P802.3dj Physical layer jitter (Clause 176/179) proposal to advance/close current comments against present JRMS and J4u03 methodologies Presented to IEEE P802.3dj Electrical Task Force January 2025. Version 1.1: January 20, 2025

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Based on draft release of IEEE P802.3dj™/D1.3 Comments

Abstract: Comments recorded against P802.3dj D1.3 (306, 219, 220, 221) are calling out for improved handling of jitter. Based on the straw-polling of gines_3dj_optx_01a_250109.pdf conducted on 01/09/2025 this contribution drives to addressing these comments

Supporters/Collaborators (Version 1.1)

Yasuo Hidaka (Credo Semi)

Mike Dudek (Marvell)

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Reference material:

Gines 01/09/2025: JHRMS technical overview and proposal for channel independent Jitter measurements
IEEE 09/24 Contribution: Jitter operations (179.9.4.7) at TP1a (33dB) : Calvin et al. , Keysight Technologies
IEEE 09/24 Contribution: VEC associated with high channel loss : Calvin et al. , Keysight Technologies
IEEE 07/24 Contribution: 1.6Tbps output jitter decomposition associated with high loss AUI-C2M channel conditions
IEC-TC85-WG22: IEC-TC85-WG22-Instrument Noise/Jitter compensation in higher order PAM modulated signals 16Dec2022
RAN 07/24 Contribution: Host channel model and loss parameters
DiMinico 11/23 Contribution: Considerations for CR Insertion Loss Budget Baseline: Cable Assemblies and Test Fixtures
Rabinovich 11/23 Contribution: 212 Gb/s PAM4 per Lane C2M Channels Via Length Performance Study

P802.3dj Clause 176/179 comment’s

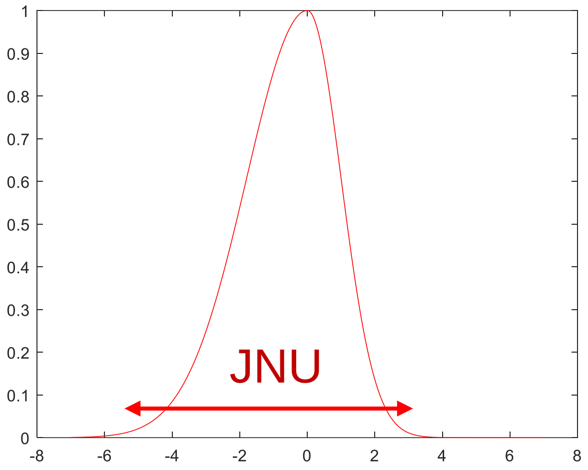
Draft 1.3 comments related to Jitter.

