Application Note 2004-021A

Measuring PDCW, PDBW (Polarization Dependency of Wavelength)

Overview

In passive optical components, when the polarization changes, the Insertion Loss (IL) also changes. This is Polarization Dependent Loss (PDL). In a passive component that has wavelength features, such as an FBG, a filter, or a MUX, there is also a change in the center wavelength as the polarization state changes, or Polarization Dependent Wavelength (PDW). This is sometimes also referred to as Polarization Dependent Center Wavelength (PDCW, or just PDC). The PDW can be measured in two different ways with the CSA, with virtually identical results, but a large difference in the time and difficulty of making the measurement.

This Application Note outlines the two methods of PDW measurement, and the correlation between the two.

Summary

The two methods are All-States, and Matrix. They each provide good measurement accuracy. The Matrix method is much faster and easier to execute, making it the method of choice.

All-States Method

The first of the two methods for measuring PDW is the All-States method, where we run an IL vs. ? sweep, compute the center wavelength, then change the polarization state, and repeat the process for a large number of polarization states. This will lead to excellent measurement results, as long as the number of sweeps is high. For an AWG MUX, variation of 1pm per degree of shift in a half or quarter waveplate is not uncommon. Thus, a very large number of states must be taken to determine the accuracy with much resolution.

PDW accuracy desired	Min step angle	Number of sweeps required	Total Time Manually (mins)	Total Time if Automated
20 pm	20 deg	81	6.8 mins	2.7 mins
10 pm	10 deg	324	27 mins	11 mins
2 pm	2 deg	8100	11 hours	4.5 hours

Figure 1: Approximate time to measure PDW with All-States method on an AWG MUX

It is conceptually possible to write an algorithm that would do an initial sweep, find the local maxima and minima of PDW, then do an optimized search routine for the actual maxima and minima, which would cut this time down. However, the second of the methods results in well-correlated results, and is incredibly fast relative to the all-states method.

