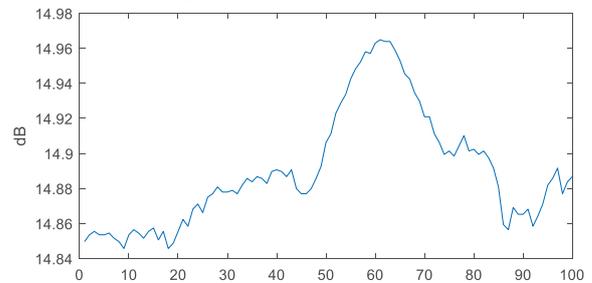
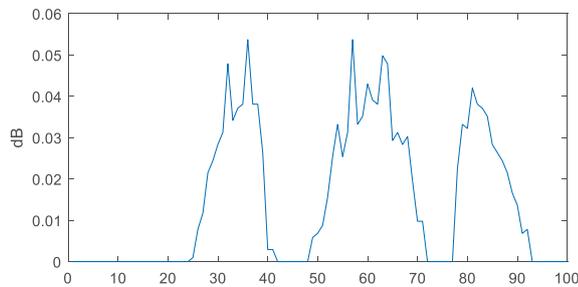
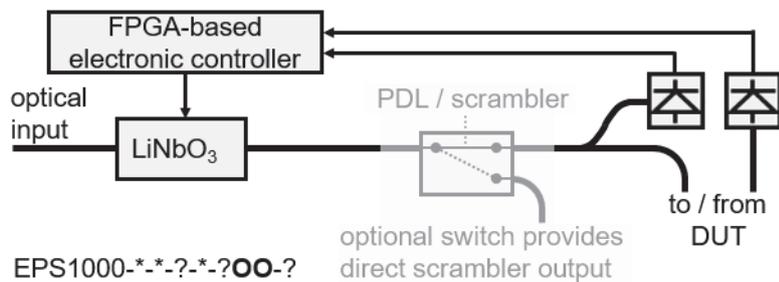


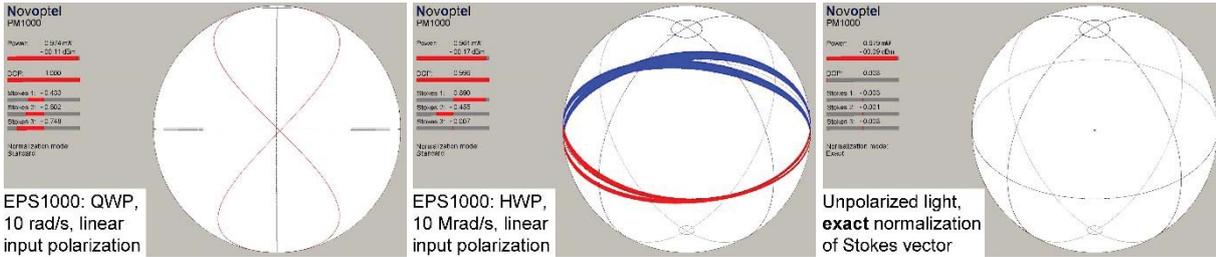
PDLM Polarization Dependent Loss Multimeter

- Usage mode or extension of EPS1000 polarization scrambler, with built-in photodetector(s).
- Polarization-dependent loss (PDL) and mean loss are calculated in firmware.
- PDL measurement interval <100 ms
- PDL measurement range 0.05...50 dB
- Optical power meter function
- Extinction method (superb especially for large PDL) and sqrt(3) method
- Polarization scrambler functionality is kept with optional switch.
- Fully programmable (USB, LAN, GUI, Matlab, Python, C, ...)

