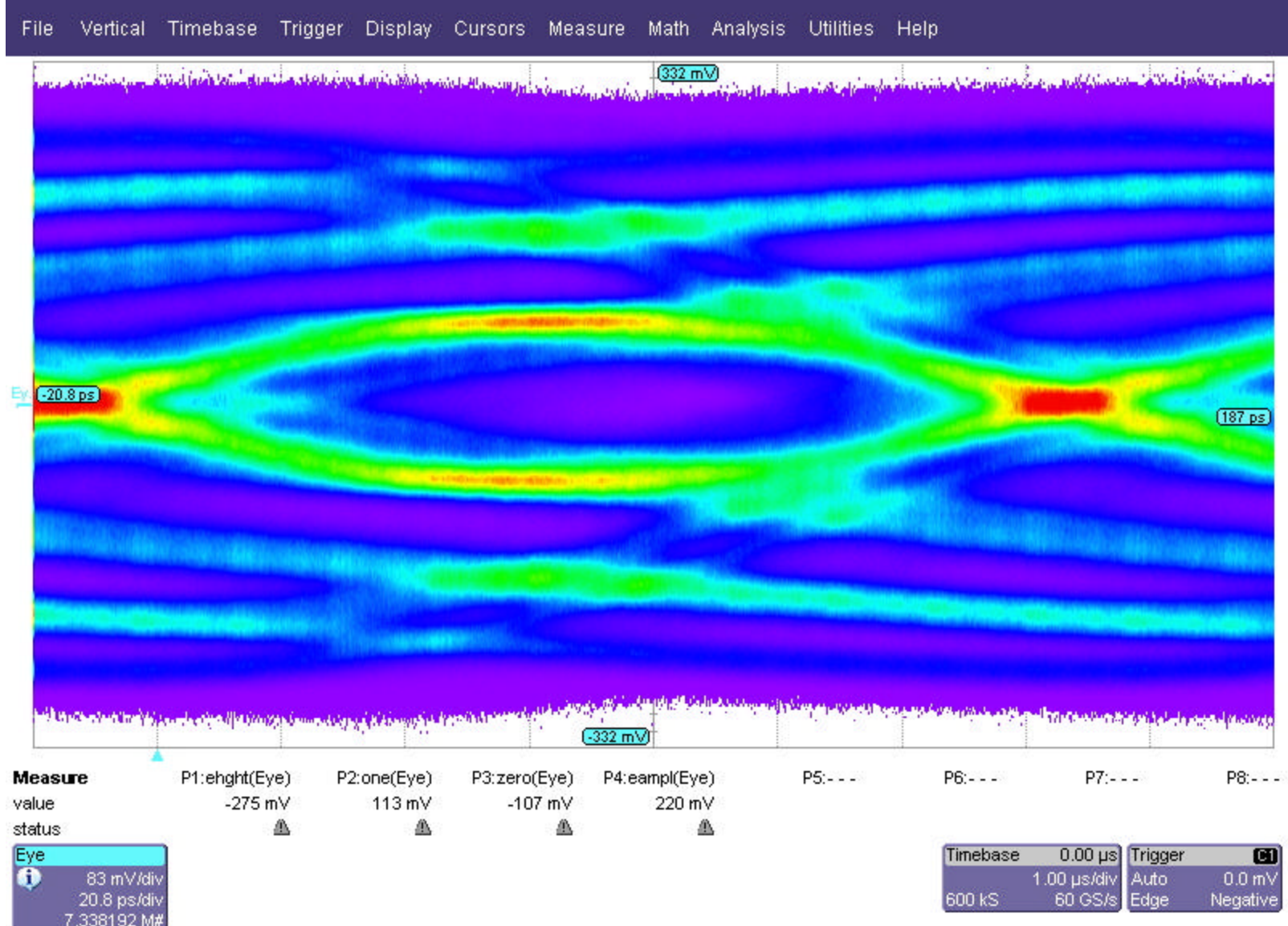
Z1 zoom(C1)
83 mV/div
1.00 ns/div

Timebase	0.00 μ s	Trigger	C1
	1.00 μ s/div	Stop	0.0 mV
600 kS	60 GS/s	Edge	Negative

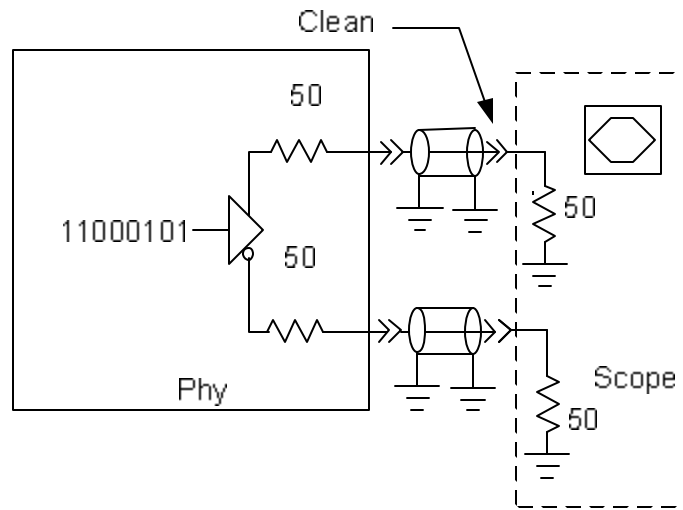
10/17/2007 9:35:23 AM

LeCroy

Real Time Bert_CJTPAT_sas10m_eye



Phy signal source clean



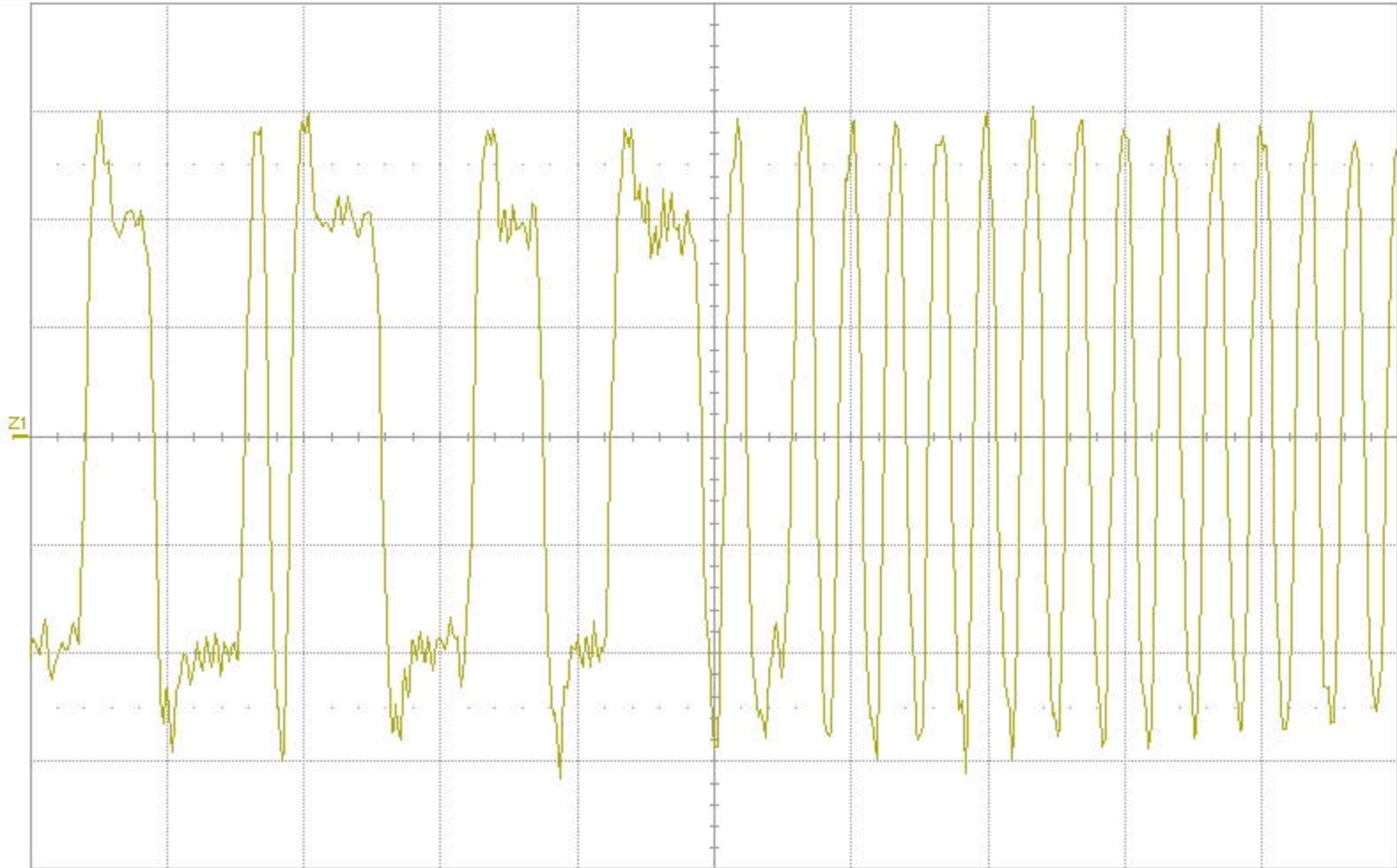
Export, CSV format:
Waveform, TJ, RJ,
Noise, Eye

