

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

Speaker: John Calvin

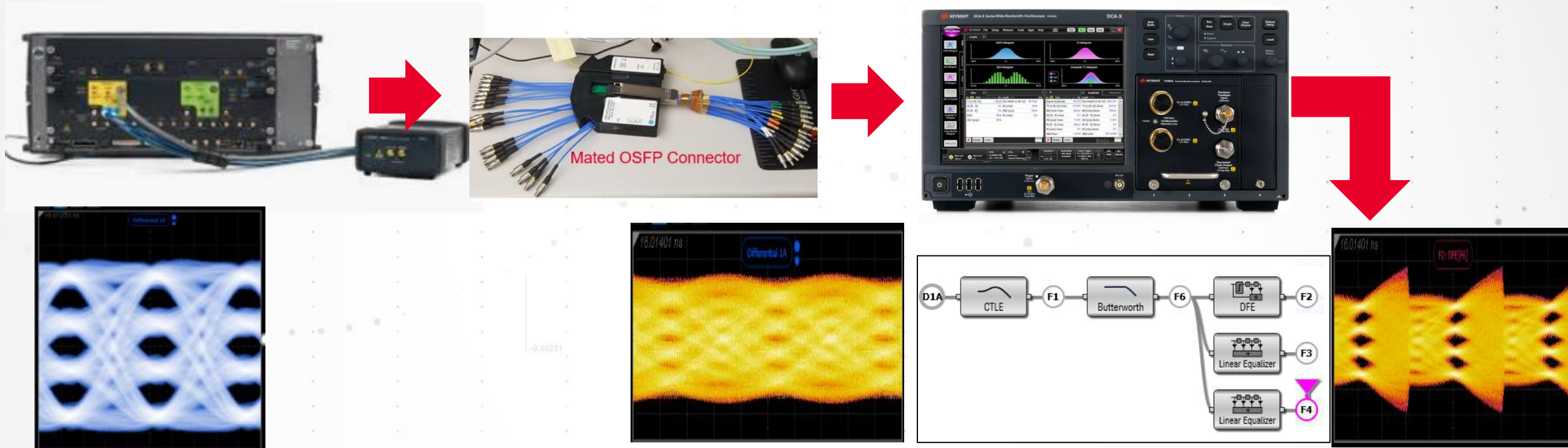
2020-01

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Ryan Chodora, Marlin Viss (Keysight Technologies)*



