

# Comment #38, #40: Jitter Test Methods for 200GAUI-4 and 400GAUI-8

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# Supporters

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- Jitter test method for 200GAUI-4 and 400GAUI-8 in the current draft is largely based on Clause 94 with a few modifications
  - Baseline was 100GBASE-KP4 in Clause 94 (li\_3bs\_01a\_0315.pdf)
  - CRJ and CDJ (as derived from J5 and J6) was changed to JRMS and J5 (hegde\_3bs\_03\_0316.pdf, hegde\_3bs\_03\_0516.pdf)
  - J5 was changed to J4 (dawe\_3bs\_0916.pdf, slide 11)
  
- This jitter test method in Clause 94 was once compared with the jitter test method in Clause 92 (healey\_3bs\_01\_0915.pdf)
  - The conclusion was that Clause 94 was preferred, because dual-Dirac fitting in Clause 92 is not accurate (moore\_3bj\_01\_0114.pdf)
  
- However, some discussion was not enough in the comparison
  - Both test methods exclude DDJ, but in a different way
    - The methods to exclude DDJ are obvious, but may not be discussed enough

## Comparison of methods

	100GBASE-CR4/KR4	100GBASE-KP4
Reference	92.8.3.8.2	94.3.12.6
Test pattern	<u>PRBS9</u>	<u>JP03A (clock pattern with 2 UI period)</u>
Data acquisition	Histogram of zero crossing times for <u>isolated rising and falling transitions</u>	1-shot capture and post-processing (filtering, average UI, and error calculations)

- Both methods clearly exclude DDJ, but in a different way
  - Clause 92 measures **isolated transitions** in PRBS9 to exclude DDJ
  - Clause 94 uses **clock pattern** JP03A to exclude DDJ
- If we switch to PRBS13Q, we should revisit Clause 92 method, because PRBS13Q has a lot of DDJ similar to PRBS9

## ■ DDJ is excluded from PRBS9

- Jitter is measured on each of **two specific transitions** in a PRBS9 pattern
  - Transition between five zeros and four ones
  - Transition between nine ones and five zeros
- EBUJ and ERJ are derived by fitting dual-Dirac model

### 92.8.3.8.2 Effective bounded uncorrelated jitter and effective random jitter

Effective bounded uncorrelated jitter and effective random jitter are measured on each of two specific transitions in a PRBS9 pattern (see 83.5.10). The two transitions occur in the sequence of five zeros and four ones and nine ones and five zeros, respectively. The sequences are located at bits 10 to 18 and 1 to 14, respectively, where bits 1 to 9 are the run of nine ones.

- The jitter components are determined according to the following method. Acquire a horizontal histogram of a transition around the zero-crossing point. The number of acquired samples should be sufficiently large to yield consistent measurement results. Designate the total number of samples as  $NS$ , the number of bins as  $NB$ , the number of samples in each bin as  $N_i$  where  $i$  is the bin number from 1 to  $NB$ , and the sample time corresponding with the center of each bin as  $t_i$ .
- Create two cumulative distribution curves  $CDFL_i$  and  $CDFR_i$  according to Equation (92–10) and

EBUJ and ERJ are obtained by fitting the histogram to dual Dirac model

## ■ We can exclude DDJ from PRBS13Q in a similar way

- But, we can skip the remaining process of fitting to dual-Dirac model

- Measure jitter on each of **12 specific transitions** in PRBS13Q in order to exclude DDJ
  
- Get a horizontal histogram for each of specific transitions
  - The 12 specific transitions are provided in the next slide
  - Each histogram should include at least  $10^5$  hits
  - Optionally, each specific transition may be replaced with a similar transition:
    - Same rise or fall, from same level to same level (e.g. rise from 0 to 3)
    - 3 or more identical levels followed by 2 or more different identical levels
  
- Derive JRMS and J4 from the histogram using the method in 120D.3.1.1
  - The method to derive EBUJ and ERJ as in Clause 92 is discouraged
    - Because EBUJ may be converted to ERJ depending on the distribution type (moore\_3bj\_01\_0114.pdf and healey\_3bs\_01\_0915.pdf)
  
