

Evaluation of 53 GBd PAM4 (“112G”) signal through Wilder OSFP Fixture

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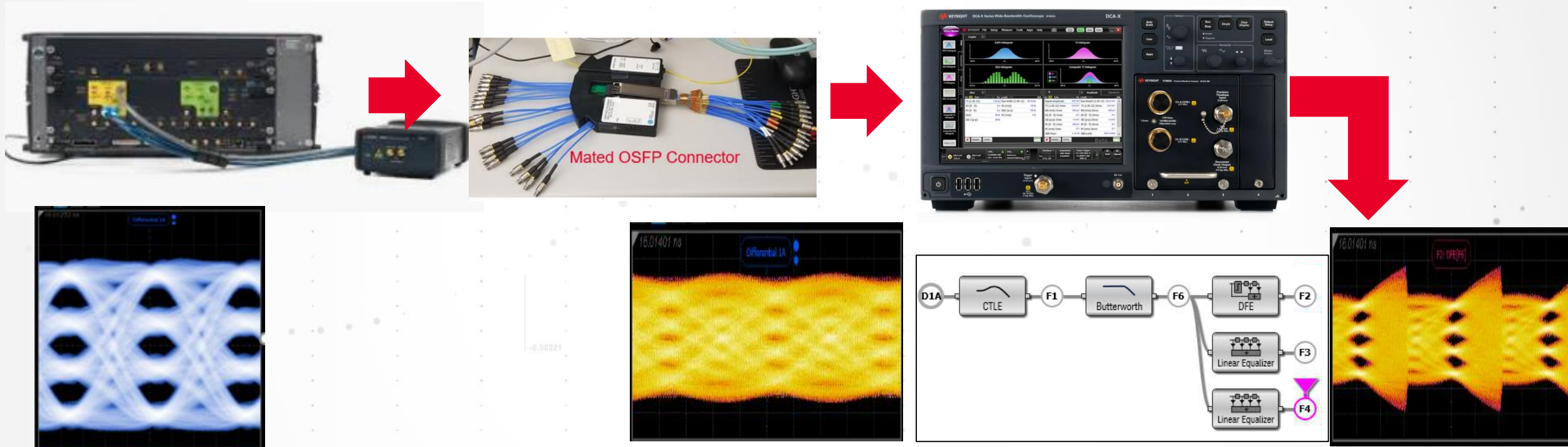
Objective



- Analyze real signals using proposed reference receiver configurations
 - Verify basic feasibility: Can we get usable measurement results?
 - Begin the process of correlating simulations with physical results
 - Confirm link budgets based on physical results
- Rev a1 updated on 01/20, includes jitter results from Beta DCA Software and Realtime Observations
- 13dB and 16dB channel configurations

