# Frequently Asked Questions for PolaMIX™ Polarization Scramblers

## 1. Q: What are the advantages of General Photonics' polarization scramblers?

A: General Photonics (GP) offers a broad line of polarization scrambling products. The major advantages include:

1) extremely low insertion loss (< 0.05 dB w/o connector);

2) low electrical power consumption (< 12 Watts for PCD-005, <9 Watts for PSM-002

3) ultra broad wavelength range

4) wide operation temperature range(-35 ~70°C case temperature possible for PSM-002);

5) small board size (board <1 inch in height);

6) low cost for wide applications;

7) custom design available. Module can be easily modified to fit OEM requirements.

GP polarization scrambler products include both modules (PCD-005, PSM-002) and a benchtop instrument (PCD-104). All are suitable for both OEM customers and R&D laboratories. In addition, the multifunction polarization controller and polarization synthesizer products have polarization scrambling functions. GP's microprocessor controlled scrambler allows intelligent scrambling control, including wavelength selection, external communications, and remote on/off switching.

## 2. Q: What does DOP stand for?

A: DOP stands for Degree of Polarization; its value shows the portion of light that is polarized during the detection time frame. For example, linearly and circularly polarized light have a DOP of 1, while natural white light has a DOP of 0.

## 3. Q: If I use a PolaRITE™ II -based scrambler at 980nm, is the fiber single mode or multimode?

The fiber used in a scrambler intended for use at 980nm is a single mode fiber that covers a wavelength range from 970nm to 1550 nm. Currently, we test our device at 1550 nm and extrapolate to 980 nm operation conditions in order to keep the DOP (degree of polarization) less than 5% at the output. Standard SMF-28 fiber will be multimode at 980 nm.

## 4. Q: What is the typical electrical power consumption of your polarization scramblers?

A: The typical power consumption of the PCD-005 is <12W. The power consumption of the PSM-002 varies with scrambling speed over a range of 0.5 to 9W.

## 5. Q: What is the maximum optical power throughput that your devices can handle?

A: GP's polarization scramblers use continuous fiber in their construction. They can therefore handle more than 1000mW optical power.

## 6. Q: Can I change the polarization scrambling frequency?

A: The scrambling frequencies of the PCD-005 polarization scrambler module and the PCD-104 instrument are preset during manufacturing for optimized DOP performance. They are based on the scrambler's resonance frequencies, and result in an effective scrambling frequency of >700kHz. The user should not change them without GP's explicit authorization. The PSM-002 generates random, discontinuous SOPs at a user-controllable rate. The PSM-002's scrambling rate is user-controllable from 0.01 to 20k points/s.

## 7. Q: What are the differences between the PCD-005 and PSM-002? How can I control them with a computer? What software is needed?

A: As mentioned above, the PCD-005 is a high frequency, resonance based scrambler. It is based on continuous sinusoidal waveform scrambling, with each channel driven at a different resonance frequency. It can be remote controlled via an RS-232 communication port on the digital interface adapter board (ADB-001) to turn the module on/off, or change the operating wavelength to any of 6 settings (980nm, 1060nm, 1310nm, 1480nm, 1550nm, 1600nm). Customers who use 980 nm or 1060 nm wavelengths need to specify this during the ordering process. The standard PCD-005 covers only 1310, 1480, 1550, and 1600 center wavelengths. Simple LabView based control software is provided with the unit. With the microprocessor controller, the polarization scrambler performance can be dynamically optimized with the temperature and wavelength.

The PSM-002 is a miniature polarization scrambler designed for hand held and field instruments. Accordingly, its size and power consumption are much smaller than those of the PCD-005. It can also have an extremely wide operating temperature range (-35 to 70°C). It operates on a random scrambling model, in which random sets of control voltages are input to the different channels of the polarization controller at a user-selected frequency. It has a single preset center wavelength and a relatively wide operating wavelength range. It can be controlled via RS-232 using a special cable provided with the module.

