Engineering Services Department
800 17th St NW | PO Box 489
Hickory, North Carolina 28603-0489

800 743-2671
f 828 901-5533
www.corning.com/cablesystems

Modal Interference in Single Mode Optical Fiber Systems

AEN 008, Revision: 6

What is Modal Interference?

Modal interference can occur in single-mode fiber systems causing signal degradation and potentially lower signal or carrier to noise figures. Modal interference results from the recombination of higher order modes exhibiting varying phase shifts with the fundamental mode. The phase shifts predominantly originate from the random wavelength changes of the optical source. Normally, when operated above a certain wavelength, a single-mode fiber propagates one fundamental mode, supporting the information carrying light signal. Under certain conditions, a second, higher order mode may be excited, which has significantly higher loss, but more importantly, may exhibit a difference in optical path length. In this state, the single-mode fiber supports multimode operation. If this secondary mode is not sufficiently attenuated or stripped out of the fiber, it may recombine with the fundamental mode at subsequent fiber connections or splices causing destructive or constructive interference.
Several conditions may cause the excitation of this higher order mode. Transmitters that launch light into the fiber with overfilled conditions can initiate this mode or the higher order mode can be generated at splice or connector junctions where significant fiber core misalignment exists: fiber geometry as well as splicing and connectorization practices are important. Additionally, if a single-mode fiber is operated below a certain wavelength - the cut-off wavelength - the fiber may support the second order mode.

How do I avoid the second order mode?

Current industry standards address cabled cut-off wavelength requirements for indoor and outdoor cables. These cut-off requirements specify test methods that are representative of actual field deployment conditions for optical fiber cable products. Since both bending and length may affect the cut-off wavelength of a fiber, the cabled cut-off measurement techniques provide consistent controls for determining the cutoff wavelength of deployed cables. Operation of the optical fiber system at a wavelength above the specified cabled cut-off wavelength will ensure that the second order mode is not propagated on long lengths of fiber. The higher order mode will be attenuated before it can recombine with the fundamental mode. Corning Cable Systems' cables with dispersion-unshifted single-mode fiber are designed and specified to have a cabled cut-off wavelength < 1260 nm, well below the typical operational wavelength of 1310 nm. However, this does not prevent excitation of the second order mode due to a source with an overfilled launch or from misaligned fiber junctions where there is insufficient attenuation of the destructive mode before the next splice or connection.

CORNING

Published: 11/31/2013

The elimination of the second order mode initiated by a laser source is achieved with the optical fiber jumper or pigtail connected to the source. Bends with an approximate radius of 3” introduced into the jumper at the end equipment will effectively remove the second order mode.

Fiber junctions typically occur at patch panels, cable transitions, or repair points. Patch panels are much like the end equipment, introducing bends into the jumpers or pigtails. Cable transitions and repair points often involve the use of fiber splice trays to package and protect the exposed fiber. Just like the end equipment and patch panel hardware, these splice trays are designed to introduce controlled bends in the fiber, around 3" radius, which eliminate the second order mode.

It is important to note that not all single-mode fiber types exhibit the same attenuation of the second order mode for a given bend diameter. Fibers that do not attenuate this mode under normal splice tray bending or jumper routing conditions, such as depressed cladding designs, must maintain a minimum length between splices to adequately suppress the higher order mode and maintain signal integrity.

References

1. Brandtner, Schicketanz, and Eoll, "Modal Noise Due to Second Mode Interference in Single-mode Fiber Systems," International Wire & Cable Symposium Proceedings 1987.
2. J.E. Matthews III, "Keep Your FO System Quiet," Telephony, November 2, 1987.

CORNING

Published: 11/20/2013