Design of a Fiber Bragg Grating for Decoding DPSK Signals

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ABSTRACT

We present the design of a Fiber Bragg Grating (FBG) to demodulate signals of a Differential Phase Shift Keying (DPSK) modulation format at a bit rate of 10 Gb/s.

1. INTRODUCTION

DPSK is a modulation format in which the information is carried in optical phase changes between bits. DPSK exhibits several advantages in long haul telecommunication systems over other conventional modulation formats, such as a higher sensitivity at the receiver. However one of its main disadvantages relates to its complex receiver structure, which includes delay interferometers and balanced-photoreceivers [1]. In this work, a FBG is designed as a means of decoding DPSK signals, potentially offering significant advantages, such as compactness, ready fiber integration, and low-cost fabrication.

2. FBG DESIGN

The design of the device is based on the technique of pulse shaping with FBGs operating in the weak grating limit [2]. In this operating regime, the impulse response $h(t)$ of a FBG is given by the inverse Fourier transform of its frequency response $H(\omega)$, which is also related to the complex form of the refractive index modulation profile of the grating.

$$h(t) = \int_{-\infty}^{\infty} H(\omega) e^{-i\omega t} d\omega$$  \hspace{1cm} (1)$$

In order to perform decoding of DPSK signals, an FBG will act as a device which compares the optical phases between two consecutive bits. For this, the impulse response of the grating, $h(t)$, will be formed by two pulses of 100ps width having a \(\pi\) phase difference between them. The reflected optical response in the frequency domain $Y(\omega)$ (the demodulated signal) to a pulse of a finite time duration $X(\omega)$, in this case the DPSK signal is given as the product of the incident signal $X(\omega)$ with the impulse response of the grating $H(\omega)$ [2]:

$$Y(\omega) = H(\omega)X(\omega)$$  \hspace{1cm} (2)$$

3. NUMERICAL SIMULATIONS

Our simulations were carried out in Matlab. A sequence of NRZ bits at a bit rate of 10 Gb/s were encoded in the DPSK format. The DPSK signal spectrum $X(\omega)$, was multiplied by a hypothetical FBG impulse response $H(\omega)$, modeled following the specifications mentioned in the previous section. This process was iterated by modifying the output $Y(\omega)$ to result in a more suitable signal in terms of intersymbol interference and spectral bandwidth. The improved signal, together with $X(\omega)$, were used to determine an apodization profile for the grating (Fig.1a). Fig.1b shows the simulation of a 7-bit DPSK sequence decoded using this FBG.

4. CONCLUSION

The design of a FBG for decoding DPSK signals was presented. The demodulation is done by comparing the phases of two consecutive bits inside the FBG structure. An FBG with a suitable impulse response has been designed, and our simulations show a correct demodulation of the DPSK signal. Issues associated with the design and performance of the FBG will be discussed during the presentation of the paper.

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REFERENCES