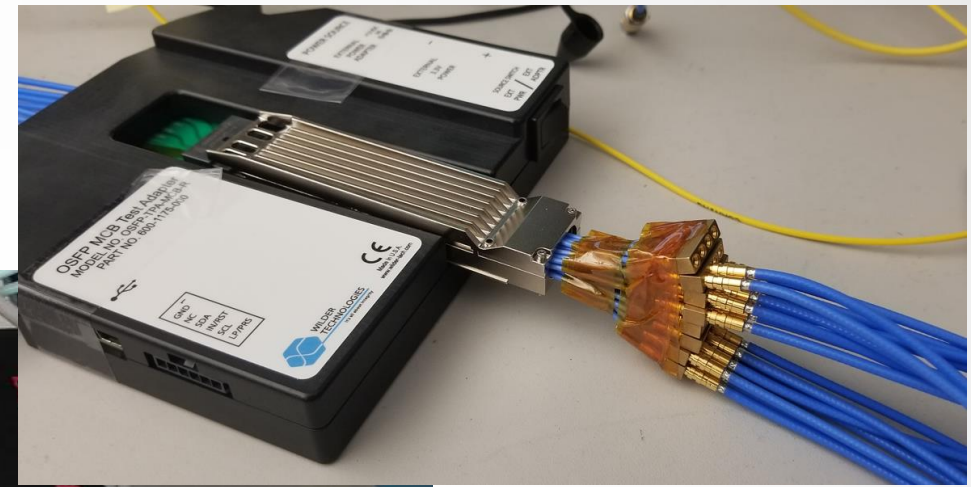
Measurement Overview



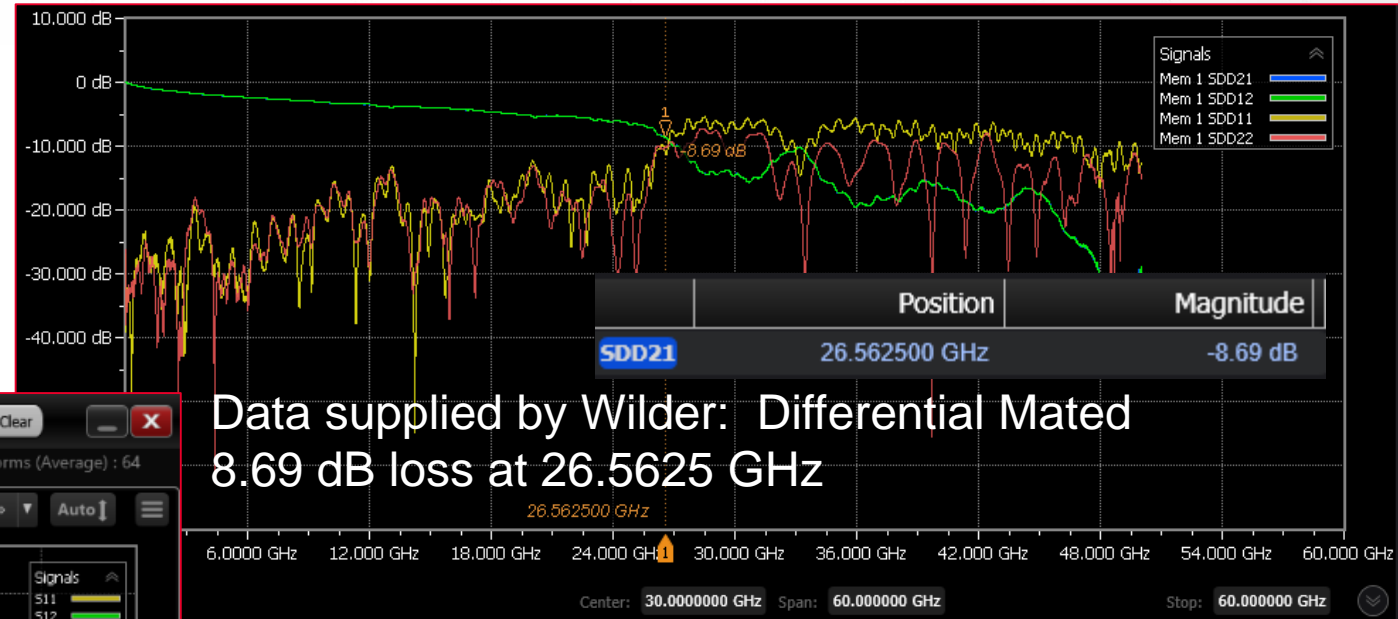
Measured Data Resources: (S-Parameters, WFM's)

