SR and PPI Jitter Budget Review Comment 162

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Presentation Overview

- Amended Comment 162 & Proposed Remedy
- Issue: Efficacy of J2 & J9 for limiting TJ(BER = 1E-12)
- Conclusions
- Analysis:
  - Jitter distribution review
    - Gaussian (G)
    - Truncated Gaussian (TG)
    - Sinusoidal (SJ)
    - Dual-Dirac (dDJ)
  - J2, J9 and TJ dependence on RJ - DJ combinations

Amended Comment 162 and Proposed Remedy

***Comment (Type* T): In Table 86A-3 (also 86A-4) the limits for J2 (0.46) and J9 (0.63) for some reasonable combinations of jitter will permit TJ (at BER = 1E-12) to exceed 0.70 UI which was not intended when these J2 and J9 limits were established. Unfortunately, a similar situation occurred at TP1 and, consequently without some relief at TP1, relief at TP4 is limited. However, it appears that J9 can be tightened from 0.63 UI to 0.62 UI. See petrilla_01_0709 for discussion.**

Further review of the receiver (sub-clause 86.7.3, page 280, Table 86-8) reveals the conditions for the stressed receiver sensitivity test generate an unneeded and undesirable over-stress condition. The choice of values for J2 (0.35 UI) and J9 (0.47) permit TJ (BER+1E-12) to reach 0.496 UI, higher than the expected 0.485 UI. Also, the vertical eye closure penalty (VECP) value (2 dB) is larger than that calculated (1.9 dB) for updated SR and PPI conditions. These are partly due to misunderstanding of the probabilities associated with J2 and J9 when these conditions were first proposed in January 2009 and partly due to slight shifts in attributes since January.

Although the current values of J2 and J9 permit a higher than expected level of TJ at TP3, this appears reasonably aligned with the current TDP requirement. Relief for the over-stress at TP3 should come from the VECP condition.

***Suggested Remedy:* In Table 86-8 change VECP from 2 to 1.9 and in Tables 86A-3 and 86A-4 change J9 from 0.63 to 0.62.**

Issue: Efficacy of J2 & J9 for limiting TJ

- As 802.3ba has adopted use of J2 and J9 as jitter metrics, it seems appropriate, if not past due, to evaluate these metrics with different jitter distributions. This begs the question, which distributions? Can distributions be found that provide boundaries?

- Background: For SR with PP1, 802.3ba has chosen J2 and J9 as metrics to control jitter. These metrics appear at TP1 and TP4 as primary controls along with an eye mask. The metrics also appear at TP3 in the SRS test conditions. The issue to examine is how well these metrics, specifically the limits and values chosen for these metrics, constrain TJ for BER = 1E-12.

- For reference J2 was J defined in clause 52 as all but 1%, i.e. 0.99, of the jitter seen in the histogram at the mean signal level and, following suit, J9 is defined as 0.999999999 of the jitter.

Conclusions (1)

- With use of J2 and J9 metrics, a single jitter distribution type, e.g. dual-Dirac, is no longer adequate to estimate TJ.
- A set of jitter distributions, including truncated Gaussians and dual-Diracs may adequately bound TJ estimates. Distributions such as Gaussian where the highest probabilities are in the center of the distribution appear to represent one boundary case and bimodal distributions such as sinusoidal of dual-Dirac where the highest probabilities are at the extremes of the distribution appear to represent another boundary case. All other cases may be approximated by these two or a combination of these two.
- At TP1, for the combination of J2 (max = 0.18 UI), X1 = 0.11 UI and J9 (max = 0.26 UI), max TJ is estimated at 0.294 UI. While higher than the expected 0.28 UI, a transmitter with base case attributes can tolerate this level and satisfy TDP and eye mask requirements since the max TJ values occur for low values of DJ or low probability DJ and TDP is now based on a 0.3 UI eye width. Some of the extra jitter is being passed downstream.

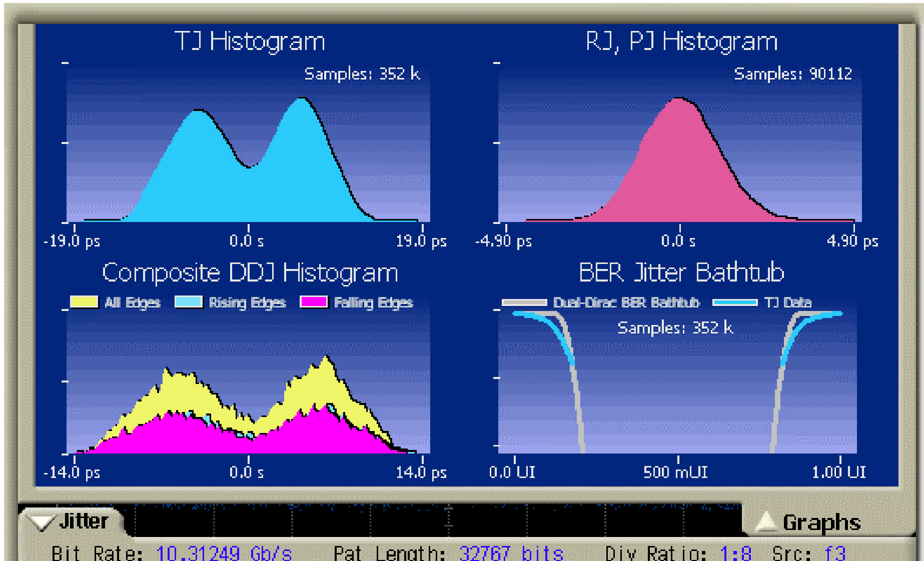
Conclusions (2)

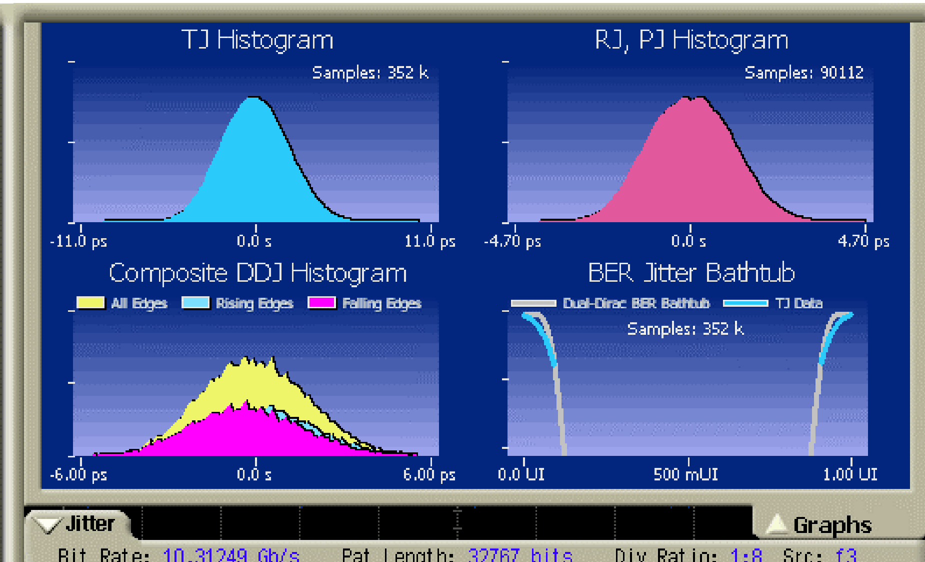
- At TP3, when J2 (0.35 UI) and J9 (0.47 UI) conditions are met simultaneously, TJ is estimated at 0.496 UI, higher than the expected 0.485 UI. However a TJ of 0.496 UI is in reasonable alignment with the upstream TDP test. Other combinations of J2 and J9 can yield a problematic max TJ overstress of 0.534 UI and should be avoided. Further review of the stressed receiver conditions shows an additional overstress in the applied vertical eye closure penalty (VECP). Relief for the combined overstress conditions is proposed by reducing the VECP condition from 2 dB to 1.9 dB.
- At TP4, for the combination of J2 (max = 0.46 UI) X1 = 0.11 UI and J9 (max = 0.63 UI), max TJ is estimated at 0.716 UI. This is higher than the expected 0.68 UI and may place too heavy a burden on the downstream receiver. Relief is proposed by reducing max J9 from 0.63 UI to 0.62 UI to yield a max TJ estimate of 0.704 UI.

