Glaz-PD

Fast photo diode pulse digitizer

Features

- Low-noise
- 16-bit resolution
- Dual-channel
- Synchronisation with PulseSync cameras
- USB-powered
- LabView integration

Applications

- Laser stability measurements
- Pulse-to-pulse normalisation
- Pump-probe sorting

Overview

Glaz-PD is a low-noise fast photo-diode digitizer with 16-bit resolution. It is optimised for biased Si detectors with rise-times between 1 ns and 100 ns. The *Glaz-PD* was specifically designed to measure pulse energy levels of fs-Lasers. It can also be used for other pulsed laser systems with pulse widths up to 50 ns.

Glaz UI (a stand-alone application) or LabView can be used to configure and communicate with *Glaz-PD* devices. Measurements can also be combined with *Glaz LineScan* cameras to provide a fully synchronised measurements system.

Specifications

Characteristic	Value		Unit
Digitizer			
Resolution	16		bit
Full-scale reading	65535		
ENOB (effective number of bits)	12.5		bit
Number of channels	2		
Selectable gain stage per channel	1x or 6x		
Photo Diode Inputs			
	Min	Max	
Input impedance	48	52	Ω
Input signal DC offset	-2	5	mV
Input signal pulse width	2	100	ns
Input signal pulse charge (1x gain)	2	200	pAs[1]
Input signal pulse charge (6x gain)	0.5	50	pAs
Pulse repetition rate		20	kHz
PC Interface			
PC interface	USB 2.0 (full-speed)		
Data transfer rate	1		MB/s
Maximum USB cable length	3		m

Table 1 Specifications.

Supported Si detectors

The following fast Si photo diode detectors are supported:

- Thorlabs DET10A
- Thorlabs DET36A
- Thorlabs DET100A

Other types of biased Si detectors with rise-times under 100 ns should also be compatible, but have not been tested.

[1] The pulse charge is equal to the integral of the detector pulse current. In the specifications, this expressed as pAs and is equal to pC (pico-coulumb).

Hardware description

Dimensions

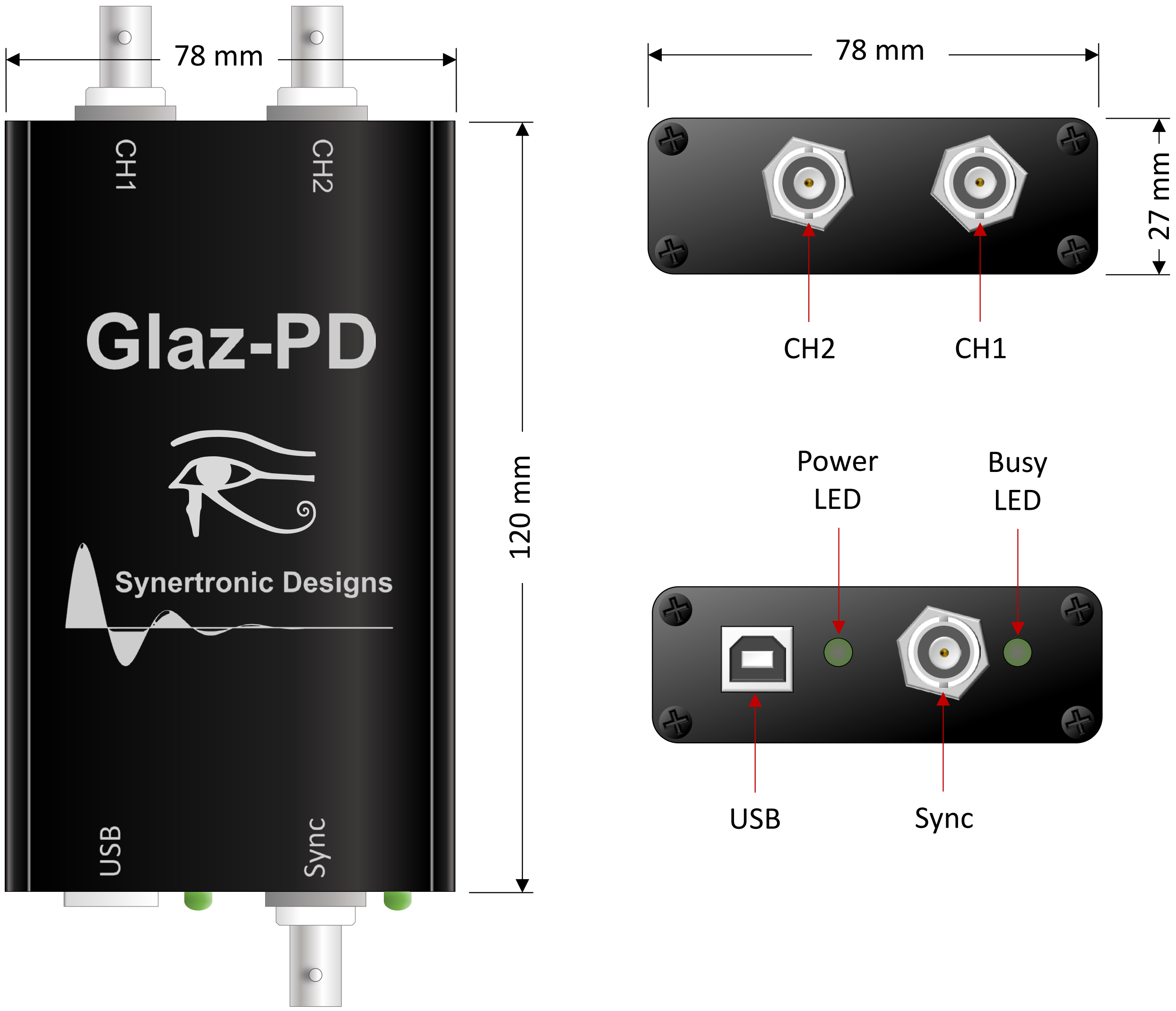


Figure 1 Mechanical dimensions and legend.

Ports

Port	Type	Function
USB	USB-B	Data connection to a PC. Also provides the camera with power.
Sync	BNC	Synchronisation signal from *PulseSync* camera.
CH1, CH2	BNC	Photo diode input ports

Table 2 Connectors.