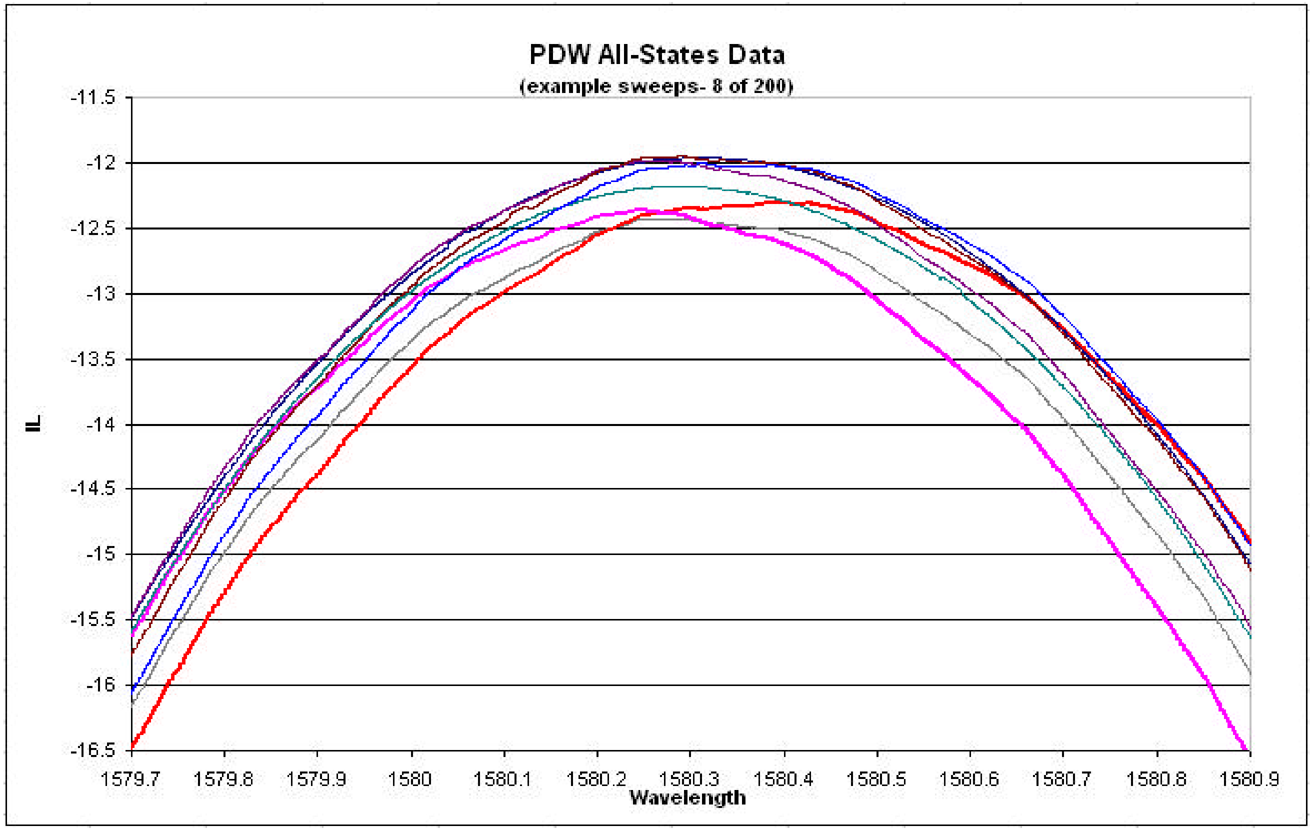


Figure 2: Example sweeps from All-States Method

The PDW varies with polarization state in an undulating manner. The PDW as a function of the states of the half and quarter waveplates can be profiled in 3D as shown below.