Screen capture:
Waveform, Eye &
Measurements

Capture:
CJTPAT (2640 bits)

Real Time phy_CJTPAT_clean_wfm

File Vertical Timebase Trigger Display Cursors Measure Math Analysis Utilities Help



Z1 zoom(C1)
186 mV/div
1.00 ns/div

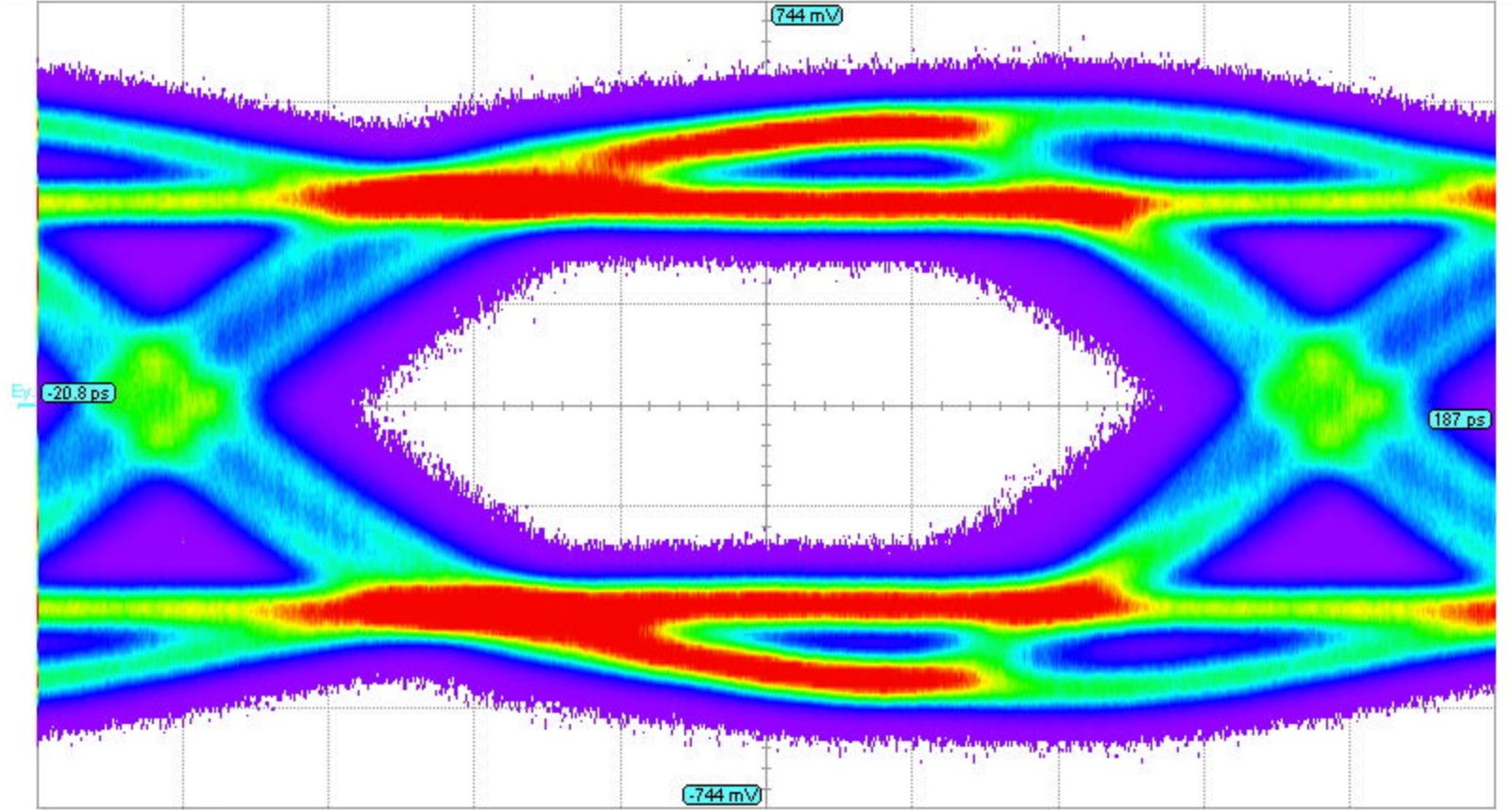
Timebase	0.00 μ s	Trigger	C1
	1.00 μ s/div	Stop	0 mV
600 kS	60 GS/s	Edge	Negative

10/17/2007 10:06:36 AM

LeCroy

Real Time phy_CJTPAT_clean_eye

File Vertical Timebase Trigger Display Cursors Measure Math Analysis Utilities Help



Measure	P1:ehght(Eye)	P2:one(Eye)	P3:zero(Eye)	P4:eamp(Eye)	P5:---	P6:---	P7:---	P8:---
value	457 mV	430 mV	-424 mV	853 mV				
status	✓	✓	✓	✓				

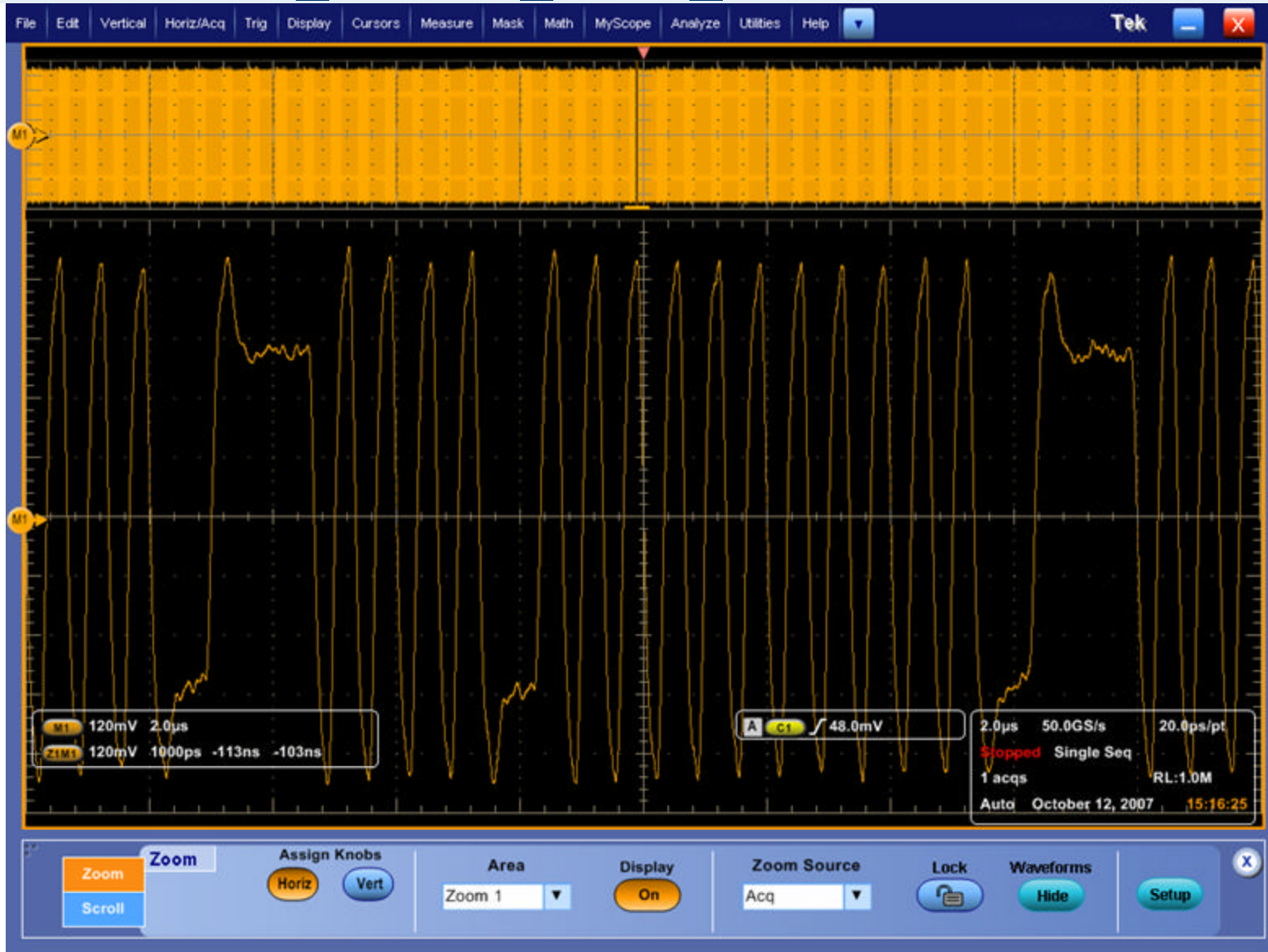
Eye
 186 mV/div
 20.8 ps/div
 3.398143 M#

Timebase	0.00 μ s	Trigger	C1
	1.00 μ s/div	Auto	0 mV
600 kS	60 GS/s	Edge	Negative