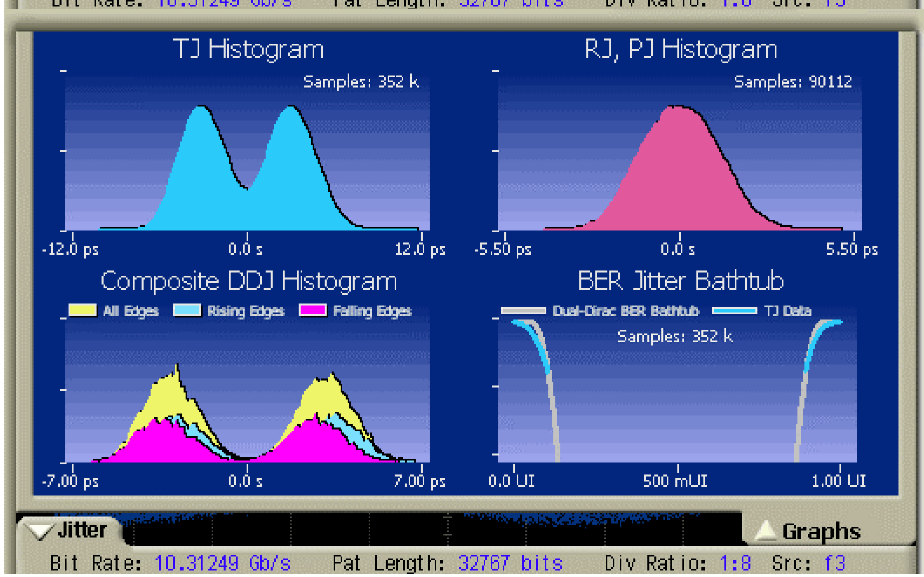
Analysis Approach

- For different jitter distributions, J2, J9 and TJ are estimated at TP1, TP3 and TP4. In addition, estimates are made at these interfaces of jitter corresponding to the X1 coordinate for a 5E-5 hit ratio eye mask.
- Distributions at TP1 were investigated (see following page) and seemed to fall into two broad categories, those for under or over equalized channels and those for well equalized channels. Distributions for well equalized channels appear Gaussian and those for under or over equalized channels appear bimodal. Similar characteristics are expected at other interfaces.
- Jitter Distributions: All evaluated distributions, CDFs, are a combination (convolution) of a Gaussian component and another component, including Gaussian, truncated Gaussian, sinusoidal and dual-Dirac distributions.

Example Distributions: Under, Over and Well Equalized

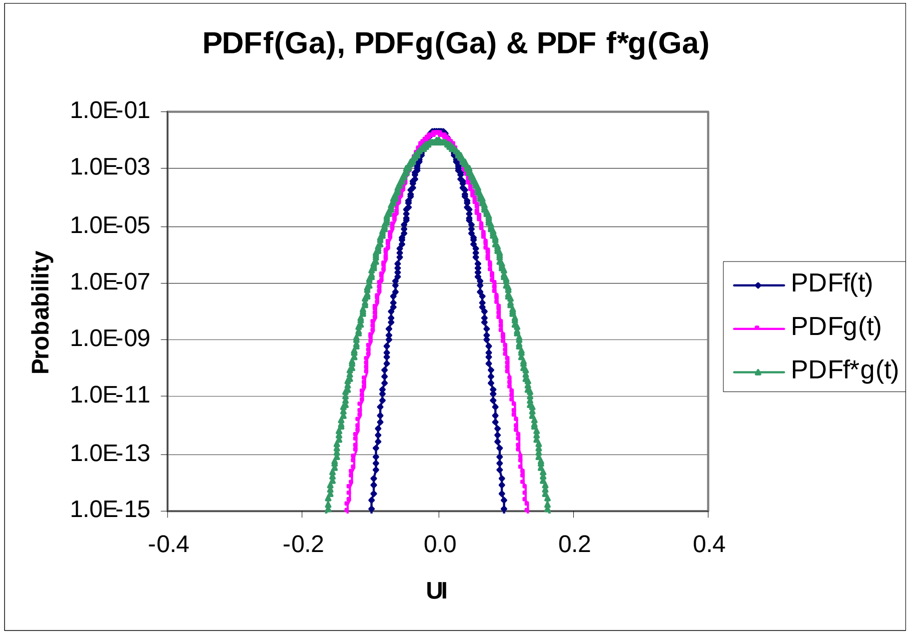


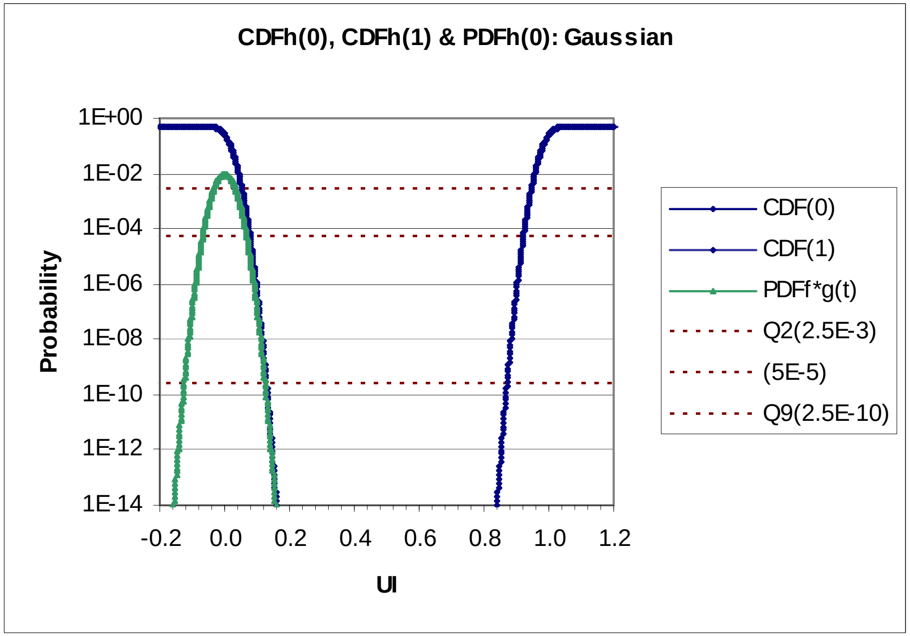




The upper left image is from an under-equalized (no de-emphasis) channel. The lower left image is from the same channel, this time over-equalized. The above image is from the same channel, now well equalized. While both under and over equalization result in bimodal DJ and TJ distributions, the well-equalized case looks Gaussian.