- J4 should meet the specification at each specific transition
- JRMS should meet the specification as the root mean square value

# 12 Specific Transitions in PRBS13Q

Label	Description	Gray coded PAM4 symbols	PAM4 symbol index			Threshold level	Binary levels		
			First	Transition	Last		MSB	LSB	
REF	Reference for index	3333333	1	/	/	7	/	/	
R03	Rise transition from 0 to 3	10000 330	1830	1834	1835	1837	$(V_0+V_3)/2$	Rise	Rise
F30	Fall transition from 3 to 0	23333 001	1269	1273	1274	1276	$(V_0+V_3)/2$	Fall	Fall
R12	Rise transition from 1 to 2	0111111 2222221	3638	3644	3645	3651	$(V_1+V_2)/2$	Rise	Fall
F21	Fall transition from 2 to 1	022222 113	1198	1203	1204	1206	$(V_1+V_2)/2$	Fall	Rise
R01	Rise transition from 0 to 1	100000 113	6835	6840	6841	6843	$(V_0+V_1)/2$		Rise
F10	Fall transition from 1 to 0	21111 003	2992	2996	2997	2999	$(V_0+V_1)/2$		Fall
R23	Rise transition from 2 to 3	32222 330	6824	6828	6829	6831	$(V_2+V_3)/2$		Rise
F32	Fall transition from 3 to 2	033333 2222223	7734	7739	7740	7746	$(V_2+V_3)/2$		Fall
R02	Rise transition from 0 to 2	10000 223	3266	3270	3271	3273	$(V_0+V_2)/2$	Rise	
F20	Fall transition from 2 to 0	122222 0000002	7282	7287	7288	7294	$(V_0+V_2)/2$	Fall	
R13	Rise transition from 1 to 3	011111 331	133	138	139	141	$(V_1+V_3)/2$	Rise	
F31	Fall transition from 3 to 1	23333 112	7905	7909	7910	7912	$(V_1+V_3)/2$	Fall	

- $V_0, V_1, V_2, V_3$  are mean signal levels defined in 120D.3.1.2.1.

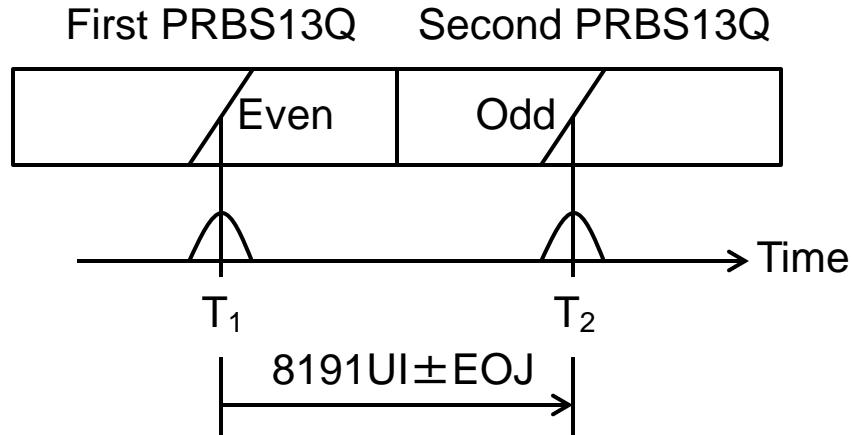
- When Tx circuit is binary (i.e. MSB+LSB)
  - MSB and LSB may be driven by different clock buffers
  - If jitter on MSB and jitter on LSB are
    - Positively correlated, then
      - R03 and F30 (same transition on MSB and LB) will be the worst
    - Negative correlated, then
      - R12 and F21 (opposite transition on MSB and LSB) will be the worst
    - Not correlated, then
      - R03, F30, R12, and F21 will be the worst
- When Tx circuit is not binary (e.g. using thermometer code)
  - Any of 12 types of transition could be the worst
- Since Tx circuit is not necessarily binary,
  - All 12 types of transitions should be mandatory