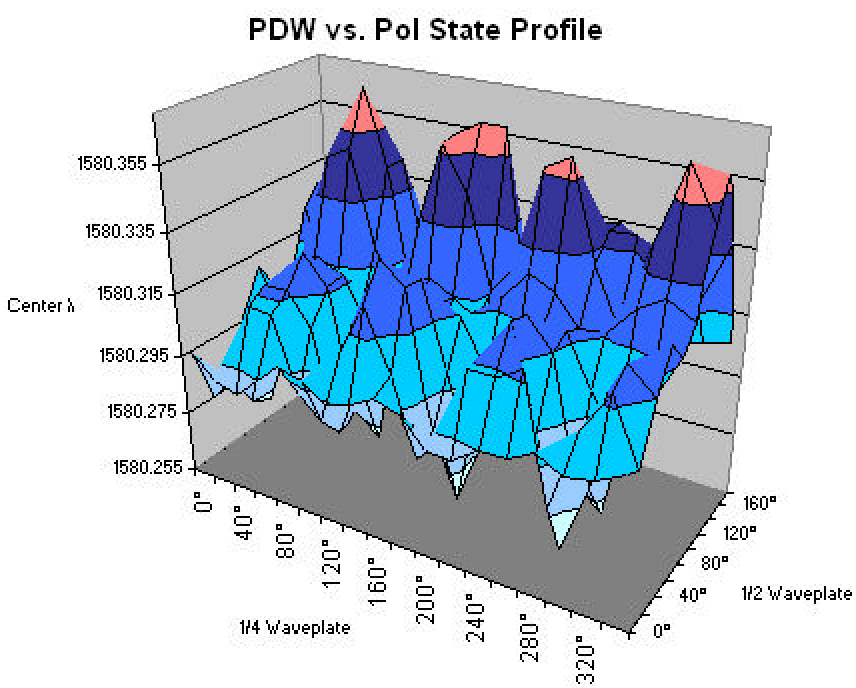


Figure 3: PDW vs. Polarization State Profile

Matrix Method

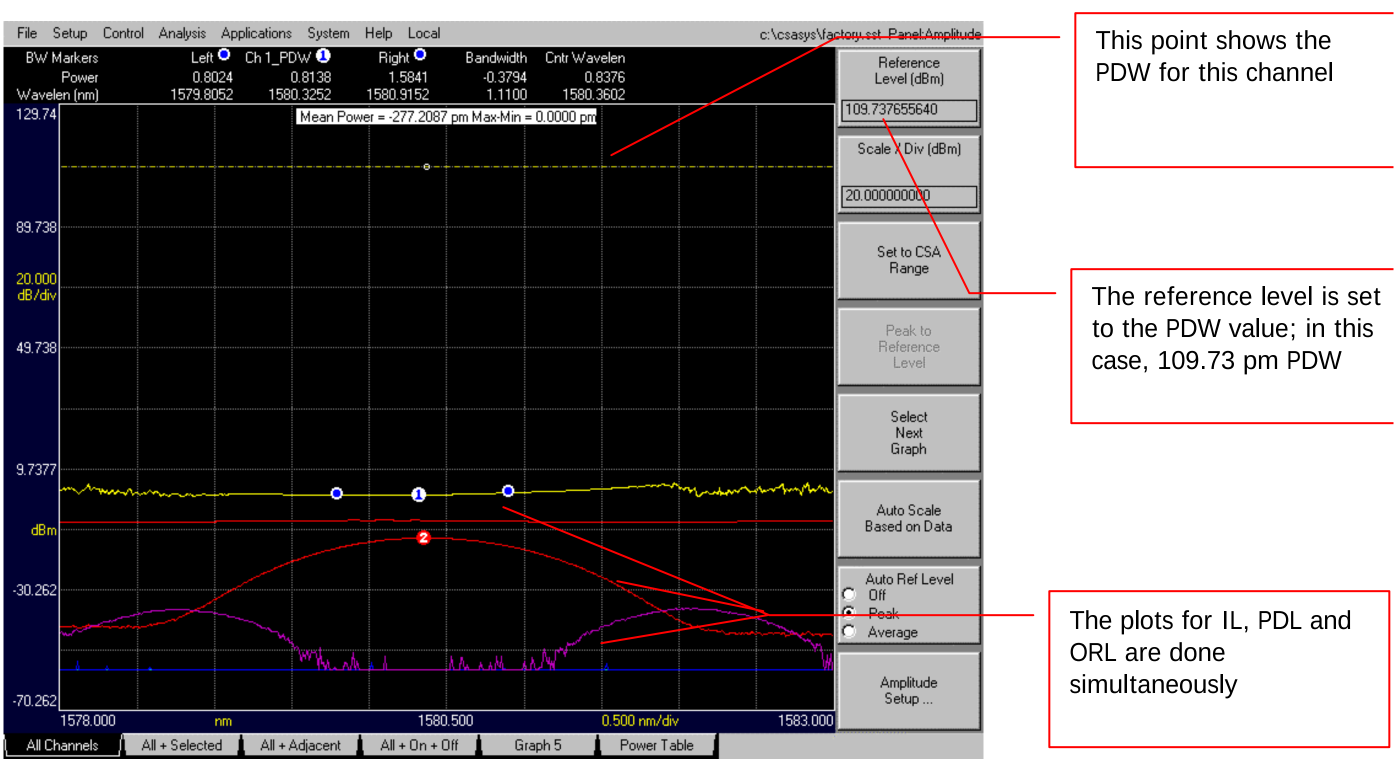
In the Matrix method, we utilize a derivation from the Mueller Matrix to determine the PDW. By determining the highest and lowest center wavelength sweeps from the envelope of the matrix, we can eliminate the localized effects of PDL and ascertain the wavelength effect of polarization state.

The primary advantage of the Matrix method for PDW is speed. Yielding the same results as a large sample size All-States measurement, it takes from 10% to 0.06% of the time the All-States measurement would take. The table below shows the speed of the Matrix Method using the CSA.

