

Application note 5

Polarization transient recording with PM1000 polarimeter

Revision history

Version	Date	Remarks	Author
0.5.1	07.03.2021	Draft version	B. Koch

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Summary

This application note describes the simple recording of polarization transients using the PM1000 polarimeter. For testing, polarization transients can be generated by an EPS1000 polarization scrambler.

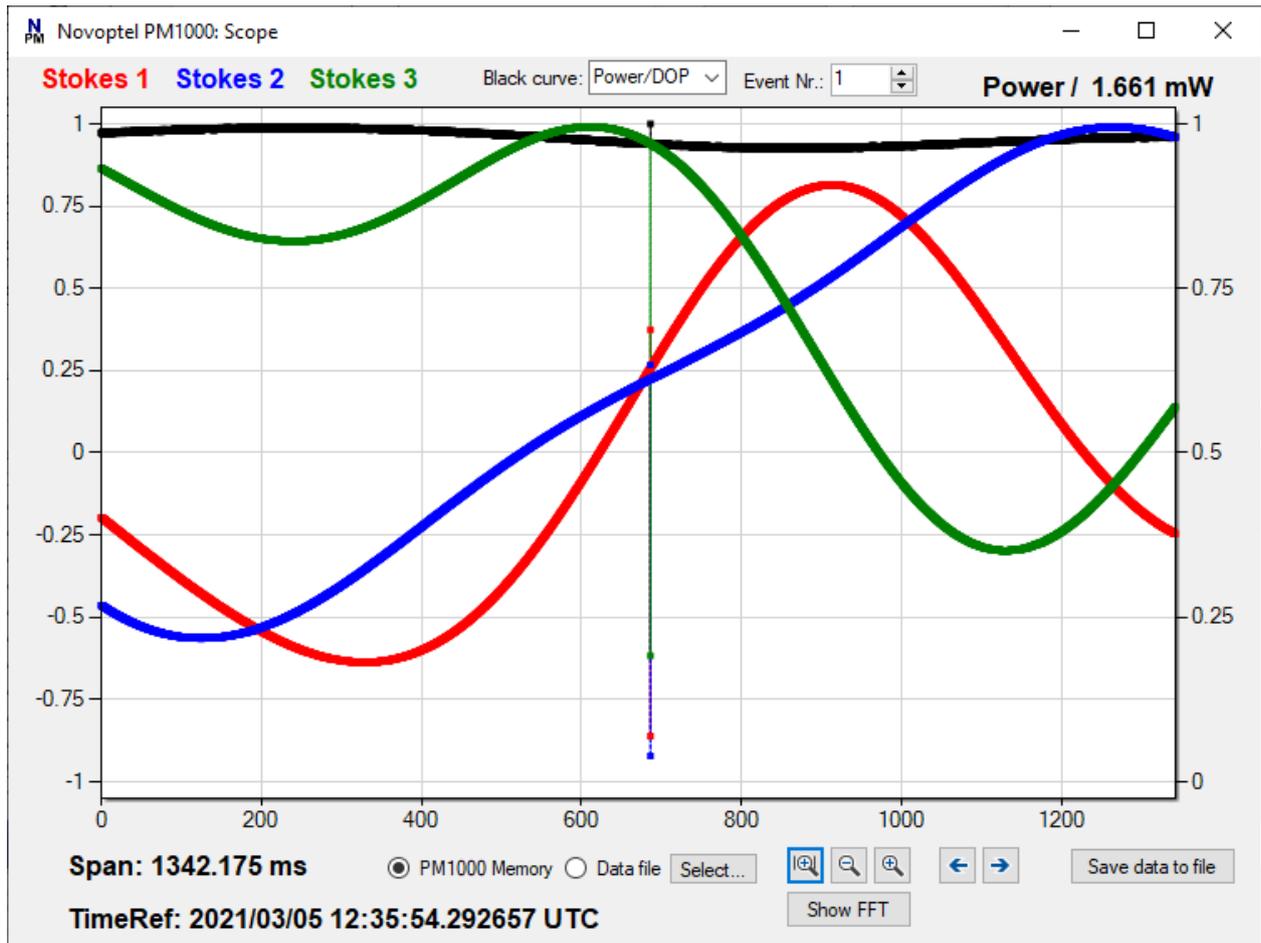
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Generating polarization transients

In the absence of lightning strikes, Novoptel EPS1000 generates state-of-polarization (SOP) pulses of up to 1 Mrad/s during 10 μ s every 1 second (1.0000102 seconds). This can be obtained by loading for instance this table into EPS1000:

```
table_mode='speed'  
1, 3, 1, 1, 3, 1, 3, 132, 61, 173, 100000, 94, 117, 79, 5000  
1, 3, 1, 3, 3, 1, 3, 132, 61, 173, 100000, 94, 117, 79, 5000  
1, 3, 1, 3, 3, 1, 3, 132, 61, 173, 0, 94, 117, 79, 1000000000  
0, 0, 0, 0, 0, 0, 0, 132, 61, 173, 0, 94, 117, 79, 200
```



In the above figure, the polarization transient occurs in the middle.

