Synertronic Designs

Glaz LineScan-I

High-speed linear array cameras

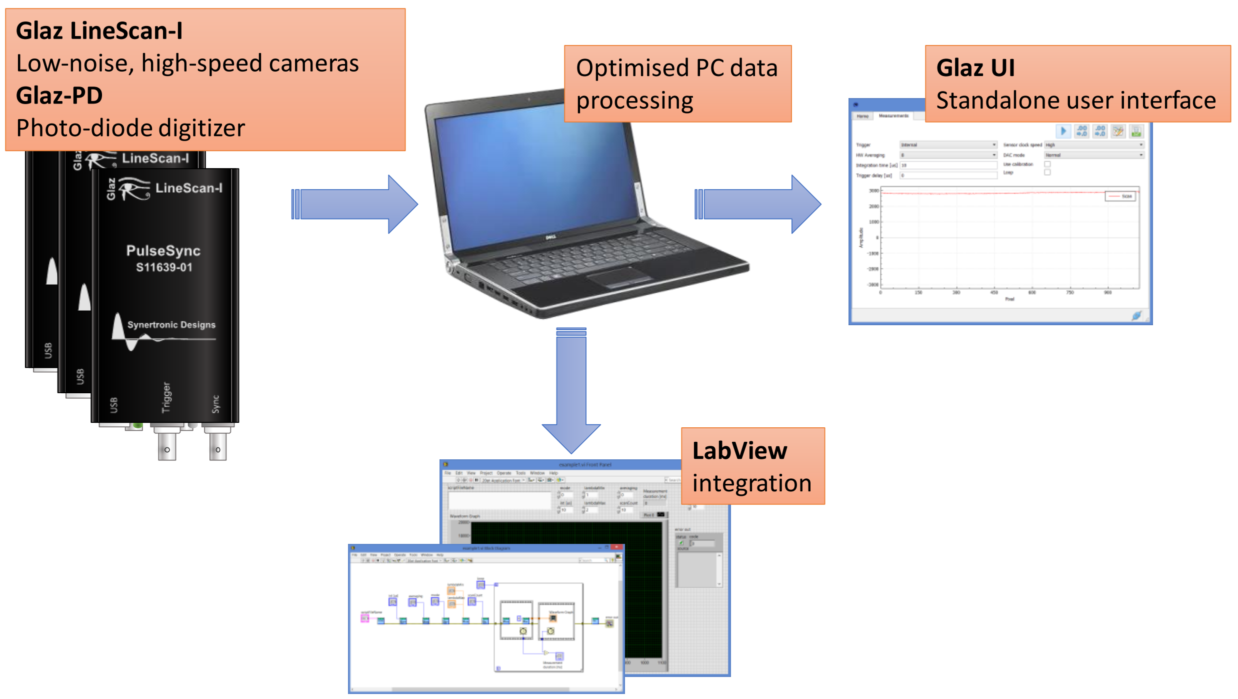
- Low-noise
- 16-bit resolution
- High-speed USB interface
- USB-powered
- LabView integration
- Flexible XML-based configurations
- Application-specific firmware flavours

Overview

Glaz LineScan-I is a low-noise camera with 16-bit resolution. Extremely low noise-levels can be obtained by a selection of hardware and/or software averaging modes. Combined with powerful PC-based data processing software, a multi-camera measuring system can be configured quickly and effortlessly.

Glaz LineScan-I cameras are available with two different firmware flavours: *PulseSync* and *TimeFill*. *PulseSync* is recommended for synchronised single- and multi-camera systems. *TimeFill* is recommended for applications requiring large temporal fill factors.

Glaz UI (a stand-alone application) or LabView can be used to configure and communicate with the cameras. Measurements with single- or multi-camera configurations can be configured, using XML-based script files. This provides a flexible way to define calculations, that need to be performed on the measured data. All data processing is performed in optimised, multi-threaded libraries, thereby providing the best possible performance.



Specifications

Characteristic	Value	Unit
PC Interface		
PC interface	USB 2.0 (high-speed)	
Data transfer rate[1]	>20	MB/s
Maximum USB cable length	3	m
Linear sensor		
Sensor type	CMOS	
Supported sensors	Hamamatsu S12198-1024Q Hamamatsu S10453-1024Q Hamamatsu S11639 Hamamatsu S11639-01	
Optical integration time	PulseSync: 2 – 5,000 TimeFill: 2 – 400,000	μs
Hamamatsu S12198-1024Q/S10453-1024Q		
Pixel count	1024	
Scan rate (half-speed clock)	3,500	lines/s
Scan rate (full-speed clock)	7,000	lines/s
Spectral response range	200 – 1000	nm
Noise level (single scan)	<520	μOD[2]
Noise level (512 averaged scans)	<25	μOD
Dynamic range[3] (single scan)	>1,900	
Dynamic range (512 averaged scans)	>40,000	
Hamamatsu S11639/S11639-01		
Pixel count	2048	
Scan rate (half-speed clock)	1,700	lines /s
Scan rate (full-speed clock)	3,500	lines /s
Spectral response range	200 – 1000	nm
Noise level (single scan)	<530	μOD
Noise level (512 averaged scans)	<30	μOD
Dynamic range (single scan)	>1,800	
Dynamic range (512 averaged scans)	>33,000	
Digitizer		
Resolution	16	bit
Full-scale reading	65535	
ENOB (effective number of bits)	13.5	bit
Drift	100	ppm/^{O}C
Total analogue front-end noise level	<1	mV_{RMS}
External trigger		
Signal type	5V-TTL	
Trigger edge	rising	
Positive-going threshold voltage	2.8	V
Negative-going threshold voltage	2.0	V
Minimum trigger pulse width	1	μs
Programmable trigger delay	0 - 200	ms
Programmable trigger delay resolution	0.1	μs

Table 1 Specifications for *LineScan-I*.

[1] Using dedicated USB 2.0 port.
[2] OD is the relative amplitude with respect to full-scale value.
[3] Dynamic range is defined as the ratio of the full-scale value and the RMS noise value.

Hardware description

Dimensions

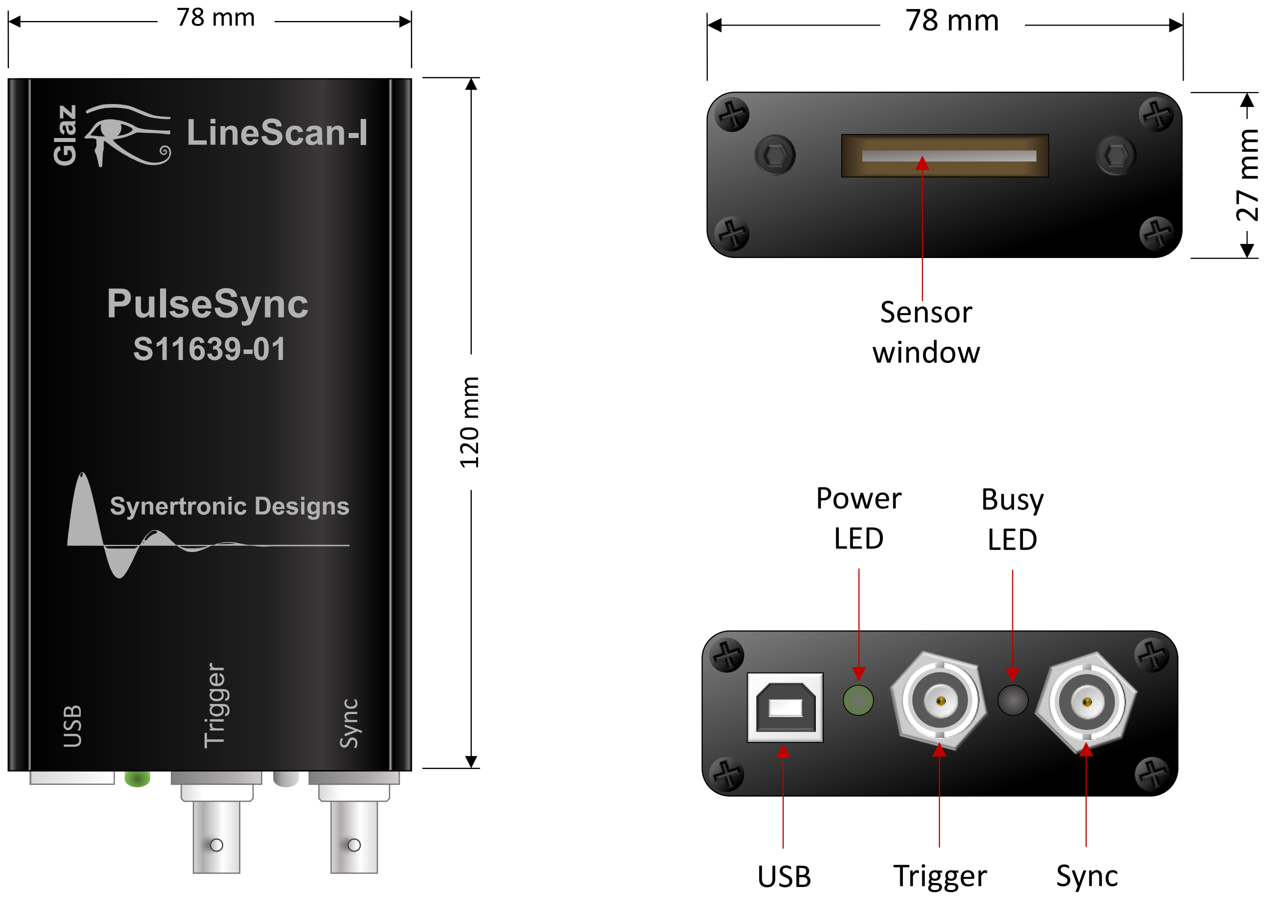


Figure 1 Mechanical dimensions and legend.

Ports

Port	Type	Function
USB	USB-B	Data connection to a PC. Also provides the camera with power.
Trigger	BNC	External trigger input.
Sync	BNC	Synchronisation signal for multi-camera operation.

Table 2 Connectors.

LEDs

LED	States	
Power LED	off	no power
	green	camera has power.
Busy LED	off	idle
	green	waiting for trigger
	green to red	triggered and busy scanning

Table 3 LEDs.

The colour of the *Busy* LED is an indication of how busy the cameras is. When the camera is not busy (i.e. not triggered) the LED will be green. When the camera is working close to its maximum scan rate, the LED will be red. For lower scan rates, the camera will be yellow.

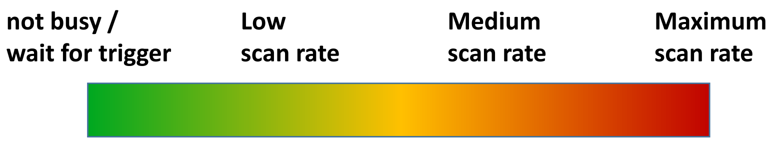


Figure 2 Ready/Busy LED colour legend.

Functional description

Connecting cameras to a PC

Cameras are connected to a PC via USB interfaces. *Glaz LineScan-I* cameras are USB 2.0 high-speed devices, but are backwards compatible with USB 1.1 interfaces. USB 1.1 interfaces have a maximum data transfer rate to less than 0.5 MB/s and will limit maximum scan rate of the camera.

If a PC has a limited number of USB ports, it is possible to use an external USB hub. Up to two cameras can be connected to a single USB 2.0 hub without significant reduction in the data transfer rate. It is possible to connect more than two cameras to a single USB 2.0 hub, but this can reduce the maximum data transfer rate and scan rate. When connecting more than two cameras to a single USB hub, it is advisable to use a USB 3.0 hub.

Camera clock speed

The internal sensor clock of the camera can be operated at two frequencies: half-speed and full-speed. The sensor noise level at full-speed is approximately 20% higher compared to the noise level at half-speed. By default, the camera uses the full-speed clock. When low-noise measurements are a priority, it is advisable to use the half-speed clock.

Clock speed	Internally sensor pixel clock
half-speed	10 MHz
full-speed	5 MHz

Table 4 Sensor pixel clock.

Triggering cameras

Cameras can be triggered either internally or externally. When running in internal trigger mode, no external trigger should be connected to the camera. In this mode, the trigger signal is generated internally by the camera itself. The frequency of the internal trigger signal depends on the firmware flavour. See “Internal trigger generator” for more information.

When running in external trigger mode, each scan is started after an external trigger pulse is applied to the trigger port. A delay can be specified between the positive going edge of the trigger pulse and the start of the sensor integration time. The delay can be specified with a resolution of 0.1 μs and can be set between 0 and 200 ms. When a delayed trigger[4] is received while the camera is busy, this trigger will be ignored.

Integration time

During the integration time, the photo-current from the CMOS sensors will be integrated. The integration time can be set between 2 and 2000 μs. For short-pulse laser applications, the preferred integration time is 5 μs.

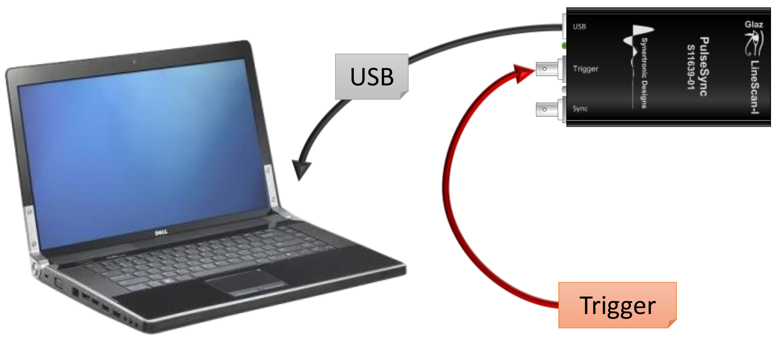


Figure 3 Single-camera configuration.

[4] The delayed trigger is the external trigger signal with the specified delay.

Single-camera configuration

In a single-camera configuration only a single camera is used. When external trigger mode is used, the camera must be provided with a trigger signal via the *Trigger* port.

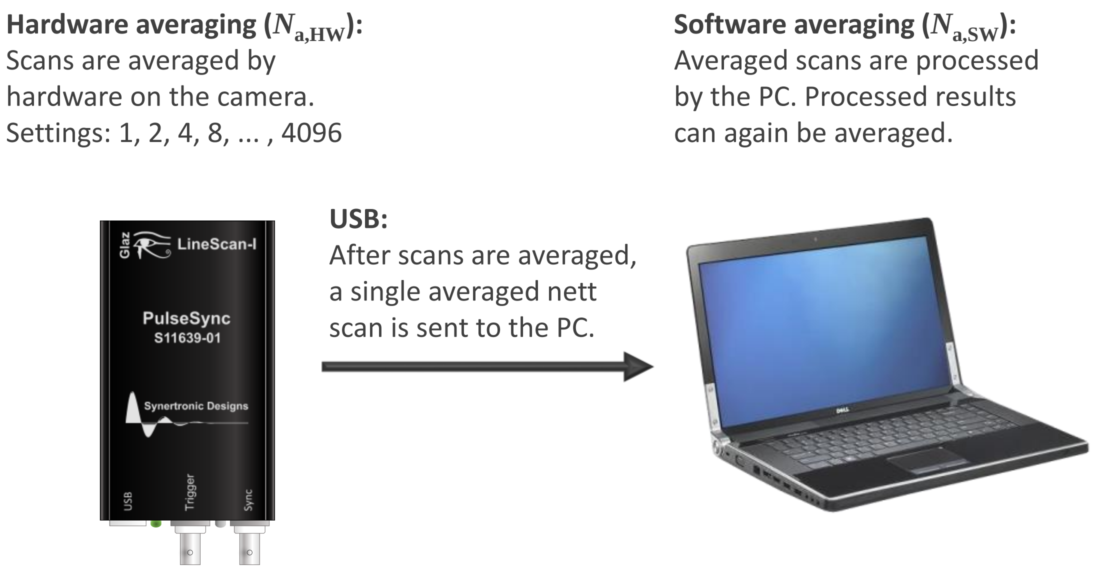
> In internal trigger mode, leave the *Trigger* port unconnected. The *Sync* port must always be left unconnected.

Hardware and software averaging

In order to reduce noise levels, averaging must be applied. *Glaz LineScan-I* provides two ways to average scans: hardware and software averaging.

