Dispersion Compensation

Objective:

Design and simulate a fiber optic system using dispersion-compensating fiber to reduce chromatic dispersion.

Theory:

Dispersion-compensating fiber (DCF) provides an optical medium with a relatively large negative chromatic dispersion factor ($D(\lambda)$) at the operating wavelength. If a transmission fiber of length L_{TF} is connected in series with a DCF of length L_{DCF}, then the total chromatic dispersion is given by

$$\Delta t = L_{TF} D_{TF}(\lambda)\Delta\lambda + L_{DCF} D_{DCF}(\lambda)\Delta\lambda$$

where $D_{TF}(\lambda)$ is the chromatic dispersion factor for the transmission fiber, $D_{DCF}(\lambda)$ is the chromatic dispersion factor for the DCF and $\Delta\lambda$ is the transmitter spectral width. Similarly, the total attenuation loss of the two-fiber combination is given by

$$Loss = L_{TF} A_{TF} + L_{DCF} A_{DCF}$$

Therefore, given target values for chromatic dispersion and attenuation loss plus specifications of the transmitter, fiber and receiver, one can determine the lengths of the transmission fiber and the DCF by solving the above two equations simultaneously.

Specifications:

Transmitter	Output power	0 dBm
	Spectral width	To be determined
	Operating wavelength	1550 nm
	Bit rate	2.5 Gb/s
Transmission Fiber	Corning SMF-28	
DCF	See below	
Receiver	Sensitivity	-35 dBm
System margin + coupling loss	Attenuation	6 dB

The DCF has the same parameters as the transmission fiber except that the chromatic dispersion factor is –200 ps/nm-km at 1550 nm and the attenuation is 0.5 dB/km at 1550 nm.

Calculations:

1. Determine the maximum allowable fiber loss
2. Determine the maximum allowable chromatic dispersion
3. Based on the results of (1) and (2), determine the lengths of the transmission fiber and the DCF.

Layout:

The main physical components of this layout are:
1. Transmitter: Bit sequence generator, non-return to zero pulse generator and a laser.
2. Transmission fiber
3. Dispersion compensation fiber (DCF)
4. Receiver: PIN detector and electrical filter.

The modulation scheme in this lab is different from the previous lab. Here the non-return to zero (NRZ) scheme is used. The signal does not return to zero between successive 1 bits. This results in a narrower spectral width than a return to zero modulation scheme.

Several visualizer components are included in the layout. Three Optical Time Domain visualizers are placed: at the output of the transmitter, after the transmission fiber and at the end of the DCF. An optical spectrum analyzer is placed at the output of the transmitter. This can be used to estimate the spectral width of the signal.

Procedure:

Adjust the laser power to obtain 0 dBm transmission output. The output power recorded by the optical power meter will be less than the peak output power of the laser due to modulation of the signal.

Use the optical spectrum analyzer to determine the spectral width of the signal. There will be some significant uncertainty with this number since the spectrum is not clean. Use your best judgment. Provide a screen capture of the spectrum analyzer that shows the markers you used to determine the spectral width.

Set the appropriate fiber lengths based on your pre-lab calculations.

Run the simulation with all parameters set according to the above specifications. Generate appropriate screen captures to be included in your report.

Measure the optical power at the receiver input, the maximum Q factor and the minimum BER. Record the eye diagram and the optical waveforms at the transmitter output, the junction between the two fibers and the receiver input.

Further Simulation and Analysis:

Set the length of the DCF length to 0 and run the simulation again. Make and record similar measurements.

Conclusions:

Discuss the effectiveness of dispersion-compensating fiber and the ability of the calculations to engineer a viable system.