

Validation of C2M and CR physical layer test-points real world -vs- COM

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Based on draft release of IEEE 802.3dj™/D1.0

Abstract: This contribution compiles efforts to bridge the physics of actual TP0v (Table 178–6), TP2 (Table 179-7) and C2M TP1a (Table 176E-1) operations with an emphasis on J3u, VEC, EH and EW as compared to what COM reports under identical conditions (Using TDMODE). It's an advancement of a similar contribution done in January with the objective of offering an existence proof that certain Jitter, VEC and EH targets are attainable in a real-world validation setting.

Supporters/Collaborators

Ray Schmeltzer (Wilder Technologies)

Richard Mellitz (Samtec)

Geoff Zhang (AMD)

Equipment used in this contribution

☐ M8042A PG

- ☐ Light 5 tap Tx de-emphasis

☐ M8067A-005-Trace

- ☐ 22.3dB @53.125GHZ – Trace 1 + Wilder 1mm OSFP MTF
- ☐ 30.76dB @53.125GHz – Trace 1+ Trace 2
- ☐ 2X pair of 1mm 8” phase matched cables (1.2dB each)
- ☐ Net TP1a test channel loss 33.15dB

☐ N1000A+N1046A Sampling scope

- ☐ Prototype Clock Recovery
- ☐ SIRC: 60GHz 4th order Butterworth
- ☐ Input referred noise $2e-9V^2/GHz$

☐ UXR0802B Real-Time scope

- ☐ DSP/SW Clock Recovery
- ☐ ~SIRC: 60GHz 4th order Butterworth rolling off to -9dB @ 80GHZ

☐ COM Version: com_ieee8023_93a_450beta3

- ☐ TDMODE (PR imported from instruments, spreadsheet in supporting material)

Overview

The draft 1.0 P802.3dj has several TBD categories in areas of key parametric measurements, due to a combination of inconclusive modeling or inability to physically make measurements due to instrument limitations.

This contribution pairs up physical channel losses to approximate current worst case loss conditions.

C2M channel assumptions (https://www.ieee802.org/3/dj/public/23_11/lusted_3dj_04_2311.pdf)

- Up to 32dB IL (M8067A-005 Trace 1 + Trace 2)
- Ref Rx: 60GHz 4th order Butterworth + input referred noise + 2-gain stage CTLE + 24 Tap FFE + 1-tap DFE (all parameters tuned directly with COM)



CR channel assumptions (https://www.ieee802.org/3/dj/public/23_11/diminico_3dj_01_2311.pdf)

- Up to 23dB IL (Wilder OSFP 1mm fixture + M8067A-005 Trace 1)
- Ref Rx: 60GHz 4th order Bessel + 5 Tap TX FFE lightly tuned for TP0V optimization. No Rx EQ, No Rx De-Embed

Channel configurations used in this study:

Closest attainable physical proxies for:

CR/TP2 targeting (HH-HL) 22.35dB

C2M/TP1a targeting (HL-HL) ~33dB

Reference : https://www.ieee802.org/3/dj/public/23_11/diminico_3dj_01_2311.pdf pg 9

https://www.ieee802.org/3/dj/public/23_11/lusted_3dj_04_2311.pdf pg 7

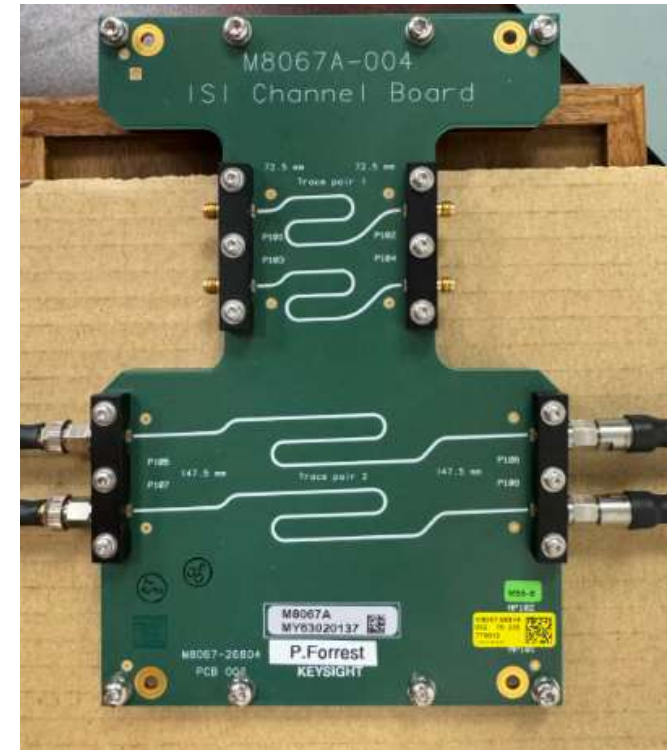
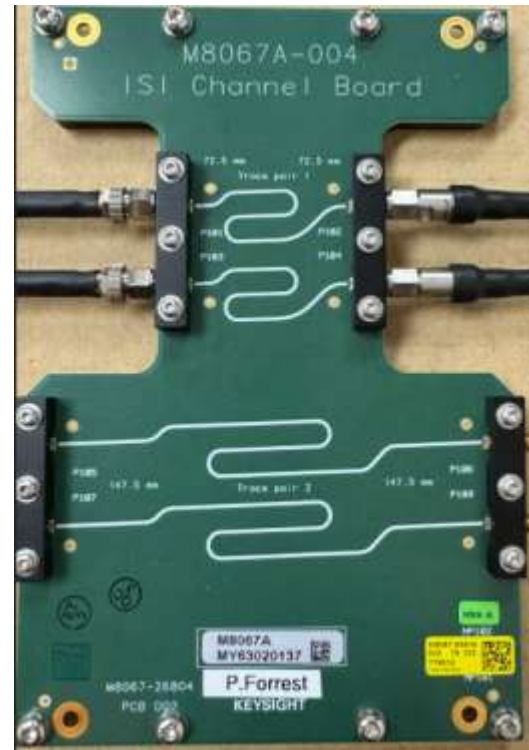


Table 178–6 Output Jitter (Max) : TBD (TP0V)

Draft Amendment to IEEE Std 802.3-2022
IEEE P802.3dj 200 Gb/s, 400 Gb/s, 800 Gb/s, and 1.6 Tb/s Ethernet Task Force

IEEE Draft P802.3dj/D1.0
10 April 2024

Consider a TP0V J3u of 115mUI identical to clause 162.9.2 Tx Characteristics. Real Silicon will be better than instrumentation.

