Performance Analysis of 40-Gb/s CSRZ-based DWDM Transmission System

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Abstract: DWDM employs the transmission of several narrowly dispersed wavelengths covering the 1550 nm wavelength region inside a optical fiber. Wavelength divisions are typically 0.8 nm and 1.6 nm. In this paper, we have discussed the generation of CSRZ modulation format and its performance analysis with 40Gb/s DWDM transmission system.

Keywords: DCF, SSMF, BER, CSRZ, Eye-opening, Non-linearities, Dispersion.

1. Introduction

DWDM stands for dense wavelength division multiplexing technique. It employs the transmission of several optical signals through the same fiber at different wavelengths. Dense means the technology that employs more than 80 optical signals i.e. wavelengths with a small difference of 0.8nm and sharing the same optical fiber. So now a day, DWDM systems are capable of handling huge amount of data and therefore this technology is more popular in cable and telecommunication companies [1].

2. Simulation Set up

Figure 1 shows the simulation model for the generation of CSRZ based modulation format. In this system, light of continuous wave (which is generated from the CW laser) and a 10 Gb/s data (from the data source) is fed to the modulator. For the generation of CSRZ signal, a clock of 20GHz and a bias signal are fed to the second modulator. The output of modulator is passed through the channel. With the help of optical receiver, it is being converted to the electrical signal.

![Fig: 1 Simulation set up for the generation of CSRZ Modulation format](image)
The CSRZ spectrum can be viewed from the optical spectrum analyzer (b6 component) and it is shown in the next slide. Now, carrier suppressed return-to-zero signal is having carrier as well as two sidebands. The carrier part of the CSRZ signal is suppressed and the spectral width between both the sidebands is approximately 40 GHz [2-3,6]. Due to this there is double reduction in spectral as compared to spectral width between first two sidebands in the return to zero format. When we have simulated this set-up then we have observed the various parameters in Optical Spectrum analyzer.

Table 1: Determined values for the Various Important Parameters for the CSRZ Modulation format

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Run 1 (0Km)</th>
<th>Run 2 (10Km)</th>
<th>Run 3 (20Km)</th>
<th>Run 4 (40Km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q-Factor (dB)</td>
<td>22.55dB</td>
<td>22.06dB</td>
<td>21.81dB</td>
<td>20.31dB</td>
</tr>
<tr>
<td>Bit-Error Rate (BER)</td>
<td>1.32e-039</td>
<td>1.13e-035</td>
<td>1.21e-033</td>
<td>5.48e-025</td>
</tr>
<tr>
<td>Eye-Opening (dB)</td>
<td>0.00016 [a.u.]</td>
<td>0.000104[a.u.]</td>
<td>6.38e-005[a.u.]</td>
<td>2.40e-005[a.u.]</td>
</tr>
<tr>
<td>Eye-Closure (dB)</td>
<td>0.5304dB</td>
<td>0.5764dB</td>
<td>0.7147dB</td>
<td>0.9001dB</td>
</tr>
<tr>
<td>Jitter (ns)</td>
<td>0.0254ns</td>
<td>0.0238ns</td>
<td>0.02317ns</td>
<td>0.02215ns</td>
</tr>
</tbody>
</table>

The determined values for the various parameters like Q-factor, eye opening, Eye-closure, Bit-error Rate and Jitter, for CSRZ modulation format are given in Table 1. Figure 2 (a-d) shows the eye-diagram for the CSRZ modulation format at a fiber length of 0km, 10km, 20km, 40km respectively.

![Eye-diagram](a) ![Eye-diagram](b)
Fig 2: Eye-diagram for the CSRZ modulation format at fiber length of (a)- 0km, (b)-10km, (c)- 20km, (d)-40km.

Figure 3 shows the simulation setup for the 40Gb/s CSRZ modulation format based DWDM transmission system. Simulation setup has been made using the well known optical simulation tool, OptiSystem. For the case of carrier suppressed return-to-zero transmitter, return-to-zero optical signal, after MZ modulator, undergoes through phase modulation process, driven by a wave generator at frequency, \( f = \frac{b_r}{2}, \) where \( f \) is frequency and \( b_r \) is the bit-rate. Therefore, phase shift between two adjoining bits becomes \( \pi \)-degree and the spectrum will be adjusted in such a way that the dominant peak at the carrier frequency \( f_c \) is suppressed [4].

![Simulation setup for the 40Gb/s CSRZ modulation format based DWDM transmission system](image)

**3. Results and Discussions**

Finally we have observed the variations of various parameters with fiber length in 40Gb/s DWDM transmission system. Fig: 4 shows the eye-diagram for various fiber lengths i.e. Runs. For the case of CSRZ signal, initially BER is zero, then it increases linearly with increase in the fiber length and after reaching at some points, it decreases linearly. Fig: 5 show the variations of Q-factor, Eye-opening, BER and Jitter with respect to fiber length. For the case of SSB-RZ signals, BER increases linearly with fiber length, after some distance, it attains a constant value. Variation of Q-factor for three different modulation formats has also been observed and it has
been found that it decreases with fiber length. This factor basically determines the quality of the spectra of the signals. From these observations we conclude that in 40Gb/s DWDM transmission system CSRZ turns to be a better modulation format for enhanced quality of optical signal and it may be better suited for future DWDM system with enhanced capacity.

![Fig:4](image1.png)  
Fig:4 Eye-diagram for (a) Run 1-0Km, (b) Run 2-10Km, (c) Run 3 - 20Km (d) Run 4-40Km

![Fig : 5](image2.png)  
Fig : 5 (a-d) Variations of Q-factor (a), Eye-opening (b), BER (c) and Jitter (d) with respect to fiber length
4. Conclusions

We have seen the performance of the 40Gb/s based DWM transmission system with CSRZ modulation format. Also we have observed the various important parameters for the CSRZ modulation format. We conclude that CSRZ based modulation format turns out to be better modulation format for DWMD based system for enhanced capacity.

References:


