PMD and CD Testing—How Far Can We Go?

Francis Audet, Sr. Product Manager, EXFO
Philip Pilgrim, Submarine Transmission Specialist, Hibernia Atlantic

By now, we all know that dispersion is a major cause of signal degradation, making it extremely important to test for both polarization mode dispersion (PMD) and chromatic dispersion (CD) in order to maintain optimum transmission performance. As current networks become increasingly larger, one of the greatest challenges in testing these phenomena has been distance. This, however, is changing.

We recently had the opportunity to test a transatlantic network for both PMD and CD, using our FTB-5500B PMD Analyzer and our FTB-5800 CD Analyzer. The link–a DWDM system capable of transmitting up to 3.84 Tb/s–was owned and operated by Hibernia Atlantic in Ireland.

Prior to this, the longest distances tested with these instruments were 844 km with the PMD analyzer, and around 1200 km with the CD analyzer. This time, the total link distance was approximately 5500 km, and the link included 121 EDFAs altogether. To give you an idea of how far that is, when we conducted the testing, the PMD and CD analyzers were set up in Europe, while the light source (FLS-5803) was based in Canada.

This opportunity was therefore very interesting as it gave us the chance to write yet another chapter in the fiber-optics history book. Below is a brief description of how the tests were performed.

PMD TEST: SETUP AND RESULTS

Since the FTB-5500B PMD Analyzer tests in less than five seconds and there are very few parameters to adjust, the PMD test was performed first. The test setup could briefly be described as follows:

- The FLS-5800 was plugged into the system (the source is polarized at around 95%).
- A polarizer was added to ensure the highest possible degree of polarization.
- Two polarization scramblers were added (one at the input, the other at the output).
- Two variable attenuators were added.
- The setup's output power was adjusted at –10 dBm with a power meter.

As PMD is dependent on the input state of polarization, adding the scramblers allows the measurement to cover as many input/output states of polarization (SOPs) combinations as possible. In addition, since these networks are extremely sensitive to input power, we wanted to avoid saturation of any of the EDFAs, which could have resulted in odd transmission behavior. By adding the variable attenuators and adjusting the power flowing into the network, potential saturation of the first EDFA and receiver was prevented.

One easy way to validate if the signal received in Europe was usable or not was to test it with an OSA and a polarizer. Since differential group delay (DGD) is wavelength-dependent, a smooth curve on the OSA would mean that only amplified spontaneous emission (ASE) noise reaches the receiver. Conversely, artifacts on the curve mean that part of the polarized (thus usable) signal was getting through (see Figure 2). Here are a few OSA screen shots of tests performed with and without the polarizer.

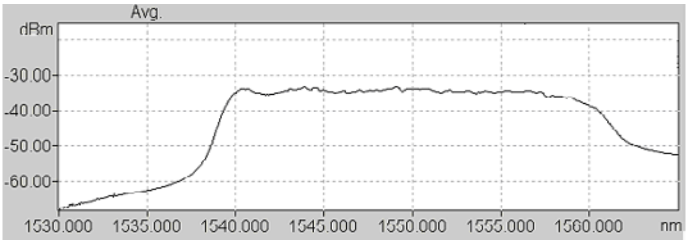

Figure 1. OSA trace without the polarizer before the OSA.

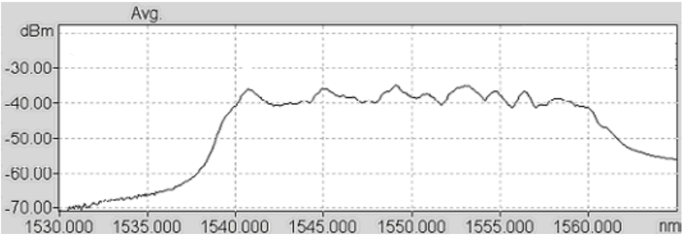

Figure 2. OSA trace with polarizer before the OSA. The artifacts on the curve prove that the signal contains PMD info and is therefore usable for the FTB-5500B.

