



## Single Photon Counting Module

# SPCMxxA Operation Manual



2021

---

Version: 1.4  
Date: 06-Dec-2021

# Contents

<b>Foreword</b>	<b>3</b>
<b>1 General Information</b>	<b>4</b>
1.1 Safety	4
1.2 Ordering Codes and Accessories	4
1.3 Requirements	5
1.3.1 Hardware Requirements	5
1.3.2 Software Requirements	5
1.3.3 Interface Requirements	5
<b>2 Installation</b>	<b>6</b>
2.1 Parts List	6
2.2 Getting Started	6
2.3 Installing Software	6
<b>3 Operating Instructions</b>	<b>10</b>
3.1 Operating Principle	10
3.2 Functional Block Diagram	11
3.3 Connecting the SPCM	12
3.4 Graphic User Interface (GUI)	13
3.4.1 Menu "File"	13
3.4.2 Menu "Device"	15
3.4.3 Menu "Option"	16
3.4.4 Menu "Help"	16
3.4.5 Menu Icons	17
3.4.6 Functional Area	18
3.4.6.1 Alignment Display	19
3.4.6.2 Table Display	20
3.4.6.3 Graph Display	20
3.4.6.4 Bar Display	21
3.5 Operating Modes	22
3.5.1 Manual Mode	22
3.5.2 Free Running Timed Counter	23
3.5.3 Externally Triggered Timed Counter	25
3.5.4 Externally Triggered Counter	27
3.5.5 External Gating	29
<b>4 SCPI Commands</b>	<b>31</b>
<b>5 Maintenance and Service</b>	<b>38</b>
5.1 Version Information	38
5.2 SPCM Firmware Update	39
5.2.1 Installing DFU Wizard	39

5.2.2	Firmware Update _____	42
5.3	Troubleshooting _____	46
<b>6</b>	<b>Appendix</b>	<b>48</b>
6.1	Typical Photon Detection Efficiency _____	48
6.2	Definitions _____	48
6.3	Pulse Out _____	50
6.4	Technical Data _____	51
6.5	Dimensions _____	52
6.6	Certifications and Compliances _____	54
6.7	Warranty _____	55
6.8	Exclusion of Liability and Copyright _____	55
6.9	List of Acronyms _____	56
6.10	Thorlabs Worldwide Contacts and WEEE Policy _____	57

---

We aim to develop and produce the best solution for your application in the field of optical measurement technique. To help us to live up to your expectations and constantly improve our products we need your ideas and suggestions. Therefore, please let us know about possible criticism or ideas. We and our international partners are looking forward to hearing from you.

*Thorlabs GmbH*

**WARNING**

Sections marked by this symbol explain dangers that might result in personal injury or death. Always read the associated information carefully, before performing the indicated procedure.

**ATTENTION**

Paragraphs preceded by this symbol explain hazards that could damage the instrument and the connected equipment or may cause loss of data.

**NOTE**

This manual also contains "NOTES" and "HINTS" written in this form.

Please read this advice carefully!

# 1 General Information

Thorlabs' Single Photon Counter Modules use a silicon avalanche photodiode to detect single photons. The SPCM counters are sensitive to photons emitted in the 350 to 900 nm range with the maximum sensitivity at 500 nm. They work by converting an incoming photon into a TTL pulse in the detector, which is counted by the internal 31-bit counter. An additional SMA connection offers a direct output pulse signal from the module that can be viewed on an oscilloscope or connected to an external counter.

An integrated Peltier element stabilizes the diode's temperature below the ambient temperature to reduce the dark count rate. The two available models, SPCM20A and SPCM50A, have low typical dark count rates of 25 and 150 counts per second, respectively, which allows them to detect power levels down to 0.14 fW.

The active quenching circuit integrated into the diode of the SPCM enables high count rates. Its high speed allows users to count a photon every 35 - 45 ns, depending on the model chosen. The SPCM20A provides an active area of  $\varnothing 20 \mu\text{m}$  and the SPCM50A offers  $\varnothing 50 \mu\text{m}$ .

The SPCM includes a software package with GUI for out-of-the-box operation.

## 1.1 Safety

### **Attention**

**The safety of any system incorporating the equipment is the responsibility of the assembler of the system.**

**All statements regarding safety of operation and technical data in this instruction manual will only apply when the unit is operated correctly as it was designed for.**

**The SPCMxxA must not be operated in explosion endangered environments!**

**Do not remove covers!**

**Do not open the cabinet. There are no parts serviceable by the operator inside!**

**This precision device is only serviceable if properly packed into the complete original packaging including the plastic foam sleeves. If necessary, ask for replacement packaging.**

**Refer servicing to qualified personnel!**

**Only with written consent from Thorlabs may changes to single components be made or components not supplied by Thorlabs be used.**

**All modules must only be operated with proper shielded connection cables.**

## 1.2 Ordering Codes and Accessories

Imperial versions:

SPCM20A            Single Photon Counter Module, 350-900 nm, 20  $\mu\text{m}$  active area

SPCM50A            Single Photon Counter Module, 350-900 nm, 50  $\mu\text{m}$  active area

Metric versions

SPCM20A/M        Single Photon Counter Module, 350-900 nm, 20  $\mu\text{m}$  active area, metric

SPCM50A/M        Single Photon Counter Module, 350-900 nm, 50  $\mu\text{m}$  active area, metric

## 1.3 Requirements

### 1.3.1 Hardware Requirements

- CPU: 1 GHz or higher
- RAM: 256 MB free space
- Graphic card with at least 32 MB memory
- Hard disc with at least 100 MB free storage space
- Free USB2.0 port (USB2.0 Full Speed; High Speed recommended)
- USB cable according the USB 2.0 specification

### 1.3.2 Software Requirements

This software was verified with the following platforms:

- Windows® XP (32-bit version)
- Windows® Vista (32-bit version)
- Windows® Vista x64 Edition (64-bit version)
- Windows® 7 (32-bit version)
- Windows® 7 x64 Edition (64-bit version)
- Windows® 10 (32-bit, 64-bit)

### 1.3.3 Interface Requirements

For full functionality it is recommended to use USB 2.0 High Speed interface.

## 2 Installation

### 2.1 Parts List

Inspect the shipping container for damage.

If the shipping container seems to be damaged, keep it until you have inspected the contents and you have inspected the SPCMxxA mechanically and electrically.

Verify that you have received the following items within the package:

1. SPCM20A (~/M) or SPCM50A (~/M)
2. Wall plug adapter (power supply 100-240 VAC / 6 VDC / 1.5 A)
3. USB 2.0 cable, A to mini B
4. Quick Start
5. CD with operating software

### 2.2 Getting Started

#### NOTE

Take care for proper air ventilation in order to ensure normal operation of the SPCMxxA. Prior to connecting the SPCMxxA to a PC, please install software from the attached CD.

### 2.3 Installing Software

#### NOTE

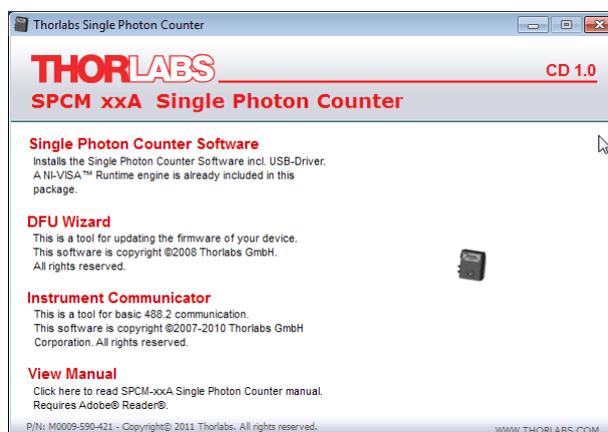
The screenshots in this manual are related to a Windows® 7 Operating System.

Insert the CD into your CD or DVD drive. If the installation screen does not appear automatically, please execute

[CD Drive]:\Autorun\autorun.exe

#### NOTE

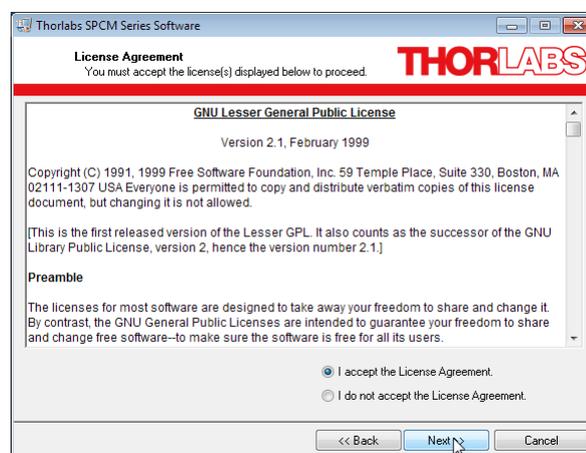
A NI-VISA Runtime Engine® is required to operate the Single Photon Counter. If NI-VISA is not installed yet, the installation package will install version 5.0.3 automatically.



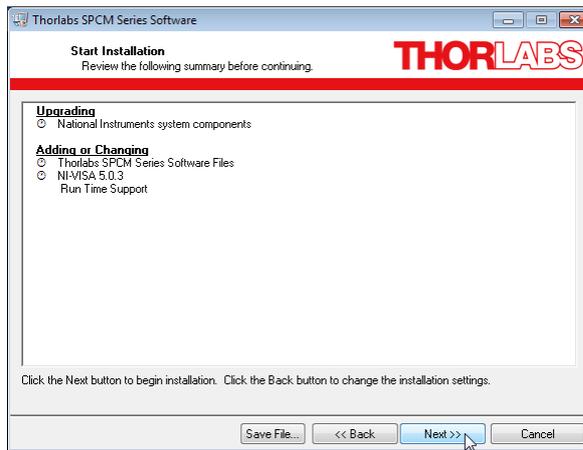
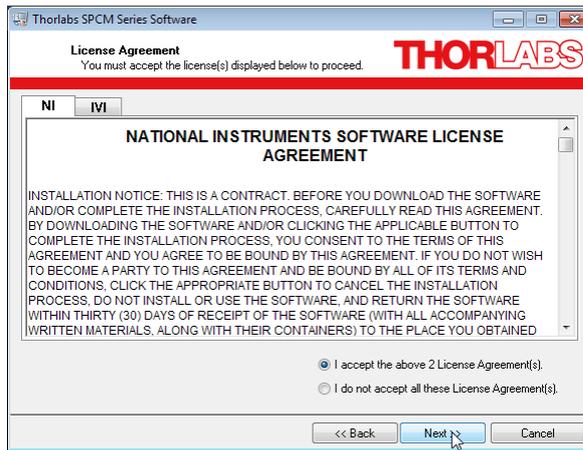
Start installation by clicking "Single Photon Counter Software"



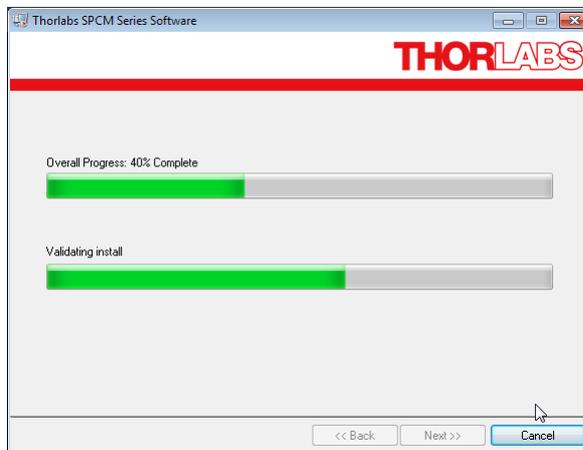
Click "Next" to continue



In the next two screens, click "I accept..." if you do so, then "Next"



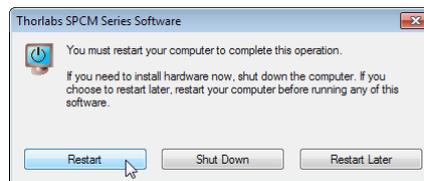
Click "Next" to continue.



After finishing the installation, the installation summary will be displayed. Click "Finish" to continue.



After completing the installation you might be prompted to restart your PC.

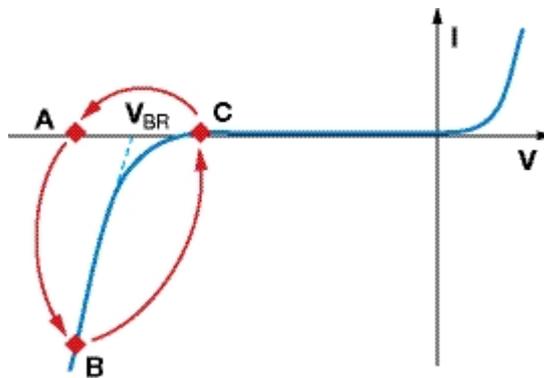


## 3 Operating Instructions

### 3.1 Operating Principle

The Thorlabs SPCMxxA uses a silicon avalanche photo diode (Si APD), operated in reverse direction and biased slightly beyond the breakdown threshold voltage  $V_{BR}$  (see diagram below, point **A**), also known as avalanche voltage.