Measurement Overview

STARTING POINT: VIEW PG SIGNALS THROUGH A TEST FIXTURE USING SEVERAL EQUALIZER CHOICES



Wilder OSFP Fixture (Mated) – S-parameter data

- Data supplied by Wilder: Differential Mated
- 8.69 dB loss at 26.5625 GHz

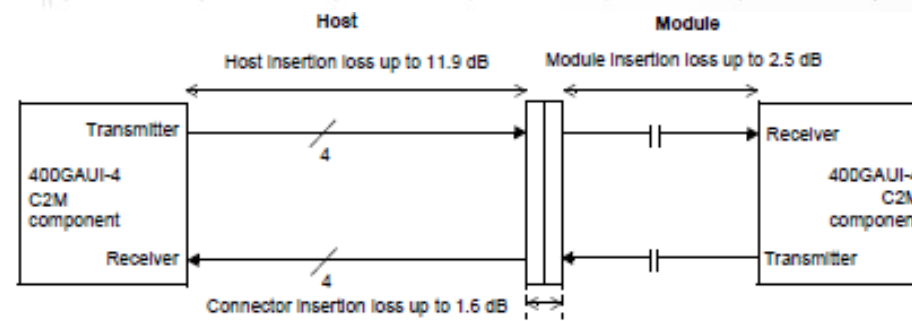
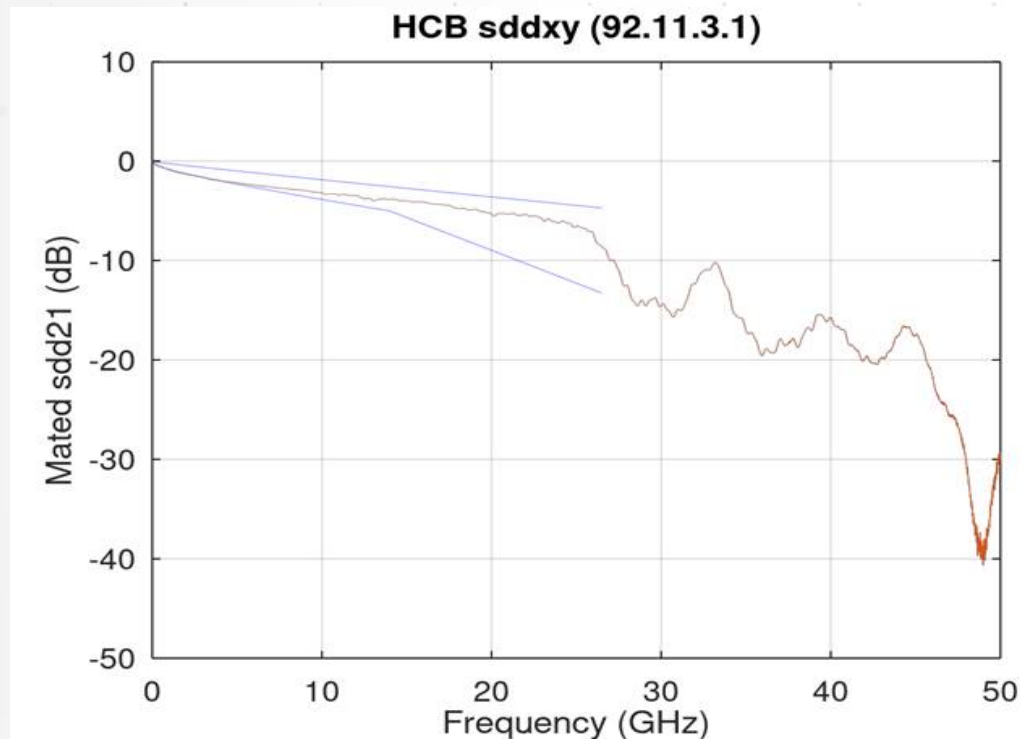
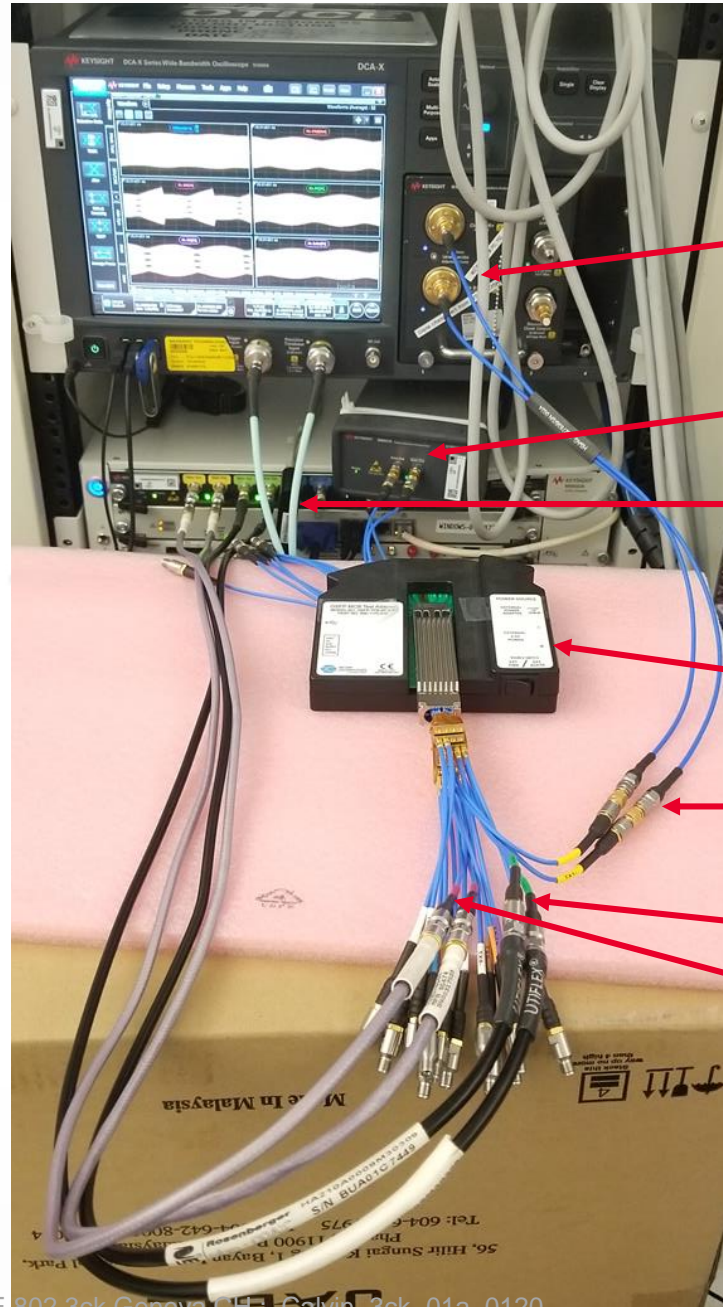


Figure 120G-4—400GAUI-4 C2M insertion loss budget at 26.56 GHz

Measurement Setup



M8040A JBERT Setup

M8040A TX EMPHASIZED USED TO OPTIMIZE PAM4 AT INPUT TO OSFP FIXTURE

- M8040A with M8045A PG (M8057A Remote Head)

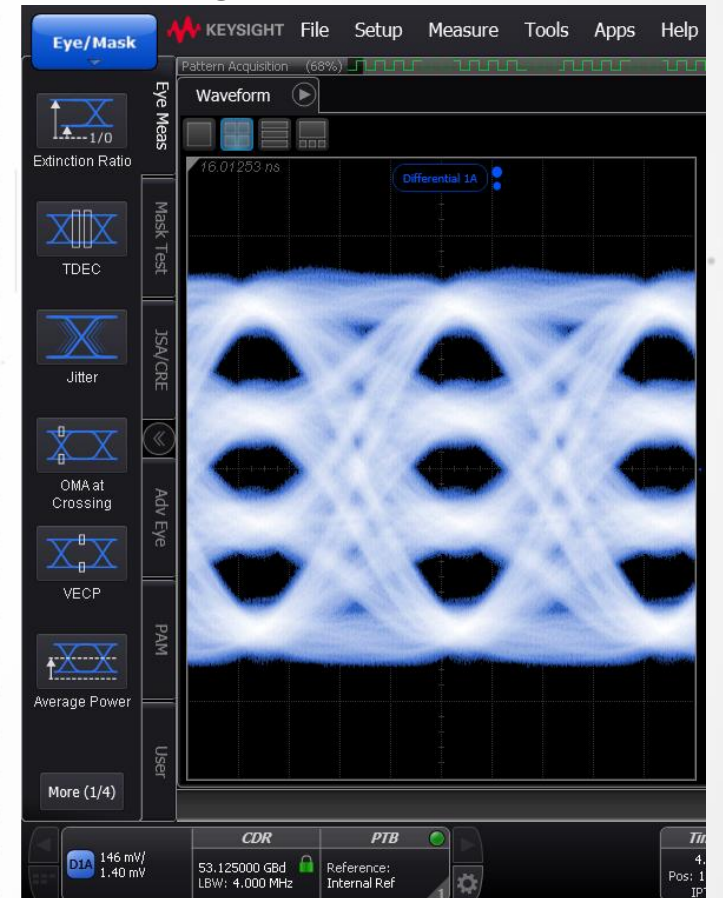
Line Coding		M1.DataOut1
Coding		PAM-4
Symbol Mapping		Gray Coded
Pre-Coder		Off
Symbol 3 Level		100 %
Symbol 2 Level		66 %
Symbol 1 Level		33 %
Symbol 0 Level		0 %

Amplifier		M1.DataOut1
Output State		On
Coupling		AC
Polarity		Non-Inverted
Amplitude		450 mV
Offset		0 mV
High		225 mV
Low		-225 mV
Clk/2 Jitter State		Off
Clk/2 Jitter		0.0 ps