LEDs

LED	States	
Power LED	off	no power
	green	camera has power.

Busy LED	off green	idle busy digitizing pulse and transmitting data over USB

Table 3 LEDs.

Functional description

Connecting to a PC

Glaz-PD digitizers are connected to a PC via USB interfaces. They are USB 2.0 full-speed devices, but are backwards compatible with USB 1.1 interfaces. Connecting a digitizer to a USB 1.1 interface will cause a reduction in the maximum data transfer rate to less than 0.5 MB/s. This will reduce the maximum measurable repetition rate to below 10 kHz.

If a PC has a limited number of USB ports, it is possible to use an external USB hub.

Digitizing fast photo-diode pulses

The *Glaz-PD* was designed to measure fast (<50 ns) photo-diode current pulses. In each channel, the current pulse from the photo-diode is passed through a pulse-forming network. The pulse-forming network consists of a cascaded leaky integrator and low-pass filter. This stretches the pulse. The stretched pulse has a maximum amplitude proportional to the integral of the photo-diode pulse.

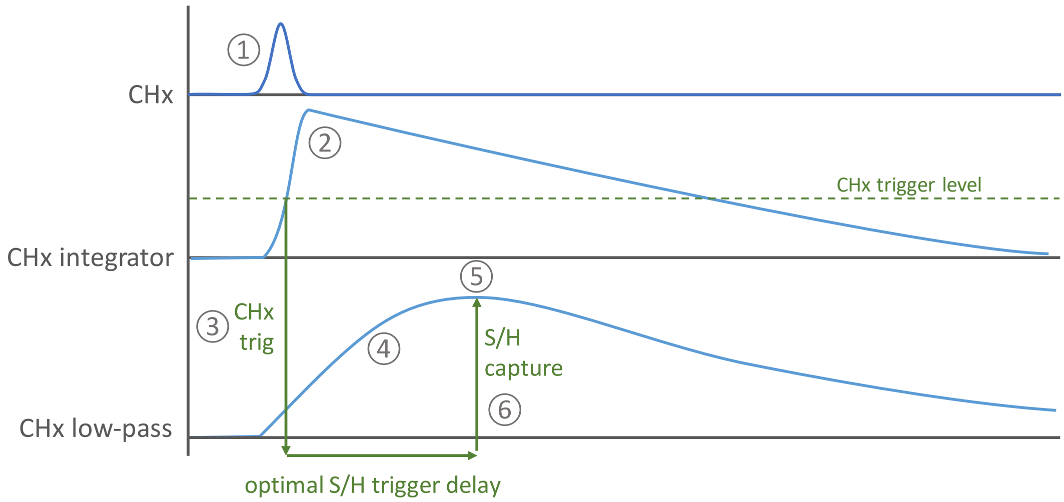


Figure 2 Pulse-forming network wave shapes.

For each pulse, the following process is followed:

1. A current pulse is received from the photo-diode.
2. The leaky integrator integrates the current. The output of the integrator is proportional to the total charge of the current pulse.
3. The rising flank of the integrator output triggers the channel.
4. The output of the leaky integrator is passed through a low-pass filter.
5. After a certain delay, the output of the low-pass filter reaches a maximum. This maximum is also proportional to the total charge of the current pulse.

6. The device is configured with an optimal delay (S/H trigger delay). This delay is the time from the channel trigger to the low-pass output maximum. At this point in time the internal sample and hold circuit captures the output of the low-pass filter.

The decay constant of the leaky integrator is approximately 5 μs. The rise-time of the low-pass filter is approximately 1 μs. The conversion factor of the integrator is 10 V/nQ.

See "Calibrating S/H trigger delay" for more information on calibrating the S/H delay.

Digitizer channels and operating modes

Glaz-PD features two digitizer channels. Each channel consists of a high-speed pulse forming network and sample-and-hold circuit. Also, each channel is triggered by the photo diode pulse current. The trigger level can be programmed independently for each channel. Two operating modes of operation are supported:

- Free-running mode
- Synchronised mode (used together with LineScan camersa)
- Stand-alone mode

Glaz-PD can be configured to use only one or both channels. When configured to use both channels, the channels will only be digitized after both channels were triggered. The connection diagram of the *Glaz-PD* is shown in Figure 3.

> ⚠ The cables connecting the photo diode detectors with the Glaz-PD must be coaxial cables with an impedance of 50 Ω. The cable must be shorter than 1.5 m.

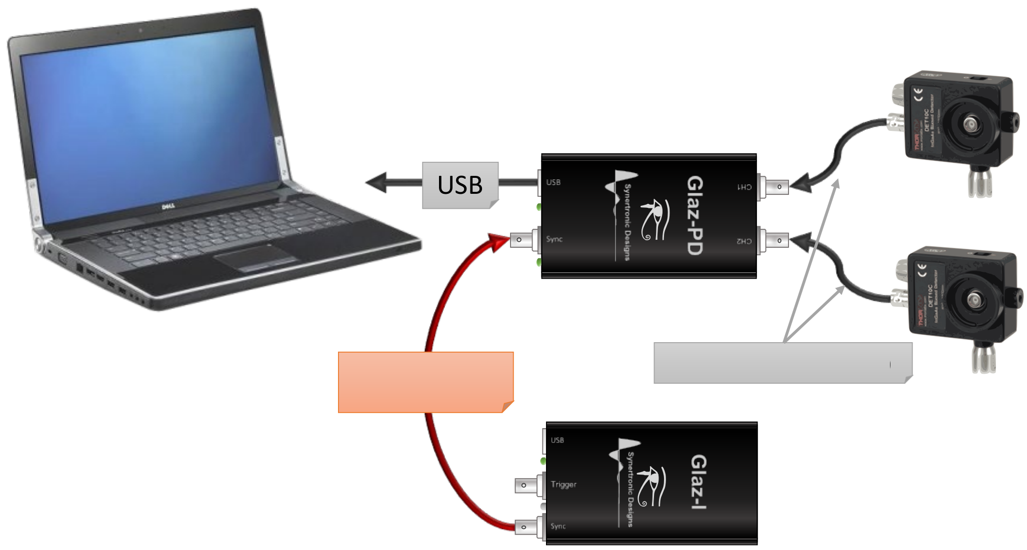


Figure 3 Connection diagram.

