Addressing Delay, Skew, and Skew Variation
Comments: 77-96, 121

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P802.3cd Task Force
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Supporters

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Introduction

• In P802.3cd Draft 1.0 the delay, skew, and skew variations for the various sublayers have been left as TBD.

• This presentation proposes values to use for these TBD values.

• Generally, values from the corresponding sublayers in related Clauses are suggested.

• For the single-lane PMDs, it is proposed that the skew values in corresponding Clauses be adjusted to account for no skew being added by single-lane PMD and medium.

• For backplane, it is proposed to separate delay target for medium from that for PMD and AN.
Delay Constraints

Adee
Delay Constraints Introduction

• The general proposal is to use the delays for corresponding sublayers for 40GBASE-R, 100GBASE-R, and 200GBASE-R.

• For the PCS and FEC, the delay values need to be scaled due to the dependence on bit rate.

• For the backplane PMDs, it is proposed that the medium delay be specified separately from the PMD.
PCS delay

• 50GBASE-R PCS is based on 40GBASE-R scale-up (12.890625 GB/s per lane instead of 10.3125 Gb/s)

• The delay constraint for the 40GBASE-R PCS is 281.6 ns = 11264 BT
  – This is equal to 44 times the 4x64 bit “unit delay” of the PCS

• Scaling up the bit rate would result in:
  – The same digital delay (11264 BT, 22 pause_quanta)
  – The absolute time constraint is 225.28 ns
RS-FEC delay

Clause 134 RS-FEC is based on Clause 91 with...

- The same codeword size
- Half the data rate

Allocated delay in clause 91 is 409.6 ns or 40960 bit times - about 7.5 codewords’ worth in RS(514, 544) mode

- Encoding delay is negligible
- The minimum decoding delay is ~55 ns for storing a codeword; another ~55 for error marking; this leaves ~5.5 codewords’ worth (~300 ns) for processing

For Clause 134, codeword delay is twice that of Clause 91, but the processing time can be similar to clause 91 (decoding is the same)

Proposed value for clause 134 is based on same processing time and twice the codeword time, so 300 + 220 = 520 ns; rounded to an integer (50) pause_quanta yields 512 ns
Backplane Delay

Currently PMD/AN and medium delay combined in one number.
• Unlike optical or copper cable in which medium is separate
• Current value is same as the copper cable (PMD+AN only), 81.92 ns (based on clause 94)
• Backplane PMDs and copper cable PMDs likely to use the same components, so same delay is expected

Proposal (in response to comment #137) is to align delays and skews of backplane and copper cable PMDs, by specifying only PMD/AN delay constraints on both cases
• “The sum of the transmit and receive delays at one end of the link contributed by the PMD, and the AN, and the medium in one direction shall be…”
• “It is assumed that the one-way delay through the medium is no more than 820 ns.”
Proposed delay constraints per clause (excluding medium)

<table>
<thead>
<tr>
<th>Sublayer</th>
<th>P802.3cd location</th>
<th>Current Delay</th>
<th>Proposal</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>ns</td>
<td>ns</td>
<td></td>
</tr>
<tr>
<td>132 MAC, +RS</td>
<td>132.1.4</td>
<td>327.68[2]</td>
<td>no change</td>
<td></td>
</tr>
<tr>
<td>133 PCS</td>
<td>133.3</td>
<td>TBD</td>
<td>225.28</td>
<td></td>
</tr>
<tr>
<td>134 FEC</td>
<td>134.4</td>
<td>TBD</td>
<td>512</td>
<td></td>
</tr>
<tr>
<td>135 PMA</td>
<td>135.5.4</td>
<td>TBD</td>
<td>92.16</td>
<td>120.5.4</td>
</tr>
<tr>
<td>136 CR</td>
<td>136.5</td>
<td>81.92</td>
<td>8</td>
<td>94.3.3</td>
</tr>
<tr>
<td>137 KR</td>
<td>137.5</td>
<td>81.92</td>
<td>8</td>
<td>94.3.3</td>
</tr>
<tr>
<td>138 SR</td>
<td>138.3.1</td>
<td>81.92</td>
<td>20.48</td>
<td>124.3.1</td>
</tr>
<tr>
<td>139 LR/FR</td>
<td>139.3.1</td>
<td>20.48</td>
<td>20.48</td>
<td>122.3.1</td>
</tr>
<tr>
<td>140 DR</td>
<td>140.3.1</td>
<td>20.48</td>
<td>20.48</td>
<td>121.3.1</td>
</tr>
</tbody>
</table>

1. Proposed delay constraint in bit times is 512 times the value in PQ.
2. Not TBD. Here for information only.
Delay Constraints Conclusions

• For backplane PMDs
  – separate the PMD/AN delay from the medium delay.
  – For the medium use 20 ns per slide 6.

• For the PHY sublayers being defined in this project use the delay constraints provided in the table in slide 9.
Skew and Skew Variation

Matt
Skew and Skew Variation Constraints Introduction

• It is proposed that we use values of Skew and Skew Variation already established for 40GBASE-R, 100GBASE-R, and 200GBASE-R with the following exception.

• For 50GBASE-R and 100GBASE-DR PMD the numbers are adjusted with the following considerations:
  – skew variation is zero at the PMD transmit input, transmit output, receive input, and receive output
  – there is no skew addition due to the PMD and the medium
### 40G/100GBASE-R Skew constraints per Clause 80

**Table 80–6—Summary of Skew constraints**

<table>
<thead>
<tr>
<th>Skew points</th>
<th>Maximum Skew (ns)&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Maximum Skew for 40GBASE-R PCS lane (UI)&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Maximum Skew for 100GBASE-R PCS lane (UI)&lt;sup&gt;c&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>SP0</td>
<td>29</td>
<td>N/A</td>
<td>≈ 150</td>
</tr>
<tr>
<td>SP1</td>
<td>29</td>
<td>≈ 299</td>
<td>≈ 150</td>
</tr>
<tr>
<td>SP2</td>
<td>43</td>
<td>≈ 443</td>
<td>≈ 222</td>
</tr>
<tr>
<td>SP3</td>
<td>54</td>
<td>≈ 557</td>
<td>≈ 278</td>
</tr>
<tr>
<td>SP4</td>
<td>134</td>
<td>≈ 1382</td>
<td>≈ 691</td>
</tr>
<tr>
<td>SP5</td>
<td>145</td>
<td>≈ 1495</td>
<td>≈ 748</td>
</tr>
<tr>
<td>SP6</td>
<td>160</td>
<td>≈ 1649</td>
<td>≈ 824</td>
</tr>
<tr>
<td>SP7</td>
<td>29</td>
<td>N/A</td>
<td>≈ 150</td>
</tr>
<tr>
<td>At PCS receive</td>
<td>180</td>
<td>≈ 1856</td>
<td>≈ 928</td>
</tr>
<tr>
<td>At RS-FEC transmit</td>
<td>49</td>
<td>N/A</td>
<td>≈ 253</td>
</tr>
<tr>
<td>At RS-FEC receive&lt;sup&gt;e&lt;/sup&gt;</td>
<td>180</td>
<td>N/A</td>
<td>≈ 4641</td>
</tr>
<tr>
<td>At PCS receive (with RS-FEC)</td>
<td>49</td>
<td>N/A</td>
<td>≈ 253</td>
</tr>
</tbody>
</table>

**MAC AND HIGHER LAYERS**

- CGMII
- CAUI-10 or CAUI-4

**MAC Layer**

- 100GBASE-R PCS
- PMA (20:n)
- SP0
- SP7

**Reconciliation**

- RS-FEC
- PMA (n:20)
- SP1
- SP6
- SP2
- SP5

**Physical Medium Dependent Interface (MDI)**

- PMD
- SP3
- SP4

**Other Skew Constraints**

- Skew = 180 ns
- ΔSkew = 20 ns
- Skew = 160 ns
- ΔSkew = 15 ns
- Skew = 145 ns
- Skew < 43 ns
40G/100GBASE-R Skew Variation (SV) constraints per Clause 80