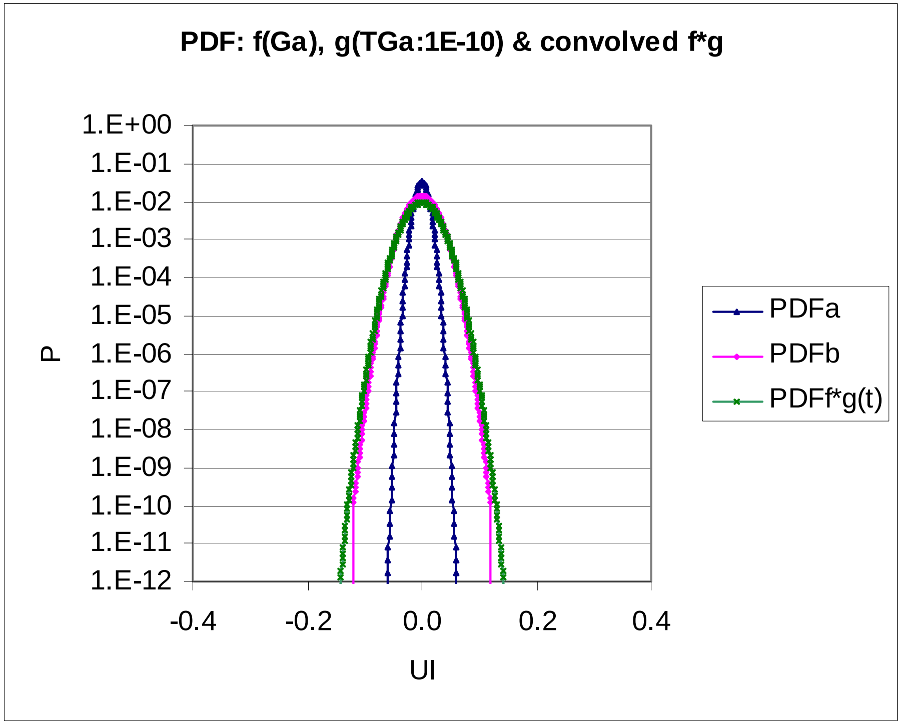
CDF for Gaussian & Gaussian Combination

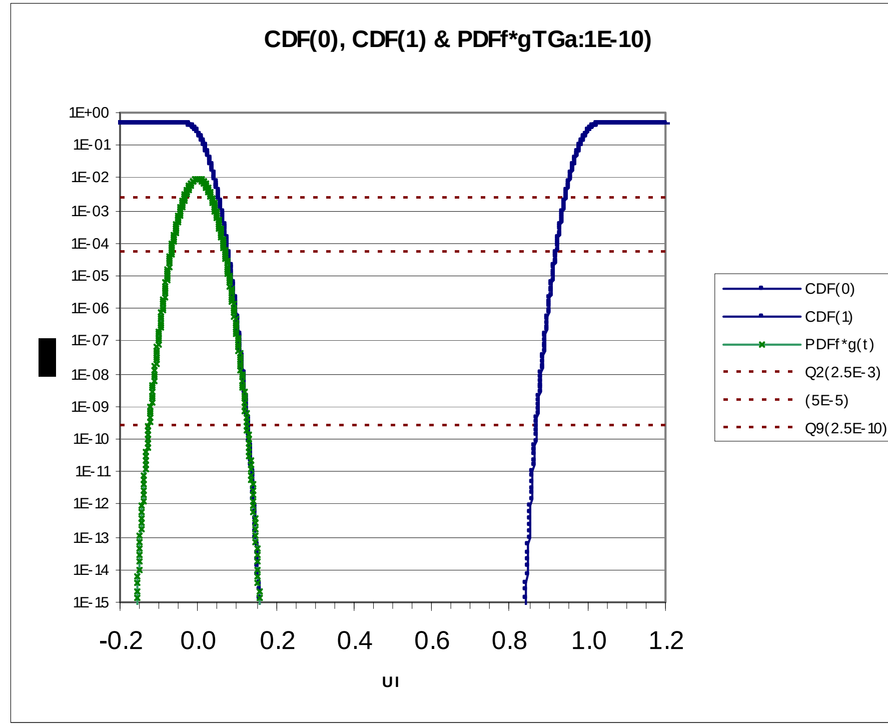




In this TP1 case, DJ is represented by the Gaussian distribution g with DJ of 0.240 UI and RJ is represented by the Gaussian distribution f with RJ of 0.178 UI that is scaled to yield J9 of 0.260 UI. In this example, J2 = 0.110 UI and TJ(BER=1E-12) = 0.294 UI. With a Gaussian and Gaussian combination it is not possible to reach simultaneously both J2 and J9 limits at any of the interfaces.