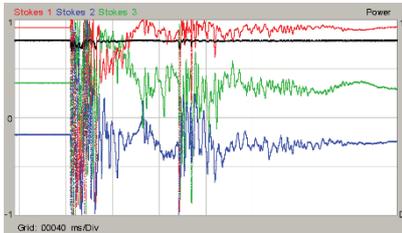


PM1000 Polarimeter

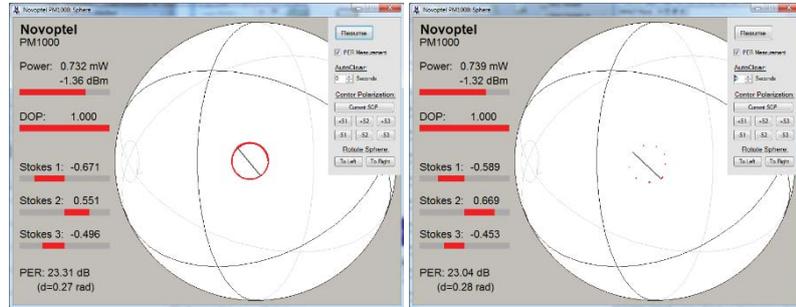
- Measurement of all 4 Stokes parameters, display on **Poincaré sphere** and in **oscilloscope mode**. Also available: Normalized Stokes vector, degree-of-polarization (DOP)
- Three choices for the normalization of Stokes parameters/vectors:
 - Standard: Normalized Stokes vectors are normalized to unit length. Regardless of power and DOP, they appear at the surface of the Poincaré sphere.
 - Exact: Normalized Stokes vectors are normalized only with respect to optical power. For DOP < 1 (or DOP = 0) they appear inside (or in the center of) the Poincaré sphere.
 - Non-normalized: Display of the non-normalized Stokes parameters. This means, DOP and optical power determine the length of the displayed S₁-S₂-S₃ Stokes vector.
- **100 MHz polarization state sampling frequency. 64 M polarization states can be recorded.**
- **30 MHz analog bandwidth.** Averaging (10 ns, 20 ns, 40 ns, ... 2.68 s), triggering, gating
- **Internal triggering on SOP or intensity events.** Selectable pre-trigger data ratio. Perfectly suited for **automated long-term assessment of polarization transients. Download while recording** next events!
- **Realtime Poincaré sphere display up to 100 MHz** in graphical user interface (GUI) or 50 MHz on connected monitor (HDMI; 720p60). **Not a single sample is lost!**
- 100 MHz memory view, zoom in oscilloscope mode, screenshots, numeric display
- Speed histogram, intensity histogram, software examples for Matlab™ and Labview™
- Hardware option: 2 sensitivity ranges extend usability to +4...-40 dBm.
- With EPS1000 or EPX1000: **Mueller & Jones matrix (≥ 5.12 us), PDL (<0.005...>60 dB), PMD measurement.** Optional lock-in detection. EPS1000 card can be plugged onto PM1000 card.
- Power consumption: ~5 W (+5 V from included power supply 100-240 V)
- Available as a standalone desktop unit, as a module card, and as an intellectual property (IP) core
- Realtime operation with Serial Peripheral Interface (SPI), trigger/gating input/output (BNC)
- Operation via control buttons of desktop unit, **USB, LAN, SPI** or graphical user interface (GUI)
- **NEW** Optional **O-E-S-C-L-U** band operation **≤182...241 THz / 1241...≥1647 nm**
- Tunable C&L band laser modules can be built in.
- Can define SOP tracking by EPS1000, also during optical frequency sweep and according to table



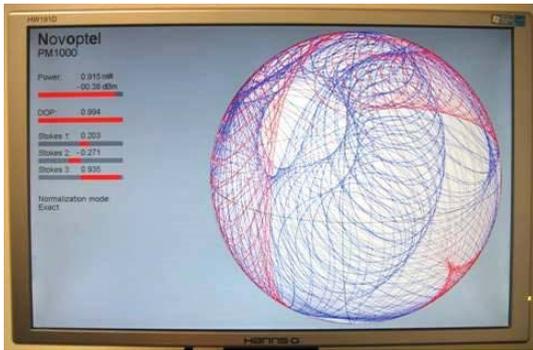
EPS1000 polarization scrambler, characterized with various settings and PM1000 averaging times



