Jitter Test Methods for 200GAUI-4 and 400GAUI-8

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Background

- 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

healey_3bs_01_0915.pdf, slide 3

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Comparison of methods

	100GBASE-CR4/KR4	100GBASE-KP4
Reference	92.8.3.8.2	94.3.12.6
Test pattern	PRBS9	JP03A (clock pattern with 2 UI period)
Data acquisition	Histogram of zero crossing times for isolated rising and falling transitions	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

Recap Jitter Test Method in Clause 92

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- 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.

a) 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.

b) 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

A New Jitter Test Method for PRBS13Q

- 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 specific transition may be replaced with a similar specific transition
    - Each histogram should include at least 10^5 hits

  - 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)

  - JRMS and J4 should meet the specification at each specific transition

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 After seed value (S0 thru S12) of 0000010101011 (This is same as example sequence in 120.5.11.2.3)	1031320220 1111301031 2123121001 2102121023 131112	1			46			
R03	Rise transition from 0 to 3	10000 330	555	559	560	562	$(V_0+V_3)/2$	Rise	Rise
F30	Fall transition from 3 to 0	23333 001	8185	8189	8190	1 (8192)	$(V_0+V_3)/2$	Fall	Fall
R12	Rise transition from 1 to 2	0111111 2222221	2363	2369	2370	2376	$(V_1+V_2)/2$	Rise	Fall
F21	Fall transition from 2 to 1	022222 113	8114	8119	8120	8122	$(V_1+V_2)/2$	Fall	Rise
R01	Rise transition from 0 to 1	100000 113	5560	5565	5566	5568	$(V_0+V_1)/2$		Rise
F10	Fall transition from 1 to 0	21111 003	1717	1721	1722	1724	$(V_0+V_1)/2$		Fall
R23	Rise transition from 2 to 3	32222 330	5549	5553	5554	5556	$(V_2+V_3)/2$		Rise
F32	Fall transition from 3 to 2	033333 2222223	6459	6464	6465	6471	$(V_2+V_3)/2$		Fall
R02	Rise transition from 0 to 2	10000 223	1991	1995	1996	1998	$(V_0+V_2)/2$	Rise	
F20	Fall transition from 2 to 0	122222 0000002	6007	6012	6013	6019	$(V_0+V_2)/2$	Fall	
R13	Rise transition from 1 to 3	011111 331	7049	7054	7055	7057	$(V_1+V_3)/2$	Rise	
F31	Fall transition from 3 to 1	23333 112	6630	6634	6635	6637	$(V_1+V_3)/2$	Fall	

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

Discussion: Which Transitions?

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- 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
- Hence,
  - R03, F30, R12, and F21 should be mandatory
  - The other 8 types of transitions may be optional (or mandatory as well)

EOJ Measurement using PRBS13Q

- 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 $\mathrm{abs}((T_2 - T_1) - (T_4 - T_3))$
    - Note: $T_4 - T_3$ is measured value of 8191 UI
  - Each histogram should include at least 10^5 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

Comparison of options

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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	• How many samples per edge is enough? A: 20 may be enough • Must be careful for degree of feedom (# of samples) that is reduced by each averaging before merge, but not reduced after merge when the final RMS value is calculated • Choice of averaging method ○ Mean: minimize $E[e^2]$, best for RJ ○ Median: minimize $E[\|e\|]$, best for BUJ • Choice of threshold levels for multi-level transitions	• Why not merging the histogram? A: To check the worst case • Why the worst case? Why not the average? A: Because not all transitions are measured. • Choice of transitions ○ All 12 mandatory (recommended) ○ 4 mandatory + 8 optional
Pros	• All transitions are measured	• Manual measurement is possible with currently available equipments • No need to exclude non-permenet edges for strong pre-emphasis setting
Cons	• Need a special software • Must exclude non-permanent edges • Unable to measure DDJ induced by Tx circuit (e.g. pre-cursor DDJ)	• Not all transitions are measure • Unable to measure DDJ induced by Tx circuit (e.g. pre-cursor DDJ)

References

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Thank you