Deemphasis		M1.DataOut1
Automatic Main-Cursor		On
Coefficient 0		0.02
Coefficient 1		0.01
Coefficient 2 (Main)		0.78
Coefficient 3		-0.17
Coefficient 4		0.02
Output Swing		100.00 %
Unit		dB
Pre-Cursor2		-0.54 dB
Pre-Cursor1		-0.28 dB
Post-Cursor1		-3.80 dB
Post-Cursor2		0.54 dB

53.125 Gbd, PAM4, PRBS13Q
Output Amplitude: 450 mV SE
TX Emphasis: 5-tap, 2-pre, 2-post

53 GBd PRBS13Q PAM4
input signal into OSFP Fixture



N1000A DCA-X plus N1060A Setup

FLEXDCA BETA REV 6.6 REQUIRED FOR NEW "112G" CTLE DEFINITION

About N1000A [?] Close

DCA FlexDCA
N1000-Series System Software
Copyright (C) 2006-2020 Keysight Technologies, Inc.

Model: N1000A LOJ,PLK,GPI,PTB
Serial #: MY58400160 **beta** P.06.60.82

System Information

- Software Version: P.06.60.82
- Software Version Date: 2020.0615
- Build Date: 1/9/2020 3:46:04 PM
- Software Options: N1010100A, N1010200A, 86100D-200, 86100D-201, 86100D-202, N1014A-1FP
- Application: N1000A
- Embedded: Yes
- Free Disk Space: 53.7 GB

Modules

- Slot 1 Module: N1060A 085,264,EVA,JSA,PTB, US57380070
- Slot 5 Module: M8196A, DE55C00140

KEYSIGHT File Setup Measure Tools Apps Help

Auto Scale Run Stop Single Clear

Pattern Acquisition (100%)

Waveform

16.01203 ns Differential IA

16.01203 ns F4: FFE(DIA)

5 tap FFE used to optimize M8040A TX emphasis.

(F4) Linear Feed Forward Equalizer Setup [?] Close

Operator Setup Display Setup

Taps

- Automatic Taps [Recalculate]
- Number of Taps: 5
- Precursors: 2

Tap Values:

0.002201, -0.001750, 1.007798, 0.001675, -0.009924

Frame Trigger Src: CDR (Slot 1) 53.125100 GBd 8191 UI

Math Signals

CTLE Setup

FLEXDCA BETA REV 6.60

(F1) CTLE Setup ? Close

Operator Setup Display Setup

Definition:
IEEE 802.3ck ▼

Gdc: ▼ ▲

Zero Frequency: ▼ ▲

Low-Frequency Zero/Pole: ▼ ▲

Gdc2: ▼ ▲

Pole 1 Frequency: ▼ ▲

Pole 2 Frequency: ▼ ▲

Preset
 ▼ +

Noise Processing

Preserve Noise

Input Noise Bandwidth:

Track Input Bandwidth ▼ ▲

Butterworth, DFE, and FFE Setup

(F6) Butterworth Setup

Operator Setup | Display Setup

Filter Order: 4

Filter Cutoff Frequency: 39.00 GHz

Noise Processing

- Preserve Noise
- Track Input Bandwidth: 43.00 GHz

(F2) Decision Feedback Equalizer Setup

Operator Setup | Display Setup

Taps

- Automatic Taps
- Number of Taps: 4
- Tap Values: 0.135346, -0.076936, 0.036706, -0.024385

Symbol Rate: 53.125100 GBd

Advanced

- Preset: Custom
- Clock Delay: -3.54 ps
- Tap Limits: Max Tap Value: 0.500000, Min Tap Value: -0.500000
- Threshold Bandwidth: Auto (Tracks Symbol Rate) 1.000 THz
- Display Thresholds Instead of Signal

(F4) Linear Feed Forward Equalizer Setup

Operator Setup | Display Setup

Taps

- Automatic Taps
- Number of Taps: 5
- Precursors: 2
- Tap Values: 0.071783, -0.233952, 1.074197, 0.037306, 0.050666

Advanced

- Preset: Custom
- Tap Spacing: Specify As: Taps/UI, 18.82 ps
- Bandwidth: Auto (Tracks Tap Spacing) 53.13 GHz
- Noise Processing: Preserve Noise, Track Input Bandwidth: 7.500 GHz

Diff Signal at input to N1060A scope (after OSFP fixture)

Diff Amplitude: ~ 550 mV pp
(input to N1060A, output of OSFP fixture)

