AN ETALON-BASED TUNABLE DISPERSION COMPENSATOR (TDC) DEVICE FOR 40-GBIT/S APPLICATIONS

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Abstract *A tunable dispersion compensator device, based on thin film multicavity etalons, with +/-200 ps/nm continuous tuning range over the entire C-band and low group delay ripple has been used in single channel experiments at 40 Gb/s with different modulation formats.*

Introduction

As the individual bit rate per channel in WDM systems increases to 40 Gb/s, a tailored chromatic dispersion compensation scheme, that can also accommodate dispersion slope, is clearly needed.

A variety of tunable dispersion compensator devices have been reported, including ring resonator all pass filters [1], fibre Bragg gratings [2], virtual phased arrays [3] and planar waveguides [4] among others. While some have looked promising, issues such as high group delay ripple and insertion loss still limit their performance. Moreover, few include operation at 40 Gb/s with the channel bandwidth utilization required to support advanced modulation formats [1,4]. Recently [5] we reported a novel multi-channel all-pass etalon based tunable dispersion compensator suitable for 10Gb/s applications.

Here we extend that work on an enhanced device with system performance results at 40Gb/s, using different modulation schemes including non-return-to-zero (NRZ), return-to-zero (RZ), and carrier-suppressed return-to-zero (CS-RZ), and therefore different channel bandwidth utilization. This TDC device can operate on all channels on a 200GHz grid over the entire C-band (the free spectral range (FSR) is 200GHz) and has low group delay ripple (GDR). The optical bandwidth, determined by the GDR, is 80GHz, wide enough to adapt to significant signal frequency detuning, with only limited power penalty.

Etalon-based TDC

The operational principle of the TDC device has been described elsewhere [5]. Briefly, it consists of concatenating two different types of multicavity all-pass etalons, designed to have equal and opposite linearly varying dispersions over a each channel so that when both are combined there is a region where the slopes cancel and the dispersion is constant, determined by the relative spectral shift of the two etalons, which we control thermally. The device reported here has a tuning range of +/– 200ps/nm, an insertion loss better than 5 dB and group delay ripple (GDR) less than +/- 5ps over the full tuning range, frequency range (192-196 THz) and bandwidth over 80 GHz. The tuning range scales linearly with the number of reflections and other scaling rules have been discussed in [5]. Figure 1 shows the group delay ripple as a function of the dispersion setting for 3 channels over the C-band obtained by subtracting a linear fit of the measured group delay over the 80GHz bandwidth.

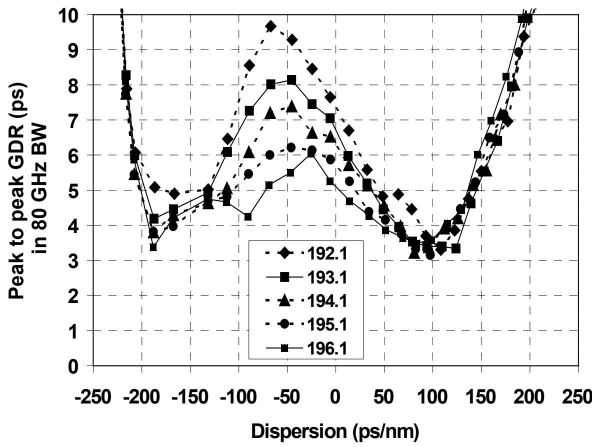

Figure 1. Measured peak to peak group delay ripple vs. dispersion setting for various channels (THz).

Experimental Results

Using a tunable laser, externally modulated at 40 Gb/s with NRZ, RZ or CSRZ pattern (PRBS, 2^{31}-1), the TDC was tested in a back-to-back configuration and then used as post compensator, after transmission through fibre. A receiver detected the signal, after being optically demultiplexed, for bit-error-rate (BER) measurements. For the baseline, in order to improve receiver sensitivity, the TDC was set with a “residual dispersion value” for NRZ (-45 ps/nm) and 33%RZ (– 5ps/nm), while none was needed for CSRZ. By detuning the transmitter wavelength within +/- 10 GHz from the channel center frequency, we measured the eye diagrams and the bit-error-rates as displayed in Figs.2 (a)-(c), indicating no significant power penalties when compared to the baseline.

To test for dispersion compensation in actual fiber transmission, we did an experiment with 25 km of single mode fiber. with an accumulated +100 ps/nm of chromatic dispersion at 1550nm.