Free-running mode

In free-running mode the *Sync* port is not used and the digitizer is only triggered by the photo diodes. The free-running timing diagram with two enabled channels is shown in Figure 4.

One acquisition cycle consists of the following steps:

1. Initially, the device is waiting to be triggered.
2. A channel is triggered when the pulse amplitude exceeds the trigger level. The trigger level can be set independently for each channel.
3. The photo diode pulse passes through a pulse-forming network and is stretched.
4. The sample-and-hold circuit is triggered, as soon as the stretched pulse reaches its maxima.
5. The device waits until all enabled channels are triggered.

6. All enabled channels are digitized.
7. A single result set is compiled and sent via USB to a PC.
8. Finally, the trigger and sample-and-hold circuits are reset.

> In free-running mode a result set is sent to the PC each time all enabled channels were triggered.

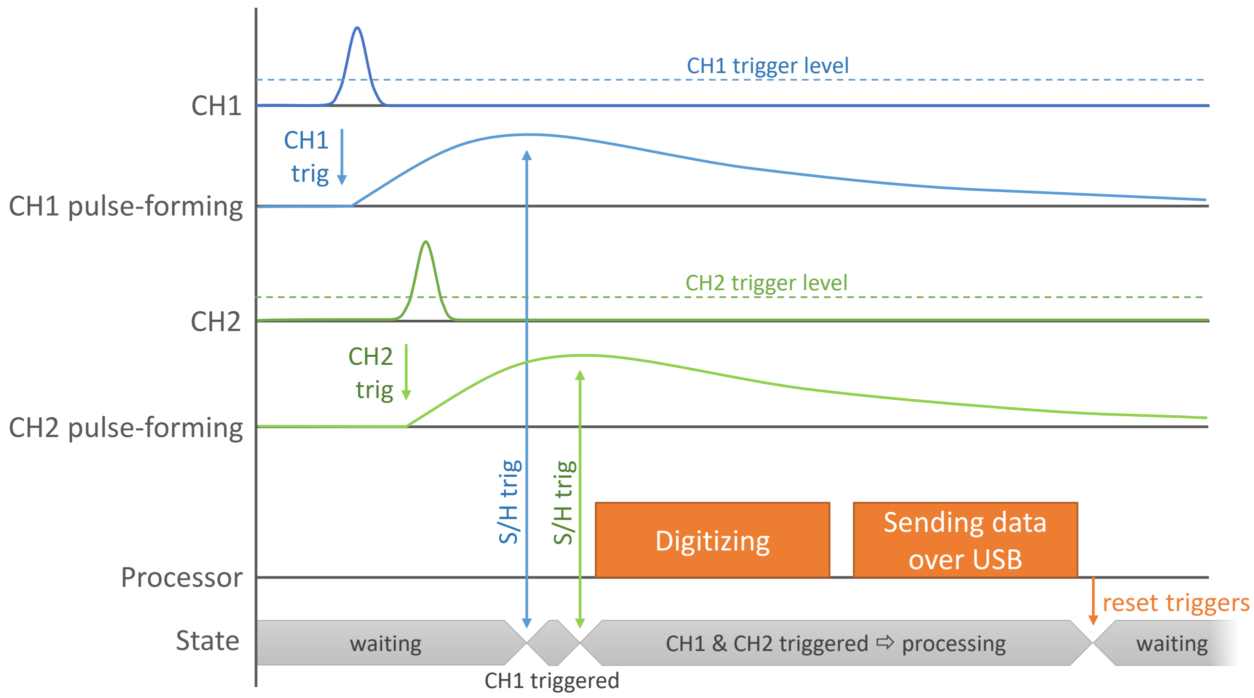


Figure 4 Timing in free-running mode with two enabled channels.

Synchronised mode

The synchronised mode provides a mechanism to synchronise *Glaz-PD* devices with *Glaz LineScan* cameras with *PulseSync* mode. The connection diagram in Figure 3 shows how to connect *Glaz PulseSync* cameras to *Glaz-PD* devices. The *Sync* port is used for this purpose. The synchronised mode timing diagram with two enabled channels is shown in Figure 5.

One acquisition cycle consists of the following steps:

1. Initially, the device is waiting for the *Sync* signal to be asserted low by the master *Glaz PulseSync* camera.
2. After the *Sync* signal is asserted low, there is a window period. All photo-diode triggers outside this window period are ignored.
3. A channel is triggered when the pulse amplitude exceeds the trigger level. The trigger level can be set independently for each channel.
4. The photo diode pulse passes through a pulse-forming network and is stretched.
5. The sample-and-hold circuit is triggered, as soon as the stretched pulse reaches its maxima.
6. The device waits until all enabled channels are triggered or the end of the window period is reached.
7. If an enabled channel was triggered within the window period, it is digitized. If an enabled channel was not triggered during the window period, the channel will not be digitized and is flagged as invalid/not triggered.
8. A single result set is compiled and sent via USB to a PC.

9. Finally, the trigger and sample-and-hold circuits are reset.

> In synchronised mode a result set is sent to the PC each time the *Sync* port is asserted low.