Goal is to record the fast polarization glitches (emulated lightning strikes) in detail and skip the times in which polarization changes only slowly.

Setting SOP speed trigger

We assume polarization transients caused by lightning strikes shall be recorded with 25 MS/s. Set ATE = 2.

Triggering shall be by the rising speed edge of the SOP.

In Triggering / Gating enable Triggering by Internal: SOP event with Rising edge /active high. Internal: Power event and External signal (BNC) are Disabled because only SOP event triggering is wanted.

The screenshot shows the Novoptel PM1000 Polarimeter Interface software. The window title is "Novoptel PM1000 Polarimeter Interface". The interface includes a menu bar with "Settings" and "Help". The status bar at the top right shows "Status: Connected" and a "Show Device Info" button. The main settings area is divided into several sections:

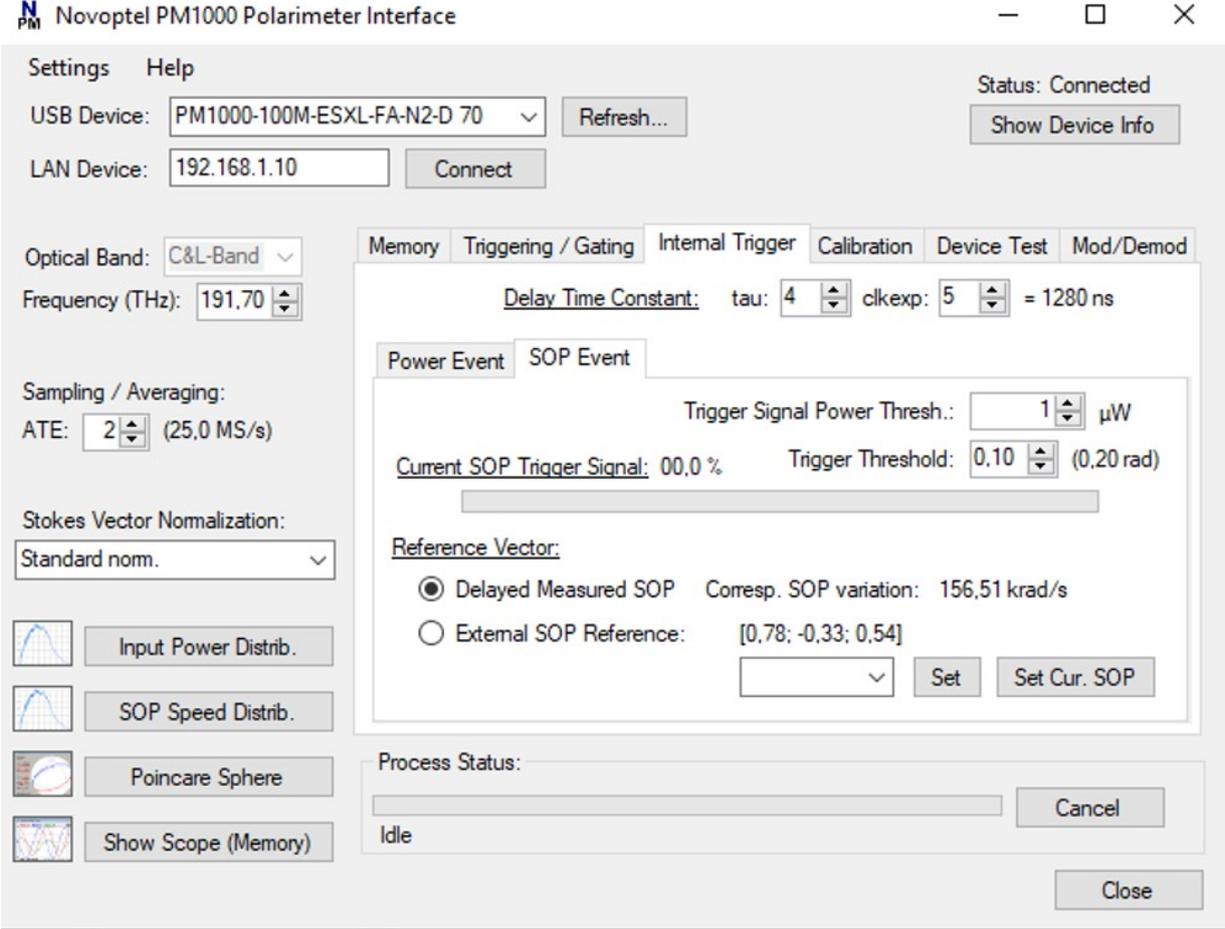
- USB Device:** PM1000-100M-ESXL-FA-N2-D 70 (with a "Refresh..." button)
- LAN Device:** 192.168.1.10 (with a "Connect" button)
- Optical Band:** C&L-Band (dropdown menu)
- Frequency (THz):** 191.70 (spinners)
- Sampling / Averaging:** ATE: 2 (spinners) (25.0 MS/s)
- Stokes Vector Normalization:** Standard norm. (dropdown menu)
- Visualizations:** Four buttons with icons: "Input Power Distrib.", "SOP Speed Distrib.", "Poincare Sphere", and "Show Scope (Memory)".

