Experimental Investigation of Modal Noise in Ultra Bend-insensitive Fibers

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Abstract— We experimentally investigate the modal noise characteristics of short length ultra bend-insensitive optical fibers with different splice conditions using broadband source/OSA technique.

1. INTRODUCTION

As the fiber penetrates indoor for FTTH, it needs to have very high bend resistance [1]. Harsh conditions like sharp turns, staples, and reduced storage space are very common in indoor applications. ITU has recommended a new fiber type called G.657 for these applications [2]. As the macro-bend loss of conventional matched clad fibers cannot be reduced beyond certain extent without disturbing mode field diameter (MFD) and dispersion, a trench in cladding design has been proposed. Fibers with trench in cladding design can achieve ultra low bend losses without compromising on MFD and dispersion. However, these fibers typically have higher cutoff wavelengths than matched clad fibers due to improved confinement of optical power [3]. Also, the existence of trench in the cladding of these fibers results in the existence of higher order mode (LP_{11} mode) beyond cutoff wavelength. The existence of this higher order mode can cause modal noise and needs to be investigated in short length bend insensitive fibers.

Because of the depressed index region in BIFs, the LP_{11} mode becomes leaky around cutoff wavelength and can interfere with fundamental mode due to superior bend resistance. Multipath interference (MPI) in a BIF is caused when signal in fundamental mode gets partially converted into higher order mode and reconverted back into fundamental mode after propagating certain distance. This can happen in a FTTH network due to closely spaced splices, staples, and bends.

In this paper, we present measurement results of modal noise in a 2 m length ultra bend-insensitive fiber (G.657B3 category) with different splice conditions. Modal noise is measured at both 1260 nm and 1310 nm with different splice losses.

2. EXPERIMENTAL SETUP

Our measurement method is based on wideband light source/OSA technique and monitors transmitted optical power through the short length fiber under test as a function of wavelength. The interference phenomenon between the fundamental and higher order mode is measured by capturing the maximum and minimum transmitted power over a range of wavelengths. Polarization variation of the input is used to ensure true power extremes are found. A schematic of the apparatus used for this test is shown in Fig. 1.

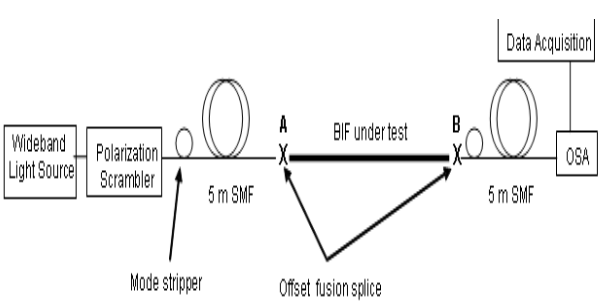

Figure 1: Experimental setup.

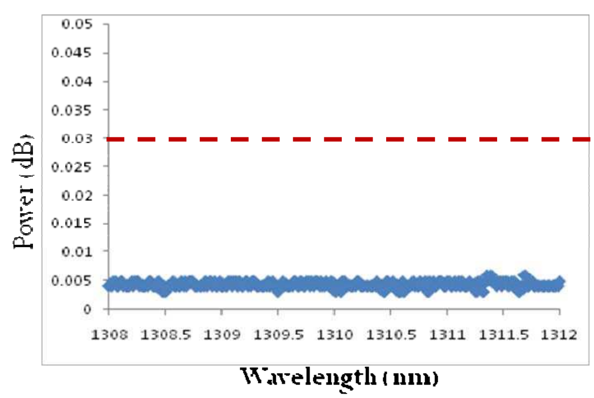

Figure 2: Source power drift with time over 15 mins.

3. RESULTS AND DISCUSSION

Spectral power stability of the source is very critical parameter and limits the baseline MPI. The fluctuations of the source power over measurement time are measured and found to be well within the requirement of $\pm 0.03\,\mathrm{dB}/15$ minutes [4] as shown in Fig. 2.

