

CD500 Chromatic Dispersion & PMD measurement system

NEW



Continued innovation and investment at **PE.fiberoptics** has yielded yet another major

improvement in the series of CD and PMD measurement systems that began with the CD3 and happily continues with the CD500-PMD.

New from-the-ground-up DSP and detection technology reduces measurement noise and greatly improves measurement speed.

All internal modular subassemblies employ TWI/I²C and RS485 technology, enabling comprehensive control over every aspect of system operation including temperatures, resulting in greatly enhanced stability.

Considerable investment has been made in the programming to control the system. **PE.fiberoptics'** latest controller package 'PECON' has been built on the Microsoft® .Net Framework which has resulted in an all-new software package that maintains our philosophy of simplicity, stability and user friendliness, whilst adding powerful features such as an all-new Report Designer.

- All New Design
- Chromatic Dispersion by Differential Phase Shift
- HIGH SPEED PMD by Fixed Analyzer & FFT
- Fully IEC, TIA and ITU compliant
- Dispersion in around 10 seconds
- PMD in around 10 seconds
- New operating software 'PECON' is Windows 8™ compatible
- PECON is built on the Microsoft® .NET Framework
- Built-in Report Designer
- Additional measurement options

PE.fiberoptics

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Chromatic Dispersion is where we started way back in the early 1980s. Whilst our name has changed a couple of times in the intervening years, one constant is the reputation we have as the leading supplier of Chromatic Dispersion test equipment to fiber and cable factories.

We first released the CD3 in 1986, and our aim was to provide the most accurate and stable Dispersion measurements without compromise, this we achieved, but we haven't rested; user feedback and technology advancements have enabled us to continually improve our designs and when the time was right, release new versions of the product.

The CD400 was released in 1997 and instantly became the standard against which other Dispersion testers were compared. The CD400 became the platform around which we developed a series of instruments that enabled measurement of parameters such as Spectral Attenuation, Cutoff Wavelength, Mode Field Diameter, Numerical Aperture, Effective Area, Hydrogen Aging and others...12 years have passed, and we have decided that it is now time to release our latest generation of measurement systems.

The **CD500-PMD** Chromatic Dispersion and Polarization Mode Dispersion measurement system is the result of 27 years of continued learning and development and takes advantage of the latest technology in electronics, optics, and software to deliver what we consider to be our best offering to date.

It is not an understatement to say that we have delivered a step change in measurement performance by delivering the speed of measurement demanded in today's competitive fiber manufacturing environment whilst still improving the accuracy and stability we are so well known for.

The **CD500** Chromatic Dispersion measurement system uses the patented and well established Differential Phase Shift method with our unique Double Demodulation technique to quickly and reliably measure the Phase Change with Wavelength that is Chromatic Dispersion.

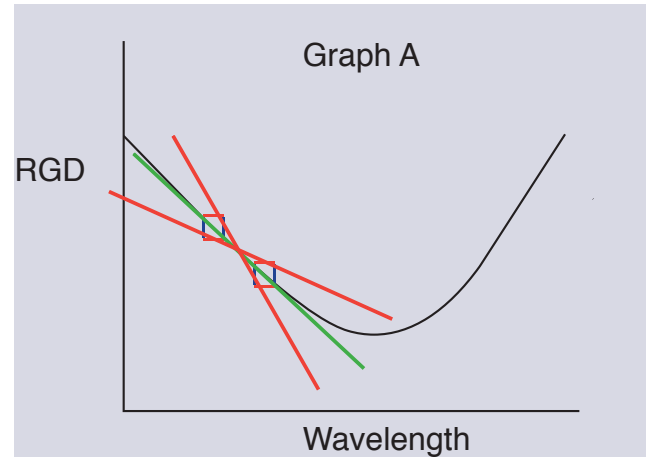
The **CD500** uses a temperature controlled solid state monochromator giving high precision and fast wavelength setting with zero hysteresis. Also, there is no degradation in these characteristics caused by its continuous use, unlike mechanical alternatives.