Hardware averaging is performed on the camera. The number of scans to average can be set to: 1, 2, 4, 8, 16, 32, 64, 128, 256, 512, 1024, 2048 or 4096. The camera will average the raw sensor data for the given number of scans. Only the final averaged result is sent to the PC. This is a useful technique to reduce the required USB bandwidth and processing speed of the PC.

Software averaging is performed on the PC. The difference compared to hardware averaging, is that the calculation result of the scanned data (i.e. processed data) is averaged. Hardware and software averaging can be combined to reduce noise and the required bandwidth and processing speed of the PC.



Hardware averaging ($N_{a,HW}$):
Scans are averaged by hardware on the camera.
Settings: 1, 2, 4, 8, ... , 4096

Software averaging ($N_{a,SW}$):
Averaged scans are processed by the PC. Processed results can again be averaged.

USB:
After scans are averaged, a single averaged nett scan is sent to the PC.

Figure 4 Hardware and software averaging.

Software pixel binning

In the latest software, binning can be enabled. Binning calculates the average of 2 or 4 adjacent. This is not a moving average. Pixels are grouped into adjacent sets of 2 or 4 pixels and the average of each groups is calculated. As a result, binning reduces the effective number of pixels of the linear array:

Binning	Pixel averaging groups	Effective number of pixels
2-pixel	[0,1], [2,3], [3,4], …	½ $N_{p,sensor}$
4-pixel	[0,1,2,3], [4,5,6,7], [8,9,10,11], …	¼ $N_{p,sensor}$

Table 5 Pixel binning.

Noise

There are several ways to define the dynamic range of a camera. In this manual, the dynamic range D is defined as the ratio of the sensor full-scale A_{FS} value and the noise RMS value A_{RMS}:

$$D = \frac{A_{FS}}{A_{RMS}}$$

In order to decrease the noise level and increase the dynamic range, averaging can be used. The RMS noise level of an averaged signal is reduced by the square root of the number of averaged scans:

$$A_{\mathrm{avg,RMS}} = \frac{A_{\mathrm{RMS}}}{\sqrt{N_{\mathrm{a}}}}$$, where N_a is the number of averaged scans.

Pixel binning further reduces the noise level:

$$A_{\mathrm{avg,binning,RMS}} = \frac{A_{\mathrm{avg,RMS}}}{\sqrt{N_{\mathrm{b}}}}$$, where N_b is the level if binning (e.g. 2 or 4).

Drift

Drift of the camera sensor becomes visible, when performing low-noise measurements with a large number of averaged scans. When averaging more than 256 scans, the noise level drops below the camera drift. Drift is mainly cause by temperature changes of the camera sensor. This is more pronounced during the first 15 minutes after the camera is power up. In Figure 5 the drift of the average sensor reading as a function of time is given. The drift is expressed relative to the final average sensor reading after 30 minutes. A change of up to 2% can be expected during the first 15 minutes after power-up.

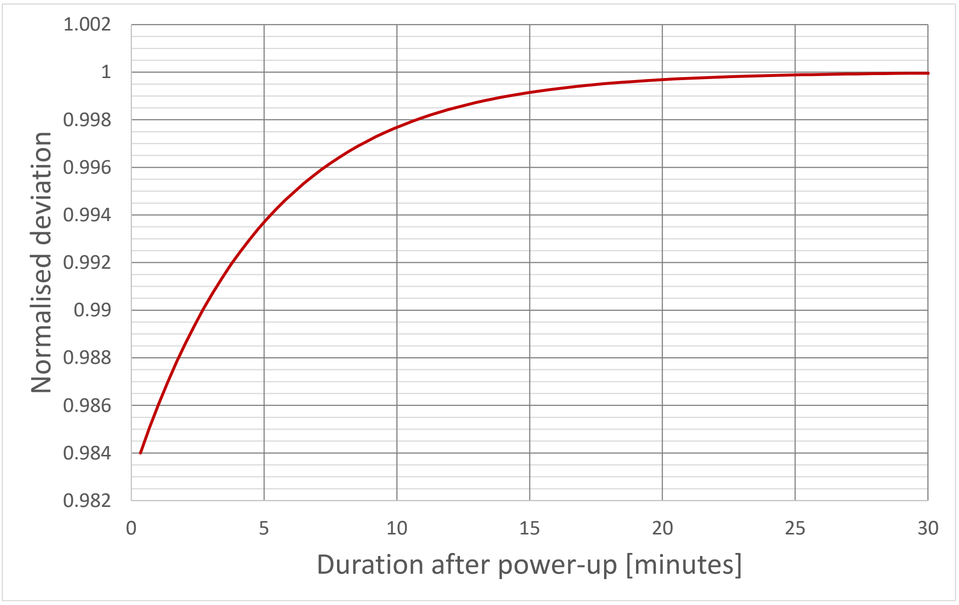


Figure 5 Drift after power-up.

In order to reduce the effect of drift, the camera should be given at least 15 minutes to warm up. In addition, the camera sensor should be shielded from air drafts and room temperatures should be kept constant. It is possible to compensate for drift by performing a background measurement in regular intervals and subtracting this background from measurements.

Photoresponse nonuniformity (PRNU)

The pixels on a linear optical array are not identical. Each pixel has a different offset and gain. *Glaz UI* supports offset calibration per pixel. Gain calibration is also supported, but is not recommended. Calibrations are stored on the camera. A typical PRNU is shown in Figure 6.

Several averaged scans (with 256 hardware averaging) were taken and plotted. Only the data from the first 128 pixels is shown. Note: the resulting dark red trace is not noise, but the sensor PRNU. The noise level for each pixel is below the PRNU and the differences in gain and offset of each pixel is clearly visible.

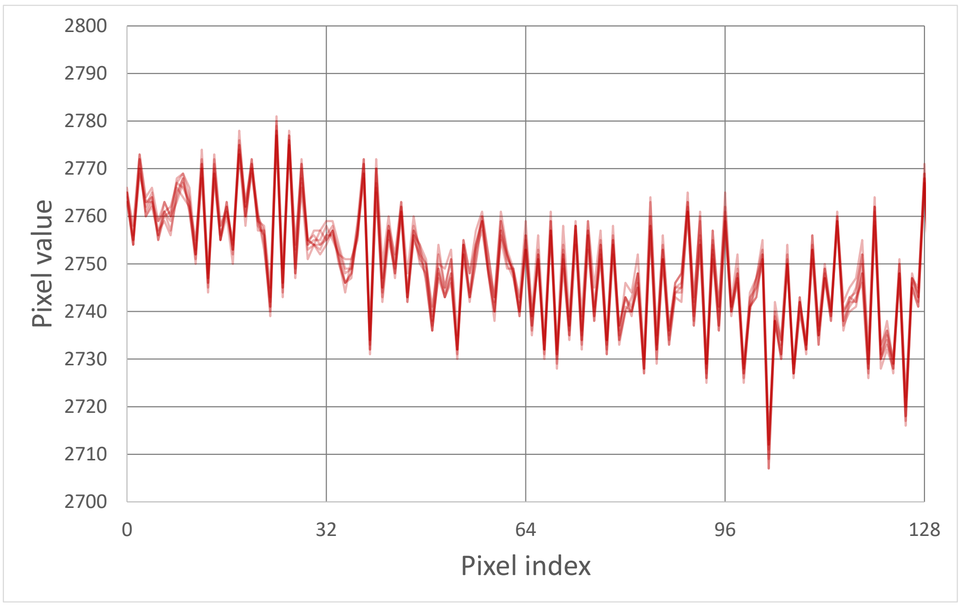


Figure 6 Example of PRNU.

PulseSync and TimeFill firmware

Instead of providing a general solution, the *Glaz LineScan-I* cameras are pre-programmed with application-specific firmware. The most notable differences between different firmware flavours are:

- Sensor read-out scheme
- *Sync* port functions
- Internal trigger generator

LineScan-II cameras provide more flexibility. They can be configured at run-time with either the *PulseSync* or *TimeFill* mode.

Sensor read-out schemes

The sensor integration period and the data read-out can either be interleaved or non-interleaved.

PulseSync – read-out scheme

PulseSync uses the non-interleaved read-out scheme. One integration and read-out cycle must be fully completed, before the next cycle can start. This is especially important for multi-camera systems to ensure reliable synchronisation.

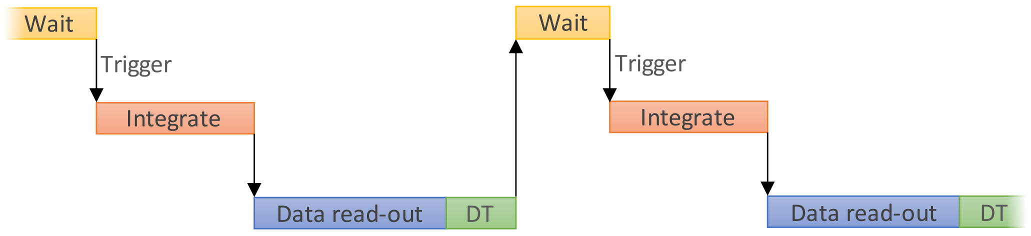


Figure 7 *PuleSync*: Non-interleaved read-out scheme

TimeFill – read-out scheme

TimeFill uses the interleaved read-out scheme. The next integration cycle can start even before the previous data read-out is completed. With this scheme, very high temporal fill factors can be achieved, but cannot be used for robust multi-camera synchronisation.

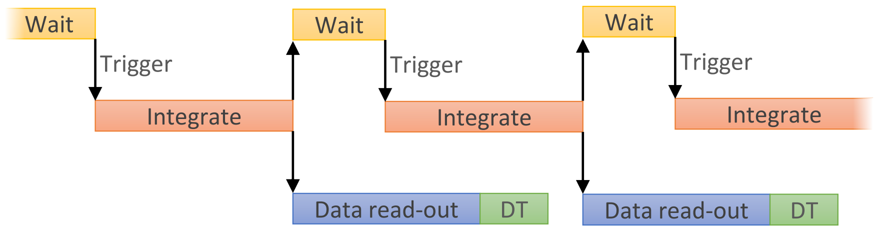


Figure 8 *TimeFill*: Interleaved read-out scheme

Sync port functions

The *Sync* port is an open-collector with internal 1.8 kΩ pull-up. The polarity is active low.

TimeFill – Sync port functions

The following *Sync* functions are supported:

- Trigger:
  The *Sync* port is pulled low for 20 µs after each internal/external trigger pulse.

- Integration window:
  The *Sync* port is pulled low during the integration period.

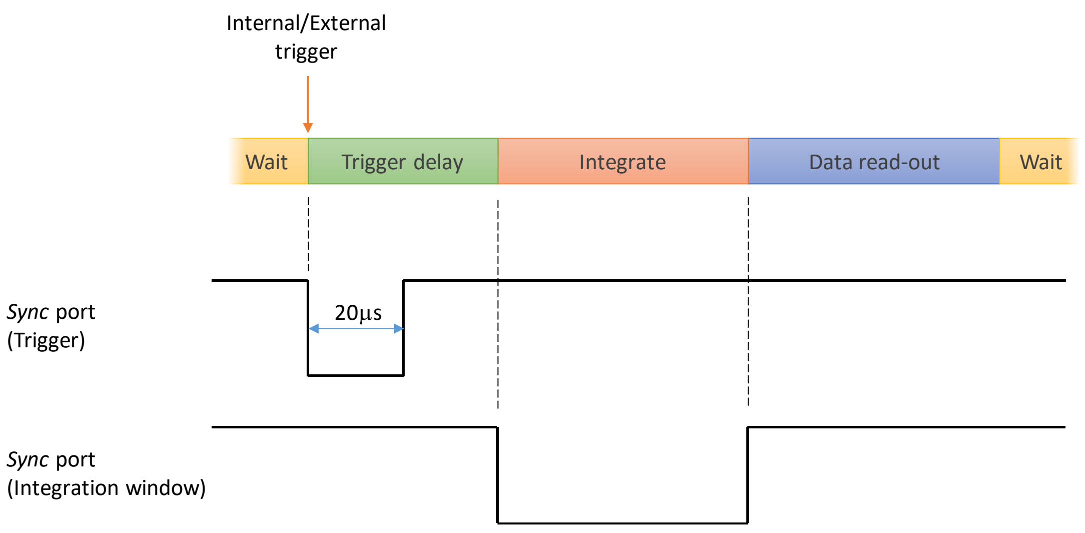


Figure 9 *TimeFill Sync* port functions.

TimeFill cannot be used for multi-camera synchronisation or combined *Glaz LineScan* and *Glaz-PD* measurements.

PulseSync – Sync port functions

With *PulseSync* the *Sync* port is exclusively used for synchronisation between *Glaz LineScan* cameras and *Glaz-PD* devices. For more information see "*PulseSync*: Multi-camera configuration and synchronisation" and "*PulseSync*: Combining Glaz LineScan-I and Glaz-PD devices".

Internal trigger generator

Cameras can be configured to run from an internal trigger. In this case, no external trigger signal is required.

TimeFill – internal trigger generator

With *TimeFill* the camera supports a free-running internal trigger generator. The trigger delay is also applied to the internal trigger. The trigger frequency ranges are:

Description	Sensor	Value	Unit
Min. frequency	All	2.4	Hz
Max. frequency	S11639 / S11639-01 S10453-1024Q / S12198-1024Q	4000 8000	Hz

Table 6 Internal trigger frequency ranges.

PulseSync – internal trigger generator

With *PulseSync* the internal trigger generator starts a line scan. Then it waits until the measurement is completed, before initiating the next line scan. A fixed trigger frequency is not supported.

Measurements and scripting

Script file structure

The calculations that need to be performed by the PC with the measured data is defined by XML script files. A typical script file is shown in Figure 10.

```
<!DOCTYPE GlazScript>
<config>
  <camera serial="SYBP005010001" number="1" master="1"/>
  <preprocessor camera="1" type="calibrate"/>
  <preprocessor camera="1" type="subtract_background"/>
  <calculation name="Camera 1" keepscans="1">
    <measurement camera="1"/>
  </calculation>
</config>
```

Camera definitions

Pre-processing steps

Calculations

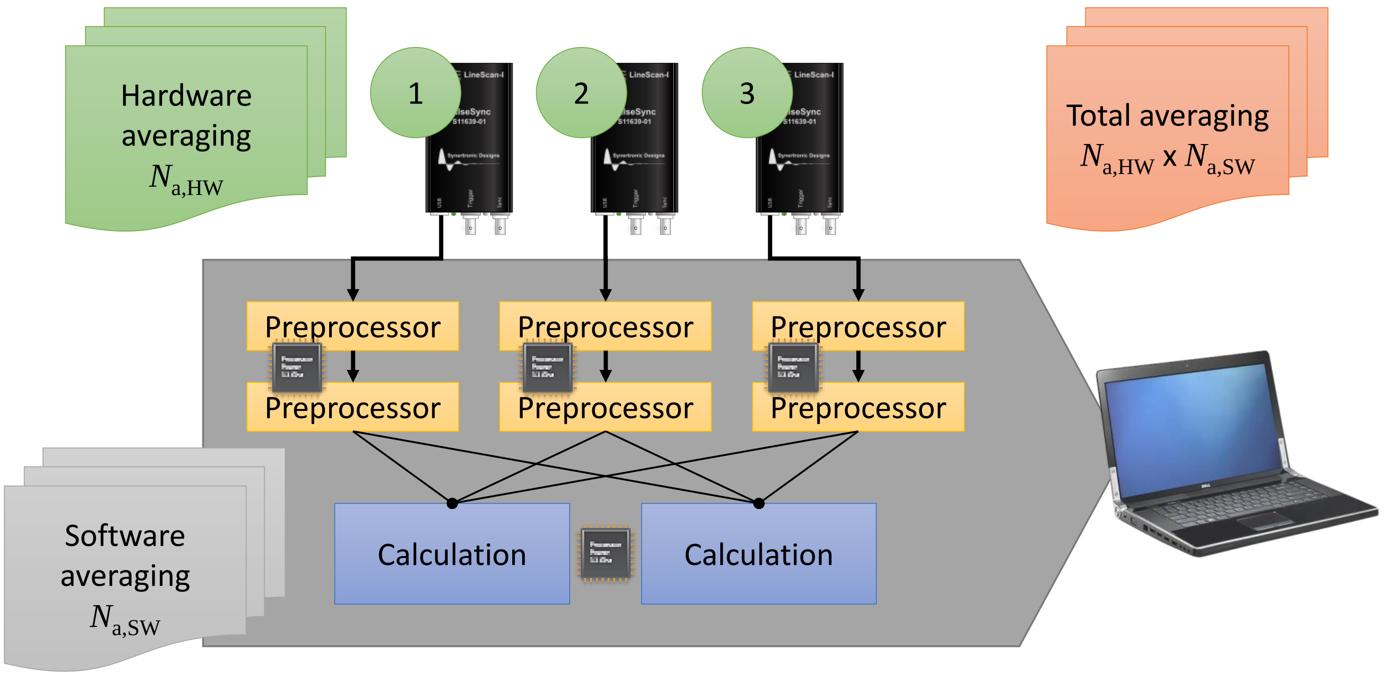
Figure 10 XML script file.