Comment ID	Commenter Name	Clause	Subclause	Page	Line	Comment	Suggested Remedy
306	Ran, Adee	179	179.9.4.6	381	21	Jitter measurements refer to 120D.3.1.8.1 for the probability distribution calculation method. As noted in https://www.ieee802.org/3/dj/public/24_11/ran_3dj_06a_2411.pdf, the method of combining measurements from different transitions into a single PDF in 120D.3.1.8.1 is troublesome. As a specific example, additive noise (which is always present) is translated to timing error in an opposite way for rising/falling transitions. If the additive noise distribution is asymmetric, the distributions created by the noise alone (in the absence of clock phase jitter) are mirror images of each other, and combining them as in the 120D method would amplify the effect of the additive noise. Especially, th4 J4u would not be representative of the true jitter distribution. It is possible to use information from multiple transitions to improve the accuracy of the measurement in the presence of additive (vertical) noise. The method of combining the distributions should be improved to mitigate additive noise and slope dependence.	A contribution with further details is planned.
221	Rysin, Alexander	179	179.9.4	374	22	J3u and JRMS measurements at TP2 are highly affected by the effects of slew rate and noise and do not reflect actual uncorrelated jitter. These effects are exacerbated by the characteristics of practical channels between TP0d and TP2 - loss and reflections, and are highly dependent on the transmitted signal amplitude. Accounting only for the faster edges does not work for practical channels at 106.25 Gbd rate and the currently proposed numbers cannot be met (and sometimes cannot be measured) even with commercial test equipment PPG. The issue was demonstrated in rysin_3dj_01a_2407. A different methodology that will better quantify phase-only uncorrelated jitter has to be explored. Presentation is planned.	Other method of uncorrelated jitter measurement should be considered.
219	Rysin, Alexander	176D	176D.5.3	724	38	J3u and JRMS measurements at TP1a are highly affected by the effects of slew rate and noise and do not reflect actual uncorrelated jitter. These effects are exacerbated by the characteristics of practical channels between TP0d and TP1a - loss and reflections, and are highly dependent on the transmitted signal amplitude. Accounting only for the faster edges does not work for practical channels at 106.25 Gbd rate and the currently proposed numbers cannot be met (and sometimes cannot be measured) even with commercial test equipment PPG. The issue was demonstrated in rysin_3dj_01a_2407. A different methodology that will better quantify phase-only uncorrelated jitter has to be explored. Presentation is planned.	Other method of uncorrelated jitter measurement should be considered.
220	Rysin, Alexander	176D	176D.5.4	725	38	J4u and JRMS measurements at TP4 are highly affected by the effects of slew rate and noise and do not reflect actual uncorrelated jitter. These effects are exacerbated by the characteristics of practical test fixtures - loss and reflections, and are highly dependent on the transmitted signal amplitude. Accounting only for the faster edges does not work for practical channels at 106.25 Gbd rate. The issue was demonstrated in rysin_3dj_01a_2407. A different methodology that will better quantify phase-only uncorrelated jitter has to be explored. Presentation is planned.	Other method of uncorrelated jitter measurement should be considered.
541	Dawe, Piers	179	179.9.4.6	381	26	As already pointed out, the "jitter measurement" method here doesn't work for the relevant bandwidths, losses and amplitudes. This is particularly obvious for J3u03; J4u03 seems to be beyond the state of the art. EOJ should be part of an eye spec like EECQ, not a separate spec item.	Delete this method. Use an eye spec to control signal quality, following the evolution of xECQ.
540	Dawe, Piers	176D	176D.5.3	724	40	As already pointed out, the "jitter measurement" method here doesn't work for the relevant bandwidths, losses and amplitudes for host output. This is particularly obvious for J3u03; J4u03 seems to be beyond the state of the art. EOJ should be part of an eye spec like EECQ, not a separate spec item.	Delete this method. Use an eye spec to control signal quality, following the evolution of xECQ.

Comment 306:

Jitter measurements refer to 120D.3.1.8.1 for the probability distribution calculation method… The method of combining the distributions should be improved to mitigate additive noise and slope dependence.

The composite histogram can have a higher JNU value than the sum of individual JNU values when histograms are not symmetric. This example shows a long tail to the left for rising, and a long tail to the right for falling edges. An additional influence on the symmetry of these distributions is biased by the pre-transition and post-transition run-length.



Rising Edge (0->3)

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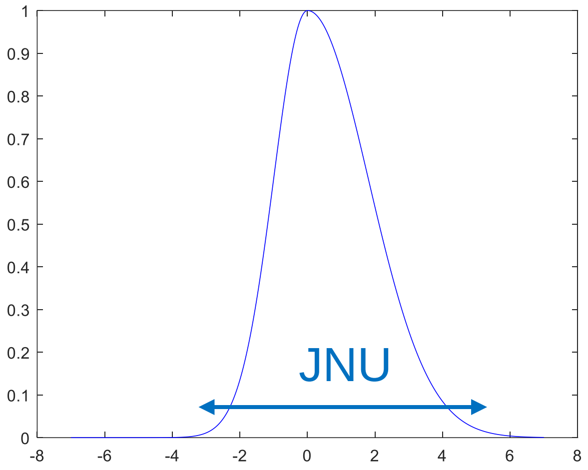

Falling Edge (3->0)