Table 178–6—Summary of transmitter specifications at TP0v

Parameter	Reference	Value	Units
Signal-to-noise-and-distortion ratio, SNDR (min)	179.9.4.6	32.5	dB
Signal-to-residual-intersymbol-interference ratio, SNR_{ISI} (min)	179.9.4.3	28	dB
Output jitter (max) TBD	179.9.4.7	TBD	UI

The starting point for this setup is TP0d amplitude calibration and jitter evaluation. Signal amplitude of 750mV was the initial setup.

Experimentation at 600mV failed for C2M and required 800mV to lock clock recovery's after 33dB of channel loss.

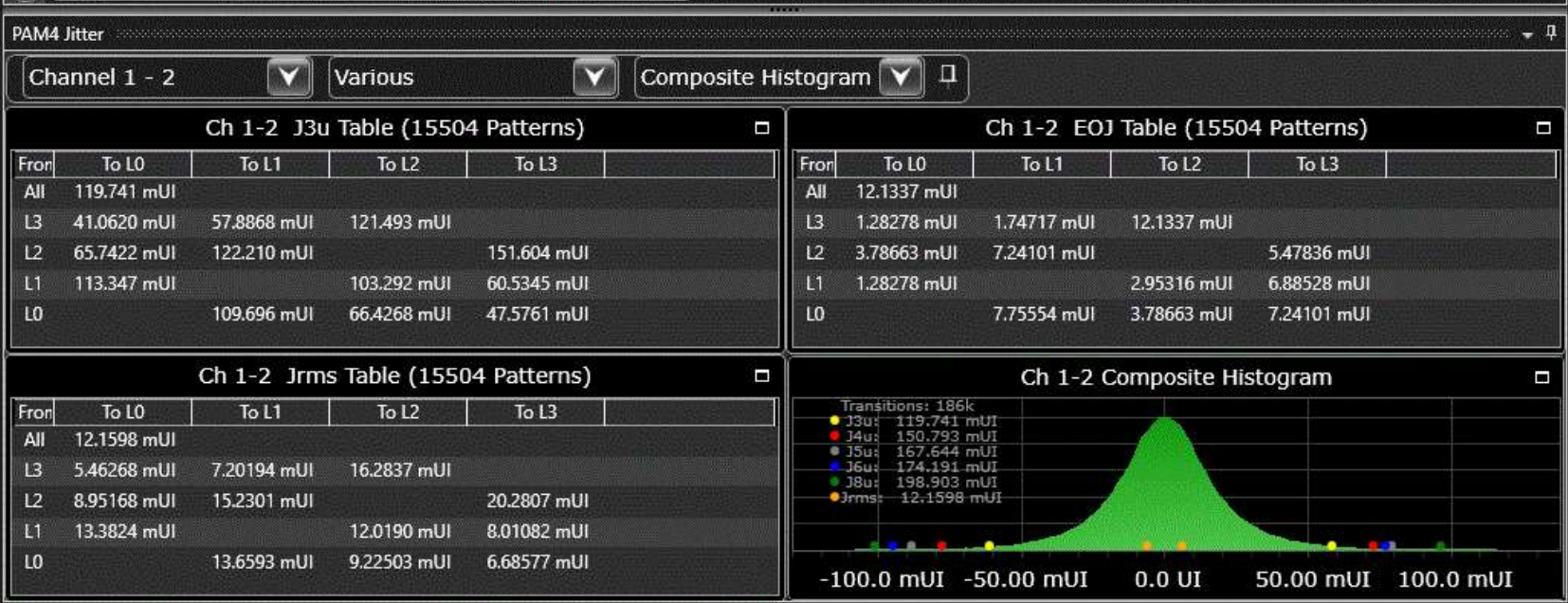
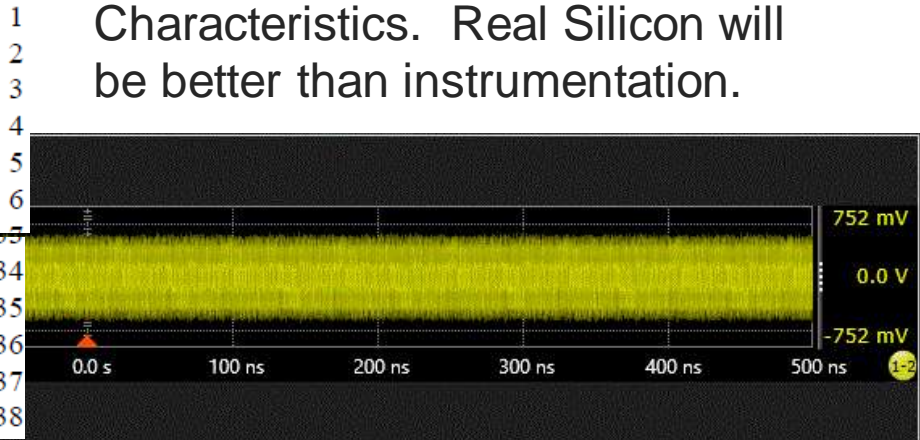


Table 179–7— transmitter specifications at TP2 (Sampling)

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IEEE P802.3dj 200 Gb/s, 400 Gb/s, 800 Gb/s, and 1.6 Tb/s Ethernet Task Force

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Table 179–7—Summary of transmitter specifications at TP2 (continued)

Parameter	Subclause reference	Value	Units
Transmitter steady-state voltage, v_f (min)	179.9.4.1.2	TBD	V
Host designation Host-Low		TBD	V
Host designation Host-Nominal		TBD	V
Host designation Host-High		TBD	V
Transmitter steady-state voltage, v_f (max)	179.9.4.1.2	0.6	V
Linear fit pulse peak ratio, R_{peak} (min)	179.9.4.1.2	TBD	—
Host designation Host-Low		TBD	—
Host designation Host-Nominal		TBD	—
Host designation Host-High		TBD	—
Level separation mismatch ratio R_{LM} (min)	179.9.4.2	0.95	—
Transmitter output waveform			
absolute value of step size for all taps (min)	179.9.4.1.4	0.005	—
absolute value of step size for all taps (max)	179.9.4.1.4	0.025	—
value at minimum state for $c(-3)$ (max)	179.9.4.1.5	-0.06	—
value at maximum state for $c(-2)$ (min)	179.9.4.1.5	0.12	—
value at minimum state for $c(-1)$ (max)	179.9.4.1.5	-0.34	—
value at minimum state for $c(0)$ (max)	179.9.4.1.5	0.5	—
value at minimum state for $c(1)$ (max)	179.9.4.1.5	-0.2	—
Signal-to-noise-and-distortion ratio, SNDR (min)	179.9.4.6	31.5	dB
Signal-to-residual-intersymbol-interference ratio, SNR_{ISI} (min)	179.9.4.3	26.7	dB
Output jitter (max)	179.9.4.7	TBD	UI

23dB Channel Loss

775mV Launch Amplitude (TP0d)

60GHz 4'th order Bessel Reference

Receiver. No tuning apart from light TX 5 tap FFE EQ. (Eye is very closed)

J3u could be further reduced by using COM to tune the TX FFE.