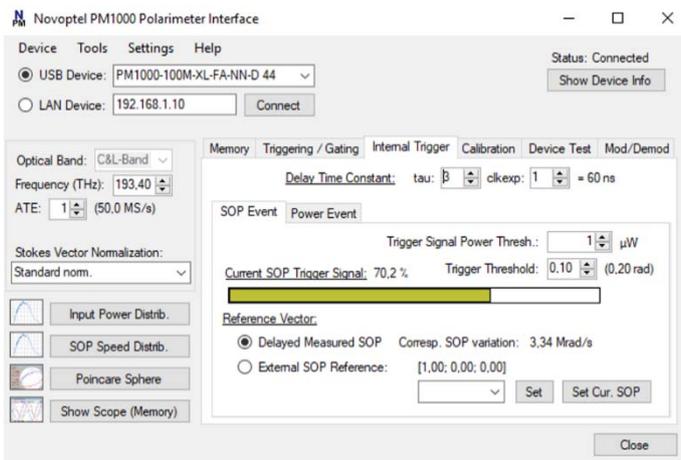
Configurable (1 rad/s ... >100 Mrad/s) internal trigger is used to record the polarization fluctuations caused by hitting a DCM cassette. Oscilloscope mode.



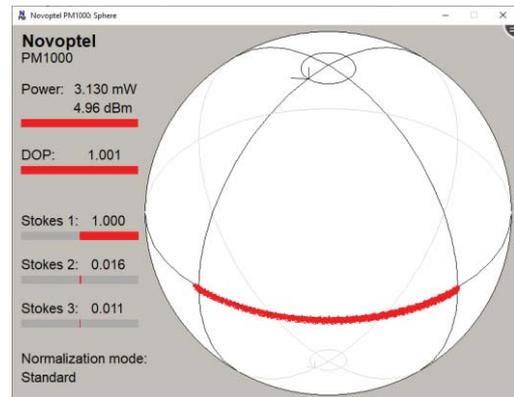
Polarization extinction ratio (PER) measurement (up to at least 44 dB) while heating PMF (left) or tuning an ITLA (right). Tuning-induced polarization transients are cut by intensity threshold.



PM1000 desktop unit comes with Windows GUI. Can be connected to monitor (HDMI; 720p60) and used without extra computer!



Rich internal and external triggering possibilities



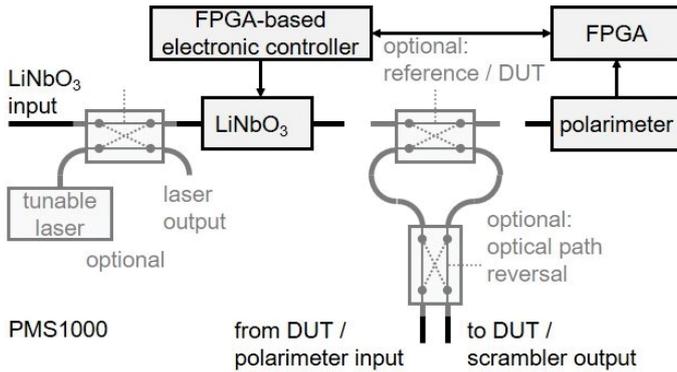
Tracking (by EPS1000, aided by PM1000) of time/frequency/wavelength-dependent predefined polarizations. **Very helpful for PIC characterization.**

Predecessors PM500 of the polarimeter PM1000 have been used by D. Charlton et al. for field measurements of state of polarization transients in optical ground wire, with time and location correlation to lightning strikes: <https://www.osapublishing.org/oe/abstract.cfm?uri=oe-25-9-9689>

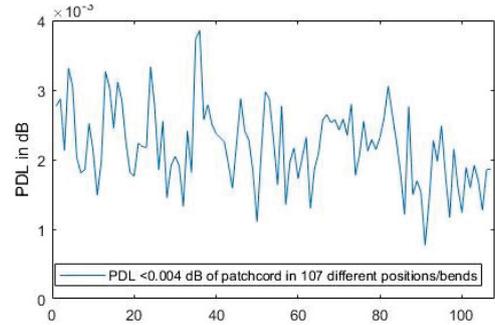
The polarimeter https://www.novoptel.de/Polarimeter/Polarimeter_PM1000_en.php has also been used by F. Pittala et al. for "Laboratory Measurements of SOP Transients due to Lightning Strikes on OPGW Cables" <https://doi.org/10.1364/OFC.2018.M4B.5>.