This operating mode is also known as "Geiger mode". An APD in Geiger mode will remain in a metastable state until a photon arrives and generates free charge carriers in the PD's junction. These free charge carriers trigger an avalanche (point **B**), leading to a significant current. An active **quenching circuit** integrated into the APD limits the current through the APD in order to avoid destruction and lowers the bias voltage below the breakdown voltage  $V_{BR}$  (point **C**) immediately after a photon released an avalanche, this way enabling high count rates (dead time between counts down to 35 - 45ns). Afterwards the bias voltage is being restored.



During the quenching time, which is known as the dead time of the diode, the APD is insensitive to any other incoming photons.

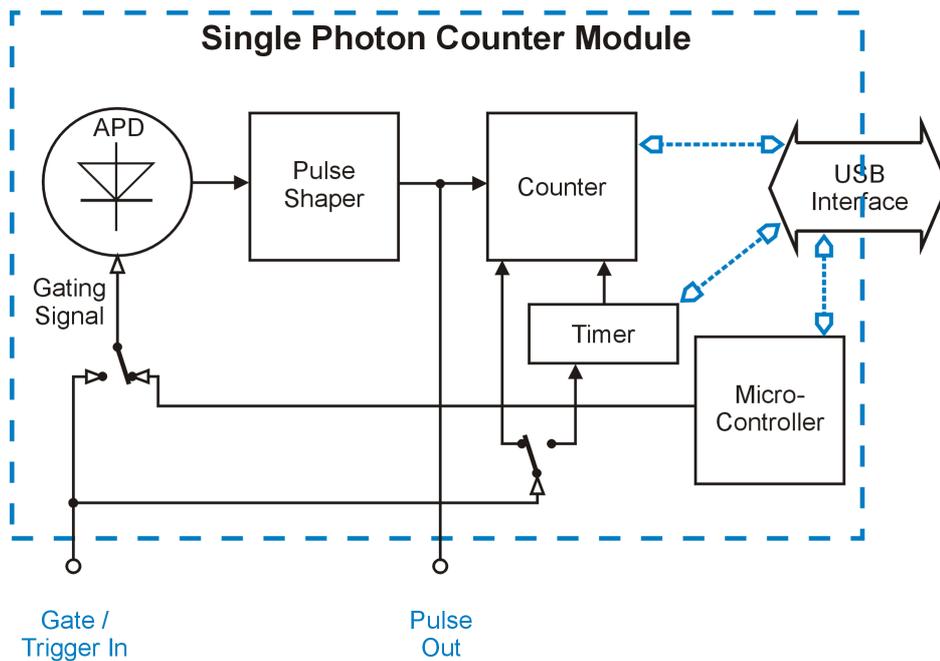
Spontaneously triggered avalanches are possible while the diode is in a metastable state. If these spontaneous avalanches occur randomly, they are called **dark counts**. An integrated Peltier element stabilizes the diode's temperature below the ambient temperature to reduce the dark count rate. For long-term temperature stability, a fan is built in.

In case the spontaneously triggered avalanches are correlated in time with a pulse caused by a photon, it is called an **afterpulse**. To ignore such afterpulses in the measurement, an additional **Pulse Blind Time** can be set in the software, which will cause the internal counter of the SPCM to ignore all pulses occurring during the set pulse blind time. This additional **Pulse Blind Time** starts at the moment when a photon was registered by the counter.

#### Note

Due to APD properties, single photons may be not counted, i.e., lost. Possible reasons are the APD's intrinsic dead time during quenching, an additionally set blind time of the SPCM and the APD's nonlinearity.

## 3.2 Functional Block Diagram



The current pulse generated by an incoming photon passes a pulse shaping circuit, which is shortening the APD's output TTL pulse duration from 35 ... 45 ns to ~ 14 ns. These pulse are applied to the SMA "Pulse Out" connector and to the internal 31-bit counter. The counter state is read out via the USB connection.

The counter can be operated in timed mode, here a programmable timer defines the counting time ("Bin Length") and the interval between subsequent counts ("Time between Bins"). Alternatively, the counter can be started directly from the PC software (Manual Mode) or by an external trigger signal. An internal buffer can save up to 4000 counts in order to comply with an insufficient USB transfer rate.

A special operating mode (External Gating mode) allows to control the APD bias voltage externally - in this mode, the external signal applied to the "Gate / Trigger In" enables the APD Geiger mode and controls the counter.

The SPCM operating modes are explained in detail in section [Operating Modes](#)<sup>22</sup>.

On the "Pulse Out" terminal the signal from the pulse shaper is applied so that counts can be viewed on an oscilloscope or registered by an external counter.

Via the USB interface, the SPCM can be controlled (Start / Stop measurement, change operating modes and settings etc.) and measurement data are transferred, as well as status information and error indications.

The SCPMxxA is powered by an external wall-plug power supply (100-240 VAC / 6 VDC / 1.5A).

### Note

"Gate / Trigger In" and "Pulse Out" are of a 50  $\Omega$  impedance. Make sure that the trigger pulse source is capable to work on a 50  $\Omega$  load and that the device connected to "Pulse Out" operates at a 50  $\Omega$  input impedance.

The SCPMxxA comes with factory default setting to [External Gating Mode](#)<sup>29</sup>.

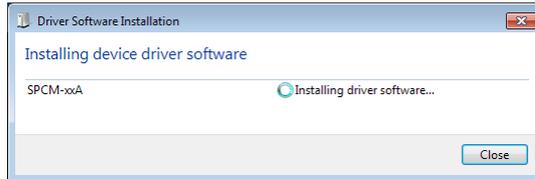
### 3.3 Connecting the SPCM

- Connect the wall plug adapter to mains outlet
- Connect the adapter's DC output cable to the SPCMxxA
- Connect the SPCMxxA via the USB cable to your PC
- Switch on the single photon counter module. The green LED, located beside the DC power input of the SPCMxxA, lights up.

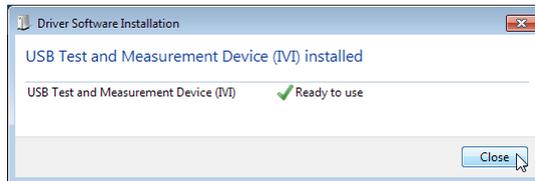
**Note**

During a measurement, the green status LED is switched off in order to avoid stray light.

- Your operating system will recognize a new hardware and automatically start the driver installation.

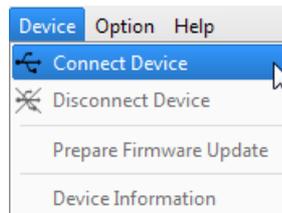


- After completing, a message will inform you that the new hardware is installed and ready to use.

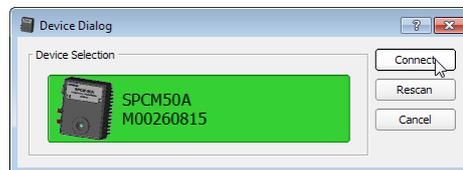


Start the software by clicking the appropriate  icon on the desktop; alternatively it can be started from Windows button - Programs - Thorlabs - SPCM Series Software - "SPCM". As a next step, the Single Photon Counter Module needs to be connected to software.

Therefore, click to the  icon in the toolbar or choose the appropriate function from the Device menu



A device selection dialog opens



The selected device is shown on a colored background. Click "Connect" - the selected hardware is connected and the dialog window closes.

If no device is shown to be selected, click "Refresh Device List" button. Select the recognized device and click "Connect".

**Note**

Multiple SPCM devices can be operated from a single PC by running a separate software instance. The Device Dialog panel will show all recognized SPCM devices, an already connected

SPCM will be inactive (grayed out), so that only a free, available SPCM can be selected to connect.

## 3.4 Graphic User Interface (GUI)

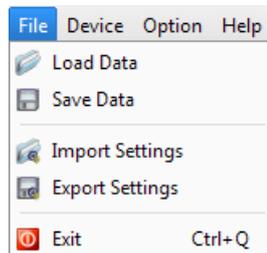
At the first start of the GUI or after selecting "Default Settings" (Menu "Option" -> "Settings") the following default measurement settings are loaded:

- Operating Mode: Free Running Timed Counter
- Bin length: 100 ms
- Time between bins: 0.001 ms
- Pulse blind time: 0.000 ns
- Array Measurement continuously: No (single)
- Bins per array: 100

The GUI comes with verbal menus and icons:



### 3.4.1 Menu "File"



The File menu allows to Save and Load measurement results with the appropriate settings. The most recent measurement can be saved also if the SPCM was disconnected from the GUI. Measurement results can be loaded with no SPCM connected, this way reproducing measurement results with the settings at which these measurements were made.

Import / Export Settings handles only settings, no measurement results. This is a useful feature to easily reproduce older measurement conditions, e.g. for comparison.

Example of saved data:

Thorlabs Single Photon Counter Data Export

Date (YYYY-MM-DD): 2011-07-11

Time (HH:MM:SS): 15:58:52

Device Name: SPCM50A

Serial Number: M00260815

GUI Revision: 0.9 Build 117

Driver Revision: 0.8.8

Firmware Revision: 0.10.0

Application settings:

Operating Mode: Free Running Timed Counter

Bin Length [ms]: 0.019

Time between Bins [ms]: 0.001

Pulse Blind Time [ns]: 0

Trigger Edge: non-applicable

Array Measurement: Yes

Array Measurement Continuously: No

Bins per Array: 5

Active APD Gating: No

Fan Off: No

Bin Number	Counts per Bin	Remarks
1	8	
2	3	
3	7	
4	5	
5	3	

Example of exported settings:

#### Thorlabs Single Photon Counter Data Export

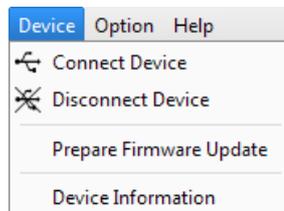
Date (YYYY-MM-DD): 2011-07-11  
 Time (HH:MM:SS): 15:58:52  
 Device Name: SPCM50A  
 Serial Number: M00260815  
 GUI Revision: 0.9 Build 117  
 Driver Revision: 0.8.8  
 Firmware Revision: 0.10.0

#### Application settings:

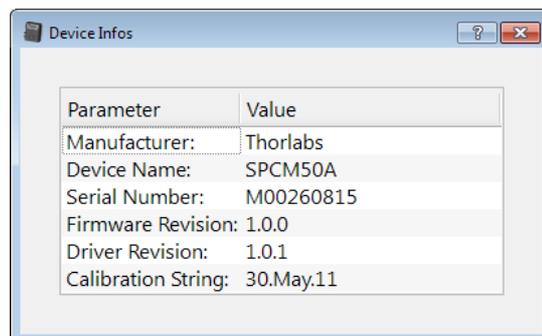
Operating Mode: Free Running Timed Counter  
 Bin Length [ms]: 0.019  
 Time between Bins [ms]: 0.001  
 Pulse Blind Time [ns]: 0  
 Trigger Edge: non-applicable  
 Array Measurement: Yes  
 Array Measurement Continuously: No  
 Bins per Array: 5  
 Active APD Gating: No  
 Fan Off: No

Loading data imports measurement results together with the settings, at which the measurement was carried out. Import settings loads only settings with no measurement data.

### 3.4.2 Menu "Device"

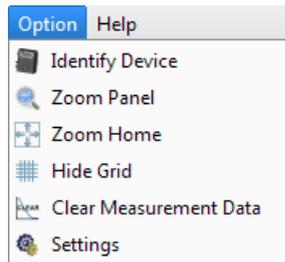


Here, an SPCM can be connected/disconnected. The topic Device Information shows information on the connected hardware:



The "Prepare Firmware Update" topic is explained in the section [Firmware Update](#) <sup>42</sup>.

### 3.4.3 Menu "Option"



This menu offers several optional control functions.

**Identify Device** - identifies the connected SPCM: In the [status bar](#)<sup>19</sup>, the device name and its serial number starts to blink, as well as the LED on the SPCM in connect, for 2 seconds.

#### Note

During a measurement, the green status LED is switched off in order to avoid stray light.

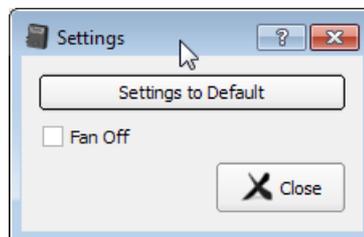
**Zoom Panel** opens a dialog for switching between auto and manual scaling of X (bin number) and Y (counts per bin) axes in both [Graph and Bar](#)<sup>18</sup> display.

**Zoom Home** returns the Graph and Bar displays to default size (showing all measurements).

**Hide Grid** toggles between hidden and shown grid in Graph and Bar displays.

**Clear Measurement Data** empties all display tabs. This might be useful to speed-up the start of a new measurement.

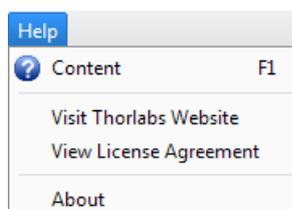
**Settings** brings up a dialog to switch off the fan of the SPCM and to return the GUI setting to default settings.



#### Note

Default settings of SPCM GUI are described in section [Graphic User Interface](#)<sup>13</sup>.