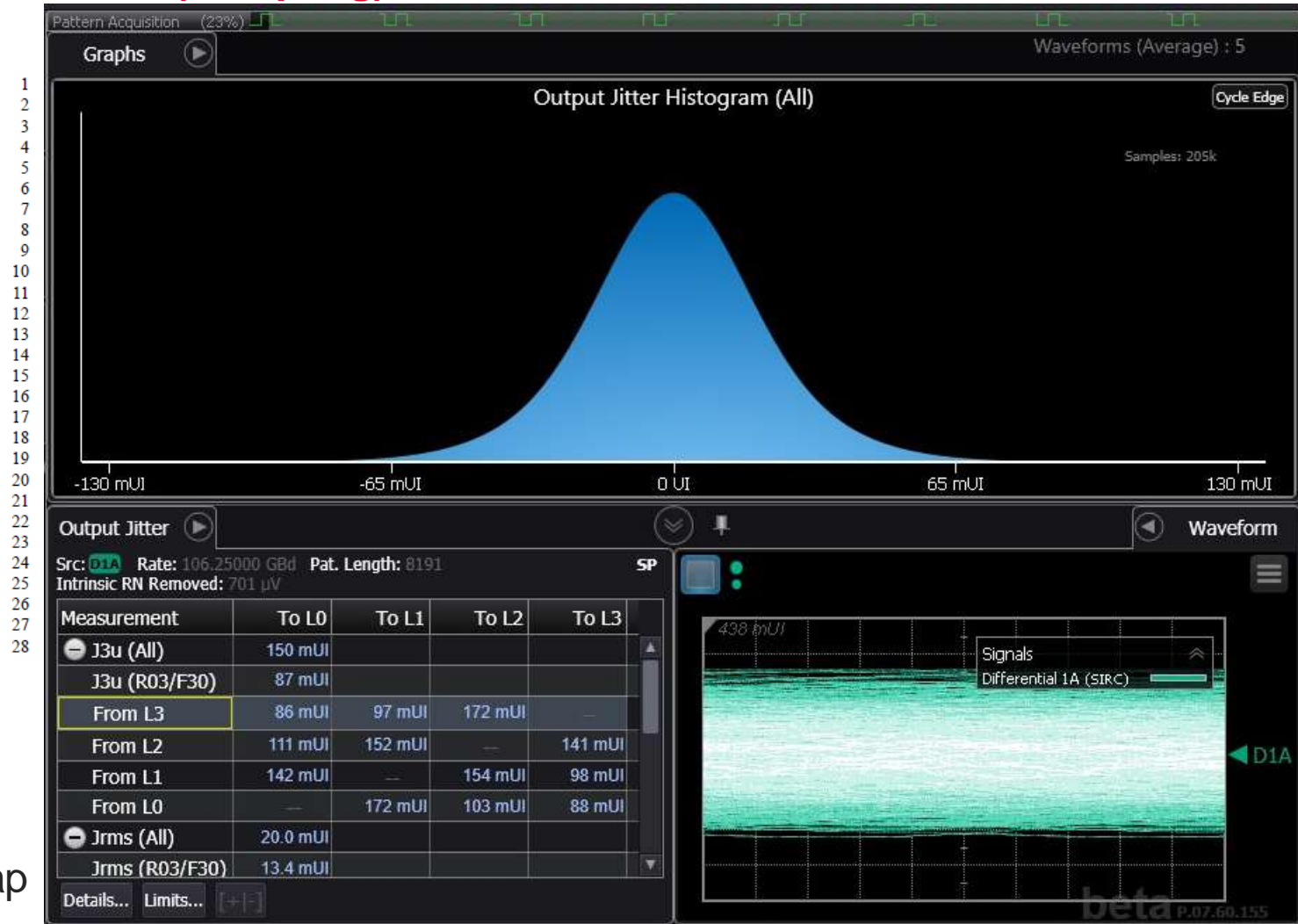


Table 179–7— transmitter specifications at TP2 (Real-Time)

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Table 179–7—Summary of transmitter specifications at TP2 (continued)

Parameter	Subclause reference	Value	Units
Transmitter steady-state voltage, v_f (min)	179.9.4.1.2	TBD	V
Host designation Host-Low		TBD	V
Host designation Host-Nominal		TBD	V
Host designation Host-High		TBD	V
Transmitter steady-state voltage, v_f (max)	179.9.4.1.2	0.6	V
Linear fit pulse peak ratio, R_{peak} (min)	179.9.4.1.2	TBD	—
Host designation Host-Low		TBD	—
Host designation Host-Nominal		TBD	—
Host designation Host-High		TBD	—
Level separation mismatch ratio R_{LM} (min)	179.9.4.2	0.95	—
Transmitter output waveform			
absolute value of step size for all taps (min)	179.9.4.1.4	0.005	—
absolute value of step size for all taps (max)	179.9.4.1.4	0.025	—
value at minimum state for $c(-3)$ (max)	179.9.4.1.5	-0.06	—
value at maximum state for $c(-2)$ (min)	179.9.4.1.5	0.12	—
value at minimum state for $c(-1)$ (max)	179.9.4.1.5	-0.34	—
value at minimum state for $c(0)$ (max)	179.9.4.1.5	0.5	—
value at minimum state for $c(1)$ (max)	179.9.4.1.5	-0.2	—
Signal-to-noise-and-distortion ratio, SNDR (min)	179.9.4.6	31.5	dB
Signal-to-residual-intersymbol-interference ratio, SNR_{ISI} (min)	179.9.4.3	26.7	dB
Output jitter (max)	179.9.4.7	TBD	UI

775mV Launch Amplitude

60GHz 4'th order Bessel Reference

Receiver. No tuning apart from light TX

5 tap FFE EQ.