<http://grouper.ieee.org/groups/802/3/ck/public/tools/index.html>

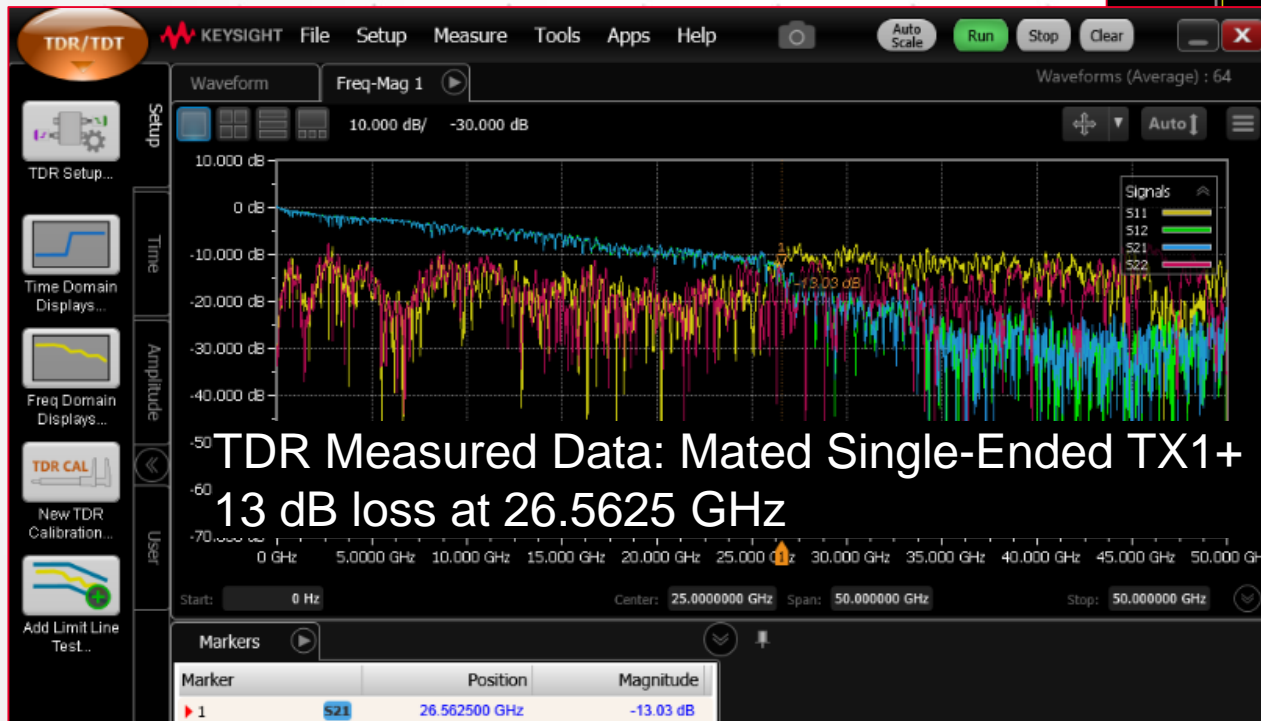
Wilder OSFP Fixture



Wilder OSFP Fixture (Mated) – S-parameter data



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

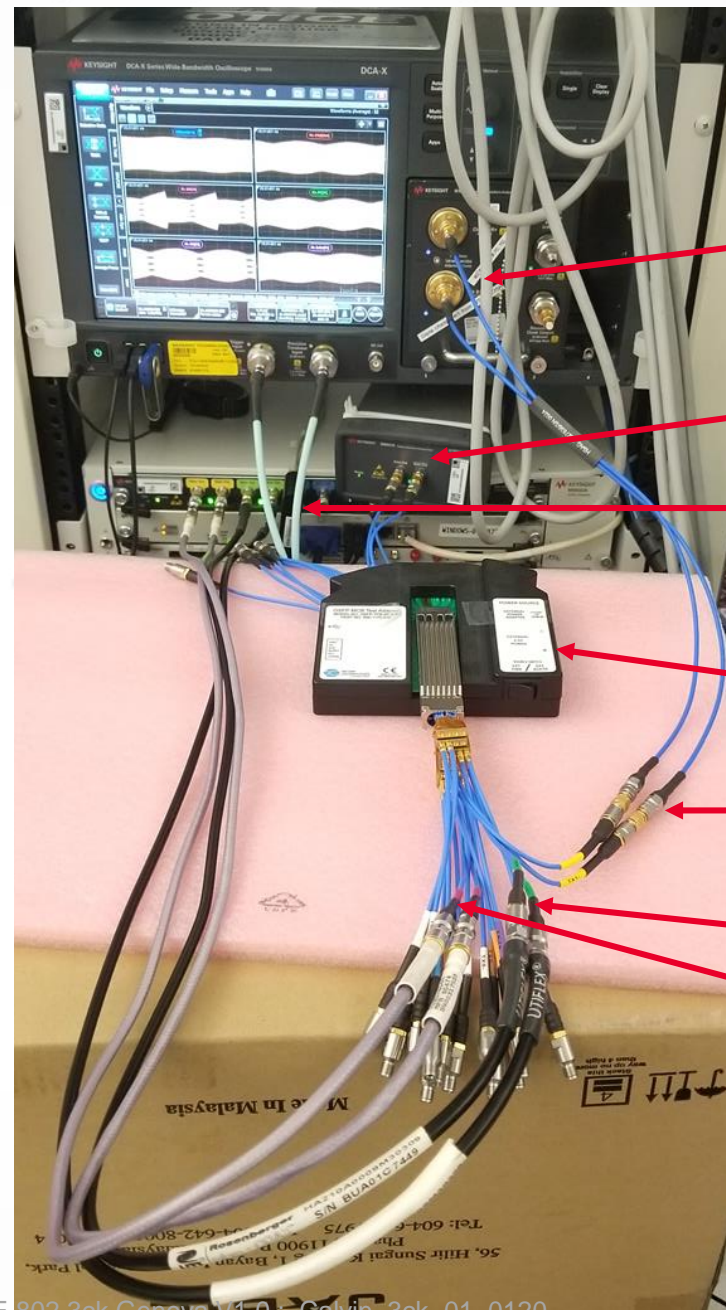


TDR Measured Data: Mated Single-Ended TX1+
13 dB loss at 26.5625 GHz

Measured insertion Loss on single-ended lanes had
13-15 dB loss at 26.56 GHz (Nyquist).

Note - N1055A was uncalibrated.