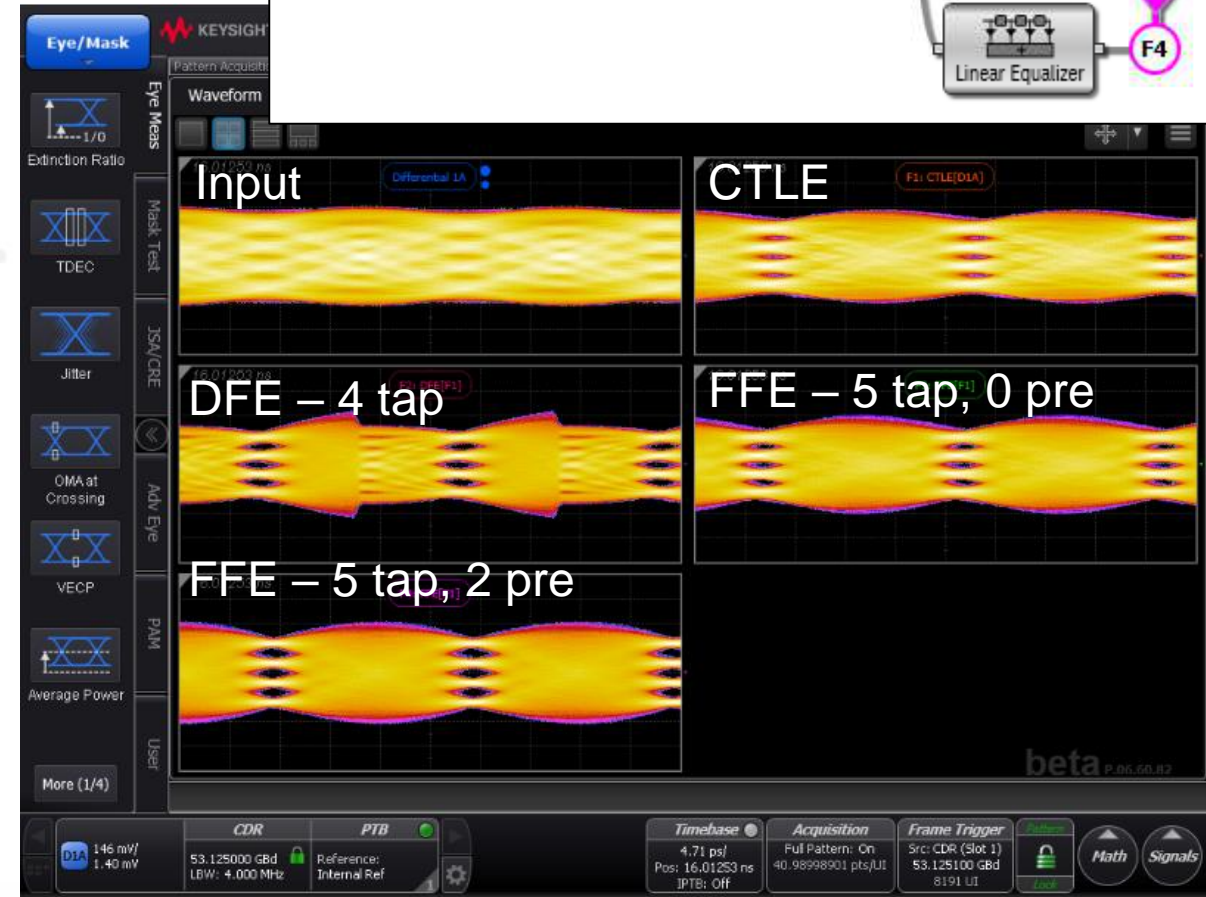
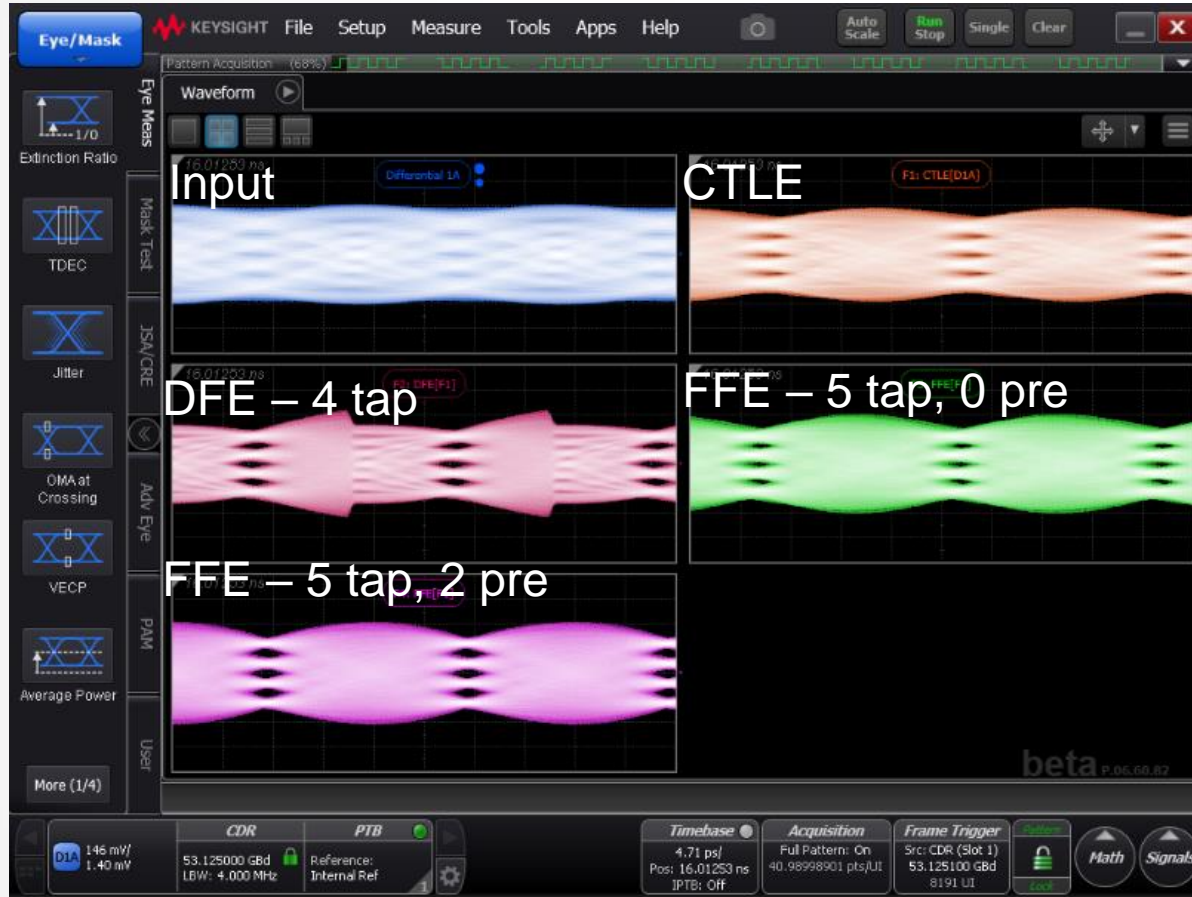
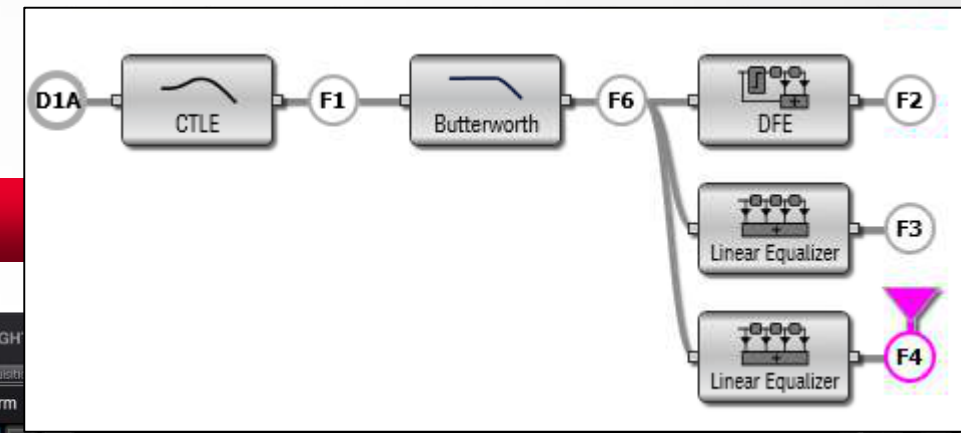