### 3.4.4 Menu "Help"



**Content** opens the online help.

**About** retrieves the current software version.

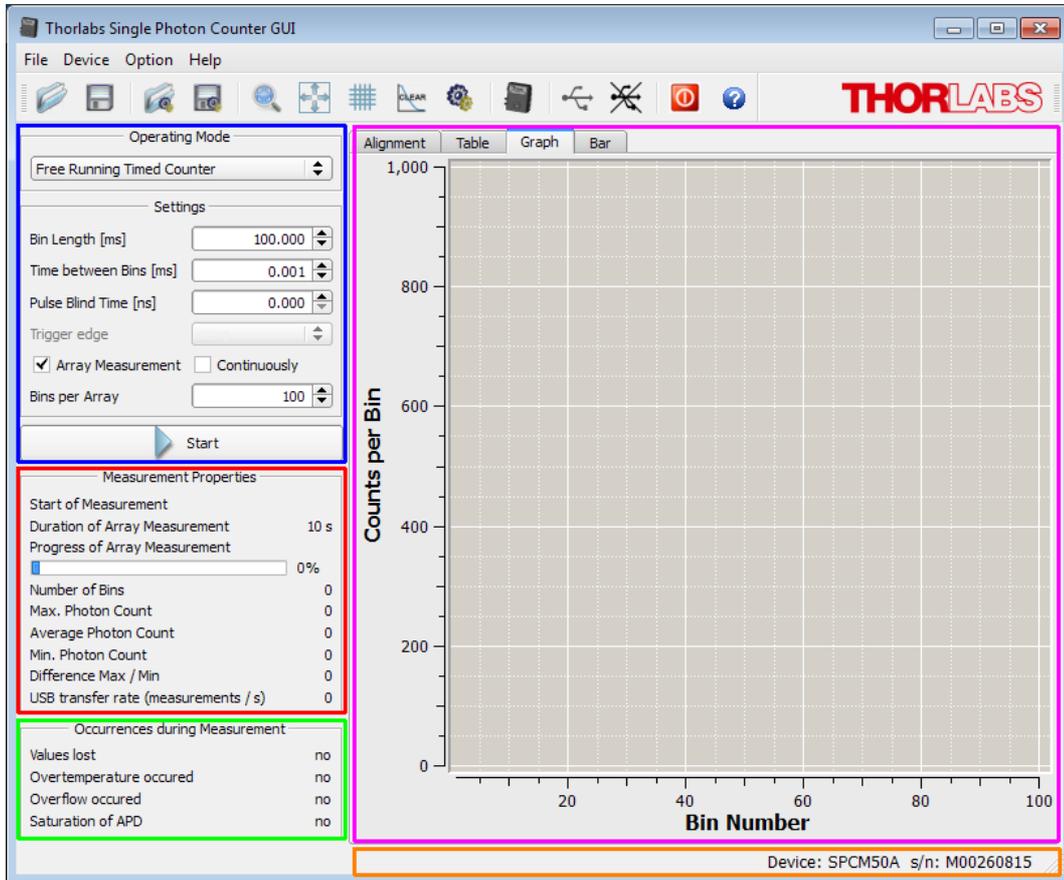
### 3.4.5 Menu Icons



-  Load Measurement Data from file
-  Save Measurement Data to file
-  Import Measurement Settings from file
-  Export Measurement Settings to file
-  Opens dialog "Zoom Panel"
-  Zoom Home
-  Toggle "hide / show grid"
-  Clear Measurement data in all tabs
-  Opens "Settings" dialog
-  Identifies connected SPCM (blinking status LED)
-  Connect Device
-  Disconnect Device
-  Exit GUI
-  Help environment

### 3.4.6 Functional Area

The GUI consists of five functional areas. When moving the mouse pointer over the GUI, appropriate tool tips appear.



- **Controls:** The desired operating mode can be selected and additional parameters, depending on the chosen operating mode, can be set. For a detailed description, please see section "Operating Modes"
- **Measurement Properties and Results:** Beside the measurement status (start time; for array measurement - duration and progress), statistics of counted photons is displayed (number of bins, max. and min. photon count per bin, average photon count and the span between the minimum and maximum count).

#### Note

The minimum photon count serves also as an indicator for counter errors:

- values  $\geq 0$  are true, valid count results
- value = -1: During measurement, a counter overflow occurred (more than 2,147,483,647 photons counted)
- value = -2: During measurement, a bin was missed and could not be transferred to the GUI
- value = -3: Read error during loading data from a file

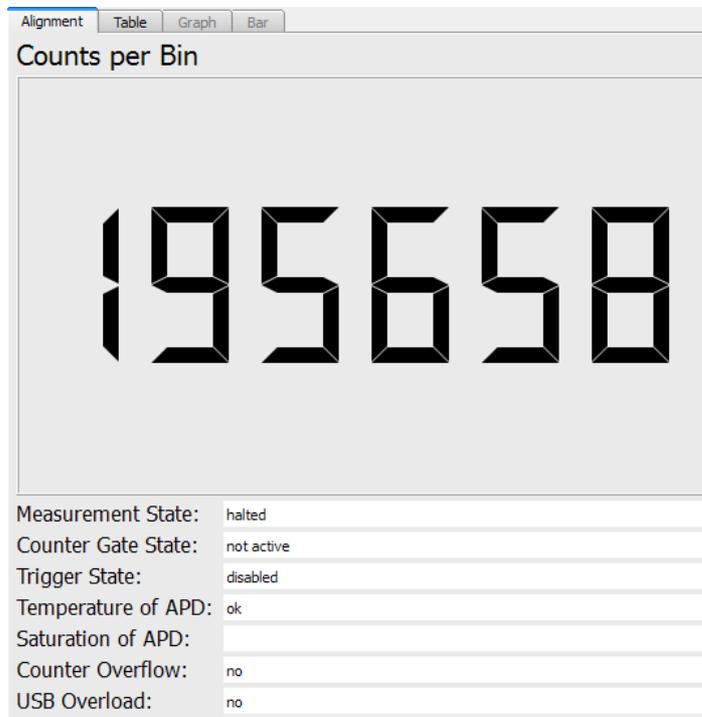
Finally, the current USB transfer rate is displayed.

- **Occurred errors during recent measurement:** Displays the history of occurred during measurement error, which may lead to incorrect photon count. In contrast to the display of

the actual SPCM status in the status bar, in this child window single error events are recorded until a new measurement is started.

- **Status bar** displays the measurement and connect status.
- **Graphical and auxiliary displays** are arranged in 4 tabs

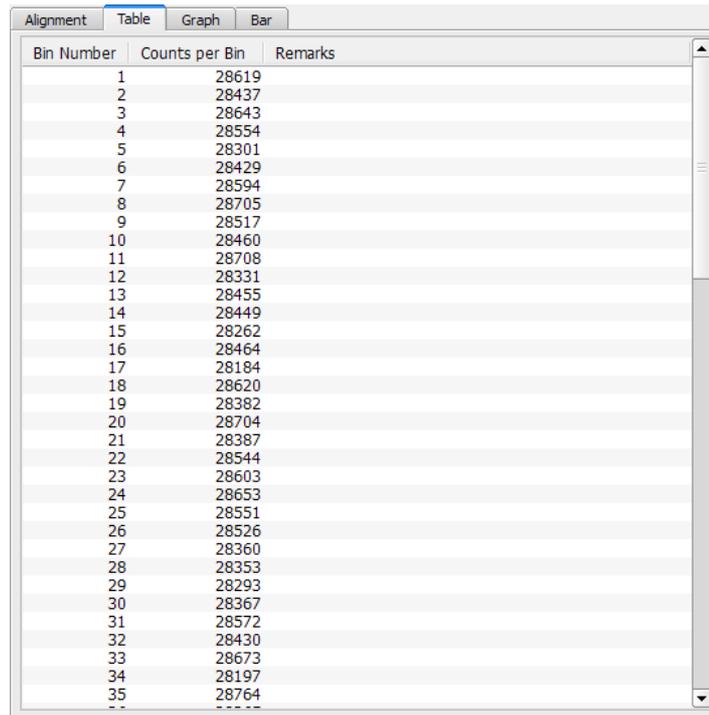
### 3.4.6.1 Alignment Display



This display is useful to adjust the optical setup. Beside the actual photon count it brings up important information on the current measurement and device status.

Measurement State	halted / running. Controlled by Start / Stop button
Counter Gate State	active (=counting) / not active
Trigger State	disabled (Manual and Free Running Timed Counter modes) enabled (all triggered modes)
Temperature of APD	"over temperature": temperature exceeds set point for > 0.5 K (see <a href="#">Technical Data</a> <sup>51</sup> )
Saturation of APD	(see <a href="#">Definitions</a> <sup>49</sup> )
Counter overflow	"overflow" indicates that more than $2^{31}-1 = 2,147,483,647$ photons were counted
USB Overload	"overload" indicates that measurement speed exceeds the USB transfer rate.

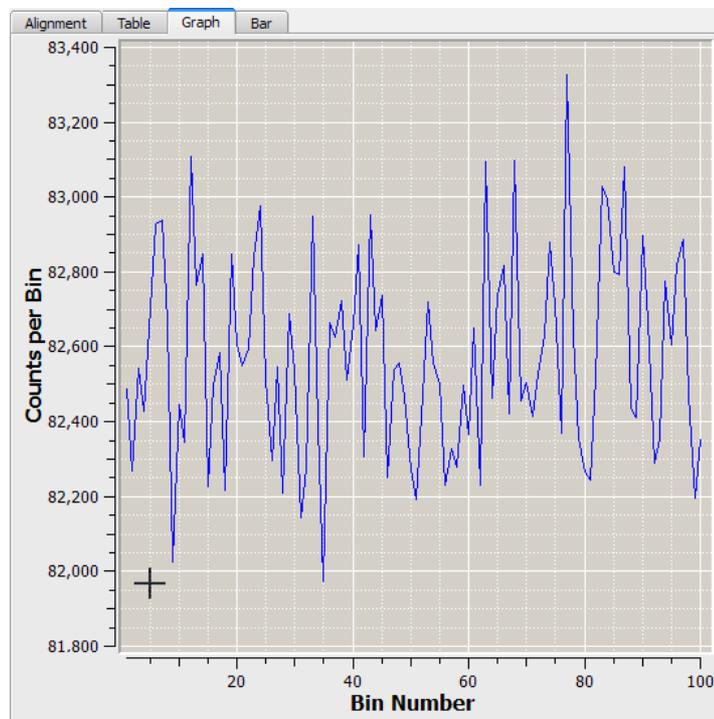
### 3.4.6.2 Table Display



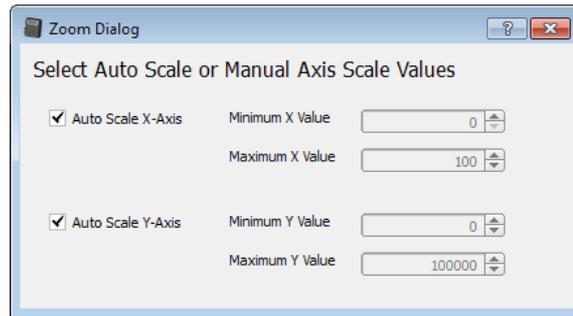
Bin Number	Counts per Bin	Remarks
1	28619	
2	28437	
3	28643	
4	28554	
5	28301	
6	28429	
7	28594	
8	28705	
9	28517	
10	28460	
11	28708	
12	28331	
13	28455	
14	28449	
15	28262	
16	28464	
17	28184	
18	28620	
19	28382	
20	28704	
21	28387	
22	28544	
23	28603	
24	28653	
25	28551	
26	28526	
27	28360	
28	28353	
29	28293	
30	28367	
31	28572	
32	28430	
33	28673	
34	28197	
35	28764	

The first two columns state bin number and the appropriate photon count. In column remarks are stated deviations from normal operation for the actual bin count (e.g., saturation level or over temperature).

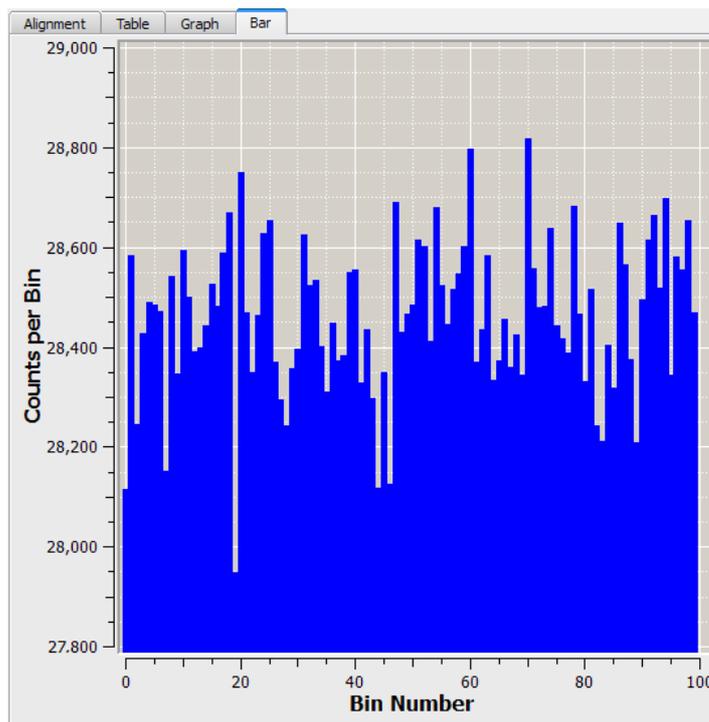
### 3.4.6.3 Graph Display



In this tab, the recent photon counts are displayed graphically. Areas of interest can be zoomed, using the cursor by click and drag to the desired region. Alternatively, the zoom area can be selected numerically from the Zoom Dialog (click to the  icon):



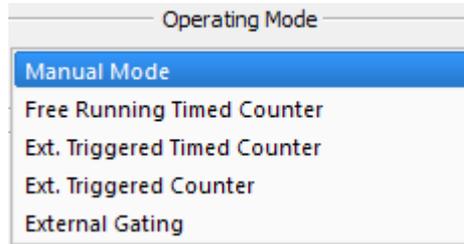
### 3.4.6.4 Bar Display



This display is similar to the [Graph display](#)<sup>20</sup>, with the difference that each bin is displayed as a bar.