Measurement Setup



N1000A DCA-X with N1060A MegaModule

M8057A Remote Head

M8196A AWG (Aggressor Source, SSPRQ)

Wilder OSFP Fixture (HCB+MCB mated)

TX1 Pair (Victim)

TX3 Pair (Aggressor)

TX4 Pair (Aggressor)

M8040A JBERT Setup

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

- M8040A with M8045A PG (M8057A Remote Head)

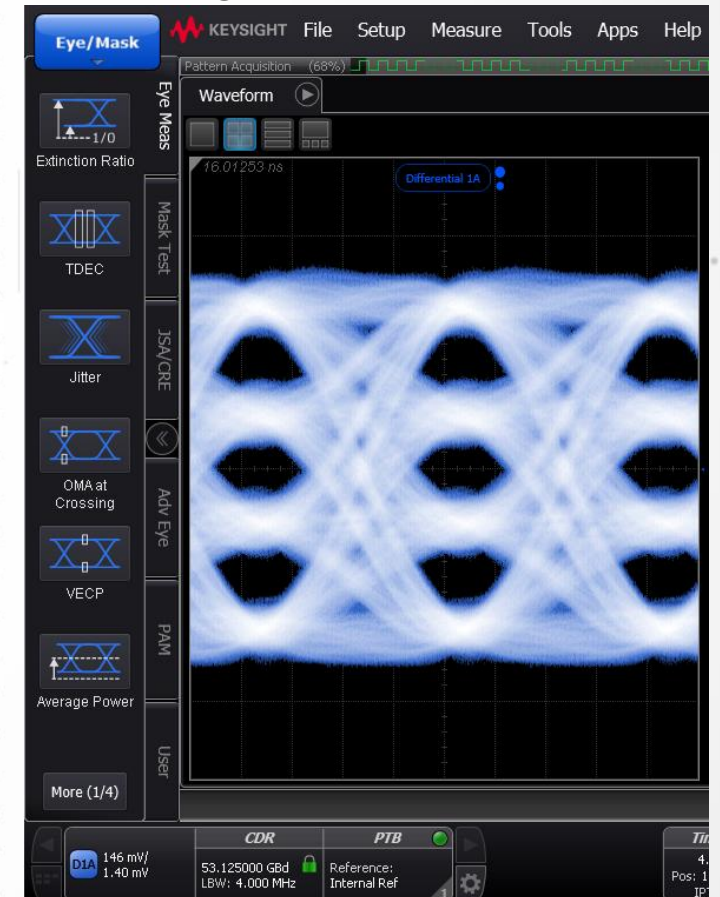
Line Coding		M1.DataOut1
Coding	PAM-4	
Symbol Mapping	Gray Coded	
Pre-Coder	<input type="checkbox"/> Off	
Symbol 3 Level	100 %	
Symbol 2 Level	66 %	
Symbol 1 Level	33 %	
Symbol 0 Level	0 %	

Amplifier		M1.DataOut1
Output State	<input checked="" type="checkbox"/> On <input type="checkbox"/> Off	
Coupling	AC	
Polarity	Non-Inverted	
Amplitude	450 mV	
Offset	0 mV	
High	225 mV	
Low	-225 mV	
Clk/2 Jitter State	<input type="checkbox"/> On <input checked="" type="checkbox"/> Off	
Clk/2 Jitter	0.0 ps	

Deemphasis		M1.DataOut1
Automatic Main-Cursor	<input checked="" type="checkbox"/>	
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

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: 53.2 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

Eye/Mask

Waveform

Extinction Ratio

TDEC

Jitter

OMA at Crossing

VECP

Average Power

More (1/4)

16.01203 ns

Differential IA

16.01203 ns

F4: FFE[D1A]

5 tap FFE used to optimize M8040A TX emphasis.

(F4) Linear Feed Forward Equalizer Setup

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

Preset

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: -2.0 dB ▼ ▲ Zero Frequency: 12.58 GHz ▼ ▲ Low-Frequency Zero/Pole: 1.328 GHz ▼ ▲

Gdc2: -2.0 dB ▼ ▲ Pole 1 Frequency: 20.00 GHz ▼ ▲ Pole 2 Frequency: 28.00 GHz ▼ ▲

Preset
Custom ▼ +

Noise Processing

☒ Preserve Noise

Input Noise Bandwidth:

☒ Track Input Bandwidth 53.00 GHz ▼ ▲

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

Input Noise Bandwidth: 43.00 GHz

☐ Track Input Bandwidth

(F2) Decision Feedback Equalizer Setup

Operator Setup Display Setup

Taps

☒ Automatic Taps Recalculate

Number of Taps: 4

Tap Values: 0.135346, -0.076936, 0.036706, -0.024385

Symbol Rate: 53.125100 GBd

Advanced

Preset Custom

Clock Delay

Delay Amount: -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 Recalculate

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: 1 18.82 ps

Bandwidth

☒ Auto (Tracks Tap Spacing) 53.13 GHz

Noise Processing

☒ Preserve Noise

Input Noise Bandwidth: 7.500 GHz

☒ Track Input Bandwidth

Diff Signal at input to N1060A (after OSFP fixture)