Table 179–7— transmitter specifications at TP2 (Real-Time)

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Table 179–7—Summary of transmitter specifications at TP2 (continued)

Parameter	Subclause reference	Value	Units
Transmitter steady-state voltage, v_f (min)	179.9.4.1.2	TBD	V
Host designation Host-Low		TBD	V
Host designation Host-Nominal		TBD	V
Host designation Host-High		TBD	V
Transmitter steady-state voltage, v_f (max)	179.9.4.1.2	0.6	V
Linear fit pulse peak ratio, R_{peak} (min)	179.9.4.1.2	TBD	—
Host designation Host-Low		TBD	—
Host designation Host-Nominal		TBD	—
Host designation Host-High		TBD	—
Level separation mismatch ratio R_{LM} (min)	179.9.4.2	0.95	—
Transmitter output waveform			
absolute value of step size for all taps (min)	179.9.4.1.4	0.005	—
absolute value of step size for all taps (max)	179.9.4.1.4	0.025	—
value at minimum state for $c(-3)$ (max)	179.9.4.1.5	-0.06	—
value at maximum state for $c(-2)$ (min)	179.9.4.1.5	0.12	—
value at minimum state for $c(-1)$ (max)	179.9.4.1.5	-0.34	—
value at minimum state for $c(0)$ (max)	179.9.4.1.5	0.5	—
value at minimum state for $c(1)$ (max)	179.9.4.1.5	-0.2	—
Signal-to-noise-and-distortion ratio, SNDR (min)	179.9.4.6	31.5	dB
Signal-to-residual-intersymbol-interference ratio, SNR_{ISI} (min)	179.9.4.3	26.7	dB
Output jitter (max)	179.9.4.7	TBD	UI

Performing L3 and L2/L3 Jnu decomposition at TP2 is entirely feasible and repeatable measurement. L1's are problematic at 23dB of loss but very consistent between the two instrument types used here.



Table 17E-1— transmitter specifications at TP1a (Sampling)

Table 176E-1—Host output characteristics at TP1a

Parameter	Reference	Value	Units
Signaling rate, each lane (range)		106.25 ± 50 ppm ^a	GBd
DC common-mode output voltage (max)	176E.5.1	2.8	V
DC common-mode output voltage (min)	176E.5.1	−0.3	V
Single-ended output voltage (max)	176E.5.1	3.3	V
Single-ended output voltage (min)	176E.5.1	−0.4	V
Peak-to-peak AC common-mode voltage (max) Low-frequency, $VC_{M_{LF}}$ Full-band, $VC_{M_{FB}}$	176E.5.1	32 80	mV
Differential peak-to-peak output voltage (max) Transmitter disabled Transmitter enabled	176E.5.1	35 750	mV
Steady-state voltage, v_f (max)	176E.5.3	TBD	mV
Eye height (min)	176E.3.3.1	TBD	mV
Vertical eye closure, VEC (max)	176E.3.3.1	TBD	dB
Common-mode to differential-mode return loss, RL_{dc} (min)	176E.3.3.2	Equation (176E-1)	dB
Effective return loss, ERL (min)	176E.3.3.3	TBD	dB
Differential termination mismatch (max)	176E.3.3.4	10	%
Transition time (min)	176E.3.3.5	TBD	ps

800mV Launch Amplitude

60GHz 4'th order Butterworth Reference

Receiver. Tuned with COM TDMODE

This is NOT an official IEEE document.

Revision: 4.50beta3 This is a computation example for exploring COM and ERL

for projects like IEEE P802.3bj/b/bs/cd/ck with some exploratory extensions and is not normative or official