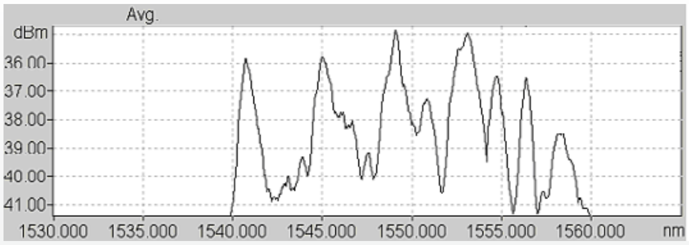

Figure 3. Signal-to-noise ratio (with the polarizer) over 6 dB makes PMD measurement possible.

As can be seen from Figure 3 above, the zoomed trace shows a signal-to-noise ratio (SNR) well above 6 dB between the useful signal and the ASE noise—this is more than enough for the FTB-5500B to take reliable PMD measurements.

A series of 96 tests was performed (the FTB-5500B can be set so these tests are done automatically) with polarization scramblers at both ends to have a full polarimetric analysis of the network (comparable to the PSA method). Then, the scramblers were removed and another series of 96 tests was launched (thus analyzing at a single state of polarization). Lastly, the polarizer was removed using the FLS-5800 source as is, and a final series of 96 tests was carried out.

The averaged results of the PMD values obtained with the source alone were well within the standard deviation of the series of tests with scrambled polarization, proving that the results were good and reliable.

PMD values of around 5 ps showed tremendous fiber quality and proved to Hibernia Atlantic that the system was totally future-proof.

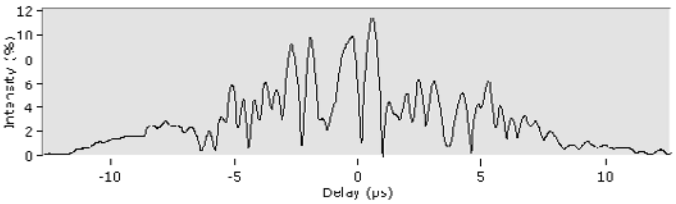

Figure 4. Interferogram of one of the tests described above.

The three tests described above were then redone but, this time, with different PMD emulators (of known values) between the network and the analyzer. The fact that these averaged results turned out to be the exact value expected (quadratic sum of network PMD and emulator PMD) proves that we were indeed measuring the true PMD, not some random value. This confirms that the FTB-5500B is truly independent of source shape and can easily, without any complicated setup, measure through a series of EDFAs. The important parameters to adjust are input and output power so that the analyzer and EDFA are not saturated.

CD TEST: SETUP AND RESULTS

As CD is not statistical, this setup was much more straightforward. Like the PMD setup, the source and a variable attenuator were placed at one end to maximize input power in the network while avoiding EDFA saturation. The receiver was placed at the other end (along with another variable attenuator to prevent it from being saturated).

In addition, launching and exit dispersion-compensating fibers were bypassed to avoid unnecessary attenuation and degradation of SNR. Optimum power was easy to find because the FTB-5800 CD Analyzer displayed messages indicating that the analyzer was saturating, while noisy points were proof of over-attenuation.

Since the FTB-5800 has the capability of adjusting averaging time to improve SNR, this gave us a second tool to optimize the test (in addition to the variable attenuator). The source sends a modulated signal (at 100 MHz), with a power modulation of about 95%, which is detected by the analyzer. With each EDFA adding non-modulated ASE noise, the ratio between the modulated signal and non-modulated signal decreases, thus reducing the SNR. After so many EDFAs, the SNR was extremely low, but the modulated signal was still strong enough to be detected. Tests were conducted with an averaging of 30 seconds per point to increase SNR. A series of 20 tests were performed to check repeatability.