## 3.5 Operating Modes

The SPCM software offers five operating modes to be selected from a drop-down list:

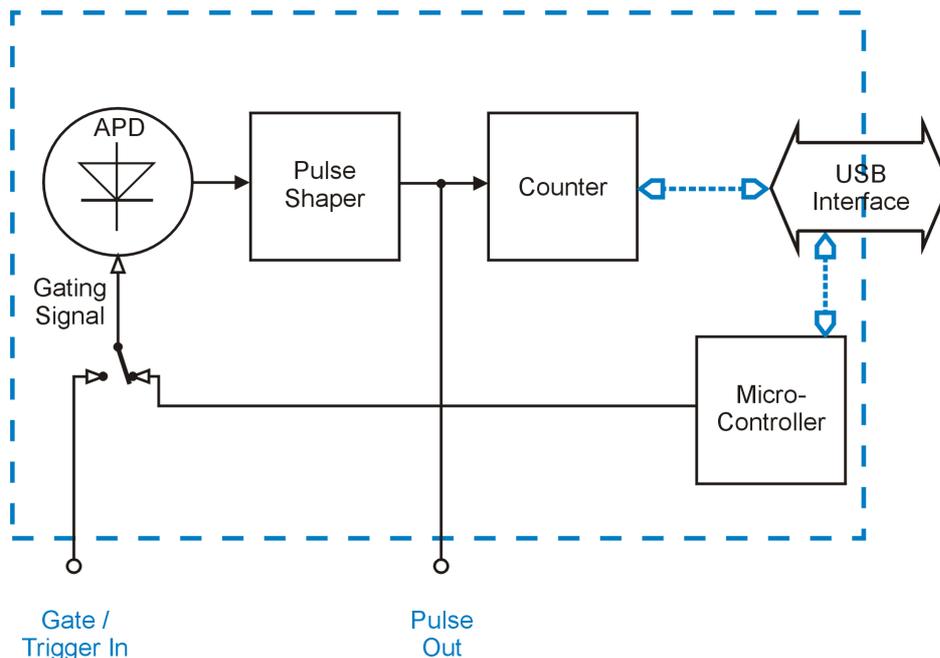


In the next chapters, these operating modes are explained in detail.

### Note

The SPCMxxA comes with factory default setting to [External Gating Mode](#)<sup>[29]</sup>. In this mode, the SPCM can be operated without PC control by applying external trigger pulses and observing the pulses generated by incident photons with an external device (scope, counter etc.)

### 3.5.1 Manual Mode



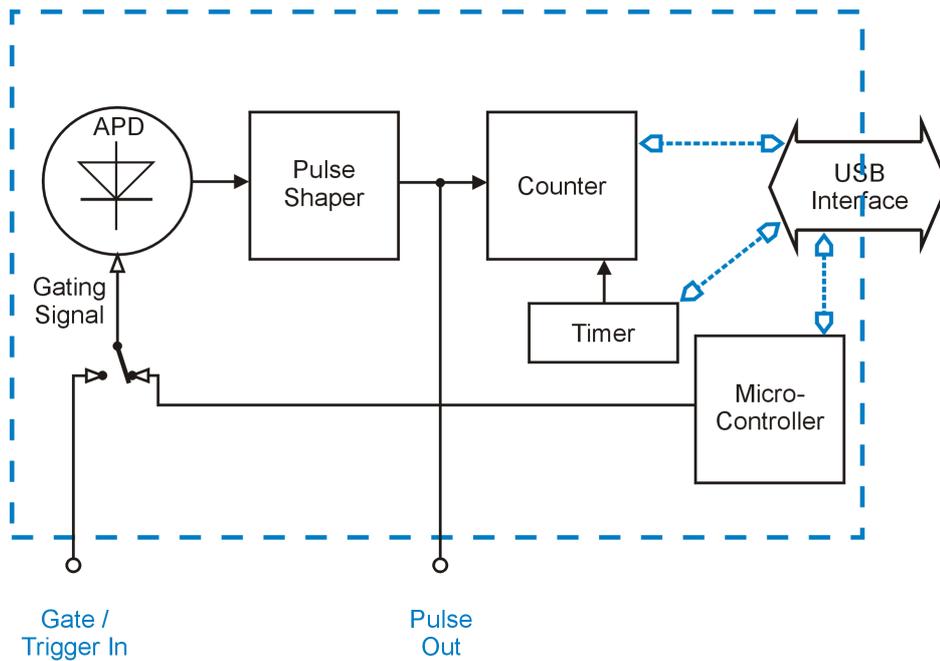
Functional Block Diagram - Manual Mode

In Manual Mode, APD is internally biased beyond breakdown voltage. The counter is started and stopped manually via the appropriate button in the software, at each "start" command the counter is reset. No settings except **Pulse Blind Time** can be made. The count result is updated 10 times per second and displayed numerically ([Alignment](#)<sup>[19]</sup> display) and graphically (tabs [Graph](#)<sup>[20]</sup> and [Bar](#)<sup>[21]</sup>).

"Pulse Out" delivers a continuous pulse stream according to the incident photons, independent of the counter state.

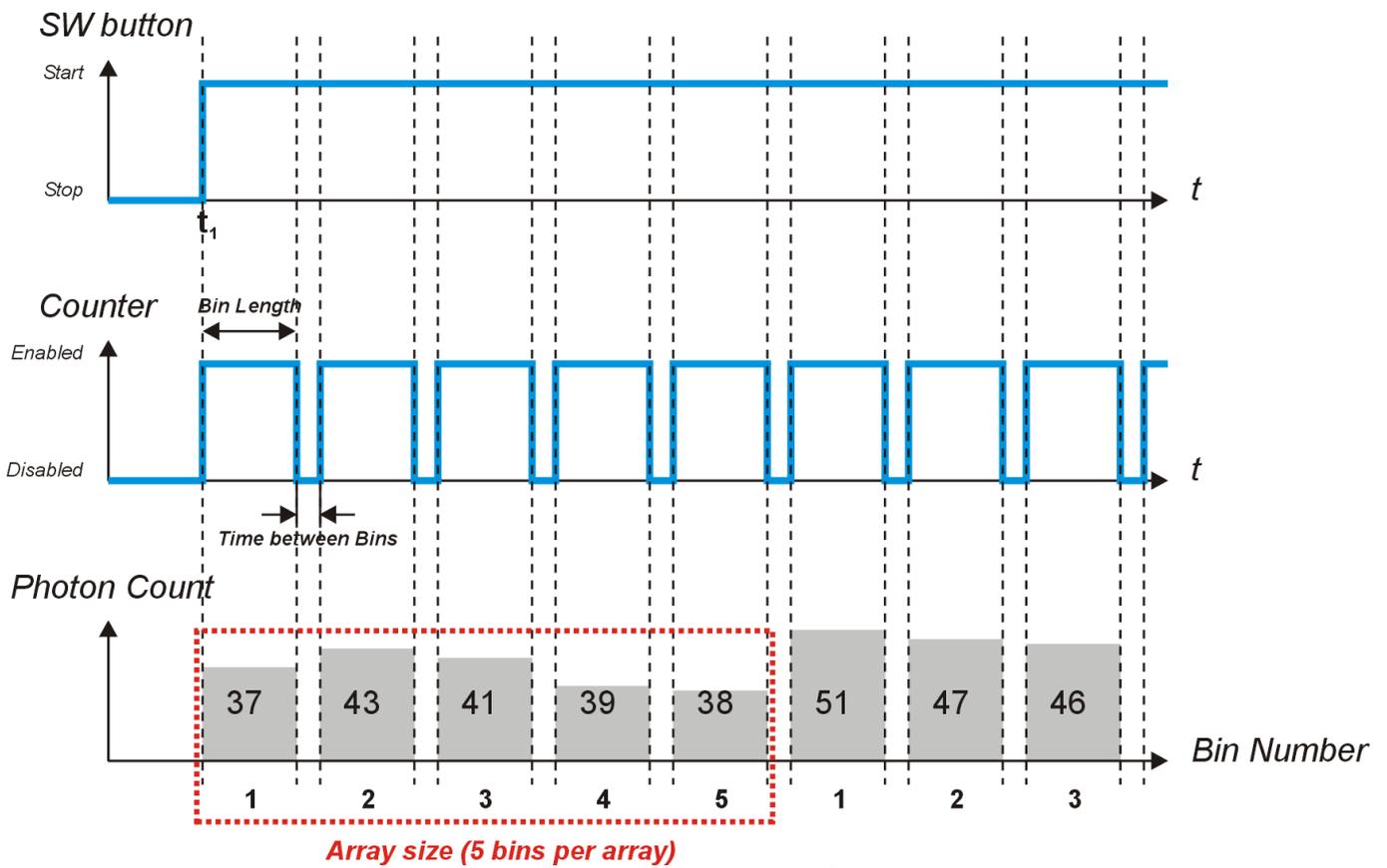
This mode is efficient for testing and alignment of the optical setup in order to optimize the photon collecting process.

### 3.5.2 Free Running Timed Counter



In this operating mode, the APD is biased beyond breakdown voltage at any time. The counter is started / stopped by the internal timer. The timer is programmed via software, this way defining the **bin length** and the waiting **time between bins**. After pushing the Start button, the timer begins to control the counter and incident photons are counted into bins until the Stop button is pressed. The results are displayed graphically and numerically, see [Graphic User Interface](#)<sup>[13]</sup>.

The Array Mode allows high measurement speed by limiting the number of bins; after completing the count is stopped (**Single Array**) or restarted (**Continuously**) by the GUI. The max. array size depends on the measurement speed, see section [Definitions](#)<sup>[48]</sup>. The time diagram below illustrates the free running timed counter mode for a repeated array count of 5 bins each:

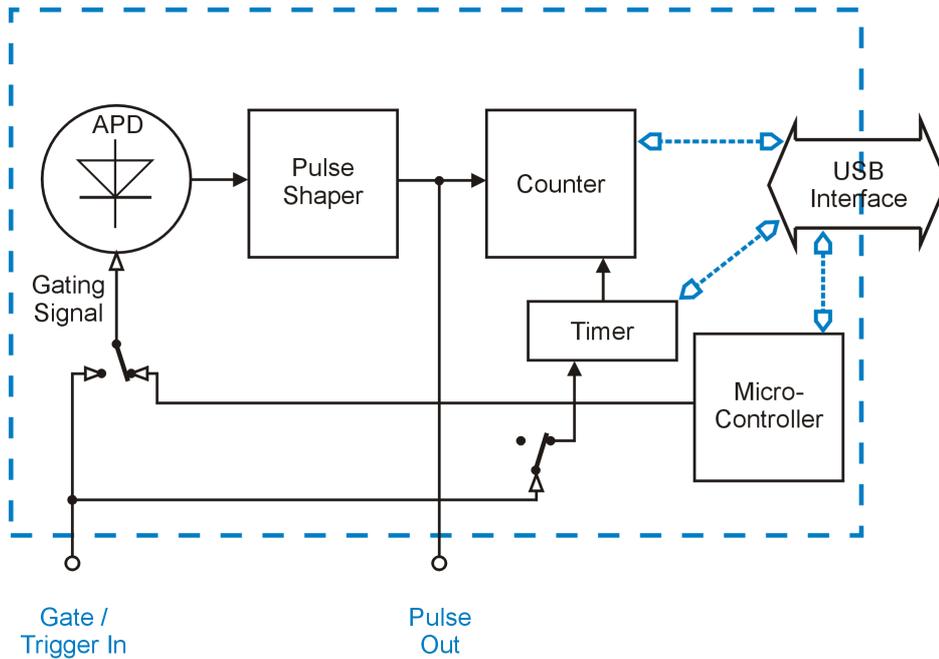


Time Diagram Free Running Timed Counter

At the moment  $t_1$  the Start button is pressed. The timer starts the counter, and during the programmed **bin length**, 37 photons are counted, then the timer stops the counter and the photon count is displayed. After the programmed time between bins, the counter is reset and restarted. The bin #2 contains 43 photons. During the array count, the results and the progress of the array measurement are being displayed.

After finishing the array of 5 bins, the display is reset, and the array counting cycle restarts. The Stop button terminates photon counting.

### 3.5.3 Externally Triggered Timed Counter



This operating mode is similar to the [Free Running Timed Counter](#)<sup>[23]</sup> mode, with the difference that the timer is started by an external trigger signal. The sensitive **trigger edge** (rising or falling) can be selected.

