



Dispersion Limited Fiber Length Solution

Pre-lab Calculation:

First, determine the maximum allowable pulse spread from the transmission bit rate based on the engineering guideline:

$$\Delta t_{\max} = \frac{1}{4R} = \frac{1}{4 \cdot 2.5 \times 10^9} = 10^{-10} \text{ sec} = 100 \text{ ps}$$

Next, determine the chromatic dispersion factor $D(\lambda)$ at the operating wavelength. From the specification sheet for Corning SMF-28 optical fiber, the zero-dispersion wavelength $\lambda_0 = 1312 \text{ nm}$ and the zero-dispersion slope $S_0 = 0.09 \text{ ps/nm}^2\text{-km}$. The operating wavelength is given as 1550 nm and $D(\lambda)$ is given by

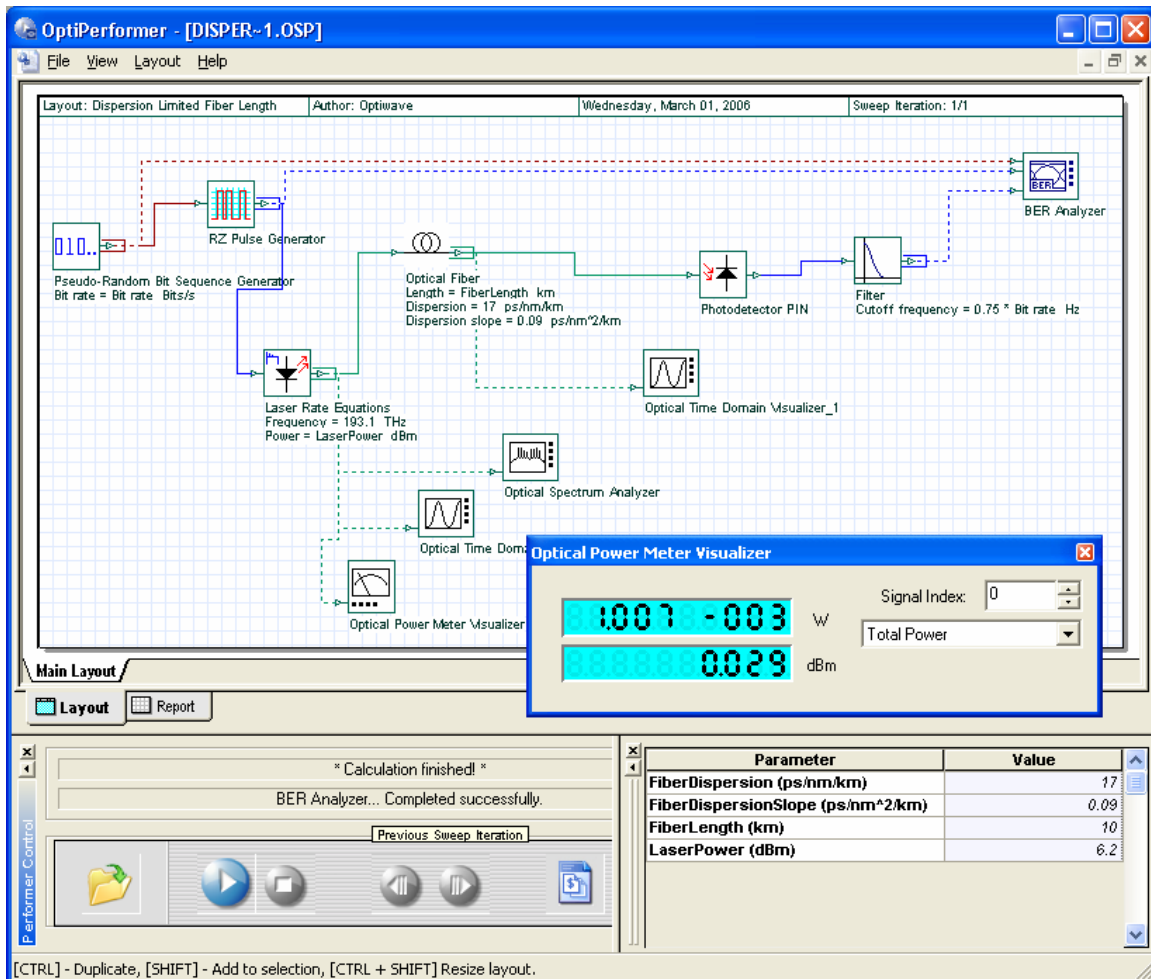
$$D(\lambda) = \frac{0.09}{4} \left(1550 - \frac{1312^4}{1550^3} \right) \approx 17 \text{ ps/nm - km}$$