CDF for Gaussian & Truncated Gaussian Combination 1

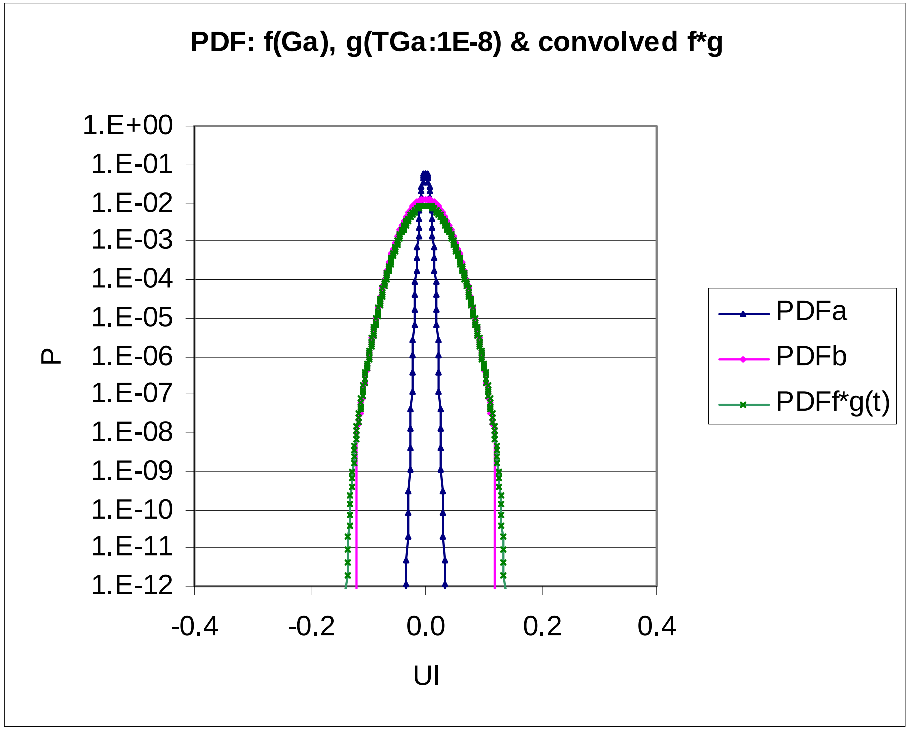


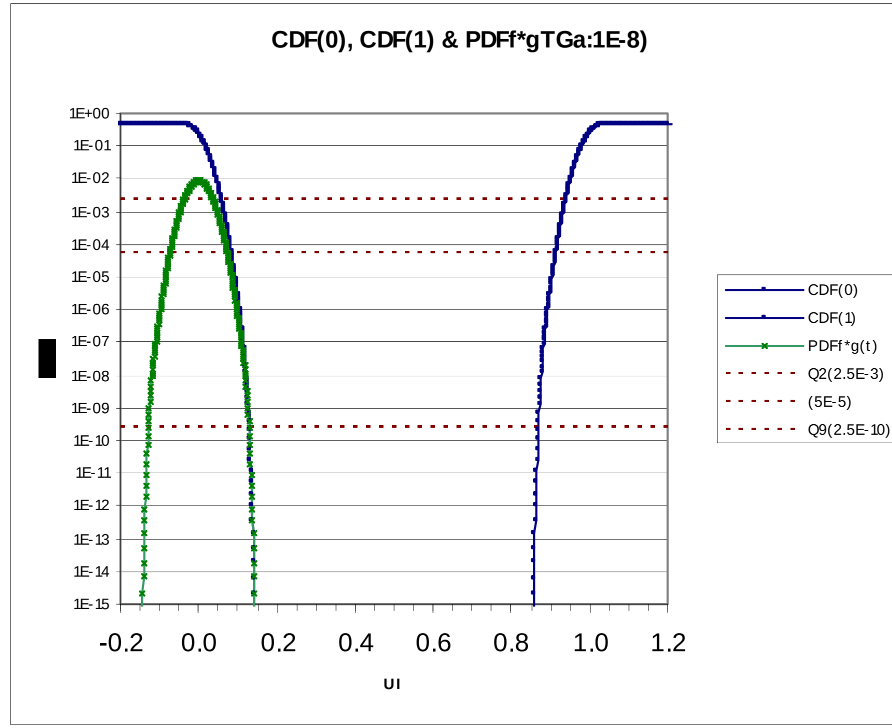


•In this TP1 case, DJ is represented by the Gaussian distribution g truncated below 1E-10 probabilities with DJ of 0.240 UI and RJ is represented by the Gaussian distribution f with RJ of 0.125 UI that is scaled to yield J9 of 0.26 UI. Here J2 = 0.112 UI and TJ(BER=1E-12) = 0.292 UI. With this Gaussian and Gaussian truncated below 1E-10 combination it is not possible to reach simultaneously both J2 and J9 limits at any of the interfaces.

•This truncated Gaussian, TG, combination may be reasonably representative of well-equalized channels and PRBS31 test patterns. Specifically, it can be considered a corner case for near Gaussian, single-mode distributions with long tails.

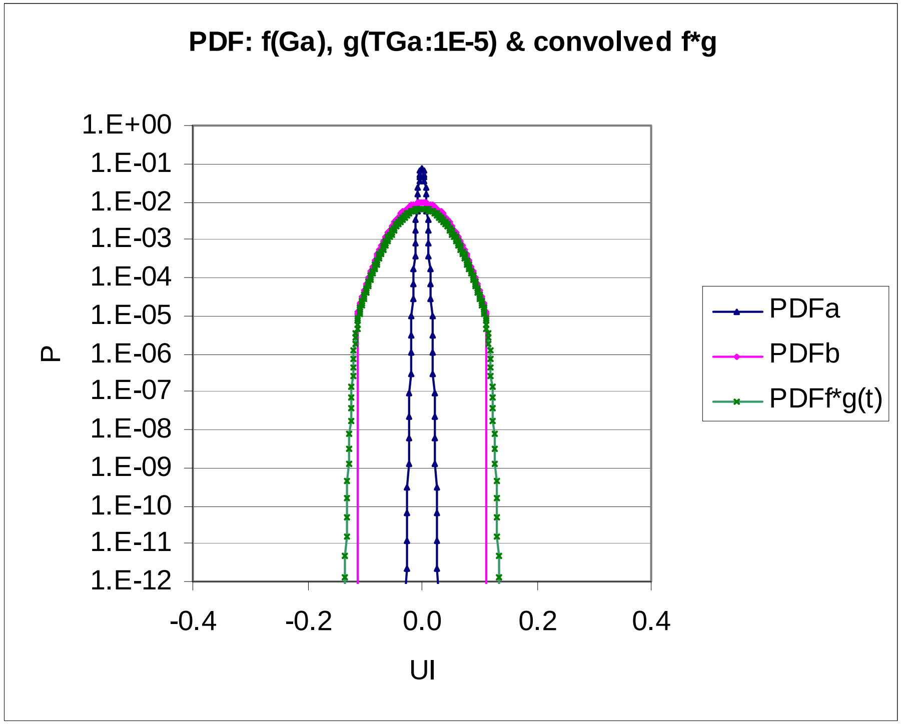
CDF for Gaussian & Truncated Gaussian Combination 2

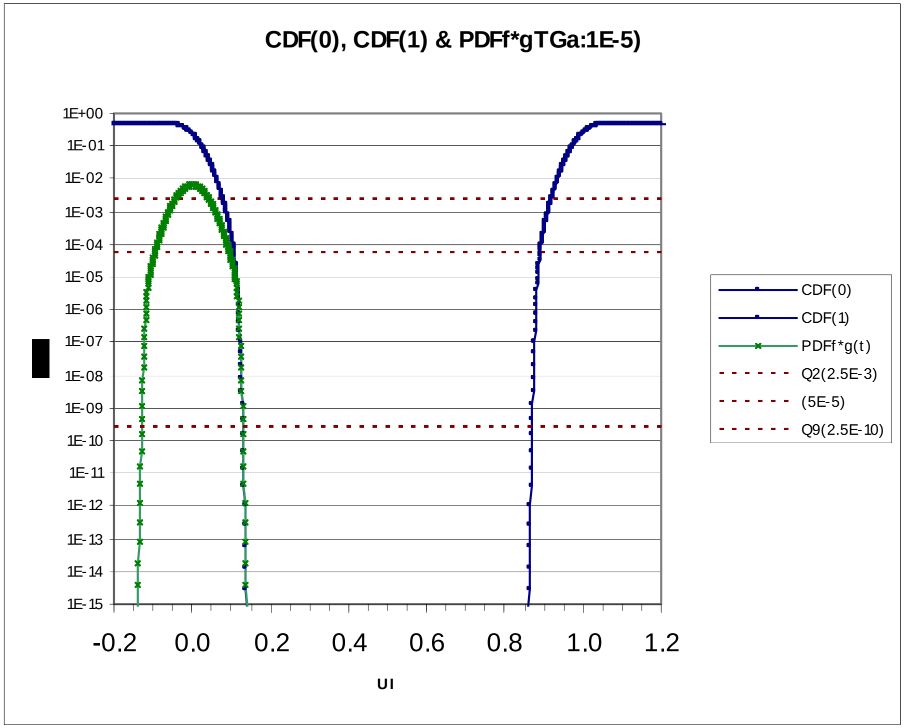




In this TP1 case, DJ is represented by the Gaussian distribution g truncated below 1E-8 probabilities with DJ of 0.240 UI and RJ is represented by the Gaussian distribution f with RJ of 0.066 UI that is scaled to yield J9 of 0.26 UI. Here J2 = 0.120 UI and TJ(BER=1E-12) = 0.276 UI. With this Gaussian and Gaussian truncated below 1E-8 combination it is not possible to reach simultaneously both J2 and J9 limits at any of the interfaces.

