

## Managing Chromatic Dispersion in 100G DWDM PAM4 Links with the ClearSpectrum™ TDCMX-SM



**For dense wavelength-division multiplexing DWDM links below 80 km, 100G PAM4 offers reduced cost, lower power consumption and smaller footprint than conventional coherent transceivers, but at the cost of having to accurately manage chromatic dispersion (CD).** Far from a showstopper, we will see that compensating CD in PAM4 links is quite simple and demonstrate this by drawing examples from two applications: DWDM 100G PAM4-only transmission and multi-rate transmission supporting a mix of data rates.

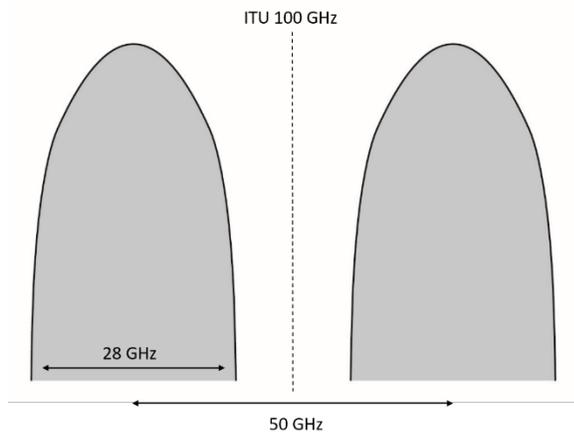
When transmitted beyond a few kilometers, 100G DWDM PAM4 requires accurate optical CD compensation; the tolerance of the receivers is in the order of  $\pm 100$  ps/nm. CD has been managed effectively for many years in long-haul direct-detect systems before the advent of coherent solutions. Tunable dispersion compensation modules (TDCM) based on fiber Bragg grating or etalon technology have been deployed for this purpose in the hundreds of thousands of units. In this application note, we will focus on fiber Bragg gratings to show how easy CD can be managed for 100G PAM4 and multi-rate applications.

### 100G DWDM PAM4-only transmission

Using 100G DWDM PAM4 is a great way to minimize the cost per bit ratio of a link, as it is possible to reach up to 4 Tb/s in a single fiber, with a CAPEX and OPEX friendly solution. It has been successfully deployed, namely in Data Center Interconnect (DCI), enterprise networks and mobile access applications.

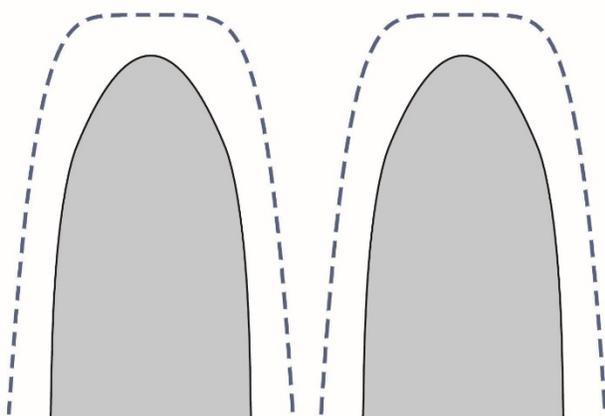
Commercially-available 100G DWDM PAM4 transceivers, such as Inphi ColorZ®, use two subcarriers transmitting at 28 Gbaud/s, both offset 25 GHz from the center frequency of an ITU 100GHz channel. While it is intuitive to set out looking for a single-part CD solution centered on the 100GHz ITU grid which would transmit both subcarriers in a superchannel up to a compensation level equivalent to 80 km, no such module exists yet.

However, there is another solution: using a single 50 GHz-spaced TDCM having its channel grid offset by 25 GHz, so that its channels are centered on each subcarrier, as shown in Figure 1. To work, the TDCM needs to provide at least 28 GHz of bandwidth at all compensation levels, to avoid spectrally clipping any part of the signal.