The dispersion-limited fiber length can now be determined as follows:

$$L_{\max} = \frac{\Delta t_{\max}}{D(\lambda)\Delta\lambda} = \frac{100}{17 \cdot 0.6} = 9.82 \text{ km}$$

This rather short distance is a consequence of operating at a high bit rate and far from the zero-dispersion wavelength without dispersion compensation. The resulting eye diagrams suggest that the fiber could be much longer than this because of the conservative nature of the engineering guide line.

Layout:



Simulation:

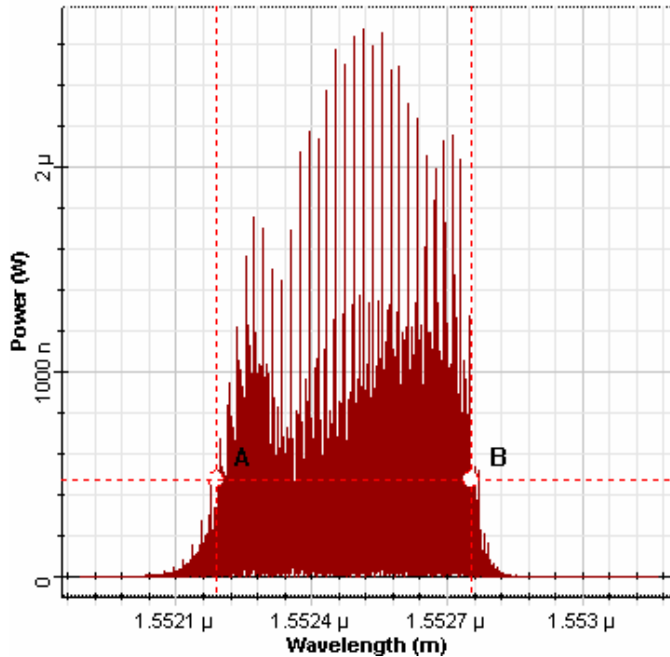
The optical spectrum analyzer is used to verify that the transmitter spectral width is close to the specified value of 0.6 nm. This value cannot be input directly – it is determined by the transient response of the laser diode model, which is based on the laser rate equations.

Using the Optical Spectrum Analyzer, one can place markers on the graph to measure distances



Optical Spectrum Analyzer

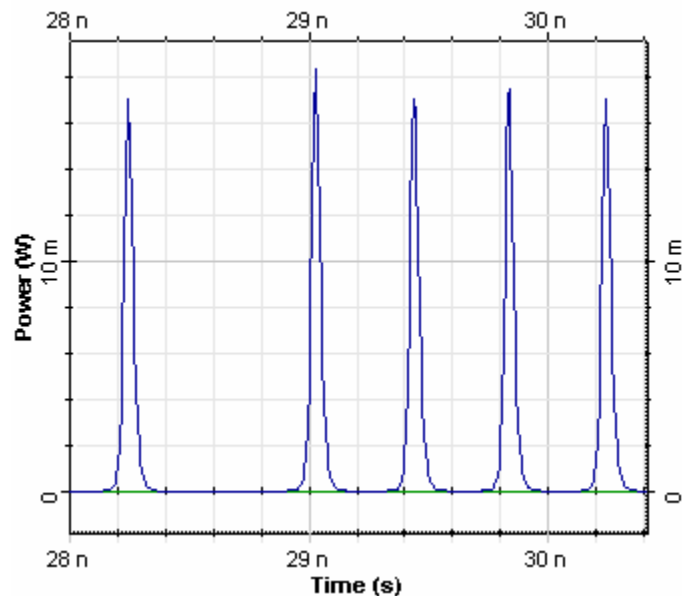
Db1 Click On Objects to open properties. Move Objects with Mouse Drag



