

## **Introduction to Polarization Mode Dispersion**

**Abstract: One inherent challenge to providing higher data rate communications is managing the dispersion effects on the system. Polarization mode dispersion, in high data rate systems, can significantly diminish the data-carrying capacity of a telecommunications network.**

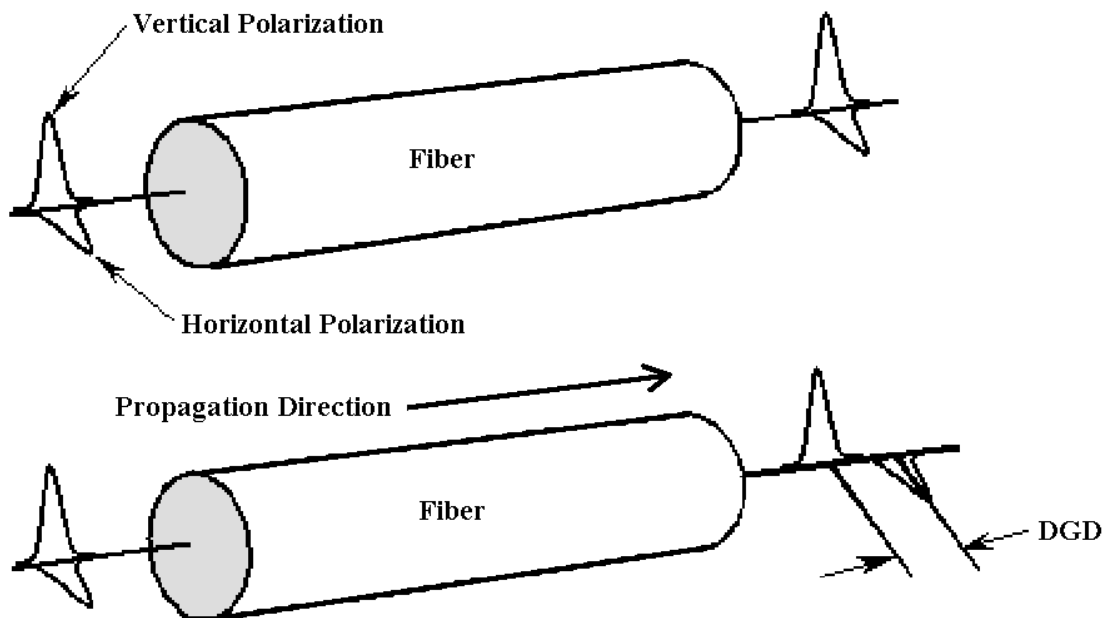
A fundamental property of single-mode optical fiber and components, *Polarization Mode Dispersion* (PMD) is a broadening of the input pulse due to a phase delay between input polarization states.

Single-mode optical fiber and components support one fundamental mode, which consists of two orthogonal polarization modes. Ideally, the core of an optical fiber is perfectly circular, and therefore has the same index of refraction for both polarization states. However, mechanical and thermal stresses introduced during manufacturing result in asymmetries in the fiber core geometry. This asymmetry introduces small index of refraction differences for the two polarization states, a property called *birefringence*. External mechanical stresses and environmental conditions exacerbate the problem.

Birefringence creates differing optical axes that generally correspond to the fast and slow axes. (These axes can also be thought of as corresponding to the *Linear Polarization* (LP) modes or *Principal States of Polarization* (PSP).) Birefringence causes one polarization

mode to travel faster than the other, resulting in a difference in the propagation time called the *differential group delay* (DGD). DGD is the unit that is used to describe PMD. DGD is typically measured in picoseconds.

**There is no PMD in a "perfect" fiber (top). Real optical fibers have some core assymetries which results in DGD (bottom).**



When mode coupling is present, both the PSP and the DGD are also dependent on optical frequency. Mode coupling refers to an exchange of power among propagating polarization modes. This is usually seen in long lengths of single-mode fiber, and is sometimes observed even in short optical components.

PMD effects resemble those of chromatic dispersion, but with some key differences: Chromatic dispersion is a rather stable, linear effect, making compensation relatively



easy, but PMD is a linear effect that is time-varying in fiber links, making compensation difficult. PMD is very stable in components. Unlike chromatic dispersion, the effects of PMD are dependent on the launched polarization state. In high-bit-rate systems, PMD may introduce errors as pulses spread into one another.