PMS1000 Polarimeter and Polarization Scrambler/Transformer

- Combination of the PM1000 polarimeter with the EPS1000 polarization scrambler/transformer
- All properties of PM1000 and EPS1000. Perfect for **PIC characterization in O-E-S-C-L-U bands**.
- Ideal for **synthesis of desired polarization states** and **device under test (DUT) polarimetry**
- Opto-mechanical or MEMS 2x2 switch can connect output of LiNbO₃ polarization transformer directly to input of polarimeter. Insertion loss of each path is thereby increased by ~0.5 dB (<1 dB).
- Another 2x2 switch can reverse propagation direction, to determine DUT reciprocity.
- **Tracking function** with feedback: optical (-2...< -50 dBm), electrical (custom or CTP10), polarimetric
- **Wide support of lasers** (LU1000 + all other manufacturers) and software (Matlab, Octave, Python)
- Desktop units (separate EPS1000 & PM1000 or combined PMS1000) or module cards

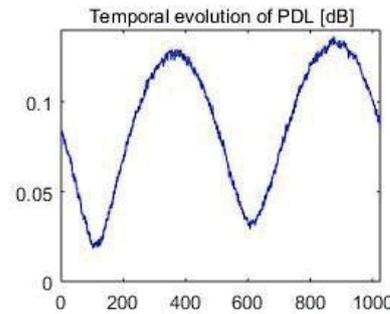


PMS1000 Mueller/Jones and PMD measurement. Optional components shaded. O/E/S/C/L band tunable lasers (such as LU1000).



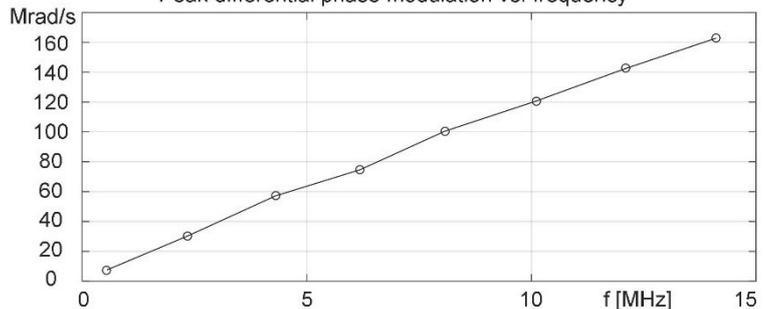
PDL measurement repeatability <0.004 dB

- ≥4 polarization states are generated for DUT and yield **Mueller matrix, Mueller-Jones matrix** (= Mueller matrix made non-depolarizing) and **Jones matrix**
- **Measurement time** can be **5.12 us** or even less.
- **Eigenmodes, retardation, mean loss, PDL (<0.005...>60 dB)** →
- Decomposition of Mueller/Jones matrices into sequences SBA + PPS + SBA. Definitions: PPS = horizontal partial polarizer and phase shifter. SBA = **Soleil-Babinet analog** = retarder with retardation 0...π and eigenmodes on S₂-S₃ great circle. An SBA does to 0°/90° polarizations the same as a Soleil-Babinet compensator to circular polarizations: mode conversion with adjustable phase shift.
- **10 ns temporal resolution** of all time-variable component properties (Mueller matrix etc.) →
- **PMD measurement <10 fs ... 10 ps with standard deviation ≤3 fs**
- With LU1000 or other tunable laser, Mueller/Jones matrices can be measured vs. optical frequency, and **PMD** is determined. Inverse scattering allows generating a **DGD profile** (= differential group delay profile; JLT 21(2003)5, p. 1198, JLT 33(2015)10, pp. 2127-2138, 2015).



Time-resolved PDL of a rotating electrooptic halfwave plate (EPS1000) as a DUT, extracted from 1024 Mueller matrices recorded with **320 ns** temporal spacing.

Peak differential phase modulation vs. frequency



LiNbO₃ phase modulator is investigated as another DUT. From measured time-resolved Mueller matrices differential phase modulation is extracted.

Measured DGD profile in the PMD vector space of two concatenated, arbitrarily oriented PMFs, with DGDs of 4 and 6.6 ps. Not only the total 1st-order PMD vector but also the structure of the DUT becomes apparent.

