Wavelength-Independent Mode-Selective Couplers for Few-Mode Fibre Networks

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Abstract Summary

A novel type of tapered fibre coupler is proposed and simulated that enables wavelength-independent directional coupling between a higher-order mode and a fundamental mode for application to few-mode optical fibre networks.

Keywords- couplers, mode multiplexing, optical fibres.

I. BACKGROUND

Currently there is growing interest in the use of few-mode fibres for significantly increasing the data rates of long-distance optical systems. In these systems, each mode of the few-mode fibre is individually excited and detected at the beginning and end of the fibre, providing an independent data channel. Several mode multiplexing/ demultiplexing methods have already been suggested based on bulk optics or gratings and symmetric couplers [1]. Here a new type of asymmetric coupler is proposed that allows for the excitation/detection of higher-order modes, largely independent of wavelength.

II. MODE-SELECTIVE COUPLER (MSC)

A MSC has three cores whose cross-section is shown in Fig. 1 and is uniform along its length. The centre core is the few-mode fibre surrounded in a uniform cladding by two identical single-mode cores whose angular offset ϕ is determined by the particular asymmetric higher-order mode of the few-mode fibre [2]. For the anti-symmetric LP_{11} mode the two single-mode cores must be at right angles to one another ($\phi = \pi/2$) to ensure 100% coupling for an arbitrary value of the angle α.

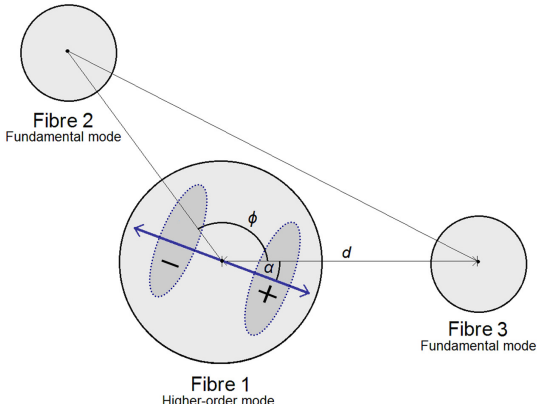

Figure 1. Mode-selective coupler cross-section [2].

By matching the three modal propagation constants and using an appropriate coupler length, this arrangement ensures all the power in one single-mode core couples to the higher-order mode. Conversely, all the power in the higher-order mode is coupled to either or both of the two single-mode cores. This happens regardless of the orientation of the higher-order mode that will be arbitrarily rotated after propagating the length of a practical few-mode fibre in a long-distance optical transmission system.

III. WAVELENGTH-INDEPENDENT MODE-SELECTIVE COUPLERS

The uniform MSC in Fig. 1 is designed for operation at or very close to the nominal source wavelength. The MSC can be made wavelength-independent by appropriate tapering of each of the cores [3]. The few-mode fibre core is down-tapered, as shown in Fig. 2(a), and the single-mode cores are up-tapered. Although not shown here, the second outer core would be out of plane (i.e. 90 degrees relative to the first) for the case of LP_{11b} mode (i.e. $\alpha = \pi/2$) coupling.

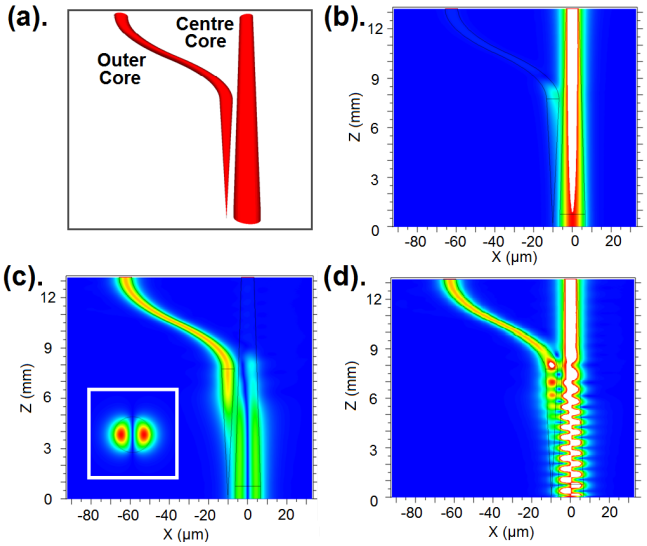

Figure 2. Tapered MSC showing: (a) layout, (b) fundamental-mode through propagation, (c) second-mode LP_{11a} ($\alpha = 0$) coupling and (d) simultaneous fundamental and second mode propagation .

Coupling occurs between the centre core LP_{11a} mode and the fundamental mode of the outer core provided the propagation constants of the two modes match somewhere along the device. In a DWDM system coupling will occur automatically for each channel wavelength albeit at marginally different positions along the coupler's length.

REFERENCES

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