LeCroy

10/17/2007 10:00:23 AM

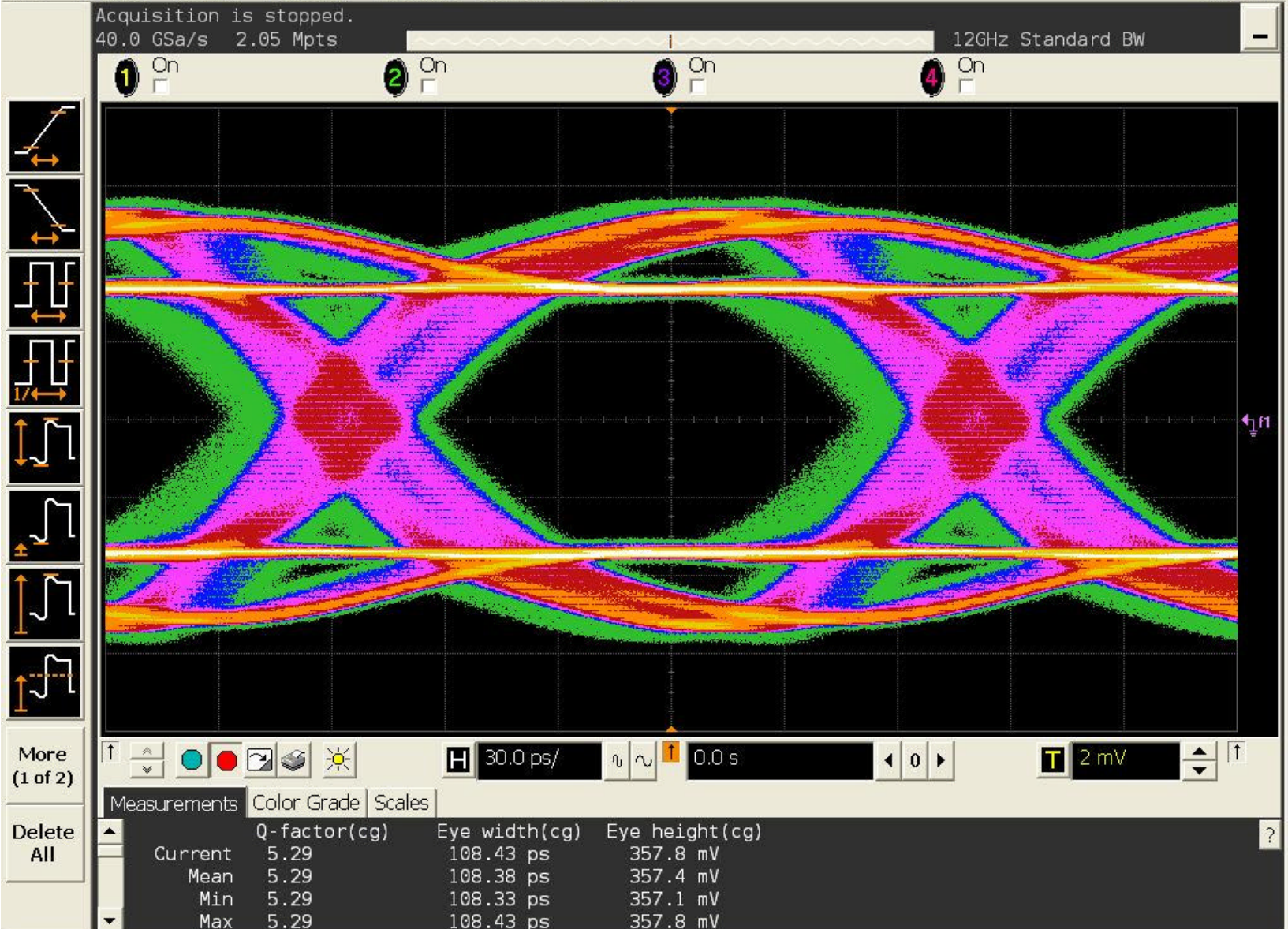
Real Time PHY_CJTPAT_clean_6G



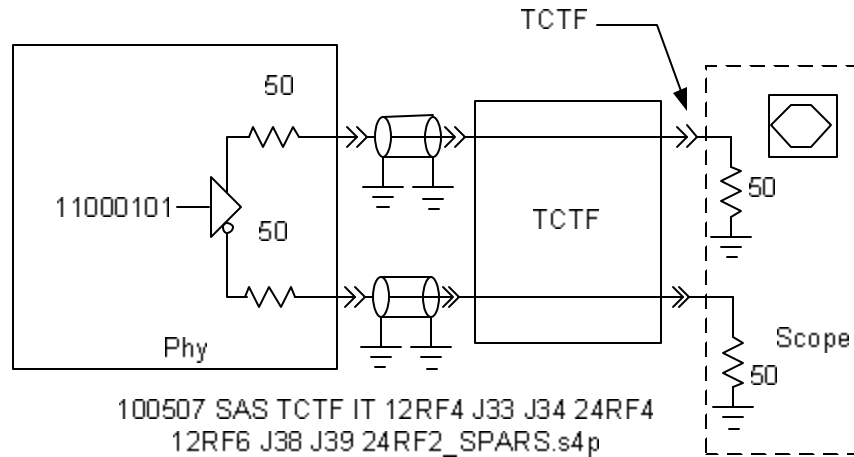
Real Time SAS_CJTPAT_PHY_Clean_Eye

File Control Setup Measure Analyze Utilities Help

3:48 PM



Phy signal source with TCTF

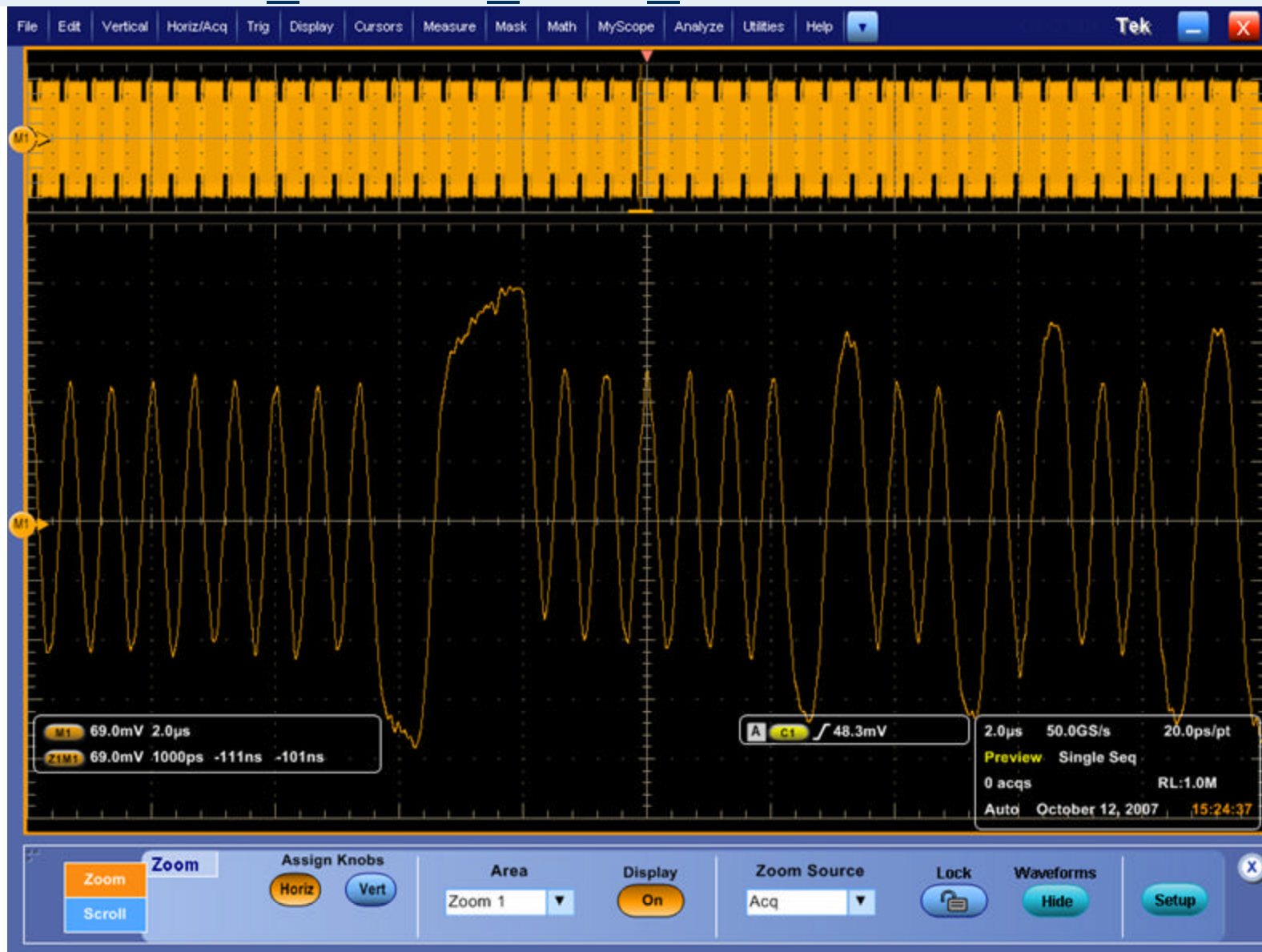


Export, CSV format:
Waveform, TJ, RJ,
Noise, Eye

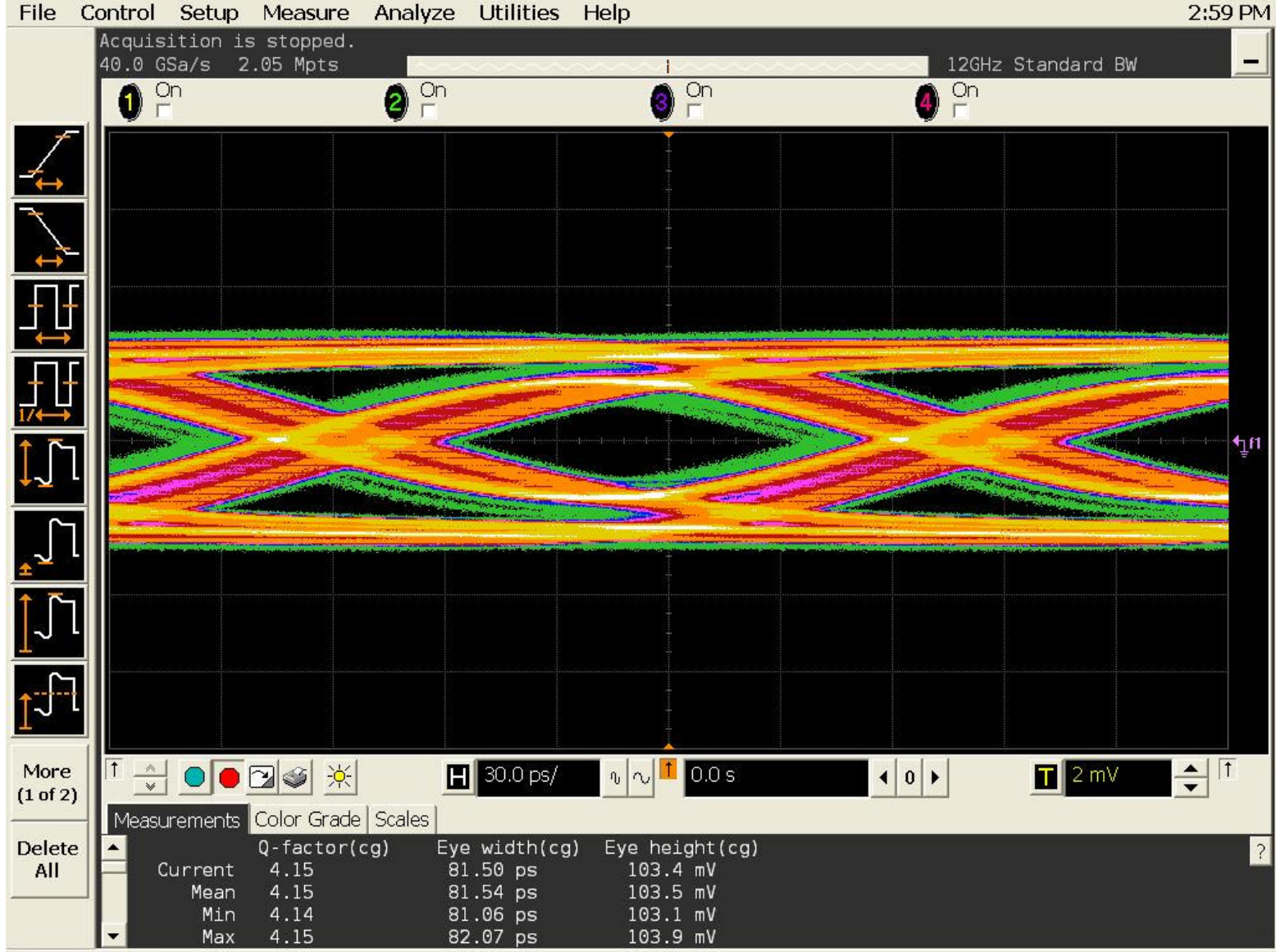
Screen capture:
Waveform, Eye &
Measurements

Capture:
CJTPAT (2640 bits)

