**PRELIMINARY**

Application Note 2004-024B

# Comprehensive Polarization Dependency Analysis for MUX, Filters and Gratings

## Overview

This application note describes a more comprehensive analysis of the behavior of optical components under the conditions of changing polarization state.

## Summary

Typically, components are characterized for their Insertion Loss (IL), Optical Return Loss (ORL) and Polarization Dependent Loss (PDL) characteristics. These are essentially a simple collection of measurements made at different wavelengths. By adding information that includes the relationship between adjacent sets of measurements in the wavelength domain, substantial new insights on the performance the components can be obtained. These include the most common Polarization Dependency of Center Wavelength (PDCW), and a number of other useful measures.

Deriving these measurements is simple with the dBm Optics CSA. See additional application notes for information on getting these parameters from the CSA using the All-States method PDL measurements, and another application note for deriving them from the Matrix Method PDL measurements.

## Polarization Dependency Evaluation

In evaluating PDL of a device with no wavelength features in its insertion loss, the only figure of merit is the PDL itself. As soon as a device has a change in insertion loss as a function of wavelength, we can broaden our view of PDL, and in doing so gain important insights into both the functionality of the component, and more importantly for component suppliers, get key insights into the design and process contributors to these important performance measures.

One scenario for a component is a device who's Insertion Loss at different wavelengths varies substantially, we can then think of PDL from five different perspectives:

1. PDL at each wavelength, independent of all other wavelengths
2. PDL relationships in specific bands; for example, the maximum value of PDL in the passband
3. The impact of PDL on the wavelength-specified parameters, including
   a. Polarization Dependency of Center Wavelength (PDCW)
   b. Polarization Dependency of Bandwidth (PDBW)
4. We can actually decompose the PDL contributions from each of the key factors, yielding
   a. Polarization Dependent Loss due to change in Center Wavelength ($PDL_{?IL@PDCW}$)
   b. Polarization Dependent Loss due to change in Insertion Loss at the apparent channel center ($PDL_{?CW}$)
   c. Polarization Dependent Loss due to change in Bandwidth center ($PDL_{?BW}$)
5. Lastly, we can look at the relationship between the PDL features vs. Wavelength and the Insertion Loss features vs. Wavelength, including
   a. Wavelength at PDL minima vs. Center Wavelength of feature

## Parameter Definitions

### <u>Polarization Dependency of Center Wavelength</u> (PDCW)

The most appropriate definition for this parameter is the maximum change in the center wavelength exhibited by the device under any potential polarization state. Center wavelength can be defined in a number of ways, including wavelength at IL minimum, wavelength at center of 0.5, 1 3, 6 or 10 dB down points, or center of a curve fit of the data.

### <u>Polarization Dependency of Bandwidth</u> (PDBW)

PDBW is the change in the exhibited bandwidth of a component or subsystem under any potential polarization state. The bandwidth can be defined in a number of ways, including bandwidth at 0.5, 1 3, 6 or 10 dB down points.

### <u>Polarization Dependent Loss Due to Change in Center Wavelength</u> ($PDL_{?CW}$)

The PDL that would be measured I there were zero Polarization Dependency of Bandwidth (PDBW) and zero Insertion Loss change in Center Wavelength ($PDL_{?IL@PDCW}$).

### <u>Polarization Dependent Loss Due to Change in Bandwidth</u> ($PDL_{?BW}$)

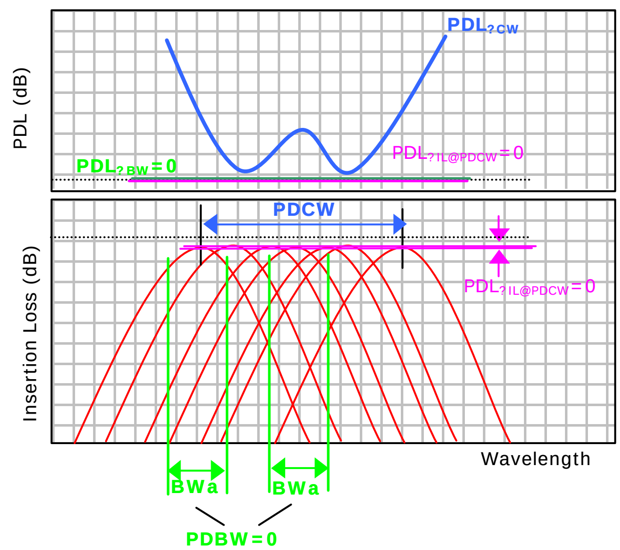
The PDL that would be measured I there were zero Polarization Dependency of Center Wavelength (PDCW) and zero Insertion Loss change in Center Wavelength ($PDL_{?IL@PDCW}$).

### <u>Polarization Dependent Loss Due to Insertion Loss Change in Center Wavelength</u> ($PDL_{?IL@PDCW}$)

Polarization Dependency of Insertion Loss at Polarization Dependent Center Wavelength is determined by evaluating the span of values for the minimum insertion loss at each polarization state.