Using the latest in TWI/I²C & RS485 technology, the **CD500** maintains constant watch over every module and component ensuring the temperature stability that is required to maintain the reproducibility that is the hallmark of **PE.fiberoptics'** products.

$$\text{Chromatic Dispersion} = \frac{\Delta\tau}{\Delta\lambda}$$

A Chromatic Dispersion test system needs to determine two things, $\Delta\tau$ and $\Delta\lambda$. Usually, the instrument will set the change in wavelength $\Delta\lambda$ and then determine the corresponding change in time or $\Delta\tau$, Dispersion simply being $\Delta\tau/\Delta\lambda$. It sounds simple, but the technology required to do this well is complex and requires care in its design

As shown in Graph A, inaccuracy, noise, or drift in either the setting of the wavelength λ or the detection of change in time $\Delta\tau$ RGD(Relative Group Delay) will result



in both inaccurate and unpredictable results. The red lines showing an exaggerated effect of differentiating the data at the limits of the error boxes.

$\Delta\lambda$ Solid State✓ V Mechanical✗

Inaccuracy, noise, and drift in setting the wavelength usually come from the designer using a mechanical method such as a stepper/gear driven grating monochromator.

The **CD500** uses a temperature stabilized solid state monochromator (SSM) driven by a digitally derived RF frequency signal that allows the wavelength to be set and maintained with picometer precision and stability.

$\Delta\tau$ Digital DSP✓ V Analog✗

Inaccuracy, noise, and drift in determining $\Delta\tau$ usually comes from the designer using analog lock-in phase measurement technology which is inherently prone to drift, this coupled with noisy APD type detectors results in poor phase difference measurements.

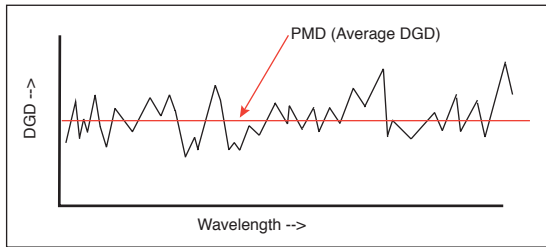
The **CD500** uses a numerical/digital approach to the measurement of $\Delta\tau$ and employs the latest in DSP technology to yield fast, low noise drift free $\Delta\tau$ results, this coupled with using non APD detection technology keeps noise and nonlinearity low.

Polarization Mode Dispersion

Polarization Mode Dispersion (PMD) is the second characteristic of the fiber that directly influences its data carrying capacity but unlike Chromatic Dispersion, it is not a linear property that can be defined with a single value; it is stochastic in nature and therefore requires test methods that enable a statistical approach that can yield estimates of the PMD value at a given point in time.

The definition of PMD is:-

$PMD \cong \text{Average(DGD)}$ for a given spectral range.



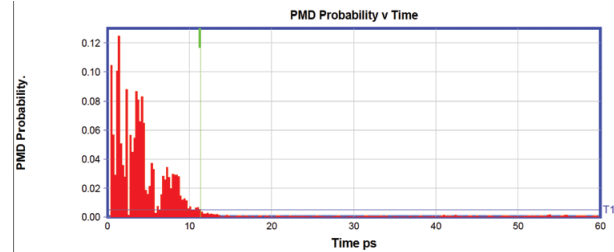
There exist several different methods to estimate the value and range of PMD, and all claim to have advantages over one another, but in reality all the methods give a best estimate with uncertainty ranges that are similar. The real choice for a PMD tester will be based upon its suitability for given environmental and attenuation conditions. Certain methods are suitable for testing long links in field installations while others are suited to testing short fibers in factory and laboratory situations.

The **CD500-PMD** has been designed to fulfill the needs of testing short lengths in cable factories and standard spool lengths in fiber factories. With PMD in fibers getting ever lower, the ability of a system to test PMD down to very small values becomes critical, and the **CD500-PMD** is better at this than any other solution. Unlike other systems that use mathematics and subtraction to estimate very small values, the **CD500-PMD** uses a very novel technique to actually measure what is happening to the light in the fiber and therefore pushes its 'MEASUREMENT' range down to an impressive 0.005ps.

Classic PMD measurement systems such as those using the Interferometric method rely on the polarized light being de-polarized by the PMD in the fiber in order to work correctly as is the case when the PMD value is larger than the coherence length of the light source being used. When the PMD is very low however, the light still maintains its high level of polarization resulting in higher uncertainties from the interferometer.

