Technical Brief #2

Depolarizers

Phoenix Photonics

This note is one of a series of technical briefs developed from customer FAQs and intended to answer the majority of questions concerning the operation of Phoenix products. They are targeted at engineers to assist in incorporating Phoenix products into designs. Any detailed technical questions should be forwarded to Phoenix support.

What is a depolarizer?

A depolarizer converts a high extinction ratio SOP (state of polarization) to a randomly polarized state.

The Lyot type depolarizer utilizes the source coherence function to provide an uncorrelated effectively random polarization state.

Principle of operation

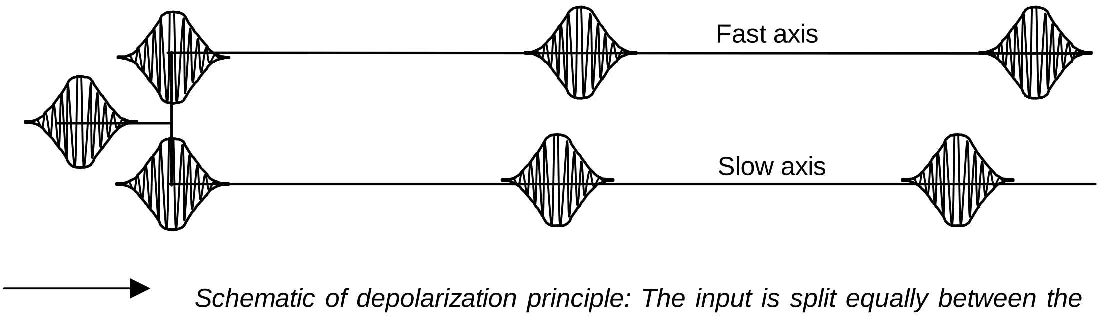
The **Phoenix depolarizer** is an **all-fiber** Lyot type depolarizer.

The principle of operation is to utilize high linear birefringence fibers to create a differential time delay between two orthogonal polarization modes.

In simple terms, if the delay time is greater than the coherence time of the source then the two orthogonal polarization modes no longer have any phase relationship and add in power. Providing the optical power is equally divided between the two birefringent axes at the input then the output is depolarized.

Phoenix depolarizers are designed to ensure that <u>any</u> input SOP is depolarized.

The DOP (degree of polarization) depends on the time delay introduced by the depolarizer and the coherence time of the source.

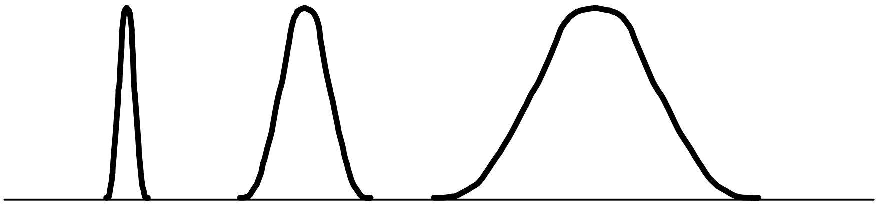


Schematic of depolarization principle: The input is split equally between the two polarization axes of the birefringent fiber. When recombined at the fiber output the light on the two axis is no longer cohrent if the differential time delay is greater than the coherence time of the source .

Source coherence function dependence

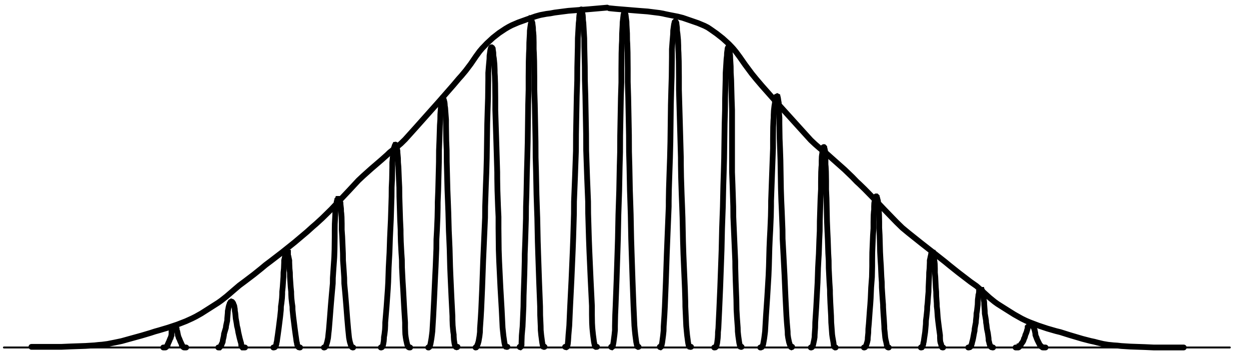
The source spectrum is critical to the design and final performance of the depolarizer.