The **Triggering / Gating** tab is active, showing the following settings:

- Internal: SOP event:** Disabled, Triggering, Gating. Edge: Rising edge / active high, Falling edge / active low. Retrigger during long SOP events.
- Internal: Power event:** Disabled, Triggering, Gating. Edge: Rising edge / active high, Falling edge / active low. Sphere Display Subject to Gating.
- External signal (BNC):** Disabled, Triggering, Gating. Edge: Rising edge / active high, Falling edge / active low. Delay: 13 x 2^0 x 10 ns = 130 ns.

The **Process Status:** section shows a progress bar and the text "Idle". There are "Cancel" and "Close" buttons at the bottom right.

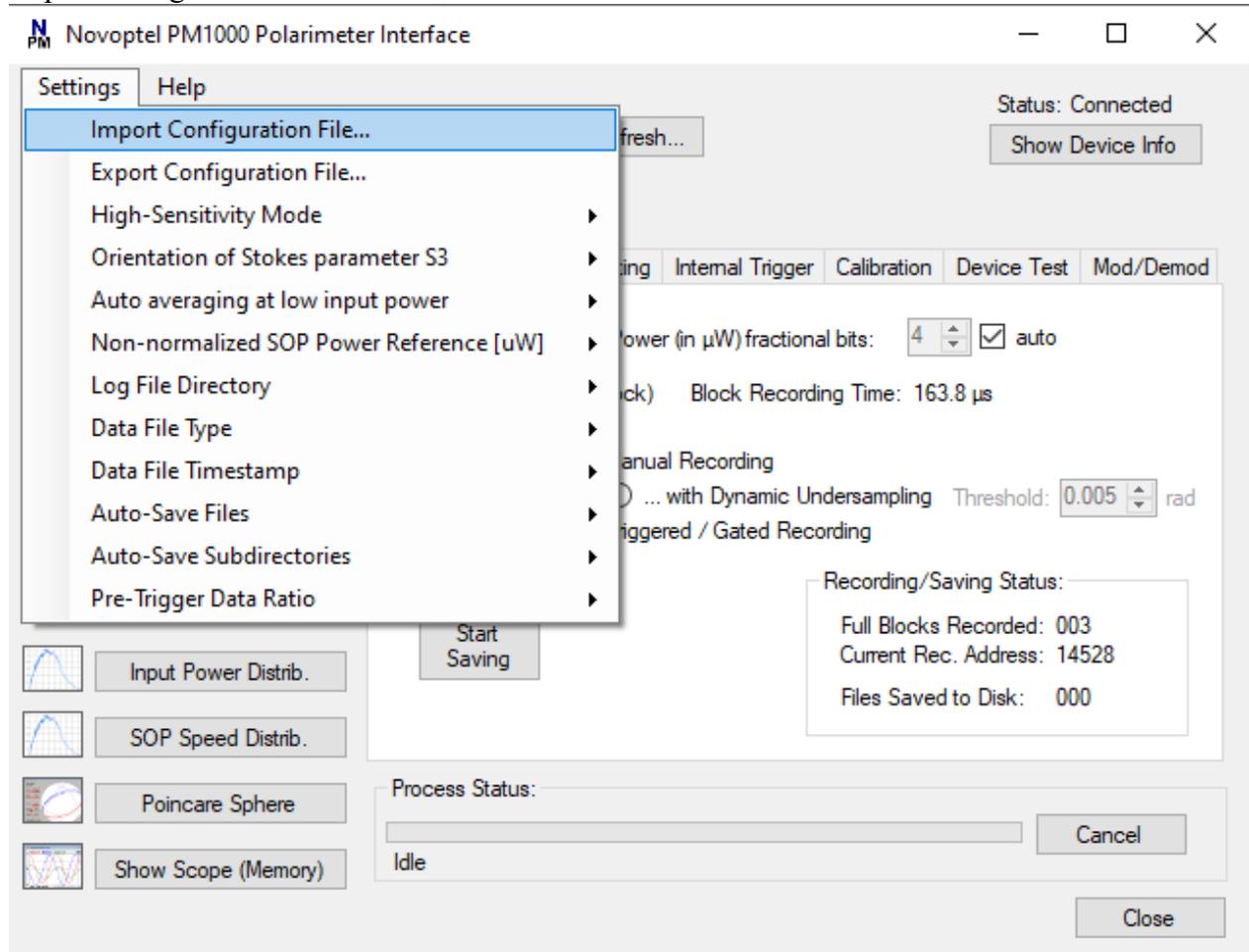
Transients shall be recorded when they surpass, for instance, a speed of 156 krad/s. In Internal Trigger set for instance $\tau = 4$, $\text{clkexp} = 5$. This gives a Delay Time Constant of 1280 ns. For SOP Event triggering, set for instance Trigger Threshold = 0.10 (times the diameter of the Poincare sphere; hence 0.20 rad). $0.20 \text{ rad} / 1280 \text{ ns} = 156 \text{ krad/s}$.