## 8. Q: What are residual phase and amplitude modulation? How are they measured?

A: Residual phase modulation is a constant phase modulation term that exists in addition to the phase difference change between two eigenmodes (e. g., Ex and Ey). The residual phase modulation is independent of input polarization state. Residual amplitude modulation is a modulation-induced insertion loss change, which is also called activation loss. Compared with other, similar products on the market, General Photonics' polarization scrambler has the lowest residual phase modulation (~ 0.1$\pi$) and amplitude modulation (0.01dB). Residual amplitude modulation can be measured by optical intensity measurements such as insertion loss tests. However, residual phase modulation cannot be determined directly from an intensity sensitive photodetector measurement. A fiber interferometer setup is required. For detailed information, please call General Photonics.

## 9. Q: What are some applications of polarization scramblers?

A: Polarization scramblers can be used to mitigate polarization dependent effects, such as polarization dependent gain (PDG) in fiber amplifier systems, polarization dependent loss (PDL)

in WDM systems, and polarization mode dispersion at data receivers. In addition to fiber optic transmission systems, polarization scramblers also have wide applications in test and measurement instrumentation. They are used in random polarization generators, PDL meters, OTDRs, and optical spectrum analyzers, to name a few.

### 10. Q: What is the difference between a passive depolarizer and a polarization scrambler?

A: General Photonics' polarization scramblers have less wavelength dependence than passive depolarizers; a polarization scrambler can cover a 100nm wavelength range with a DOP of less than 5%. In addition, passive depolarizers are highly dependent on the coherence length of laser output; they operate effectively only when the light source has a short coherence length, while General Photonics' polarization scramblers can work with light sources of any coherence length, including DFB lasers, diode pumped solid state lasers and so on. Due to their all-fiber construction, GP's polarization scramblers also have extremely low insertion loss. On the other hand, polarization scramblers require an electrical power supply, while passive depolarizers have no electrical power requirement.

### 11. Q: What are the resonant frequencies of the polarization scrambler?

A: Several resonant frequencies are used in a polarization scrambler. There is a distribution of these resonant frequencies depending on individual components. Typically, the resonant frequencies are distributed between several bands: 50 ~ 70 kHz, 90 ~ 120 kHz, 125 ~ 146 kHz and 150 ~ 170 kHz.

### 12. Q: What are the operating temperature ranges for GP's polarization scramblers? If my condition is slightly out of that range (for example, by 5 ˚C), what is the result?

A: For the specified DOP of 5% or less, the operating temperature ranges are 10 to 45˚C or -5˚C to 65˚ C for the PCD-005, and 0 to 65˚C or -35 to 70˚C (case temperature) for the PSM-002. When operation temperatures are outside of these ranges, DOP values may increase gradually, sometimes reaching 10%.

### 13. Q: What is the wavelength coverage? If my wavelength is out of the coverage range, how much does the DOP change?

A: Most polarization scramblers consist of multiple sections of birefringent modulators that are sensitive to wavelength changes. A typical polarization scrambler is tuned for minimum DOP operation in a band centered at a specified wavelength. The operation bandwidth in which the DOP is specified is called the wavelength coverage of the polarization scrambler. GP's multi-band polarization scrambler (PCD-005/104) covers most popular center wavelengths from 980 nm to 1650 nm in 6 user-selectable bands. The mini-scrambler (PSM-002) covers >±50nm from the center wavelength. If your wavelength is outside the coverage range, the DOP may increase gradually as the differences between the center and actual wavelengths increase.

### 14. Q: Can I use a polarization scrambler to measure Polarization Dependent Loss (PDL)?

A: Yes. There are several methods to measure PDL, such as the random scanning (minimum-maximum) method, Mueller-Matrix method, Jones-Matrix method, and reference method. The random scanning method employs a polarization scrambler in the measurement. Depending on the speed of the photodetectors and electronic circuits, different scrambling speeds are used to scan polarization states to the DUT. GP offers both fast (>700 KHz) and slow (down to quasi-DC) polarization scramblers to meet customers' measurement needs.

### 15. Q: What are the advantages of measuring PDL using GP's polarization scrambler?

A: The extremely low PDL (PDL $\leq$ 0.05 dB, 0.01 dB typical) of GP's polarization scramblers provides a clean measurement environment for PDL testing. In other words, GP's polarization scrambler assures that the PDL reading error due to scrambler PDL will be much smaller than the test instrument's PDL resolution.