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Free-space Optics Type Mode-dependent Loss Compensator for Few-mode Fiber Transmission

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Abstract: We design and fabricate free-space-optics type mode-dependent loss compensator for 4LP-mode transmission. We also evaluate loss characteristics of the MDL compensator.

Introduction

Mode dependent loss is known to have significant impact on the transmission reach of mode-division-multiplexed transmission systems. The effect of MDL on FMF transmission systems have been studied [1, 2]. In recent FMF transmission experiment using cyclic mode permutation, 6300-km 3-mode transmission was demonstrated [3]. In this experiment, interference cancellation mitigated MDL-impact. Another candidate of the solutions to mitigate MDL-impact is an MDL compensator [4, 5]. A free space optics type (FSO) MDL compensator has some features such as the ability to produce negative MDL, low excess loss, and low cost. However, less attention has been focused on the FSO-MDL compensator.

In this paper, we describe the FSO-MDL compensator for 4LP-mode transmission, and then evaluate loss characteristics of the FSO-MDL compensator.

FSO-MDL compensator for 4LP modes

We designed an FSO-MDL compensator for 4LP modes. Figure 1(a) shows a schematic diagram of the FSO-MDL compensator.

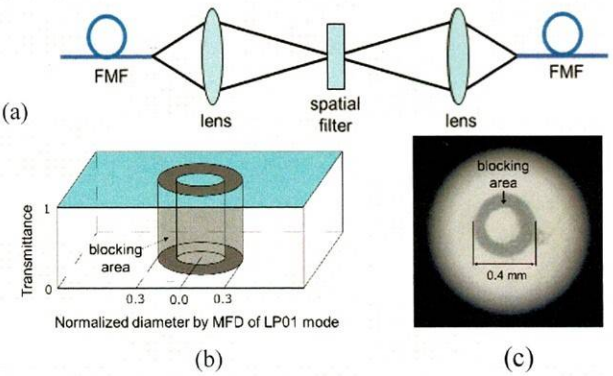

Fig. 1. (a) Schematic diagram of FSO-MDL compensator. (b) Spatial filter. (c) Photograph.

The compensator consists of a lens to magnify mode field diameter (MFD) of light from an FMF, a spatial filter to compensate intensity distribution of the light, and another lens to focus power-compensated light into another FMF. The FSO-MDL compensator utilizes a spatial filer as shown in Fig. 1(b). We designed the spatial filter to be a step profile for its absorption, and its blocking ring has larger absorption.

Loss value of each mode depends on normalized diameter and width of the blocking ring by LP01 mode MFD. Table 1 shows calculated loss characteristics of the FSO-MDL compensator, when the normalized diameter and width are 0.60 and 0.17, respectively. Since loss of the lower order mode is larger than that of higher order mode, it is expected that this device can compensate the MDL of 4LP-mode FMF with low excess loss and low cost.

Table 1. Loss characteristics of MDL compensator

	LP01	LP11	LP21	LP02
calculated value	2.1 dB	2.0 dB	1.0 dB	0.3 dB
measured value	1.1 dB	0.5 dB	0.3 dB	0.8 dB

Next, we fabricated a spatial filter with silica glass. Figure 1(c) shows a photograph of the spatial filter. Measured loss characteristics are shown in the Table 1. Mode profiles before and after spatial filter are shown in Fig. 2. The measured loss values of LP01, LP11, and LP02 are lower than those of calculated values. From the mode profiles, attenuation of blocking ring is not enough to obtain large loss at lower order modes.

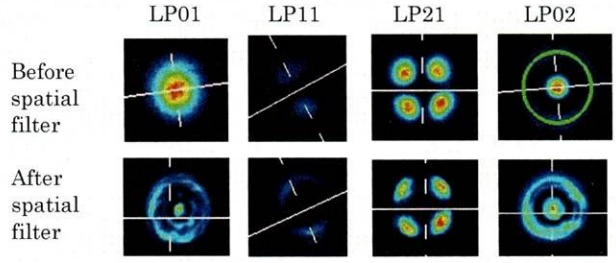

Fig. 2 Mode profiles before and after spatial filter

Conclusions

We have described the FSO-MDL compensator for 4LP-mode transmission. We also theoretically and experimentally evaluated loss characteristics of the MDL compensator. It is expected that this MDL compensator is useful for long distance FMF transmission.

References

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