

# 1.6Tbps Vertical Eye Closure associated with high loss AUI-C2M channel conditions Version 1.1

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Abstract: Performing VEC operations near the limits of current channel profiles requires precision EQ tuning and noise management. This contribution will offer an overview of VEC post COM 4.6b2 MMSE tuning and contrast the incremental values of MLSE under these high loss conditions.

Supporters/Collaborators (Version 1.0)

Reference: Previous IEEE P802.3dj version 1.2. <u>https://www.ieee802.org/3/dj/public/24\_05/calvin\_3dj\_01b\_2405.pdf</u>

#### Instrumentation used in this contribution

M8042A/M8050A PG
 No Tx de-emphasis 300mV SE/ 600mV Diff

M8067A-005/003-Trace (1mm)
 31.1dB @53.125GHz – (35mm + 185mm Traces )
 2X pair of 1mm 8" phase matched cables (1.2dB each)
 Net TP1a test channel loss 33.5dB

#### □UXR 1104B Real-Time scope

DSP/SW Clock Recovery

□~SIRC: 60GHz 4<sup>th</sup> order Bessel Thomson rolling off to -9dB @ 90GHZ

#### □N1000A+N1046A Sampling scope

Prototype Clock Recovery

SIRC: 60GHz 4<sup>th</sup> order Bessel Thomson SIRC

#### COM Version: com\_ieee8023\_93a\_460beta2

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

#### **Overview**

The draft 1.1 P802.3dj specifications omits familiar Vertical Eye Closure (VEC) operations. Many have asked whether VEC can be computed under aggressive C2M channel configurations at 33dB of loss. This presentation is a collection of experiments and observations related to this question.



The operations demonstrated in this contribution focus on both Real-Time instrumentation (Keysight UXR 1104B), digital clock recovery (1'st order 4MHz) and a 60GHz 4'th order Bessel Thomson (4BT) response with brickwall at 90GHZ. This configuration operates with an approximate ENOB of 5.2 dB at this bandwidth.

The Equivalent-Time counterpart (DCA N1046/N1071AETA) with early release CDR capability. This configuration applies a precision phase and magnitude controlled reference receiver also with a 4BT bandwidth of 60GHz. The comparable ENOB of this system on nominally 7dB.

Signal generation in this contribution is with a Keysight M8042A PG transmitting a PRBS13Q test pattern, no TX EQ, with a single **ended amplitude** of 300mV at the source.



# Com Results 220mm (Source Synchronous/Explicit Clock) 33dB



# Equivalent-Time 33dB VEC, source synchronous clocked (not spec'd)

#### (35mm + 185mm) mm case [33dB]



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Eye Src: F4 Measure	Rate: 105.2500 ment	0 GBd Pat. Leng Eye 0/1	oth: 133	PRO Eye 2/3	B SP	Src: F4 Rate: 106 Intrinsic RN Remove	25000 GBd P ed: 736 pV	at. Length: 513		) L PI
Eye Src: F4 Measure Eye Wid	Rate: 106.500 ment th (1.0E-5)	D Gild Pat. Leng Eye 0/1 132 mUl	101: 111 Eye 1/2 188 mUl	PRO Eye 2/3 142 mUl	B SP	Src: 64 Rate: 16 Intrinsic RN Remove Measurement	25000 GBd P ed: 736 HV Level 0	at. Length:	Level 2	) L PF
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Eye Src: Fa Measure Eye Wid Eye Heig VEC (1.0 Eye Sker TJ (1.0E DJ (ð - ð RJ (rms) PJ (ð - ð	Rate: 100-500 ment th (1.0E-5) ht (1.0E-5) ie-5) w -5) i)	2 684 Pat. Leng Eye 0/1 132 mUI 7.70 mV 10.6 dB 4 mUI 868 mUI 763 mUI 14.0 mUI 14.0 mUI 13 mUI 206 mUI	th: 2121 Eye 1/2 188 mUl 9.90 mV 8.95 dB 0 Ul 812 mUl 671 mUl 19.0 mUl 13 mUl 734 mUl	PRO Eye 2/3 142 mUl 8.25 mV 10.2 dB 2 mUl 858 mUl 744 mUl 15.0 mUl 13 mUl 13 mUl	B SP	Src: F4) Rate: 100 Intrinsic RN Remove Measurement Level TI (1.0E-5) RN (rms) DI (δ - δ) ISI (ρ-ρ) PI (δ - δ) PI (rms) Signal Amplitude	25000 GBd P ed: 736 µV Level 0 -40.0 mV 16.6 mV 1.28 mV 6.4 mV 8.6 mV 2.08 mV 995 µV 80.0 mV	at. Length: Level 1 -14.2 mV 16.0 mV 1.30 mV 5.4 mV 7.8 mV 1.46 mV 725 µV	Level 2 13.4 mV 16.6 mV 1.30 mV 6.4 mV 9.6 mV 1.64 mV 815 µV	Leve 40.0 17.0 1.28 7.0 8.6 2.38 1.165
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PRBS13Q, no TXEQ, 220mm trace M8067A-00

# Com Results 220mm (Recovered Clock) 33dB



## VEC Results 220mm 31dB using N1071AETA Early Technology CDR unit

 The N1071AETA CDR unit needs additional investigation, and a follow-up contribution will be needed to fully determine this CDR's sensitivity limits. The 33dB is compounded by an additional 20/80 signal distribution network that is leaving very little energy for the phase detector to lock.





7.0328

#### VEC\_MLSE =



dVEC =

-0.0109

Die to die loss = dB run time = 0.404101 min WC All cases PASS ... VEC = 7.044 dB WC All cases PASS ... EH = 8.104 mV WC All cases PASS ... COM = 5.105 dB WC All cases DER = 2.794e-08 at COM threshold redo string is: eval(['My var 0 = ' getappdata(0,'cmd str')])



# Real-Time 24dB VEC



VEC COM =



9:38 PM 7/12/2024 KEYSIGHT

0.0 V

1.88 ps

Count

0

280649

1

3.76 ps

5.65 ps

7.53 ps

9.41 ps

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50

### Summary

- 600mV differential signal launch through a 33.5dB signal path representing a worst case TP1a condition. This contribution shows Clock Recovery operations on both Equivalent Time(ET) and Real Time(RT) architectures here.
- Low initial signal levels (600mV) and 33.5dB of channel loss constitutes a very challenging setting to do high precision COM and VEC operations.
- The only experiment that could be deemed a success here is the 33dB explicit clocking configuration which did showcase passing COM and VEC results and close simulation to physical layer correlation.
- N1071AETA Early Technology CDR operating at the end of a 33dB channel, will be examined and possibly a modified signal path split will be required. (50/50 rather than 20/80) for high sensitivity applications.
- Real-Time instrumentation was not successful with VEC at 33dB either. Efforts to perform better noise management are needed to improve the SNR at these losses. Part of this may be attributed to instrument ETA\_Zero challenges as well as lower ENOB compared to the ET configuration.

# Thank you



# Backup

 M8067A-005 ISI trace Performance



#### <sup>10.000</sup>**M**8067A-005 Trace 1, Trace 2, Trace 2 + Trace 1