A script file consists of three sections:

1. Camera definitions:
   Each camera used for the measurement must be listed here.
2. Pre-processing steps:
   The pre-processing steps for each camera listed in the camera definitions must be specified.
3. Calculations:
   Any number of calculations can be specified. Each calculation can use the pre-processed results of one or more cameras.

Measurement data flow

Figure 11 depicts a multi-camera configuration with three cameras, two pre-processing steps for each camera and two calculations. Hardware averaged scans are sent from each camera to the PC via USB. The scans are then passed through the pre-processing steps. Data reception and pre-processing are performed on separate threads for each camera. On a quad-core PC, this would imply that the data from each camera is pre-processed on a separate core.



Hardware averaging $N_{a,HW}$
1
2
3
Total averaging $N_{a,HW}$ x $N_{a,SW}$
Preprocessor
Preprocessor
Preprocessor
Preprocessor
Preprocessor
Preprocessor
Software averaging $N_{a,SW}$
Calculation
Calculation

Figure 11 Measurement data flow.

Calculations are performed only when the pre-processed data from all the cameras for a given hardware averaged scan is available. The process of receiving averaged scans and performing pre-processing and calculations is performed $N_{\mathrm{a,SW}}$ times. The results of the calculations are accumulated and at the end of the measurement the software average for each calculation is determined.

Scripting – Camera definitions

In order to use cameras, the must first be uniquely identified. Each camera has an entry in the script file using the following format[5]:

```
<camera serial="SN" number="NUM" [master="M"] [reverse="R"] [binning="B"]/>
```

SN : The serial number of a camera is printed onto the back of the camera. The serial number has 13 digits and has the format: SYPB + device number + device version + instance number. For example: SYPB005010001. A serial number may only be defined once in a script file.

NUM : The camera number that will be assigned to the camera with the given serial number. This number will be used in the rest of the script file. This must be a unique number in the range [1 .. 1000].

M : Can be one of the following values: *0*, *1*, *true* or *false*. If the value is *1* or *true* the camera will be configured as the master camera. The master camera is the camera that must receive the trigger signal. Only one camera may be defined as the master. The default value is *0* or *false*.

R : Can be one of the following values: *0*, *1*, *true* or *false*. If the value is *1* or *true* the scan will be reversed and the data from pixels 0 to 1023 will be processed as pixels 1023 down to 0. The default value is *0* or *false*.

B : This value specifies the level of binning. It can be one of the following values:

0	no binning (default)
1	2-pixel binning
2	4-pixel binning

Scripting – Pre-processing steps

Each camera in the camera definition section may have its own set of pre-processing steps. The pre-processing steps are executed in the same order as defined in the script file. It is important to specify the pre-processing steps in the correct order. The following pre-processing steps are supported:

- Calibrate:
  Calibrates the scan data using the calibration stored on the corresponding camera.
- Inverse Fourier transform (IFFT):
  Calculates the inverse transform of a scan. It is assumed that a scan is performed with constant wavelength increments. The wavelength for each pixel is given by:

  $$\lambda_n = \lambda_{\min} + \frac{\lambda_{\min} - \lambda_{\max}}{N-1} n \qquad \text{with} \qquad n = 0\,..\ 1023,$$

  where n is the pixel number and $\lambda_{\min}$ and $\lambda_{\max}$ are the wavelength limits. The wavelength limits are specified outside the script file. In LabView a VI is provided to set the limits and in the stand-alone Glaz UI the limits can be specified on the user interface. The IFFT pre-processor will interpolate the scan in frequency space with constant increments. The IFFT is performed on the interpolated data.

  It is possible to turn interpolation off, by setting the `interpolate` attribute to *false*. In this case, the IFFT is performed directly on the scan data.

[5] Parameters in square brackets […] are optional.

- Background subtract:
  Before performing a measurement the background must be measured. In LabView a VI is provided and in the stand-alone Glaz UI an action can be triggered to take a background measurement.
  Note: The stored background will be the resulting data after pre-processing. The background subtraction must, therefore, always be the last pre-processing step.

A pre-processing step entry in the script file has the following format:

```
<preprocessor camera="NUM" type="T" [interpolate="I"]/>
```

NUM	:	The camera number that was assigned to a camera in the camera definition section. This pre-processing step will be applied to the scan data from the camera with the given number.
T	:	Can be one of the following values: *calibrate*, *ifft* or *background_subtract*.
I	:	This attribute is only applicable to the IFFT pre-processor. It can be one of the following values: *0*, *1*, *true* or *false*. If the value is *1* or *true*, the IFFT is performed on the interpolated data. If the value is *0* or *false*, no interpolation is done and the IFFT is performed directly on the scan data. The default value is *1* or *true*.

Scripting – Calculations

Any number of calculations in the calculations section can be defined. Calculations support operations on complex and real vectors. Complex vectors are supported, because the result from the IFFT pre-processor yields a complex vector. Each calculation uses a nested definition. The definition describes an expression tree (Wikipedia description). Below is an example of a calculation:

```
<calculation name="Example">
    <subtract>
        <divide>
            <measurement camera="1"/>
            <measurement camera="2"/>
        </divide>
        <divide>
            <measurement camera="3"/>
            <measurement camera="4"/>
        </divide>
    </subtract>
</calculation>
```

The equivalent equation for the above definition is:

$$\text{Example} = \frac{M_1}{M_2} - \frac{M_3}{M_4} \quad ,$$

where M_1, M_2, M_3 and M_4 are the pre-processed results from camera 1 to 4, respectively. In the example, the `subtract`, `divide` and `measurement` XML tags define the operations to be performed by the calculation. These tags are also called operators.

There are binary, unary and leaf operators. Binary operators require two child tags. In the example above, each `divide` operator has two `measurement` tags as children. A unary operator requires a single child tag. Leaf operators do not have child tags. Leaf operators are furthest to the right in the nested definition. In the above example, all `measurement` tags are leaf operators.

Table 7, Table 8 and Table 9 list the supported binary, unary and leaf operators, respectively.

Operation	Scalar-Scalar (s_1, s_2)	Scalar-Vector (s, v)	Vector-Vector (v_1, v_2)
Multiplication	$s_1 \cdot s_2$	$v_n \cdot s$ or $s \cdot v_n,\ \ n = 0..N$	$v_{1,n} \cdot v_{2,n},\ \ n = 0..N$
Division	s_1 / s_2	$v_n / s,\ \ n = 0..N$	$v_{1,n} / v_{2,n},\ \ n = 0..N$
Addition	$s_1 + s_2$	$v_n + s$ or $s + v_n,\ \ n = 0..N$	$v_{1,n} + v_{2,n},\ \ n = 0..N$
Subtraction	$s_1 - s_2$	$v_n - s,\ \ n = 0..N$	$v_{1,n} - v_{2,n},\ \ n = 0..N$

Table 7 Binary operators.

Operation	Scalar (s)	Vector (v)
Magnitude	Not supported	$\lvert v_n \rvert,\ \ n = 0..N$
Phase	Not supported	$\widehat{v_n},\ \ n = 0..N$

Table 8 Unary operators.

Operation	Result
Measurement	Returns the data of a given camera. The data is returned as a vector containing the 1024 values of the last pre-processed scan. If the IFFT pre-processor is used, the vector will contain complex values.
Scalar	Defines a single real, scalar value.

Table 9 Leaf operators.

Calculation definition start

A calculation and its definition starts with a calculation entry. A calculation entry in the script file has the following format:

```
<calculation [name="NAME"] [keepscans="K"]>
   … (operations)
</calculation>
```

NAME : The name of the calculation. In the Glaz UI this will be displayed in the legend of the measurement plot.

K : Can be one of the following values: *0*, *1*, *true* or *false*. If the value is *1* or *true* each hardware averaged scan is saved and can be viewed in the Glaz UI. The default value is *0* or *false*.

The operations of a calculation are described by a nested definition using the operators summarised in Table 7, Table 8 and Table 9. See the sections below for more information on operators.

The calculation entry must only contain a single operator. This can either be a binary, unary or leaf operator.

After receiving the pre-processed data from each camera, the calculations are performed. The result of each calculation is accumulated and an average is calculated (see “Hardware and software averaging”). It is assumed, that the result is real. If the result contains complex values, the imaginary part will be ignored.

Binary operators

All binary operators have the following format:

```
<OP>
   <…>      (first child operator)
   <…>      (second child operator)
</OP>
```

OP : Can be one of the following values: *add*, *subtract*, *multiply* or *divide*.

The function of the first and second child operators are described in the table below:

Operation	First child operator		Second child operator
Add	term 1	+	term 2
Subtract	minuend	-	subtrahend
Multiply	factor 1	·	factor 2
Divide	numerator	/	denominator

Table 10 Child tags of binary operators.

Unary operators

All unary operators have the following format:

```
<OP>
    <…>       (child operator)
</OP>
```

OP : Can be one of the following values: `magnitude` or `phase`.

The magnitude or phase is calculated from the data defined by the child operator.

The phase operator supports phase unwrapping. The algorithm for unwrapping the phase uses a threshold value. If the difference in phase between two successive data points is larger than the threshold value, then 2π will be added or subtracted from the next data point. The threshold value can be tweaked with the `threshold` attribute:

```
<phase [threshold="T"]>
```

T : A decimal number specifying the threshold as a faction of 2π. The default value is 0.75. For **T** > 1.0, phase unwrapping will be disabled.

Leaf operators

Tree leaf operators are supported: *scalar*, *measurement* and *reference*. The scalar operator has the following format:

```
<scalar value="V"/>
```

V : A decimal number. This is the return value of the scalar operator.

The measurement operator returns the pre-processed scan result of a camera. It has the following format:

```
<measurement camera="NUM" [ifft="IFFT"] [interpolate="I"]/>
```

NUM : The camera number that was assigned to a camera in the camera definition section. The operator will return the pre-processed data for the given camera.

IFFT : Can be one of the following values: *0*, *1*, *true* or *false*. When not specified, the default value is *false*. If the value is *1* or *true* the operator will return the inverse Fourier transform (IFFT) of the pre-processed scan result. This function is useful when both IFFT and non-IFFT results are required. Note: this method is less efficient, than using the IFFT pre-processor.

I : Can be one of the following values: *0*, *1*, *true* or *false*. If the value is *1* or *true*, the IFFT is performed on the interpolated data. If the value is *0* or *false*, no interpolation is done and the IFFT is performed directly on the scan data. The default value is *1* or *true*.

The reference operator is used to access the result of another calculation. This is necessary when gated calculations need to be combined into a higher-level calculation. It has the following format:

```
<reference calculation="CALC"/>
```

CALC : The name of a previously defined calculation (see “Calculation definition start”). The operator will return result of the referenced calculation.

A calculation containing a measurement operator is also called a measurement calculation. A calculation containing a reference operator is also called a reference calculation.

A calculation may not contain both a measurement and a reference operator. Reference calculations should only reference measurement calculations. Measurement calculations should be defined first, followed by any required reference calculations.

PulseSync: Multi-camera configuration and synchronisation

The *Glaz LineScan-I with PulseSync* was designed to support multi-camera operation. The design ensures that cameras remain synchronised and that they take scans at the same time. To achieve synchronisation, all the *Sync* ports of a multi-camera configuration must be connected together. Each camera is connected to a separate USB port on the PC or USB hub.

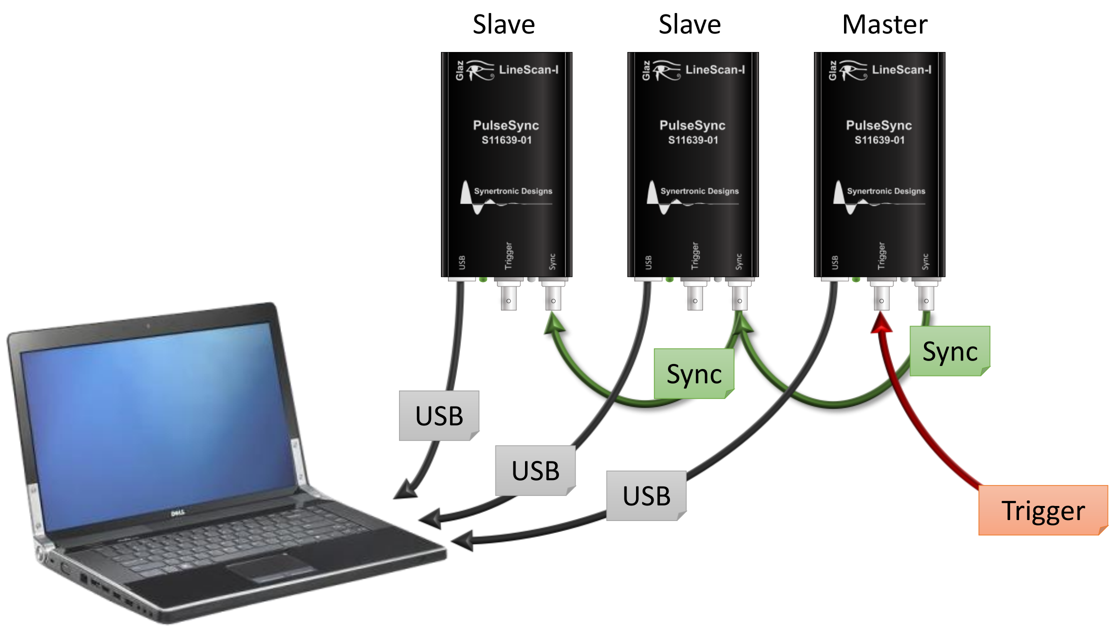


Figure 12 Multi-camera configuration with three cameras.

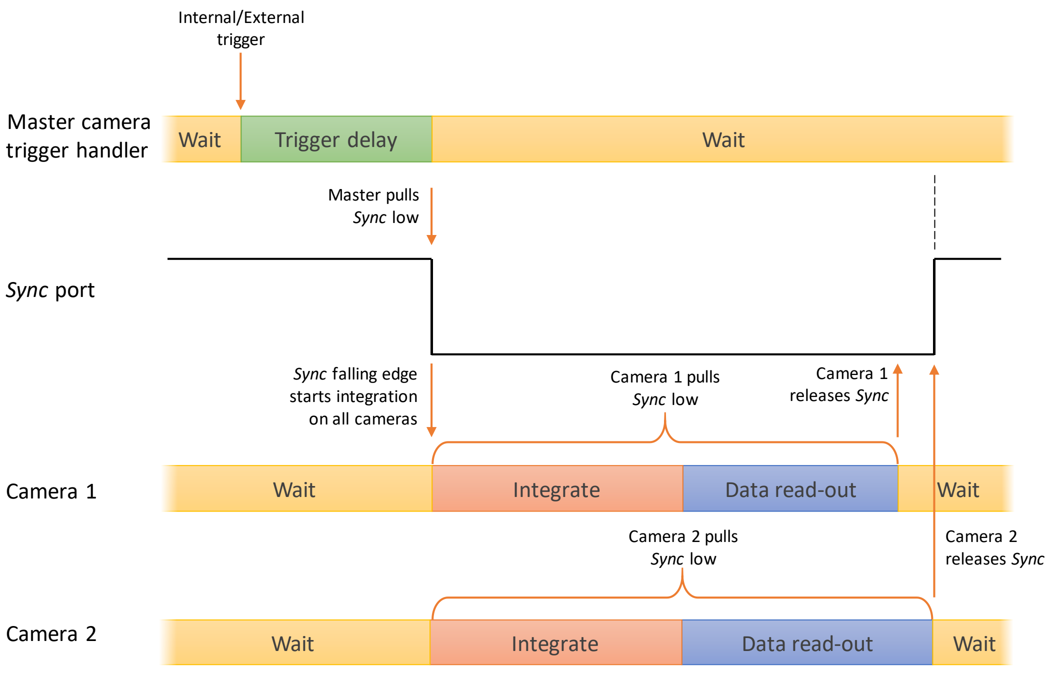


Figure 13 *PulseSync* synchronisation via the *Sync* port.