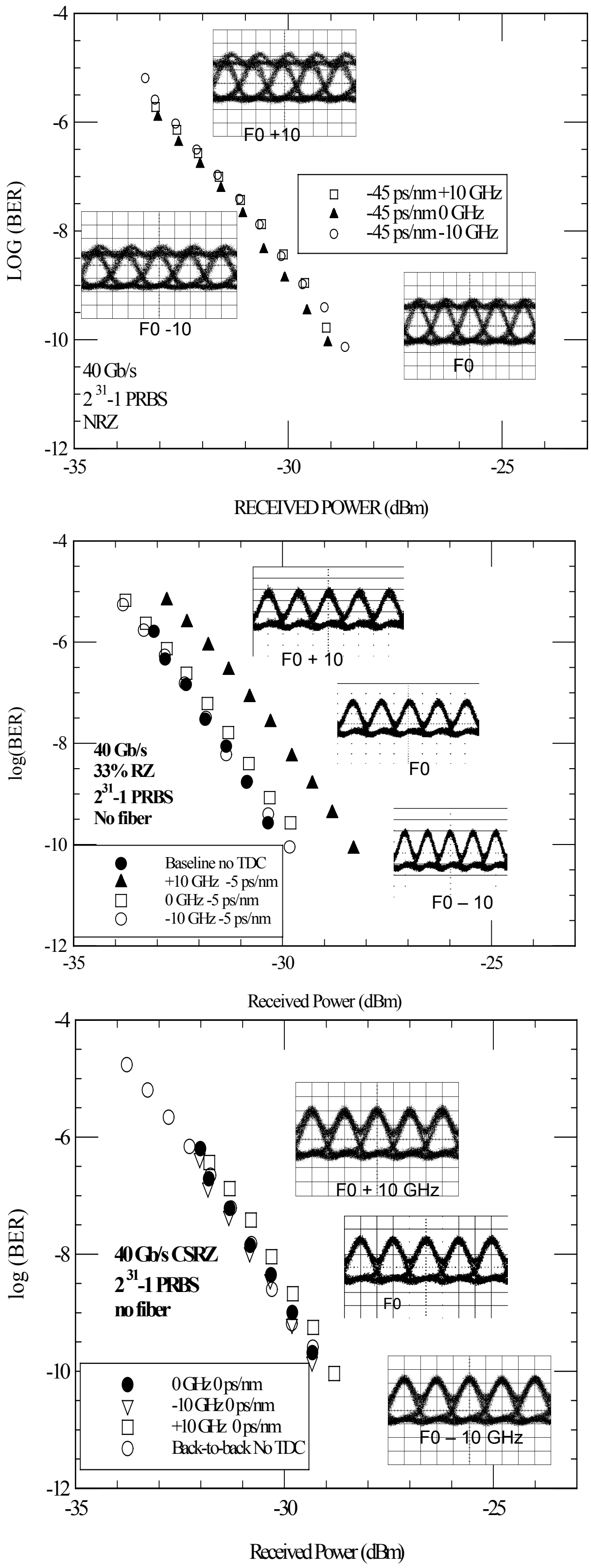

Figure 2. Measured bit-error-rate with center wavelength (193.5 THz or 1549.32 nm) detuning with the TDC set to (a) (top) -45 ps/nm (NRZ), (b) (center) –5 ps/nm (RZ) and (c) (bottom) 0 ps/nm (CSRZ).

To test in system-like conditions, we performed two fiber transmission experiments (950 m of dispersion compensation fiber (DCM) and 25 km non-zero dispersion shifted fibre (NZDSF), with an accumulated dispersion of –90 and +100 ps/nm at 1550 nm, respectively). Figure 3 (a,b) shows the measured bit-error-rates at 40Gb/s CSRZ modulation for both cases, with a penalty better than 1.5dB compared to the baseline, at BER=10^{-9}. For reference, the insets display the complete eye closure (no TDC), and restored with the TDC.

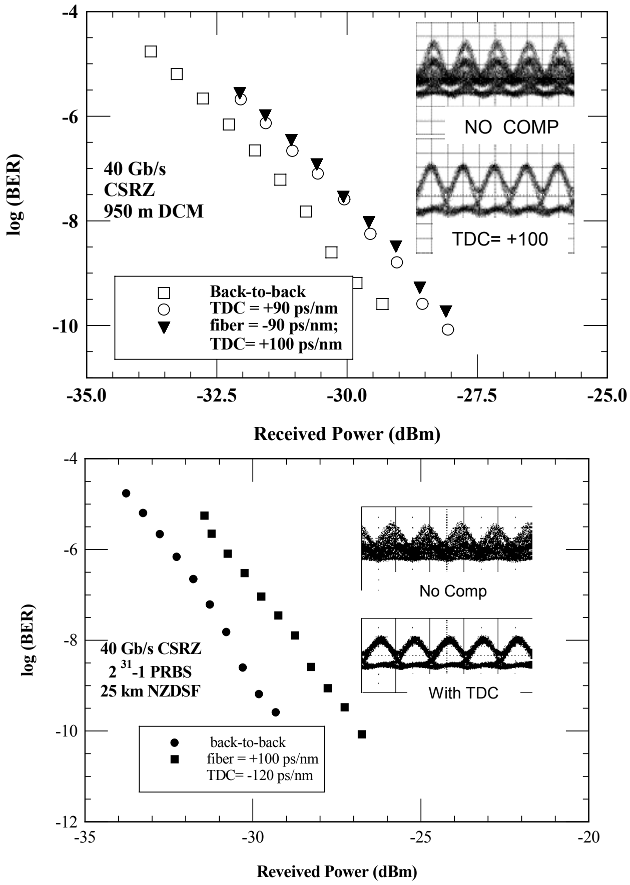

Figure 3. Measured bit-error-rates for 1549.32 nm: top (950m DCF) and bottom (25 km SMF) while the insets display the eye diagrams with and without the TDC. The left curve is the baseline.

Summary

In conclusion, we demonstrated a multichannel all-pass etalon tunable dispersion compensator (TDC), operating at 40 Gb/s, for NRZ, RZ and CSRZ modulation formats. Fibre transmission results have been presented as well.

References

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