Table 80-7—Summary of Skew Variation cc

<table>
<thead>
<tr>
<th>Skew points</th>
<th>Maximum Skew Variation (ns)</th>
<th>Maximum Skew Variation for 10.3125 GbD PMD lane (UI)</th>
<th>Maximum Skew Variation for 25.78125 GbD PMD lane (UI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SP0</td>
<td>0.2</td>
<td>≈ 2</td>
<td>N/A</td>
</tr>
<tr>
<td>SP1</td>
<td>0.2</td>
<td>≈ 2</td>
<td>N/A</td>
</tr>
<tr>
<td>SP2</td>
<td>0.4</td>
<td>≈ 4</td>
<td>≈ 10</td>
</tr>
<tr>
<td>SP3</td>
<td>0.6</td>
<td>≈ 6</td>
<td>≈ 15</td>
</tr>
<tr>
<td>SP4</td>
<td>3.4</td>
<td>≈ 35</td>
<td>≈ 88</td>
</tr>
<tr>
<td>SP5</td>
<td>3.6</td>
<td>≈ 37</td>
<td>≈ 93</td>
</tr>
<tr>
<td>SP6</td>
<td>3.8</td>
<td>≈ 39</td>
<td>≈ 98</td>
</tr>
<tr>
<td>SP7</td>
<td>0.2</td>
<td>≈ 2</td>
<td>N/A</td>
</tr>
<tr>
<td>At PCS receive</td>
<td>4</td>
<td>≈ 41</td>
<td>N/A</td>
</tr>
<tr>
<td>At RS-FEC transmit</td>
<td>0.4</td>
<td>N/A</td>
<td>≈ 10</td>
</tr>
<tr>
<td>At RS-FEC receive</td>
<td>4</td>
<td>N/A</td>
<td>≈ 103</td>
</tr>
<tr>
<td>At PCS receive (with RS-FEC)</td>
<td>0.4</td>
<td>N/A</td>
<td>≈ 10</td>
</tr>
</tbody>
</table>

MAC AND HIGHER LAYERS

- CGMII
- 100GBASE-R PCS
- PMA (20:n)
- CAUI-10 or CAUI-4
- SP0
- SP7
- PMA (n:20)
- RS-FEC
- PMA (4:4)
- SP1
- SP6
- PMA (4:4)
- SP2
- SP5
- PMD
- SP3
- SP4
- MDI
- 100GBASE-R

ΔSV = 0.2 ns
SV < 4 ns
SV < 3.5 ns
SV < 3.8 ns
SV < 0.4 ns
50GBASE-CR/KR/SR/FR/LR PMD skew and skew variation

MAC AND HIGHER LAYERS

RECONCILIATION

50GMII

50/base-R PCS
RS-FEC
PMA (2:n)

50GAUI-n

PMD SERVICE INTERFACE

MDI

50/base-R

50GMII

50/base-R PCS
PMA (4:2)

LAUI-2

SP0

SP7

PMA (2:4)

RS-FEC

PMA (2:n)

50GAUI-n

SP1

SP6

PMA (n:1)

SP2

SP5

50/base-R

PMD SERVICE INTERFACE

MDI

SP3

SP4

SP2

SP5

PMD

SP3

SP4

PMD

no SV skew < 43 ns

Skew = 15 ns

ΔSkew = 20 ns

Skew = 15 ns

SV < 0.2

skew < 68 ns

ΔSkew = 15 ns

no SV

skew < 43 ns

no SV

skew < 43 ns

no SV skew < 43 ns

no SV skew < 43 ns

no SV skew < 43 ns
100GBASE-DR Skew and Skew Variation (SV)

MAC AND HIGHER LAYERS

RECONCILIATION

CGMII

CAUI-10 or CAUI-4

CAUI-4

PMD SERVICE INTERFACE

MDI

100GBASE-R4

100GBASE-R PCS

PMA (20:n)

SP0 down, SP7 up

PMA (n:20)

RS-FEC

PMA (4:4)

SP1 down, SP6 up

PMA (4:4)

SP2

100GBASE-R PCS

PMA (20:n)

SP0 down, SP7 up

PMA (n:20)

RS-FEC

PMA (4:4)

SP1 down, SP6 up

PMA (4:4)