Importing / exporting configuration file

Work with PM1000, for instance the trigger setting, is eased by the possibility of importing and exporting configuration files (from March 2021 on).

Import configuration file:



An example configuration file (.dat) for lighting strikes recording with 25 MS/s is available (PM_config_05_051.dat):

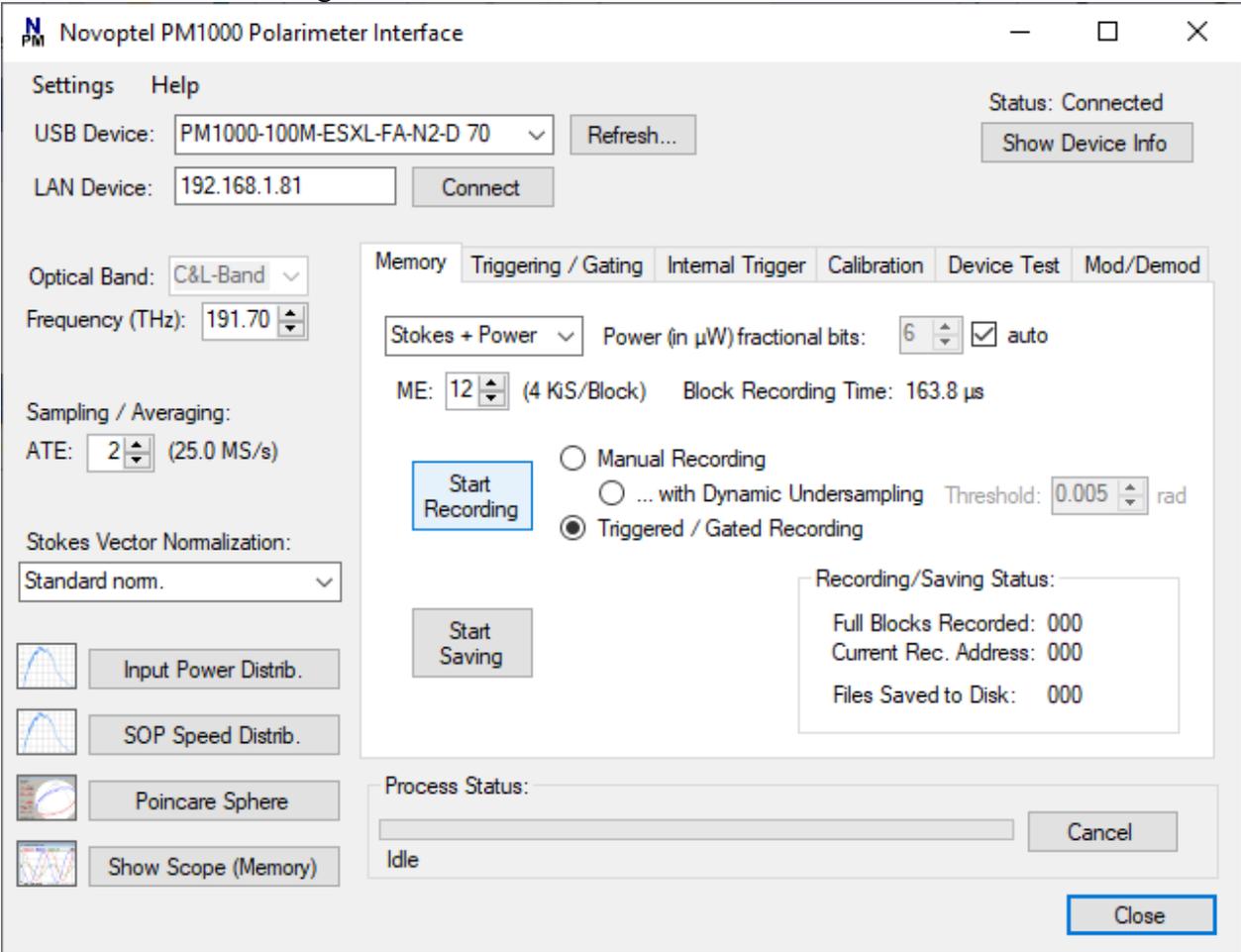
```
# General:
BandSel 0
FreqSel 191.7
ATE 2
Normalization 1
# Memory:
DataName Power
PowerLeftShift 4
PowerLeftShiftAuto True
ME 12
Rec_Type TRIG
DUS_Threshold 0.005
# ToolStrip Settings:
HiSens_Mode 0
S3_Orient 1
AutoAvg 0
```

```
NonNormPowRef 1000
LogFileDir 1
DataFileType 1
DataFileTimestamp 0
AutoSaveFiles 0
AutoSaveSubDir 0
PreTriggerSamples 50%
# Triggering/Gating:
Int_SOP_Event TRIG
Int_SOP_Event_Rising True
Int_POW_Event DIS
Int_POW_Event_Rising True
Ext_BNC_Event DIS
Ext_BNC_Event_Rising True
BNC_Delay 13
BNC_DelayExp 0
Retrigger True
SphereGating True
IntTriggerDelay 4
IntTriggerDelayExp 5
POWTriggerGradient False
POWTriggerGradientDeviation 0
POWTriggerThreshold 100
POWTriggerReference 1000
SOPTriggerPowerThreshold 1
SOPTriggerThreshold 0.10
SOPTriggerExternal False
SOPTriggerExternalS1 0
SOPTriggerExternalS2 0
SOPTriggerExternalS3 0
# Calibration:
FactoryCalibration True
# Device Test:
MuellerMatrNrSOPs 1
```