FOM: 17 dB

TXFFE coefficients: 1

SNR ISI: 34 dB

CTLE DC gain: -9 dB

CTF peaking gain: -3.4 dB

Symbol Available signal: 0.0061807

Die to die loss = dB

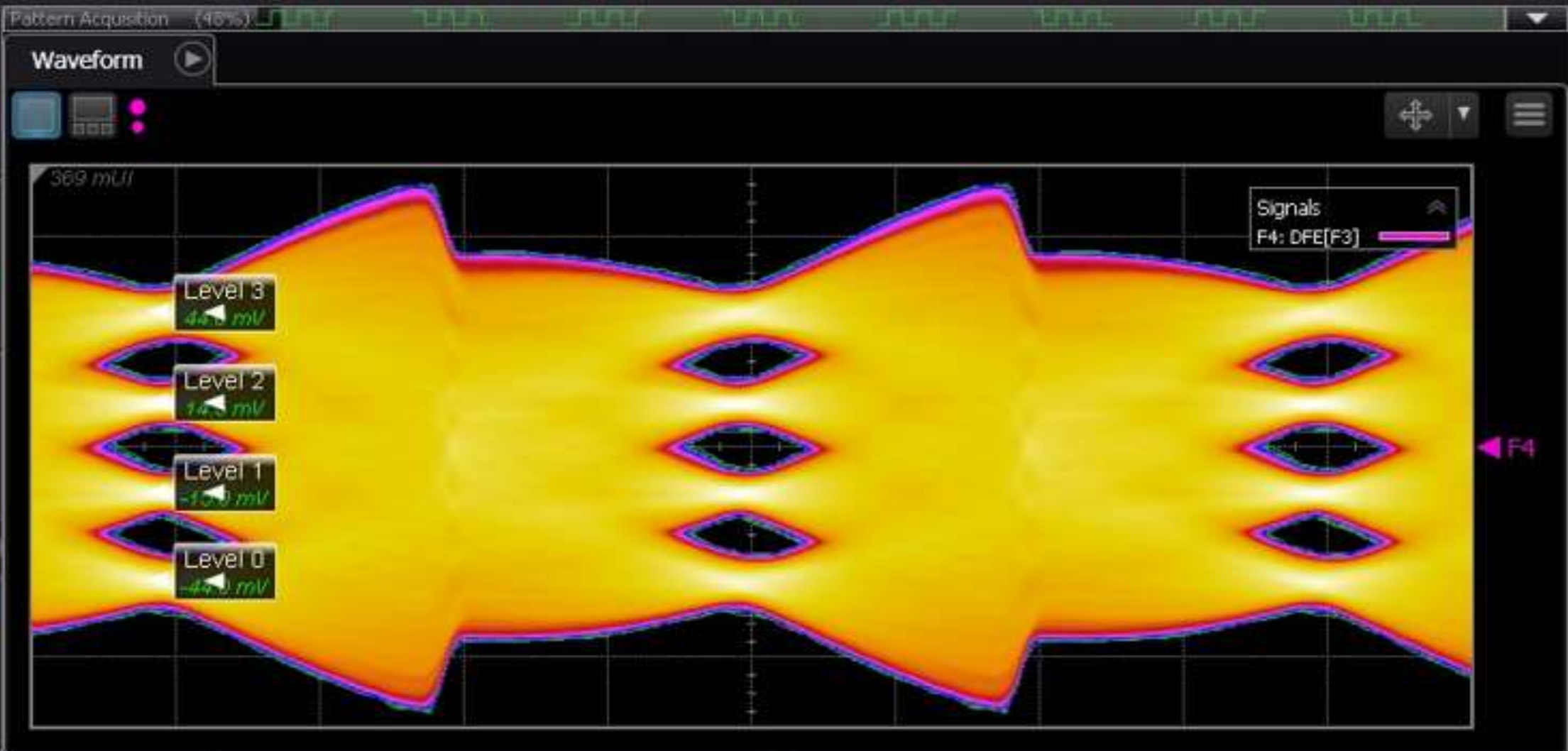
run time = 0.412117 min

WC All cases PASS ... VEC = 7.494 dB

WC All cases PASS ... EH = 5.112 mV

COM 4.3b3 Output

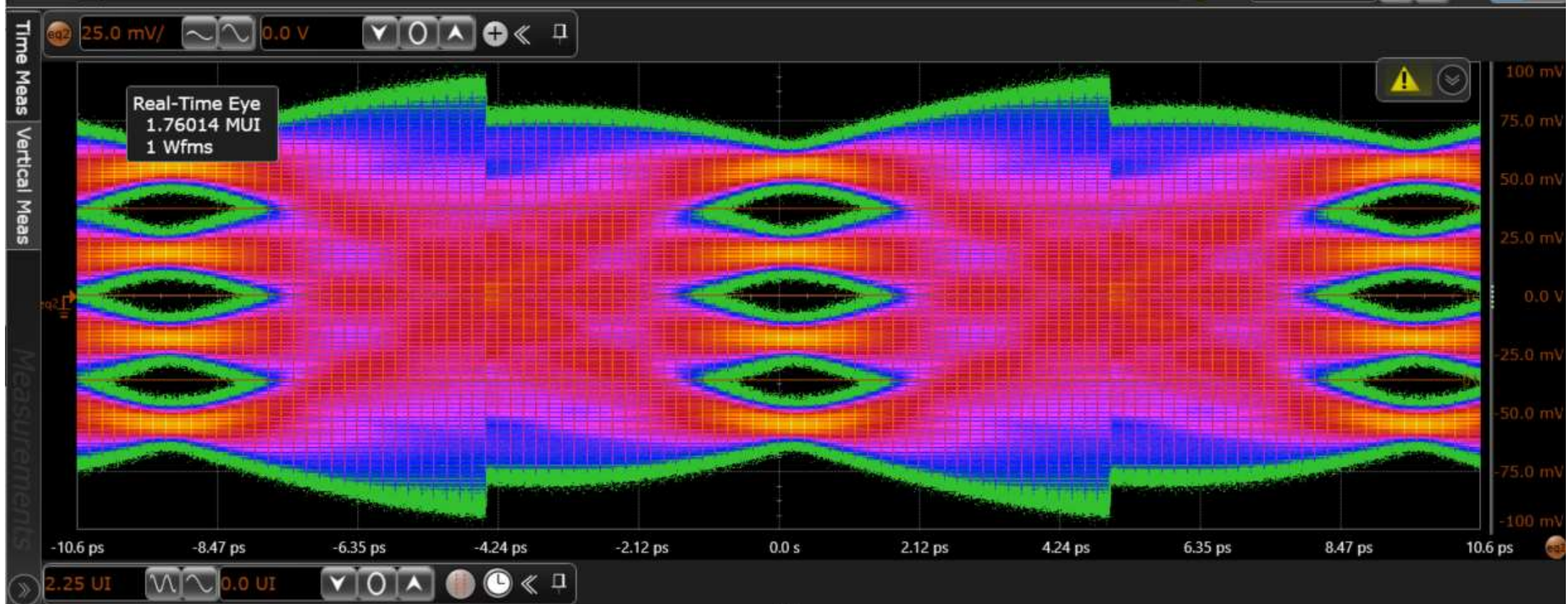
SNR_ISI_XTK_normalized_1_sigma	22.5571
SNR_ISI_est	34.3572
Pmax_by_Vf_est	0.6402
Tr_measured_from_step_ps	9.1176
CTLE_zero_poles	[4.2500e+10,1.06...
CTLE_DC_gain_dB	-9
g_DC_HP	-2
HP_poles_zero	1.3281e+09
TXLE_taps	1
Pre2Pmax	[]
DFE_taps	0.5944
floating_tap_locations	[]
RxFFE	19x1 double
RxFFEgain	0
itick	-15
error_propagation_probability	[]
burst_probabilities	[]
sgm_Ani_isi_xt_noise	8.7403e-04
sgm_isi_xt	4.8674e-04
sgm_noise_gaussian_noise_p_DD	7.2596e-04
sgm_p_DD	4.1651e-04
sgm_gaussian_noise	5.9459e-04
sgm_G	5.9459e-04
sgm_rjit	2.0833e-04
sgm_N	2.7970e-04



Results

RLM (802.3 A_120D) F4	TDECQ F4	Eye 2/3 VEC (2.0E-5) F4	Eye 1/2 VEC (2.0E-5) F4	Eye 0/1 VEC (2.0E-5) F4
0.979	0.77 dB	7.92 dB	6.40 dB	7.71 dB
Eye 2/3 Width (2.0... F4	Eye 1/2 Width (2.0... F4	Eye 0/1 Width (2.0... F4	Eye 2/3 Height (2.... F4	Eye 1/2 Height (2.... F4
183.2 mUI	206.4 mUI	176.4 mUI	11.80 mV	14.20 mV
Eye 0/1 Height (2.... F4				
11.95 mV				

Offline 104.3 mV



Results (Measure All Edges)

Measurement	Current	Mean	Min	Max	Range (Max-Min)	Std Dev	Count
1 Eye 2/3 Width(eq2)	189.8 mUI	189.8 mUI	189.8 mUI	189.8 mUI	0.0 UI	0.0 UI	1
2 Eye 1/2 Width(eq2)	203.9 mUI	203.9 mUI	203.9 mUI	203.9 mUI	0.0 UI	0.0 UI	1
3 Eye 0/1 Width(eq2)	172.3 mUI	172.3 mUI	172.3 mUI	172.3 mUI	0.0 UI	0.0 UI	1
4 Eye 2/3 Height(eq2)	12.9 mV	12.9 mV	12.9 mV	12.9 mV	0.0 V	0.0 V	1
5 Eye 1/2 Height(eq2)	12.3 mV	12.3 mV	12.3 mV	12.3 mV	0.0 V	0.0 V	1
6 Eye 0/1 Height(eq2)	11.5 mV	11.5 mV	11.5 mV	11.5 mV	0.0 V	0.0 V	1
7 VEC(eq2)	10.01 dB	10.01 dB	10.01 dB	10.01 dB	0.0 dB	0.0 dB	1
8 SER, cumulative(eq2)	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	176013t