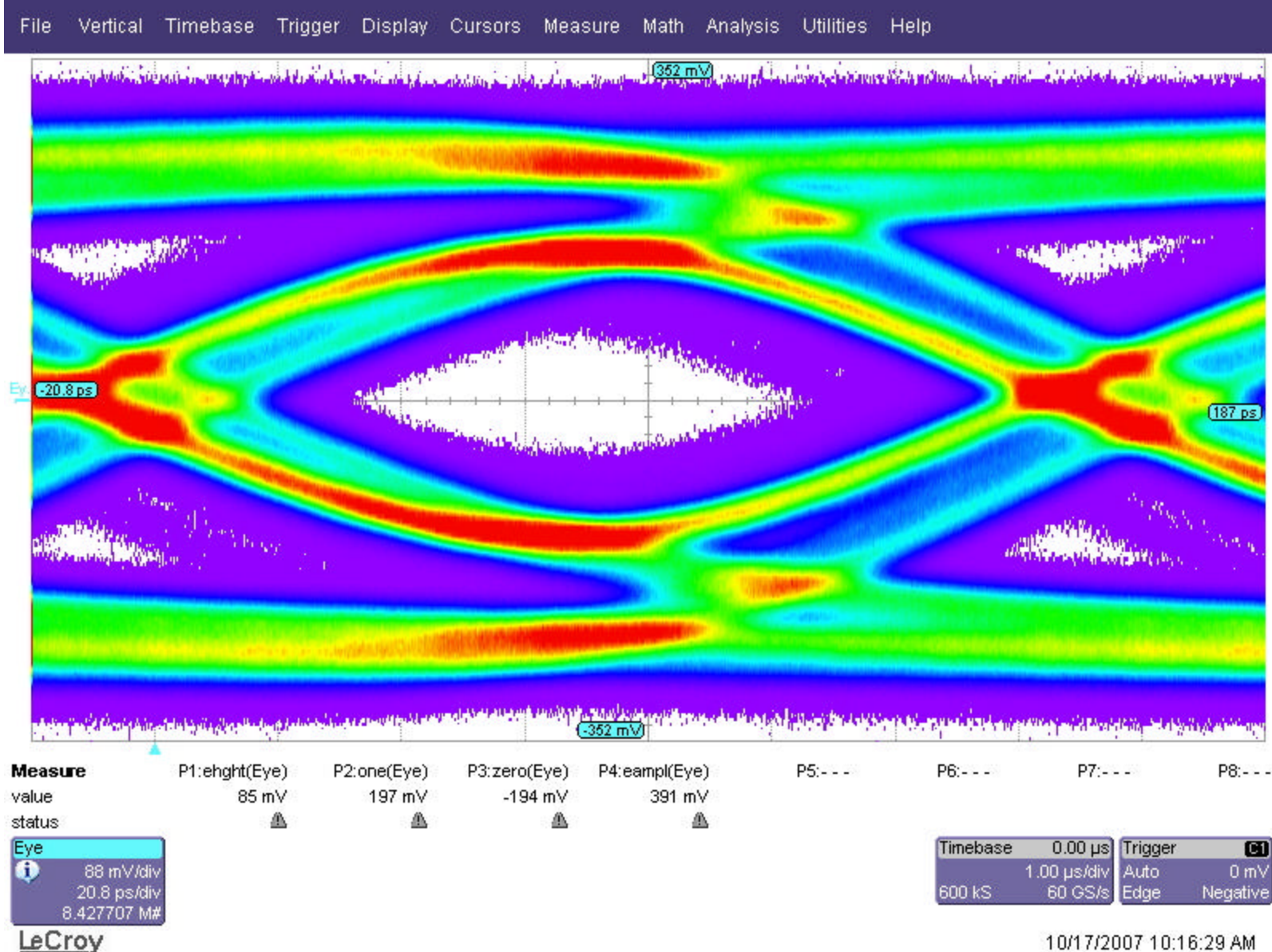
Real Time PHY_CJTPAT_TCTF_6G

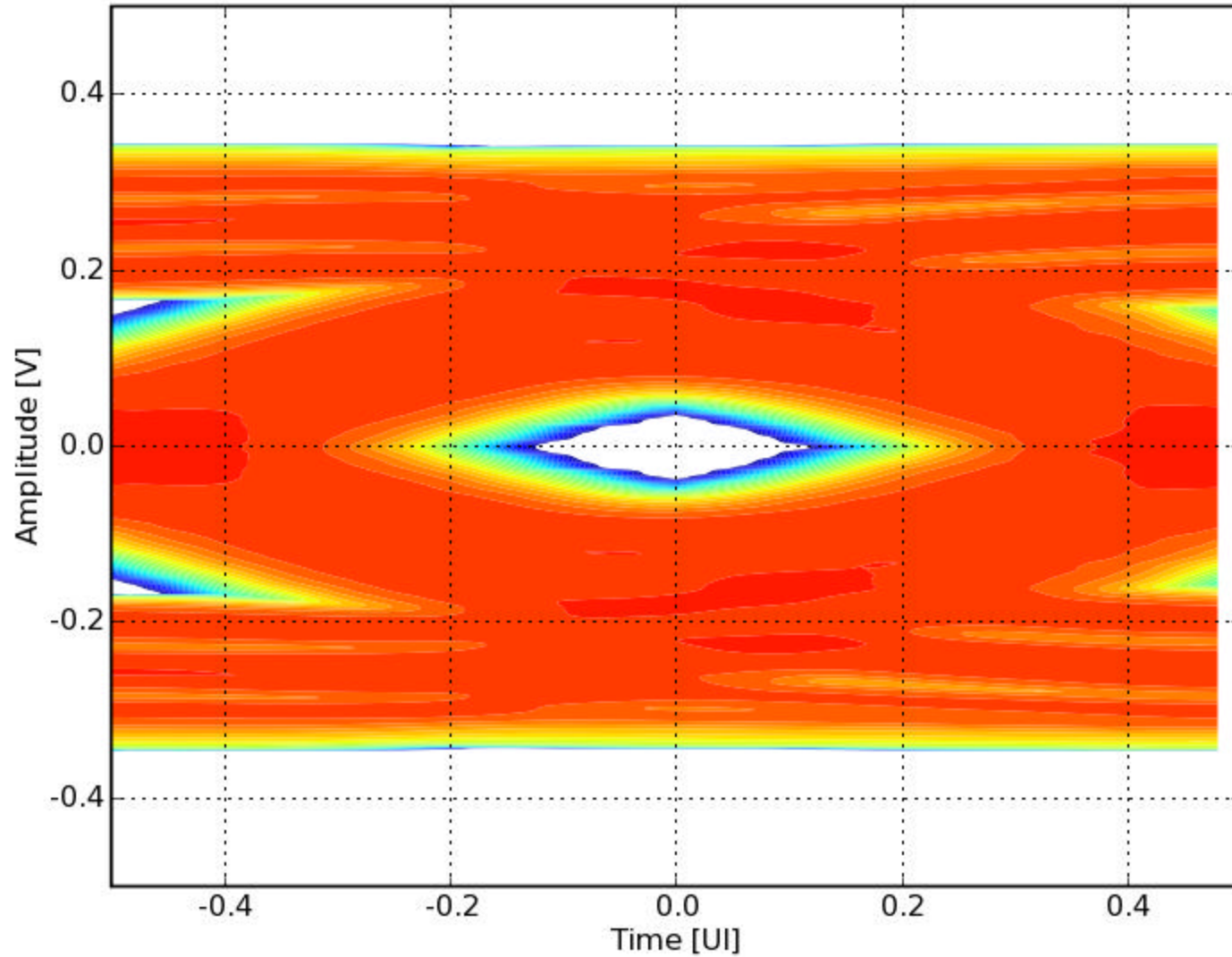


Real Time SAS_CJTPAT_PHY_TCTF_Eye.jpg



Real Time phy_CJTPAT_tctf

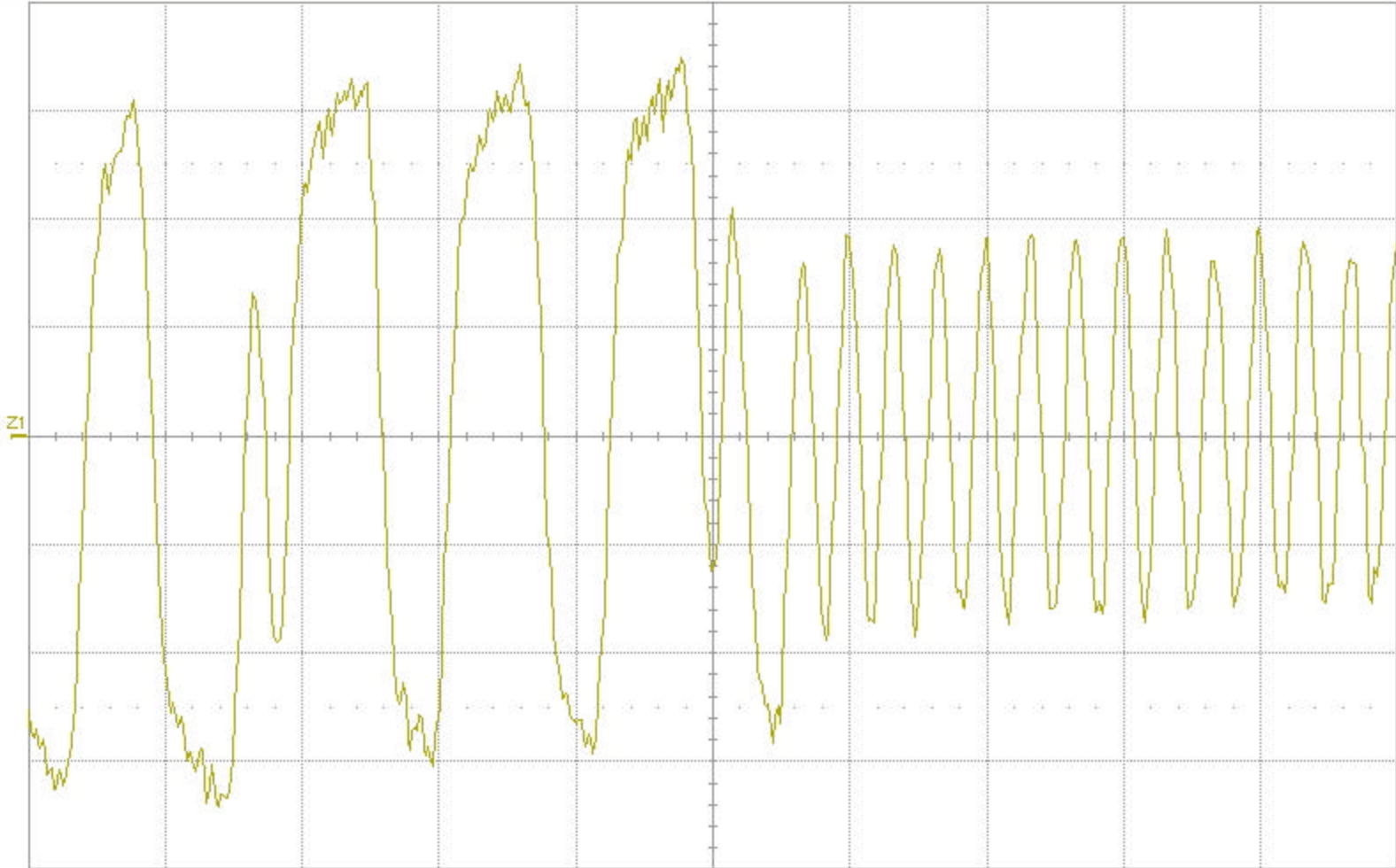




Real Time phy_CJTPAT_tctf_wfm



File Vertical Timebase Trigger Display Cursors Measure Math Analysis Utilities Help



