AUREA correlation option for TCSPC measurements

1 Aurea TCSPC features.

Possible configuration:

- SPD_V_M1: with one detection head
- SPD_V_M2: with two detection head, independently controlling
- SPD_VT_M1: with one detection head and TDC integrated.
- SPD_VT_M2: with two detection head, TDC integrated and inter-correlation mode available

**Time to digital converter specification**

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Specifications</th>
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<tbody>
<tr>
<td>Time Bin resolution</td>
<td>60 ps rms (60ps step)</td>
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<tr>
<td>Photon count rate</td>
<td>0.4 Million counts/sec</td>
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<tr>
<td>Trigger rate</td>
<td>20 MHz max</td>
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<tr>
<td>Measurement range</td>
<td>5 to 250 ns in gating mode</td>
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<td></td>
<td>Up to 210 ms in free gating mode</td>
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</table>

The photon counting module can be provided with a time to digital converter (TDC), placed at the two APD electrical output. It’s possible to acquire directly via the GUI, the photons arrival time relative to the trigger input or between two photons arrival time named Time Correlation Single Photon Counting (TCSPC).
The correlation acquisition can be set in 4 different modes:

- **Clk– Out1**: time \((T_1)\) between the trigger (start) and the photon detection of APD1 (Stop1)
- **Clk– Out2**: time \((T_2)\) between the trigger (start) and the photon detection of APD2 (Stop2)
- **Out1 –Out2**: time \((T_2-T_1)\) between the photon detection of APD1 (Stop1) and the photon detection of APD2 (Stop2).
- **Out2 –Out1**: time \((T_1-T_2)\) between the photon detection of APD2 (Stop2) and the photon detection of APD1 (Stop1).

![Timing diagram of correlation measurements](image)

![Example of correlation measurements in histogram representation](image)

In this TCSPC representation, each photon arrival time is placed in some time bin. This time bin are incremented during the cumulative measurement.
The TDC offers the possibility of measuring the arrival time of each detected photon relative to an excitation signal (laser pulse), this within a time window (gate) selected by the user.

![Gated detection of optical pulses excitations](image)

The n triggers corresponding to n gate, the TDC records (accumulates) the measured time between the excitation and detection of each photon. These arrival times are then classified and help build a histogram time. The size of the time increment "time bin" reflects the temporal resolution of the TDC.
- The correlator settings and characteristics in gating mode.

The minimum software correlation measurement resolution is fixed at 60ps.

- In Start-Stop1 and Start-Stop2 mode, the minimum delay measurement is 5ns.

The arrival time can be measure in 250ns windows maximum, according to the maximum gate with (100ns) and the maximum internal delay range (127 ns). I.e. The photons cannot be detected after 227 ns range.

- In Stop1-Stop2 and Stop2-Stop1 mode, the photon arrival time can be measure in a time window of -250 ns to 250 ns.

For correlation measurements:

- The minimum Dead time do not exceed 4 µs.
- Maximum trigger frequency for Stop1(2)-Stop2(1) mode: 2 MHz
2. The correlation acquisition software

THE CORRELATOR WINDOW IS COMPOSED OF THREE PRINCIPAL PARTS:

- The “histogram” or “curve” plot for arrival time cumulative photon representation
- The “Raw Data” for plot the time data without calculation.
- The settings part to set the correlation measurement parameters.

Main windows for correlation measurement

On the principal graph, the photon arrival time can be plot in two different forms:

- An histogram for “bin” representation
- A curve representation
The two representation mode can be change at the end of measurements.

The "settings" box:

- **Counts**: set the number of point for the measurement. Maximum: **1 million points**
- **Max value**: The measurements stop when the max of the histogram (curve) reached this set value.
- **Mode**: Set the correlation measure option: using APD1 output or APD2 output or the twice.
- **Start**: launch the correlation measurement. The acquisition stop when the number of point selected is allowing or when you click on **Stop** button.
- **Save**: At the end of measurement, you can save the histogram data directly to a "*.txt" file.
- **Save Raw**: Save the Raw data in "*.txt" file.

The "graphic" box set the histogram or curve parameters:

- **Step** to choose the resolution time bin: **60ps** min, 0.06ns step.

This tool is used to measure with a **cursor** the time between two points of the curve or histogram. When you click on the "time measurement" button, the cursor appears directly on the curve.
3 Labview VI and DLL C or Visual Basic.

- Aurea can provide some Labview interfaces:
  - Labview VIs (see SPD labview functions tree)
  - Labview VI Examples for a rapid development.
Example of LabView VI interface to control and measure photon correlation with the SPD

- Aurea provide a DLL C, C++ or Visual Basic allowing users to easily create their own interface. A complete documentation and assistance can be proposed to help the user in this way.