SP2

100GBASE-P

PMD

SP3 down, SP4 up

MEDIUM

no SV

skew < 43 ns

no SV

skew < 43 ns

ICT

Skew = 15 ns

Skew = 20 ns

CAUI-10 or CAUI-4

skew < 88 ns

ΔSkew = 20 ns

SV < 0.2 ns

skew < 68 ns

ΔSkew = 15 ns

no SV

skew < 43 ns

no SV

skew < 43 ns

no SV

skew < 43 ns

100GBASE-DR Skew and Skew Variation (SV)
Skew Budget for 50GBASE-*R and 100GBASE-DR

<table>
<thead>
<tr>
<th>Skew Points</th>
<th>40GBASE-R 100GBASE-R (ns)</th>
<th>50GBASE-*R 100GBASE-DR (ns)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SP0</td>
<td>29</td>
<td>29</td>
</tr>
<tr>
<td>SP1</td>
<td>29</td>
<td>29</td>
</tr>
<tr>
<td>SP2</td>
<td>43</td>
<td>43</td>
</tr>
<tr>
<td>SP3</td>
<td>54</td>
<td>43</td>
</tr>
<tr>
<td>SP4</td>
<td>134</td>
<td>43</td>
</tr>
<tr>
<td>SP5</td>
<td>145</td>
<td>43</td>
</tr>
<tr>
<td>SP6</td>
<td>160 (145+15)</td>
<td>68 (43+15)</td>
</tr>
<tr>
<td>SP7</td>
<td>29</td>
<td>29</td>
</tr>
<tr>
<td>at PCS Rx w/o RS-FEC</td>
<td>180</td>
<td>N/A</td>
</tr>
<tr>
<td>at RS-FEC Tx</td>
<td>49</td>
<td>49</td>
</tr>
<tr>
<td>at RS-FEC Rx</td>
<td>180 (160+20)</td>
<td>88 (68+20)</td>
</tr>
<tr>
<td>at PCS Rx with RS-FEC</td>
<td>49</td>
<td>49</td>
</tr>
</tbody>
</table>
### Skew Variation Budget for 50GBASE-*R and 100GBASE-DR

<table>
<thead>
<tr>
<th>Skew Points</th>
<th>40GBASE-R</th>
<th>50GBASE-*R</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>100GBASE-R</td>
<td>100GBASE-DR</td>
</tr>
<tr>
<td>SP0</td>
<td>0.2</td>
<td>0.2</td>
</tr>
<tr>
<td>SP1</td>
<td>0.2</td>
<td>0.2</td>
</tr>
<tr>
<td>SP2</td>
<td>0.4</td>
<td>0</td>
</tr>
<tr>
<td>SP3</td>
<td>0.6</td>
<td>0</td>
</tr>
<tr>
<td>SP4</td>
<td>3.4</td>
<td>0</td>
</tr>
<tr>
<td>SP5</td>
<td>3.6 (3.4+0.2)</td>
<td>0</td>
</tr>
<tr>
<td>SP6</td>
<td>3.8 (3.6+0.2)</td>
<td>0.2</td>
</tr>
<tr>
<td>SP7</td>
<td>0.2</td>
<td>0.2</td>
</tr>
<tr>
<td>at PCS Rx w/o RS-FEC</td>
<td>4</td>
<td>N/A</td>
</tr>
<tr>
<td>at RS-FEC Tx</td>
<td>0.4</td>
<td>0.4</td>
</tr>
<tr>
<td>at RS-FEC Rx</td>
<td>4</td>
<td>0.4 (0.2+0.2)</td>
</tr>
<tr>
<td>at PCS Rx with RS-FEC</td>
<td>0.4</td>
<td>0.4</td>
</tr>
</tbody>
</table>
Skew and Skew Variation Constraints

Conclusions

• For 50GBASE-R, update the skew budget and skew variation budget in Clause 131 and the constraints in each of the relevant sublayer clauses according to the proposed values in Slide 17 and Slide 18, respectively.

• For 100GBASE-DR PMD update the skew to be 43 ns at SP2, SP3, SP4, and SP5

• For 200GBASE-*R, PMDs and all other 100GBASE-*R PMDs update the skew and skew variation constraints consistent with budgets in Clause 116 and Clause 80, respectively.
Thanks!