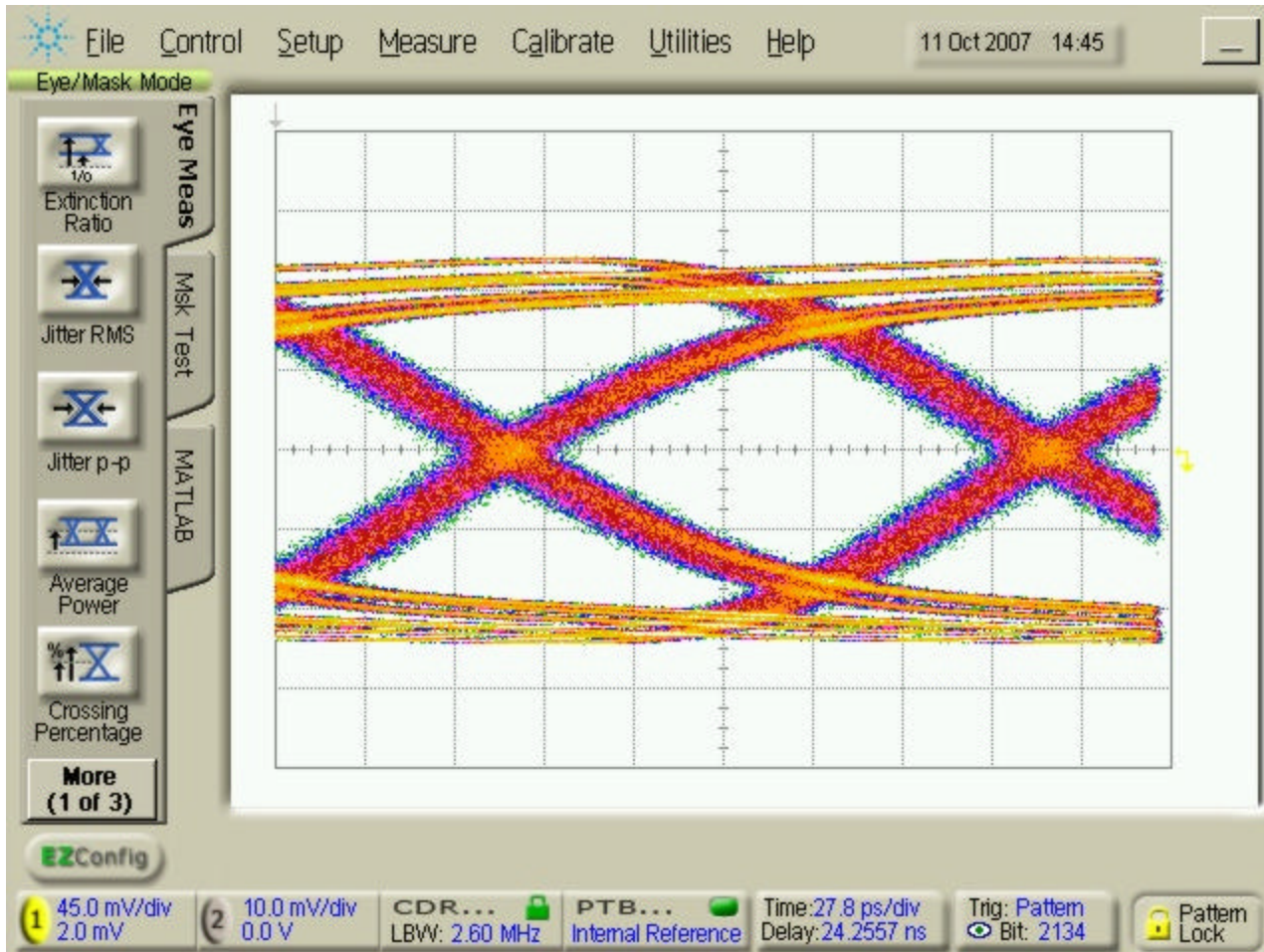
Z1 zoom(C1)
88 mV/div
1.00 ns/div

Timebase	0.00 μ s	Trigger	C1
	1.00 μ s/div	Stop	0 mV
600 kS	60 GS/s	Edge	Negative

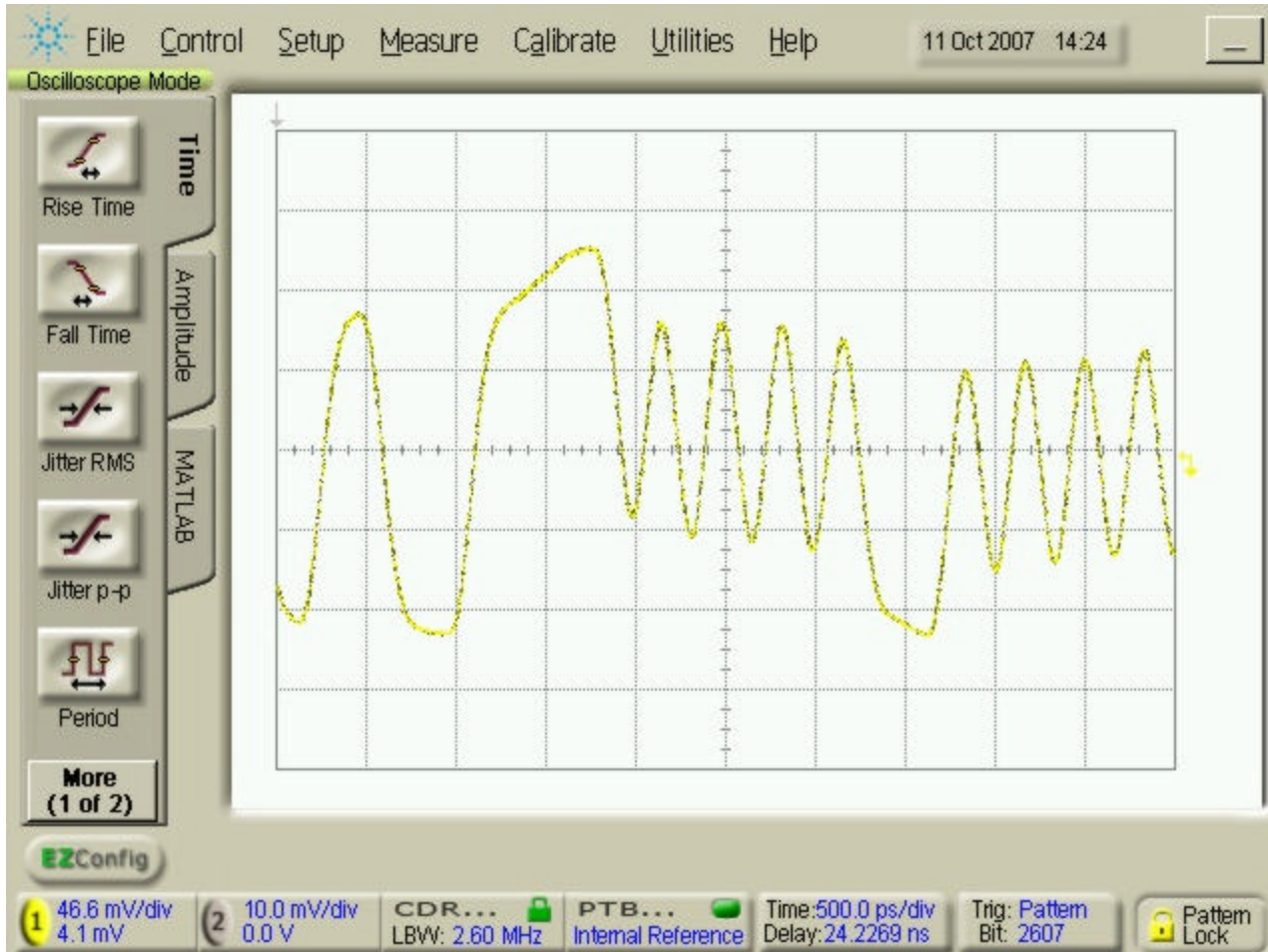
10/17/2007 10:22:45 AM

LeCroy