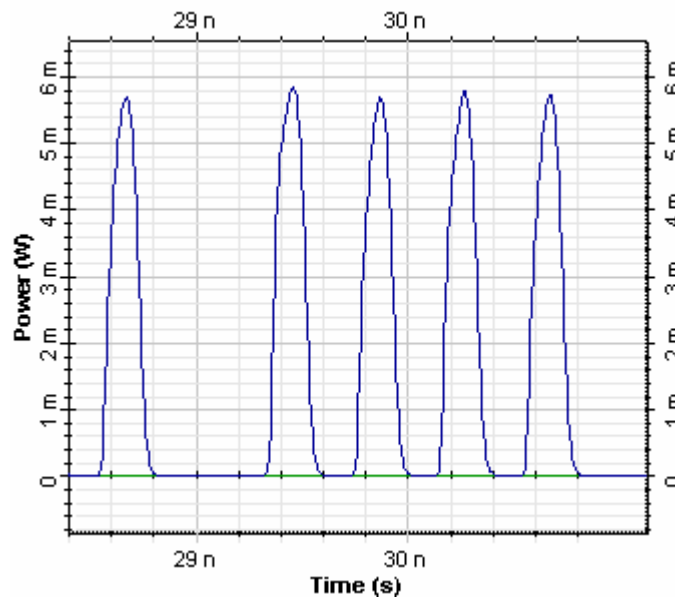
Info-Window	
Pos:	(x: 1.55403E-006 y: -2.67577E-007)
Markers:	
A:	(1.55219E-006, 4.71565E-007)
B:	(1.55275E-006, 4.75376E-007)
A-B:	(5.63908E-010, 3.81043E-009)

Transmitter output power spectrum

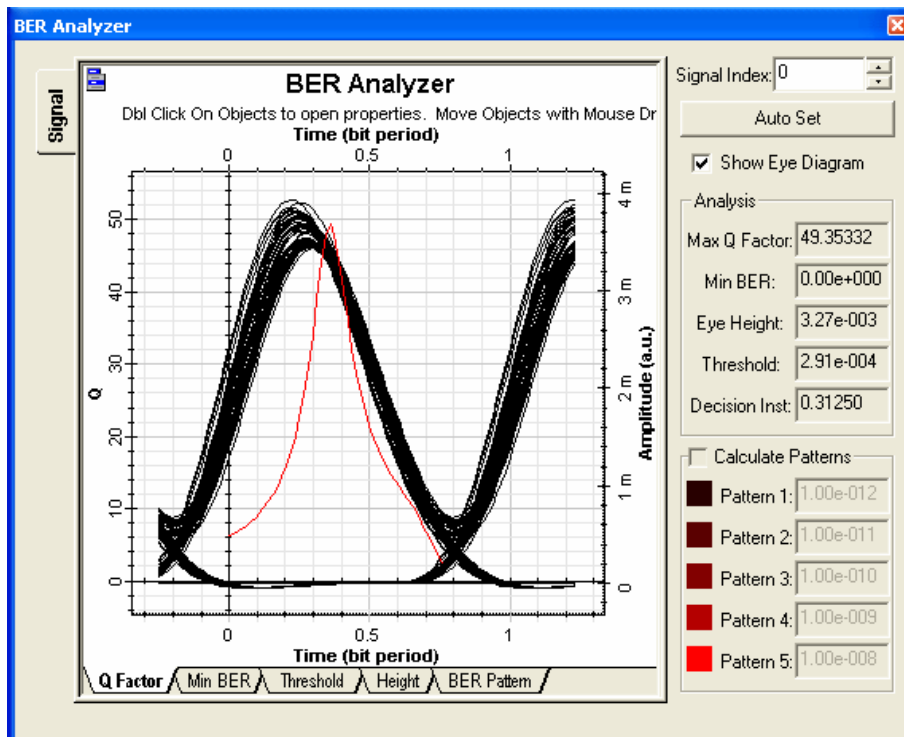
Iteration 1, for which the fiber length is just over the calculated dispersion-limited fiber length (10 km vs. 9.8 km), shows that there is little pulse spread and also shows a very open eye diagram.



