Chapter 6

System performance of the experimented tunable dispersion compensation device

6.1. Introduction

After measuring the different group delay curves for the various desired dispersion values, as demonstrated in section 5.4, we want to verify how well the perturbed chirped microstrip line works in a real optical communication system. In order to validate the experimented results, we simulate an optical system by utilizing the commercially available Optsim® software. In particular, we simulate the propagation of a NRZ IMDD signal at 10 Gb/s over different reaches of uncompensated SMF. Thanks to suitable simulation, we analyze the dispersion tolerance achieved through the signal predistortion induced by the microwave analog chirped microstrip line, whose characteristics are taken by the experimentation obtained.
To model the device, the measured characteristics of the built tunable NTL described in the previous chapter are used.

### 6.2. Simulation Set up

*Figure 6.1* shows the optical system simulated by the Optsim\textsuperscript{R} software. The system is constituted by 3 different blocks; the transmitter stage, the transmission link and the receiver stage.

![Optsim circuit](image)

*Figure 6.1 Optsim\textsuperscript{R} circuit used to simulated the performance of a 10 Gb/s NRZ system predistorted by our experimented compensator*

#### 6.2.1. The Transmission stage

The transmitter is constituted by a 20 GHz clock modulated by an electrical 10Gb/s NRZ signal. The modulated signal is filtered by a microwave filter designed by taking into account the experimentally measured real characteristics of the perturbed chirped
microstrip line in phase and in amplitude. Once the modulated 10Gb/s NRZ signal is predistorted by such a filter it is then demodulated to achieve the in-phase and in-quadrature components. Both signals are filtered with a low pass filter in order to reduce noise. Finally the output signals are used to modulate an optical source by using a dual-parallel Mach-Zehnder modulator, which guaranties the linear conversion between the electrical field and the optical field.

6.2.2. The transmission Link

The optical modulated signal, coming from an optical source is centered at 1550 nm with 1 MHz of FWHM (Full Width Half Maximum) linewidth, propagates along a multispans amplified link constituted by SMF with 0.2 dB/km of attenuation and +16ps/nm/km of fiber chromatic dispersion. Each span has a total length of 100 km amplified by an Erbium Doped Fiber Amplifier (EDFA) with 35 dB of signal gain and 5 dB of Noise Figure (NF).

6.2.3. The receiver stage

The receiver is constituted by an optical filter to reduce optical received noise and by a PIN photodiode. The detected signal eyediagram is estimated in order to verify how well the system works for different value of the transmission reach. We can compare the performance of the uncompensated NRZ signal with the predistorted signal with a fixed OSNR by evaluating the closure of the eye of the received signal.
6.3. Simulative Results

In the following table the measured dispersion values in ps/GHz experimented for the chirped microstrip line are shown together with the simulated propagation distance in km and the corresponding dispersion in ps/nm. For each reach taken into account, we report the simulated eyeclosure obtained in case of NRZ and in case of predistorted signal.

<table>
<thead>
<tr>
<th>Distance (km)</th>
<th>Corresponding Dispersion Compensation (ps/nm)</th>
<th>Chirped Microstrip line dispersion (ps/GHz)</th>
<th>Bandwidth (GHz)</th>
<th>NRZ Eyeclosure (dB)</th>
<th>Predistorted NRZ Eyeclosure (dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>128.85</td>
<td>-2061.60</td>
<td>-16.51</td>
<td>20.80</td>
<td>6.86</td>
<td>5.24</td>
</tr>
<tr>
<td>163.89</td>
<td>-2624.76</td>
<td>-21.02</td>
<td>20.50</td>
<td>7.54</td>
<td>3.75</td>
</tr>
<tr>
<td>206.04</td>
<td>-3296.56</td>
<td>-26.40</td>
<td>20.40</td>
<td>10.11</td>
<td>3.79</td>
</tr>
<tr>
<td>245.60</td>
<td>-3929.65</td>
<td>-31.47</td>
<td>19.50</td>
<td>17.41</td>
<td>4.82</td>
</tr>
<tr>
<td>275.49</td>
<td>-4407.91</td>
<td>-35.30</td>
<td>19.40</td>
<td>22.06</td>
<td>4.64</td>
</tr>
<tr>
<td>319.12</td>
<td>-5105.93</td>
<td>-40.89</td>
<td>19.20</td>
<td>22.06</td>
<td>4.26</td>
</tr>
<tr>
<td>359.24</td>
<td>-5747.76</td>
<td>-46.03</td>
<td>19.00</td>
<td>22.06</td>
<td>5.97</td>
</tr>
<tr>
<td>392.72</td>
<td>-6283.45</td>
<td>-50.32</td>
<td>18.70</td>
<td>22.06</td>
<td>5.44</td>
</tr>
</tbody>
</table>
Uncompensated NRZ propagation at 10 Gb/s over 125 km with a fixed value of OSNR 21 dB shows an eyeclosure of 6.86 dB while the predistorted NRZ has an eyeclosure of 5.24 dB. By taking into account these results we find that the uncompensated NRZ signal can slightly propagate over its propagation limit of 80 km, on the contrary the predistorted NRZ signal still propagates quite well.
Figure 6.3 shows the eyediagram for 164 km propagation of 10Gb/s for uncompensated and predistorted NRZ signal with a fixed value of OSNR of 21 dB. The uncompensated NRZ signal has an eyeclosure of 7.54 dB which means that the NRZ is not able to propagate while the predistorted NRZ has an eyeclosure of 3.75 dB. Here the differences in terms of performance between the two signals are very remarkable.

Figure 6.4 On the left an uncompensated 10Gb/s NRZ and on the right a predistorted NRZ eyediagrams in case of 206 km propagation

The differences between the eyediagrams of the uncompensated and predistorted NRZ signals become more significant when we increase the propagation length. Notice that after 245 km propagation the eyediagram of the uncompensated NRZ is practically closed while the eyeclosure for the predistorted NRZ remains good also for 360 km propagation.
Figure 6.5 On the left an uncompensated 10Gb/s NRZ and on the right a predistorted NRZ eyediagrams in case of 245 km propagation

Figure 6.6 On the left an uncompensated 10Gb/s NRZ and on the right a predistorted NRZ eyediagrams in case of 275 km propagation
Figure 6.7 On the left an uncompensated 10Gb/s NRZ and on the right a predistorted NRZ eyediagrams in case of 319 km propagation.

Figure 6.8 On the left an uncompensated 10Gb/s NRZ and on the right a predistorted NRZ eyediagrams in case of 360 km propagation.
Figure 6.9 On the left an uncompensated 10Gb/s NRZ and on the right a predistorted NRZ eyediagrams in case of 393 km propagation