The **CD500-PMD** uses the fixed analyzer method that analyses how the polarization state rotates with changing wavelength; an effect caused by the birefringence in the fiber; the source of PMD. When the PMD is at nominally normal levels, the polarization can rotate several times over the scanned spectrum, and it is then easy to pass the resulting spectral data through a FFT to convert from

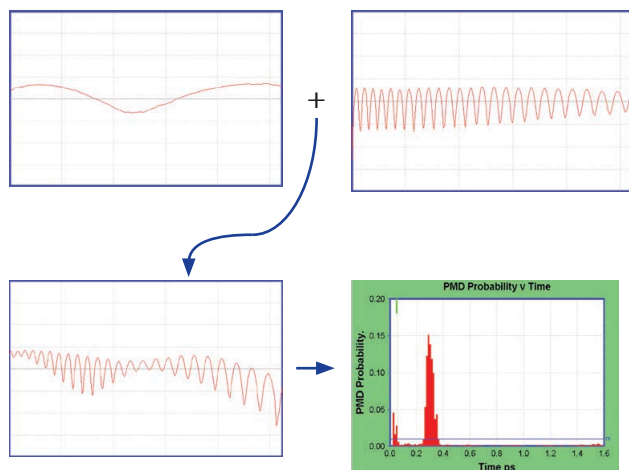
the Frequency to Time domain and directly yield the histogram that shows the distribution of different delay (DGD) in the measurement; the Graphs below showing this process. As the definition of PMD is the average DGD over the measurement spectrum, doing a simple statistical analysis of the histogram finding the second moment of the distribution will deliver the PMD value.



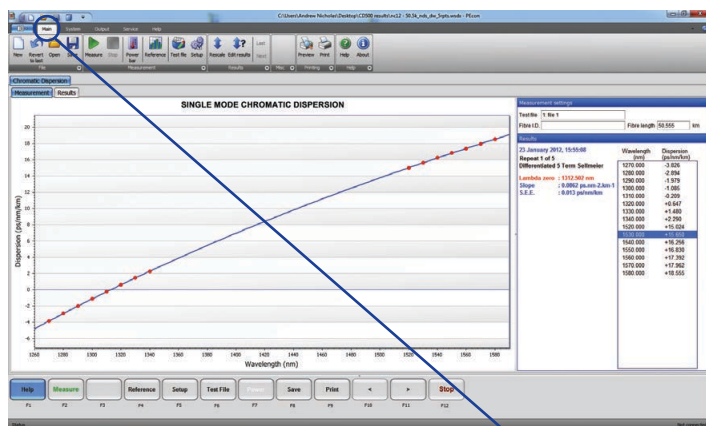
As can be seen from this example, the distribution of DGD is significant and the statistical analysis can be considered valid.

CD500-PMD547

When the PMD is very low and the range of distribution of DGD is very low, statistical processes break down and it is necessary to use a method that is able to cope with this very slowly changing data. Luckily, history in the form of radio transmission and modulation methods have given us a technique called heterodyning, where a higher frequency is mixed with the lower frequency thus shifting the analysis away from the nominal DC part of the frequency spectrum. We can then process this 'shifted' data and then re-subtract the higher frequency to yield the required results. This heterodyning is achieved in the optical domain by using a birefringent crystal that has a known and fixed DGD value that is constant and well defined over the measurement spectrum. This measurement option is known as the **CD500-PMD547**.



PECON Instrument control software.



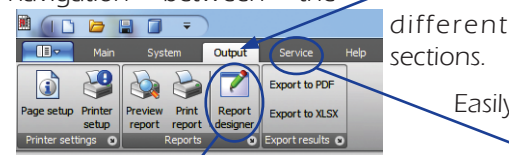
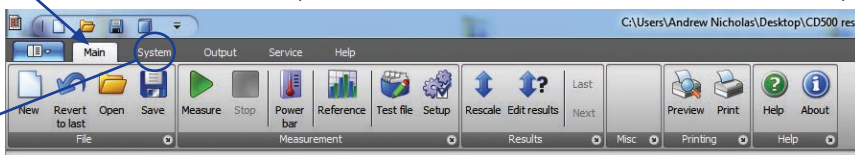
PECON is the name given to a suite of software, designed to support a complete new range of measurement instruments starting with the CD500.

From the beginning, our philosophy has been to keep our product up-to-date with the latest technology whilst still maintaining the ease of use and reliability for which we have come to be known. We believe that with PECON, we have succeeded.

The structure has remained simple, with most common functions being available either from the 12 function keys at the bottom of the screen, or the Ribbon tabs at the top of the screen.

Where possible, menus have been limited to 1 level deep.

Each tabbed Ribbon is configured logically with functions relative to that context being included. Inactive Ribbon tab headers remain visible allowing quick navigation between the



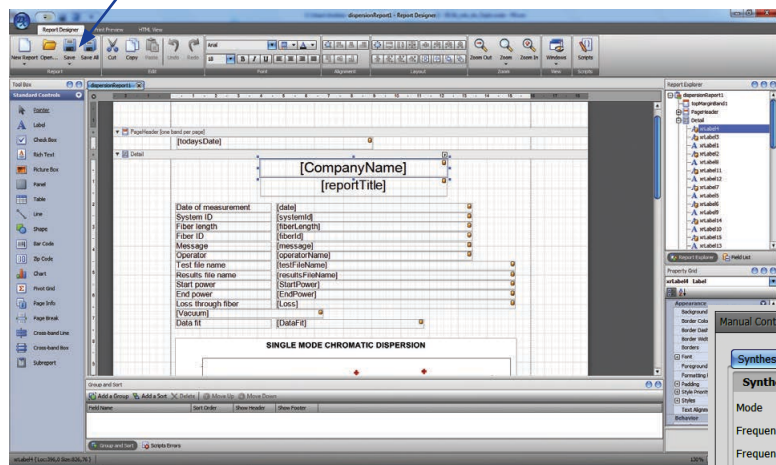
different sections.

Easily the most significant addition to our control software is the Report Editor.

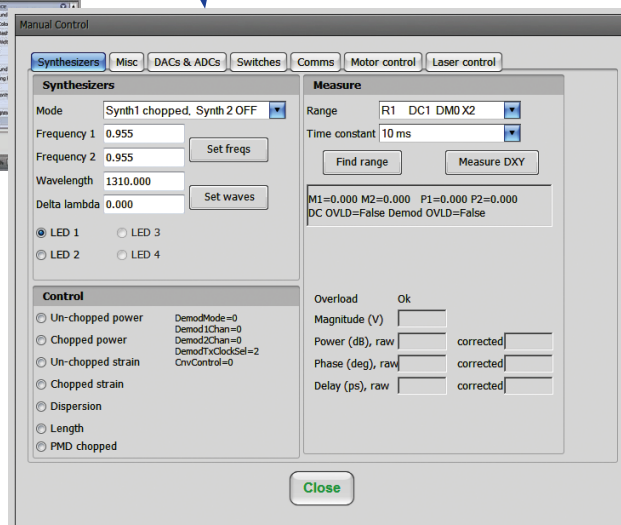
Located in the 'Output' Ribbon tab, the report designer enables for the first time, user definition of what is reported, how it is reported and the layout of that report.

Once defined, the report can be used for printing, converting to PDF, exporting to Excel or HTML, or saving as text/csv files.

Any number of reports can be stored for use as and when required.



Not to be forgotten is the role of support, and in this regard, the software delivers; access to valuable diagnostic tools in the service menu is available for authorised engineers by means of a password.



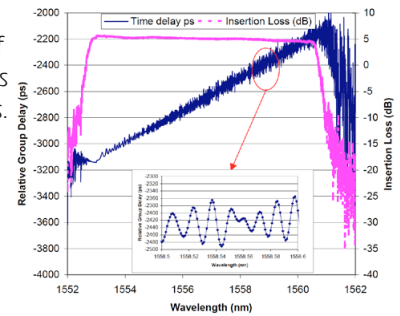
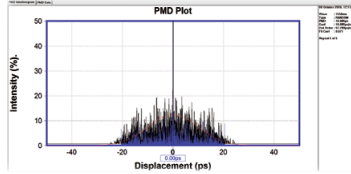
Measurement options, add-Ins and system variations

CD500L Tuneable Laser based CD and PMD. (External Laser)

The CD500L option brings the ultra-high power and narrow spectral output of tuneable Lasers to the CD500, enabling measurement of fibers and components that require such characteristics. The CD500L can support up to 4 tunable sources. This option is also available as an add-on module to the CD500 as the CD550.

PMD500HS Ultimate PMD system.

The PMD500HS is available as a stand alone PMD system offering both a high speed interferometer combined with the fast fixed analyzer as fitted to the CD500. This combination allows measurement of almost any range of PMD from 0.005ps right up to and beyond 100ps with scans of DGD beyond 300ps available.