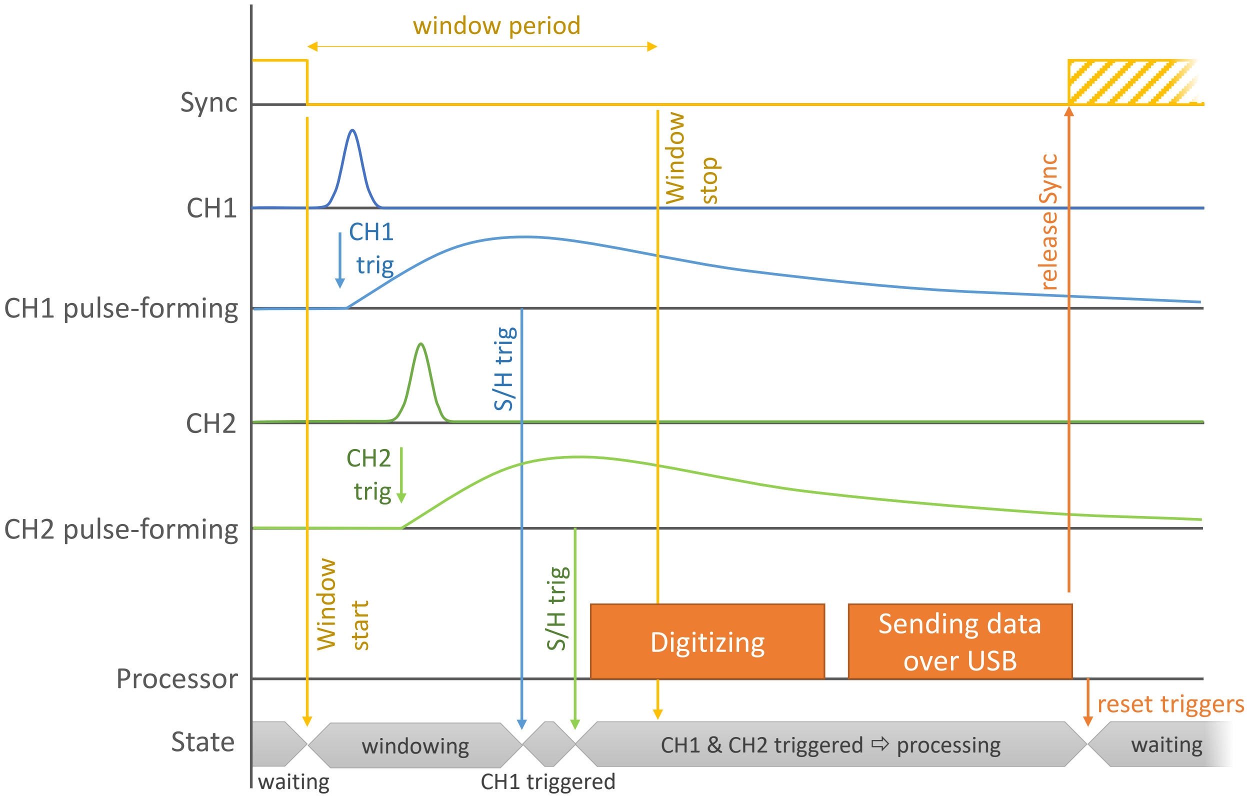


Figure 5 Timing in synchronised mode with two enabled channels.

Some examples of channel validation are shown in Figure 5 and Figure 6.

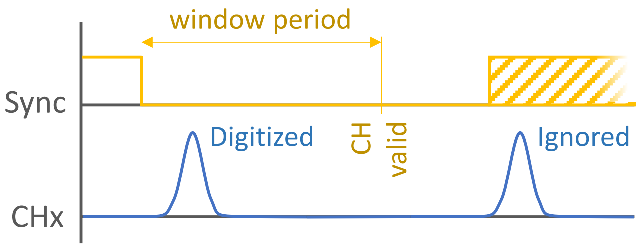


Figure 6 Channel validation example 1.

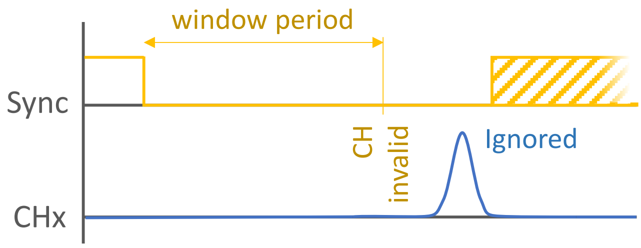


Figure 7 Channel validation example 2.

- Example 1:
  Two pulses are received. The first pulse falls within the window period and is digitized. The channel is flagged as valid. The second pulse falls outside the window period and is ignored.
- Example 2
  One pulse is received outside the window period. It will be ignored and no pulse was received inside the window period. The channel is flagged as invalid/not triggered.

The synchronised mode also provides a mechanism to gate *Glaz PulseSync* calculations. Gating is used to perform different calculations by the *Glaz* script, depending on whether a channel was valid (triggered) or invalid (not triggered) during the synchronous window period.

Stand-alone mode

> ⚠ Stand-alone mode is only supported by firmware version 1.6 or higher and by Glaz LabView driver 9.6 or higher.

The stand-alone mode provides a mechanism to synchronise *Glaz-PD* devices with an external trigger source. The connection diagram in Figure 8 shows how to connect *Glaz-PD* to an external trigger source. The *Sync* port is configured as input and can be trigger on the rising or falling edge of the external trigger.

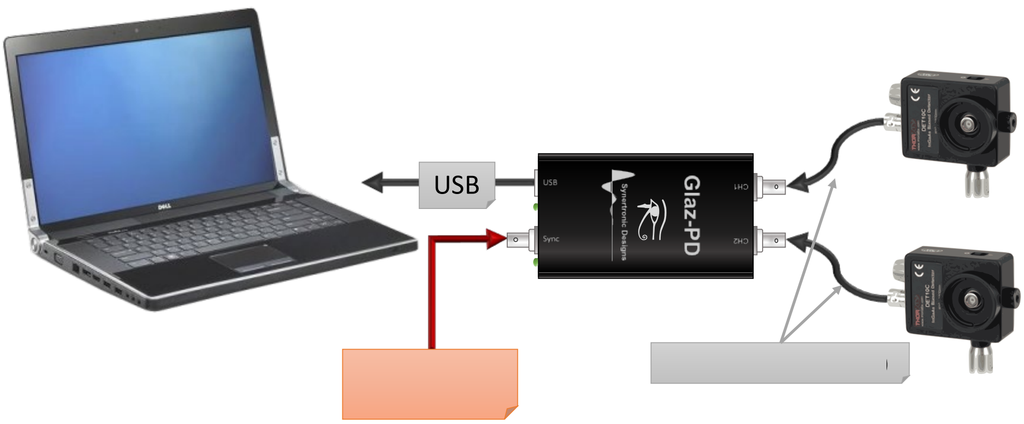


Figure 8 Stand-alone connection diagram.

The stand-alone mode timing diagram with two enabled channels is shown in Figure 9.