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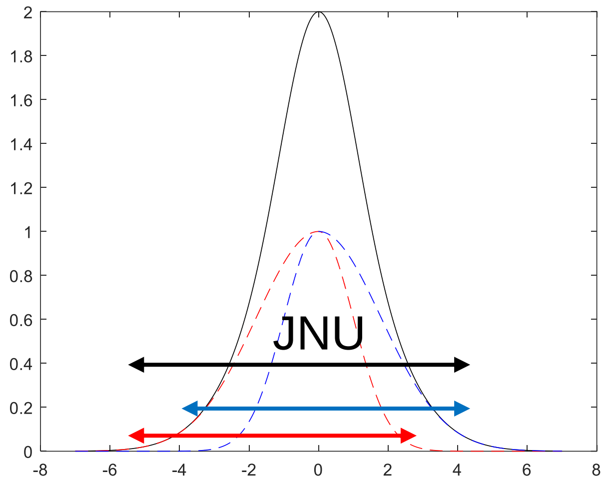


Composite
The JNU values for rising (red) and falling (blue) are shown for reference.

Comment 306:

Jitter measurements refer to 120D.3.1.8.1 for the probability distribution calculation method… The method of combining the distributions should be improved to mitigate additive noise and slope dependence.

120D.3.1.8.1 J4u and J_{RMS} jitter

For each transition i, $1 \le i \le 12$, of the transitions specified in Table 120D–4, obtain a set $S_i = \{t_i(1), t_i(2), \ldots\}$ of transition times modulo the period of the pattern. The 12 sets should be of equal size and the size of all sets should be chosen to enable calculation of J4u (as defined below) with sufficient accuracy.

Calculate the average of each set S_i, $Tavg_i$, and subtract it from all elements of that set, to create a set $S0_i = \{t_i(1) - Tavg_i, t_i(2) - Tavg_i, \ldots\}$.

Combine the sets $S0_i$, i=1 to 12, to create an estimated probability distribution $f_i(t)$.

J4u is defined as the time interval that includes all but 10^{-4} of $f_i(t)$, from the 0.005th to the 99.995th percentile of $f_i(t)$.

J_{RMS} is defined as the standard deviation of $f_i(t)$.

Ch 1 J3u Table (220 Patterns)

Fron	To L0	To L1	To L2	To L3	
All	186.458 mUI				
L3	119.790 mUI	206.195 mUI	301.569 mUI		
L2	208.866 mUI	309.057 mUI		292.380 mUI	
L1	296.663 mUI		291.097 mUI	194.962 mUI	
L0		293.189 mUI	210.147 mUI	109.196 mUI	

- As illustrated in calvin_3dj_01b_2407 Pg 7, the process of "combining the sets" results a composite result that is substantially greater than the sum of its parts.
- Rising edge Jnu histograms have a "left" bias, and corresponding falling edge histograms have a "right" bias. "Combining" or adding these two histograms into a composite value has always been problematic.
- It is recommended that within a given transition level class (e.g. 3 level transitions) that the composite value be associated with the **RMS (root mean squared)** of the individual distributions, not their sum.

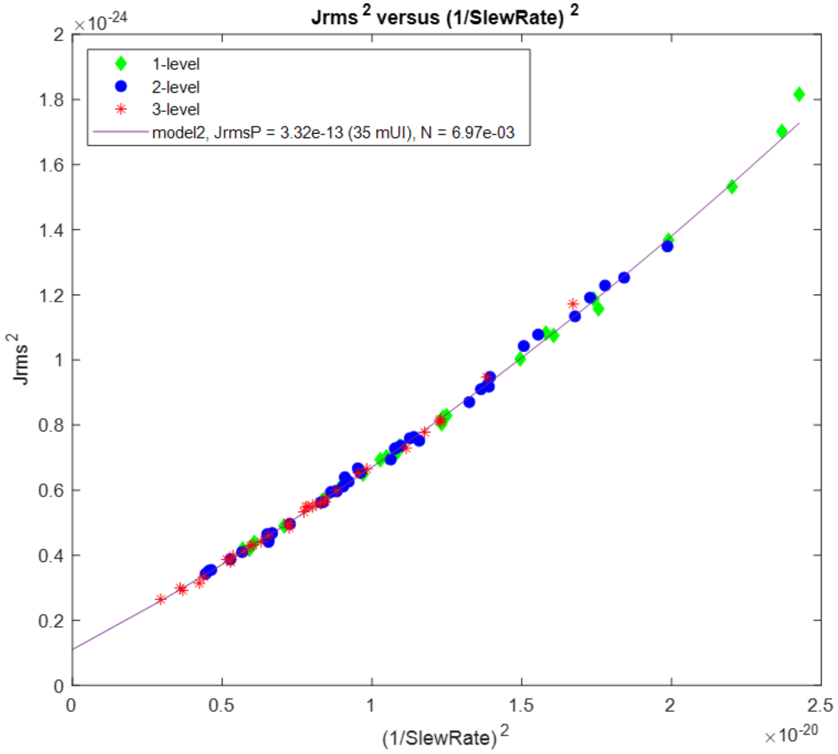
Comments 219, 220 and 221:

J3u and JRMS measurements at TP2 are highly affected by the effects of slew rate and noise and do not reflect actual uncorrelated jitter.. A different methodology that will better quantify phase-only uncorrelated jitter has to be explored

The Jnu and JRMS operations need to be separated for this comment. A methodology that is highly resilient to channel loss has been described in gines_3dj_optx_01a_250109 and introduces the concept of JHRMS which is largely what the original spec writers intended rather than what was described in 120D.3.1.8.1.

The Jnu operations need to be modeled with one proposal described in gines_3dj_optx_01a_250109 (Pg 12) the only thing needing extraction here is DJHdd which should correspond to Add.

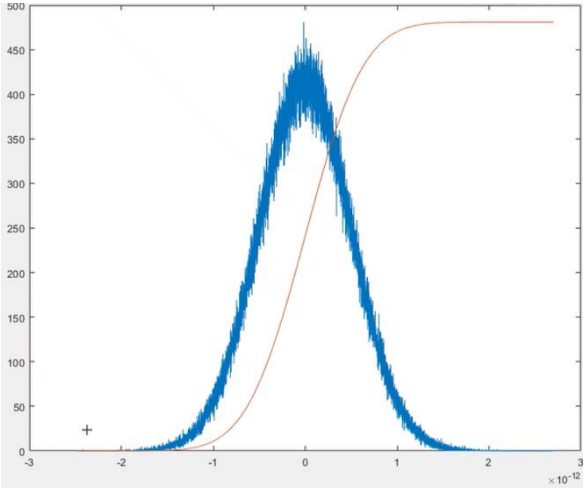
$$JNUH = DJH_{dd} + Q * RJH_{rms}^{2}$$



Comments 219, 220 and 221:

Reference: IEC-TC85-WG22-Noise_Jitter_Compensation_Dec_16_2022: Noise compensation in higher order PAM modulated signals
Credits: Kalev Sepp

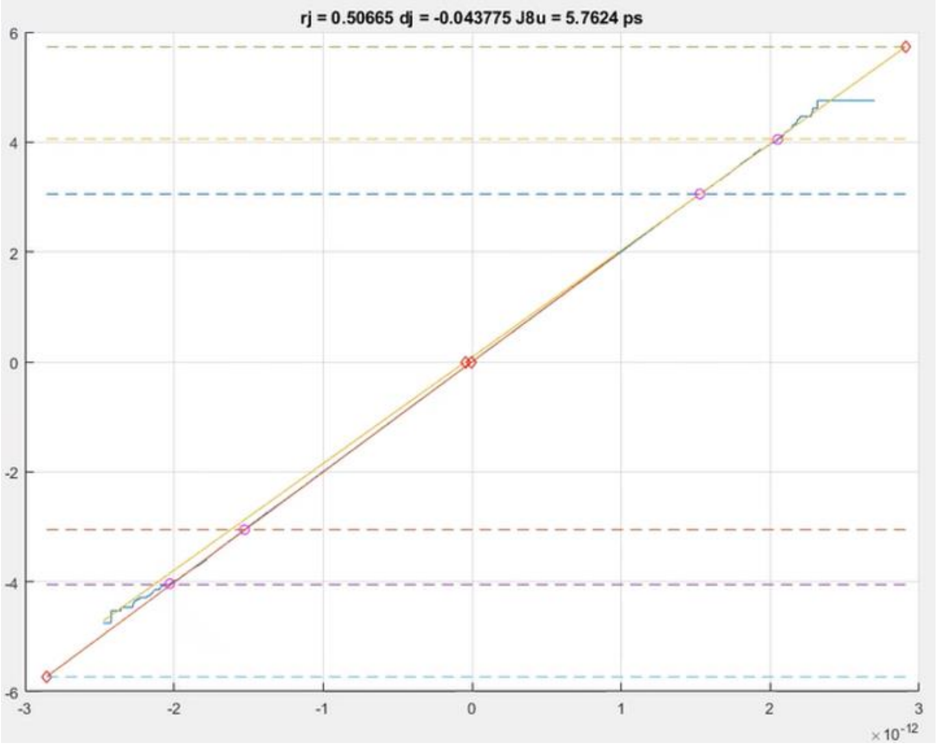
Q-Scale and Jitter components (Rj only)