Color Grade

- 1 - 60
- 61 - 121
- 122 - 243
- 244 - 487
- 488 - 974
- 975 - 1949
- 1950 - 3899

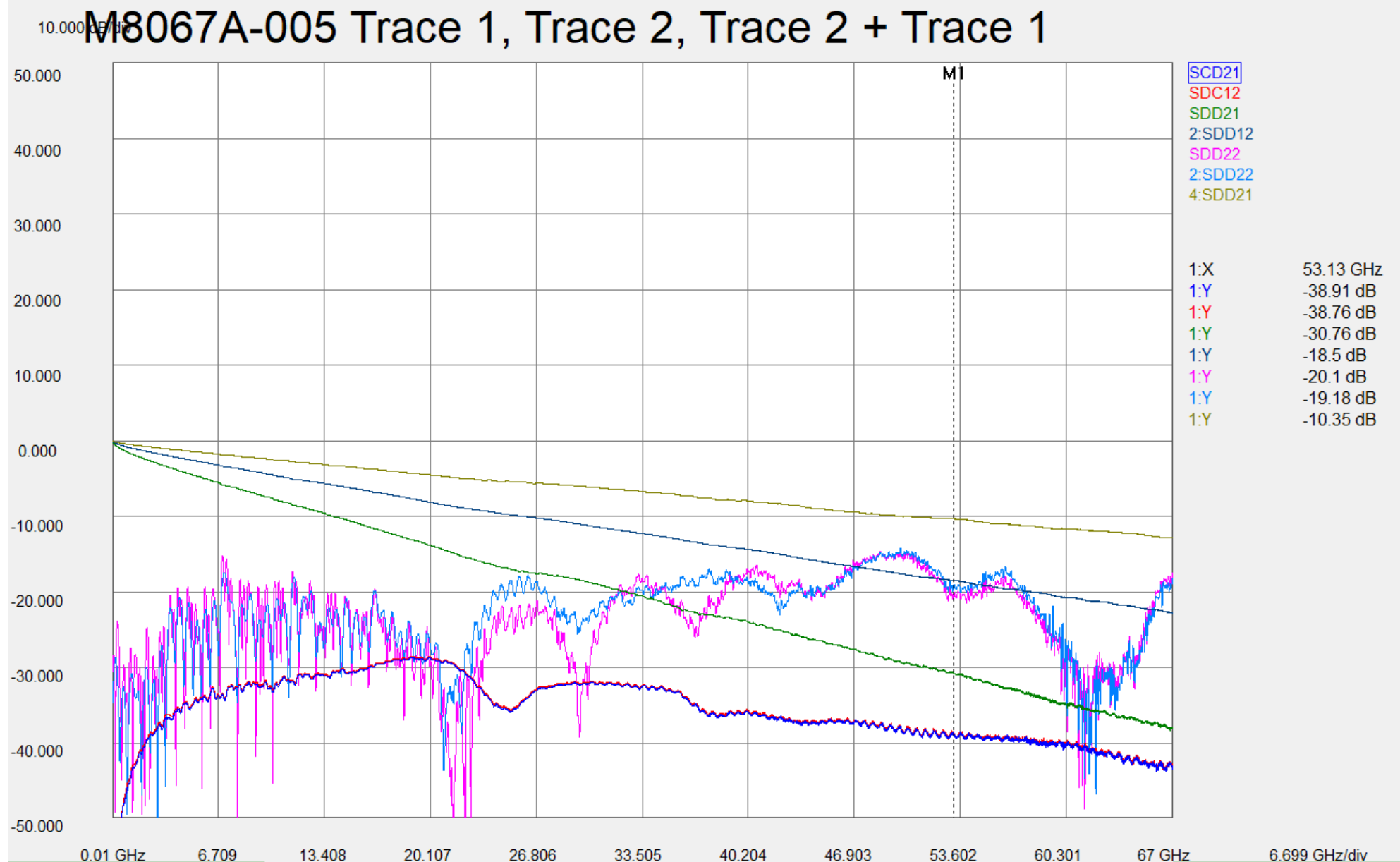
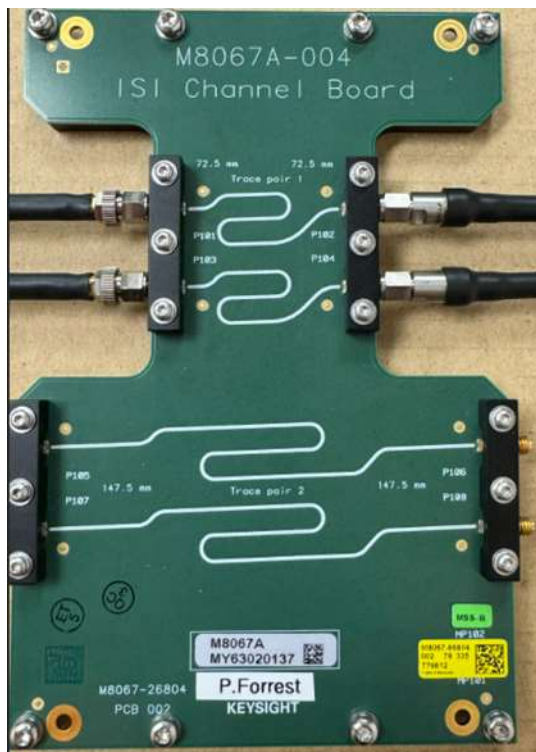
Summary

- Efforts to test TP1a with a minimum allowable signal amplitude of 600mV exceed the sensitivity of contemporary test equipment. 800mV (TP0d) of signal amplitude was the minimum measurable after 33dB.
- At 800mV launch, with Rx CTLE, Rx 20 tap FFE and 1 tap DFE we get 1. an open eye! 2. VEC , EW and EH values. The output of the DFE with this high a gain is a bit suspect as we correlate well on VEC but not well on EH. (DFE's are non-linear, can we really believe the EH?)
- CR's signal amplitude of 775mV works fine in a TP2 worst case setting of 23dB.
 - Jitter Decomposition may want to focus on L3 or L2/L3 combinations if clause 162.9.4 limits are retained.
 - More aggressive TX FIR with 7'tap EQ tuned with COM would bring current J3u Jitter closer but will not match clause 162.9.4 allowable limits of 125mUI. Either remove the single level transitions (which have the highest measurement error) or increase the J3u limit to 150mUI (from 125mUI).
- Two distinct classes of instrumentation were demonstrated in this contribution with reasonable result correlation at TP1a and TP2, TP0v. There are still some curious post high gain DFE eye height results but the use of COM as a tuning agent to extract proper "system level tuning" was a success.