The APD is biased beyond breakdown voltage at any time. The counter is started / stopped by the internal timer. The **bin length** is programmed via software. After pushing the Start button, the trigger is armed and waits for the first pulse slope. When the selected trigger edge is detected, the timer is started and photons are counted for a time, defined by the set **bin length**. After finishing the bin, the counter stops. With the next trigger slope, the count starts again. This continues until the Stop button is pressed. The results are displayed graphically and numerically, see [Graphic User Interface](#)<sup>[13]</sup>.

After starting the measurement (Start button), the Alignment display shows the Trigger State "enabled". As soon as trigger pulses are detected, the current status (armed / triggered) is being displayed in the status bar:

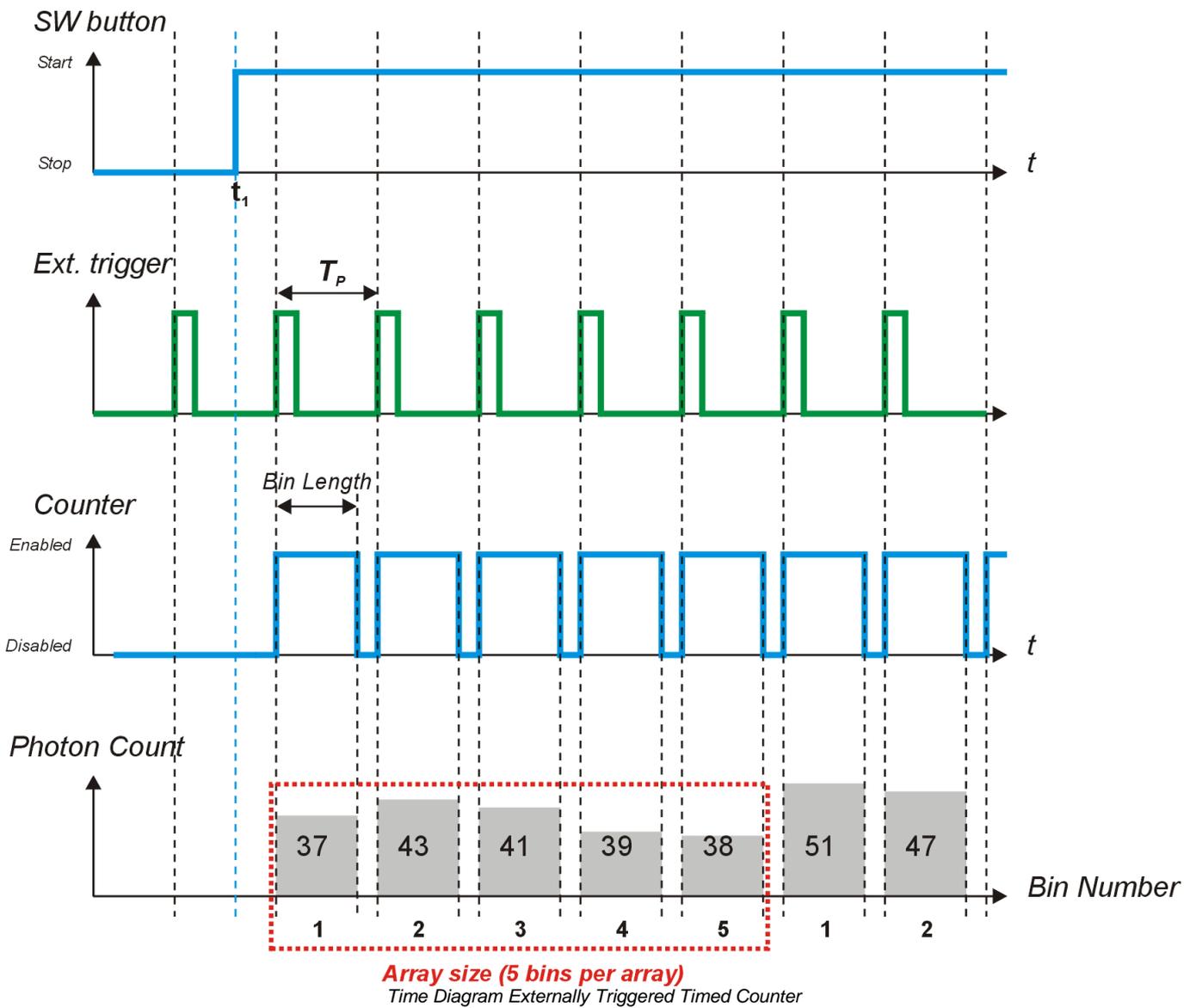
Trigger Armed: The SPCM waits for the next active trigger edge to start the timer.

Triggered: The timer is running. After the count is finished, the timer is ready for the next trigger pulse, so the status "Trigger armed" appears.

#### Note

If the trigger period (time between two subsequent trigger slopes  $T_p$ ) is less than **bin length**, or by other words, if the next trigger pulse arrives earlier than the bin count is finished, the trigger pulse will be ignored. The programmed bin length has the priority over the external trigger pulse.

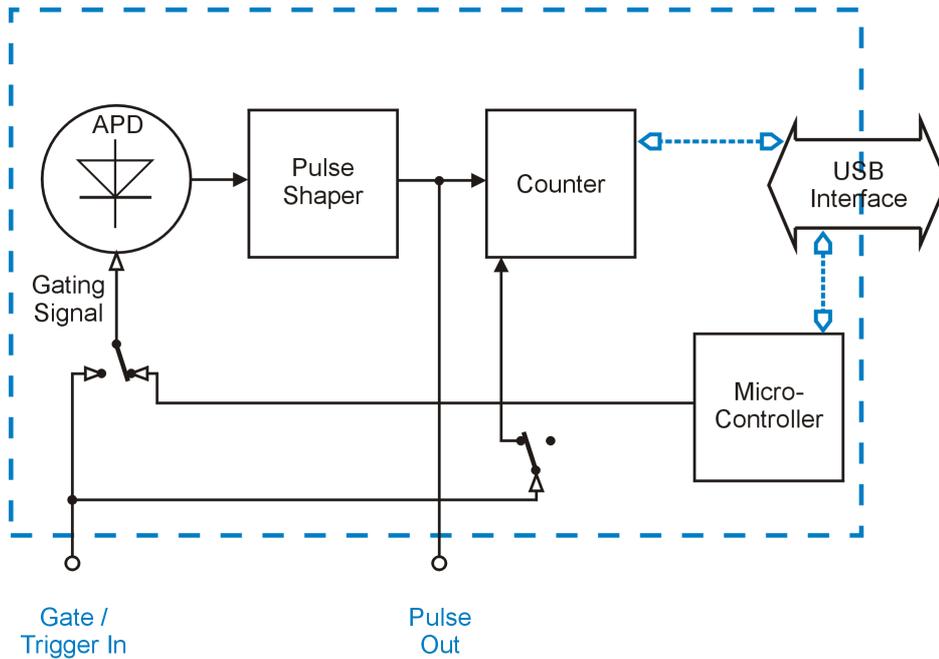
In externally triggered timed counter mode, an array measurement is possible as well. It allows high measurement speed by limiting the number of bins; after completing the count is stopped (**Single Array**) or restarted (**Continuously**) by the GUI. The max. array size depends on the measurement speed, see section [Definitions](#)<sup>[48]</sup>. The time diagram below illustrates the externally triggered timed counter mode for a repeated array count of 5 bins each:



At the moment  $t_1$  the Start button is pressed, the trigger is armed. With the detection of the first valid trigger signal, the timer starts the counter, and during the programmed **bin length**, 37 photons are counted. Then the timer stops the counter, the photon count is displayed and the timer waits for the next trigger. The bin #2 contains 43 photons. During the array count, the results and the progress of the array measurement are being displayed.

After finishing the array of 5 bins, the display is reset, and the array counting cycle restarts. The Stop button terminates photon counting.

### 3.5.4 Externally Triggered Counter

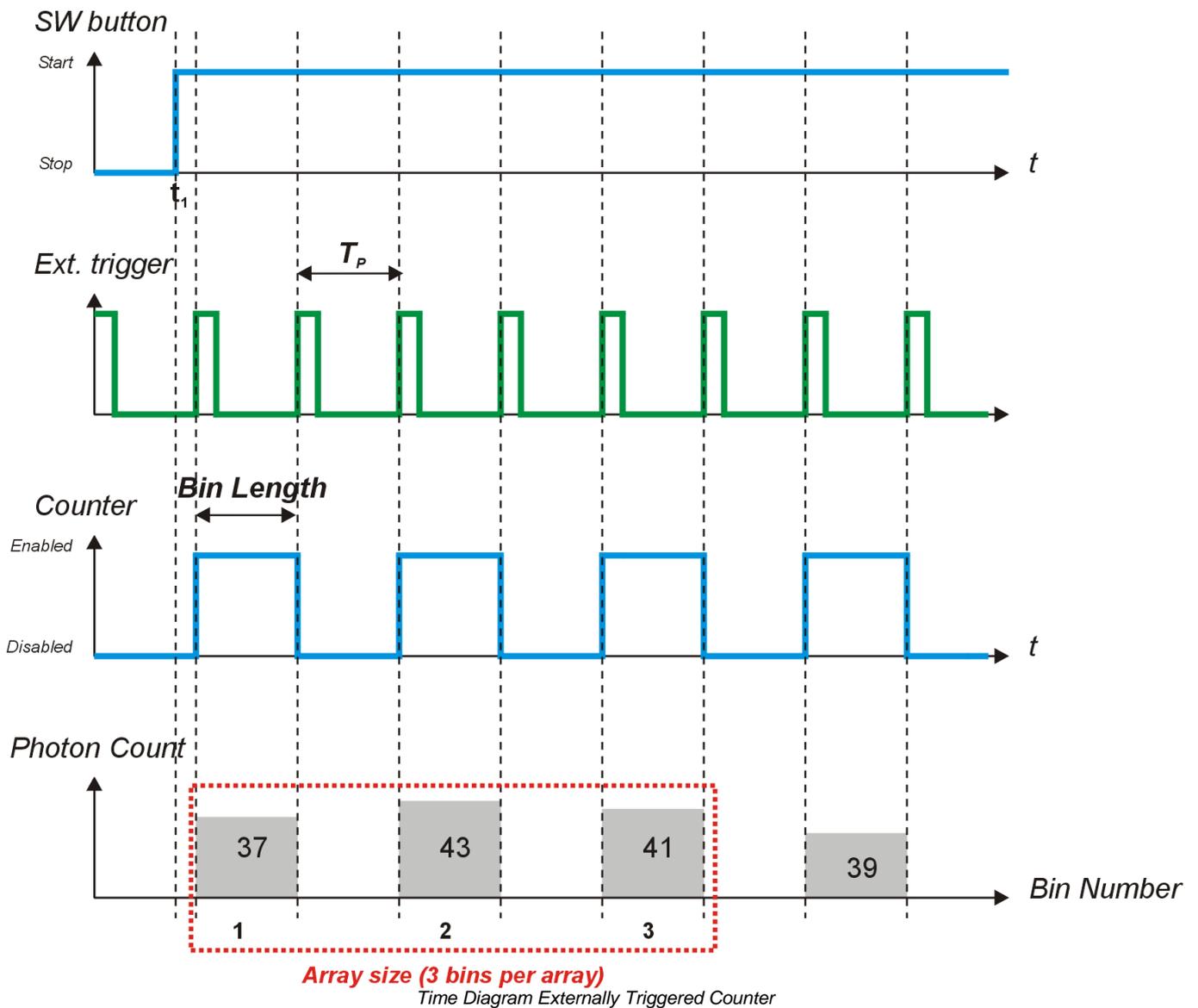


In this mode, the counter is not timed, but controlled (started and stopped) only by an external trigger signal. The sensitive **trigger edge** (rising or falling) can be selected.

The APD is biased beyond breakdown voltage at any time. After pushing the Start button, the trigger is armed and waits for the first pulse slope. When the selected trigger edge is detected, the counter starts photon count until the next trigger pulse arrives. As for this reason, the trigger period  $T_p$  defines the **bin length** as well as the time between subsequent bins. This counting process continues until the Stop button is pressed. The results are displayed graphically and numerically, see [Graphic User Interface](#)<sup>13</sup>.

After starting the measurement (Start button), the Alignment display shows the Trigger State "enabled" and in the status bar appears "Trigger armed".