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

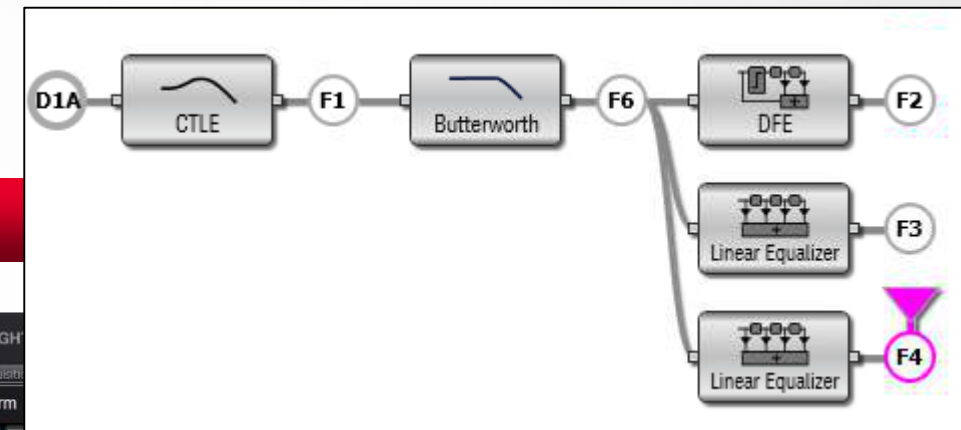