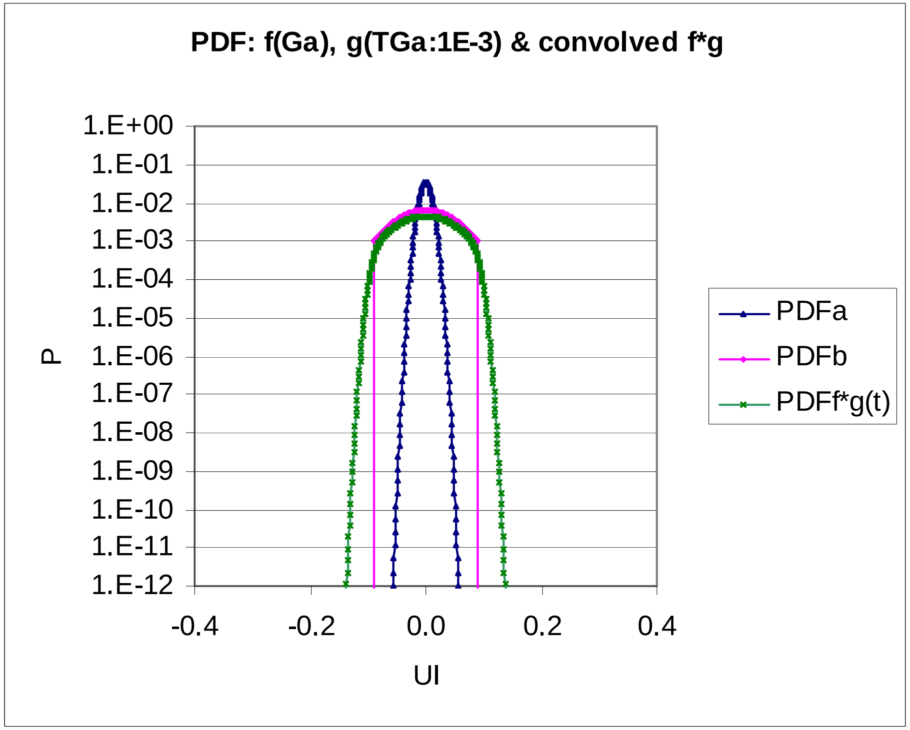
CDF for Gaussian & Truncated Gaussian Combination 3

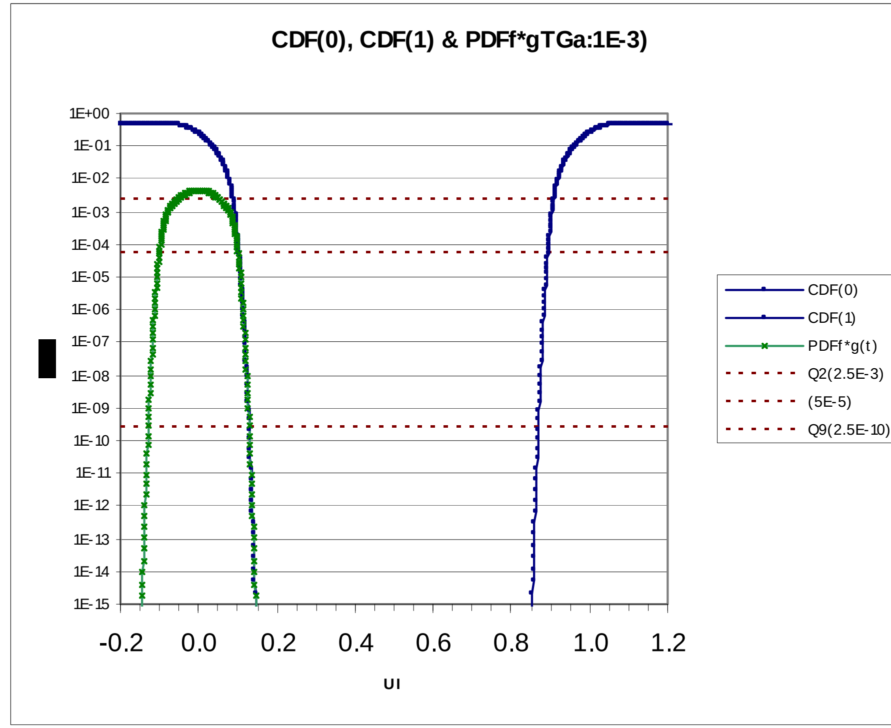




In this TP1 case, DJ is represented by the Gaussian distribution g truncated below 1E-5 probabilities with DJ of 0.228 UI and RJ is represented by the Gaussian distribution f with RJ of 0.057 UI that is scaled to yield J9 of 0.26 UI. Here J2 = 0.160 UI and TJ(BER=1E-12) = 0.270 UI. With this Gaussian and Gaussian truncated below 1E-5 combination it is not possible to reach simultaneously both J2 and J9 limits at TP1 and TP3.