At least one camera must be defined as the *Master*. The *Master* receives the external trigger signal or generates the internal trigger signal. After the configured trigger delay, the *Master* pulls the *Sync* port low. This initiates the integration period on all connected cameras. Each camera pulls the *Sync* port low during the integration and data read-out period. The *Sync* port is released only after all the cameras have completed the data read-out. As long as any one of the cameras are busy with a scan or are sending data to a PC, the *Sync* signal will remain asserted low.

If triggered internally, leave the *Trigger* port unconnected. The *Trigger* port of all slave cameras must be left unconnected.

When a delayed trigger signal is received by the master camera, while the *Sync* signal is asserted, this trigger will be ignored. A multi-camera configuration will remain synchronised, even if the trigger frequency is higher than the processing speed of the cameras and PC. If the trigger frequency is higher than system’s processing speed, some of the triggers will be ignored. Important to note, that all cameras will ignore the same trigger signal. It is safe to use a multi-camera configuration with USB 1.1 interfaces, USB 2.0 hubs or with slower PCs. The only side-effect will be a lower achievable scan rate and measurements can take longer.

PulseSync: Combining Glaz LineScan-I and Glaz-PD devices

It is possible to combine *Glaz LineScan-I PulseSync* camera measurements with *Glaz-PD* devices. More information about *Glaz*-PD devices and its concepts can be found in the *Glaz-PD* manual.

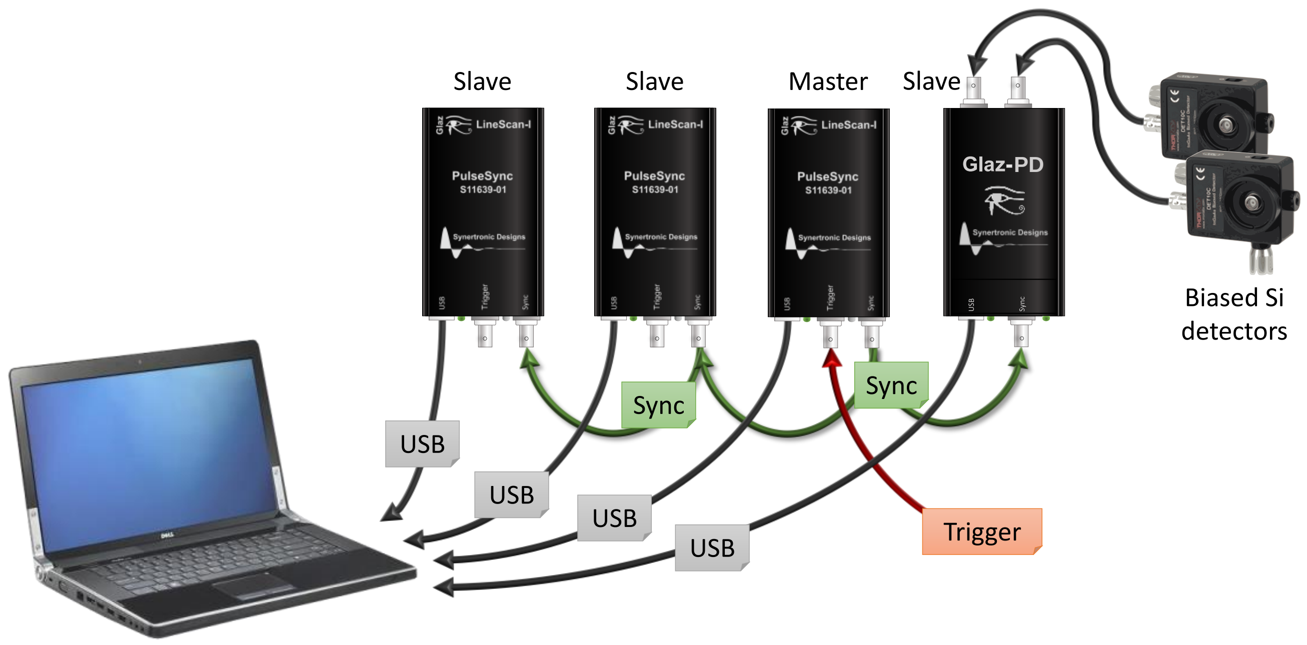


Figure 14 Combining *Glaz LineScan-I PulseSync* cameras and *Glaz-PD*.

The following operations can be performed in conjunction with *Glaz-PD* devices:

- Normalisation of camera scans using measured laser pulse intensities from *Glaz-PD* devices.
- Gating of calculations based on “triggered” and “not triggered” states, detected by *Glaz-PD* devices.

In order to use measurements from *Glaz-PD* devices together with camera measurements, the *Glaz-PD* must be operated in synchronised mode. A typical connection diagram is shown in Figure 14.

Scripting – Glaz-PD definitions

In order to use *Glaz-PD* devices, the must first be uniquely identified. Each *Glaz-PD* has an entry in the script file as depicted in the example in Figure 15.

```
<!DOCTYPE GlazScript>
<config>
  <camera serial="SYBP005010001" number="1" master="1"/>    Camera definitions
  <pd serial ="SYBP006010001" number="1" ch1="1"/>          Glaz-PD definitions
  <preprocessor camera="1" type="calibrate"/>               Pre-processing steps
  <preprocessor camera="1" type="subtract_background"/>
  <calculation name="Camera 1" keepscans="1">               Calculations
    <measurement camera="1"/>
  </calculation>
</config>
```

Figure 15 Defining *Glaz-PD* devices in the XML script file.

Each device definition uses the following format:

```
<pd serial="SN" number="NUM" [ch1="E1"] [ch2="E2"]
 [highgain2="G1"] [highgain1="G2"] [window="W"]/>
```

SN : The serial number of a device is printed onto the back of the camera. The serial number has 13 digits and has the format: SYPB + device number + device version + instance number. For example: SYPB006010001. A serial number may only be defined once in a script file.

NUM : The device number that will be assigned to the *Glaz-PD* device with the given serial number. This number will be used in the rest of the script file. This must be a unique number in the range [1 .. 1000].

E1,E2 : Can be one of the following values: *0*, *1*, *true* or *false*. If the value is *1* or *true* the given channel will be enabled. The default value is 0 or *false* and when omitted the relevant channel will be disabled.

G1,G2 : Can be one of the following values: *0*, *1*, *true* or *false*. If the value is *1* or *true* the high-gain stage (x6 gain) for the given channel will be enabled. The default value is *0* or *false* and when omitted the relevant high-gain stage will be disabled.

W : This specifies the window period in [μs]. The default value is 10 μs.

Scripting - Normalising camera scans

Calculations can be normalised using one of two methods.

A camera measurement may be directly normalised by adding an additional parameter to the camera measurement leaf operator (see “Leaf operators”):

```
<measurement camera="NUM" pdnorm="PD_LIST"/>
```

NUM : The camera number that was assigned to a camera in the camera definition section. The operator will return the pre-processed data for the given camera.

PD_LIST : This is a comma-separated list of *Glaz-PD* device numbers and channel numbers. Each entry in the list uses the following format: **PD_NUM:PD_CH**
For example: `pdnorm="1:1,1:2"`. This will use channel 1 and 2 of the *Glaz-PD* device with the device number “1” to normalise the camera scan. The resulting normalisation factor for the *i*th scan will be:

$$\frac{I_{1:1,0}}{I_{1:1,i}} \cdot \frac{I_{1:2,0}}{I_{1:2,i}}$$

A calculation can also be normalised at a higher level by adding a unary normalisation operator. The operator has the following format:

```
<normalise pdnorm="PD_LIST">
    <…>      (child operator)
</normalise>
```

PD_LIST : This is a comma-separated list of *Glaz-PD* device numbers and channel numbers. Each entry in the list uses the following format: **PD_NUM:PD_CH**
For example: `pdnorm="1:1,1:2"`. This will use channel 1 and 2 of the *Glaz-PD* device with the device number “1” to normalise the camera scan. The resulting normalisation factor for the *i*th scan will be:

$$\frac{I_{1:1,0}}{I_{1:1,i}} \cdot \frac{I_{1:2,0}}{I_{1:2,i}}$$

Scripting - Gating calculations

It is possible to “gate” calculations. This makes it possible to perform defined calculations only if the associated *Glaz-PD* channel was either triggered or not triggered. In order to gate a calculation additional parameters must be specified in the calculation start definition (see “Calculation definition start”):

```
<calculation [name="NAME"] [keepscans="K"] pdgate="PD" gatestate="S">
    … (operations)
</calculation>
```

`NAME`	:	The name of the calculation. In the Glaz UI this will be displayed in the legend of the measurement plot.
`K`	:	Can be one of the following values: *0*, *1*, *true* or *false*. If the value is *1* or *true* each hardware averaged scan is saved and can be viewed in the Glaz UI. The default value is *0* or *false*.
`PD`	:	This is only one entry, instead of a list, defining the *Glaz-PD* device number and channel number. The entry uses the following format: **`PD_NUM:PD_CH`** For example: `pdgate="1:2"`. This will use channel 2 of the *Glaz-PD* device with the device number "1".
`S`	:	Can be one of the following values: *0*, *1*, *true* or *false*. If the value is *1* or *true* the calculation will be performed and accumulated only when the associated Glaz-PD channel was triggered. If the value is *0* or *false* the calculation will be performed and accumulated only when the associated Glaz-PD channel was <u>not</u> triggered.

When `keepscans` is enabled for a gated calculation all scans are kept, even scans for which the calculation was not performed. When a calculation is not performed due to gating, that kept scan will be all zeros.

Error detection

A measurement will be terminated if a digitized value from a *Glaz-PD* was expected, but that channel was not triggered. This will happen if a camera scan needs to be normalised, but the channel used for the normalisation was not triggered during the specified *Glaz-PD* window period.

Glaz UI

Glaz UI is a stand-alone user interface to configure and take measurements with *Glaz LineScan-I* cameras. It is also a useful tool to test camera performance and script files.

Installing Glaz UI

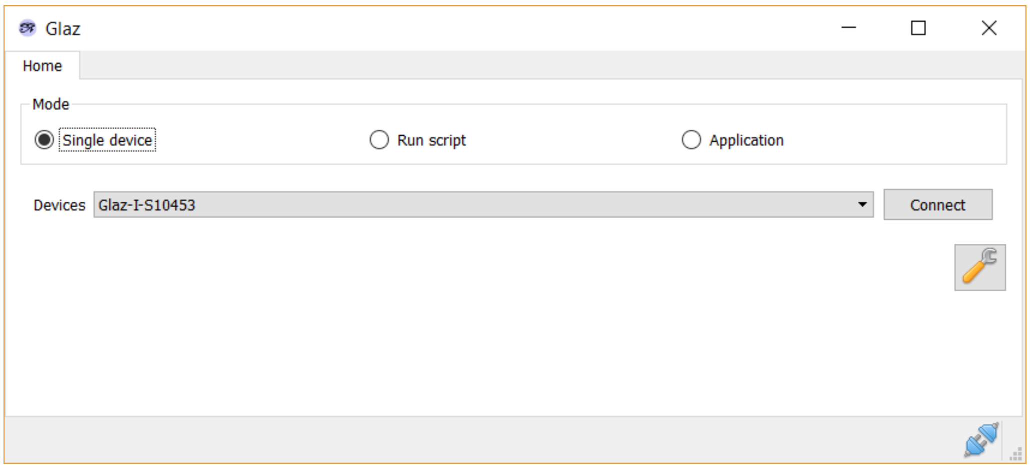
The installer for *Glaz UI* can be downloaded from the Synertronic Designs web page. Download and run the installer.

If the target PC is not connected to the internet, it is advisable to pre-install the USB device driver. The USB device driver can be downloaded from the Synertronic Designs web page.

Home page

When starting the application, the **Home** page is displayed. The application can be used in several modes:

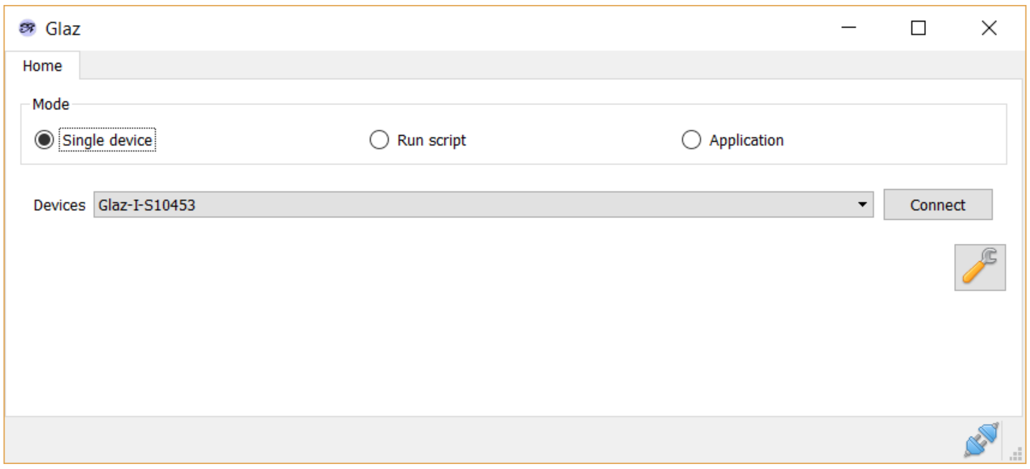
- **Single device**
  Use this mode to connect with a single device. This is a quick way to do basic measurements, test device functions and perform calibrations.
- **Run script**
  This mode requires a script file and can be used to test scripts and perform more complex multi-camera measurements.
- **Application**
  This mode offers several application-specific extensions. See the application-specific documentation on the Synertronic Designs web page.



Mode: [✓ Single device] Run script Application

Devices: Glaz-I-S10453

Single device mode



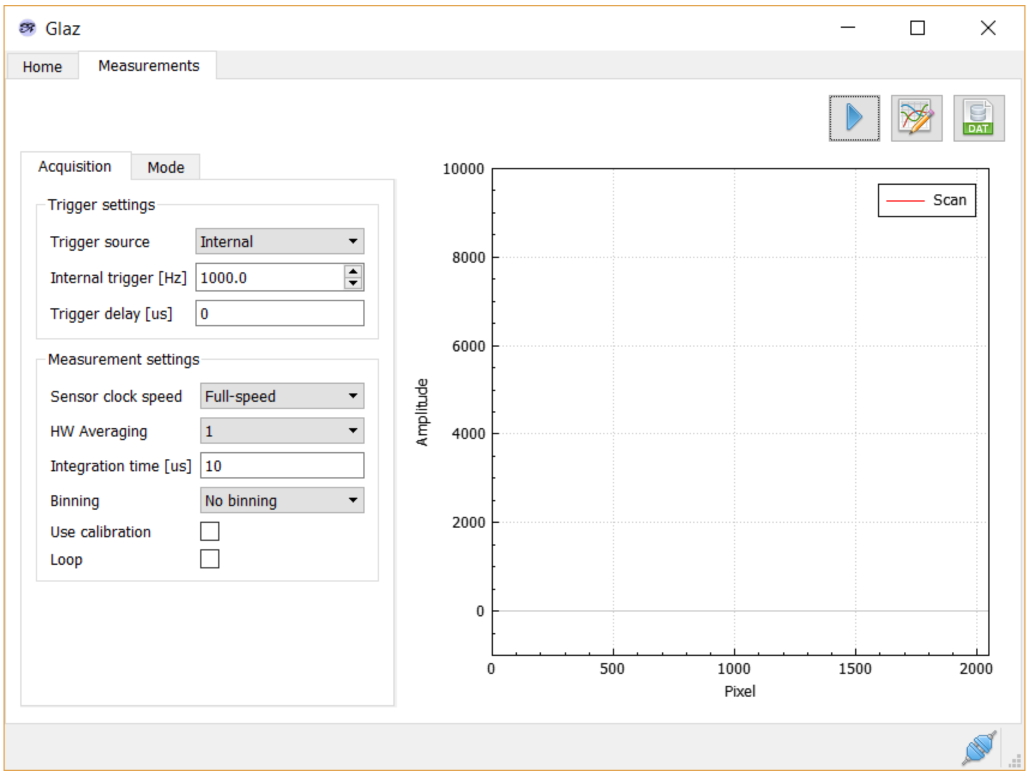
Mode: [✓ Single device] Run script Application

Devices: Glaz-I-S10453

1. Select the **Home** page.
2. Select **Single device** mode.
3. Select the *Glaz-PD* device in the **Devices** drop-down.
4. Click **Connect**.