Instrument acquired histogram (PDF) and it's integral (CDF)
106Gbd 5mV 0mUI djdirac0mUI

Jitter PDF (above) -> CDF ->erf -> Q-Scale representation of edge timing distribution

$$\operatorname{erf} z = \frac{2}{\sqrt{\pi}} \int_0^z e^{-t^2}\, dt.$$



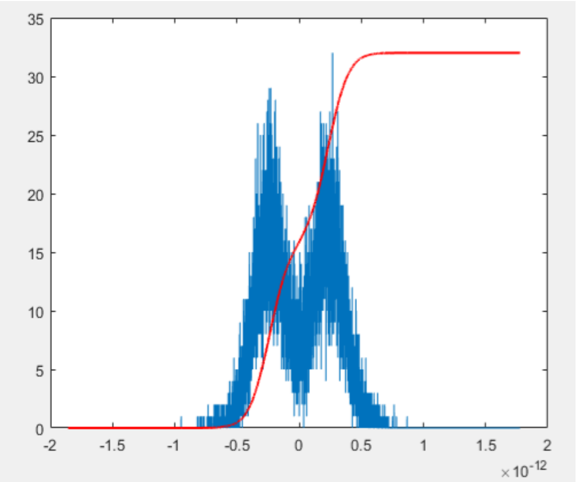
Q-Scale transformed CDF projected onto a "Q" scale from 0 to 6 sigma.

- The Q-Scale transform offers a method of transforming a probability distribution into Q-Space
- It's an effective means to both determine how Gaussian a distribution is, and to predict lower probability behavior.

Comments 219, 220 and 221:

Reference: IEC-TC85-WG22-Noise_Jitter_Compensation_Dec_16_2022: Noise compensation in higher order PAM modulated signals: Credits: Kalev Sepp

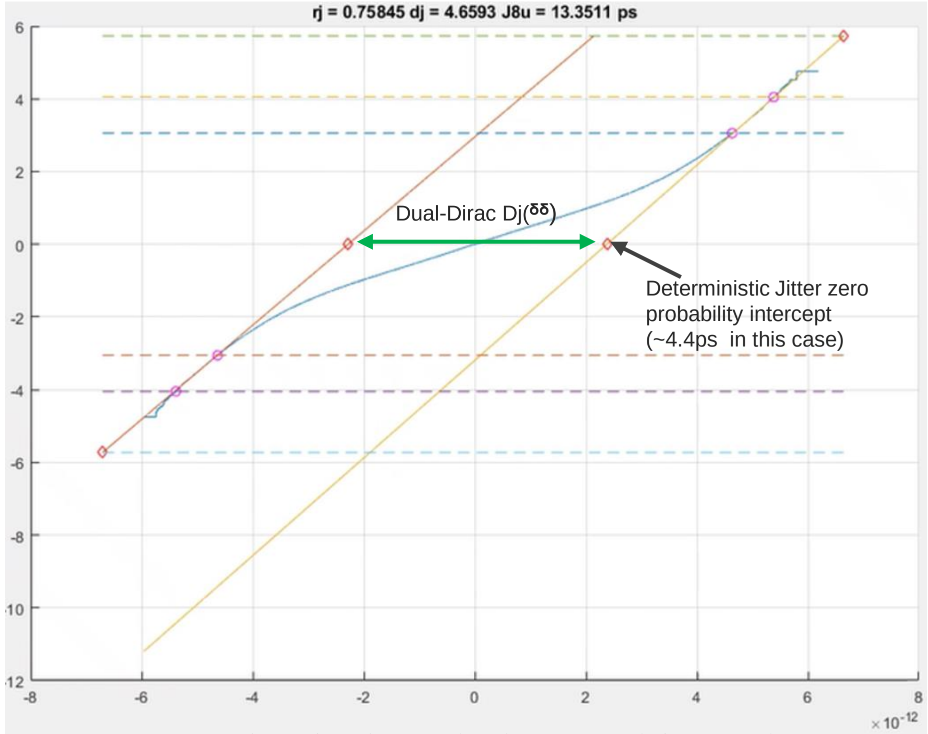
Q-Scale and Jitter components (Rj + DJ)