CDF for Gaussian & Truncated Gaussian Combination 4

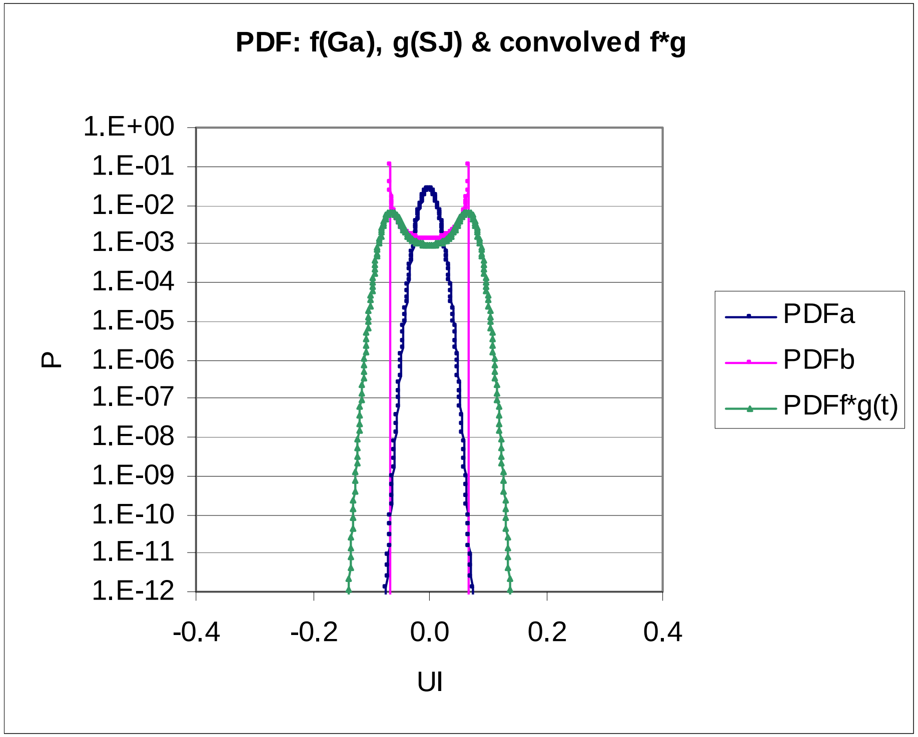


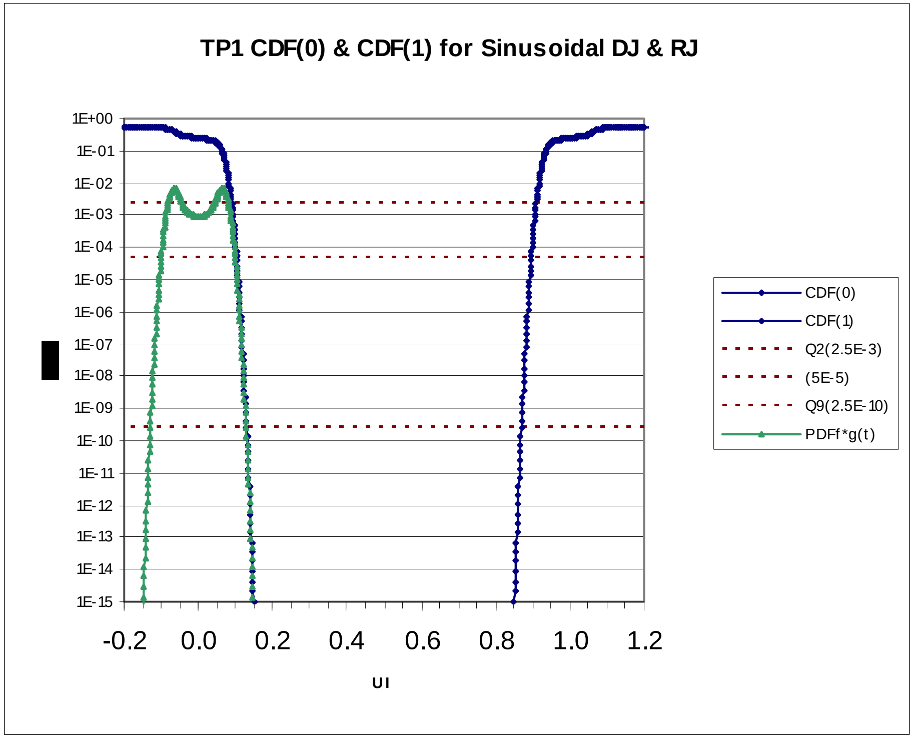


•In this TP1 case, DJ is represented by the Gaussian distribution g truncated below 1E-3 probabilities with DJ of 0.178 UI and RJ is represented by the Gaussian distribution f with RJ of 0.115 UI that is scaled to yield J9 of 0.260 UI. Here J2 = 0.180 UI, the max limit for J2, and TJ(BER=1E-12) = 0.276 UI. With this combination it is possible to reach simultaneously both J2 and J9 limits at all interfaces.

•This truncated Gaussian combination may be reasonably representative of well-equalized channels and short test patterns, e.g. PRBS9.

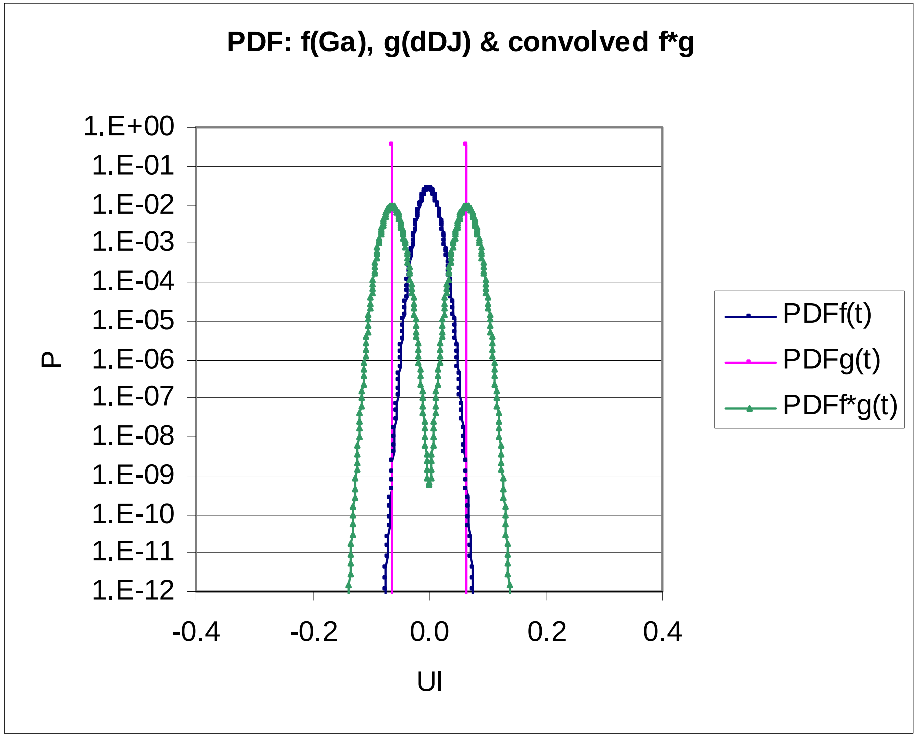
CDF for Gaussian & Sinusoidal Combination

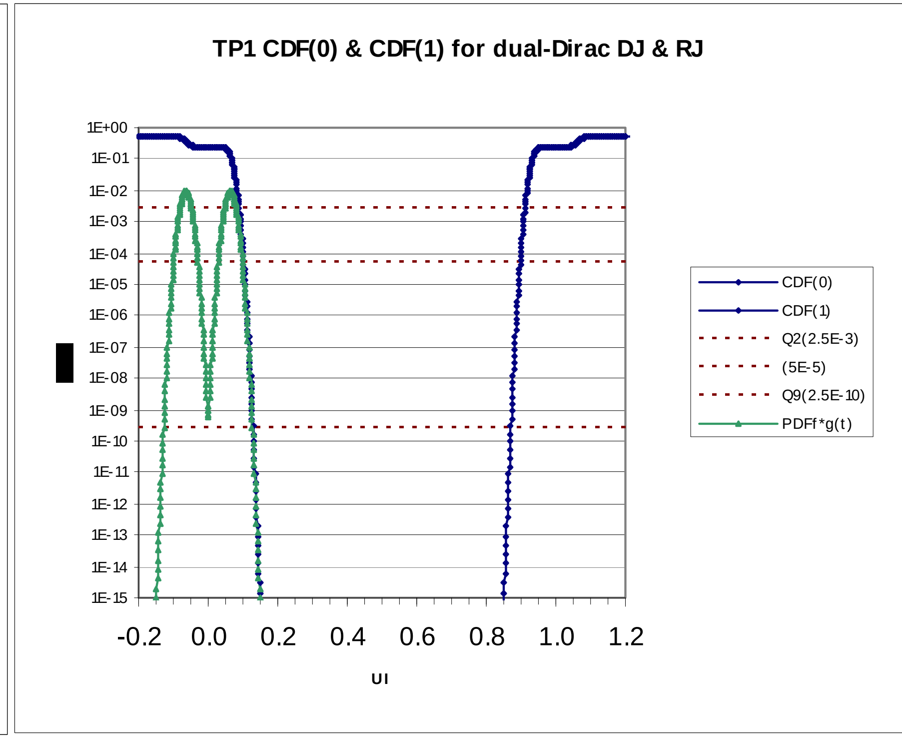




- In this TP1 case, DJ is represented by the sinusoidal distribution g with DJ of 0.137 UI and RJ is represented by the Gaussian distribution f with RJ of 0.149 UI that is scaled to yield J9 of 0.26 UI. Here J2 = 0.180 UI, the max limit for J2, and TJ(BER=1E-12) = 0.278 UI. With this combination it is possible to reach simultaneously both J2 and J9 limits at all interfaces.
- This sinusoidal combination may be reasonably representative of jitter generated for input stress conditions. Such a distribution may have long or short tails depending on RJ content and the complexity and/or length of the test pattern.