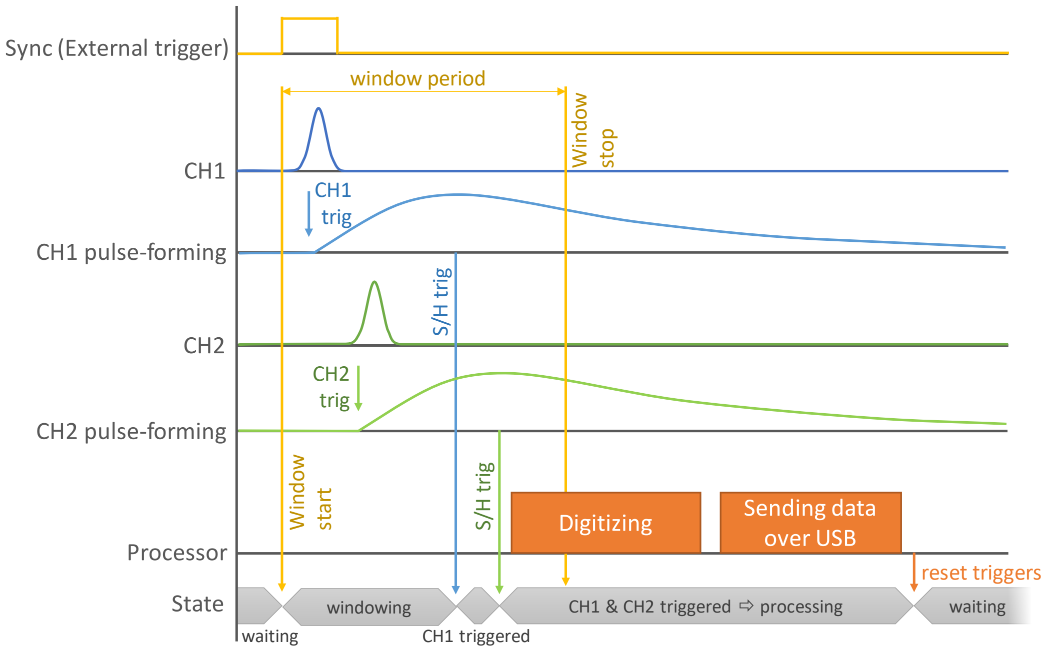


Figure 9 Timing in stand-alone mode with two enabled channels.

One acquisition cycle consists of the following steps:

1. Initially, the device is waiting for the external trigger on the *Sync* port. The *Sync* port can be configured to sense the rising or falling edge of the external trigger.
2. After the external trigger was received, there is a window period. All photo-diode triggers outside this window period are ignored.
3. A channel is triggered when the pulse amplitude exceeds the trigger level. The channel trigger level can be set independently for each channel.
4. The photo diode pulse passes through a pulse-forming network and is stretched.
5. The sample-and-hold circuit is triggered, as soon as the stretched pulse reaches its maxima.
6. The device waits until all enabled channels are triggered or the end of the window period is reached.
7. If an enabled channel was triggered within the window period, it is digitized. If an enabled channel was not triggered during the window period, the channel will not be digitized and is flagged as invalid/not triggered.
8. A single result set is compiled and sent via USB to a PC.
9. Finally, the trigger and sample-and-hold circuits are reset.

Gain stages

Each channel contains a gain stage. The gain stage can be configured to provide a gain of 1x (low gain) or a gain of x6 (high gain).

DC offset

The analogue input stages have a relatively high DC gain. It is important that the DC offset of the photo diode detectors should be within the specified limits. Excessive DC offsets will degrade the dynamic range of the digitizer. It is possible to perform a zero-offset calibration to remove the DC offset during digitizing. The zero-offset calibration should be performed each time the gain stage values are changed. See "Calibrating zero-offset" for more information.

Oversampling

The *Glaz-PD* provides oversampling support. The digitizers can be configured to sample each enabled channel 4, 8 or 16 times for each pulse. The average of these samples are calculated by *Glaz-PD* and sent to the PC.

Timestamps

The *Glaz-PD* is able to take timestamps for each result set. The timestamp trigger for the different modes is shown below:

Mode	Trigger
Free-running	Channel 1 trigger
Synchronised	Sync asserted low by *Glaz PulseSync* camera

Table 4 Timestamp triggers.

When a measurement is started the timestamp counter is reset and all timestamps are measured relative to the first timestamp trigger.

Glaz UI

Glaz UI is a stand-alone user interface to configure and take measurements with *Glaz-PD* devices. It is also a tool to calibrate trigger levels, DC offsets and sample-and-hold delays.

Installing Glaz UI

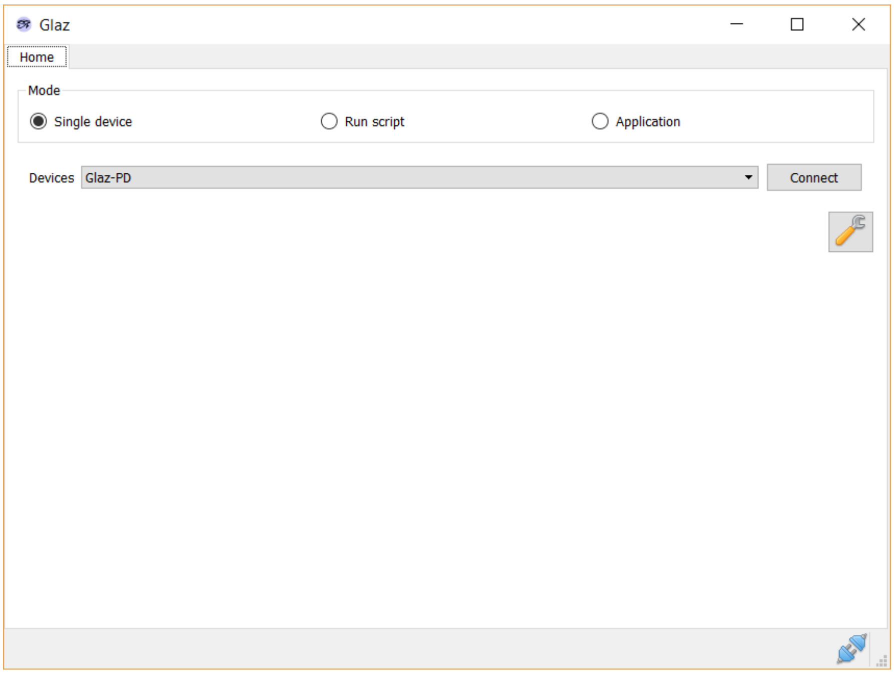
The installer for *Glaz UI* can be downloaded from the Synertronic Designs web page. Download and run the installer.