After successfully connecting to a device, a **Measurements** tab is added. Click on the **Measurements** tab to switch to the measurement page.

Measurements page (Single device)



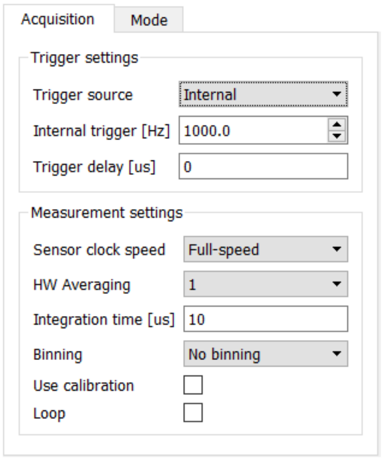
Trigger settings

Trigger source	Internal
Internal trigger [Hz]	1000.0
Trigger delay [us]	0

Measurement settings

Sensor clock speed	Full-speed
HW Averaging	1
Integration time [us]	10
Binning	No binning
Use calibration	☐
Loop	☐

Acquisition tab



Trigger settings

Trigger source	Internal
Internal trigger [Hz]	1000.0
Trigger delay [us]	0

Measurement settings

Sensor clock speed	Full-speed
HW Averaging	1
Integration time [us]	10
Binning	No binning
Use calibration	☐
Loop	☐

There are several **Acquisition** parameters that can be set and are grouped into **Trigger settings** and **Measurement settings**.

The following **Trigger settings** are provided:

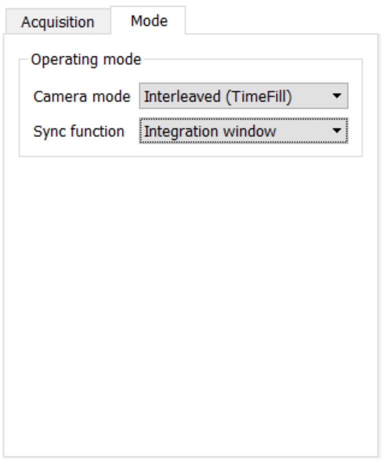
- **Trigger source** Select either **External** or **Internal** trigger. See “Triggering cameras” for more information.

- **Internal trigger [Hz]** Set the internal trigger frequency. This is only supported for *TimeFill* cameras. See “Triggering cameras” for more information.
- **Trigger delay [us]** Set the trigger delay in µs. See “Triggering cameras” for more information.

The following **Measurement settings** are provided:

- **Sensor clock speed** Set the internal pixel clock speed of the camera. See “Camera clock speed” for more information.
- **Hardware averaging** Set the number of scans for hardware averaging. See “Hardware and software averaging" for more information.
- **Integration time [us]** Specify the integration time of the camera in µs. See “Integration time” for more information.
- **Binning** Sets the level of pixel binning. See “Software pixel binning” for more information.
- **Use calibration** When checked, the calibration stored on the camera will be used to compensate for offset and gain differences. See “Photoresponse nonuniformity (PRNU)” for more information. When unchecked, no calibration will be used.
- **Loop** When unchecked, the application will only take one measurement when clicking the ▶ button. When checked, the application will keep taking measurements, until the ⏹ button is clicked.

Mode tab



Operating mode

Camera mode: Interleaved (TimeFill)

Sync function: Integration window

There are several **Mode** parameters that can be set and are grouped into **Operating mode**.

The following **Operating mode** options are provided:

- **Camera mode** This drop-down displays the firmware flavour. This can be either *TimeFill* or *PulseSync*. *LineScan-I* cameras are pre-programmed with one of the two firmware flavours. See “PulseSync and TimeFill firmware” for more information.
- **Sync function** Select the function of the *Sync* port. See “*Sync* port functions” for more information.

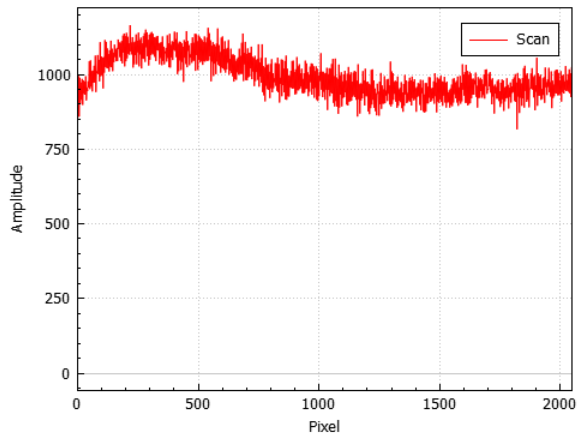
Buttons

The functions of the buttons:

▶	Starts a measurement. When a measurement starts, the button changes to the stop button ⏹.
⏹	Stops the measurement.
📈	Performs a noise analysis with the current camera settings. See "Noise analysis" for more information.
DAT	Export the plotted data to a CSV (comma separated values) file.

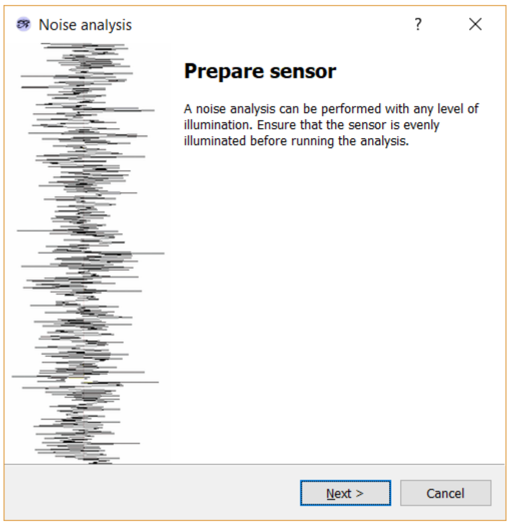
Perform a measurement (Single device)

1. Set the relevant **Trigger settings** and **Measurement settings**.
2. Click ▶ to start the measurement.
3. The start button ▶ changes to a stop button ⏹.
4. Wait until the measurement is finished or click ⏹ to abort the measurement.
5. When the measurement is completed or was aborted, the stop button ⏹ changes back to the start button ▶ .
6. The result is displayed in the 2D graph.



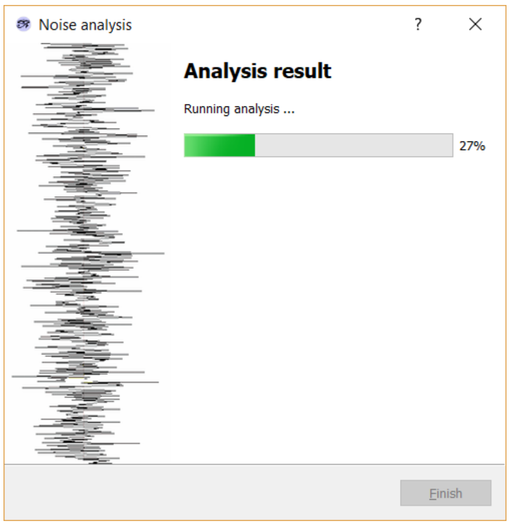
Noise analysis (Single device)

1. Set the relevant **Trigger settings** and **Measurement settings**.
2. Click 📈 to open the **Noise analysis** dialog.
3. You are instructed to prepare the sensor illumination, before starting the noise analysis.
4. Click **Next** to start the noise analysis or **Cancel** to abort the analysis.
5. After clicking **Next,** the camera starts taking measurements. A progress dialog is displayed. Wait until the measurement is completed.



Prepare sensor

A noise analysis can be performed with any level of illumination. Ensure that the sensor is evenly illuminated before running the analysis.

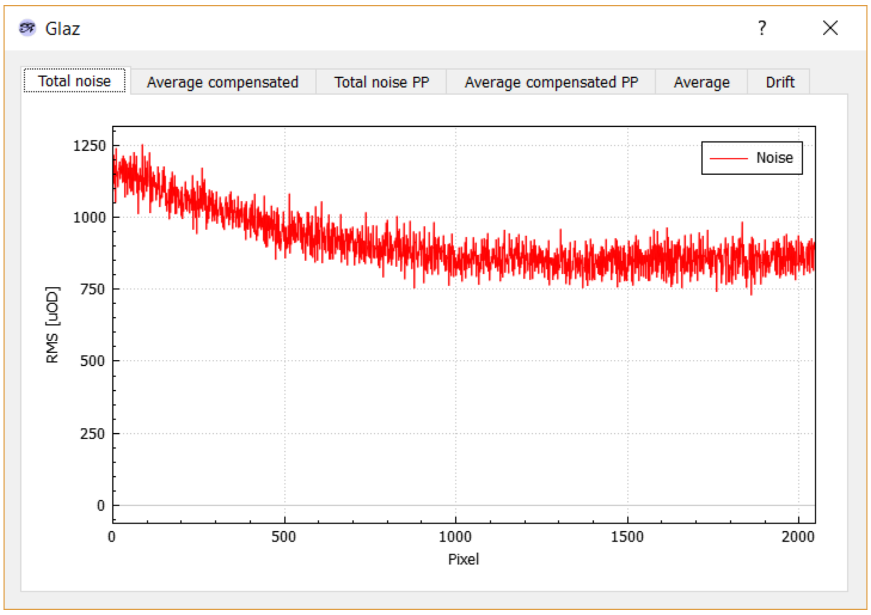


Analysis result

Running analysis ...

27%

6. After completing the measurements, the result dialog is displayed:

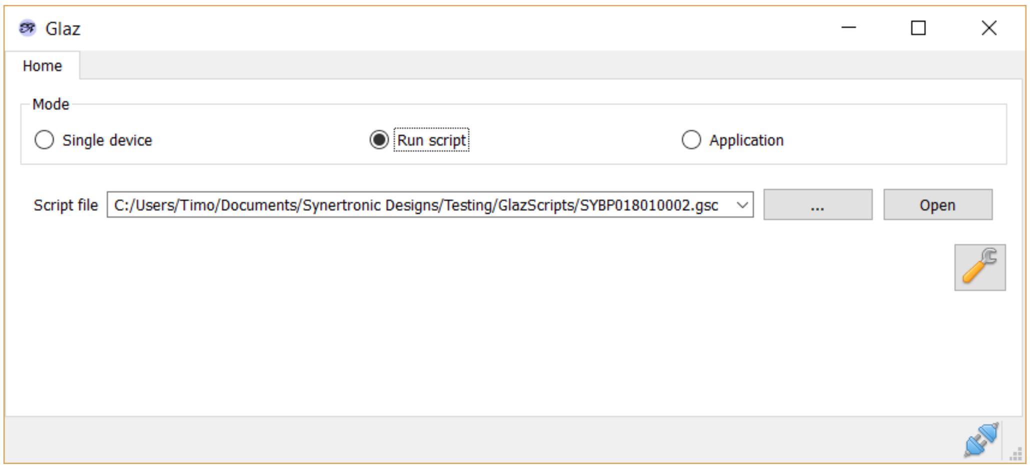


7. Click × in the top right corner of the dialog to close the dialog.
8. Click **Finish** on the **Noise Analysis** dialog.

The noise analysis is performed on 100 scans using the current measurement settings. The following results are shown:

- Total noise: A graph of the RMS noise level for each pixel. This RMS noise graph includes the effect of drift.
- Average compensated: A graph of the average compensated RMS noise level for each pixel. To compensate for drift, the average of each scan is subtracted from each pixel reading.
- Total noise PP: A graph of the total peak-peak noise level for each pixel. The noise levels include the effect of drift.
- Average compensated PP: A graph of the average compensated peak-peak noise level for each pixel. To compensate for drift, the average of each scan is subtracted from each pixel reading.
- Average: A graph of the average sensor reading for each of the 100 scans.
- Drift: A graph of the difference of the average of each of the 100 scans relative to the average of the first scan.

Script mode



Glaz

Home

Mode

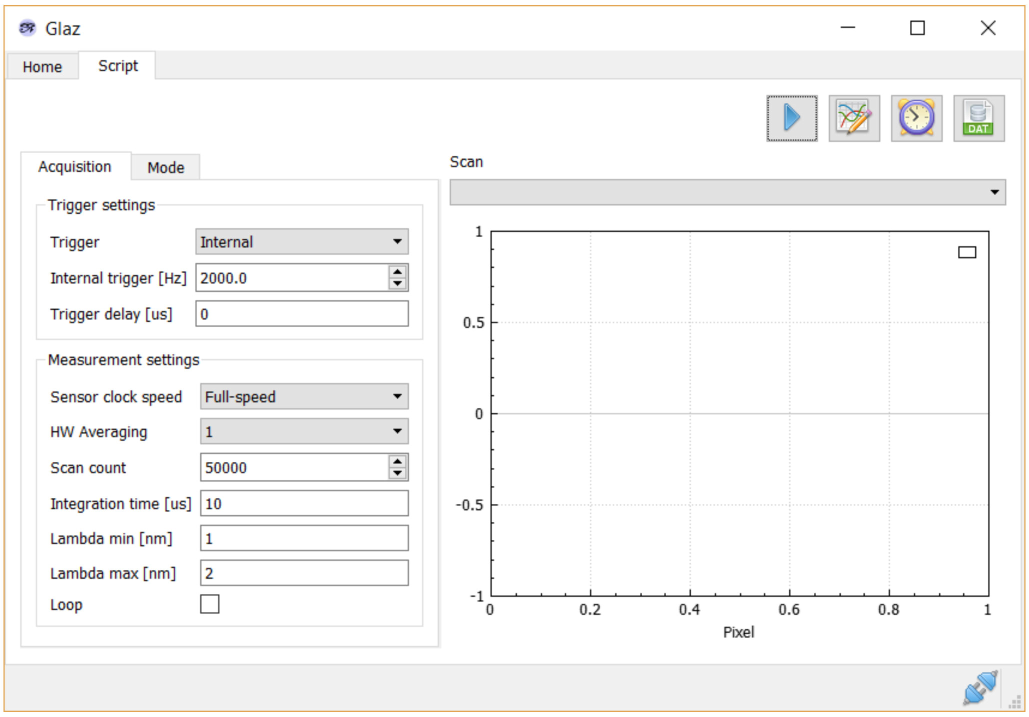
Single device [✓ Run script] Application

Script file: C:/Users/Timo/Documents/Synertronic Designs/Testing/GlazScripts/SYBP018010002.gsc

1. Select the **Home** page.
2. Select **Run script** mode.
3. Select a script file by using one of the following methods:
   - Click ... to open a file dialog to select a script file.
   - Type the script file name into the **Script file** line edit.
   - Use the **Script file** drop-down to select a previously entered script file.
4. Click **Open** to load the script file.

After successfully loading the selected script, a **Script** tab is added. Click on the **Script** tab to switch to the script page.

Script page (Run script)



Glaz

Home | Script

Acquisition | Mode

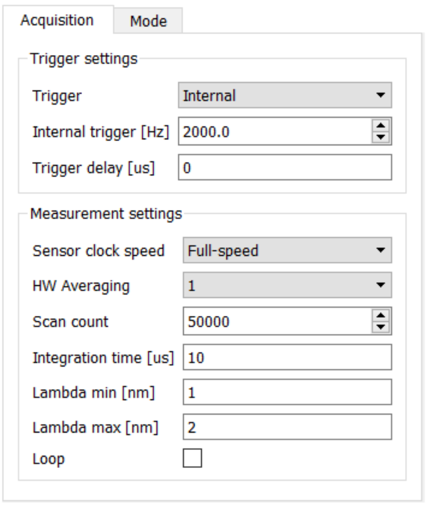
Trigger settings

Trigger	Internal
Internal trigger [Hz]	2000.0
Trigger delay [us]	0

Measurement settings

Sensor clock speed	Full-speed
HW Averaging	1
Scan count	50000
Integration time [us]	10
Lambda min [nm]	1
Lambda max [nm]	2
Loop	☐

Acquisition tab



Trigger settings

Trigger	Internal
Internal trigger [Hz]	2000.0
Trigger delay [us]	0

Measurement settings

Sensor clock speed	Full-speed
HW Averaging	1
Scan count	50000
Integration time [us]	10
Lambda min [nm]	1
Lambda max [nm]	2
Loop	☐

There are several **Acquisition** parameters that can be set and are grouped into **Trigger settings** and **Measurement settings**.