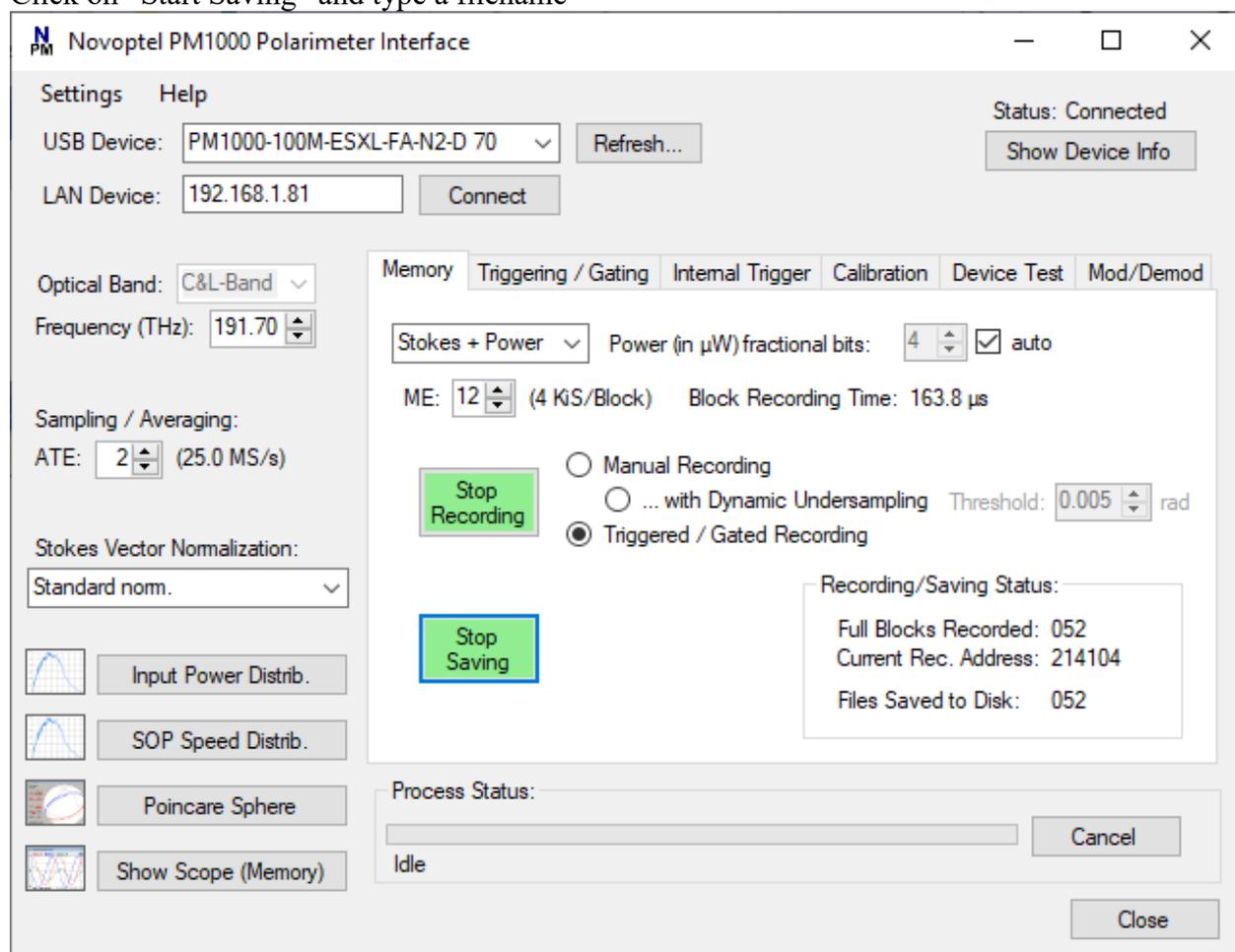
Depending on Windows language setting, decimal indicators may be ‘.’ or ‘,’.