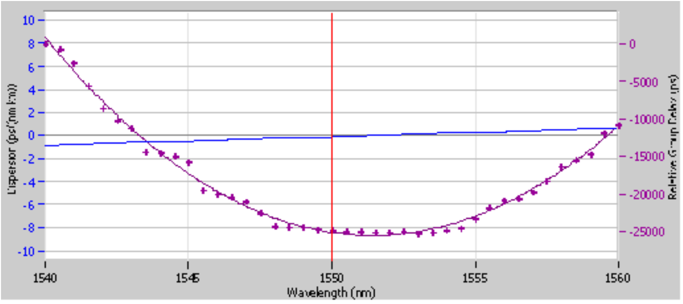

Figure 5. CD measurement of one of the tests described above.

Averaging several tests confirmed the shape and dispersion values. The odd wobbling shape in the RGD curve is produced in part due to the amount of gain-flattening filters, EDFAs, gain-equalization units and high-loss loopbacks that contain their own CD.

Then, a known DUT was inserted into the link being tested, and another series of 20 tests were conducted. The sum of the obtained CD value of the network, plus the known CD value of the DUT, was subtracted from the total network CD value found earlier. This, once again, resulted in the expected CD value of the DUT. At 1550 nm, the difference between both tests was slightly over 400 ps/nm (higher at 1560 nm and lower at 1540 nm), which was expected considering 25 km of G.652-type fiber was being used.

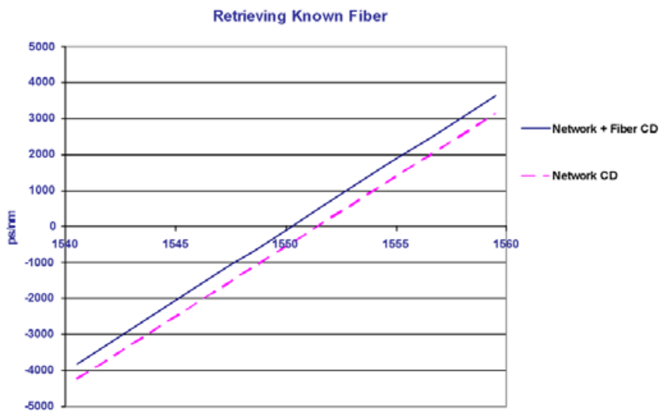

Figure 6. Test on the network with and without known DUT.

The FTB-5800 is truly capable of measuring through long series of EDFAs without a complicated setup. As mentioned, the key parameters are input and output power; the idea is to optimize power without saturating the EDFA or analyzer.

Thanks to these tests, Hibernia Atlantic is well-prepared for high-bit-rate error-free transmission across the ocean. Of course, being able to test such links is impressive, but keep in mind that both the PMD Analyzer and CD Analyzer are also perfect matches for standard metro and long-haul applications.

EXFO Corporate Headquarters > 400 Godin Avenue, Quebec City (Quebec) G1M 2K2 CANADA | Tel.: +1 418 683-0211 | Fax: +1 418 683-2170 | info@EXFO.com

Toll-free: +1 800 663-3936 (USA and Canada) | www.EXFO.com

EXFO America	3701 Plano Parkway, Suite 160	Plano, TX 75075 USA	Tel.: +1 800 663-3936	Fax: +1 972 836-0164
EXFO Asia	100 Beach Road, #22-01/03 Shaw Tower	SINGAPORE 189702	Tel.: +65 6333 8241	Fax: +65 6333 8242
EXFO China	36 North, 3rd Ring Road East, Dongcheng District Room 1207, Tower C, Global Trade Center	Beijing 100013 P. R. CHINA	Tel.: + 86 10 5825 7755	Fax: +86 10 5825 7722
EXFO Europe	Omega Enterprise Park, Electron Way	Chandlers Ford, Hampshire S053 4SE ENGLAND	Tel.: +44 2380 246810	Fax: +44 2380 246801
EXFO NetHawk	Elektroniikkatie 2	FI-90590 Oulu, FINLAND	Tel.: +358 (0)403 010 300	Fax: +358 (0)8 564 5203
EXFO Service Assurance	270 Billerica Road	Chelmsford, MA 01824 USA	Tel.: +1 978 367-5600	Fax: +1 978 367-5700

Printed in Canada 11/04

Assessing Next-Gen Networks