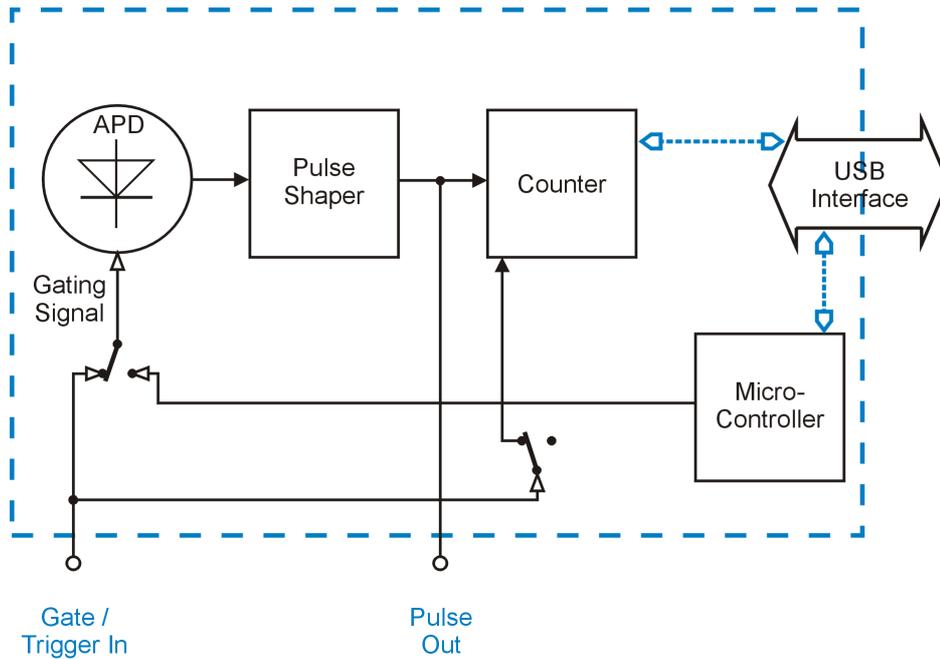
In externally triggered timed counter mode, an array measurement is possible as well. It allows high measurement speed by limiting the number of bins; after completing the count is stopped (**Single Array**) or restarted (**Continuously**) by the GUI. The max. array size depends on the measurement speed, see section [Definitions](#)<sup>48</sup>. The time diagram below illustrates the externally triggered timed counter mode for a repeated array count of 3 bins each:



At the moment  $t_1$  the Start button is pressed, the trigger is armed. With the detection of the first valid trigger signal, the photon count starts. The next trigger pulse terminates the current bin count, 37 photons are counted, the photon count is displayed and the counter waits for the next trigger. The bin #2 contains 43 photons. During the array count, the results and the progress of the array measurement are being displayed.

After finishing the array of 3 bins, the display is reset, and the array counting cycle restarts. The Stop button terminates photon counting.

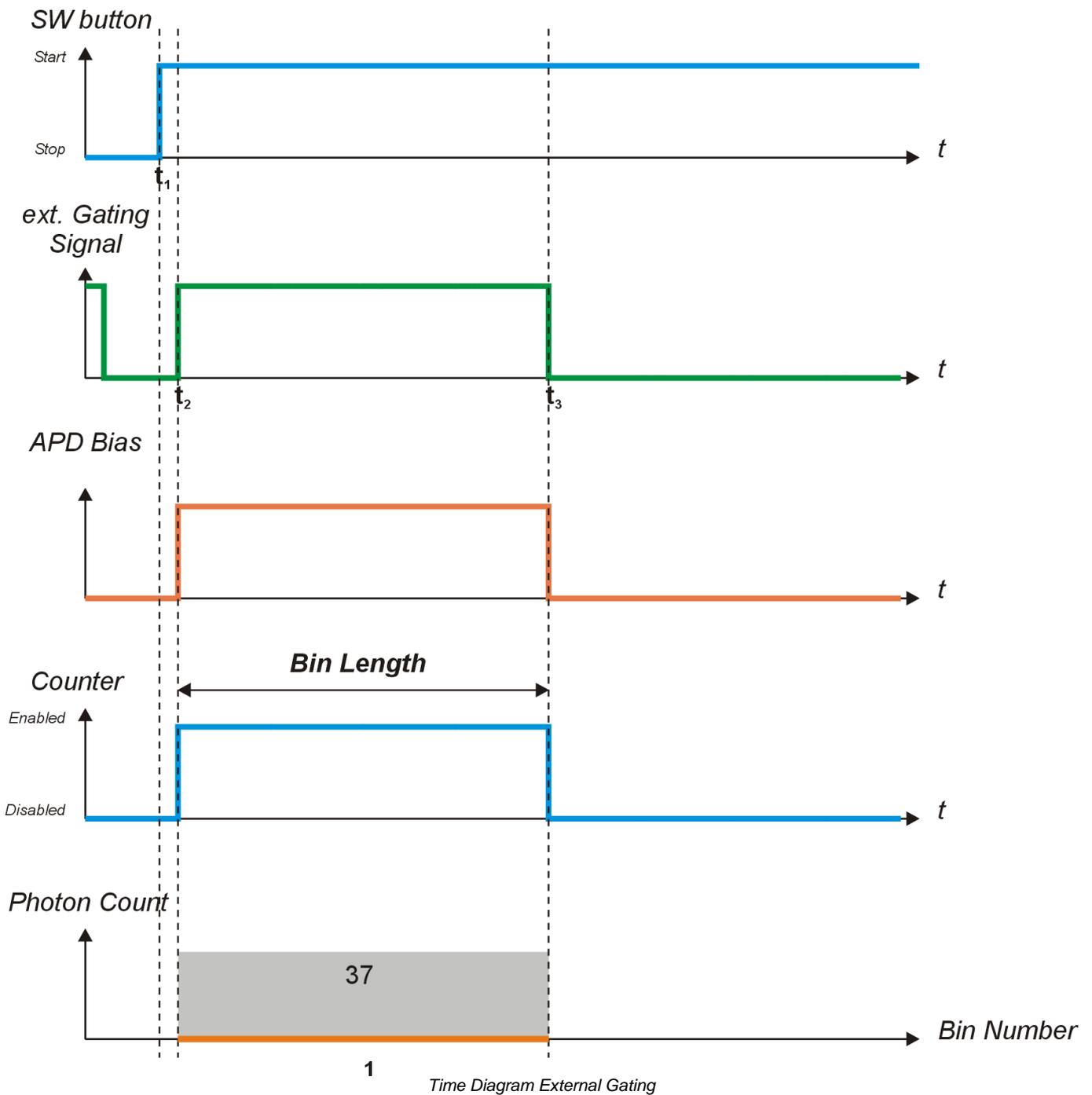
### 3.5.5 External Gating



The External Gating is similar to Externally Triggered Counter mode. The significant difference is that the APD is not always biased beyond breakdown voltage, but the APD bias is controlled by an external gating signal. The advantage of this active gating is in a lower probability to miss a photon: In previously described modes, the APD is always biased beyond breakdown voltage. That means, it reacts to incident photons at any time. This reaction includes also the activity of the quenching circuit; during the quenching time (35 - 45ns) the APD is "blind" for incident photons. When the APD is gated actively, it is armed with the arrival of the gating signal so that every first incoming photon can be counted.

In External Gating mode, the counter is not triggered on a selectable edge, but enabled as long as a gating signal is present. The gating signal must be TTL level compatible, HI = active. As this signal is not a trigger signal, in Alignment display the Trigger State will show up as disabled.

In External Gating mode, an **Array** measurement is possible as well. It allows high measurement speed by limiting the number of bins; after completing the count is stopped (**Single Array**) or restarted (**Continuously**) by the GUI. The max. array size depends on the measurement speed, see section [Definitions](#)<sup>48</sup>. The time diagram below illustrates the external gating mode:



At the moment  $t_1$  the Start button is pressed, the external Gating Signal detection circuit is armed. As soon as the **Gate In** input turns to HI level ( $t_2$ ), the APD is gated and the photon count starts. This count continues until the external gating signal disappears ( $t_3$ ) - in this moment, the counter stops and the APD gating is switched off. During an array count, the results and the progress of the array measurement are being displayed. The Stop button terminates photon counting.

## 4 SCPI Commands

Below is a list of implemented SCPI firmware commands. These commands can be sent using an Instrument Communicator via USB to the SCPMxxA. For further information about SCPI please see SCPI Standard available at [www.ivifoundation.org](http://www.ivifoundation.org).

### 1. Set Operating Mode

[SENS:][COUN:]GATE:MODE {0 | 1 | 2 | 3 | 4 | 5}

with value = 0...5

- 0 - idle
- 1 - manual mode (by command from start to stop)
- 2 - free running timed counter
- 3 - externally triggered timed counter
- 4 - externally triggered counter
- 5 - external gating

### 2. Get Operating Mode

[SENS:][COUN:]GATE:MODE?

Returns the actual operating mode (0 ... 5)

- 0 - idle
- 1 - manual mode (by command from start to stop)
- 2 - free running timed counter
- 3 - externally triggered timed counter
- 4 - externally triggered counter
- 5 - external gating

### 3. Set Gating Mode

[SENS:][COUN:]APD:GATE {OFF | 0 | ON | 1}

with values =      OFF | 0 - counter gating only (APD always active)  
                       ON | 1 - active APD and counter gating

Remark: In active APD gating mode, the APD is gated internally by the micro controller in the moment, when the counter is started. This mode is not accessible via the GUI. See also [External Gating Mode](#)<sup>29)</sup> section.

### 4. Get Gating Mode

[SENS:][COUN:]APD:GATE?

Returns the actual gating mode

- 0 - counter gating only (APD always active)
- 1 - active APD and counter gating

Remark: In active APD gating mode, the APD is gated internally by the micro controller in the moment, when the counter is started. This mode is not accessible via the GUI. See also [External Gating Mode](#) <sup>29</sup> section.

### 5. Set Timer Gate Length

[SENS:][COUN:]GATE:APERture <value>

Sets the bin length

with value = 0.000001 - 2147,483647 s

resolution = 0.000001 s

### 6. Get Timer Gate Length

[SENS:][COUN:]GATE:APERture?

Returns actual timer value (bin length)

value = 0.000001 - 2147,483647 s,

resolution = 0.000001 s

### 7. Set Pause

Sets the time between bins in free running timed counter mode

[SENS:][COUN:]GATE:DELay <value>

with values = 0.000001 - 2147,483647 s

resolution = 0.000001 s

### 8. Get Pause

Returns the time between bins in free running timed counter mode

[SENS:][COUN:]GATE:DELay?

with values = 0.000001 - 2147,483647 s

resolution = 0.000001 s

### 9. Set Trigger Edge

Sets actual trigger edge

[SENS:][COUN:]GATE:EXTernal:SLOPe <value>

with values 0 - falling edge

1 - rising edge

### 10. Get Trigger Edge

Returns actual trigger edge

[SENS:][COUN:]GATE:EXTernal:SLOPe?

0 - falling edge

1 - rising edge

### 11. Set Array Length

Sets the number of bins per array

ARRay:NPOInts <value>

with values = 1 - (1000) 10000

Remark: For fast measurements with over 50000 values per second maximum array length is 1000.

### 12. Get Array Length

Returns actual array length (bins per array)

[SENS:][COUN:]ARRay:NPOInts?

1 - 10000

Remark: For fast measurements with over 50000 values per second maximum array length is 1000.

### 13. Set Array State

Sets the array measurement mode

[SENS:][COUN:]ARRay:STATe {OFF | 0 | ON | 1}

with values = OFF | 0 - continuous measurement mode (no array mode)

ON | 1 - array measurement mode

### 14. Get Array State

Returns the array measurement mode

[SENS:][COUN:]ARRay:STATe?

0 - continuous measurement mode (no array mode)

1 - array measurement mode

### 15. Get Counter Value

[SENS:][COUN:]DATA?

Returns 3 values:

1. Counter: - number of counted photons from 0 to 2147483647 (31 bit)  
- MSB contains overflow sign (resulting in 32 bit value)
2. State of the measurement system (16 bit)
3. Index of actual counter value (32 bit): 1 - N (0 - no counter value available)

Remark: In continuous mode there may be a gap between two sequenced index values - that means you lost one or more values because your PC is not fast enough to read out all measured values from the device -> use array mode if possible or a USB-Hub between device and PC may solve the problem, use a faster PC. - working with SPCM-GUI use Alignment-Panel instead of Bar-, Graph- and Table-Panel and/or make the panel as small as possible or shrink it to the task bar.

**State** is a 16 bit integer of actual states of measuring system with the following meanings for every bit:

Bit #	Description
0	measurement running (1) or not running (0)
1	counter gate active (1) or not active (0)
2	waiting for trigger (1) or not waiting for trigger (0)
3	counter overflow (1) or not (0)
4	overload of the measurement unit (1) or not (0) (more counter results produced than processible by micro controller, USB, and/or PC)
5	overtemperature of APD-Tec (1) or not (0)
6	APD-Saturation bit 0 *)
7	APD-Saturation bit 1 *)
8	n/a
9	n/a
10	counter overflow accumulated (1) or not (0)
11	overload of the measurement unit accumulated (1) or not (0) (more counter results produced than processible by micro controller, USB, and/or PC)
12	overtemperature of APD-TEC accumulated (1) or not (0)
13	APD-Saturation accumulated bit 0 *)
14	APD-Saturation accumulated bit 1 *)
15	n/a

\*) If both bits result in value 3, a saturation alert appears in the GUI

Note: Bits 10 to 14 represent accumulated results of events happened since start of the device or since last clear command (STATus:MEASurement:CLEAr) .

## 16. Start Measurement

Starts counting in user mode (1) and enables counting in all other modes (running)

[SENS:][COUN:]MEASure:START

## 17. Stop Measurement

Stops counting in user mode (1) and disables counting in all other modes (not running)

MEASure:STOP

**18. Get Measurement State**

STATus:MEASurement?

Returns a 16 bit integer of actual states of measuring system with the following meanings for every bit:

Bit #	Description
0	measurement running (1) or not running (0)
1	counter gate active (1) or not active (0)
2	waiting for trigger (1) or not waiting for trigger (0)
3	counter overflow (1) or not (0)
4	overload of the measurement unit (1) or not (0) (more counter results produced than processible by micro controller, USB, and/or PC)
5	overtemperature of APD-Tec (1) or not (0)
6	APD-Saturation bit 0 *)
7	APD-Saturation bit 1 *)
8	n/a
9	n/a
10	counter overflow accumulated (1) or not (0)
11	overload of the measurement unit accumulated (1) or not (0) (more counter results produced than processible by micro controller, USB, and/or PC)
12	overtemperature of APD-TEC accumulated (1) or not (0)
13	APD-Saturation accumulated bit 0 *)
14	APD-Saturation accumulated bit 1 *)
15	n/a

\*) If both bits result in value 3, a saturation alert appears in the GUI

Note: Bits 10 to 14 represent accumulated results of events happened since start of the device or since last clear command (STATus:MEASurement:CLEAr) .