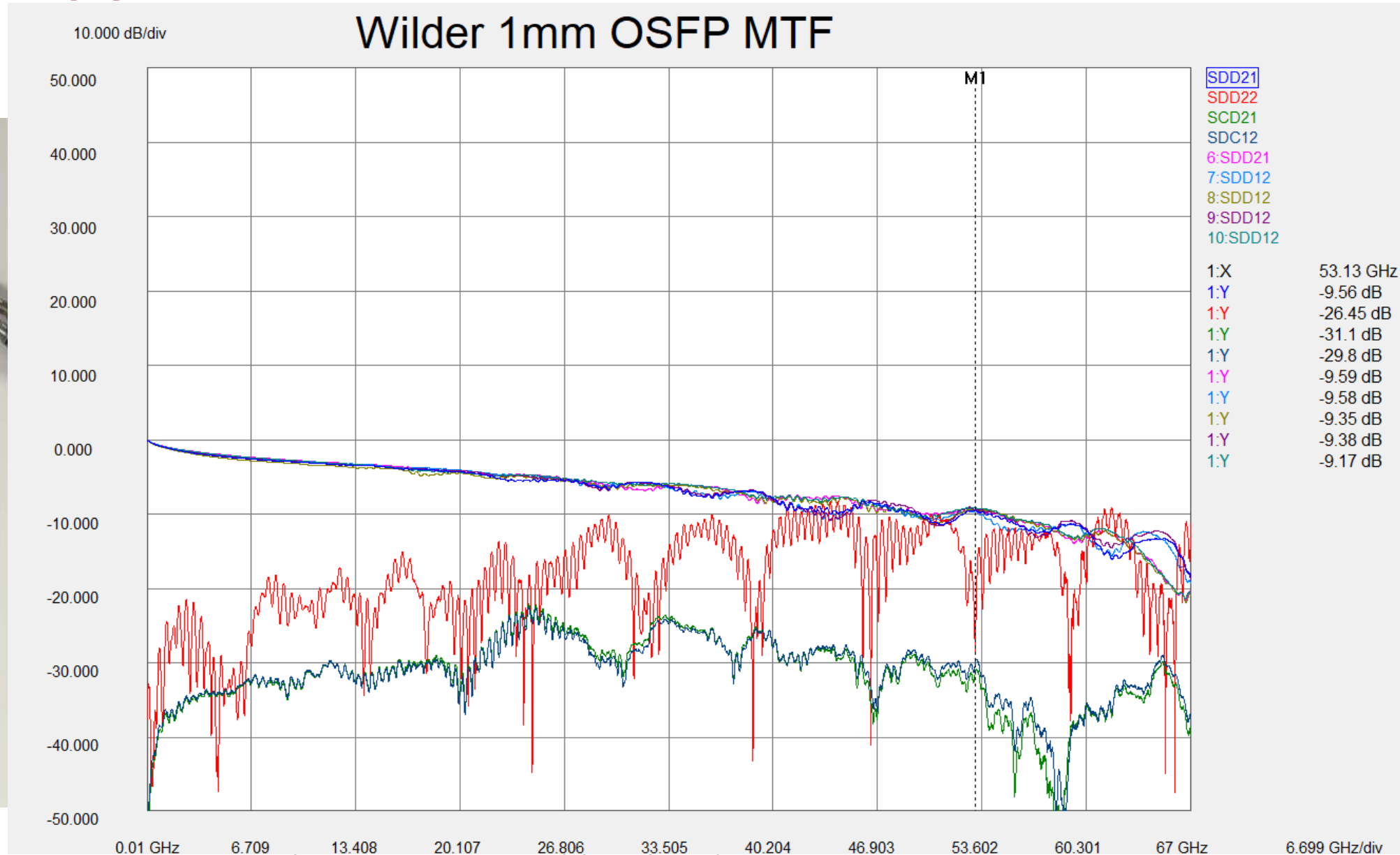
Thank you

Backup

- M8067A-005 ISI trace Performance

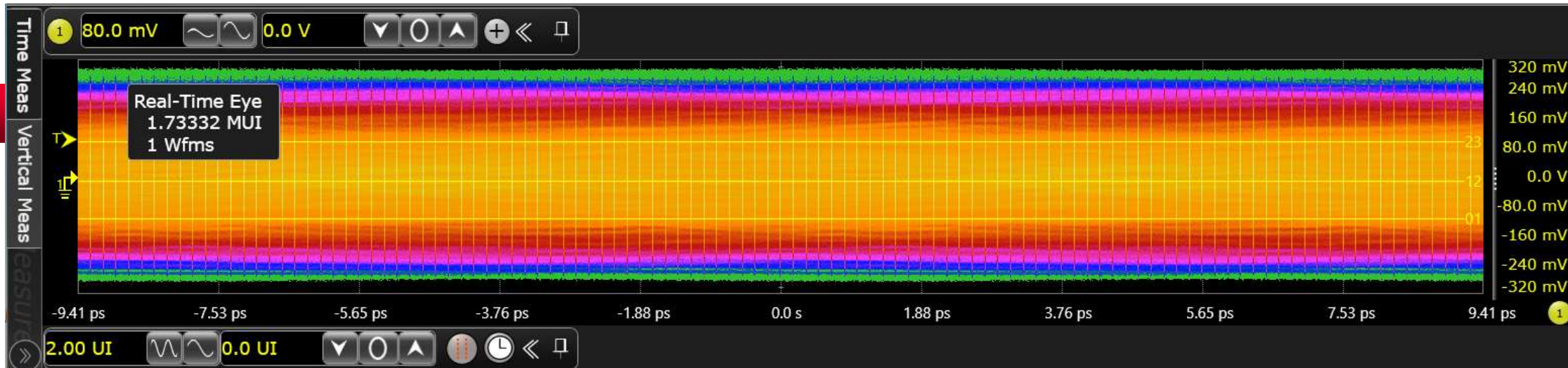


Wilder 1mm OSFP MTF



TP1a COM Table

Table 93A-1 parameters				I/O control			Table 93A-3 parameters				SAVE_CONFIG2MAT	1	
Parameter	Setting	Units	Information	DIAGNOSTICS	1	logical	Parameter	Setting	Units	Information	Receiver testing		
f_b	106.25	GBd		DISPLAY_WINDOW	1	logical	package_tl_gamma0_a1_a2	0.0008455 0.000340225			RX_CALIBRATION	0	logical
f_min	0.05	GHz		CSV_REPORT	1	logical	package_tl_tau	0.00644805	ns/mm		Sigma BBN step	5.00E-03	V
Delta_f	0.01	GHz		RESULT_DIR	.\results\KRCR_1_{date}\		package_Z_c	[50]	Ohm		ICN parameters		
C_d	[0.4e-4 0.9e-4 1.1e-4; 0.4e-4 0.9e-4 1.1e-4]	nF	[TX RX]	SAVE_FIGURES	0	logical	z_p select	[1]		[test cases to run]	f_v	0.278	Fb
L_s	[0.13 0.15 0.14; 0.13 0.15 0.14]	nH	[TX RX]	Port Order	[1 3 2 4]		z_p (TX)	0	mm	[test cases]	f_f	0.278	Fb
C_b	[0.3e-4 0.3e-4]	nF	[TX RX]	RUNTAG	CRKR_eval_		z_p (NEXT)	0	mm	[test cases]	f_n	0.278	Fb
R_o	50	Ohm		COM_CONTRIBUTION	0	logical	z_p (FEXT)	0	mm	[test cases]	f_2	61.625	GHz
R_d	[50 50]	Ohm	[TX RX]				z_p (RX)	0	mm	[test cases]	A_ft	0.450	V
A_v	0.413	V	vp/vf=				C_p	[0.5e-4 0.5e-4]	nF	[TX RX]	A_nt	0.450	V
A_fe	0.413	V	vp/vf=	TDR and ERL options									
A_ne	0.45	V		TDR	1	logical	Filter: Rx FFE				Parameter	Setting	
L	4			ERL	1	logical	ffe_pre_tap_len	1	UI		board_tl_gamma0_a1_a2	6.44084e-4 3.6036e-0	1.4 db/in @ 53.125G
M	32			ERL_ONLY	0	ns	ffe_post_tap_len	17	25		board_tl_tau	5.790E-03	ns/mm
filter and Eq				TR_TDR	0.01		ffe_tap_step_size	0			board_Z_c	100	Ohm
f_r	0.58	*fb		N	100	logical	ffe_main_cursor_min	1			z_bp (TX)	32	mm
c(0)	1		min	TDR_Butterworth	1		ffe_pre_tap1_max	1			z_bp (NEXT)	32	mm
c(-1)	0		[min:step:max]	beta_x	0		ffe_post_tap1_max	1			z_bp (FEXT)	32	mm
c(-2)	0		[min:step:max]	TDR_W_TXPKG	0	UI	ffe_tapn_max	1			z_bp (RX)	32	mm
c(-3)	0		[min:step:max]	N_bx	20						C_0	[0.2e-4 0]	nF
c(-4)	0		[min:step:max]	fixture delay time	[0 0]		Operational				C_1	[0.2e-4 0]	nF
c(1)	0		[min:step:max]	Tukey_Window	1		ERL Pass threshold	10	dB		Include PCB		
N_b	1	UI		Noise, jitter			COM Pass threshold	3	db		Seletions (rectangle, gaussian,dual_rayleigh,triangle		
b_max(1)	0.85		As/dffe1	sigma_RJ	0.01	UI	DER_0	2.00E-05			Histogram_Window_Weight	gaussian	selection