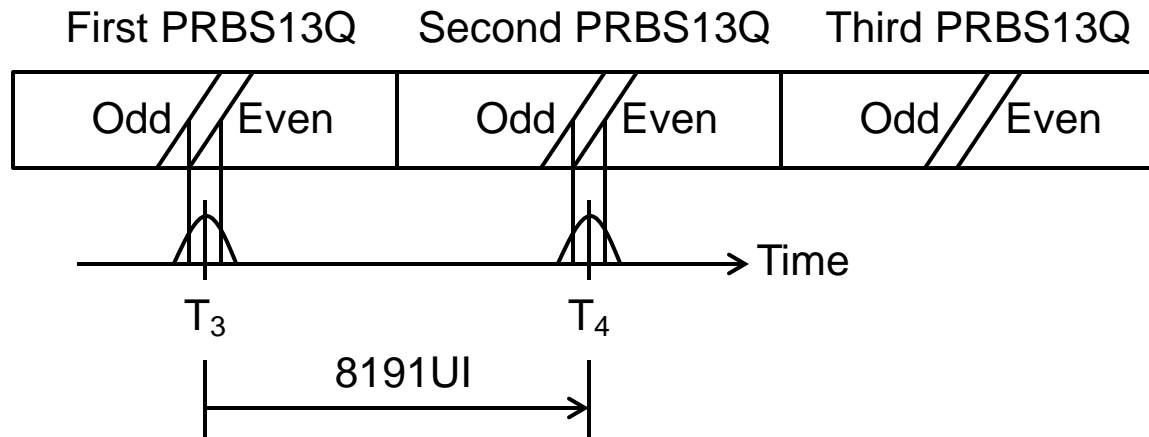
- For each of **12 specific transitions** in PRBS13Q
  - Measure 2 cycles of PRBS13Q test pattern
    - Get a first histogram for the transition in the first PRBS13Q
      - Let  $T_1$  be the mean time of the first histogram
    - Get a second histogram for the transition in the second PRBS13Q
      - Let  $T_2$  be the mean time of the second histogram
  - Measure 3 cycles of PRBS13Q test pattern
    - Get a third histogram for the transition in the first PRBS13Q
      - Let  $T_3$  be the mean time of the third histogram
    - Get a fourth histogram for the transition in the second PRBS13Q
      - Let  $T_4$  be the mean time of the fourth histogram
  - Calculate EOJ as  $\text{abs}((T_2 - T_1) - (T_4 - T_3))$ 
    - Note:  $T_4 - T_3$  is measured value of 8191 UI
  - Each histogram should include at least  $10^3$  hits
  - EOJ should meet the specification at each of 12 specific transitions
  - Each specific transition may be replaced with a similar specific transition as long as the same transition is measured for each histogram

# EOJ Measurement using PRBS13Q (2/2)

## ■ 2 cycles of PRBS13Q



## ■ 3 cycles of PRBS13Q



- If we do not allow flexibility of choosing a similar transition
  - Jitter is measured on each of 12 specific transitions in a PRBS13Q pattern (see 120.5.11.2.3). The transitions occur in the sequence of all possible combinations of four identical levels followed by two different identical levels as shown in Table xxxx (Table in slide 6). The sequences are located by the symbol indices given in the table where symbol 1 to 7 are the run of seven 3s.
  
- If we allow flexibility of choosing a similar transition
  - Jitter is measured on each of 12 transitions in a PRBS13Q pattern (see 120.5.11.2.3). The transitions occur in the sequence of all possible combinations of at least three identical levels followed by at least two different identical levels as shown in Table xxxx (Table in slide 6 with the title of the column changed to Example Gray coded PAM4 symbols). Example locations of the transitions are given in the table by the symbol indices where symbol 1 to 7 are the run of seven 3s.

