Broadening of Gaussian Pulses
Solution

Calculations:

Value	Symbol
RMS width of transmitted pulse	T_{in}
RMS spectral width of transmitted pulse	$\Delta\lambda$
RMS width of fiber impulse response	T_F
RMS width of pulse at fiber far end	T_{out}

The FWHM width of the transmitted pulse is 0.5 bit period which, for a bit rate of 2.5 Gb/s, is T_{FWHM} = 200 ps. The RMS width is therefore T_{in} = 200/1.665 ps or 120 ps.

The RMS spectral width of the transmitted pulse is given by the formula

$$\Delta\lambda = \frac{\lambda^2\sqrt{1+C^2}}{2\pi cT}$$

From the calculated value of T_{in} and the specified values of the other parameters, the calculated value of the RMS spectral width is 0.065 nm.

The RMS width of the fiber impulse response and is calculated from the formula

$$T_F = LD(\lambda)\Delta\lambda$$

where L is the fiber length, $D(\lambda)$ is the fiber dispersion coefficient and $\Delta\lambda$ is the RMS spectral width of the optical source. $D(\lambda)$ is calculated using the formula

$$D(\lambda) = \frac{S_0}{4}\left(\lambda - \frac{\lambda_0^4}{\lambda^3}\right)$$

where S_0 is the zero-dispersion slope (0.09 ps/nm²-km for SMF-28) and λ_0 is the zero-dispersion wavelength (1312 nm for SMF-28). At the operating wavelength of λ = 1550 nm, $D(\lambda)$ = 17 ps/nm-km. T_F is calculated using this value, the specified values for L and the calculated value for $\Delta\lambda$. The result is T_F = 55 ps.

The RMS width of the pulse at the far end of the fiber is given by

$$T_{out} = \sqrt{T_{in}^2 + T_F^2}$$

which results in an output RMS pulse width of 132 ps.

The chirp parameters include the chirp factor C, which is entered as a negative number.

The fiber parameters are set in a straightforward manner. This simulation requires no sweep iterations or optimizations.
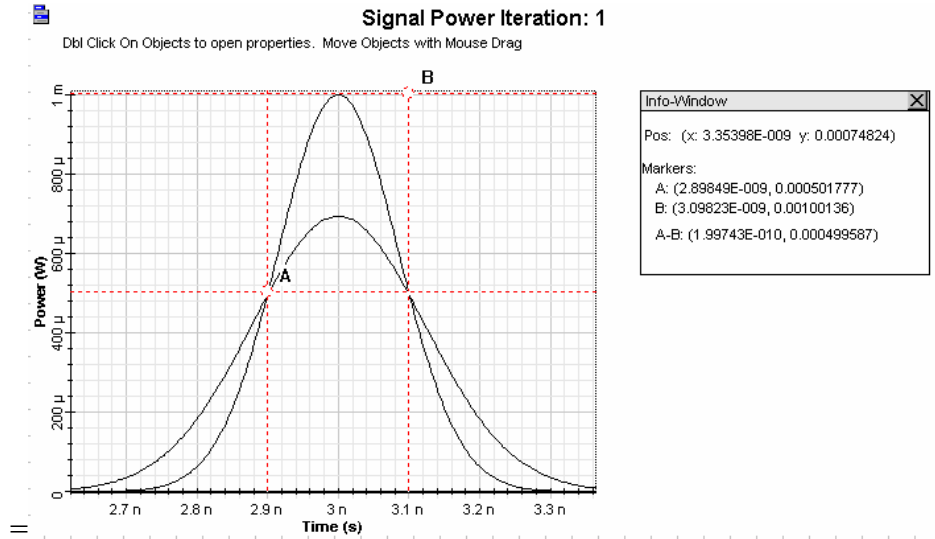
Simulation:

The visualizers are used to measure characteristics of the pulse at the input and the output of the fiber. The next figure below is the frequency domain views of the input (i.e., the transmitted) pulse.
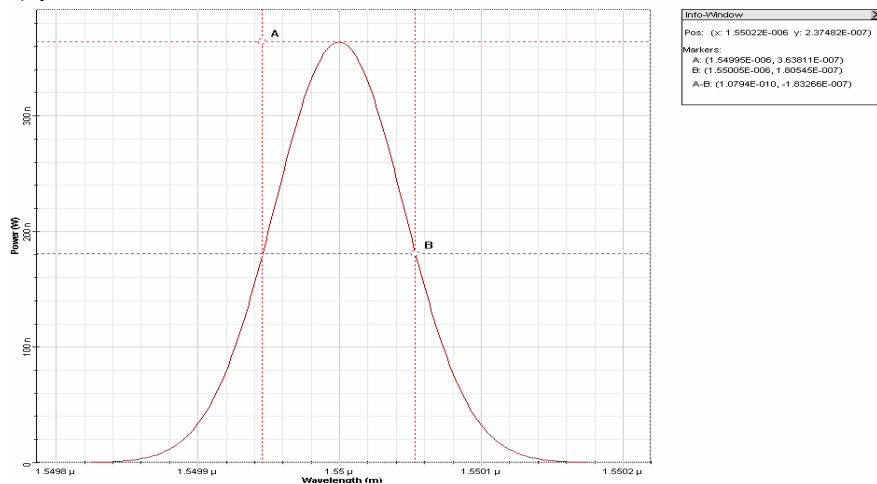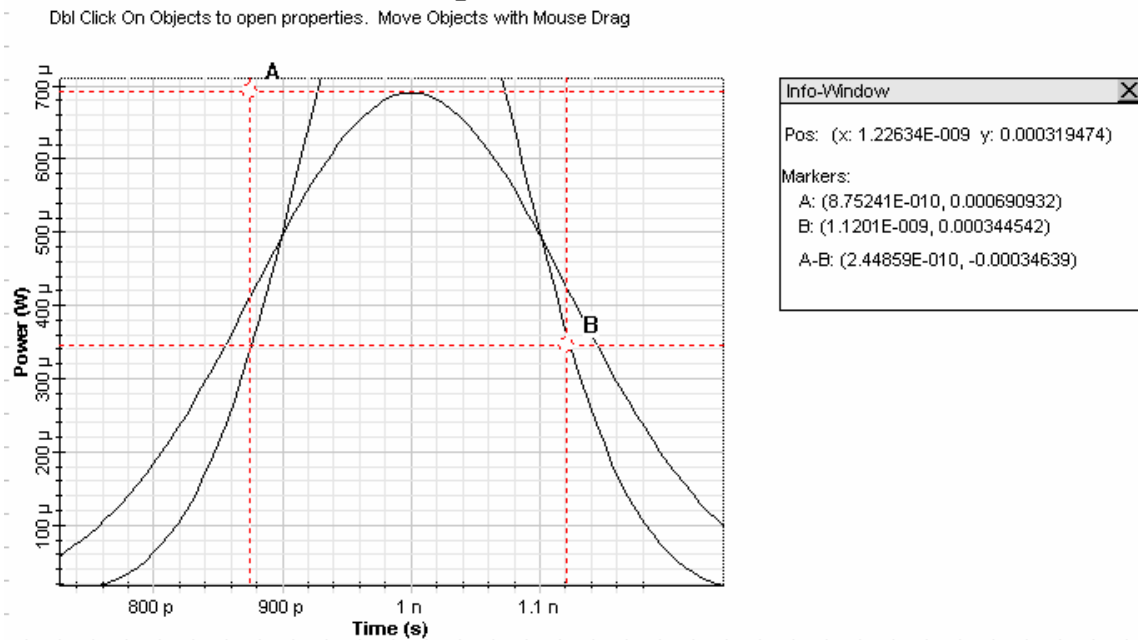

The info-window shows that the FWHM spectral width is 0.108 nm so that the RMS spectral width is 0.108/1.665 = 0.065 nm as specified. Thus the calculated chirp factor indeed results in the specified RMS spectral width.

The next two graphs show a time domain graph of the two pulses (from the results page). It clearly shows that the pulses have broadened during propagation. The first one shows the makers placed to measure the FWHM of the input pulse.

Signal Power Iteration: 1

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

Info-Window

Pos: (x: 3.35398E-009 y: 0.00074824)

Markers:
A: (2.89849E-009, 0.000501777)
B: (3.09823E-009, 0.00100136)
A-B: (1.99743E-010, 0.000499587)

The FWHM of the original pulse is 200ps. Tin = 120ps as required.

This next graph is the same as the previous except that the we have zoomed in and placed the markers are placed to measure the output pulse. The FWHM is 100 ps.

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

Info-Window

Pos: (x: 1.22634E-009 y: 0.000319474)

Markers:
A: (8.75241E-010, 0.000690932)
B: (1.1201E-009, 0.000344542)
A-B: (2.44859E-010, -0.00034639)

From the info-window (not shown), the FWHM pulse width is 244 ps so that the RMS pulse width is 245/1.665 = 147 ps. This is somewhat higher than the calculated.