**18. Clear Measurement State**

STATus:MEASurement:CLEAr

Clears the accumulated state bits.

**19. Set Fan State**

SYSTem:FAN[:STATe] {OFF | 0 | ON | 1}

with values      OFF | 0 - fan off  
                    ON | 1 - fan on

## 20. Get Fan State

SYSTem:FAN[:STATe]?

Returns actual fan state:

0 - fan off

1 - fan on

## 21. Set LED State

SYSTem:LED[:STATe] {OFF | 0 | ON | 1}

with values OFF | 0 - led off

ON | 1 - led on

Remark: LED is set on by default. Starting a measurement switches LED off (to avoid influence of the measurement) and stopping a measurement switches LED on.

## 22. Get LED State

SYSTem:LED[:STATe]?

Returns actual led state:

0 - led off

1 - led on

Remark: LED is set on by default. Starting a measurement switches LED off (to avoid influence of the measurement) and stopping a measurement switches LED on.

## 23. Set DFU State

A command to prepare device for firmware update

STATus:DFU <value>

with values 0 - DFU off

1 - DFU on

2 - DFU once (disappears after device power cycle)

**Remark:** Setting DFU state to 1 or 2 results in enumeration of the USB device - the connection will be lost. Do not power off the device until firmware update is complete. Use Thorlabs DFU Wizard downloadable from the Thorlabs website for updating the firmware of the SPCM.

**Hint:** Use "DFU once" for a normal firmware update to avoid that a second USB driver (for DFU) is needed to be installed if the Single Photon Counter is connected to another USB port. Especially moving the SPC to another PC may be problematic because the needed DFU driver may not exist on this PC (it comes with Thorlabs DFU Wizard).

**24. Get DFU State**

STATus:DFU?

Returns actual DFU state:

0 - DFU off

1 - DFU on

2 - DFU once (disappears after device power cycle)

Remark: DFU state must be 1 or 2 in order to enable the device to get a firmware update.

**25. Get Detector Saturation Voltage**

(APD saturation measurement)

[SENS:][COUN:]SATURation:VOLTage?

Returns actual saturation voltage: 0.0 - 3.3 [V]

## 5 Maintenance and Service

Protect the SPCMxxA from adverse weather conditions. The SPCMxxA is not water resistant.

### Attention

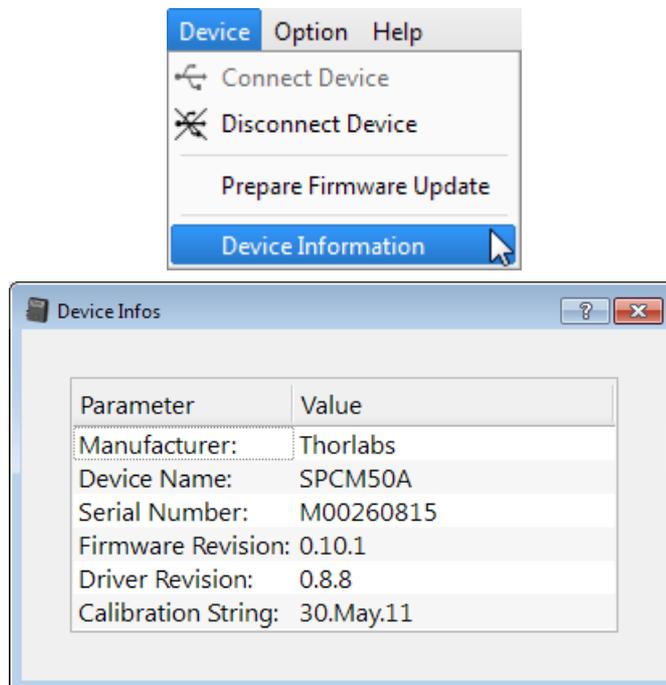
**To avoid damage to the instrument, do not expose it to spray, liquids or solvents!**

The unit does not need a regular maintenance by the user. It does not contain any modules and/or components that could be repaired by the user himself. If a malfunction occurs, please contact [Thorlabs](http://Thorlabs.com) <sup>57</sup> for return instructions.

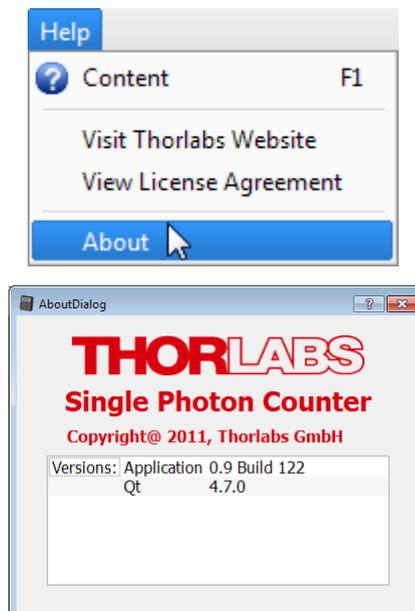
Do not remove covers!

### 5.1 Version Information

Information on the SPCMxxA hardware can be retrieved from the menu bar:



Information on the current software version can be found in Help menu:

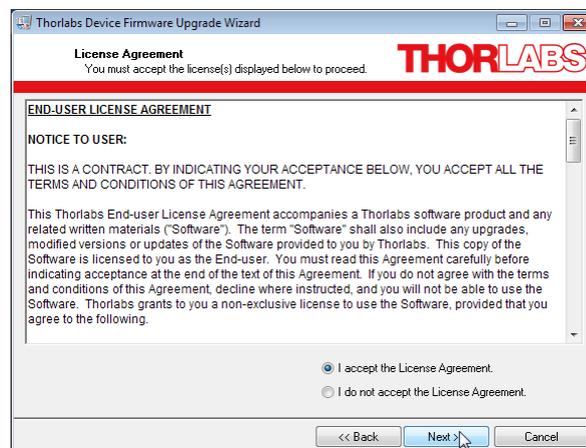


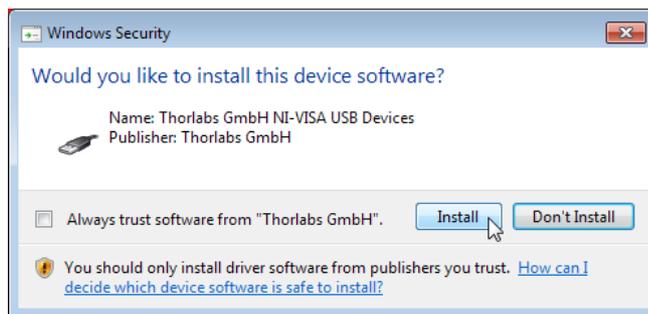
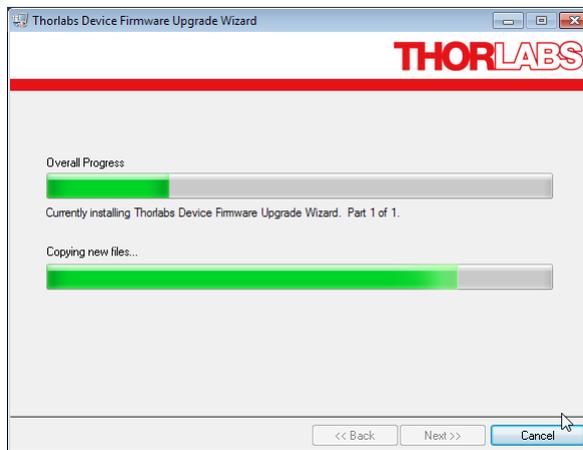
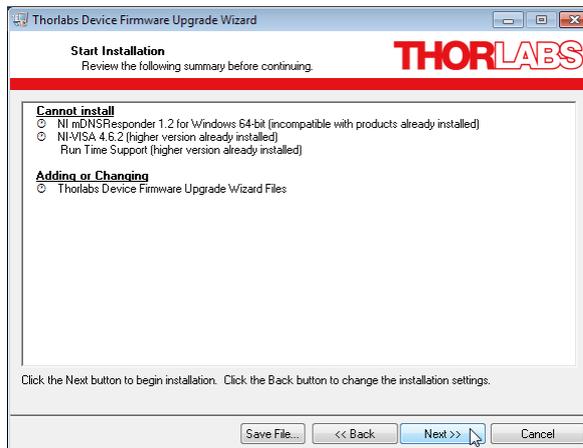
Please have this information ready when you are contacting [Thorlabs](http://Thorlabs.com) <sup>57</sup> for technical support.

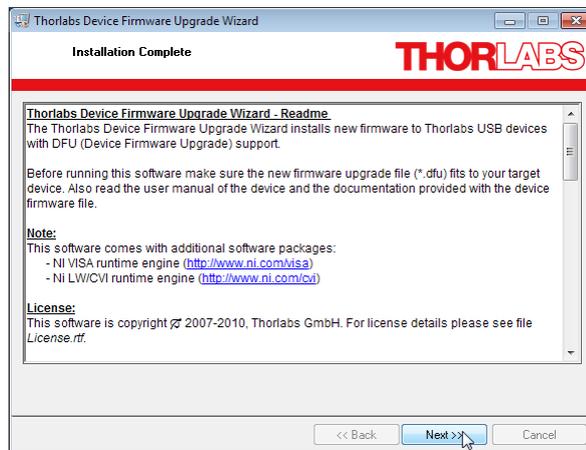
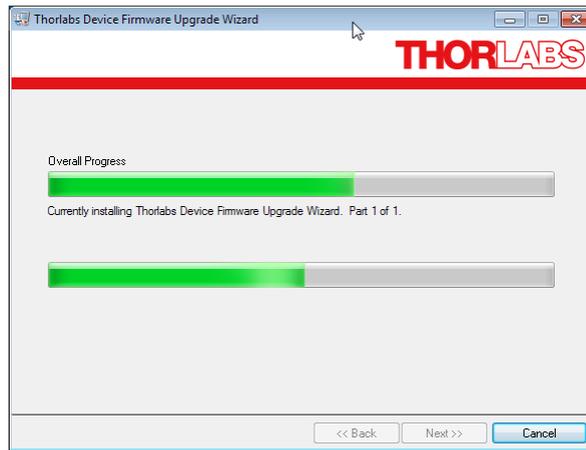
## 5.2 SPCM Firmware Update

### 5.2.1 Installing DFU Wizard

The DFU Firmware Upgrade Wizard is included in the software CD, shipped with the SPCMxxA. Insert the CD and choose from the start menu the topic "DFU Wizard". Then please follow the steps as shown in the screenshots hereinafter:







## 5.2.2 Firmware Update

Prior to proceed with the firmware update, an actual FW version must be downloaded from [www.thorlabs.com](http://www.thorlabs.com). Therefore, please open the SPCM product page and click to the tab "Software" in the main table. In the software tab, click on the link that will redirect you to our Product Software pages. On the SPCM software page you will find a tab "Firmware" - please open that tab. Save the zipped firmware file by right clicking to the link ("Save As..."). The default download folder (Windows7) is

C:\Users\[Current\_User]\Downloads

### Attention

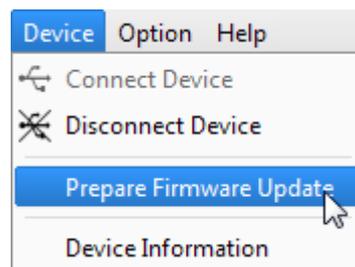
Make sure that only one DFU capable device is connected to your PC!

### Preparation of the SPCMxxA for firmware update

### Warning

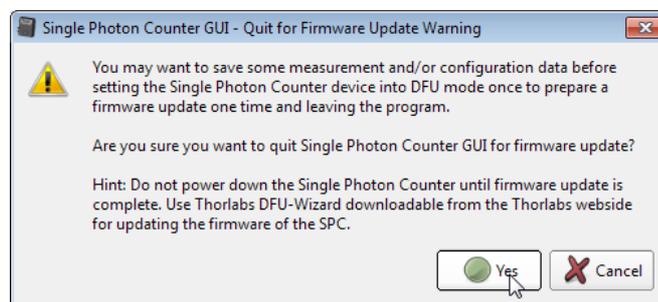
**During the following steps, do not manually disconnect or switch off the SPCMxxA or unplug it's power supply!** This may lead to data loss and/or inoperability of your SPCM!