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 calibration.
- *Run script*
  This mode requires a script file. Use this mode to test scripts and perform more complex multi-camera measurements. Script files are not described in this manual and more information can be found in the *Glaz LineScan-I* and *Glaz LineScan-II* manuals.
- *Application*
  This mode offers several application-specific extensions. See the application-specific documentation on the Synertronic Designs web page.

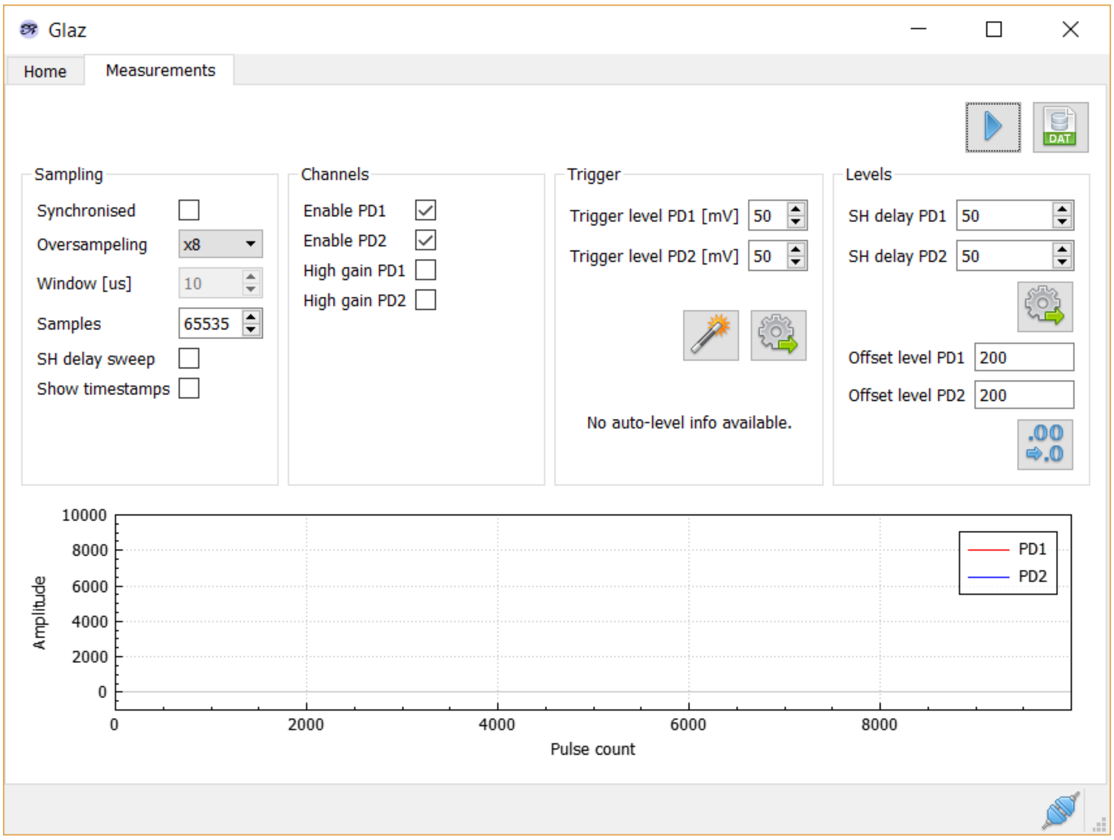


Single device mode

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)



There are several parameters that can be set and are grouped into *Sampling*, *Channels*, *Trigger* and *Levels*.

The following *Sampling* parameters are provided:

- *Synchronised* — Toggle between synchronised and free-running mode. See "Free-running mode" and "Synchronised mode" for more information.
- *Oversampling* — Specify the number of oversamples. See "Oversampling" for more information.
- *Window [us]* — Specify the window period when using synchronised mode. See "Synchronised mode" for more information.
- *Samples* — Specify the number of pulses to sample.
- *SH delay sweep* — Enable this option when calibrating the S/H trigger delay. See "Calibrating S/H trigger delay" for more information.
- *Show timestamps* — Instead of showing the "Pulse count" on the x-axis of the graph, the timestamps of each sampled pulse is shown.

The following *Channel* options are provided:

- *Enabled PDx* — Specify which channels should be enable. When using only a single channel it is recommended to use channel 1.
- *High gain PDx* — Specify to use low or high gain.

The following *Trigger* options are provided:

- *Trigger level PDx [mV]* — Manual trigger level in [mV].
- Let the *Glaz-PD* automatically determine the trigger levels.
- Commit the manual trigger levels.

The following *Levels* options are provided:

- *SH delay PDx* — Specify the S/H trigger delay. See "Error! Reference source not found." and "Calibrating S/H trigger delay" for more information.
- Commit the S/H trigger delay settings.
- *Offset level PDx* — Shows the zero-offset calibration (read-only).
- .00 ⇒.0 — Perform a zero-offset calibration. See "DC offset" and "Calibrating zero-offset" for more information.

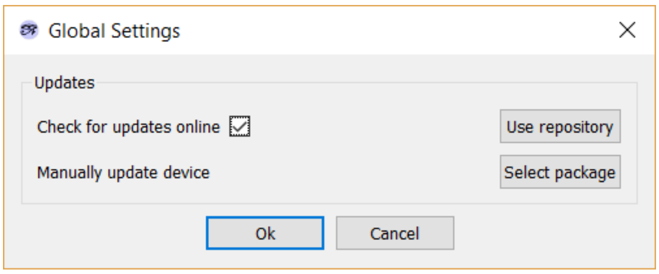
> ⚠ Care should be taken when changing the S/H trigger delays. Only change these settings if you are familiar with the S/H trigger delay calibration procedure.

The functions of the buttons:

- Starts a measurement. When a measurement starts, the button changes to the stop button.
- Stops the measurement.
- DAT — Export the plotted data to a CSV (comma separated values) file.

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.

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.

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.