CDF Example for Gaussian & Dual-Dirac Combination

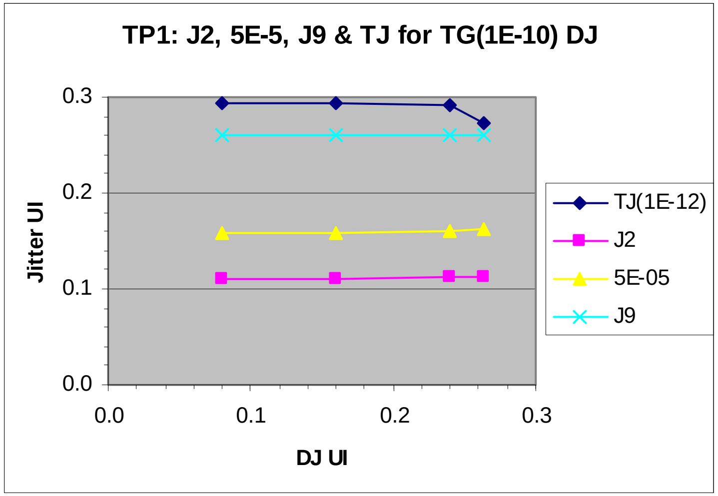


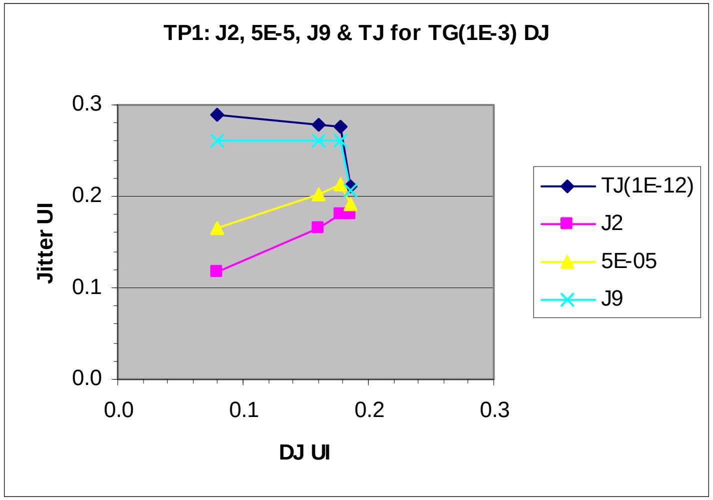


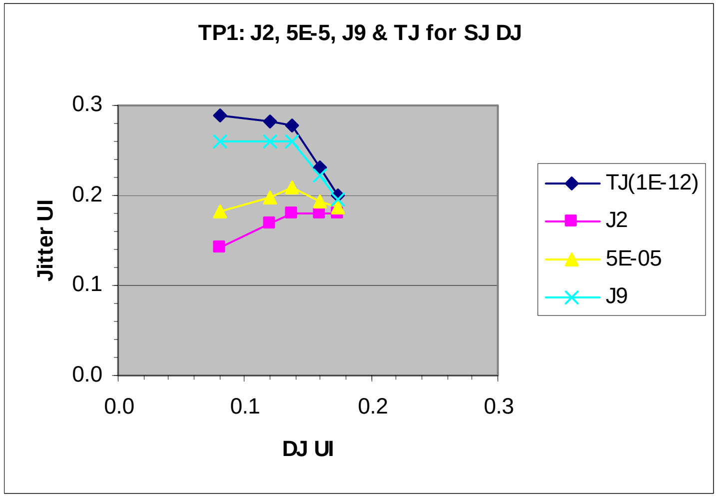
•In this TP1 case, DJ is represented by the dual-Dirac distribution g with DJ of 0.129 UI and RJ is represented by the Gaussian distribution f with RJ of 0.153 UI that is scaled to yield J9 of 0.260 UI. Here J2 = 0.180 UI, the max limit for J2, and TJ(BER=1E-12) = 0.278 UI. With this combination it is possible to reach simultaneously both J2 and J9 limits at all interfaces.

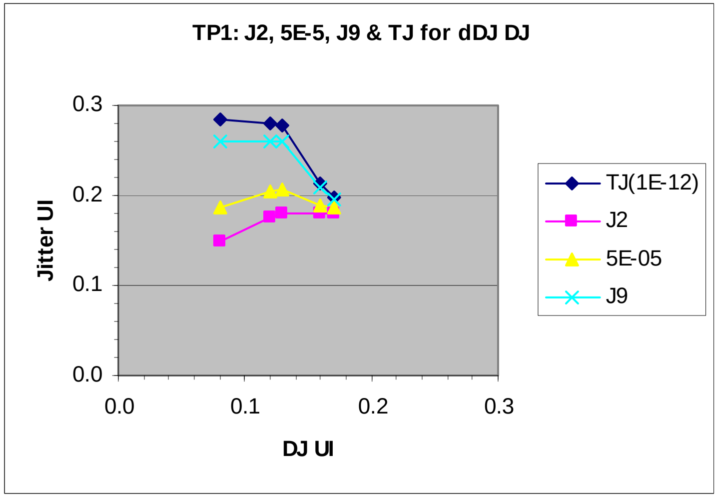
•This dual-Dirac combination may be reasonably representative of under or over equalized channels. Such a distribution may have long or short tails depending on the RJ content and length and complexity of the test pattern. It can be considered a corner case for bimodal distributions with short or long tails.