N1000A DCA-X with N1060A MegaModule



OSFP TX1 Output, No Aggressors

EYE/MASK MODE



➤ Open Eye at output of all equalizers

OSFP TX1 Output, DFE output, No Aggressors

JITTER MODE RESULTS ON TX1 DFE

CTLE: 2 gain stage, manual optimization
 Butterworth: 4th Order, 39 GHz BW

DFE: 4 tap

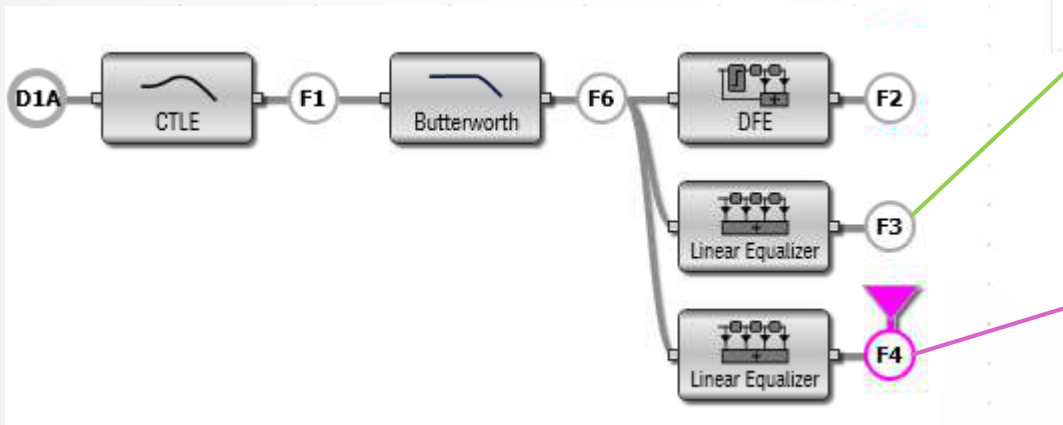
- EH5: 32-38 mV
- EW5: Not available

Eye			
Src: F2 Rate: 53.125100 GBd Pat. Length: 8191			
Measurement	Eye 0/1	Eye 1/2	Eye 2/3
Eye Width (1.0E-5)	DFE?	DFE?	DFE?
Eye Height (1.0E-5)	31.9 mV	38.5 mV	34.3 mV



OSFP TX1 Output, FFE output, No Aggressors

- CTLE: 2 gain stage, manual optimization
- Butterworth: 4th Order, 39 GHz BW
- **FFE, F3: 5 tap, 0-precursors (almost closed)**
 - EW5: 1.7 – 2.1 ps
 - EH5: 14 - 29 mV
- **FFE, F4: 5 tap, 2-precursors (best eye opening)**
 - EW5: 2.8 – 3.2 ps
 - EH5: 41 – 45 mV



Configure Source for AWG Channel 1

The diagram shows a signal flow from a Data Source block through a Filter block and a Jitter block to an M8196A device. The Data Source block is on the left, the Filter block is in the middle, and the Jitter block is at the bottom. The M8196A device is on the right. A plus sign in a circle is located between the Filter and Jitter blocks, indicating a summing junction.

Data Source

- Type: Data
- Amplitude: 500.000 mV
- Offset: 0 V
- Skew: 0 s
- Level 2: 66.7 %
- Level 1: 33.3 %

Filter

- 4th order Bessel
- BW: 50.00 GHz

Jitter

- No Jitter Configured

M8196A

- Channel 1

Turn on 2 PAM4 Aggressors (AWG, 500 mV, SSPRQ)

Keysight M8196A(Slot5) Setup

AWG memory is up to date.

AWG Mode: Basic

Common

- Waveform Type: Data
- Format: PAM4
- Symbol Rate: 53.12500000 Gbd
- Pattern: SSPRQ (65535 symbols)
- Clock Div. Ratio: 1:2 (Sub-Rate)

Channels

Channel	Type	Setup...
1	Data	Setup...
2	Data	Setup...
3	Data	Setup...
4	Data	Setup...

Auto Update

Optimize...


OSFP TX1 Output, DFE output, With 2 Aggressors (TX3, TX4)

JITTER MODE RESULTS ON TX1 DFE

CTLE: 2 gain stage, manual optimization
Butterworth: 4th Order, 39 GHz BW

DFE: 4 tap

- EH5: 32-38 mV (no aggressors)
- EH5: 27 – 32 mV (with aggressors)
- EW5: Not available