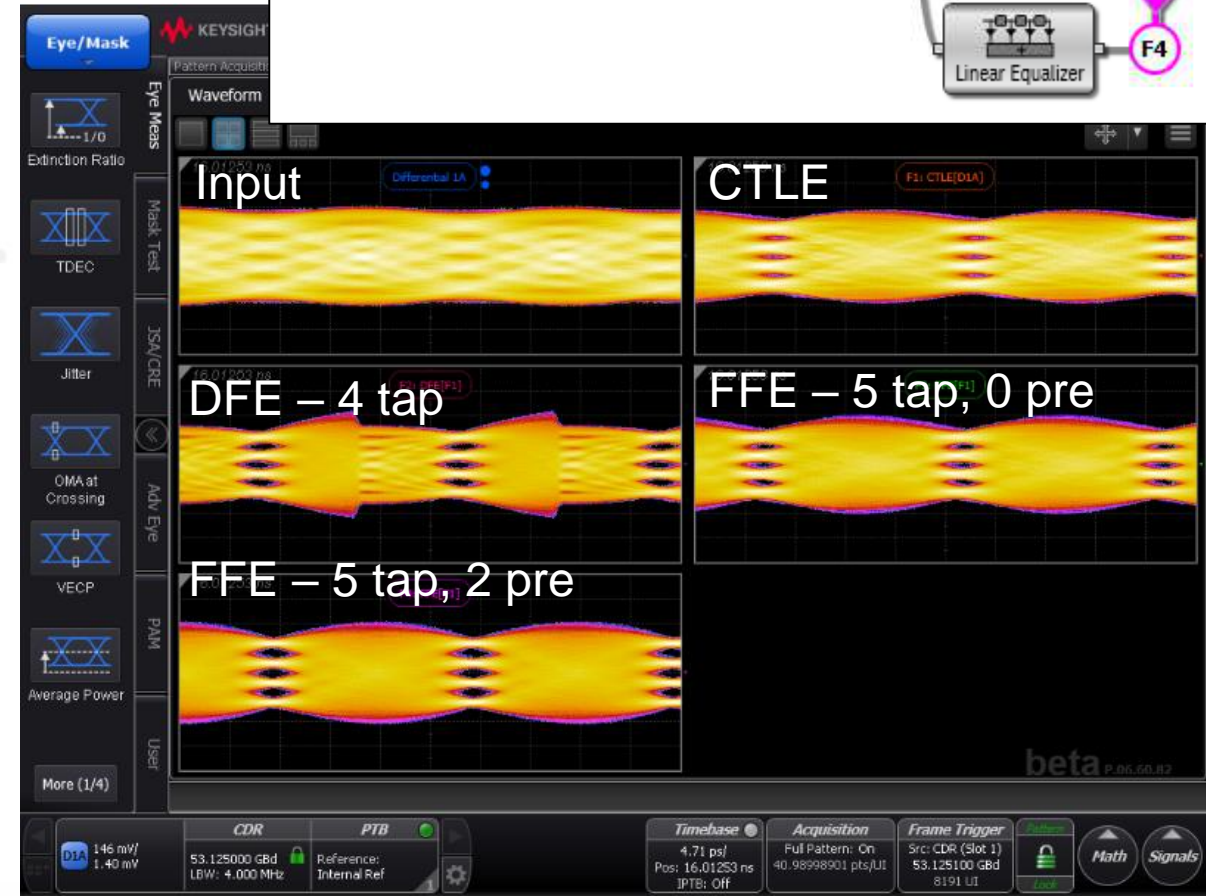
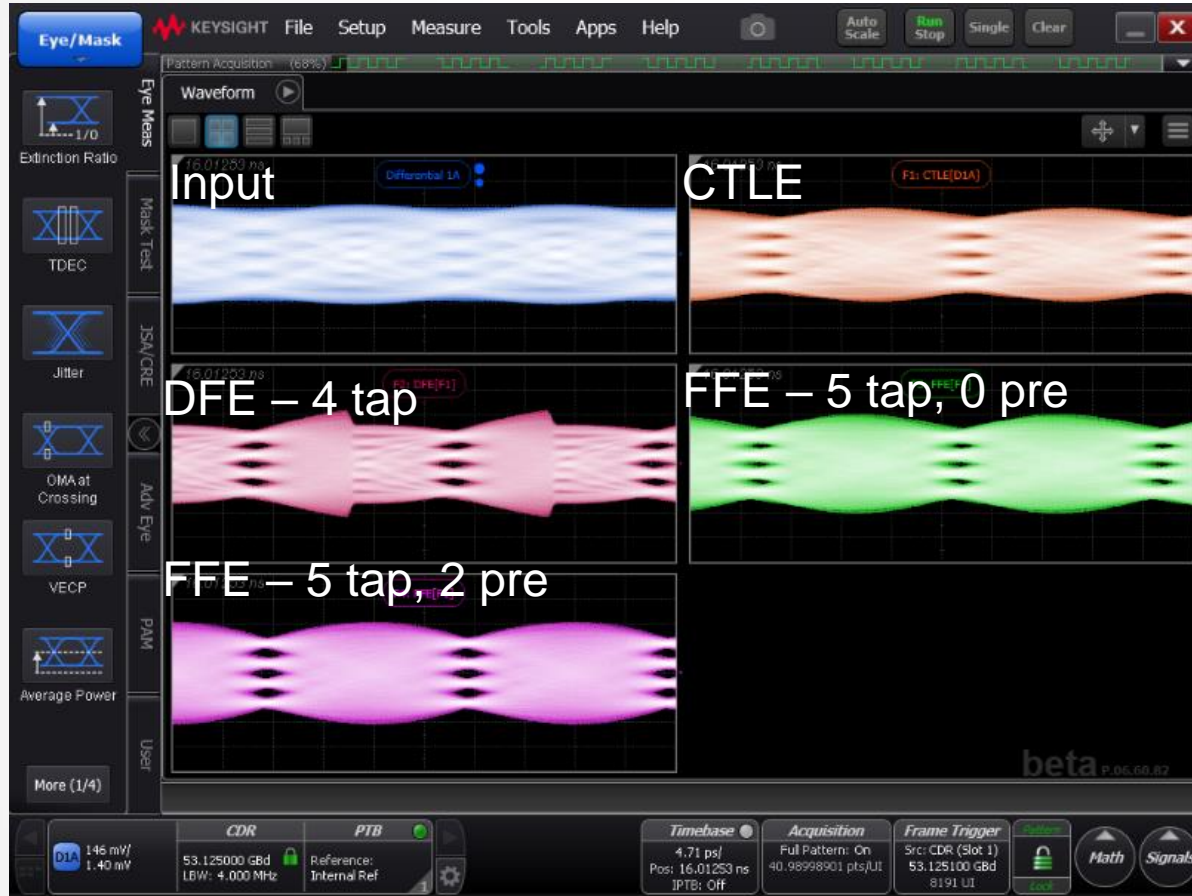