Pulses at transmitter output



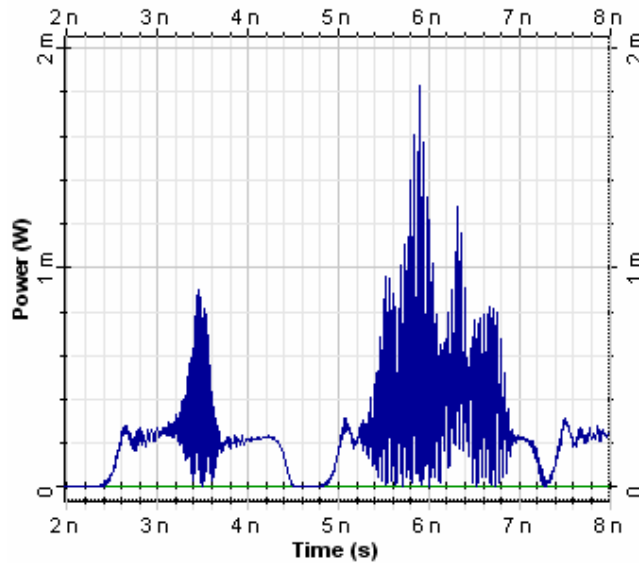
Pulses far end of 9.8 km fiber



Eye diagram with 9.8 km fiber

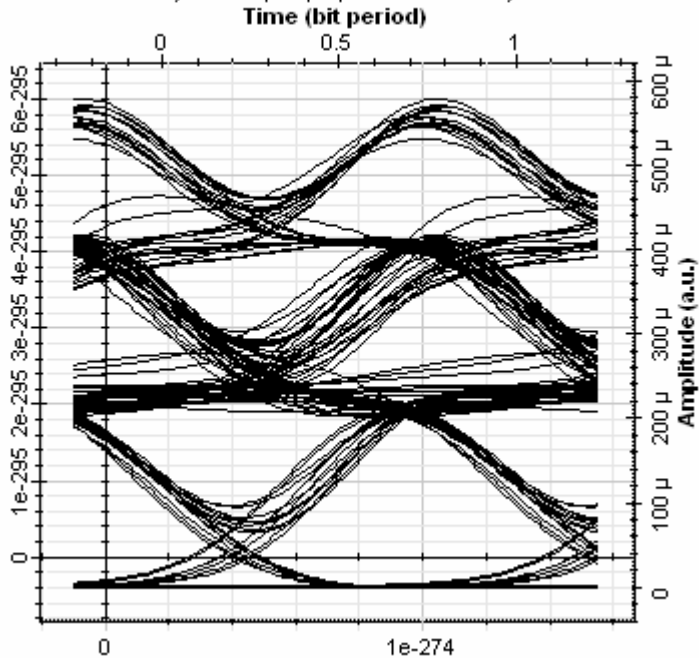
Sweep iteration 5 (below) clearly shows that the pulse spread results in inter-symbol interference and the corresponding eye diagram shows that even in the absence of noise the received signal is undetectable.

