# Multipath Interference Phenomenon in Bend Insensitive Fiber

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**Abstract:** We measured Multi Path Interference (MPI) phenomenon in our bend-insensitive fiber and ultra bend-insensitive fiber with different cutoff wavelengths. Their MPI values are lower than the threshold (-30dB), which ensures system stability.

## 1. Introduction

With the rapid development of FTTH in worldwide, especially in China, the application of Bending Insensitive Fiber (BIF, meets ITU-T G.657.A2 recommendation) and Ultra-Bending Insensitive Fiber (UBIF, meets ITU-T G.657.B3 recommendation) is becoming an inevitable trend in actual FTTH optical fiber deployment and installation. For the sake of tightly bending loss requirement in small bending radii (Bending radius less to 5mm), UBIF is more suitable for FTTH deployment and installation.

However, the complicated installation and applications of BIF&UBIF, such as connections, fusion splice points, or strong bends, may cause the Multipath Interference (MPI) phenomenon, which could affect the system cost, and power penalty in system. For BIF&UBIF's MPI phenomenon, a serials of experiments have been studied [1-3], the fiber parameters, such as Mode field diameter, cutoff and bending performance, which lead by the unique fiber design of every company, are the key factor for MPI performance of BIF&UBIF.

Based on PCVD and RIC process technology, YOFC BIF&UBIF (Easyband® Plus and Easyband® Ultra) can achieve a better balance between cutoff wavelength and macro-bending, micro-bending by optimizing fiber profile design. In this paper, we study the relation between fiber design and MPI, shows the MPI reliability and stability of YOFC BIF&UBIF under different conditions.

## 2. Theory

It's well known there are many factors could stimulate MPI in BIF&UBIF fiber design and fiber deployment [1-3] and the threshold -30dB is acknowledged as the safety line. In all experiments, the cutoff is the most important factor for BIF&UBIF, which is also the key for BIF&UBIF macro-bending performance. In other words, high cutoff could improve BIF&UBIF's macro-bending, but lead to bad MPI performance. Because high-mode mechanism of bend insensitive fiber is different from that in convention single-mode fiber and its cutoff wavelength is more sensitive to fiber length than bending. BIF&UBIF with trench-assistant profile can couple power to core and clad benefited from deep trench around inner cladding. Trench volume plays an important role in bending resistance. Increasing trench volume will decrease bending loss and raise high mode cutoff wavelength. Especially for trench-assistant UBIF, large trench will lead cutoff wavelength higher than 1310nm, even though the cable cutoff wavelength still below 1260nm [4]. Therefore, we adopt improving cutoff wavelength to obtain excellent fiber bending resistance, but high cutoff wavelength will worsen MPI, leading power penalty in system. So controlling proper cutoff wavelength to keep a balance in macro-bending speciality and MPI is a key point in fiber design and process control.

Table 1 G.657 ITU-T recommendation

| Attribute | G.657.A2（BIF） | | | G.657.B3(UBIF) | | |
|---|---|---|---|---|---|---|
| MFD@1310nm[μm] | (8.6-9.5)±0.4 | | | (8.6-9.5)±0.4 | | |
| cable cutoff[nm] | ≤1260 | | | ≤1260 | | |
| Bending radius[mm] | 7.5 | 10 | 15 | 5 | 7.5 | 10 |
| Bending number | 1 | 1 | 10 | 1 | 1 | 1 |
| Bending Induced Loss@1550nm [dB] | ≤0.5 | ≤0.1 | ≤0.03 | ≤0.15 | ≤0.08 | ≤0.03 |
| Bending Induced Loss@1625nm [dB] | ≤1.0 | ≤0.2 | ≤0.1 | ≤0.45 | ≤0.25 | ≤0.1 |

ITU-T G.657 recommendation is shown in table 1. In 2012, the latest revised edition highlights the UBIF compatibility with G.652.D in MFD. For fiber used in FTTH, not only the feature of low bending loss in smaller bending diameter is requested, but also its connectivity with SSMF is important. MPI is associated with bend loss, fusion splice, mechanical splices loss, connections loss. The results show staples, splices or connections and bends have little influence on MPI [1-3, 5].

It is common to calculate the zero spectral width (ZSW) and the finite spectral width (FSW) MPI using the following statistics equation, based on peak-to-peak (ptp) fluctuations:

$$MPI = 20\log\left(\frac{10^{ptp_{dB}/20}-1}{10^{ptp_{dB}/20}+1}\right) \quad (1)$$

Here, ptp means the power difference (in dB) between the maximum power and the minimum power received at a fixed wavelength or in a wavelength range over a period of time.

### 3. MPI measurement Experiment

Our measurement setup is demonstrated in Fig.1. A tuneable external cavity laser (Santec TSL-510) with linewidth 100 kHz, power >-4dBm at the shortest wavelengths of interest (usually 1260nm and 1310nm) and wide tuning range (~100nm) is used. Its wavelength scale is 1255~1355nm. The stability of the power should be < 0.01dB over the testing time and should vary < 0.05dB over the wavelength range required to sample the free spectral range (FSR) of the jumper interference pattern (this is typically ~2nm). The laser RIN should be less than -145dBm/Hz over the 10 MHz -500MHz range. It is useful to measure the MPI of the ECL in isolation and values typically are < -55 dB. Output should be taken through standard single mode fiber with an angled connector. We change signal polarization state via scrambler to capture the limited maximum and minimum power. Our BIF&UBIF sample information is shown in Table 2， and fiber length is 2-meter.