N1000A DCA-X with N1060A MegaModule



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

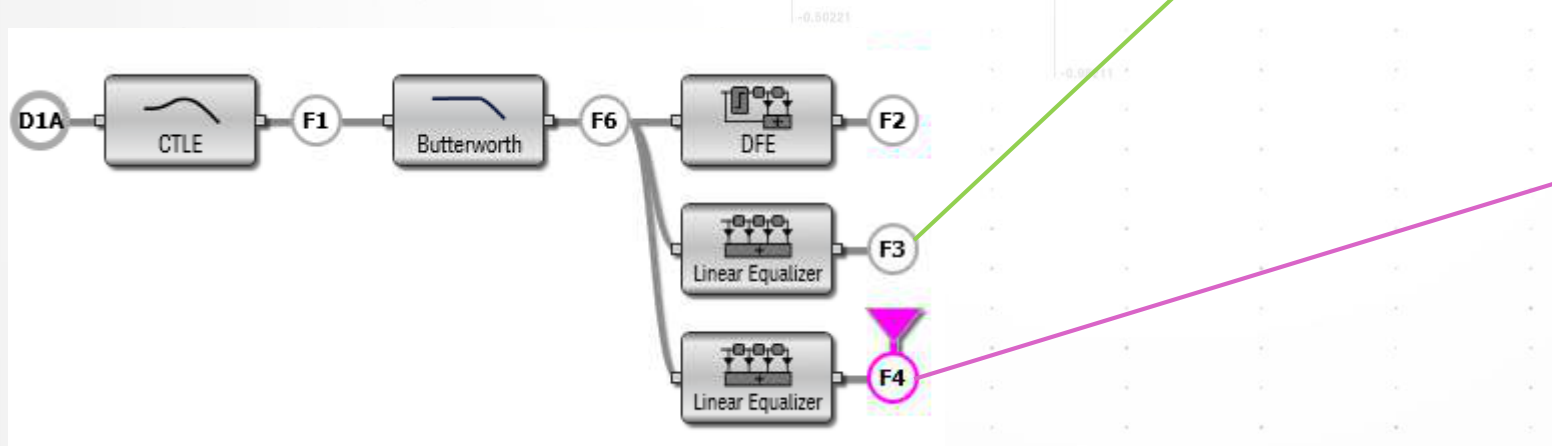
- EH5: 32-38 mV
- EW5: Not available

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





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

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

☒ Auto Update

Optimize...

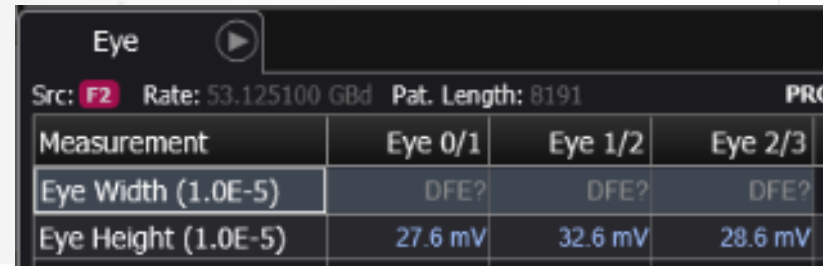
OSFP TX1 Output, DFE output, With 2 Aggressors (TX3, TX4)