The baseline MPI, which is the minimum MPI that can be measured with the system, is measured without sample with polarization scrambler switched on. Fig. 3 shows the Max and Min power curves without sample with polarization scrambler switched on. Baseline MPI is calculated using this Max and Min data and the formula given below [5].

$$\mathrm{MPI}\,(\mathrm{dB}) = 20 \log \left[\frac{10^{PR/20} - 1}{10^{PR/20} + 1} \right] \tag{1}$$

where PR is the difference between the maximum and minimum power levels detected (in dB). The baseline MPI is measured to be $\sim -40.77\,\mathrm{dB}$.

The fiber sample used for measuring multipath interference (MPI) is a G.657B3 category fiber with a macrobend loss of 0.07 dB/turn at a bend radius of 5 mm and cable cutoff wavelength of 1240 nm.

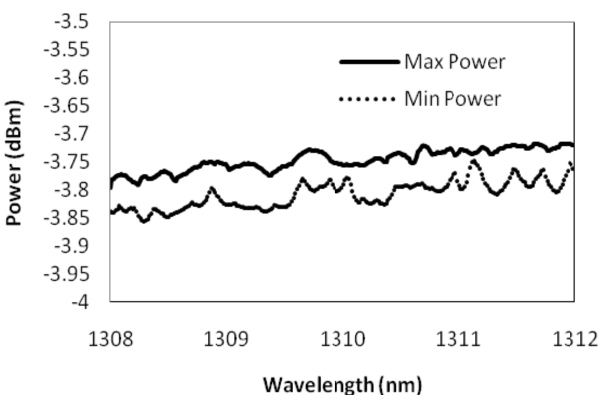

Figure 3: Max and Min power data for baseline MPI.

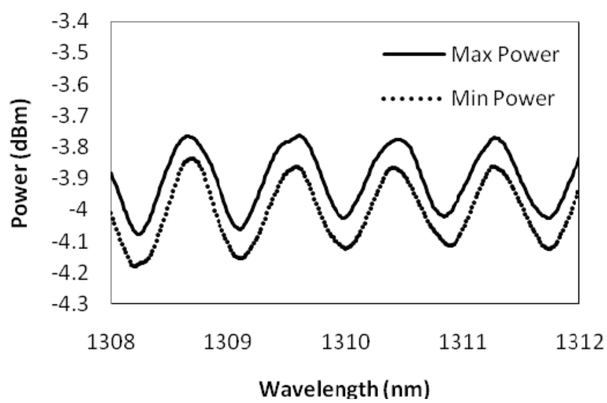

Figure 4: Measured Max and Min power curves at 1310 nm for an insertion loss of 1.49 dB.

MPI of the sample is measured at both 1260 and 1310 nm by inserting the sample and switching on the polarization scrambler. OSA was set into MAX and MIN hold mode and Max and Min power was measured for 15 minutes. This time was sufficient for the scrambler to explore all the polarization states on Poincare sphere. Fig. 4 shows measured Max and Min power curves at 1310 nm for an insertion loss of 1.49 dB.

MPI dependence on insertion loss is shown in Fig. 5. Required insertion loss is achieved through creating manually controlled offset splices. Measured MPI values as a function of insertion loss are

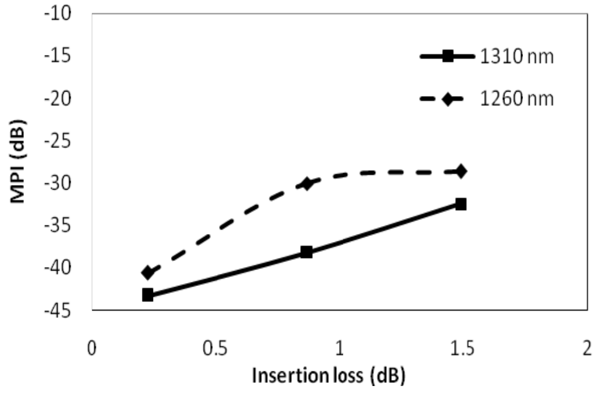

Figure 5: Dependence of MPI on insertion loss at 1260 nm and 1310 nm.

plotted at both 1260 nm and 1310 nm. As seen from this figure, MPI value increased with insertion loss. Also, as expected MPI value at 1260 nm is higher than that at 1310 nm.

4. CONCLUSION

We investigated modal noise in a 2 m length ultra bend-insensitive fiber with different splice conditions. It is found that MPI is negligible for fibers with worst case splice conditions at both 1260 nm and 1310 nm.

REFERENCES

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