Project: PMD simulations

GOALS

1. To understand the limitation of PMD on transmission.
2. To understand the extent to which PMD leads to pulse spreading and how pulse spreading is related to pulse format and width.

REFERENCES

1. M. Karlsson, "Polarization mode dispersion-induced pulse broadening in optical fibers," Opt. Lett. **23** (9), pp. 688–690, 1998.
2. J. P. Gordon and H. Kogelnik, "PMD fundamentals: Polarization mode dispersion in optical fibers," Proc. Nat. Acad. Sci. **97** (9), pp. 4541–4550, 2000.

PROCEDURE

1. Simulation setup: Zero dispersion, zero nonlinearity, zero loss/amplification, nonzero PMD, vector simulation. Use 80 steps over 160 km, coarse step method with equal steps. For a 32-bit PRBS of RZ raised cosine 10 Gb/s data, simulate in OCS propagation followed by a receiver. Compare eye diagrams for fiber PMD of 0.2, 0.4, 0.8, and 1.6 ps/km$^{1/2}$. What is the dominant effect of the PMD?
2. Run a Monte Carlo simulation of 100,000 fiber realizations for the setup in part 1. Make a plot of the pdf of the RMS pulse width for this simulation, averaging over all ONE bits in all fiber realizations. How does the mean pulse spreading vary with the fiber PMD?
3. Do the same task as in part 2, but for a Gaussian pulse with 10% duty cycle and for an $N = 6$ super-Gaussian pulse with 80% duty cycle. The power in a super-Gaussian pulse is described by

$$P(t) = P_0 \exp\left(-t^{2N}/t_0^{2N}\right), \tag{1}$$

where t_0 is proportional to the FWHM pulse width. First find the relationship between t_0 and the pulse's duty cycle. How does the mean pulse spreading scale with the initial duty cycle of the pulse for each of these pulses? What is the effect of the different modulation formats on PMD-induced RMS pulse spreading?

4. Calculate the pdf of the differential group delay (DGD) from your Monte Carlo simulations. If you change the number of steps to 800 without changing the total fiber length or the PMD, does it change? Make the fiber realizations periodic by repeating the first 80 sections 10 times. What effect does this have on the DGD distribution? What happens if the period is 40 steps? 160 steps? 400 steps? Explain physically what you are observing in your simulations in these cases.