Instrument acquired histogram (PDF) and it's integral (CDF)
106Gbd 5mV 10mUI djdirac50mUI

Jitter PDF (above) -> CDF ->erf -> Q-Scale representation of edge timing distribution

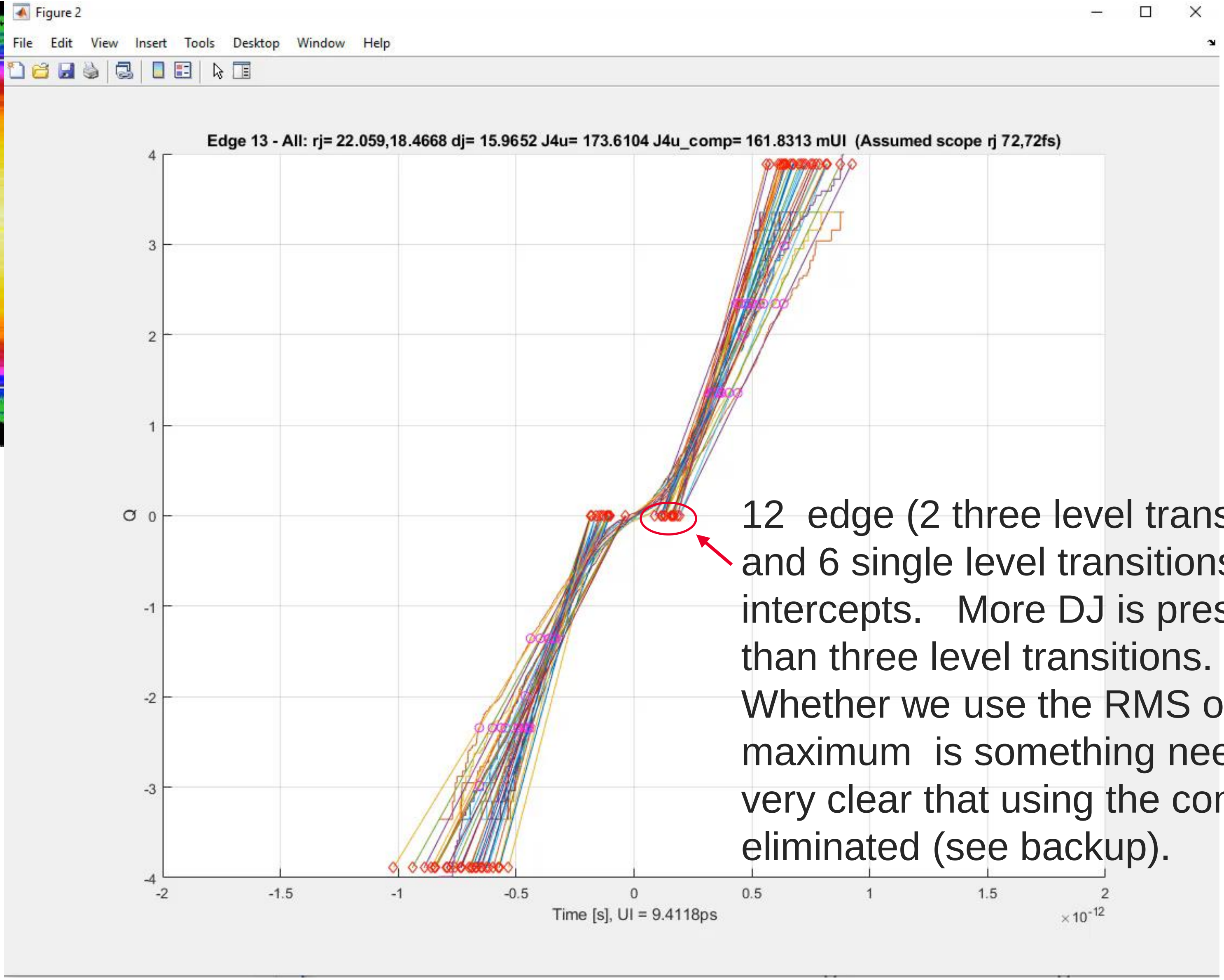
$$\operatorname{erf} z = \frac{2}{\sqrt{\pi}} \int_0^z e^{-t^2}\, dt.$$