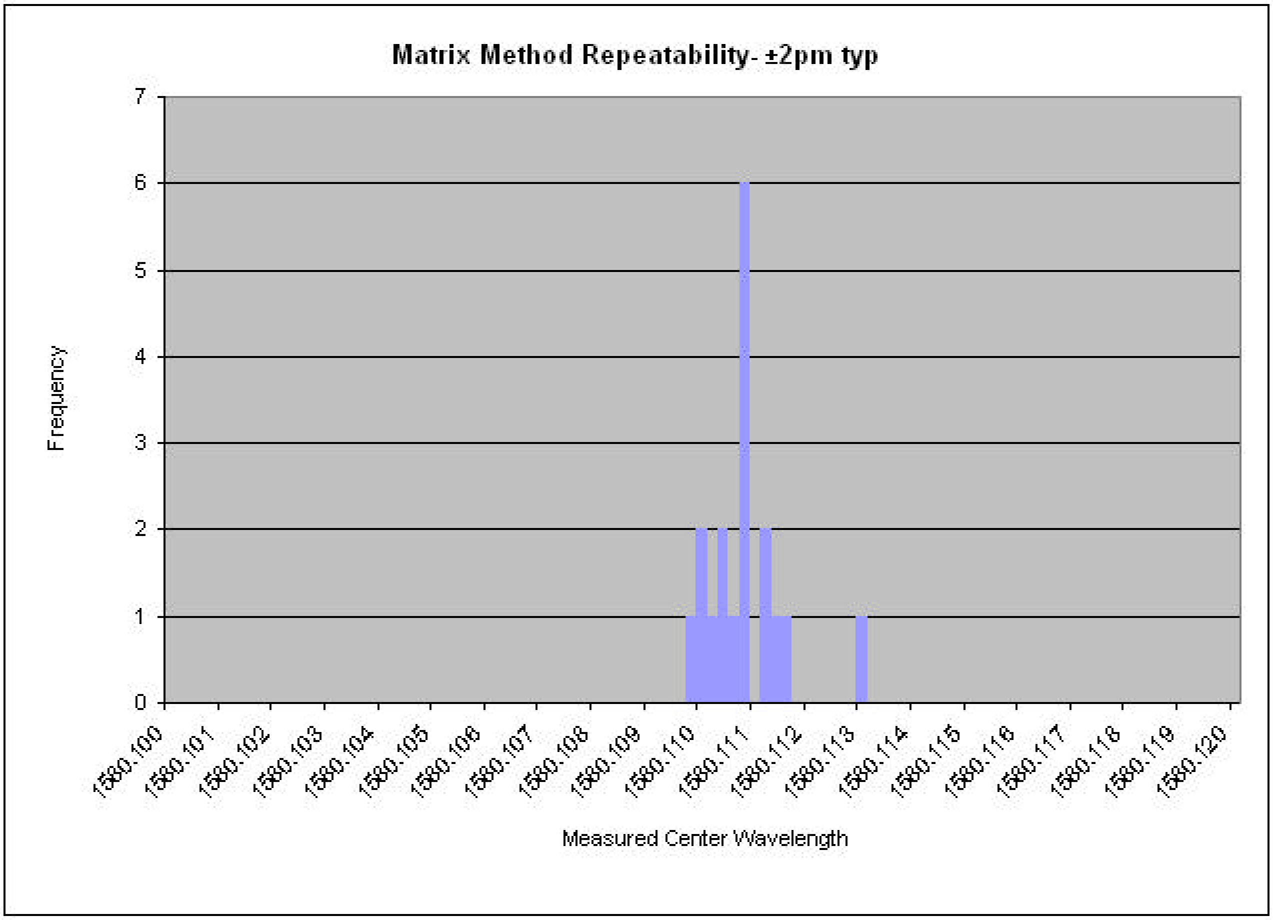
PDW accuracy desired	Min step angle	Number of sweeps required	Total Time Manually (mins)	Total Time if Automated
20 pm	na	4	na	11.3 seconds
10 pm	na	4	na	11.3 seconds
2 pm	na	4	na	11.3 seconds

Figure 1: Approximate time to measure PDW with Matrix method on an AWG MUX

The Matrix PDW function is automatic inside the CSA. To set it up, generate a PDL trace on each channel you wish to monitor the PDW on. Then create a PDW trace on any 1 of those channels (the PDW trace will automatically generate the PDW values for each channel in the system that has a PDL trace. The printout is shown below:



The variability (repeatability) of the Matrix method was evaluated. The histogram below shows the results of these tests. The typical repeatability for this device was +/-2pm.



Correlation

Measurements were made to ascertain the degree of correlation between the All-States method and the Matrix Method. To do this, 3 separate runs of the All-States method were run on one device (an AWG MUX). Then, these data were compared to the Matrix results.

Comparison of Results between All-States and Matrix PDW Measurement

	Measured PDW
All-States Results	**102 - 117 pm**
Matrix Results	**110-113 pm**
Nominal Difference	**2 pm**
Maximum Difference	**11 pm**