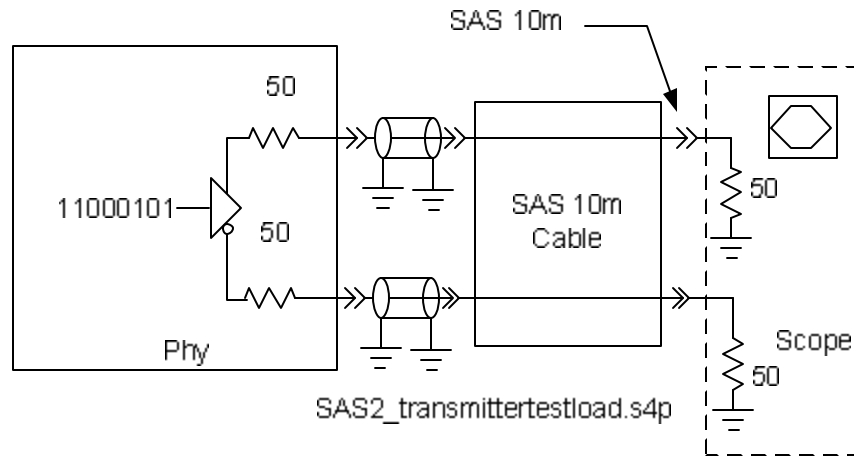
Equivalent Time PHY TCTF CJTPAT EYE



Equivalent Time PHY TCTF CJTPAT Waveform



Phy signal source with SAS 10m



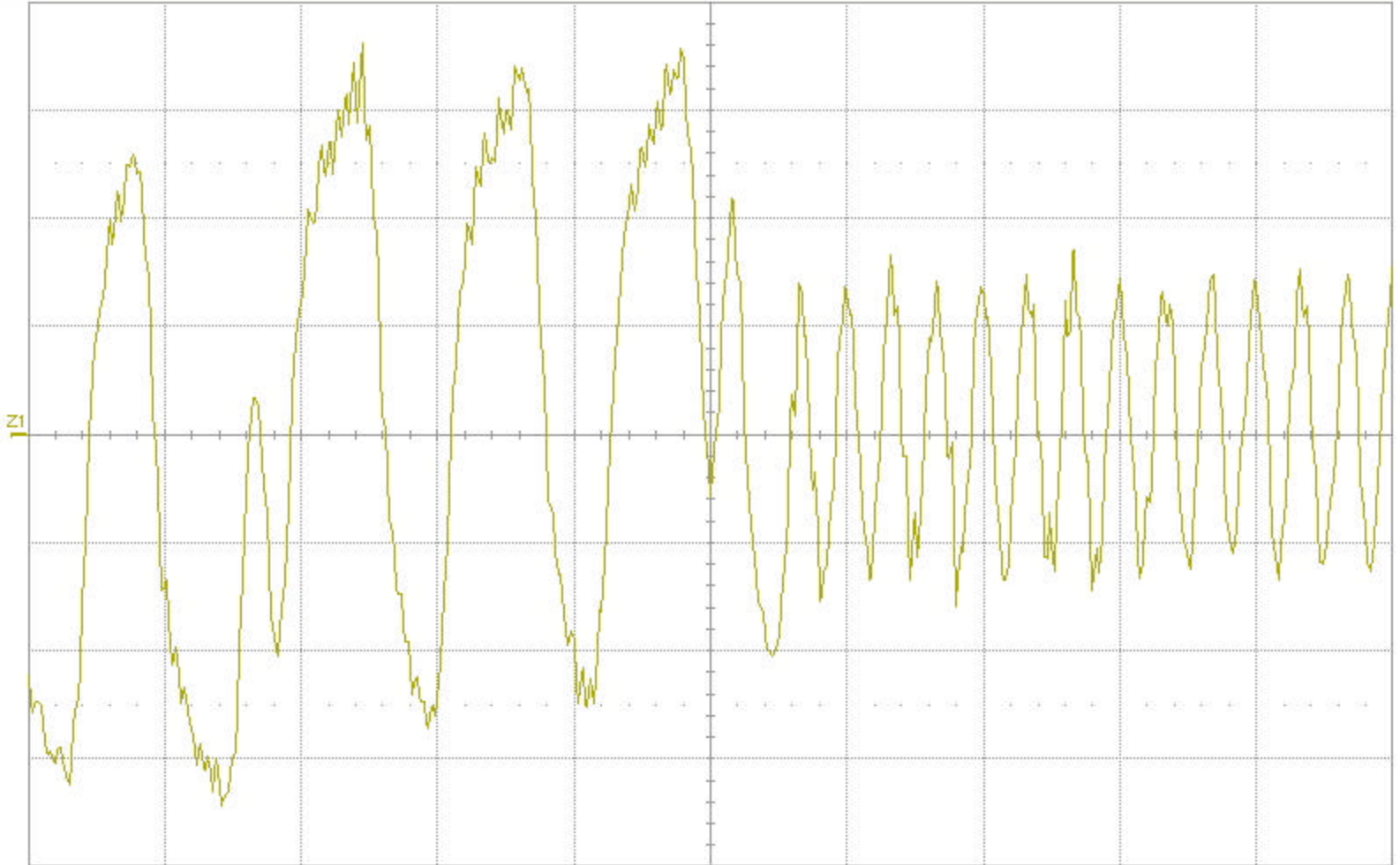
Export, CSV format
Waveform, TJ, RJ,
Noise, Eye