Q-Scale transformed CDF projected onto a "Q" scale from 0 to 6 sigma.

- The JHRMS relies on a "y-intercept" method of determining the random jitter.
- This DJHdd similarly operates on a "x-intercept" of the Q-Scale transformed edge distributions.

RJ Compensation 12-edge Synthetic 5mv RN,40mUI DJ, 31dB Channel 0RJ



12 edge (2 three level transitions, 4 two level transitions and 6 single level transitions) provide a distribution of x-intercepts. More DJ is present in single level transitions than three level transitions.

Whether we use the RMS of these DJ intercepts, or maximum is something needing research. One thing is very clear that using the composite edge needs to be eliminated (see backup).

Comments 540, 541:

As already pointed out, the "jitter measurement" method here doesn't work for the relevant bandwidths, losses and amplitudes. This is particularly obvious for J3u03; J4u03 seems to be beyond the state of the art. EOJ should be part of an eye spec like EECQ, not a separate spec item.

Regarding the “relevant Bandwidths and losses” there is real concern that a Via has a filter cutoff well below the 60GHz 4BT prescribed by the current post Via bandwidth in rabinovich_3dj_01_230116

calvin_3dj_01b_2407.pdf (Pg 16) illustrates the impact of lower BW filter selections on Jitter relative to the specified 60GHz 4BT outlined in clause 178.9.2. The empirical data supports that the 60GHz 4BT does provide the lowest jitter values.

Clause 179.9.4.6 Output jitter states the following regarding EOJ03

EOJ_{03} is calculated using the measurement method specified in 162.9.4.7 for even-odd jitter, except that only the transitions R03 and F30 are used.

calvin_3dj_01b_2407.pdf (Pg 7) Suggested that the reported EOJ03 should be the RMS (root mean squared) of the two (0->3, 3->0) three level EOJ values.