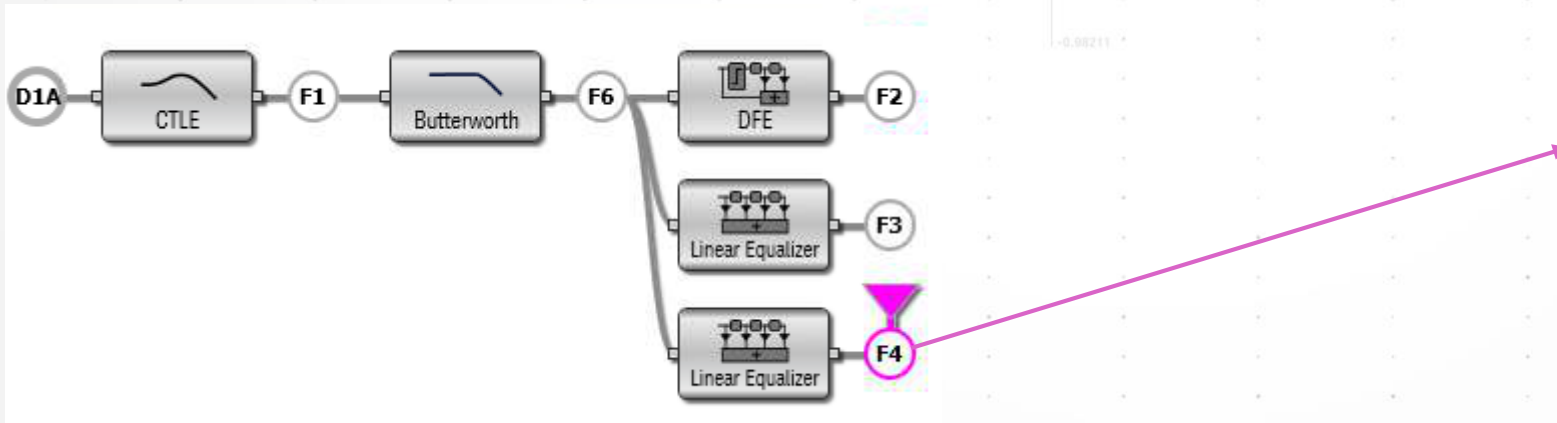


Measurement	Eye 0/1	Eye 1/2	Eye 2/3
Eye Width (1.0E-5)	DFE?	DFE?	DFE?
Eye Height (1.0E-5)	27.6 mV	32.6 mV	28.6 mV



OSFP TX1 Output, FFE output, No Aggressors

- CTLE: 2 gain stage, manual optimization
- Butterworth: 4th Order, 39 GHz BW
- **FFE, F3: 5 tap, 0-precursors (almost closed)**
 - EW5: 1.7 – 2.1 ps (no aggressors), 1.4 – 1.75 ps (with aggressors)
 - EH5: 14 - 29 mV (no aggressors), 9 – 14 mV (with aggressors)
- **FFE, F4: 5 tap, 2-precursors (best eye opening)**
 - EW5: 2.8 – 3.2 ps (no aggressors), 2.65 – 2.9 ps (with aggressors)
 - EH5: 41 – 45 mV (no aggressors), 37 – 40 mV (with aggressors)



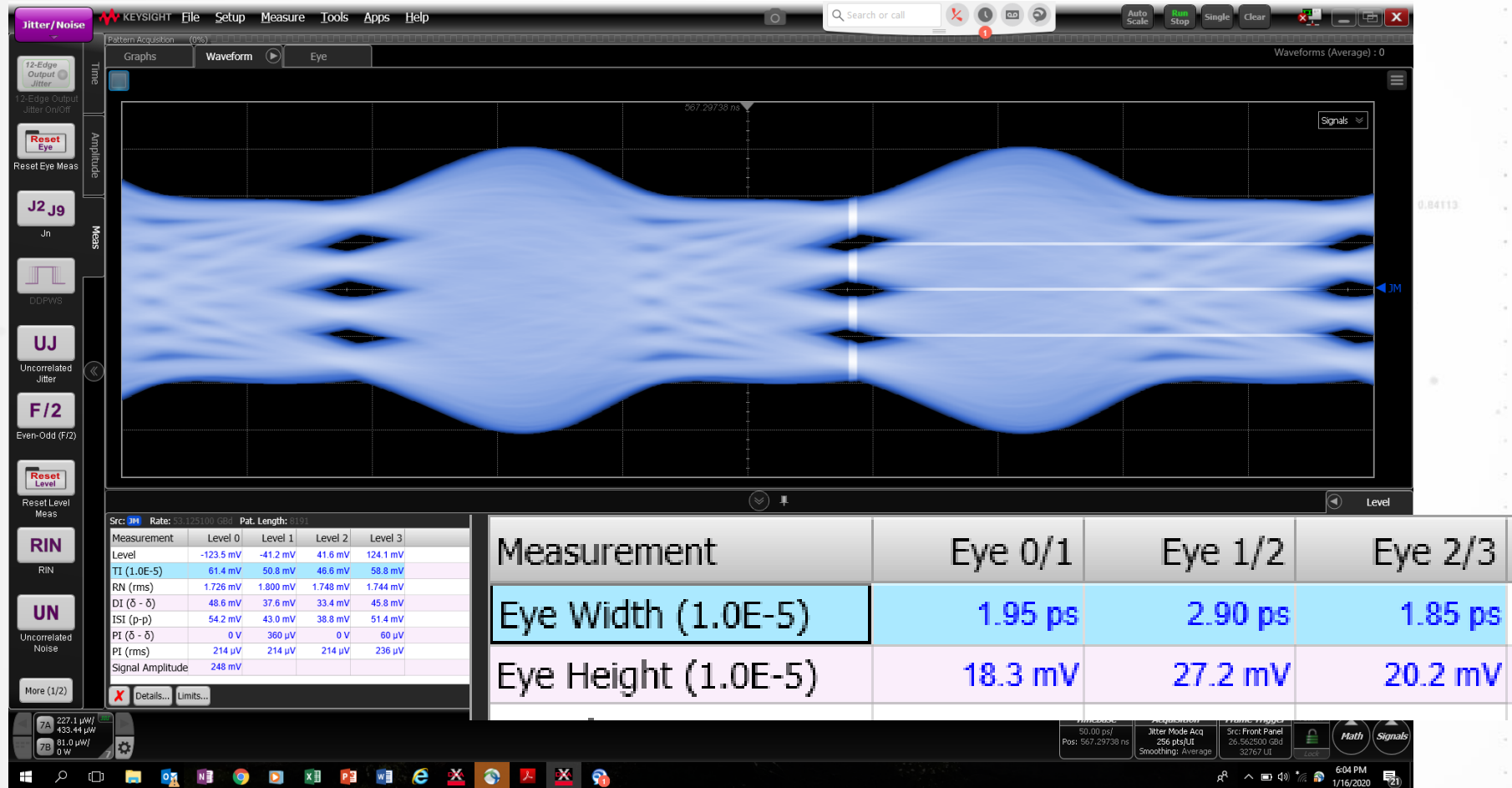
Increase differential loss to > 13 dB

- 0.5 meter coaxial cables added to increase total insertion loss to ~13 dB at 26.56 GHz



DFE

NEW BETA FW PROVIDES EYE WIDTH OF DFE OUTPUT



Realtime CTLE + DFE (same equalization as DCA)

