Optiwave

Broadening of Gaussian Pulses

Objective:

Compare the results predicted by the linear system model of an optical fiber with the results of simulation.

Theory:

An optical fiber can be represented approximately by a linear system with an impulse response h(t) or a transfer function H(jω). If the optical source has a spectral width much greater than the signal bandwidth (e.g., the source is a directly modulated laser diode) and the operating wavelength is far from the zero-dispersion wavelength, then H(jω) is approximately Gaussian, i.e.,

$$H(\omega) = \exp(-T_F^2\omega^2)$$

where T_F is the RMS width of the impulse response and is given approximately by

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

where L is the fiber length, D(λ) is the fiber dispersion coefficient and Δλ is the RMS spectral width of the optical source.

A chirped Gaussian pulse can be used to represent the output of a directly modulated laser diode. A chirped Gaussian pulse is characterized by an RMS pulse width T_{in} and a chirp factor C. The RMS pulse width is related to the FWHM pulse width by the formulas

$$T_{FWHM} = 1.665 T_{in}$$

The RMS spectral width of the pulse is obtained from the relationship

$$\Delta\lambda = \frac{\lambda^2\sqrt{1+C^2}}{2\pi c T_{in}}$$

where λ is the operating wavelength and c is the speed of light.

If a Gaussian pulse is input to a linear system with a Gaussian impulse response, then the output is also a Gaussian pulse that has an RMS width given by

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

where all pulse widths are RMS values.

Calculations:

The system parameters are listed in the following table.

Transmitter – Gaussian Pulse Generator		
Operating wavelength	1550	nm
Bit rate	2.5	Gb/s
FWHM pulse width	0.5	Bit period
Chirp factor	-6	
Fiber		
Type	Corning SMF-28	
Length	50	km

Calculate the following:

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}

Layout:

Place and connect the following components:

1. User-defined bit sequence generator – set to generate a single pulse of the specified width
2. Optical Gaussian pulse generator – enter the chirp factor as a negative number
3. Optical fiber – set according to the specifications
4. Optical spectrum analyzers and optical time domain visualizers at input and output of fiber

Simulation:

Set the parameters and run the simulation and use the visualizer displays to measure the following:

- FWHM width of input and output pulses
- FWHM width of optical spectra

Analysis:

Compare the simulation results with the calculations and discuss any observed differences.