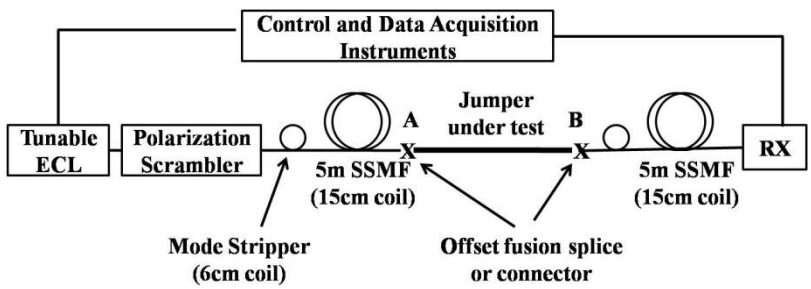


Fig.1. Schematic of setup for Narrowband ECL/PM method. Here the "RX" receiver consists of a power meter

Table 2 Fiber Sample cutoff wavelength information

| Fiber Sample | Fiber 1# | Fiber 2# | Fiber 3# | Fiber 4# | Fiber 5# | Fiber 6# | Fiber 7# | Fiber 8# | Fiber 9# | Fiber 10# |
|---|---|---|---|---|---|---|---|---|---|---|
| Fiber Cutoff wavelength [nm] | 1261 | 1269 | 1278 | 1288 | 1299 | 1311 | 1317 | 1328 | 1341 | 1366 |

Fibers that meet the G.652 standards have cable cutoff wavelength less than 1260nm measured on 22m of uncabled fiber. For shorter fiber length (<22m), the cutoff wavelength can be higher than 1260nm. The experiment result shows all the MPI is below -30dB. This -30dB threshold ensures power penalty lower than 0.5dB for a signal-to-noise ratio of 10dB and a BER of $10^{-9}$.

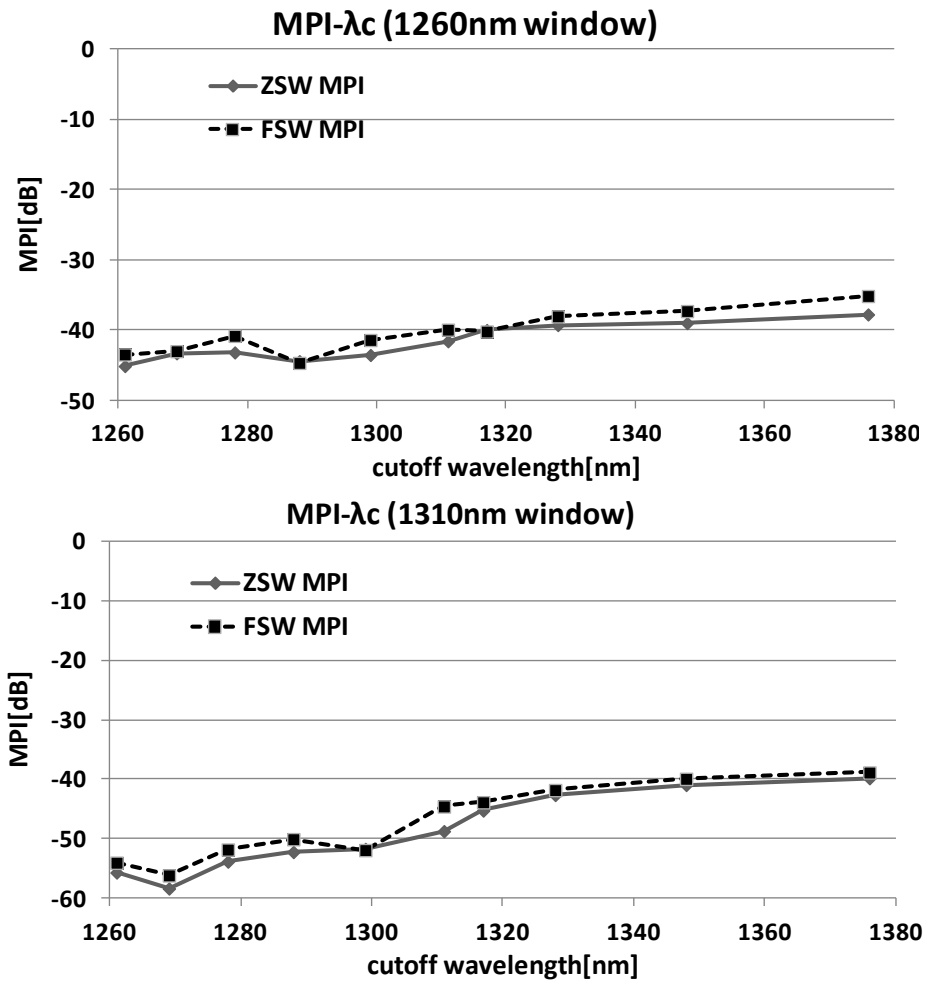


Fig.1. MPI value vs cutoff wavelength in different wavelength windows, 1260nm (top) and 1310nm (buttom)

## 4. Conclusion

By optimizing the trench volume, our BIF&UBIF with single trench manufactured by PCVD and RIC process technology, can take an excellent balance between cutoff wavelength and macro-bending, micro-bending. According to the experiment result, under different deployment conditions, our BIF&UBIF MPI value is lower than the threshold-30dB, which could guarantee the system stability in FTTH deployment.

## 5. Reference

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