JITTER MODE RESULTS ON TX1 DFE

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

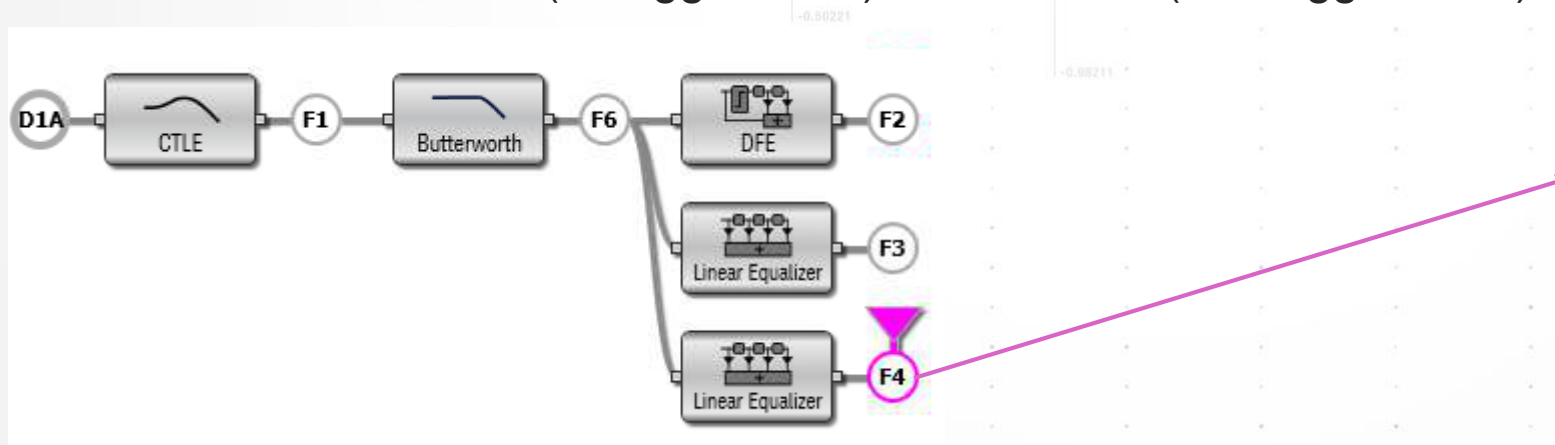
DFE: 4 tap

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



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)

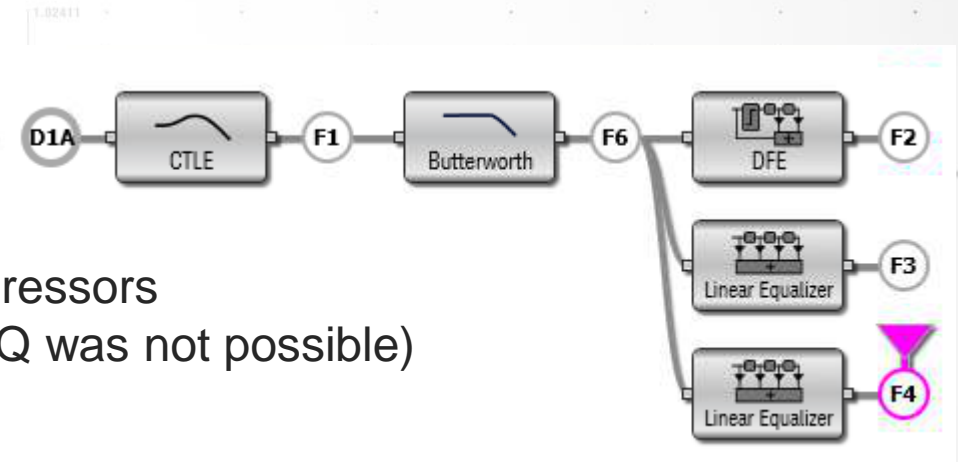


Summary

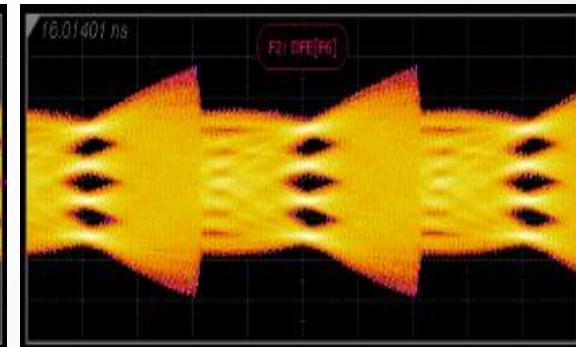
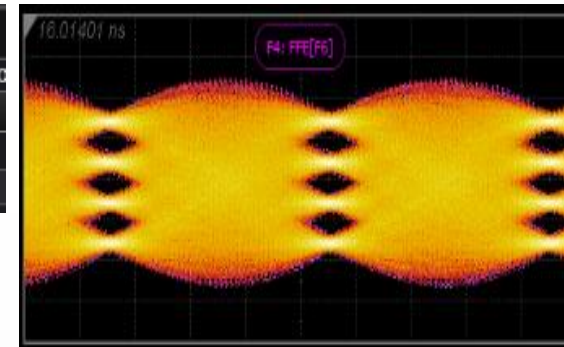


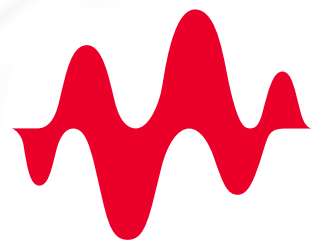
Summary

- 53 GBd, PRBS13Q signal from M8040A BERT PG was passed through Wilder OSFP Fixture
 - Insertion Loss needs to be verified using VNA
- Output of OSFP Fixture was connected to oscilloscope, and passed through 3 EQ different paths. CTLE + Butterworth followed by:
 - DFE 4 tap
 - FFE 5 tap, 0 pre
 - 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)
- 2 aggressors reduced eye openings by > 10% (compared to no aggressors)



Eye			
Src:	Rate: 53.125100 GBd	Pat. Length: 8191	PRO
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





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