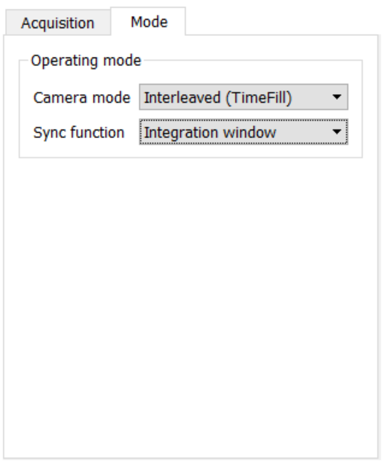
The following **Trigger settings** are provided:

- **Trigger source** Select either **External** or **Internal** trigger. See "Triggering cameras" for more information.
- **Internal trigger [Hz]** Set the internal trigger frequency. This is only supported for *TimeFill* cameras. See "Triggering cameras" for more information.
- **Trigger delay [us]** Set the trigger delay in µs. See "Triggering cameras" for more information.

The following **Measurement settings** are provided:

- **Sensor clock speed** Set the internal pixel clock speed of the camera. See "Camera clock speed" for more information.
- **Hardware averaging** Set the number of scans for hardware averaging. See "Hardware and software averaging" for more information.
- **Scan count** Set the number of scans for software averaging. See "Hardware and software averaging" for more information.
- **Integration time [us]** Specify the integration time of the camera in µs. See "Integration time" for more information.
- **Lambda min [nm]** The minimum wavelength. This must be set when using IFFT pre-processors.
- **Lambda max [nm]** The maximum wavelength. This must be set when using IFFT pre-processors.
- **Loop** When unchecked, the application will only take one measurement when clicking the ▶ button. When checked, the application will keep taking measurements, until the ⏹ button is clicked.

Mode tab



Operating mode

Camera mode: Interleaved (TimeFill)

Sync function: Integration window

There are several **Mode** parameters that can be set and are grouped into **Operating mode**.

The following **Operating mode** options are provided:

• **Camera mode**	This drop-down displays the firmware flavour. This can be either *TimeFill* or *PulseSync*. *LineScan-I* cameras are pre-programmed with one of the two firmware flavours. See "PulseSync and TimeFill firmware" for more information.
• **Sync function**	Select the function of the *Sync* port. See "*Sync* port functions" for more information.

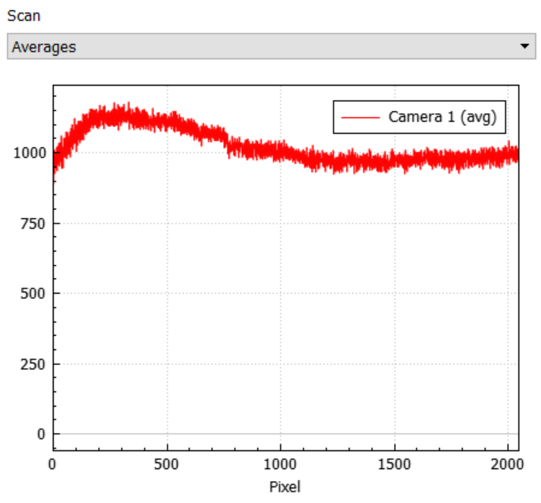
Buttons

The functions of the buttons:

▶	Starts a measurement. When a measurement starts, the button changes to the stop button ⏹.
⏹	Stops the measurement.
📈	Captures the background of each camera.
⏰	Displays the timestamps for each averaged scan. This is useful to check that cameras are running synchronously.
DAT	Export the plotted data to a CSV (comma separated values) file.

Perform a measurement (Run script)

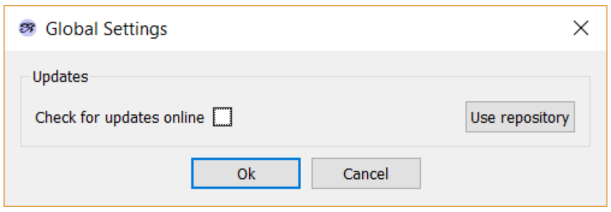
1. Set the relevant **Trigger settings** and **Measurement settings**.
2. Click ▶ to start the measurement.
3. The start button ▶ changes to a stop button ⏹.
4. Wait until the measurement is finished or click ⏹ to abort the measurement.
5. When the measurement is completed or was aborted, the stop button ⏹ changes back to the start button ▶.
6. The results are displayed in the 2D graph. There will be a trace for each camera.
7. Use the **Scans** drop-down to select the overall averaged result or individual scan results. Individual scan results are only available if `keepscans` was enabled in the script.
8. Use the **Scans** drop-down to select the *Glaz-PD* results. This will only be available, if *Glaz-PD* devices were used in the script.



Software and firmware updates

Enabling online check for updates

1. Select the **Home** page.
2. Click to open the **Global Settings** dialog.
3. In the **Updates** group, enable or disable **Check for updates online**. When enabled, **Glaz UI** will try to connect to the online update repository and download any new software and firmware.


Global Settings

Updates

Check for updates online ☐

Updating the application

1. When check for online updates is enabled, **Glaz UI** will try to download the latest software and firmware updates from the online repository of Synertronic Designs.
2. If a new version of **Glaz UI** is available, the user will be notified.
3. When the application closes, the application will ask if the new version must be installed.

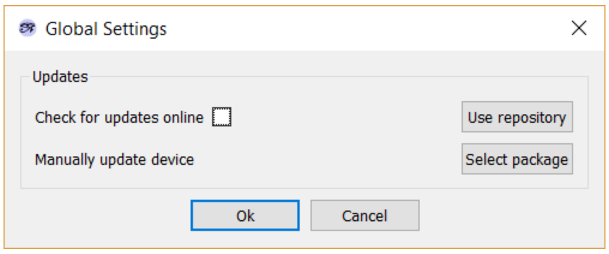
Automatic firmware updates

1. Select **Single device** on the **Home** page.
2. Connect to the target device.
3. If new firmware is available, the user will be asked to update the firmware of the connected device. Firmware updates can take between 3 to 5 seconds.

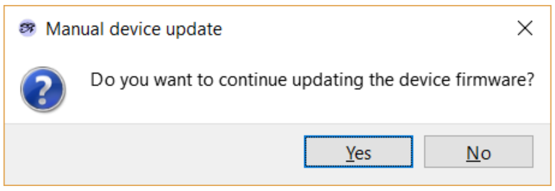
Under no circumstances, disconnect the device during a firmware update. If a firmware update fails due to a power or connection failure, the device must be returned to Synertronic Designs for reprogramming.

Manual firmware updates

1. Select **Single device** on the **Home** page.
2. Connect to the target device.
3. Click to open the **Global Settings** dialog.

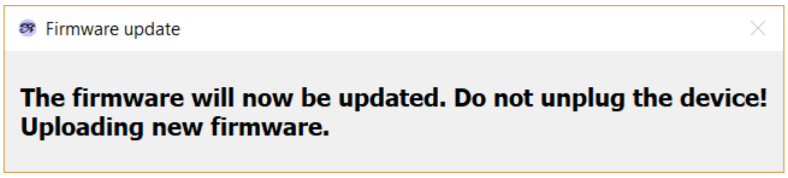


4. In the **Updates** group, click **Select package**.
5. Use the file dialog to navigate to and select the firmware package provided by Synertronic Designs.
6. You are queried if you want to continue with the update. Click **Yes** to continue or **No** to abort.



Do you want to continue updating the device firmware?

7. If **Yes** was selected the firmware update process is started.



The firmware will now be updated. Do not unplug the device!
Uploading new firmware.

8. Wait for the update process to complete. Do not unplug the device!

> Under no circumstances, disconnect the device during a firmware update. If a firmware update fails due to a power or connection failure, the device must be returned to Synertronic Designs for reprogramming.

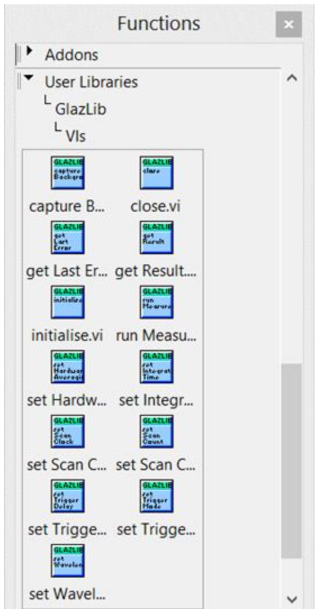
LabView integration

Installation

Follow these steps to install the LabView driver:

1. Download *GlazLabView.zip*
2. Unzip *GlazLabView.zip* in the *user.lib* directory of your LabView installation
3. Run LabView
4. Select *Tools → Find VIs on Disk…*
5. Search the *user.lib* directory to find the Glaz LabView VIs

The VIs for interfacing with Glaz devices should now be visible in LabView's *Functions* palette.



An example showing how to use the *Glaz* VIs can be found in the */user.lib/GlazLib/example* directory.

Usage notes and Error handling

The *Glaz* LabView integration consists of a set of VIs. Every VI uses the standard LabView error handling technique and each VI has an *Error in* and *Error out* parameter. The error parameters are standard LabView error structures, which provide error feedback and flow control.

The following workflow is recommended:

1. Initialise a session using either `initialise` VI or `initialise Single Device` VI.
2. Apply settings with the setter VIs.
3. Capture the background (optional, only used when background subtraction is required).
4. Run a measurement.
5. Retrieve and process results.
6. Repeat from either:
    - Step 1 and initialise with a new script file.
    - Step 2 with new settings.
    - Step 4 with the same settings.
7. Close the session by calling the `close` VI.

VIs

intialise

Initialise the session with the given `scriptFileName`. If the session was initialised before, the previous session is closed and disconnects from all previously connected devices.

Parameters:

`scriptFileName`	`String (in)`	File path of the *Glaz* script file.

Return error codes:

`ERROR_NONE`	No error and initialisation was successful.
`ERROR_SCRIPT`	The specified script was not found or contains an error.
`ERROR_CONNECTING_TO_CAMERAS`	There was an error while connecting to the devices specified in the script file. This can be caused by an USB communication error or the specified device was not found or is busy.
`ERROR_INVALID_SETTINGS`	The script contains an invalid combination of settings and devices.
`ERROR_DOWNLOADING_CALIBRATIONS`	There was an error while downloading the camera calibration from one of the target devices.

initialise Single Device

Initialise the session in single-device mode. If the session was initialised before, the previous session is closed and disconnects from all previously connected devices.

During single-device initialisation the *Glaz* back-end is initialised with the following script:

```
<!DOCTYPE GlazScript>"
<config>"
     <camera serial=<SN> number="1" master="1"/>
     <calculation name="Camera 1" keepscans=<KS>>
         <measurement camera="1"/>
     </calculation>
</config>
```

The serial number **<SN>** and keep-scans **<KS>** attribute are determined from the `singelDeviceType` and `keepScans` parameters.

Parameters:

`singelDeviceType`	`Integer (in)`	Specifies the type of *Glaz* LineScan camera. Must be one of the following values (as defined at the top of the header file): `GLAZ_LINESCAN_I_PULSESYNC_S10453_SINGLE_DEVICE_TYPE` 1 `GLAZ_LINESCAN_I_PULSESYNC_S11639_SINGLE_DEVICE_TYPE` 2 `GLAZ_LINESCAN_I_TIMEFILL_S11639_SINGLE_DEVICE_TYPE` 3 `GLAZ_LINESCAN_I_SPECTROCAM_S11639_SINGLE_DEVICE_TYPE` 4 `GLAZ_LINESCAN_II_SINGLE_DEVICE_TYPE` 5 Note: LineScan-I PulseSync S10453 was previously called the *Glaz-I*. LineScan-I TimeFill S11639 was previously called the *Glaz-S*.
`keepScans`	`Boolean (in)`	When set to `true` all individual scans (lines) will be stored in memory and can be accessed via the **`get Scan`** VI after the **`run Measurement`** VI was called.

Return error codes:

`ERROR_NONE`	No error and initialisation was successful.
`ERROR_INVALID_SINGLE_DEVICE_TYPE`	An invalid value was passed for `singelDeviceType`.

ERROR_INITIALISING_SINGEL_DEVICE	Unknown error while initialising the internal session.
ERROR_CONNECTING_TO_CAMERAS	There was an error while connecting to the devices specified in the script file. This can be caused by an USB communication error or the specified device was not found or is busy.
ERROR_INVALID_SETTINGS	Unknown error while initialising the internal session.
ERROR_DOWNLOADING_CALIBRATIONS	There was an error while downloading the camera calibration from one of the target devices.

close

Closes the script file and disconnects from all cameras.

Always execute this VI at the end of the LabView program.

set Scan Clock Speed

Sets pixel clock scan speed. See “Camera clock speed” for more information.

Restrictions:

Only supported by *LineScan-I* devices.

Parameters:

speed	Integer (in)	The clock speed. Default = SCAN_CLOCK_FULL_SPEED. Must be one of the following values: SCAN_CLOCK_FULL_SPEED 0 SCAN_CLOCK_HALF_SPEED 1

Return error codes:

ERROR_NONE	No error and settings were applied.
ERROR_NOT_INITIALISED	The session was not initialised. First call the **initialise** VI or **initialise Single Device** VI.
ERROR_CLOCK_SPEED_UNSUPPORTED	Variable clock speed is not supported. It is only supported by *LineScan-I* devices.
ERROR_INVALID_SCAN_CLOCK_SPEED	An invalid clock speed was specified.

set Wavelengths

Sets the minimum and maximum wavelengths. It is important to set these values when using the IFFT pre-processor (see “Scripting – Pre-processing steps” for more information).

Parameters:

lambdaMin	Double (in)	The minimum wavelength. Default = 1.0. Validation: lambdaMin > 0.0
lambdaMax	Double (in)	The maximum wavelength. Default = 2.0. Validation: lambdaMax > 0.0 lambdaMax > lambdaMin

Return error codes:

ERROR_NONE	No error and settings were applied.
ERROR_NOT_INITIALISED	The session was not initialised. First call the **initialise** VI or **initialise Single Device** VI.
ERROR_INVALID_WAVELENGTHS	The lambdaMin and/or lambdaMax parameters failed validation.

set Hardware Averaging

Sets the number of scans to use during hardware averaging. This value is also equal to the number of hardware averaged scans $N_{a,HW}$. See “Hardware and software averaging” for more information.

Restrictions:

⚠ The supported levels of hardware averaging are device-dependent.

Parameters:

averaging	Integer (in)	The hardware averaging level. Default = AVERAGING_X1. Must be one of the following values: AVERAGING_X1 0 AVERAGING_X2 1 AVERAGING_X4 2 AVERAGING_X8 3 AVERAGING_X16 4 AVERAGING_X32 5 AVERAGING_X64 6 AVERAGING_X128 7 AVERAGING_X256 8 AVERAGING_X512 9 AVERAGING_X1024 10 AVERAGING_X2048 11 AVERAGING_X4096 12

Return error codes:

ERROR_NONE	No error and settings were applied.
ERROR_NOT_INITIALISED	The session was not initialised. First call the **initialise** VI or **initialise Single Device** VI.
ERROR_INVALID_AVERAGING	The specified hardware averaging level is invalid or not supported.

set Scan Count

Sets the number of hardware average scans to perform. This value is also equal to the number of software averaged scans $N_{a,SW}$. See “Hardware and software averaging” for more information.

Parameters:

scanCount	Integer (in)	The number of scans (lines) to be measured during one measurement run. Default = 1. Validation: scanCount > 0 scanCount <= 50000

Return error codes:

ERROR_NONE	No error and settings were applied.
ERROR_NOT_INITIALISED	The session was not initialised. First call the **initialise** VI or **initialise Single Device** VI.