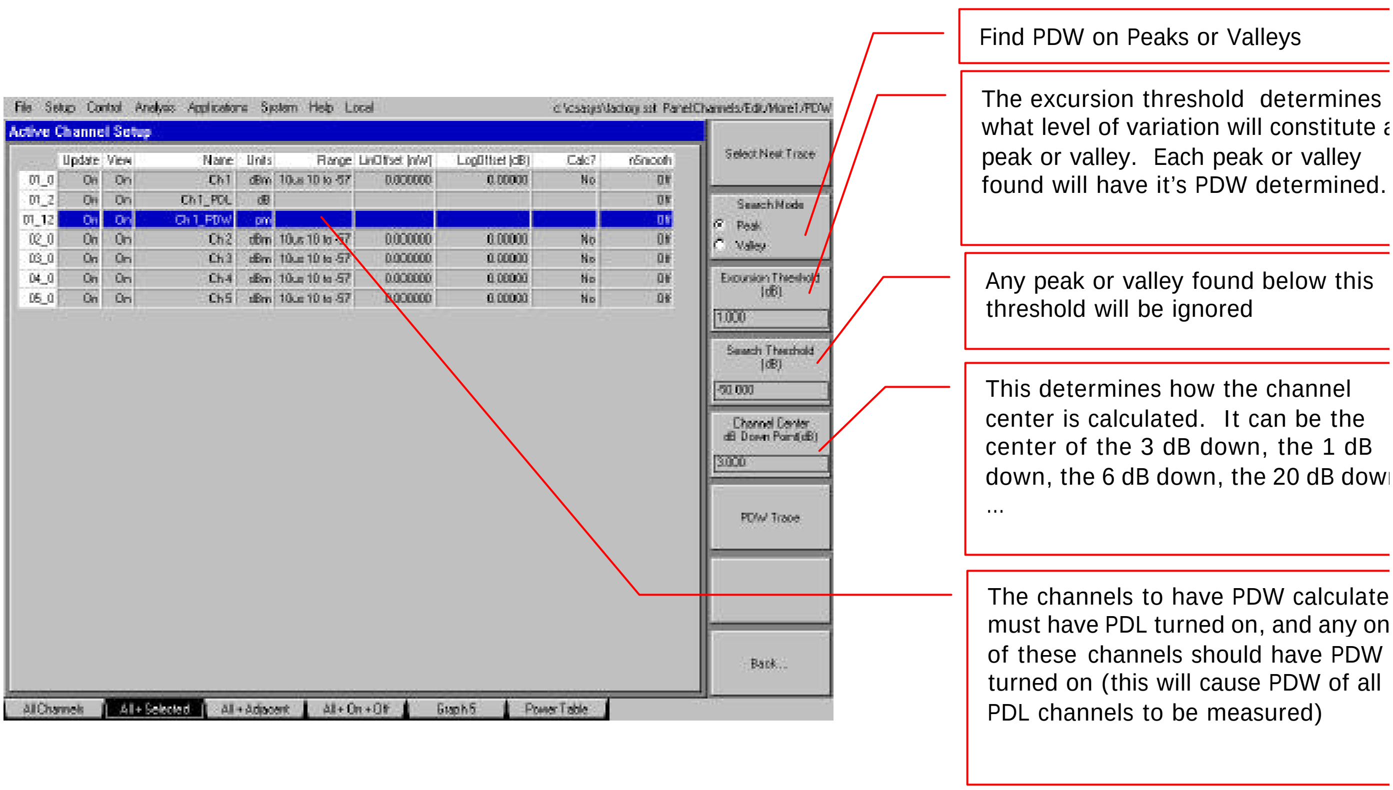
As can be seen, the correlation between the methods was good. Measurements were also made on a Thin Film Based MUX with similar results (actually lower error, but much lower PDW).

If the reader would like a more in-depth understanding of the methodology behind our PDW measurement, contact our Applications Engineering team by email, phone, or fax.

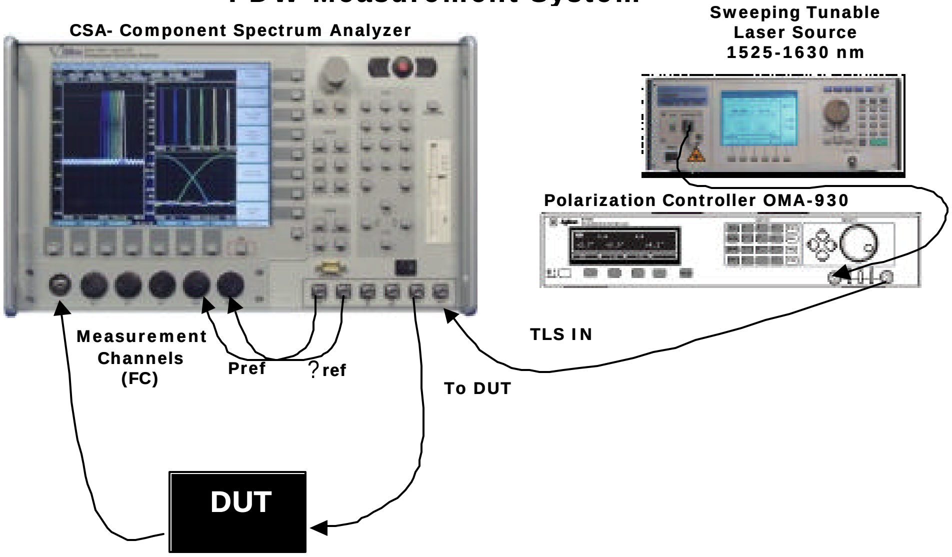
Setup and Notes

These measurements were made with a dBm Component Spectrum Analyzer equipped with OMM-202 measurement modules, -310 Power Reference module, and a –401 Wavelength Reference Card.

Setup for PDW is shown below:



PDW Measurement System



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