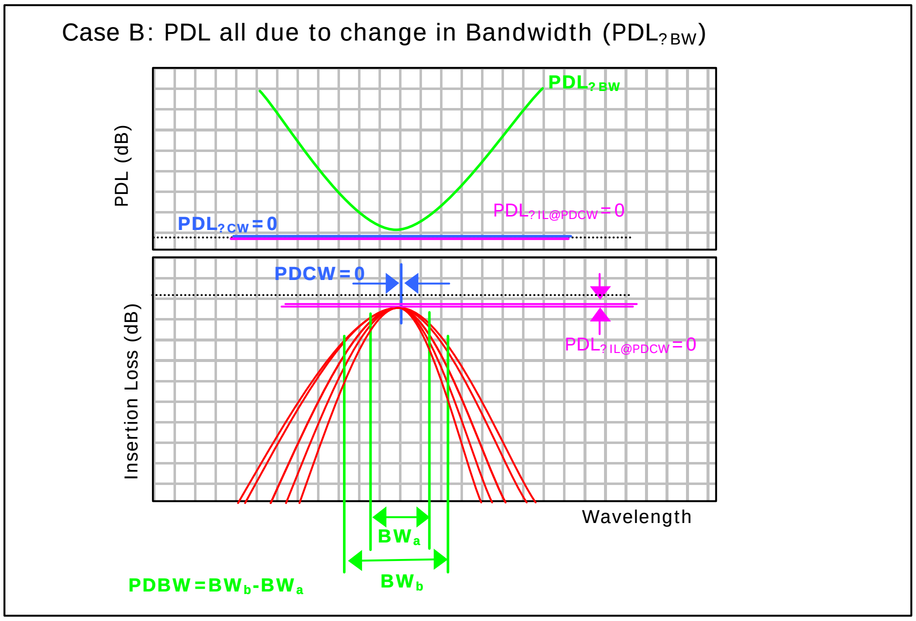
## Example Component Performance

Case A: PDL all due to change in Center Wavelength ($PDL_{?CW}$)



The diagram Case A illustrates a component whose PDL is entirely due to a shift in the center wavelength. There is no change in the Insertion Loss profile shape, nor is there a change in the bandwidth of the device. The multiple red traces illustrate the performance over many different polarization states. Note that depending on the device, doing these measurements by running sweeps over different polarization states can take a large number of polarization states to yield accurate, repeatable results.

The diagram Case B illustrates the case of a component whose PDL is exclusively due to a change in the bandwidth of the device, with no change in either center wavelength or in the Insertion Loss value or profile.

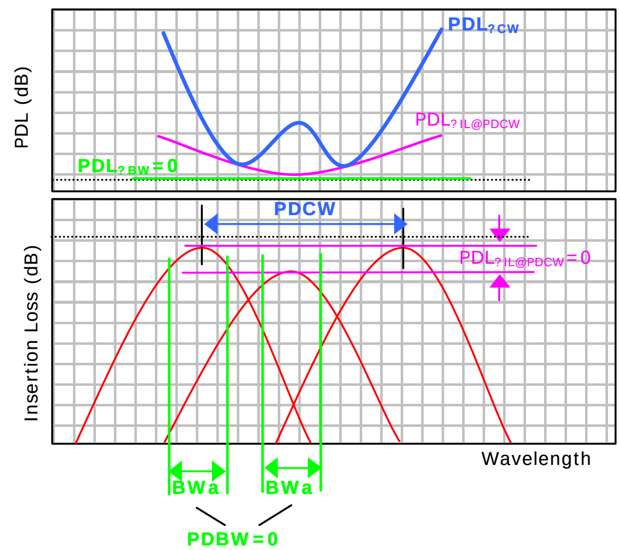



The diagram Case C illustrates the case of a component whose PDL is exclusively due to a change in the bandwidth of the device, with no change in either center wavelength or in the Insertion Loss value or profile.

Combining effects can have unanticipated impacts, due to the interaction of the effects over wavelength.

The diagram Case D illustrates to combination of PDL due to both change in Center Wavelength ($PDL_{?CW}$) and change in Insertion Loss at Center ($PDL_{?IL@PDCW}$).

Case D: PDL due to both change in Center Wavelength ($PDL_{?CW}$) and change in Insertion Loss at Center ($PDL_{? IL@PDCW}$)




## Conclusion

As can be seen from the data, there are several potential sources If apparent PDW. These different sources may, depending on the technology of the component, have different solutions. Being able to discriminate the different contributors of PDW can be a benefit in isolating and resolving cases of larger-than-anticipated PDW.

## Additional Investigation

There is a significant opportunity for additional research to correlate specific measurement results with specific component characteristics (in design and process). Also, we have not explored the potentially rewarding information that can be ascertained from an analysis of the differences between channel center and the PDL minima (which seems to have a direct relationship to alignment), and also between the ORL maxima, the PDL minima, and the channel center wavelength.



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