Screen capture:
Waveform, Eye &
Measurements

Capture:
CJTPAT (2640 bits)

Real Time phy_CJTPAT_sas10m_wfm

File Vertical Timebase Trigger Display Cursors Measure Math Analysis Utilities Help



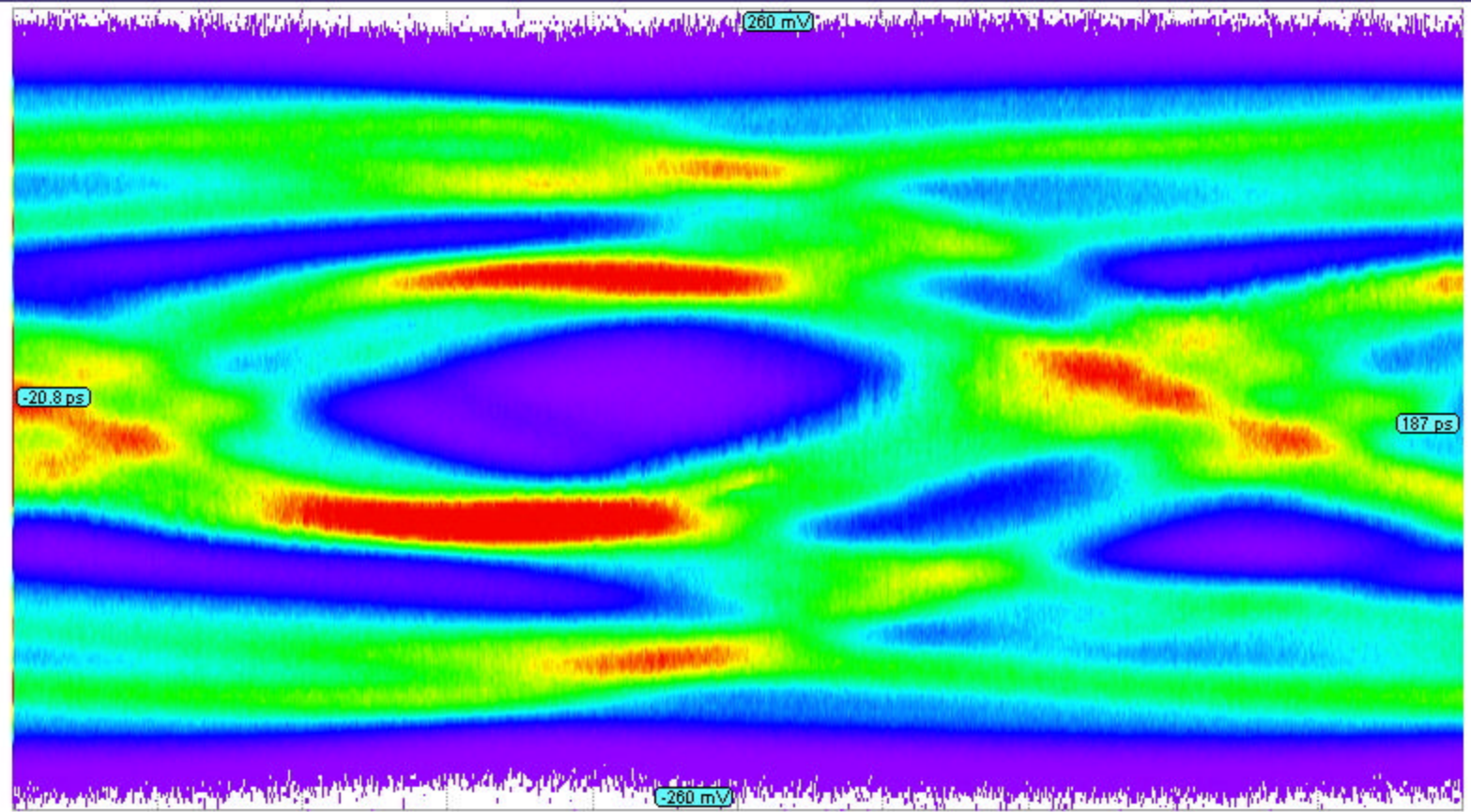
Z1 zoom(C1)
65 mV/div
1.00 ns/div

Timebase	0.00 μ s	Trigger	C1
	1.00 μ s/div	Stop	0.0 mV
600 kS	60 GS/s	Edge	Negative

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Real Time phy_CJTPAT_sas10m_eye

File Vertical Timebase Trigger Display Cursors Measure Math Analysis Utilities Help



Measure	P1:ehght(Eye)	P2:one(Eye)	P3:zero(Eye)	P4:eamp(Eye)	P5:---	P6:---	P7:---	P8:---
value	-132 mV	113 mV	-107 mV	220 mV				
status								

Eye

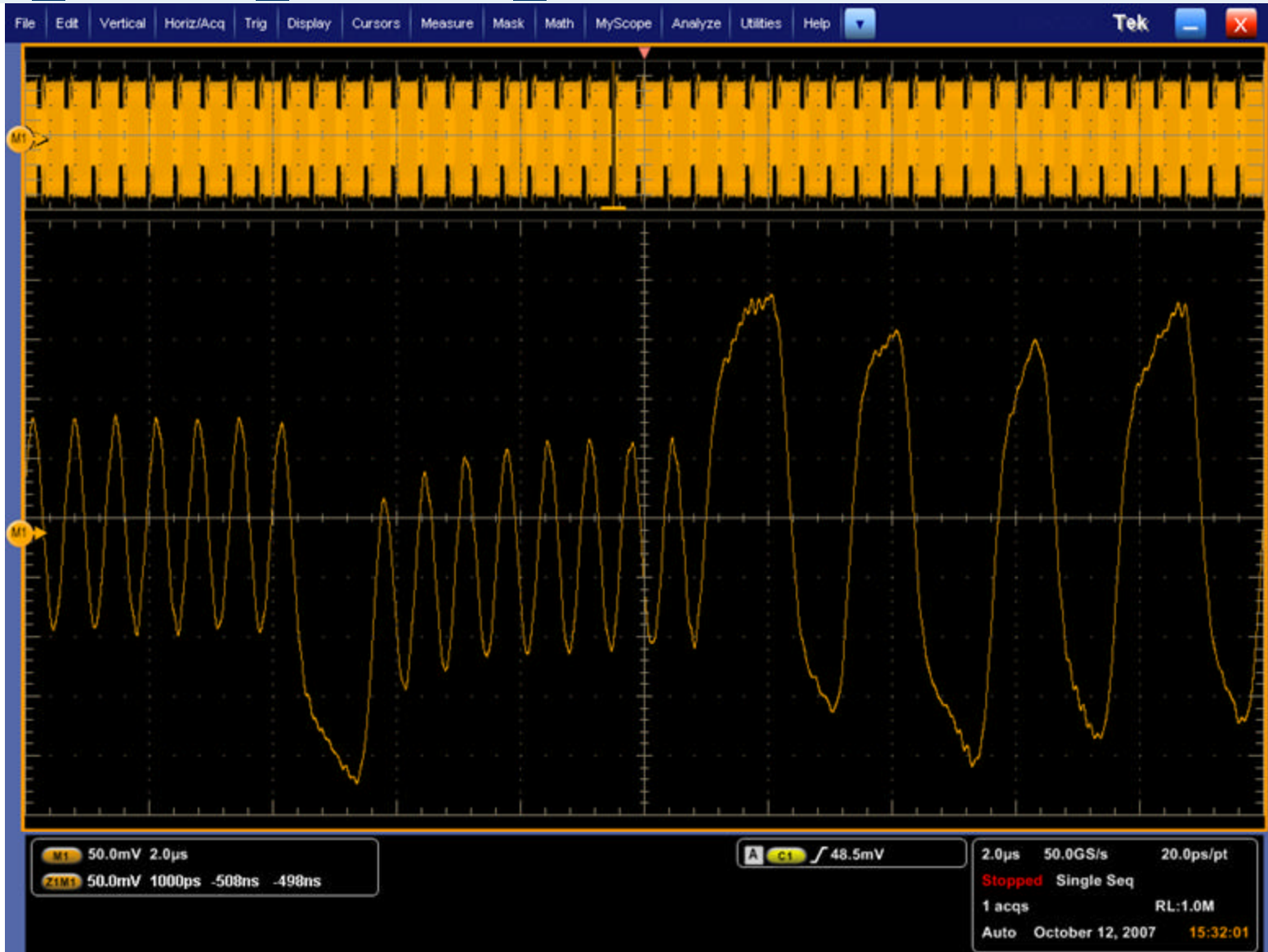
- 65 mV/div
- 20.8 ps/div
- 4.992688 M#

Timebase	0.00 μ s	Trigger	C1
	1.00 μ s/div	Auto	0.0 mV
600 kS	60 GS/s	Edge	Negative