# Comparison of options

Option	A (dawe_3bs_0916.pdf)	B (This presentation)
DDJ removed by	Align average edge location	Focus particular edge location
Measured edges	All transitions	12 specific transitions
Merge histogram	Yes	No (also possible)
Discussion	<ul style="list-style-type: none"> <li>• How many samples per edge is enough? A: 20 may be enough</li> <li>• Must be careful for degree of freedom (# of samples) that is reduced by each averaging before merge, but not reduced after merge when the final RMS value is calculated</li> <li>• Choice of averaging method                             <ul style="list-style-type: none"> <li>○ Mean: minimize <math>E[e^2]</math>, best for RJ</li> <li>○ Median: minimize <math>E[ e ]</math>, best for BUJ</li> </ul> </li> <li>• Choice of threshold levels for multi-level transitions</li> </ul>	<ul style="list-style-type: none"> <li>• Why not merging the histogram? A: To check the worst case</li> <li>• Why the worst case? Why not the average? A: Because not all transitions are measured.</li> <li>• Choice of transitions                             <ul style="list-style-type: none"> <li>○ All 12 mandatory (this proposal)</li> <li>○ 4 mandatory + 8 optional</li> </ul> </li> </ul>
Pros	<ul style="list-style-type: none"> <li>• All transitions are measured</li> </ul>	<ul style="list-style-type: none"> <li>• Manual measurement is possible with currently available equipments</li> <li>• No need to exclude non-permanent edges for strong pre-emphasis setting</li> </ul>
Cons	<ul style="list-style-type: none"> <li>• Need a special software</li> <li>• Must exclude non-permanent edges</li> <li>• The other lanes must send asynchronous test pattern such as PRBS31Q</li> <li>• Unable to measure DDJ induced by Tx circuit (e.g. pre-cursor DDJ)</li> </ul>	<ul style="list-style-type: none"> <li>• Not all transitions are measured</li> <li>• The other lanes must send asynchronous test pattern such as PRBS31Q</li> <li>• Unable to measure DDJ induced by Tx circuit (e.g. pre-cursor DDJ)</li> </ul>

- Pavel Zivny, Charles Moore: 802.3bj D2.1 Transmitter output jitter specification for NRZ PMDs  
[http://www.ieee802.org/3/bj/public/jul13/zivny\\_3bj\\_01a\\_0713.pdf](http://www.ieee802.org/3/bj/public/jul13/zivny_3bj_01a_0713.pdf)
- Charles Moore: Experiments with simulated jitter  
[http://www.ieee802.org/3/bj/public/jan14/moore\\_3bj\\_01\\_0114.pdf](http://www.ieee802.org/3/bj/public/jan14/moore_3bj_01_0114.pdf)
- Adam Healey: CDAUI-8 chip-to-chip transmitter output jitter requirements  
[http://www.ieee802.org/3/bs/public/15\\_09/healey\\_3bs\\_01\\_0915.pdf](http://www.ieee802.org/3/bs/public/15_09/healey_3bs_01_0915.pdf)
- Raj Hegde, Magesh Valliappan, Adam Healey: CDAUI-8 Chip-to-chip Jitter Budget Proposal  
[http://www.ieee802.org/3/bs/public/16\\_03/hegde\\_3bs\\_03\\_0316.pdf](http://www.ieee802.org/3/bs/public/16_03/hegde_3bs_03_0316.pdf)  
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- Adam Healey: CDAUI-8 chip-to-chip even-odd jitter measurements  
[http://www.ieee802.org/3/bs/public/16\\_05/healey\\_3bs\\_02\\_0516.pdf](http://www.ieee802.org/3/bs/public/16_05/healey_3bs_02_0516.pdf)
- Piers Dawe: Jitter measurement and patterns for chip-to-chip 200GAUI-4 and 400GAUI-8  
[http://www.ieee802.org/3/bs/public/16\\_09/dawe\\_3bs\\_01\\_0916.pdf](http://www.ieee802.org/3/bs/public/16_09/dawe_3bs_01_0916.pdf)

# Thank you