OCDMA LOW COST ACCESS NETWORK BY USING BRAGG GRATING ENCODERS/ DECODERS

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Abstract: In a DS-OCDMA system, prime sequences implementation is achieved by designing and realizing Sampled Bragg Gratings (SBG). Optimizing the characteristics of the SBGs allows to reach the low cost aim of access network.

1. Introduction

Optical Code Division Multiple Access (OCDMA) presents an attractive solution for low cost all optical access networks. Direct Sequence-OCDMA (DS-OCDMA) allows to each subscriber to use a specific codeword (or a code sequence) to modulate its data sequence. The resulting coded sequences of the various users, are superposed, transmitted via the optical amplified channel and at least, detected by the suitable receivers.

Earlier, implementation of the optical codes has been achieved by using fiber splitters, optical delay lines and combiners [1]. Using the reflection properties of Sampled Bragg Gratings (SBG) to implement optical encoders/ decoders permits to overcome the integrability and the accuracy needed for delay line lengths.

The efficiency of short SBG encoders / decoders is demonstrated in this paper, since they present better performances than previous devices [2], and consequently permit to improve the power link budget leading to the suppression of user amplifiers. In addition, the filter properties of SBG components reduce the noise induced by the optical amplified channel.

2. Sampled Bragg Grating Encoders/ Decoders

Design and Realization

Because of non-coherent detection, bipolar sequences may not be used as codewords in an OCDMA system. The choice of appropriate unipolar optical codes permits to reduce the effects of Multi Access Interferences (MAI) by controlling the cross-correlation level between two different codewords.

In our application, Prime Sequences (PS) C_{1}(100010001) and C_{2}(100100100) will be implemented respectively by SBG_{1} and SBG_{2} components since PS present a better multiplexing capacity than other optical codes [3-4].

Table 1 gives the different parameters of the SBGs encoders/ decoders. The Bragg wavelength of these devices (\lambda_{b}) is 1550.95 nm and the total reflected optical power of each encoder/ decoder is around 13%.

<table>
<thead>
<tr>
<th>SBG</th>
<th>L_{kg} (mm)</th>
<th>R (%)</th>
</tr>
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<tbody>
<tr>
<td>BG_{1}</td>
<td>21 mm</td>
<td>15 mm</td>
</tr>
<tr>
<td>BG_{2}</td>
<td>21 mm</td>
<td>15 mm</td>
</tr>
<tr>
<td>BG_{3}</td>
<td>21 mm</td>
<td>15 mm</td>
</tr>
</tbody>
</table>

Table 1: Encoders / Decoders characteristics

To generate codewords composed by pulses with the same level, each sampled grating is designed to present a different reflection rate, which compensates the incident wave attenuation during its propagation through the SBG device.

Encoders/ decoders technological realization is achieved by photo-inscription of in-fiber short Bragg gratings with the phase mask method. To accurately control the length separating two successive gratings, the fiber was mounted on a piezo translation stage with a computer controlled interferometric rule. The accuracy of the BG positioning was in nm range.

3. Experimental Multiplexing Set Up

The realized encoders/ decoders device properties have been integrated in an all-optical CDMA system Figure 1).

The experimental set up consists of a 1550.95 nm DFB laser with an Integrated cElectro-absorption Modulator (ILM). This system driven by a 20 Gbit/s clock signal from a pattern generator (PG) allows the laser to operate in a pulse regime. The full-width at half-maximum (FWHM) of the generated pulses is 50 ps.

The pulse train is then RZ modulated by an
electro-optic modulator (EOM) at a data rate of 2 Gbit/s per user with a pulse ratio 1:10.

For each user, an SBG encoder generates the appropriate code sequence. Figure 2 shows an example of the generated codeword $C_1(100010001)$ associated to the first user.

The FWHM of the pulses is 50 ps and each two pulses are separated by a time duration of three "0" chips equal to 150 ps.

The coded signals obtained by the SBG devices are superposed by a 3 dB coupler, transmitted via 15 km optical fiber, amplified and decoded by a matched decoder device, which is composed by the same BGIs that are used in the encoder.

To estimate the performances of the proposed system, we have measured the auto and cross-correlation functions of the two users. Figure 3 shows the autocorrelation associated to the first user before and after the 15 km optical fiber. The autocorrelation peak corresponds to a matched decoding and its FWHM is 52 ps due to the chromatic dispersion. This effect has no influence on the decoder performances. In addition, the cross-correlation function plotted in Figure 3 shows that it is impossible to recover the data bits with a mismatched decoder.

The high SBG reflection rate leads to suppress the additional user amplifiers usually employed to detect the decoded signals. The SBG's filtering properties allows to reduce the noise induced by the optical amplified channel. This demonstrates the efficiency of our OCDMA low cost communication system.

![Diagram of All-optical CDMA communication system](image)

Fig. 1: All-optical CDMA communication system

![Experimental optical code pulses](image)

Fig. 2: Experimental optical code pulses.

![Graphs of auto-correlation and cross-correlation functions](image)

(a): auto-correlation function (b): cross-correlation function

Auto-correlation functions
(a): before 15 km optical amplified channel
(b): after 15 km optical amplified channel

Fig. 10: Auto and cross correlation functions

4. Conclusion

The realization of a low cost all optical access network by using DS-OCDMA multiplexing technique and SBG devices as encoders/decoders has been reported.

Design and the realization of SBG components are performed to improve their mean reflected optical power. Furthermore, they permit to generate pulse chips with the same peak optical power level. At least, the multiplex of two encoded signals through a typical 15 km access network length is demonstrated without additional optical filter and user amplifier.

5. References

2. H.Geiger and al, ECOC'98 (20-24 Sept 1998), pages 337-338