Recording and analyzing polarization transients

Click on “Start Recording”:



Click on “Start Saving” and type a filename

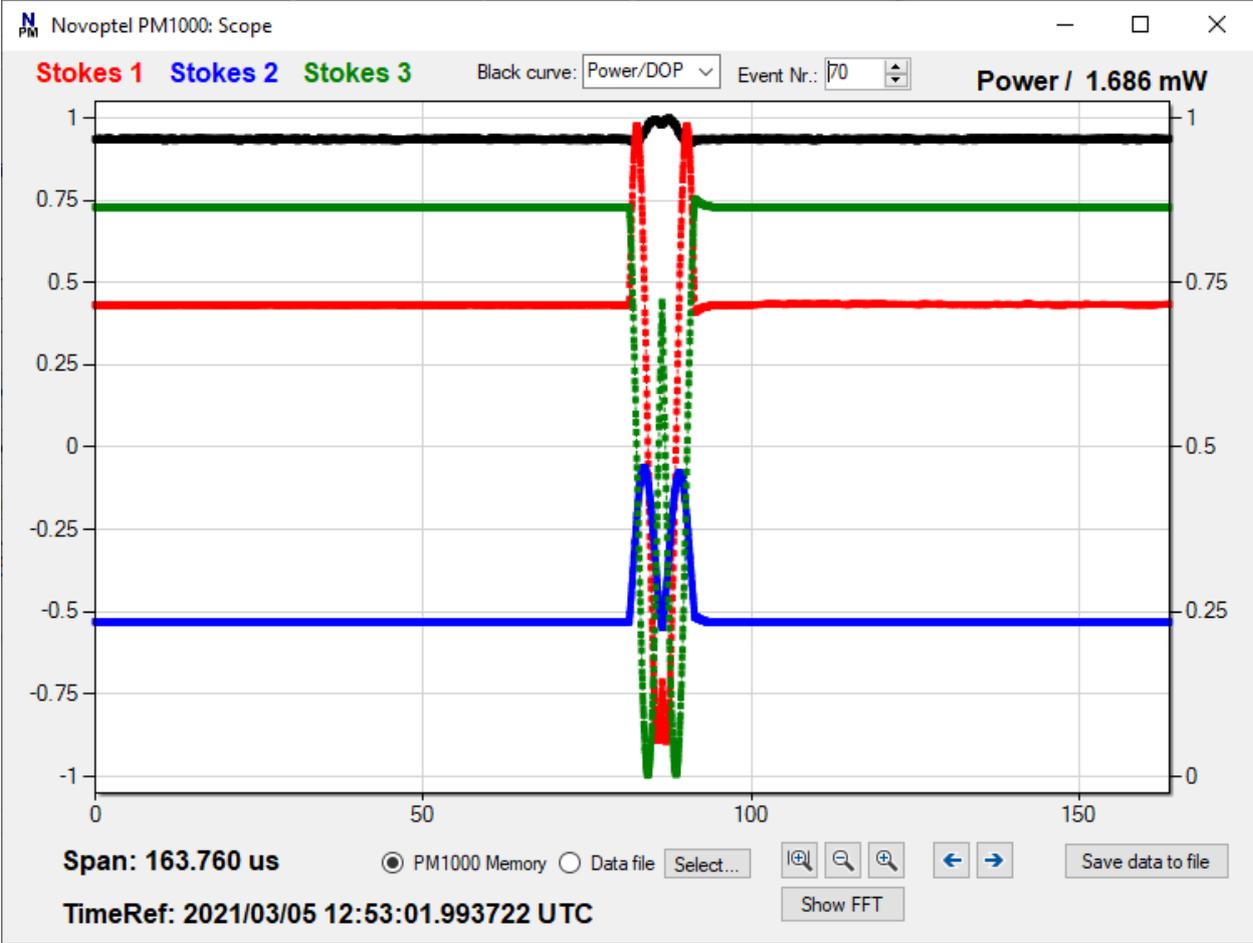


