Single Mode Fibre Skew Variation

Pete Anslow, Nortel Networks

IEEE 802.3 HSSG, Seoul, September 2007
The architecture proposed for 100 Gbit/s Ethernet in \texttt{gustlin 01 0107} includes the use of a gearbox function where the number of lanes in the optical link is not equal to the number of lanes in the electrical interconnect.

In order to aid the scoping of this function, it is useful to understand the maximum amount by which the lane to lane skew of the optical link can change during the life of any one link.

This contribution calculates this skew variation for several possible implementations of the optical link.
Delay equations

Equations for the minimum and maximum relative delay coefficients were given in anslow_01_0107

\[
\text{Delay}_{\text{max}} = A + \frac{0.093\lambda^2}{8} \left[ 1 + \left( \frac{1300}{\lambda} \right)^4 \right]
\]

\[
\text{Delay}_{\text{min}} = A + \frac{0.093\lambda^2}{8} \left[ 1 + \left( \frac{1324}{\lambda} \right)^4 \right]
\]
A 4 lane solution has been proposed using 10GBASE-LX4 λs. Largest skew change is for λ₀ 1324 nm.

Chan 1 1269.0 to 1282.4 nm
Chan 2 1293.5 to 1306.9 nm
Chan 3 1318.0 to 1331.4 nm
Chan 4 1342.5 to 1355.9 nm

Max skew = 147 ps / km
Min skew = 80 ps / km
Max skew change = 66 ps / km

For lane rate = 25.78125 Gbit/s
Max skew change 10 km = 17.1 bits
Max skew change 40 km = 68.3 bits
4 lane CWDM solution using ITU CWDM

A 4 lane solution has been proposed using ITU CWDM. Largest skew change is for $\lambda_0$ 1300 nm.

Chan 1 1284.5 to 1297.5 nm
Chan 2 1304.5 to 1317.5 nm
Chan 3 1324.5 to 1337.5 nm
Chan 4 1344.5 to 1357.5 nm

Max skew = 147 ps / km
Min skew = 78 ps / km
Max skew change = 69 ps / km

For lane rate = 25.78125 Gbit/s
Max skew change 10 km = 17.9 bits
Max skew change 40 km = 71.4 bits
4 lane DWDM solution using ITU 800GHz grid

A 4 lane solution has been proposed using DWDM grid [cole_01_0507]
For a 800 GHz channel spacing, largest skew change is for $\lambda_0$ 1324 nm

Assuming tolerance ±20% spacing
Chan 1 1304.24 to 1306.06 nm
Chan 2 1308.79 to 1310.63 nm
Chan 3 1313.38 to 1315.23 nm
Chan 4 1318.00 to 1319.86 nm

Max skew = 17.6 ps / km
Min skew = 13.5 ps / km
Max skew change = 4.1 ps / km

For lane rate = 25.78125 Gbit/s
Max skew change 10 km = 1.1 bits
Max skew change 40 km = 4.3 bits
4 lane DWDM solution using ITU 400GHz grid

A 4 lane solution has been proposed using DWDM grid traverso_01_0407. For a 400 GHz channel spacing, largest skew change is for $\lambda_0$ 1324 nm.

Assuming tolerance ±20% spacing:
- Chan 1: 1308.11 to 1309.02 nm
- Chan 2: 1310.40 to 1311.31 nm
- Chan 3: 1312.69 to 1313.61 nm
- Chan 4: 1314.99 to 1315.92 nm

Max skew = 8.8 ps / km  
Min skew = 6.7 ps / km  
Max skew change = 2.1 ps / km

For lane rate = 25.78125 Gbit/s:
- Max skew change 10 km = 0.5 bits  
- Max skew change 40 km = 2.1 bits
Summary

<table>
<thead>
<tr>
<th>Spacing</th>
<th>25 nm</th>
<th>20 nm</th>
<th>800 GHz</th>
<th>400 GHz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max skew ps/km</td>
<td>147</td>
<td>147</td>
<td>17.6</td>
<td>8.8</td>
</tr>
<tr>
<td>Skew change ps/km</td>
<td>66</td>
<td>69</td>
<td>4.1</td>
<td>2.1</td>
</tr>
<tr>
<td>10 km Max skew bits</td>
<td>37.9</td>
<td>37.9</td>
<td>4.5</td>
<td>2.3</td>
</tr>
<tr>
<td>10 km Skew change bits</td>
<td>17.1</td>
<td>17.9</td>
<td>1.1</td>
<td>0.5</td>
</tr>
<tr>
<td>40 km Max skew bits</td>
<td>151.4</td>
<td>151.6</td>
<td>18.2</td>
<td>9.1</td>
</tr>
<tr>
<td>40 km Skew change bits</td>
<td>68.3</td>
<td>71.4</td>
<td>4.3</td>
<td>2.1</td>
</tr>
</tbody>
</table>

Note – these are the wavelength induced skews only, tracking and electronics will add to these values.
Thanks!

Pete Anslow,
Nortel Networks