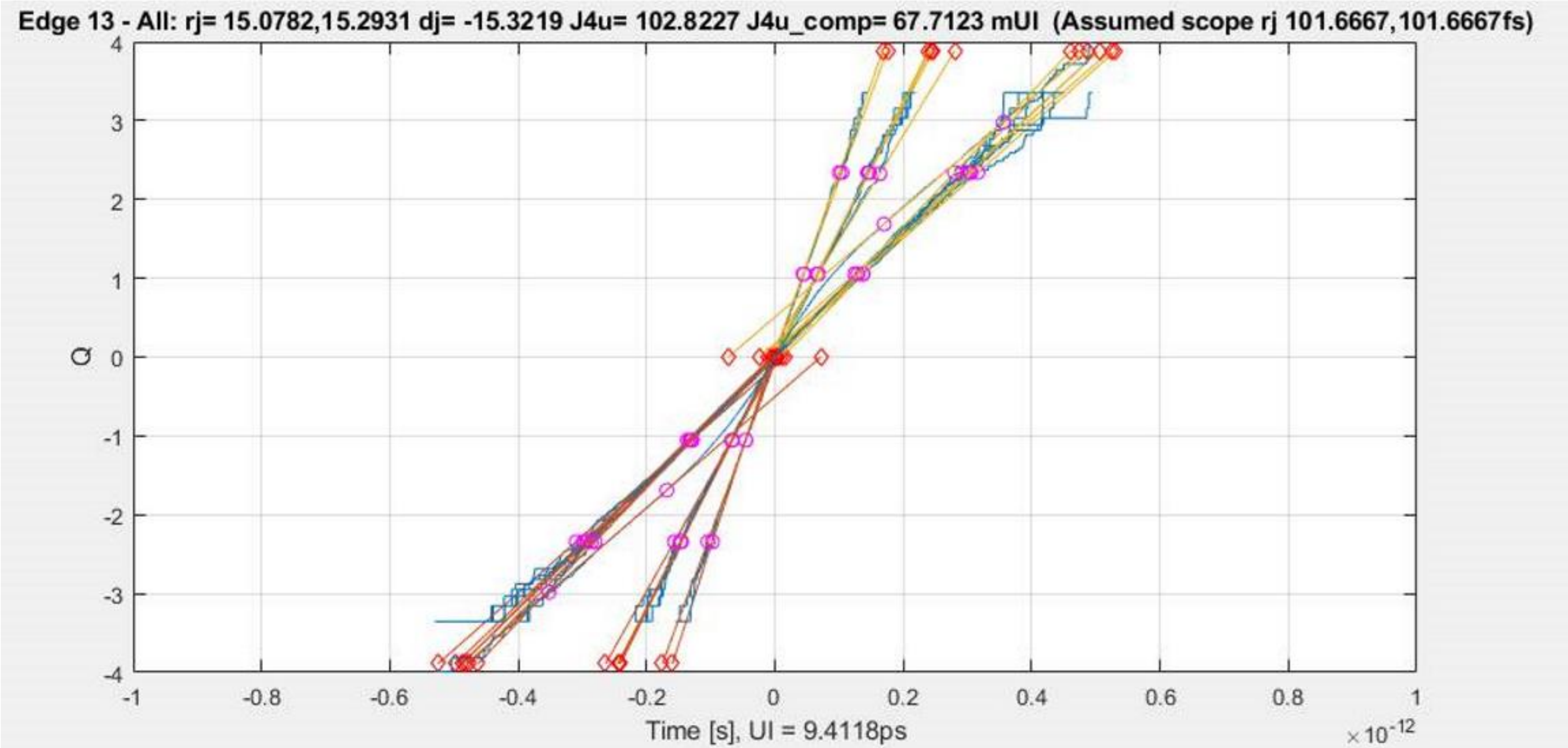
Conclusions

- JRMS, JNU and EOJ have all undergone significant "improvement" since our earlier clause 120D.3.1.8.1 experiences. With margins being very restricted, higher accuracy methods have been developed through the "Clause 120D experience". This presentation proposes and provides reference contributions which support advancing the state-of-the-art in jitter decomposition as the principal interoperability indicator of transmitter properties.
- JRMS should translate to JHRMS which eliminates the impact of interference and emphasizes the "Phase Only Jitter" components as cited in gines_3dj_optx_01a_250109
- EOJ03 is sound from a methodology standpoint, however the composite aspect should be eliminated and the RMS (root mean squared) of the rising EOJ03 or the falling EOJ03 should be reported.
- JNUH as cited in gines_3dj_optx_01a_250109 needs experimentation to determine the most effective method of DJHdd determination. One method here is cited and tracks some activity in IEC TC85: December 16, 2022 of Q-Scale x-intercept methods. Other valid methods exist and our next meeting will narrow in on better spec'ing JNUH.

Thank you

Backup

Credits: Kalev Sepp



- Analysis of the Clause 120D.3.1.8.1 12 edge composite waveform leads to a highly aberrant result. At it's core the sum of multiple Gaussian Distributions does not yield a Gaussian distribution. The choice of pre-determined edges (12 Edges) results in an internal dependency which breaks the Central Limit theorem. We have pattern dependent determinism. We should fix this and go back to 120D.3.1.8.1 and make some retroactive improvements.