Optical Time Domain Visualizer_1
 Left Button and Drag to Select Zoom Region. Press Control Key and



Pulses at far end of 100 km fiber

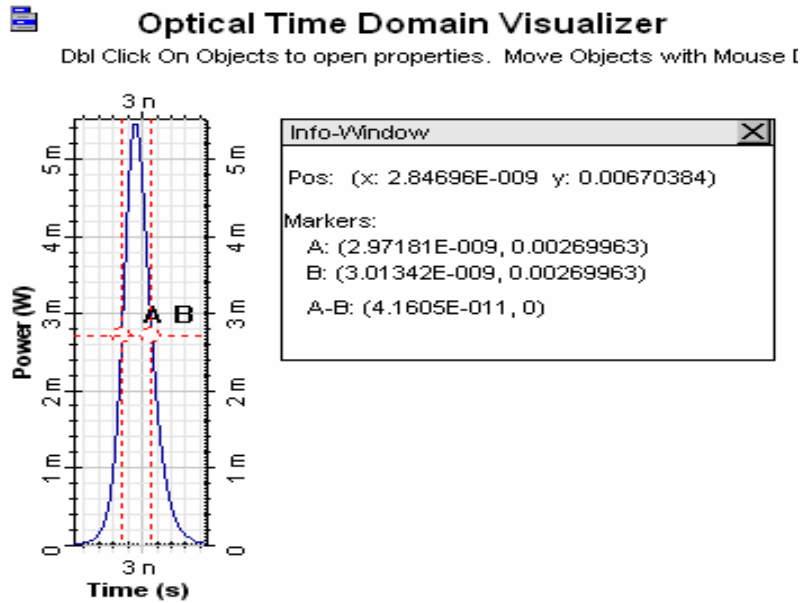
BER
 Dbl Click On Objects to open properties. Move Objects with Mouse Dr



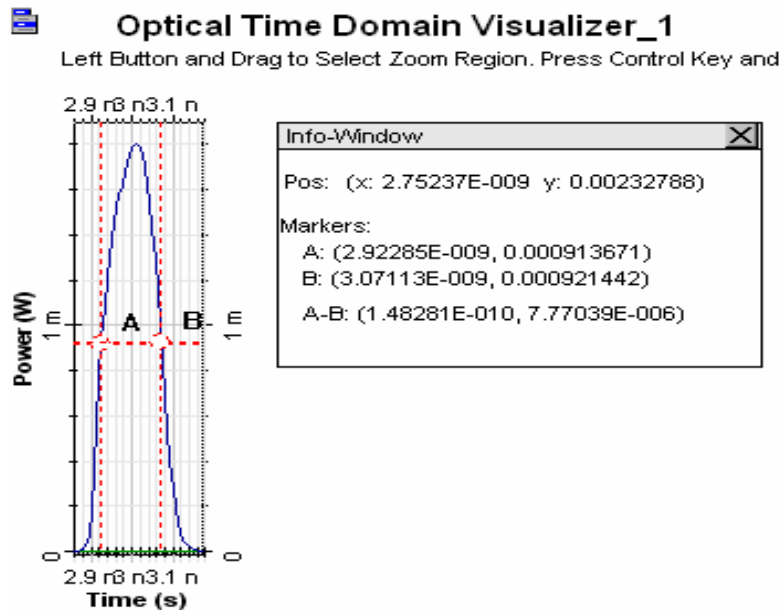
Eye diagram with 100 km fiber

Analysis:

The results of the simulation can be analyzed further to compare the calculated and measured pulse spread. The following two figures are obtained by using the zoom feature of the optical time domain visualizer to isolate a single pulse and the marker feature to measure the pulse width.



Single pulse at transmitter output



Single pulse at far end of 9.8 km fiber



From the above two displays, it appears that the pulse width (FWHM) increases from 42 ps to 148 ps, closely matching the calculated value of Δt (100 ps).