b_max(2..N_b)	0.3		As/dfe2..N_b	A_DD	0.02	UI	T_r	0.00450	ns		Qr	0.02	UI
b_min(1)	0		As/dffe1	eta_0	2.00E-09	V^2/GHz	FORCE_TR	1	logical		Floating Tap Control		
b_min(2..N_b)	-0.15	S	As/dfe2..N_b	SNR_TX	30.5	dB	PMD_type	C2M			N_bg	0	0 1 2 or 3 groups
g_DC	[-10:1:0]	dB	[min:step:max]	R_LM	0.98		EW	0			N_bf	4	taps per group
f_z	42.50	GHz	10E10/Off				MLSE	0	logical		N_f	20	UI span for floating taps
f_p1	42.50	GHz		benartsi_3df_01a_2211	2.4 dB, 5.8 dB, 7 dB, 9.1 dB		ts_anchor	1			bmaxg	0.2	max DFE value for floating taps
f_p2	106.25	GHz		mli_3df_02_220316			sample_adjustment	[-16 16]			B_float_RSS_MAX	0.2	rss tail tap limit
g_DC_HP	[-5:1:0]		[min:step:max]	healey_3dj_01_2309	slide 6 rounded up		Local Search	0			N_tail_start	18	(UI) start of tail taps limit
f_HP_PZ	1.328125	GHz		lim_3dj_04_2309			TDMODE	1	time domain pulse response		BREAD_CRUMBS	1	
							VEC Pass threshold	12					
							num_ui_RXFF_noise	1024					



PAM4 Jitter

Channel 1

Various

Composite Histogram

Ch 1-2 J3u Table (211 Patterns)

Frqr	To L0	To L1	To L2	To L3
All	185.199 mUI			
L3	45.3909 mUI	64.2134 mUI	174.782 mUI	
L2	75.8925 mUI	158.889 mUI		156.139 mUI
L1	140.528 mUI		161.069 mUI	76.8441 mUI
L0		134.223 mUI	97.3740 mUI	49.3245 mUI

Ch 1-2 J5u Table (211 Patterns)

Frqr	To L0	To L1	To L2	To L3
All	198.403 mUI			
L3	49.8766 mUI	71.8315 mUI	223.163 mUI	
L2	92.3221 mUI	200.480 mUI		189.258 mUI
L1	157.367 mUI		205.391 mUI	97.4737 mUI
L0		160.151 mUI	130.155 mUI	59.6440 mUI

Ch 1-2 EOJ Table (211 Patterns)

Frqr	To L0	To L1	To L2	To L3
All	13.3115 mUI			
L3	9.71298 μ UI	2.26458 mUI	12.8374 mUI	
L2	6.68119 mUI	13.3115 mUI		7.63018 mUI
L1	9.71298 μ UI		41.1302 μ UI	13.0903 mUI
L0		5.12475 mUI	6.68119 mUI	13.3115 mUI

Ch 1-2 J4u Table (211 Patterns)

Frqr	To L0	To L1	To L2	To L3
All	185.199 mUI			
L3	45.9439 mUI	66.1626 mUI	198.976 mUI	
L2	82.8346 mUI	178.193 mUI		170.888 mUI
L1	144.674 mUI		182.746 mUI	86.9178 mUI
L0		145.310 mUI	115.382 mUI	54.1733 mUI

Ch 1-2 Jrms Table (211 Patterns)

Frqr	To L0	To L1	To L2	To L3
All	17.1604 mUI			
L3	6.77483 mUI	10.6368 mUI	22.4946 mUI	
L2	10.2134 mUI	20.7275 mUI		24.8052 mUI
L1	25.1113 mUI		21.0606 mUI	9.81725 mUI
L0		17.6221 mUI	13.7397 mUI	7.52190 mUI

Ch 1-2 Composite Histogram