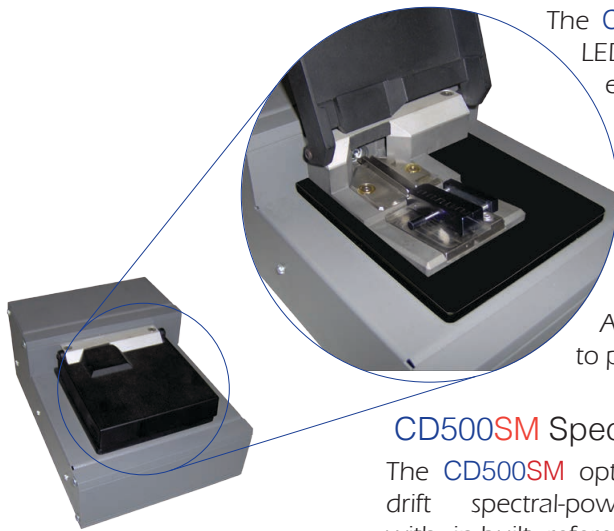


CD500SA Spectral Attenuation. (External detector)

The CD500SA option utilizes the ultra-stable and programmable LED sources and the low noise DSP technology in the CD500 to enable very accurate and repeatable attenuation measurements on both very short and very long fibers and cables, something that alternative systems are unable to do.

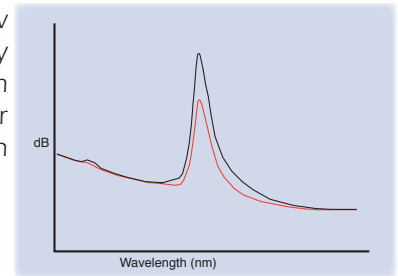
The ultra high High NA optics with no adjustment or optimization required allows fast and easy connection ensuring all the light is captured, resulting in guaranteed accuracy independent of fiber type.

Already well established in SM400A version, this option promises to push the boundaries of test limits even further.



CD500SM Spectral Loss Monitoring.

The CD500SM option offers a low noise low drift spectral-power measurement facility with in-built referencing to enable long term spectral attenuation change measurements for applications such as Hydrogen aging. This option is also available as a stand-alone system SM500



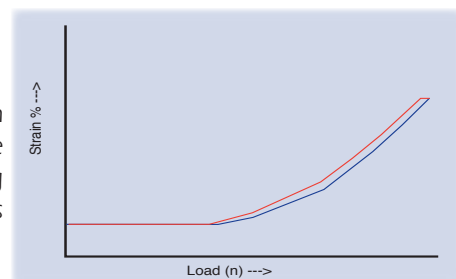
CD516 Multiplexer.

The CD516 options adds a level of automation to everyday testing, allowing measurements to be made on multiple fibers with a single button press.

Measurements that can be automated include Chromatic Dispersion and PMD (CD500), Cable Strain (SPL500), and Spectral Loss Monitoring (CD500SM)

CD509 Cable Strain measurement option.

The CD509 option adds a high stability Strain Power and Length measurement facility with in-built referencing to enable real-time monitoring of the physical and optical conditions of the fiber during mechanical and environmental stressing of the cable. The CD509 is also available as a stand alone system SPL500



Preliminary Specifications

Measurement according to applicable TIA/IEC/ITU recommendations.

Chromatic Dispersion and PMD

Spectral Characteristics*	1310 LED	1550 LED	15/16 LED	Other LEDs available
Chromatic Dispersion	1250 - 1340	1500 - 1600	1520 to 1630	
PMD	1200 to 1650			2 & 3 LED system
Source Spectral width (nm)	<4			
Wavelength increment (nm) (minimum)	0.001			User definable

Measurement speeds**

CD	10 seconds	Typical multipoint scan
PMD	15 seconds	Typical spectral scan

Measurement performance***

	Repeatability	Accuracy	
Chromatic Dispersion (ps/nm.km)	<0.0075	<0.05 or 1.5% +/-0.02	Based on 20 measurements of 25km spool G652 fiber. Accuracies limited by/related to calibration artefact used.
Lambda Zero (nm)	<0.008	<0.2	
Slope at Lambda zero (ps/nm.km^2)	<0.1%	<1.5%	
PMD	0.002ps	<0.02 +/- 1% PMD	Based on 20 measurements of PMD546 0.3ps calibration artefact
Dynamic range	>45dB		LED dependent

CD500 series product datasheet issue 1.0.6

All specifications are typical based on systems using High power CD525 option and subject to improvement or modification without notice or obligation.

* The wavelengths ranges mentioned are nominal and measurement outside these ranges is available however the performance specifications may vary.

** Measurement speeds mentioned are for a nominal measurement configuration and will vary according to the particular setup.

*** Specifications vary dependant on fiber length and type.

Please refer to any formal offers for confirmation of specification.

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This product complies with 21 CFR 1040.10 Class I LED product

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