`ERROR_INVALID_SCAN_COUNT`	The `scanCount` parameter failed validation.

set Trigger Mode

Sets the trigger mode. See "Triggering cameras" for more information.

Parameters:

`mode`	`Integer (in)`	The hardware averaging level. Default = `TRIGGER_EXTERNAL`. Must be one of the following values:
		`TRIGGER_EXTERNAL    0`
		`TRIGGER_INTERNAL    1`

Return error codes:

`ERROR_NONE`	No error and settings were applied.
`ERROR_NOT_INITIALISED`	The session was not initialised. First call the **`initialise`** VI or **`initialise Single Device`** VI.
`ERROR_INVALID_TRIGGER_MODE`	The specified trigger mode is invalid or not supported.

set Trigger Delay

Sets the trigger delay in μs. This value is only used in external trigger mode. See "Triggering cameras" for more information.

Parameters:

`us`	`Double (in)`	The trigger delay. Default = 0 us. Validation:
		`us >= 0`
		`us <= 100000`

Return error codes:

`ERROR_NONE`	No error and settings were applied.
`ERROR_NOT_INITIALISED`	The session was not initialised. First call the **`initialise`** VI or **`initialise Single Device`** VI.
`ERROR_INVALID_TRIGGER_DELAY`	The `us` parameter failed validation.

set Internal Trigger Frequency

This sets the internal trigger frequency. This trigger frequency is used when the trigger mode is set to *internal trigger.*

Restrictions:

Not supported by LineScan-I devices with PulseSync firmware.

Parameters:

`Hz`	`Double (in)`	The internal trigger frequency. Default = 1000 Hz.

Return error codes:

`ERROR_NONE`	No error and settings were applied.

`ERROR_NOT_INITIALISED`	The session was not initialised. First call the **`initialise`** VI or **`initialise Single Device`** VI.
`ERROR_INVALID_TRIGGER_FREQUENCY`	The specified trigger frequency falls outside the valid range.

set Integration Mode

Glaz LineScan-I devices are pre-programmed with a specific integration mode (PulseSync or TimeFill) and the integration mode cannot be changed at run-time. *Glaz LineScan-II* devices support dynamic integration modes and the integration mode can be changed at run-time. This function is only used for *LineScan-II* devices. See the “PulseSync and TimeFill” for more information on integration modes.

Restrictions:

> Not supported by LineScan-I devices.

Parameters:

`mode`	`Integer (in)`	The integration mode. Default = `INT_MODE_TIMEFILL` (*LineScan-II* only). Must be one of the following:
		`INT_MODE_PULSESYNC 0`
		`INT_MODE_TIMEFILL 1`

Return error codes:

`ERROR_NONE`	No error and settings were applied.
`ERROR_NOT_INITIALISED`	The session was not initialised. First call the **`initialise`** VI or **`initialise Single Device`** VI.
`ERROR_INVALID_INTEGRATION_MODE`	The specified integration mode is invalid or not supported.

set Integration Time

Sets the integration time in μs. See “Integration time” for more information.

Restrictions:

> Supported integration time ranges are device-dependent.

Parameters:

`us`	`Double (in)`	The integration time. Default = 10 us.

Return error codes:

`ERROR_NONE`	No error and settings were applied.
`ERROR_NOT_INITIALISED`	The session was not initialised. First call the **`initialise`** VI or **`initialise Single Device`** VI.
`ERROR_INVALID_INTEGRATION_TIME`	The specified integration time falls outside the valid range.

set Sync Out Mode

Sets the output mode of the *Sync* port. The supported modes are device-dependent. For devices in PulseSync mode, the *Sync* output mode is automatically forced to `OUT_BUSY`. See “Functional description” for more information.

Restrictions:

> ⚠ Not supported by *LineScan-I* devices with PulseSync firmware.
> For other devices the supported modes are device-dependent.
> *LineScan-II* devices support all modes.

Parameters:

`mode`	`Integer (in)`	The output mode. Default = `OUT_INT_WINDOW`. Must be one of the following values: `OUT_INT_WINDOW` 0 `OUT_TRIGGER` 1 `OUT_BUSY` 2 `OUT_TRIGGER_CYCLE_START` 3 `OUT_TRIGGER_CYCLE_RUNNING` 4 `OUT_OFF` 5

Return error codes:

`ERROR_NONE`	No error and settings were applied.
`ERROR_NOT_INITIALISED`	The session was not initialised. First call the **`initialise`** VI or **`initialise Single Device`** VI.
`ERROR_INVALID_SYNC_OUT_MODE`	The specified output mode is invalid or not supported.

set Sync Out Polarity

Sets the output polarity of the *Sync* port. This functionality is only supported by *LineScan-II* devices. For devices in PulseSync mode, the *Sync* output polarity is automatically forced to `OUT_POLARITY_ACTIVE_LO`. See “Functional description” for more information.

Restrictions:

> ⚠ Only supported by *LineScan-II* devices.

Parameters:

`polarity`	`Integer (in)`	The output polarity. Default = `OUT_POLARITY_ACTIVE_LO`. Must be one of the following values: `OUT_POLARITY_ACTIVE_HI` 1 `OUT_POLARITY_ACTIVE_LO` 0

Return error codes:

`ERROR_NONE`	No error and settings were applied.
`ERROR_NOT_INITIALISED`	The session was not initialised. First call the **`initialise`** VI or **`initialise Single Device`** VI.
`ERROR_OUT_POLARITY_NOT_SUPPORTED`	Polarity settings are not supported by the device.
`ERROR_INVALID_OUT_POLARITY`	The specified polarity is not one of the values listed above.

set Aux Out Mode

Sets the output mode of the *Aux* port. This functionality is only supported by *LineScan-II* devices. See “Functional description” for more information.

Restrictions:

⚠ Only supported by *LineScan-II* devices.

Parameters:

`mode`	`Integer (in)`	The output mode. Default = `OUT_INT_WINDOW`. Must be one of the following values: `OUT_INT_WINDOW` 0 `OUT_TRIGGER` 1 `OUT_BUSY` 2 `OUT_TRIGGER_CYCLE_START` 3 `OUT_TRIGGER_CYCLE_RUNNING` 4 `OUT_OFF` 5

Return error codes:

`ERROR_NONE`	No error and settings were applied.
`ERROR_NOT_INITIALISED`	The session was not initialised. First call the **`initialise`** VI or **`initialise Single Device`** VI.
`ERROR_INVALID_SYNC_OUT_MODE`	The specified output mode is invalid or not supported.

set Aux Out Polarity

Sets the output polarity of the *Aux* port. This functionality is only supported by *LineScan-II* devices. See “Functional description” for more information.

Restrictions:

⚠ Only supported by *LineScan-II* devices.

Parameters:

`polarity`	`Integer (in)`	The output polarity. Default = `OUT_POLARITY_ACTIVE_LO`. Must be one of the following values: `OUT_POLARITY_ACTIVE_HI` 1 `OUT_POLARITY_ACTIVE_LO` 0

Return error codes:

`ERROR_NONE`	No error and settings were applied.
`ERROR_NOT_INITIALISED`	The session was not initialised. First call the **`initialise`** VI or **`initialise Single Device`** VI.
`ERROR_OUT_POLARITY_NOT_SUPPORTED`	Polarity settings are not supported by the device.
`ERROR_INVALID_OUT_POLARITY`	The specified polarity is not one of the values listed above.

capture Background

Captures the camera background. Subsequent measurements using the background subtract pre-processor, will use the last captured background.

Return error codes:

`ERROR_NONE`	Backgrounds were captured successfully.
`ERROR_NOT_INITIALISED`	The session was not initialised. First call the **`initialise`** VI or **`initialise Single Device`** VI.
`ERROR_CAPTURING_BACKGROUNDS`	There was a communication error while receiving data from the connected *LineScan* devices. Check the USB cable connections.

run Measurement

Starts a measurement run. The connected devices will perform a measurement with the previously specified settings. If settings were not specified, the default values are used. This function will only return, when the measurement run is completed, a time-out was encountered or an error was detected. A measurement run is completed after all `scanCount` number of scans (lines) were captured by the *Glaz LineScan* devices, the data was received via USB and processed by the back-end.

Return error codes:

`ERROR_NONE`	No error and measurement was run successfully.
`ERROR_NOT_INITIALISED`	The session was not initialised. First call the **`initialise`** VI or **`initialise Single Device`** VI.
`ERROR_INVALID_SETTINGS`	An invalid combination of settings were specified.
`ERROR_RUNNING_MEASUREMENT`	There was a communication error while receiving data from the connected *LineScan* devices. Check the USB cable connections.

get Result

Returns a vector with N_{pixel} values containing the software-averaged calculation with the given index. The calculation indices start at zero.

Parameters:

`calculationIndex`	`Integer (in)`	The index of the calculation specified in the *Glaz* script file. The index is zero-based and depends on the order of calculations defined in the script file. The first calculation in the script file will have `calculationIndex = 0`, the second calculation will have `calculationIndex = 1` and so on. When the session was initialised with the **`initialise Single Device`** VI, the only valid value is `calculationIndex = 0`.
`values`	`Double array (out)`	Array (vector) with N_{pixel} values containing the averaged data for the calculation with the given index *calculationIndex.*

Return error codes:

`ERROR_NONE`	No error and values were returned successfully.
`ERROR_NOT_INITIALISED`	The session was not initialised. First call the **`initialise`** VI or **`initialise Single Device`** VI.
`ERROR_INVALID_CALCULATION_INDEX`	The `calculationIndex` is out of range. Check the script file and determine the correct index.
`ERROR_INVALID_RESULT_DATA_SIZE`	The array size of the result array `values` does not match the number of pixels. This is most likely caused if a gated calculation was defined, but

	the calculation was never triggered. Check the gating attributes in the script file and the trigger level of the *Glaz-PD* device.
`ERROR_NO_MEASUREMENT_RUN`	The **`run Measurement`** VI was not called and there are no results available.

get Complex Result

Returns two vectors with each N_{pixel} values containing the real and imaginary components of the software-averaged calculation with the given index. This VI is recommended for applications using inverse Fourier transforms. The calculation indices start at zero.

Parameters:

`calculationIndex`	`Integer (in)`	The index of the calculation specified in the *Glaz* script file. The index is zero-based and depends on the order of calculations defined in the script file. The first calculation in the script file will have `calculationIndex = 0`, the second calculation will have `calculationIndex = 1` and so on. When the session was initialised with the **`initialise Single Device`** VI, the only valid value is `calculationIndex = 0`.
`real`	`Double array (out)`	Array (vector) with N_{pixel} values containing the real component of the averaged data for the calculation with the given index *calculationIndex.*
`imag`	`Double array (out)`	Array (vector) with N_{pixel} values containing the imaginary component of the averaged data for the calculation with the given index *calculationIndex.*

Return error codes:

`ERROR_NONE`	No error and values were returned successfully.
`ERROR_NOT_INITIALISED`	The session was not initialised. First call the **`initialise`** VI or **`initialise Single Device`** VI.
`ERROR_INVALID_CALCULATION_INDEX`	The `calculationIndex` is out of range. Check the script file and determine the correct index.
`ERROR_INVALID_RESULT_DATA_SIZE`	The array size of the result array `values` does not match the number of pixels. This is most likely caused if a gated calculation was defined, but the calculation was never triggered. Check the gating attributes in the script file and the trigger level of the *Glaz-PD* device.
`ERROR_NO_MEASUREMENT_RUN`	The **`run Measurement`** VI was not called and there are no results available.

get Scan

Returns a vector with N_{pixel} values containing the calculation with the given index for the given scan index. The calculation and scan indices start at zero. In order to obtain individual scans the `keepscans` parameter in the calculation start definition must be enabled.

Parameters:

`calculationIndex`	`Integer (in)`	The index of the calculation specified in the *Glaz* script file. The index is zero-based and depends on the order of calculations defined in the script file. The first calculation in the script file will have `calculationIndex = 0`, the second calculation will have `calculationIndex = 1` and so on.

		When the session was initialised with the **`initialise Single Device`** VI, the only valid value is `calculationIndex = 0`.

`scanIndex`	`Integer (in)`	The index of the scan. Validation:
		`scanIndex >= 0`
		`scanIndex < scanCount`
		Where `scanCount` is the parameter that was passed to the **`set Scan Count`** VI.

`values`	`Double array (out)`	Array (vector) with N_{pixel} values containing the individual calculation with the given index *calculationIndex* for the given index *scanIndex*.

Return error codes:

`ERROR_NONE`	No error and values were returned successfully.
`ERROR_NOT_INITIALISED`	The session was not initialised. First call the **`initialise`** VI or **`initialise Single Device`** VI.
`ERROR_INVALID_CALCULATION_INDEX`	Either the `calculationIndex` or `scanIndex` is out of range. Check the script file and determine the correct calculation index. Also check the `scanCount` parameter that was passed to the **`set Scan Count`** VI.
`ERROR_INVALID_RESULT_DATA_SIZE`	The array size of the result array `values` does not match the number of pixels. This is most likely caused if a gated calculation was defined, but the calculation was never triggered. Check the gating attributes in the script file and the trigger level of the *Glaz-PD* device.
`ERROR_NO_MEASUREMENT_RUN`	The **`run Measurement`** VI was not called and there are no results available.

get Complex Scan

Returns two vectors with each N_{pixel} values containing the real and imaginary components of the calculation with the given index for the given scan index. This VI is recommended for applications using inverse Fourier transforms. The calculation and scan indices start at zero. In order to obtain individual scans the `keepscans` parameter in the calculation start definition must be enabled.

Parameters:

`calculationIndex`	`Integer (in)`	The index of the calculation specified in the *Glaz* script file. The index is zero-based and depends on the order of calculations defined in the script file. The first calculation in the script file will have `calculationIndex = 0`, the second calculation will have `calculationIndex = 1` and so on. When the session was initialised with the **`initialise Single Device`** VI, the only valid value is `calculationIndex = 0`.

`scanIndex`	`Integer (in)`	The index of the scan. Validation:
		`scanIndex >= 0`
		`scanIndex < scanCount`
		Where `scanCount` is the parameter that was passed to the **`set Scan Count`** VI.

`real`	`Double array (out)`	Array (vector) with N_{pixel} values containing the real component of the individual calculation with the given index *calculationIndex* for the given index *scanIndex*.
`imag`	`Double array (out)`	Array (vector) with N_{pixel} values containing the imaginary component of the individual calculation with the given index *calculationIndex* for the given index *scanIndex*.

Return error codes:

`ERROR_NONE`	No error and values were returned successfully.
`ERROR_NOT_INITIALISED`	The session was not initialised. First call the **`initialise`** VI or **`initialise Single Device`** VI.
`ERROR_INVALID_CALCULATION_INDEX`	Either the `calculationIndex` or `scanIndex` is out of range. Check the script file and determine the correct calculation index. Also check the `scanCount` parameter that was passed to the **`set Scan Count`** VI.
`ERROR_INVALID_RESULT_DATA_SIZE`	The array size of the result array `values` does not match the number of pixels. This is most likely caused if a gated calculation was defined, but the calculation was never triggered. Check the gating attributes in the script file and the trigger level of the *Glaz-PD* device.
`ERROR_NO_MEASUREMENT_RUN`	The **`run Measurement`** VI was not called and there are no results available.

get All Scans

Returns a matrix containing all scans for the calculation with the given index. The calculation index starts at zero. The `keepscans` parameter in the *Glaz* script file must be enabled.

Parameters:

`calculationIndex`	`Integer (in)`	The index of the calculation specified in the *Glaz* script file. The index is zero-based and depends on the order of calculations defined in the script file. The first calculation in the script file will have `calculationIndex = 0`, the second calculation will have `calculationIndex = 1` and so on. When the session was initialised with the **`initialise Single Device`** VI, the only valid value is `calculationIndex = 0`.
`values`	`Unsigned short 2D matrix (out)`	2D Matrix containing all scans for the calculation with the given *calculationIndex*.

