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Polarization-independent all-fiber flat-top comb filter

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Abstract

A novel polarization-independent all-fiber flat-top comb filter based on high birefringent (Hi–Bi) fiber Sagnac interferometer is proposed for the first time to our knowledge. The numerical simulation results show that the proposed device exhibits flat-top and the extinction ratio reads about 30 dB. A good agreement between the numerical simulations and the experimental results is achieved.

Keywords: Comb filter; Sagnac interferometer; Extinction ratio; Flat-top

1. Introduction

Wavelength-division-multiplexing (WDM) is an attractive fiber-optical communication technique. Optical comb filters are the key components to control light signals for such techniques. In WDM networks, every nod needs to drop required signals, add new signals and pass the others to the next node. Optical comb filters can be used for signals dropping or adding in the optical networks. Among the parameters of the filters, a high extinction ratio is the key factor to reduction adjacent channel crosstalk [1]. The flat-top is an essential feature for high-speed optical communication systems. Therefore, it is important to improve the extinction ratio and achieve flat-top performance for comb filters. In the mean-

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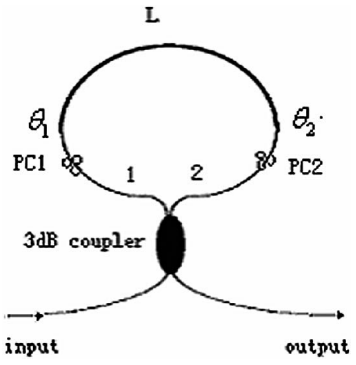

Fig. 1. HBF loop.

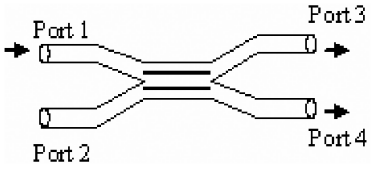

Fig. 2. Coupler.

time, as we all know, we also have to consider the polarization state of ordinary fibers. As a results the polarization-independent filter is necessary.

Several optical comb filters have been proposed such as Mach–Zehnder interferometer filters [2], arrayed waveguide gratings (AWG) [3], and Hi–Bi fiber Sagnac interferometer [4–7]. Among these filters, the Hi–Bi fiber Sagnac interferometer (or loop) is a potential candidate for its low loss, good tunability, and spectral polarization independence [4].

In paper [5], a flat-top comb filter is obtained by a six-order Solc–Sagnac filter which includes five HB fibers in a Sagnac loop. However, the framework is difficult to construct.

In this letter, we propose a novel comb filter based on Sagnac interferometer (or loop) with flat-top transmission spectrum, higher extinction, and its output light intensity is insensitive to the polarization state of input light.

2. Principle

2.1. Hi–Bi fiber loop

A standard Hi–Bi Sagnac loop, as shown in Fig. 1, consists of a 3 dB directional coupler, a section of HB fiber denoted by the thick line inside the loop, two polarization controllers, and two sections of conventional single mode fiber used to connect the HB fiber and the coupler.

The 3 dB coupler in Fig. 1 has a four-port structure as shown in Fig. 2, and its Jones matrix can be represented as

$$\begin{pmatrix} E_3 \\ E_4 \end{pmatrix} = \begin{pmatrix} \sqrt{1-k} & j\sqrt{k} \\ j\sqrt{k} & \sqrt{1-k} \end{pmatrix} \begin{pmatrix} E_1 \\ E_2 \end{pmatrix}, \tag{1}$$

where E_1, E_2, E_3, and E_4 are electric-field vectors at the four ports, respectively, k is the coupling ratio of the fiber coupler, which equals $1/2$. (The same applies to the input lights form ports 3 and 4.)

The polarization controllers, PC1 and PC2, are set to produce polarization rotations of θ in relation to the fast axes of the Hi–Bi fiber for beams coming from both directions, and