After 71 seconds, 71 events have been recorded, and 71 files have been created. Click on “Stop Recording”

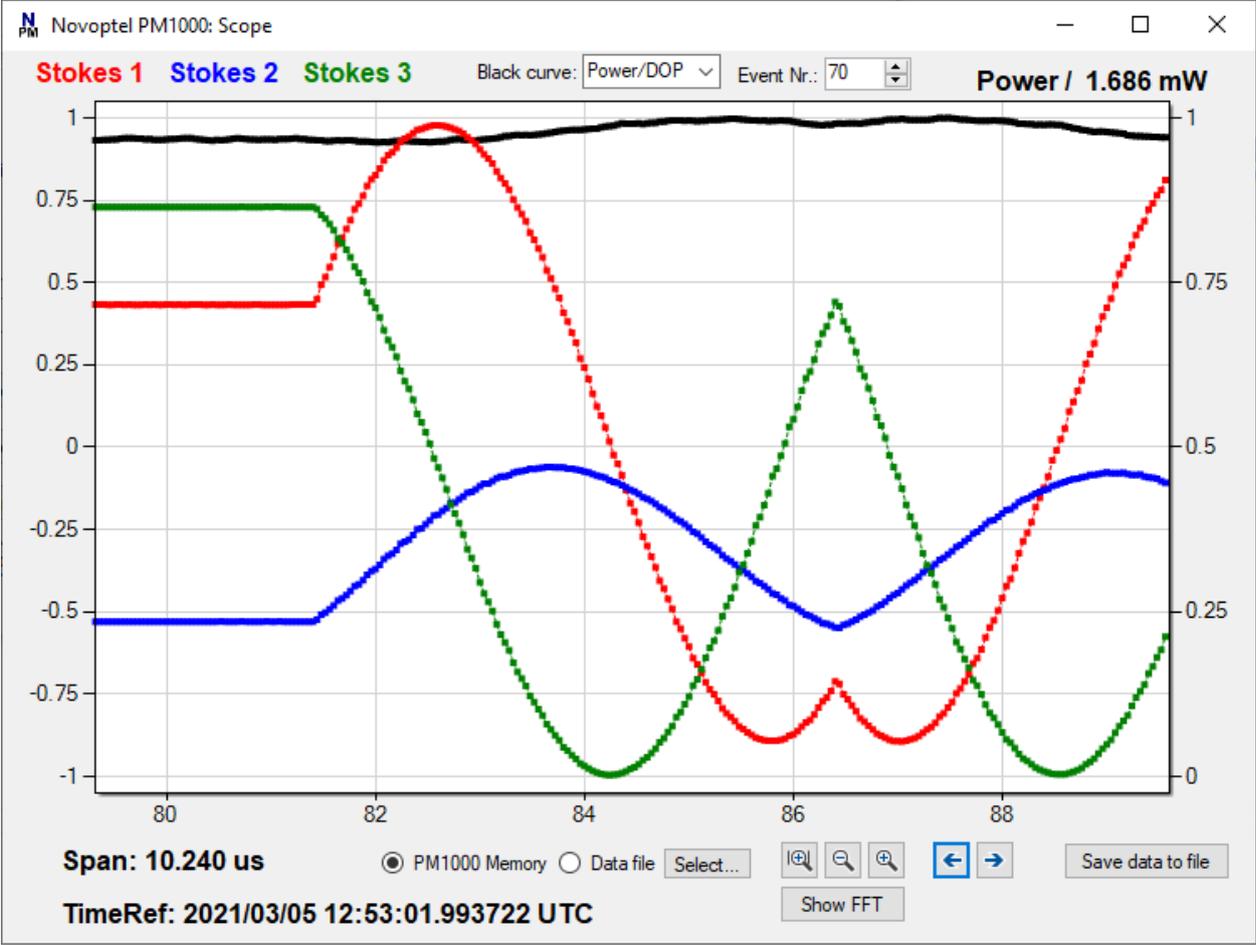
Click on “Show Scope (Memory)” to show the recorded data.



You can browse through the events by decreasing “Event Nr.”



You can zoom and shift to view the event in detail



You can review the event at a later time by checking “Data file” and selecting one of the 71 created files.

The files contain all relevant configuration data and a timestamp:

```
# TimestampUTC='2021/03/05 12:53:01.993722060';
# ATE=2;
# SamplePeriod_ns=40;
# ME=12;
# Data1Name='Power';
# PowerLeftShift=4;
# Normalization=1;
# NonNormPowRef=1000;
# TriggerGatingReg=32769;
# DynamicUnderSampling=0;
# CyclicRecording=1;
# PreTriggerSamples=0.5;
# TriggerSource='SOP 156.51 krad/s';
# SOPTriggerConfiguration=647;
# SOPTriggerThreshold=655;
# SOPTriggerPowerThreshold=1;
# POWTriggerReference=1000;
# POWTriggerThreshold=100;
0,    26117,    46949,    15407,    56670
40,    26113,    46941,    15396,    56674
80,    26084,    46946,    15396,    56672
120,    26089,    46921,    15406,    56684
160,    26095,    46930,    15416,    56689
200,    ...
```

Some comments:

The Stokes parameters have been saved in format

```
# Normalization=1;
```

This is achieved by setting in the GUI Stokes Vector Normalization: “Standard norm.” (on Poincare sphere surface if DOP=1, inside sphere for DOP<1).

Power is transferred, not DOP, due to

```
# Data1Name='Power';
```

This is achieved by setting in the GUI, Memory tab, “Stokes + Power”.

```
# PowerLeftShift=4;
```

Power in uW = Power value / $2^{\text{PowerLeftShift}}$.

In the GUI, Memory tab, set Power (in uW) fractional bits: “4”. Or better, check “auto”. Then the current power is measured and a useful value will be automatically determined.

The original record length was $2^{\text{ME}} = 2^{12} = 4096$. ME is set in the GUI, Memory tab.

The first sample of the record is the timestamp. The GUI has fabricated the first line of the .txt file from the timestamp. The data length is $2^{\text{ME}} - 1$. One can calculate $2^{\text{ME}} - 2$ usable polarization change speed values.

The time stamp corresponds to the first value 0 (= 0 ns) in the first data. The trigger instant depends on record length and PreTriggerSamples (0.5 here, i.e. in the middle of the record, or 0.25 or 0.125; can be set in the GUI).

Alternative example: analyzing polarization transient in .xlsx

One of the recorded files is lightning_events_065.txt.

If you don't want to analyze (or reload and analyze) it in the GUI then you can for instance use Microsoft Excel:

Open the .txt file with Excel. In the dialog pages select

Separated (as opposed to Fixed)

Continue

Check "Comma" in addition to the already-checked "Tabstop". (This is because the GUI separates the integer values of a data sample by commas.)

Finish

The time stamp corresponds to the first value 0 (= 0 ns) in the first data, field A19.

Insert functions in columns F:O. They calculate the maximum polarization change speed in krad/s in field M19. To conserve this, save the file as .xlsx. The functions are found in the resulting file lightning_events_065.xlsx.

Since we have the string

```
# PowerLeftShift=4;
```

the power conversion factor must be determined step by step in fields F6:F8.

$$\text{DOP} = \sqrt{S1^2 + S2^2 + S3^2}$$
$$\text{angle_change} = 2 * \arcsin(\text{distance_between_Stokes_vectors_of_adjacent_samples}/2)$$

If the DOP differs (substantially) from 1 the above equation must be modified (take arc angle instead of assuming the distance to be situated at the Poincare sphere surface).

A speed diagram is also inserted in the lightning_events_065.xlsx file.

If one copies columns F:O and inserts them into files with other records of the same length the corresponding polarization change speed will be calculated.

Further automation or doing the same calculation by other programs is possible.