**Figure 1: PAM4 subcarriers location compared to the 100 GHz ITU grid**

In its 50 GHz spacing configuration, TeraXion’s TDCMX-SM is perfectly adapted to 100G DWDM PAM4 since it provides a bandwidth of 30 GHz and a tuning range covering 0 to 80 km, as shown in Figure 2. With this single, marker-sized module, it is also possible to actively offset the grid by  $\pm 30$  GHz and to maximize optical signal-to-noise ratio (OSNR) thanks to its low insertion loss.



**Figure 2: PAM4 subcarriers transmitted through 50 GHz TDCMX-SM**

#### Multi-rate transmission up to 80 km

Multi-rate transmission consists in transmitting different signal types, like 10G, 25G, 100G PAM4/coherent and 400G, through the same DWDM line system. This makes for flexible and future-proof networks.

#### About FBG-Based TDCMs

Fiber Bragg grating-based TDCMs are small opto-electronic modules that use fiber Bragg grating (FBG) mirrors written within the core of optical fiber to correct for the chromatic dispersion that accrues with the distance when light travels in an optical fiber.

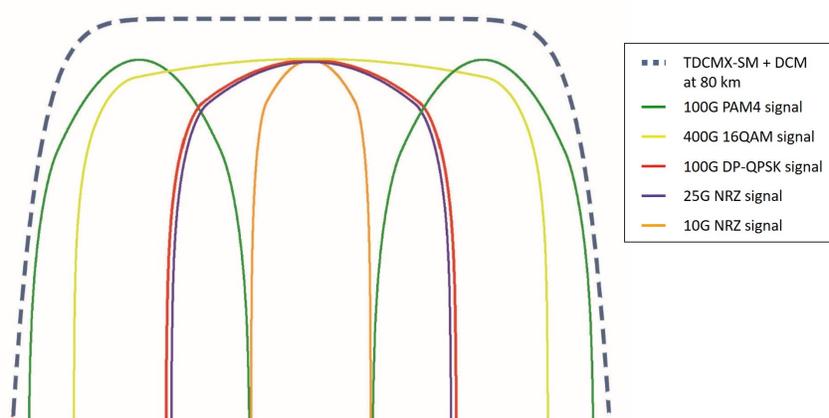
There are two kinds of FBG-based TDCMs: single-channel and multi-channel, the latter of which simultaneously compensate dispersion on every channel of the C-band. Multi-channel devices can offer either flat dispersion compensation (the same dispersion value for every channel) or dispersion compensation matched to the dispersion slope of the transmission fiber, which minimizes the differential residual dispersion at the receiver’s end.

Unlike other fiber-based CD compensation solutions, FBG-based TDCMs are made with only a short span of optical fiber, for a small footprint. This also contributes to their low insertion loss, typically in the range of 5.5 dB, which minimizes their impact on the system optical signal-to-noise ratio (OSNR).

In the last 20 years, fiber Bragg gratings have been made in the hundreds of thousands of units using a simple, repeatable manufacturing process, making them both procurable and highly reliable in the field.

Extra attention should be paid to the selection of the TDCM for multi-rate line systems, because it must not interfere with the transmission of the different signals, some of which are centered on the ITU grid, and some offset.

TeraXion's 100 GHz-spacing TDCMX-SM provides a bandwidth of 68 GHz up to 40 km, which is sufficiently large to transmit the 100G PAM4 subcarriers and 400G. To reach 80 km, it is possible to cascade a wide-bandwidth fixed DCM to get the results shown in Figure 3.



**Figure 3: Multiple signals transmitted through a TDCM+DCM cascade, at 80km**

Compensating chromatic dispersion on the physical layer with the TDCMX-SM is simple and enables the use of cost-effective, high data rate direct-detect solutions such as 100G PAM4 in longer links. The TDCMX-SM is a small, easy-to-integrate module perfectly adapted to meet the needs of high data rate direct-detect transmission up to 80 km.

#### For more information

For questions, specific requirements or to learn more about TeraXion's products, contact us at [info@teraxion.com](mailto:info@teraxion.com)

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