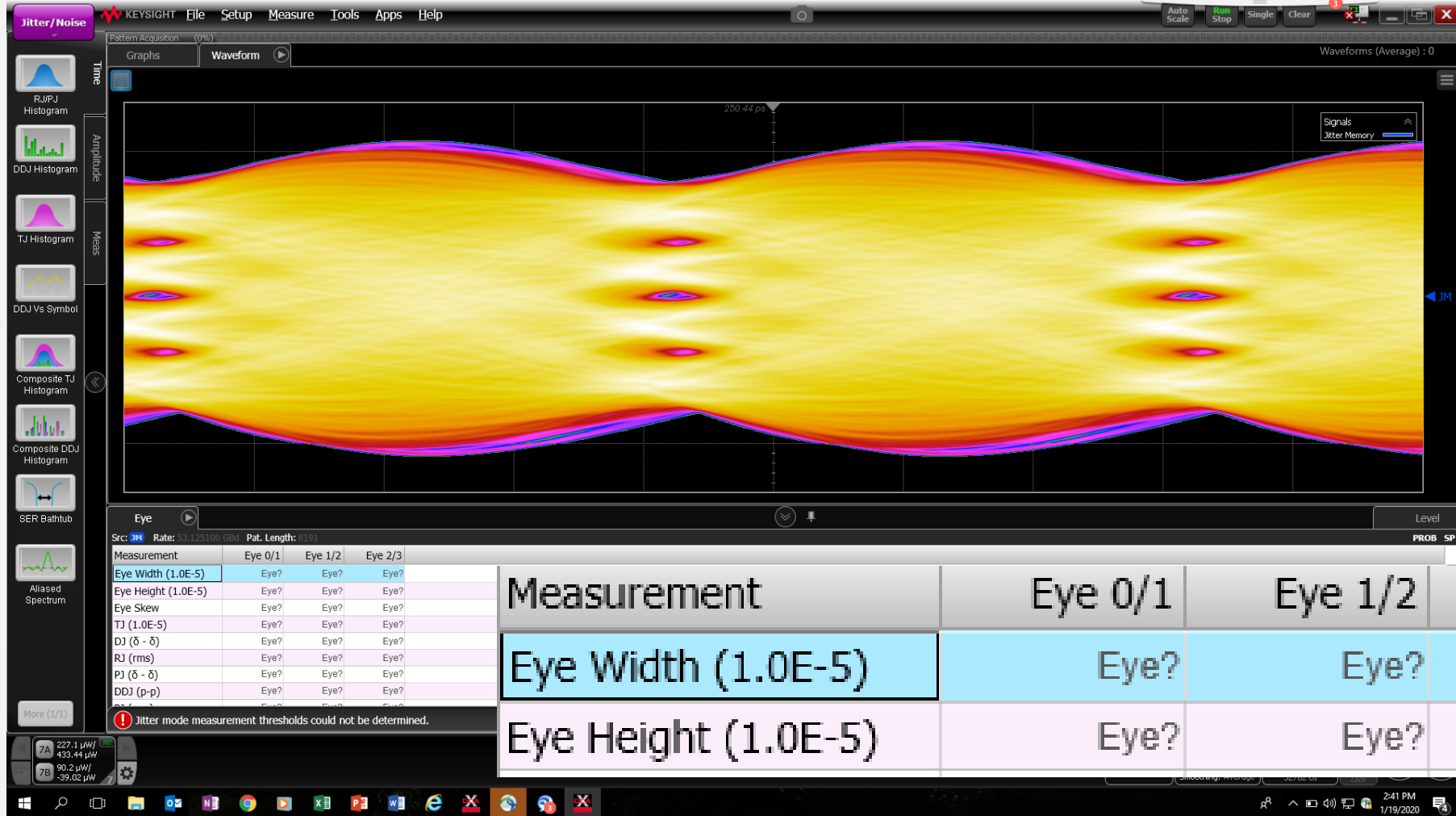
ABSENT BUTTERWORTH PRE-FILTER (FYI)

- Eye Width
 - 2.06, 2.08, 2.4ps
 - Nominally 30% wider than ET, No-Butterworth
- Eye Height
 - 26.6, 25.9, 31mV
 - Nominally 25% higher than ET, No-Butterworth

