APPLICATION NOTE

Microbending & Macrobending Power Losses in Optical Fibers

Scope: Guidance on understanding the difference between Microbending and Macrobending losses in optical fibers

1.0 INTRODUCTION

It is widely understood by optical fiber users that severely bending a "live" optical fiber will incur an optical power loss, and the received signal power will be reduced.

One way to observe the effect of bending losses is to use a Visual Fault Locator (VFL) where the visible red light glow seen at the point of bend indicates light escaping from the fiber core, passing through the cladding and fiber coatings before escaping into the environment.

A second way to observe bending losses is to use an OTDR in "real time" mode where a severe induced bend causes a noticeable drop in the backscattered power level beyond the point of bending. The leaked signal is not visible to the naked eye at the point of bending as networks and optical testing instruments operate in the infra red (heat) portion of the electromagnetic (EM) spectrum.

The bend losses described so far are "Macrobending" type losses. This Application Note describes the two principal bending loss mechanisms "Microbending" and "Macrobending".

Sensitivity of optical fibers to bending losses is dependant on a number of mechanical and optical parameters such as the refractive indices of the fiber core and cladding, transmission wavelength and the core filling and mode propagation state.

The critical angle for the core-cladding interface is the key parameter in determining whether the signal is internally reflected back into the fiber core or refracted into the cladding. Bending losses occur when the critical angle is exceeded. Longer wavelengths are more susceptible to bending losses than shorter wavelengths. Many users of singlemode fiber will know that transmission at 1550nm is more susceptible to bending losses than 1310nm.

Reduced Bend Sensitivity (RBS) singlemode and multimode fibers benefit from a reduced refractive index zone referred to as a trench located in the cladding region. The trench has the effect of reducing the critical angle such that the signal is much more likely to be reflected back into the core rather than refracted into the cladding.

The two bending loss mechanisms described occur in both step index (SI) singlemode fibers and graded index multimode (GIMM) optical fibers.

2.0 INDUDED MICROBENDING LOSSES

Microbending (bends too small to be seen with the naked eye) occur when pressure is applied to the surface of an optical fiber. The pressure applied to the surface results in deformation of the fiber core at the core-cladding interface. Microbending losses occur when surface pressure causes numerous tiny contact point indentations on the fiber surface even though the fiber itself may be laid out straight.

Microbending can be simulated by placing a straight optical fiber between two sheets of abrasive paper such as sandpaper on a flat bench and loading the top sheet with a weight. Microbending losses are induced under conditions of surface pressure such as crushing.

The Diagram 1 below shows a schematic using a high order mode in a multimode fiber as an example of how surface induced Microbends cause the transmitted mode to exceed the critical angle at the fiber Microbend. Consequently the signal is refracted into the cladding and lost from the system.

Microbend losses typically occur over an appreciable length of fiber rather than at a single point on the fiber. Consequently an OTDR user would observe a backscattered trace with a continuous high power loss, sometimes referred to as a “tail off”.

Microbending in multimode fibers will preferentially strip away cladding modes before more centrally propagated modes. Fiber defects such as lumps on the fiber-cladding interface can also be a cause of Microbending type losses.

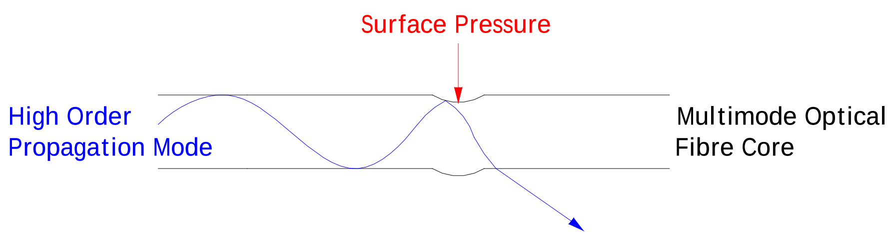

Diagram 1: Microbending

3.0 INDUCED MACROBENDING LOSSES

Macrobending (fiber bends large enough to be seen with the naked eye) loses occur when fibers are physically bent beyond the point at which the critical angle is exceeded.

Diagram 2 uses a high order mode in a multimode fiber core as an example to demonstrate Macrobending losses.

Where the critical angle is exceeded the high order mode is refracted out of the core into the cladding. This is the origin of the red glow seen at the point of Macrobending in Picture 1 below. The red glow from the 650nm VFL is red light that has been refracted out of the core through the 125µm cladding, 250µm primary coating and 900µm secondary coating. Light can also be seen radiating from the end of the fiber and device connection.

OTDR Macrobend detection software makes use of the difference in bend sensitivity (power loss due to bending) at two transmission wavelengths to determine the Macrobend location and magnitude. A comparison is made between the losses at the less sensitive shorter wavelength and more sensitive longer wavelength. This comparison is analysed by software to determine whether the event is actually a point Macrobend and not a fusion splice or mated connectors.

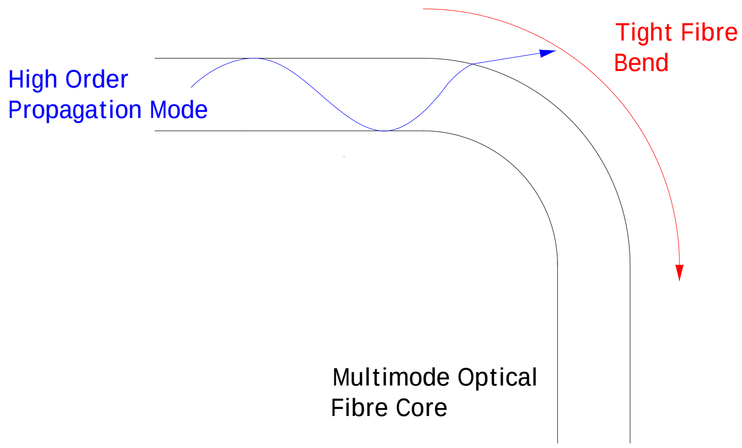

Diagram 2: Macrobending

Picture 1: Detecting Macrobending with a VFL

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