Two general source types are identified by Phoenix; smooth continuous spectrum and 'spiky', multimode spectrum.
The **smooth spectrum** is typical of broadband sources such as ELEDs, SLDs and ASEs and single mode lasers such as DFBs. In this case the coherence function can be determined from knowledge of the center wavelength, linewidth (FWHM) and spectral shape (Gaussian, Lorentzian).



Schematic of smooth spectra of different linewidths

The **multimode spectrum** is typical of Fabry Perot lasers and Raman pump lasers. The coherence function for these sources is periodic and can vary according to the stability of the modes within the spectrum. The coherence function envelope is determined by the individual mode linewidth and the individual peak widths within the envelope are determined by the spectral envelope linewidth. The periodicity of the coherence peaks is defined by the modal spacing in the spectrum.



Schematic of multimode spectrum

Depolarizer realization

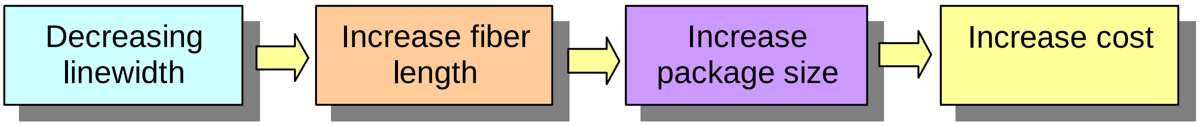
The spectrum of the source defines the parameters of the depolarizer such as:

- Complexity
- Size
- Insertion loss
- Achievable DOP
- Price

Smooth spectrum

Phoenix depolarizers are available in a range of standard linewidth specifications or can be tailored to a particular source requirement and to a customer defined packaging size and style.

For smooth spectrum sources the following holds:



The minimum linewidth that can be depolarized by this technique is limited by the lengths of fiber required. Increased fiber lengths, increases insertion loss and cross talk, which affects the achievable DOP.

In general, the minimum linewidth that can be effectively depolarized by this method is 0.1nm.

Multimode spectrum

With knowledge of the spectrum the depolarizer is optimized to operate within a coherence function null, thereby substantially reducing the fiber length requirement, package size and price.

There are several factors concerning the modal distribution, stability and overall spectrum which determine the performance of a depolarizer designed for these applications.

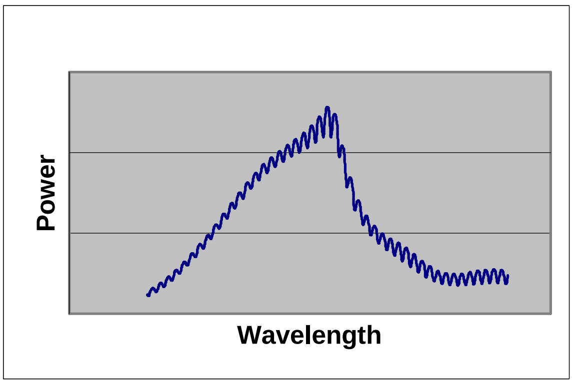
Input linear polarization state definition

In general Phoenix depolarizers are designed to depolarize any input SOP. However if a linear input SOP is defined in the system the design can be refined, reducing fiber requirements.

In addition, a linear polarizer can be incorporated into the depolarizer to 'clean up' the input polarization and improve overall depolarizer performance.

For sources with Polarization maintaining fiber pigtails, this option is more appropriate.

Phoenix Raman pump depolarizers are specifically designed for use with Raman pump lasers and have a polarization maintaining fiber input lead to splice directly to the pump laser pig tail.



Typical Raman pump laser spectrum

Temperature dependence

The birefringence of the fibers used in the depolarizer are very temperature sensitive, however the devices have been designed such that the overall affect on differential delay is insufficient to modify the performance within normal operational limits.

Wavelength dependence

Depolarizers can be fabricated at any wavelength for which high birefringence fiber can be obtained.

The devices are very broadband, for example a standard broadband depolarizer designed to operate at 1300nm will depolarize up to and beyond 1610nm.