TP1 J2, 5E-5, J9 & TJ vs DJ



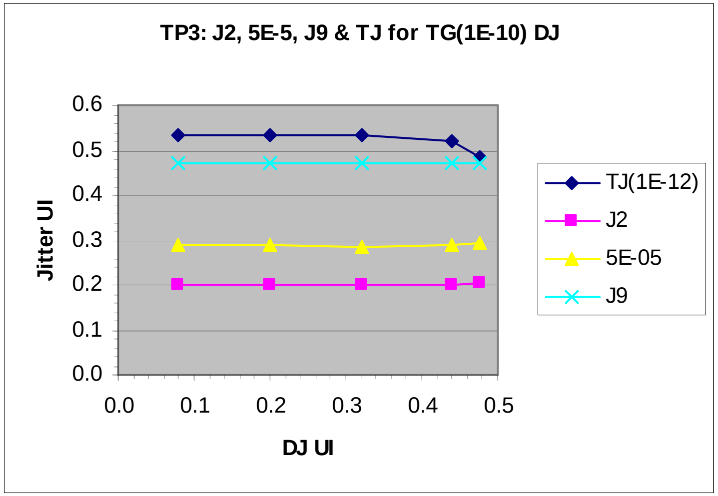


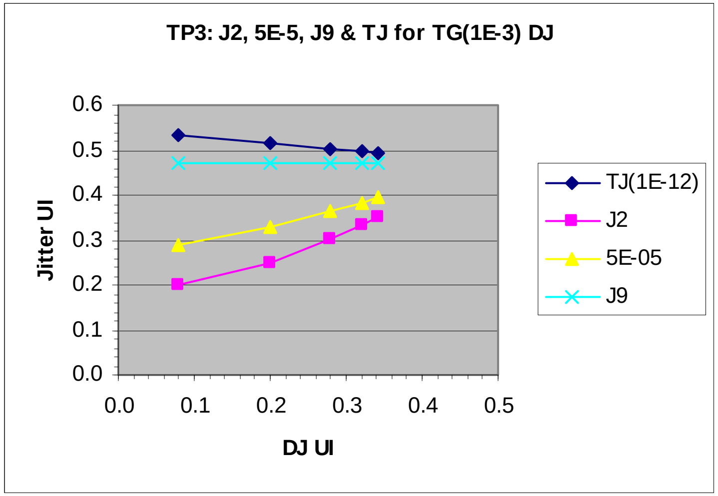


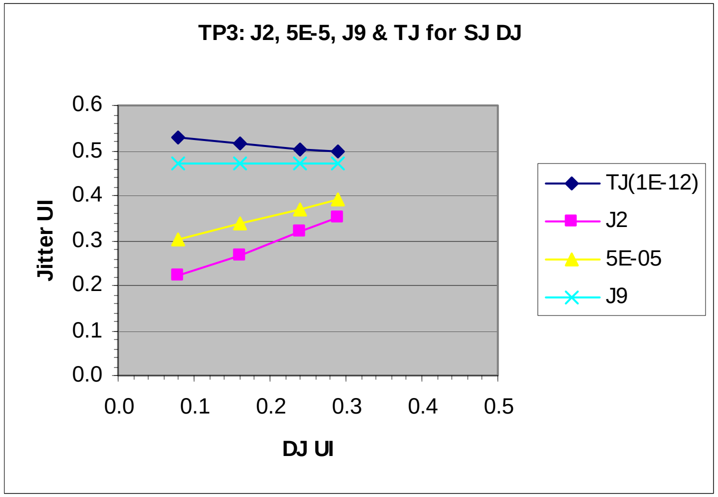


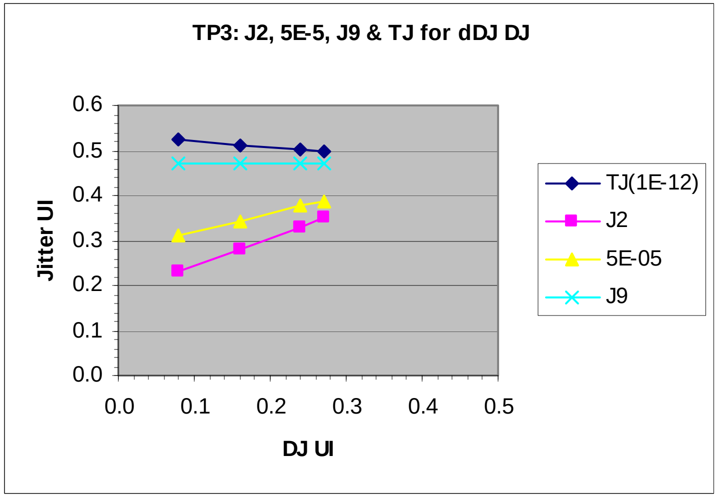
In the above, for a given DJ, RJ was increased until either J2 or J9 was at its max. Max values of TJ (0.294 UI) occur for low values of DJ. For high values of DJ and low values of RJ, TJ and J9 approach the max J2 limit.

TP3 J2, 5E-5, J9 & TJ vs DJ



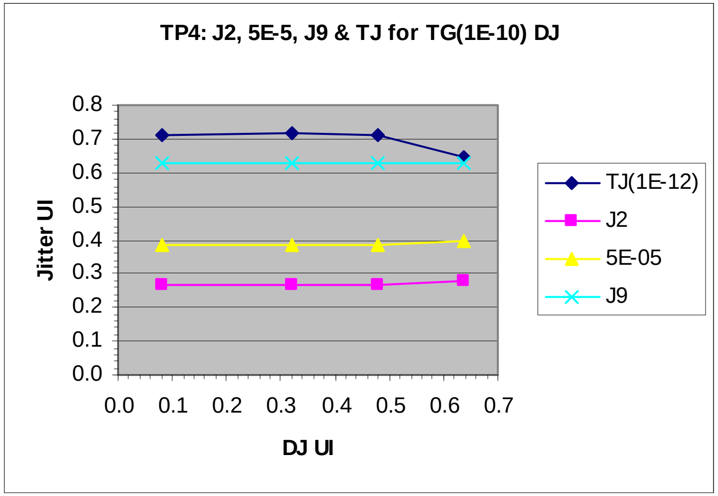


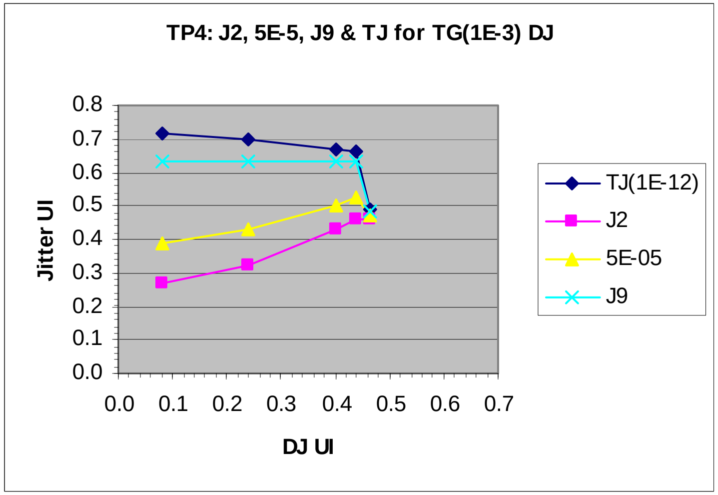


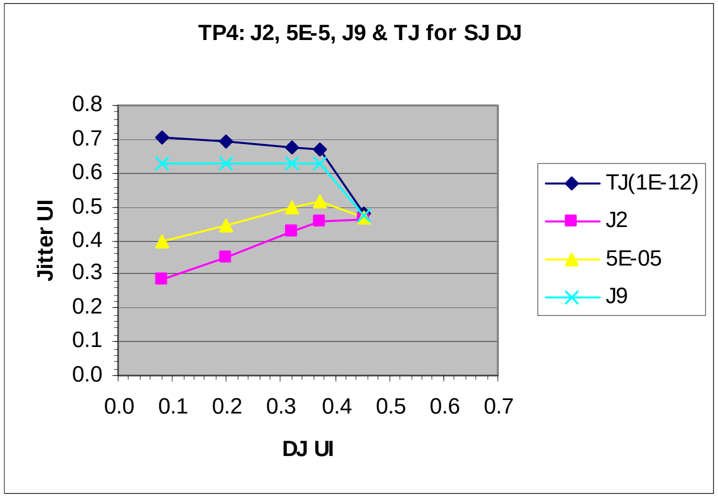


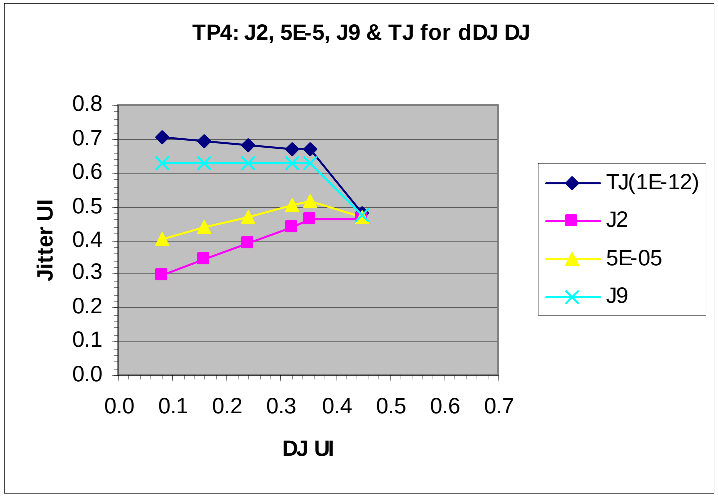
In the above, for a given DJ, RJ was increased until either J2 or J9 was at its max. Max values of TJ (0.534 UI) occur for low values of DJ. For high values of DJ and low values of RJ, TJ and J9 approach the max J2 limit.

TP4 J2, 5E-5, J9 & TJ vs DJ









In the above, for a given DJ, RJ was increased until either J2 or J9 was at its max. Max values of TJ (0.716 UI) occur for low values of DJ. For high values of DJ and low values of RJ, TJ and J9 approach the max J2 limit.