

A Sagnac Interferometer as a Variable Optical Attenuator

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Abstract

There is a strong demand for Variable Optical Attenuators (VOA) in present optical fiber telecommunication systems. In this work we study the usage of a linear optical fiber Sagnac interferometer (SI) as a VOA. A polarization controller was inserted in the SI loop to control the intensity of the transmitted signal at the output of the interferometer, showing the viability of using this setup as a device for controlling a transmitted signal. Further extension of this study is under investigation by the replacement of the polarization controller with other devices that could possibly control the intensity of the transmitted signal at the output of the Sagnac interferometer.

Introduction

Nowadays, there has been extensive research towards all-fiber devices due to the fact that companies are in pursuit of high-speed optical networks. As telecommunication systems have increasingly more optical components and less electronic devices, faster systems with higher capacity and lower loss are possible.

There has been a strong demand for Variable Optical Attenuators (VOAs) in DWDM networks, among other systems, due to their variable attenuation range [1]. Today, there are several types of commercial VOAs, using diverse technologies such as microelectromechanical systems (MEMS), liquid crystals, thin film filters and all-fiber devices. The key advantages for all-fiber VOAs are high stability, high speed and low loss.

An important technique for controlling the transmitted signal in a fiber loop reflector has been shown by Mortimore [2], presenting an interesting result on how to control the transmitted signal by inducing birefringence. In the present work we study an all-fiber VOA device based on a Sagnac Interferometer configuration.

Experimental Setup

The experimental setup consists of a Sagnac Interferometer (SI) configuration as depicted in figure 1. The fiber interferometer configuration uses a 50:50 coupler with its two output ports connected to form a loop [3]. The pump source used was a low power (0.166mW) DFB laser@1550nm that enables us to describe the system taking into account only linear phenomena. The signal at the output port was measured with a Power Meter (Eigenlight 420).

The 50:50 coupler splits the input light in two counterpropagating signals. Without the polarization controller (shown in figure 1), after the second pass through the coupler the signals interfere constructively in the top leg and destructively in the bottom leg, i.e. all light is reflected back to the input leg and no light is transmitted to the Power Meter.

To control the intensity of the transmitted signal at the output of the interferometer, we inserted in the loop a polarization controller based on a pressure mechanism (the Yao polarization controller). This polarization controller has a screw that is rotated to apply pressure to a small portion of the fiber, thus producing a linear birefringence with the slow axis parallel to the direction of the pressure. Rotating the screw varies the retardation

between the slow and fast axis from 0 to 2π , which varies the relative phase change between the clockwise and the counter clockwise signals.

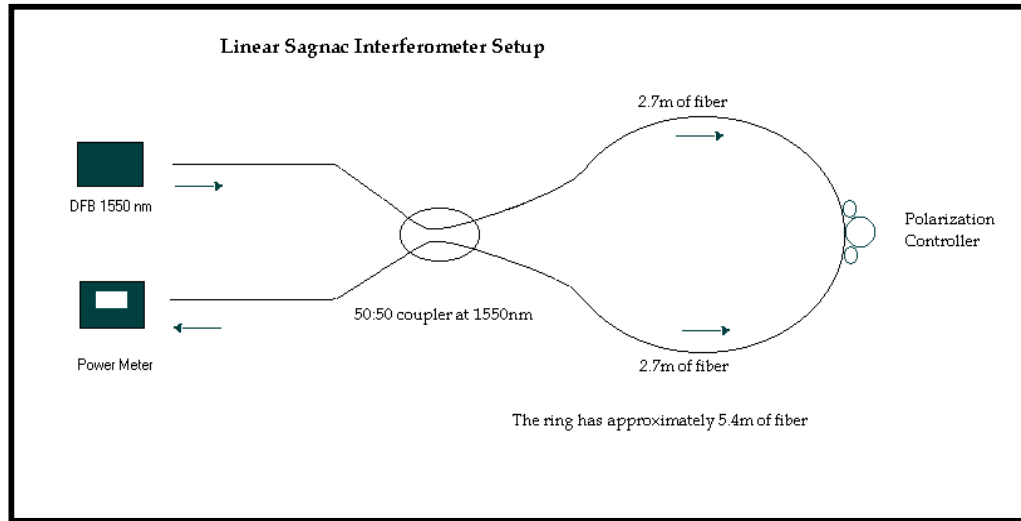


Figure 1: Experimental setup scheme

Results and Discussions

Using the setup shown in Figure 1, the transmitted signal at the output of the SI was measured as a function of the variation on the polarization induced by the polarization controller. The transmitted signal was measured at each $\pi/2$ turn of the polarization controller's screw. As shown in Figure 2, the maximum transmitted signal was 0.126mW (75.86% of the input power) and the minimum transmitted signal was less than 0.001mW (precisely 0.16% of the input power); the extinction ratio was 26.7dB. Similar results were obtained with a Lefevre polarization controller (Mickey Mouse Ears, Three Paddles). As can be seen, it is possible to control the intensity of the output signal by inducing changes in the polarization. The setup acts as a variable optical attenuator (VOA).

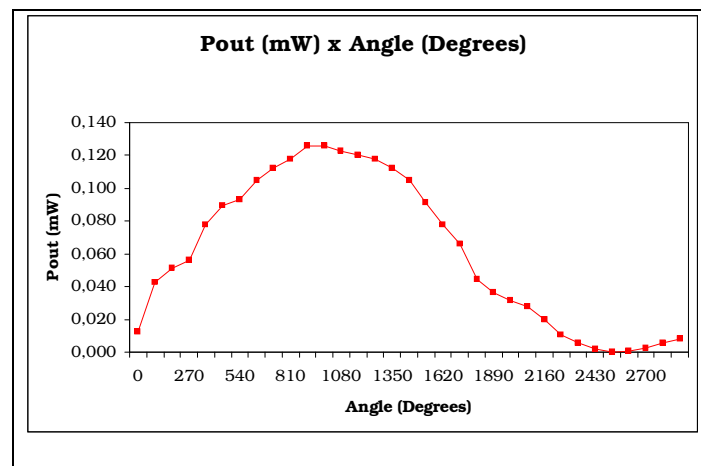


Figure 2: Output power versus polarization state

Conclusions

Since the behavior observed in this experiment matches the characteristics of a VOA, this setup can be used as a variable optical attenuator. The key issue is then to know how to control the polarization state, and therefore know how to indirectly control the interference taking place in the coupler. If the interference can be controlled, the attenuation of the optical power can be controlled.

A possible extension of this study would consist of replacing the polarization controller with devices that control the intensity of the transmitted signal at the output of the SI by other means. An interesting approach would be a device that could vary the optical path of the counter propagating fields, therefore changing the interference in the coupler.

Acknowledgements

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