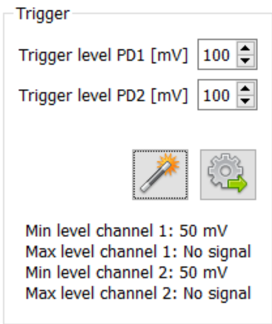
Calibrations

Device calibration can be performed in single-device mode:

1. Select the *Home* page.
2. Select *Single device* mode.
3. Select the *Glaz-PD* device in the *Devices* drop-down.
4. Click *Connect*.
5. Click on the *Measurements* tab to switch to the *Measurements* page.

Calibrating trigger levels

The trigger levels for each channel can be specified manually or auto-trigger level can be performed for both channels.



Manually setting trigger levels

1. Enter the trigger values in *Trigger level PD1 [mV]* and *Trigger level PD2 [mV]*.
2. Click in the *Trigger* group to upload the trigger levels to the device. The values are stored in non-volatile memory on the device.

Automatically setting trigger levels

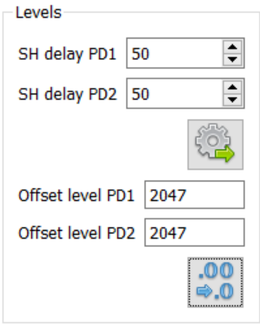
1. Connect the *Glaz-PD* to the relevant photo-diodes.
2. Ensure that the photo-diodes are illuminated by the laser source.
3. Click in the *Trigger* group to start the automatic trigger level calibration.
4. The *Glaz-PD* performs trigger level measurements. The results are stored in non-volatile memory on the device.
5. When completed, the trigger levels and information at the bottom of the *Trigger* group are updated.

The information at the bottom of the *Trigger* group indicates the minimum and maximum detected levels for each channel. The trigger level for each channel is set to:

Trigger level [mV] = 0.6 • (Max level – Min level) + Min level

If no signal was detected, the trigger level is set to 100 mV and the maximum level for the corresponding channel is indicated as *No signal*.

Calibrating zero-offset



The DC offset of each channel can be removed by performing a zero-offset calibration:

1. Connect the *Glaz-PD* to the relevant photo-diodes.
2. Ensure that the photo-diodes are blocked and not illuminated by the laser source.
3. Click .00 .0 in the ***Levels*** group to start the zero-offset calibration.
4. The *Glaz-PD* performs zero-offset calibration. The results are stored in non-volatile memory on the device.
5. When completed, the ***Offset level PD1*** and ***Offset level PD2*** fields are updated.

> ⚠ The zero-offset calibration should be performed each time the gain stage values are changed.

> ⚠ Offset levels larger than 1000 indicate excessive background illumination of the photo diode detectors. This will degrade the dynamic range of the digitizer.

Calibrating S/H trigger delay

> ⚠ The S/H trigger delays are factory calibrated and should not be changed under normal circumstances. This section is provided only when the S/H trigger delay calibration is lost due to some unknown causes.

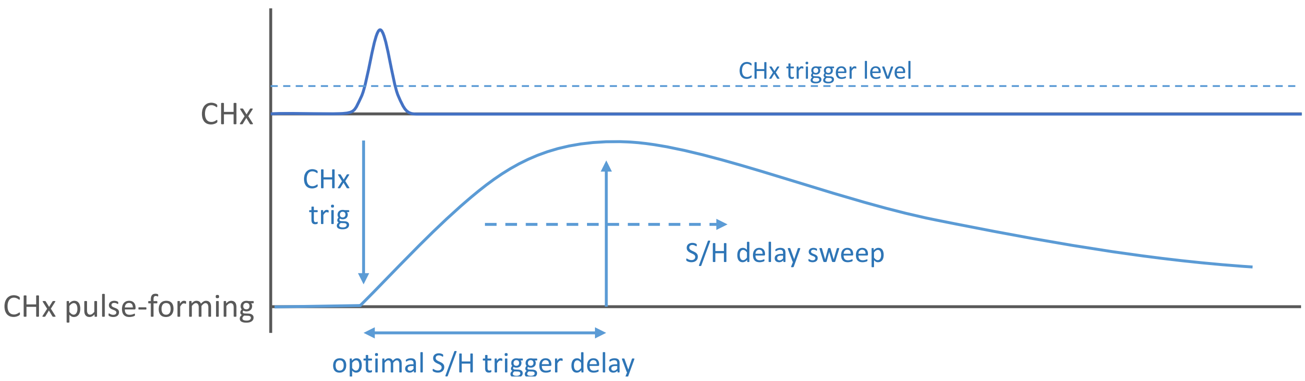


Figure 10 S/H trigger delay.

S/H trigger delay calibration requires an S/H delay sweep. The S/H trigger delay is depicted in Figure 10. The current pulse from the photo-diode is passed through a pulse-forming network. This stretches the pulse. See "Digitizing fast photo-diode pulses" for more information. The stretched pulse has a maximum amplitude proportional to the integral of the photo-diode current pulse. An S/H delay sweep takes measurements for different S/H delay values. During the S/H delay sweep, the delay is slowly increased from a value of 50 up to a maximum value of 660. The delay value is a pure numerical value and cannot be directly mapped into to a real time value.

S/H delay sweep

1. Uncheck *Synchronised* in the *Sampling* group.
2. Uncheck *Show timestamps* in the *Sampling* group.
3. Check *SH delay sweep* in the *Sampling* group.
4. Enable the relevant Channels in the *Channels* group. Only check the channels with a connected photo-diode.
5. Ensure that the photo-diode is illuminated by the laser source.
6. Click the ▶ button.
7. The application now performs an S/H delay sweep and the measured peak values are plotted as a function of the S/H delay.

Traces of a typical S/H sweep is depicted in Figure 11.