Return error codes:

`ERROR_NONE`	No error and values were returned successfully.
`ERROR_NOT_INITIALISED`	The session was not initialised. First call the **`initialise`** VI or **`initialise Single Device`** VI.
`ERROR_INVALID_CALCULATION_INDEX`	The `calculationIndex` is out of range. Check the script file and determine the correct index.
`ERROR_INVALID_RESULT_DATA_SIZE`	The sub-array size of the result array `values` does not match the number of pixels. This is most likely caused if a gated calculation was defined, but the calculation was never triggered. Check the gating attributes in the script file and the trigger level of the *Glaz-PD* device.
`ERROR_NO_MEASUREMENT_RUN`	The **`run Measurement`** VI was not called and there are no results available.

write All Scans To File

Writes all scans for the calculation with the given index to a binary file. The binary file is written in big-endian format and has the following structure:

uint16	number of scans, Ns
uint16	number of pixels, Np (for cameras with the S11639 sensor this will always be 2048)
Np x uint16	(1. scan)
Np x uint16	(2. scan)

…
Np x uint16 (Ns. scan)

⚠ This VI must be called before running a measurement. The scans are written to the target file while the measurement is performed.

Parameters:

`calculationIndex`	`Integer (in)`	The index of the calculation specified in the *Glaz* script file. The index is zero-based and depends on the order of calculations defined in the script file. The first calculation in the script file will have `calculationIndex = 0`, the second calculation will have `calculationIndex = 1` and so on. When the session was initialised with the **`initialise Single Device`** VI, the only valid value is `calculationIndex = 0`.
`filename`	`String (in)`	File path of the target data file.

Return error codes:

`ERROR_NONE`	No error and settings were applied.
`ERROR_NOT_INITIALISED`	The session was not initialised. First call the **`initialise`** VI or **`initialise Single Device`** VI.
`ERROR_INVALID_CALCULATION_INDEX`	The `calculationIndex` is out of range. Check the script file and determine the correct index.

get PD Reference

Returns the reference value used to normalise calculations (see “Scripting” for more information). After the **`run Measurement`** VI is called, this will be the first valid received value from a Glaz-PD device.

Parameters:

`pdNumber`	`Integer (in)`	The number specified for a Glaz-PD in the script file (see “Scripting” for more information).
`pdChannel`	`Integer (in)`	One of the following values: 1 Channel 1 2 Channel 2
`value`	`Double (out)`	The value used as reference for the specified channel and the Glaz-PD defined by *pdNumber*.

Return error codes:

`ERROR_NONE`	No error and values were returned successfully.
`ERROR_NOT_INITIALISED`	The session was not initialised. First call the **`initialise`** VI or **`initialise Single Device`** VI.
`ERROR_INVALID_PD_NUMBER`	The `pdNumber` is out of range. Check the script file and determine the correct device number.
`ERROR_INVALID_PD_CHANNEL`	The `pdChannel` is out of range or the specified channel is not enabled in the script file.

get PD Values

Returns all the measured values for a given Glaz-PD device and channel. Values which are invalid (i.e. the Glaz-PD device was not triggered) are shown as zero.

Parameters:

`pdNumber`	`Integer (in)`	The number specified for a Glaz-PD in the script file (see “Scripting” for more information).
`pdChannel`	`Integer (in)`	One of the following values: 1 Channel 1 2 Channel 2
`count`	`Integer (out)`	The number of measured values. This should be equal to *scanCount* as specified via the **`set Scan Count`** VI.
`value`	`Double (out)`	Array (vector) with the measured values.

Return error codes:

`ERROR_NONE`	No error and values were returned successfully.
`ERROR_NOT_INITIALISED`	The session was not initialised. First call the **`initialise`** VI or **`initialise Single Device`** VI.
`ERROR_INVALID_PD_NUMBER`	The `pdNumber` is out of range. Check the script file and determine the correct device number.
`ERROR_INVALID_PD_CHANNEL`	The `pdChannel` is out of range or the specified channel is not enabled in the script file.

Error codes

Code	Description	Reason
0	ERROR_NONE	No error
1	ERROR_NOT_INITIALISED	The *initialise* VI was not executed. First execute the *initialise* VI with the correct script file, before executing any other *Glaz* VI.
2	ERROR_SCRIPT	There is an error in the script. The error output of the VI contains more information about the error.
3	ERROR_CONNECTING_TO_CAMERAS	There is a problem connecting with one or more cameras. Make sure that all cameras are connected and not used by another application. Check that the camera definition section in the script file contains the correct cameras.
4	ERROR_DOWNLOADING_CALIBRATIONS	Communication error while trying to download the camera calibration. Check the USB cable connection.
5	ERROR_INVALID_WAVELENGTHS	Incorrect wavelength parameters. Check that *lambdaMin* < *lambdaMax* and that both *lambdaMin* and *lambdaMax* are larger than zero.
6	ERROR_INVALID_AVERAGING	`averaging` parameter is out of range.
7	ERROR_INVALID_SCAN_COUNT	`scanCount` parameter is out of range.
8	ERROR_INVALID_TRIGGER_MODE	Trigger `mode` parameter is out of range.
9	ERROR_INVALID_TRIGGER_DELAY	Trigger delay `us` parameter is out of range.
10	ERROR_INVALID_INTEGRATION_TIME	Integration time `us` parameter is out of range.
11	ERROR_INVALID_SCAN_CLOCK_SPEED	Incorrect or unsupported scan clock `speed` parameter.
12	ERROR_INVALID_SETTINGS	There are some invalid settings. The error output of the VI contains more information about the error.
13	ERROR_CAPTURING_BACKGROUNDS	Communication error while trying to capture the camera background. Check the USB cable connection.
14	ERROR_RUNNING_MEASUREMENT	Communication error while trying to take a measurement. Check the USB cable connection.
15	ERROR_INVALID_CALCULATION_INDEX	Incorrect calculation index was specified. The calculation index starts at zero and must be smaller than the number of calculations specified in the script file.
16	ERROR_INVALID_RESULT_DATA_SIZE	The size of the result data is not N_{pixel}. Check that the calculation was specified correctly in the script file.
17	ERROR_INVALID_PD_NUMBER	*Glaz-PD* device number does not match any *Glaz-PD* device number specified in the *Glaz* script file.
18	ERROR_INVALID_PD_CHANNEL	*Glaz-PD* channel number may only be 1 or 2.
19	ERROR_INVALID_CAMERA_NUMBER	Camera number does match any camera number specified in the *Glaz* script file.
20	ERROR_INVALID_TRIGGER_FREQUENCY	Trigger frequency `Hz` parameter is out of range or trigger frequency function is not supported.
21	ERROR_NO_MEASUREMENT_RUN	Trying to retrieve results before a measurement was run.

Code	Description	Reason
22	ERROR_INITIALISING_SINGEL_DEVICE	Unable to initialise single-device mode.
23	ERROR_INVALID_SINGLE_DEVICE_TYPE	An invalid or unsupported single device type was specified.
24	ERROR_INVALID_SYNC_OUT_MODE	Invalid or unsupported *Sync* out mode.
25	ERROR_INVALID_INTEGRATION_MODE	Invalid or unsupported integration mode.
26	ERROR_CLOCK_SPEED_UNSUPPORTED	Variable pixel clock speed is not supported.
27	ERROR_INVALID_AUX_OUT_MODE	Invalid or unsupported *Aux* out mode.
28	ERROR_CYCLE_COUNT_UNSUPPORTED	Cycle counting is not supported.
29	ERROR_INVALID_CYCLE_COUNT	Cycle count parameter is out of range.
30	ERROR_INVALID_TEST_MODE	Invalid or unsupported test mode
31	ERROR_OUT_POLARITY_NOT_SUPPORTED	Configurable port polarity is not supported.
32	ERROR_INVALID_OUT_POLARITY	Invalid port polarity.

Examples

In order to get a better understanding of how to compile script files a few examples are presented. The *Glaz UI* installation contains an example script file for each example discussed below.

The following symbols are used:

- S_n The measured spectrum from the nth camera.
- B_n The measured background for the nth camera.
- I_m The intensity measured by a *Glaz-PD* device.
- F_k Functions that need to be calculated.

In each example, a function is presented. The way to compile a script file to calculate this function is shown and how function is mapped onto the script. Mappings are indicated by coloured boxes: Boxes with the same colour in the script and on the function show the equivalent mapping.

All calculations performed by the script are averaged over the specified number of scans (see Hardware and software averaging).

⚠ The serial numbers used in the scripts are for illustration only. In a practical set-up, the actual camera serial numbers must be used.

Example 1 – Single camera measurement

$$\boxed{F_1 = S_1 - B_1}$$

The function simply takes scans with a single camera and subtracts the initially measured background. The script is written as follows:

```
<!DOCTYPE GlazScript>
<config>
    <camera serial="SYBP005010001" number="1" master="1"/>
    <preprocessor camera="1" type="subtract background"/>
    <calculation name="F1">
        <measurement camera="1"/>
    </calculation>
</config>
```

The function is mapped as follows:

$$\boxed{F_1 = S_1 \boxed{- B_1}}$$

The blue box represents the pre-processor step in the script. This step already subtracts the background from each camera measurement. The calculation simply returns the camera measurement, which includes the background subtraction.

Example 2 – Ratio of two camera measurements

$$\boxed{F_2 = \frac{S_1 - B_1}{S_2 - B_2} - 1}$$

The function simply takes scans from two cameras and subtracts the initially measured backgrounds from each scan. The ratio of the scans (with subtracted backgrounds are then taken). The script is written as follows:

```
    <!DOCTYPE GlazScript>
    <config>
        <camera serial="SYBP005010001" number="1" master="1"/>
        <camera serial="SYBP005010002" number="2" master="0"/>
        <preprocessor camera="1" type="subtract_background"/>
        <preprocessor camera="2" type="subtract_background"/>
        <calculation name="F2">
            <subtract>
                <divide>
                    <measurement camera="1"/>
                    <measurement camera="2"/>
                </divide>
                <scalar value="1"/>
            <subtract>
        </calculation>
    </config>
```

The function is mapped as follows:

$$F_2 = \boxed{\boxed{\frac{\boxed{S_1 \boxed{- B_1}}}{\boxed{S_2 \boxed{- B_2}}}} - \boxed{1}}$$

The blue and red boxes represent the pre-processor steps in the script. These steps already subtract the backgrounds from each camera measurement. The calculation divides the measurements from camera 1 with the measurements from camera 2 and subtracts the value of 1. The measurements (green and yellow boxes) already include the background subtraction.

Example 3 – Normalised ratio of two camera measurements

$$F_3 = \frac{I_{1,0}}{I_1}\left(\frac{S_1 - B_1}{S_2 - B_2} - 1\right)$$

The function is the same as in Example 2, except the result is also normalised with respect to the first measured intensity $I_{1,0}$ (see “Scripting - Normalising camera scans” for more information). The script is written as follows:

```
    <!DOCTYPE GlazScript>
    <config>
        <camera serial="SYBP005010001" number="1" master="1"/>
        <camera serial="SYBP005010002" number="2" master="0"/>
        <pd serial="SYBP006010001" number="1" ch1="1" ch2="0"/>
        <preprocessor camera="1" type="subtract_background"/>
        <preprocessor camera="2" type="subtract_background"/>
        <calculation name="F3">
            <normalise pdnorm="1:1">
                <subtract>
                    <divide>
                        <measurement camera="1"/>
                        <measurement camera="2"/>
                    </divide>
                    <scalar value="1"/>
                </subtract>
            </normalise>
        </calculation>
    </config>
```

The function is mapped as follows:

$$F_3 = \boxed{\frac{I_{1,0}}{I_1}}\boxed{\left(\frac{S_1 - B_1}{S_2 - B_2} - 1\right)}$$

The grey box represents the same calculation as in Example 2. The red box represents the normalisation. In this example the normalisation is performed using channel 1 of *Glaz-PD* device number 1 (`pdnorm="1:1"`). The measurement of the initial intensity $I_{1,0}$ and calculation of the ratio $I_{1,0}/I_1$ is performed automatically.

Example 4 – Gated (even/odd) measurements with two cameras

$$F_4 = \frac{I_{2,0}}{I_{2,\text{even}}} \cdot \frac{I_{1,0}}{I_{1,\text{even}}}\left(\frac{S_{1,\text{even}} - B_1}{S_{2,\text{even}} - B_2} - 1\right) - \frac{I_{2,0}}{I_{2,\text{odd}}}\left(\frac{S_{1,\text{odd}} - B_1}{S_{2,\text{odd}} - B_2} - 1\right)$$

In many spectroscopic applications a pump-probe approach is used. In these applications the target is illuminated by only one laser beam or by two laser beams in an alternating fashion. Calculations have to be performed based on the condition if two or only one laser beam illuminates the target. This is also called even/odd measurements. The *Glaz-PD* device is used to differentiate between these two conditions. Calculations are gated based one of these two conditions. The script is written as follows:

```
    <!DOCTYPE GlazScript>
    <config>
        <camera serial="SYBP005010001" number="1" master="1"/>
        <camera serial="SYBP005010002" number="2" master="0"/>
        <pd serial="SYBP006010001" number="1" ch1="1" ch2="1"/>
        <preprocessor camera="1" type="subtract_background"/>
        <preprocessor camera="2" type="subtract_background"/>
        <calculation name="Even" pdgate="1:1" gatestate="1">
            <normalise pdnorm="1:1,1:2">
                <subtract>
                    <divide>
                        <measurement camera="1"/>
                        <measurement camera="2"/>
                    </divide>
                    <scalar value="1"/>
                </subtract>
            </normalise>
        </calculation>
        <calculation name="Odd" pdgate="1:1" gatestate="0">
            <normalise pdnorm="1:2">
                <subtract>
                    <divide>
                        <measurement camera="1"/>
                        <measurement camera="2"/>
                    </divide>
                    <scalar value="1"/>
                </subtract>
            </normalise>
        </calculation>
        <calculation name="F4">
            <subtract>
               <reference calculation="Even"/>
               <reference calculation="Odd"/>
            </subtract>
        </calculation>
    </config>
```

The function is mapped as follows:

$$F_4 = \boxed{\underbrace{\boxed{\frac{I_{2,0}}{I_{2,\text{even}}}\cdot\frac{I_{1,0}}{I_{1,\text{even}}}\left(\frac{S_{1,\text{even}}-B_1}{S_{2,\text{even}}-B_2}-1\right)}}_{\text{Even term}} - \underbrace{\boxed{\frac{I_{2,0}}{I_{2,\text{odd}}}\left(\frac{S_{1,\text{odd}}-B_1}{S_{2,\text{odd}}-B_2}-1\right)}}_{\text{Odd term}}}$$

The yellow and green boxes each represent the same calculation as in Example 3. Except, the even term (yellow box) uses two normalisation factors. In this example channel 1 of the *Glaz-PD* device number 1 is used to perform the gating function. When a scan is triggered and *Glaz-PD* channel 1 is also triggered, then the even term will be calculated. When a scan is triggered and *Glaz-PD* channel 1 is not triggered, then the odd term will be calculated (see "Scripting - Gating calculations" for more information). Since gating can only be applied to calculations, the complete function F_4 cannot be represented by a single calculation in the script file. A third calculation needs to be defined. This calculation subtracts the odd term from the even term. This is a reference calculation and it references the "Even" calculation (yellow boxes) and "Odd" calculation (green boxes). The reference calculation is performed each time an "Odd" and "Even" calculation result is available. This happens only with every second scan.

The result for 10 scans could look as follows:

Scan	**Glaz-PD channel 1 triggered?**	**"Odd"**		**"Even"**		**"F4"**	
		Calculated?	**Kept scan result**	**Calculated?**	**Kept scan result**	**Calculated?**	**Kept scan result**
1	×	✓	✓	×	All zeros	×	All zeros
2	✓	×	All zeros	✓	✓	✓	✓
3	×	✓	✓	×	All zeros	×	All zeros
4	✓	×	All zeros	✓	✓	✓	✓
5	×	✓	✓	×	All zeros	×	All zeros
6	✓	×	All zeros	✓	✓	✓	✓
7	×	✓	✓	×	All zeros	×	All zeros
8	✓	×	All zeros	✓	✓	✓	✓
9	×	✓	✓	×	All zeros	×	All zeros
10	✓	×	All zeros	✓	✓	✓	✓
Average		2,4,6,8,10		1,3,5,7,9		1,3,5,7,9	

The ✓ and × indicate whether a calculation is performed or not. In addition, the result for kept scans (when `keepscans="1"`) is also indicated. In the bottom row the scan numbers used to calculate the averages is shown.

IMPORTANT NOTICE

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