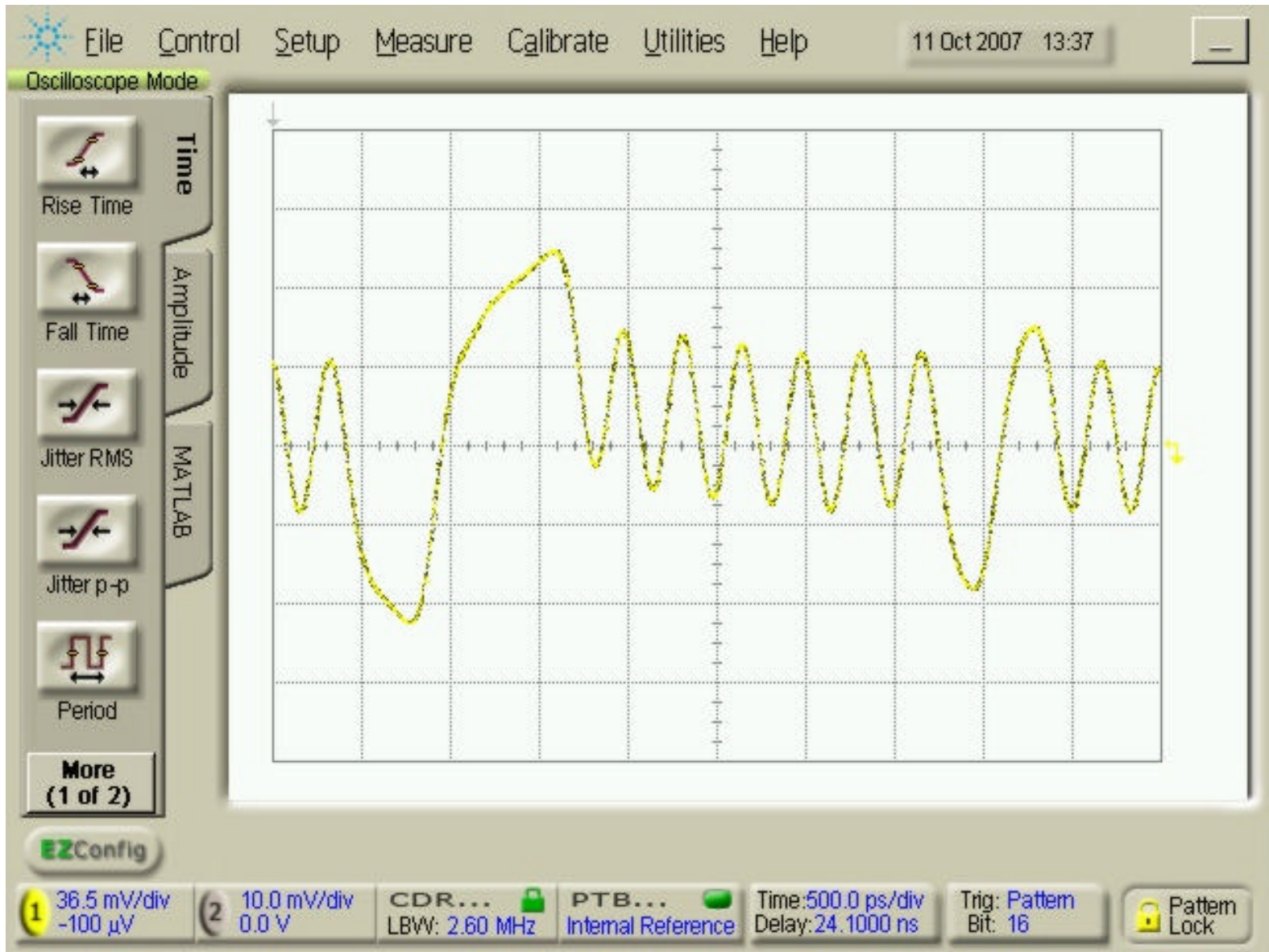
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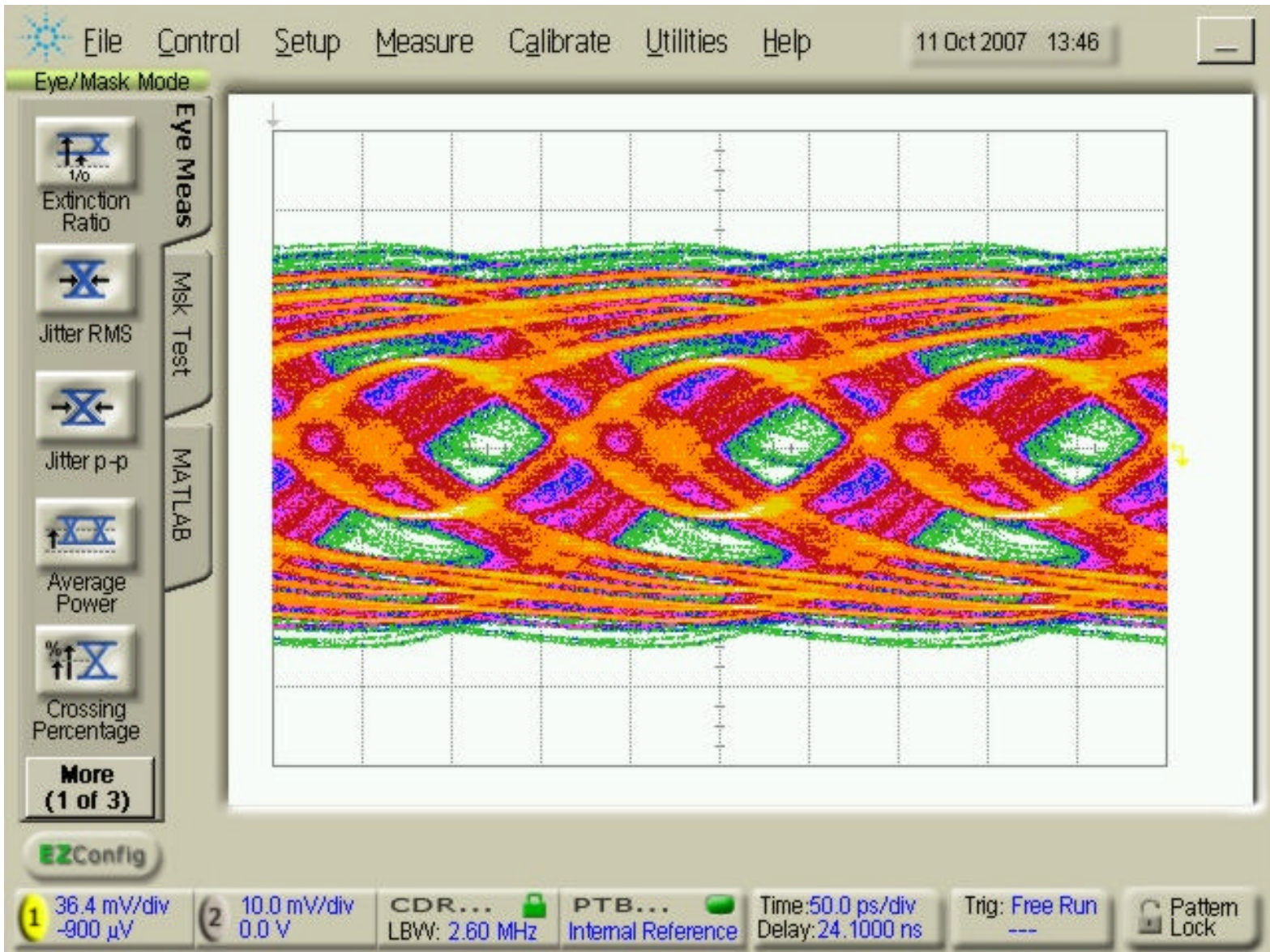
PHY_CJTPAT_SAS10m_6G



PHY CJTPAT SAS10m Waveform



PHY CJTPAT SAS10m EYE





We commit.
We innovate.
We partner.
We create value.



Never stop thinking