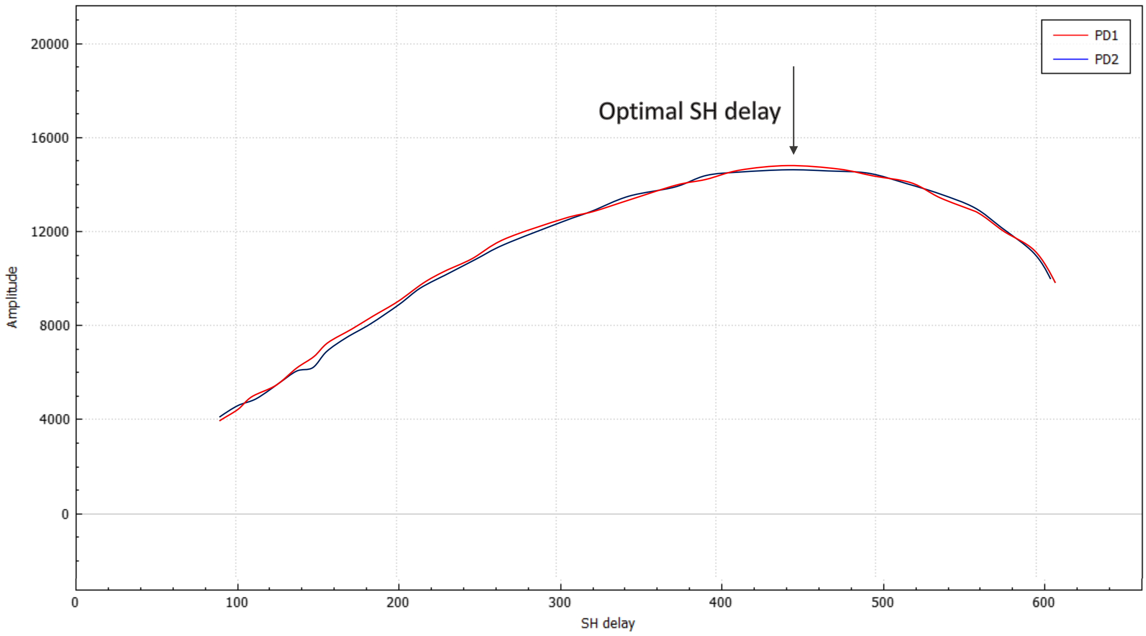


Figure 11 S/H delay sweep result.

Setting the optimal S/H delay

From the traces in Figure 11 it is possible to determine the optimal S/H delay value for each channel. The optimal S/H delay value for a channel is the S/H delay for which that channel has a maximum amplitude. In the example shown in Figure 11 the optimal S/H delay values would be approximately 450 for each channel. To set the S/H values:

1. Specify the optimal S/H delay *SH delay PDx* for each channel in the *Levels* group.
2. Click in the *Levels* group to upload the S/H delay values.
3. The delay values are storied in non-volatile memory on the device.

LabView driver

The Glaz-PD can be controlled with the *Glaz* LabView driver. For more information see the *Glaz* LabView manual.

Using Glaz-PD in stand-alone mode

1. Create a *Glaz* script file with the *Glaz-PD* settings.
2. Call initialse Session with the script file path.
3. Set the number of scans to be captured during a measurement run with set Scan Count.
4. Call run Measurement to start the measurement run
5. Call get PD Values to obtain the captured values of the relevant photo-diode channels.
6. Repeat from step 4 as required.
7. Call close Session at the end of the LabView program.

Below is an example of a *Glaz* XML script file:

```
<!DOCTYPE GlazScript>
<config>
    <pd serial="SYBP00601XXXX" number="1" ch1="1" ch2="1" window="10"
     standalonesync="rising"/>
</config>
```

The script file contains the *Glaz-PD* device definition. The device definition, <pd>, has the following form and attributes:

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

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 must be a unique number in the range [1 .. 1000].

E1,E2 : Must be one of the following values:

- *1* or *true*: The given channel will be enabled.
- *0* or *false* (default): The given channel will be disabled.

G1,G2 : Must be one of the following values:

- *1* or *true*: The high-gain stage (x6 gain) for the given channel will be enabled.
- *0* or *false* (default): Normal gain will be used.

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

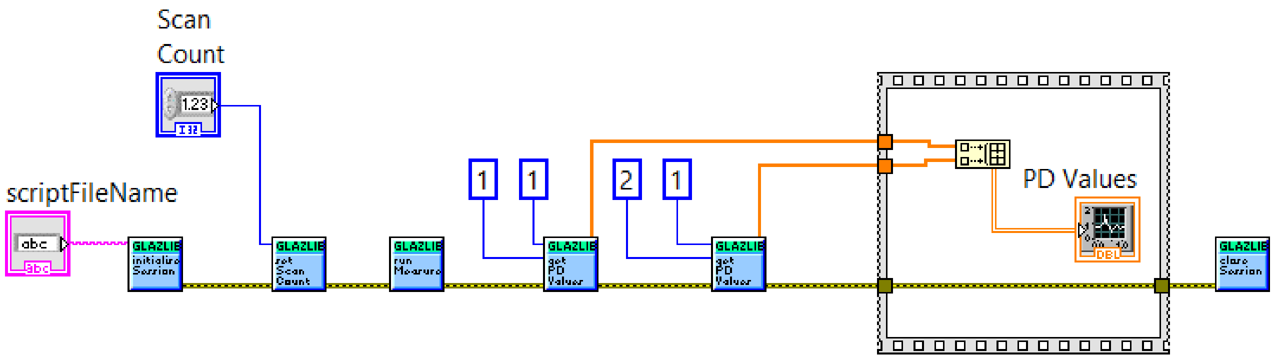
A : Specifies the amount of hardware averaging performed by the *Glaz-PD*. Must be one of the following values:

- *lo*: Less hardware averaging will be used to increase the capture rate of the *Glaz-PD*. Use this option for capture higher than 10 kHz.
- *hi* (default): More hardware averaging will be used to improve the noise performance.

SYNC : Specifies the polarity of the trigger signal connected to the *Sync* port. Must be one of the following values:

- *rising*: Triggered on the rising edge of the *Sync* signal.
- *falling*: Triggered on the falling edge of the *Sync* signal.

Below is an example of a LabView program using the *Glaz-PD* in stand-alone mode:



Combining Glaz-PD and Glaz LineScan cameras

Glaz-PD devices can be combined with *Glaz LineScan-I* and *LineScan-II* cameras in *PulseSync* mode. More information on how to perform measurements and combining *Glaz-PD* and *Glaz LineScan* cameras can be found in the *Glaz LineScan-I* and *Glaz LineScan-II* manuals.

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