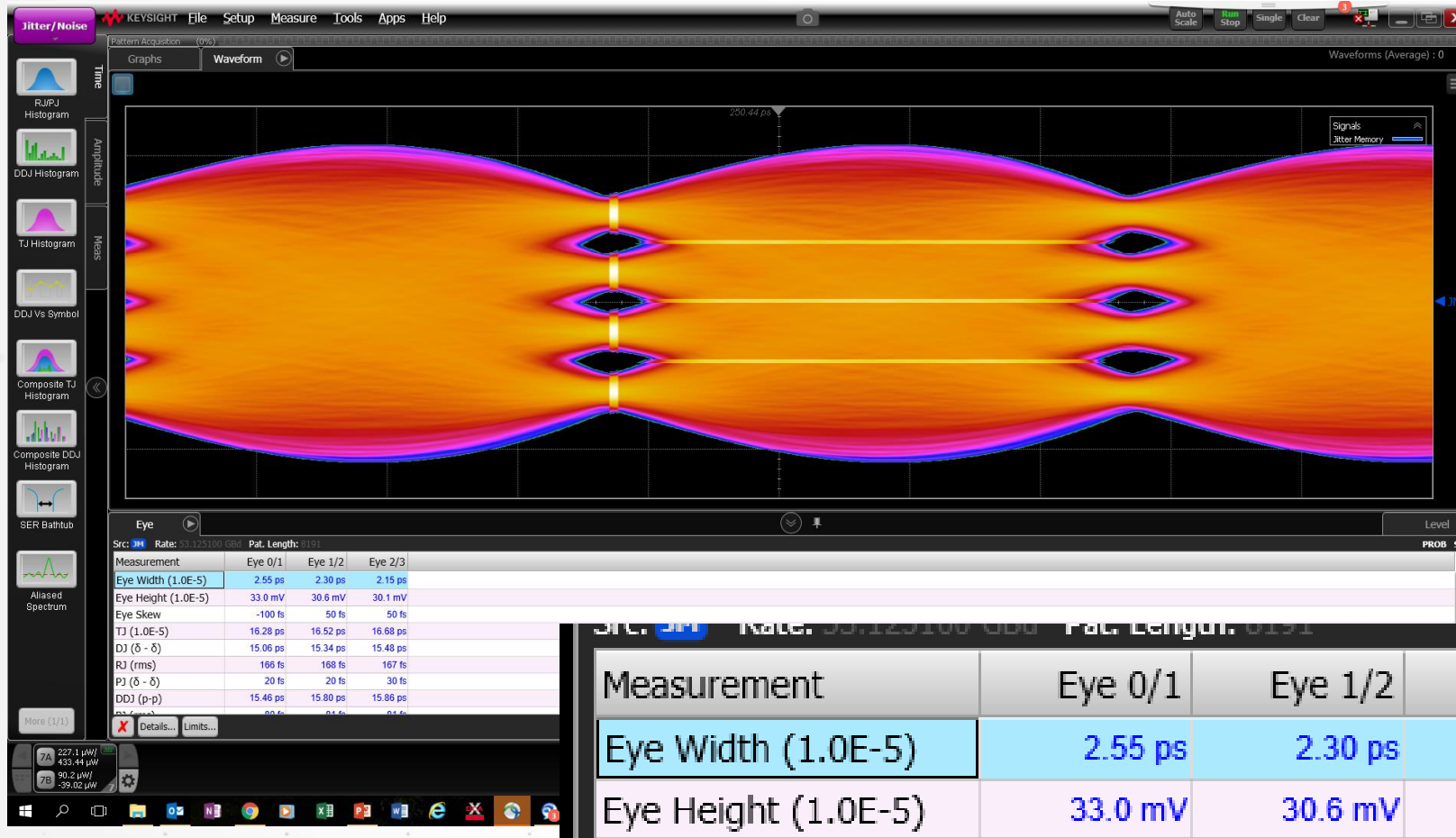


FFE no precursors

EYE CLOSURE PREVENTS ANALYSIS



FFE 2 precursors

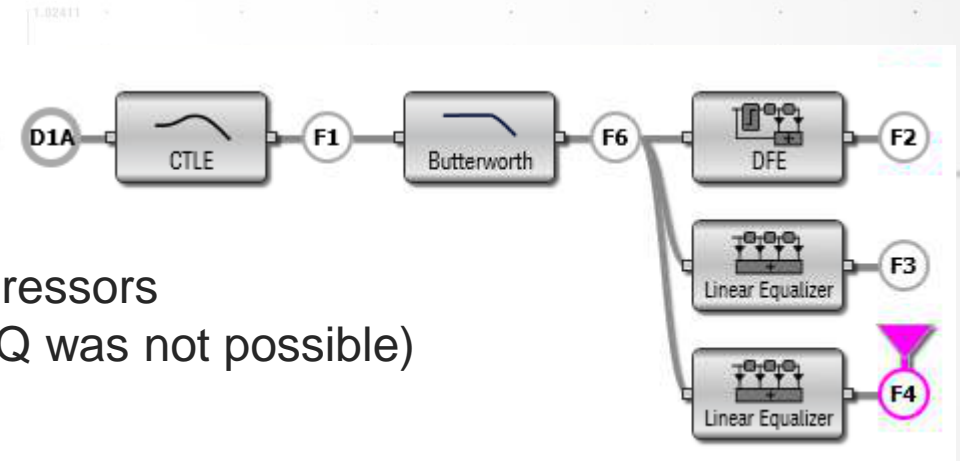


Summary



Summary

- 53 GBd, PRBS13Q signal from M8040A BERT PG was passed through Wilder OSFP Fixture
 - Insertion Loss needs to be verified using VNA (differential measurement)
- Output of OSFP Fixture was connected to oscilloscope, and passed through 3 EQ different paths. CTLE + Butterworth followed by:
 1. DFE 4 tap
 2. FFE 5 tap, 0 pre
 3. FFE 5 tap, 2 pre



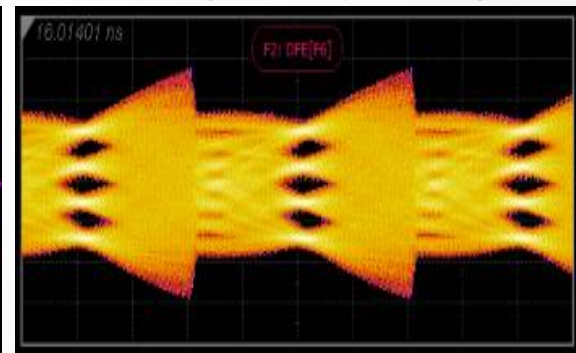
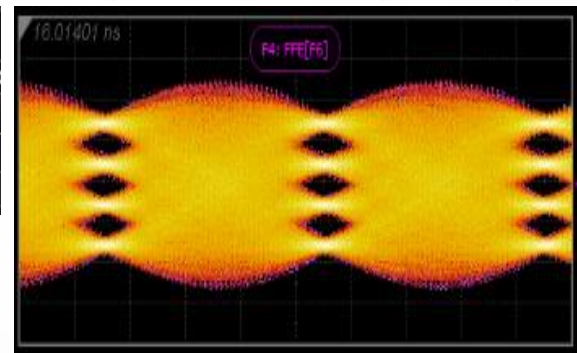
- Eye Opening was measured with no aggressors, and with 2 aggressors (Aggressor signals from AWG: 53 GBd, SSPRQ since PRBS31Q was not possible)

- Open eyes (small) at output of all 3 EQ models

- FFE 5 tap, 2 pre (best)
- DFE 4-tap (2nd)
- FFE 5 tap, 0 pre (3rd)

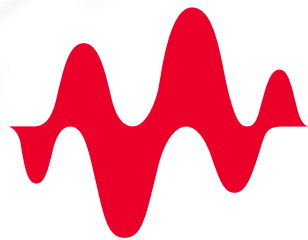
Measurement	Eye 0/1	Eye 1/2	Eye 2/3
Eye Width (1.0E-5)	2.65 ps	2.90 ps	2.65 ps
Eye Height (1.0E-5)	39.6 mV	39.9 mV	37.2 mV

- 2 aggressors reduced eye openings by > 10% (compared to no aggressors)



Need to perform analysis on real signals through real channels

- Need to verify the measurements can be performed when observing signals with the loss and reflections that will exist in real systems
- Automate the DFE optimization (pulse response) around Annex 93A.2 for optimal phase and DFE tap weight.



KEYSIGHT
TECHNOLOGIES

4.50221

Backup 16dB Channel