In order to enable your SPCM to receive a FW update, it's instrument properties must be changed to DFU device. The GUI offers an appropriate command:

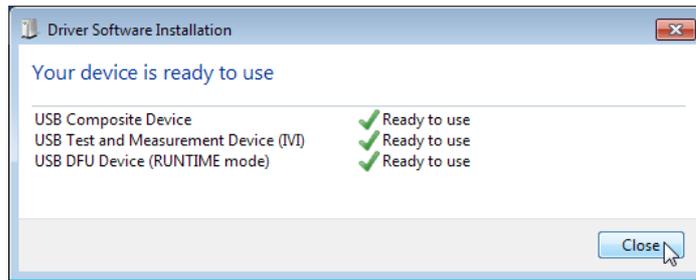


### Note

The GUI cannot communicate with a DFU device, as for this reason, after initializing your SPCM as a DFU device, the USB connection will be disconnected and the SPCM software terminated:



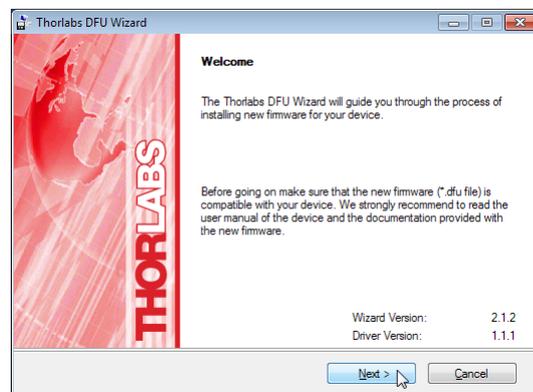
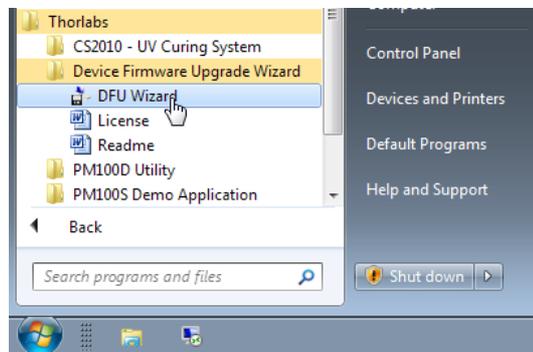
Confirm "Yes". The GUI closes. Now, the operating system recognizes a new USB device of DFU type and installs device drivers:



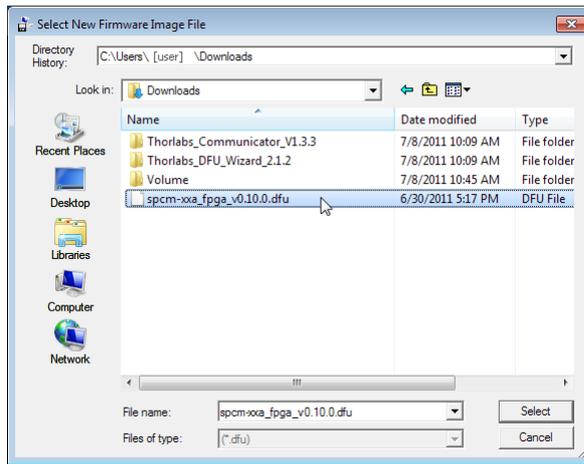
After the drivers have been installed successfully, above dialog appears - click "Close" to continue.

### Executing the firmware update

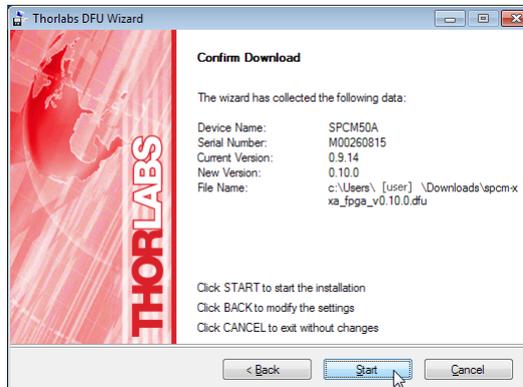
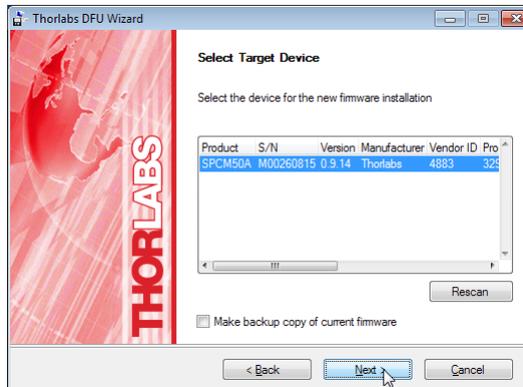
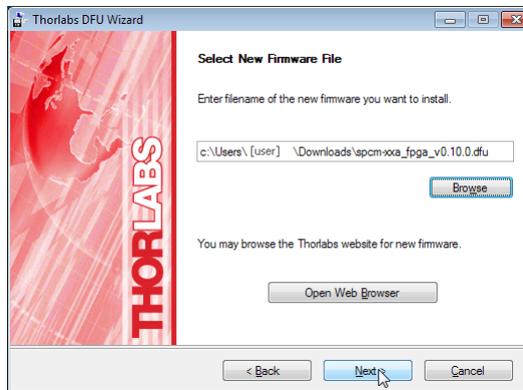
Start the FW update program from Windows-Button -> All Programs -> Thorlabs -> Device Firmware Upgrade Wizard:



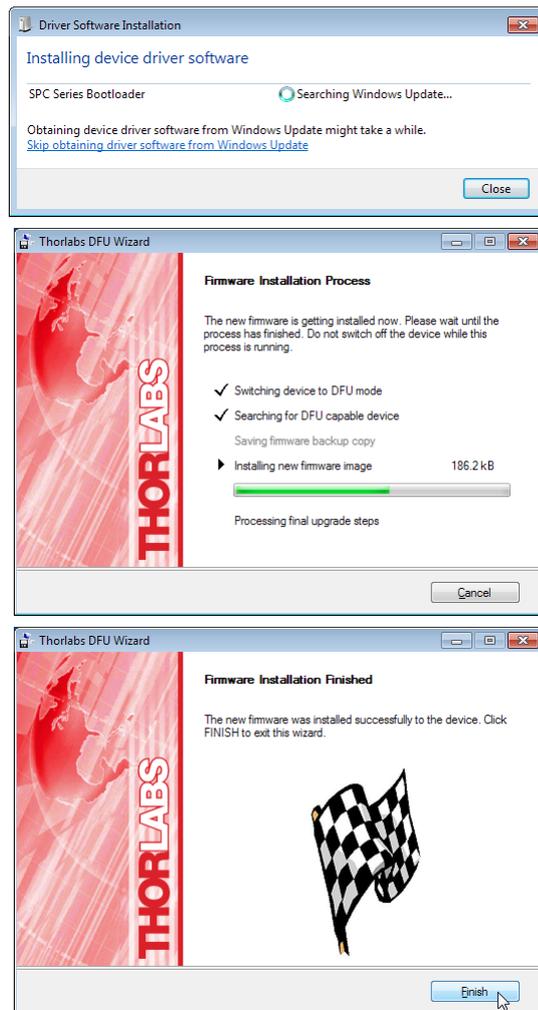
Click "Next" to continue. In the next dialog you will be prompted to choose the \*.dfu file. Click to "Browse" and select the downloaded file in C:\Users\[user\_name]\Downloads:



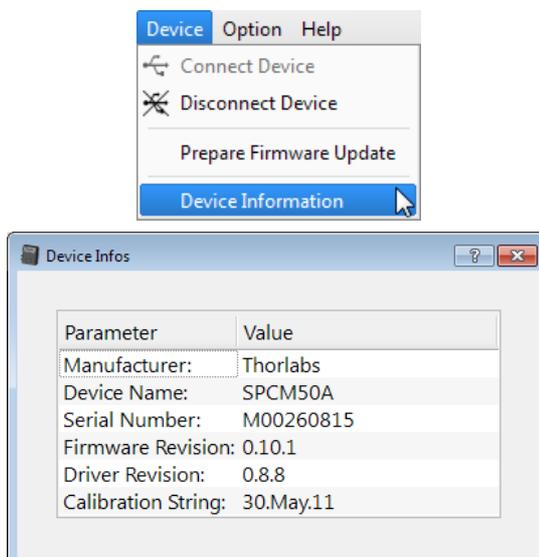
Click "Select" to continue. In the subsequent dialogs, click "Next":



Click "Start" to run the FW upgrade. The DFU Wizard installs the driver for SPCM bootloader; after finishing click "Close"



Click "Finish". The DFU Wizard closes, the SPCM is reset and the USB connection to the DFU device is terminated. The SPCMxxA resumes to appear as a Test and Measurement. Now, the SPCM GUI can be restarted. From the Device->Device Information menu the actual FW version can be retrieved:



## 5.3 Troubleshooting

### When attempting to connect an SPCMxxA, no device is found

Check if the SPCM is powered (power supply connected, SPCM switched on, green LED in on).

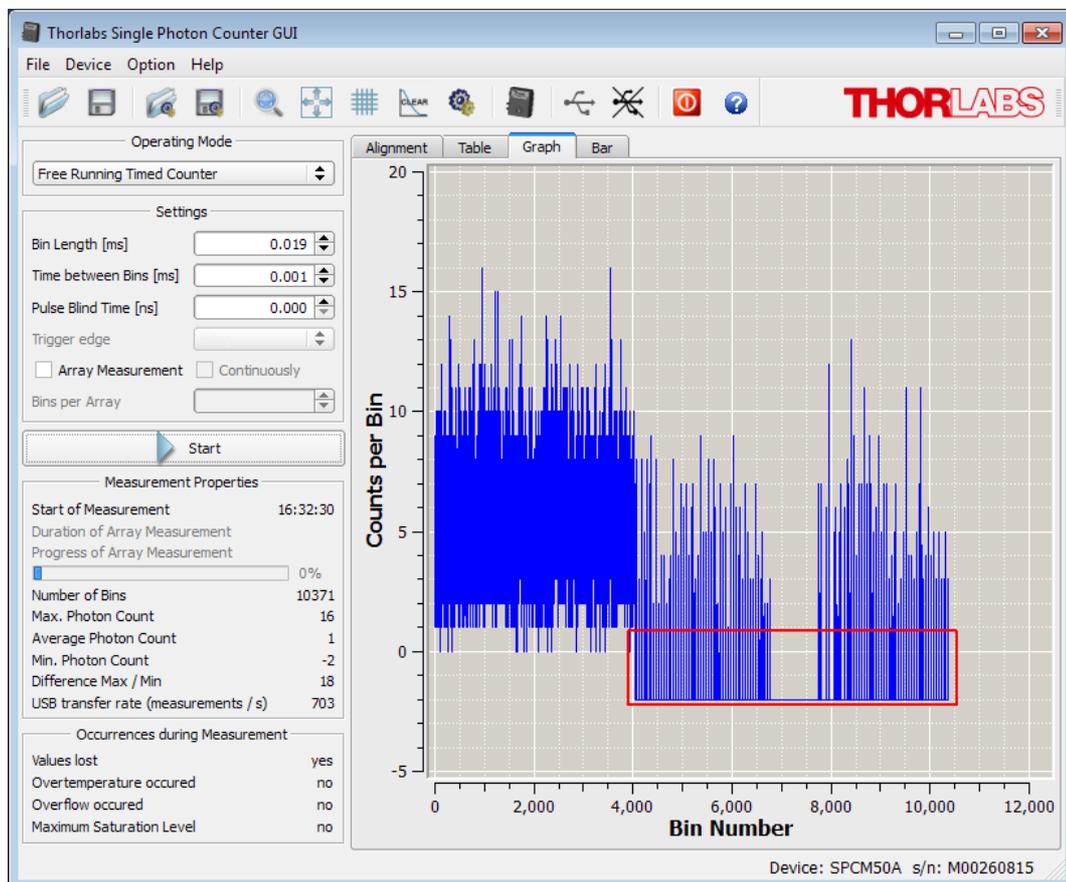
Check the USB connection.

Make sure, that after 1<sup>st</sup> connect of an SPCMxxA the operating system recognized the device, installed drivers and found the new device ready for operation.

Click in the [Device Dialog](#) to "Rescan".

### Minimum photon count is < 0

The minimum photon count serves as an error descriptor, see section "[Functional Area](#)". Particularly, this happens if using the free running timed counter mode - if the measurement speed is too high with regards to the USB data transfer rate, the SPCM internal buffer (max. 4000 bins) overflows and bin counts are lost. In the Graph display this appears as repeated "-2" counts (see red marked area):



### APD over temperature indicated

The temperature control circuit recognized that the actual temperature of the APD exceeded the set point for more than 0.5°C. Under normal operation conditions this should not happen, even after long term operation. However, increased beyond 28°C room temperature or incident to the SPCM thermal radiation can cause overtemperature alert.

Make sure the fan is switched on and operates (rotation and air stream)

Make sure the SPCM heat sink is not covered and that the fan's air stream is not blocked.

**During measurement, the software indicates lost USB connection**

Check if the SPCM is powered (power supply connected, SPCM switched on, green LED in on), check the USB connection.

Possibly, due to high data processing load, the SPCM micro controller was unable to process USB operation. Switch the SPCM off and on again, reconnect and lower the measurement speed. Array measurement (up to 1,000 bins per array) is safe under point of micro controller load.

**In Table display, during measurement only a fixed number of lines is displayed (e.g., 1 through 35)**

Use the scroll bar to scroll down in order to display further measurement data. The table is not automatically scrolling to avoid lowering of measurement speed.

**USB overload**

This error message appears particularly when short bin lengths and small intervals between bins are set.

Change to Array measurement.

Alternatively, extend time between bins (preferred) or bin length.

In case of a triggered mode, lower the trigger frequency (if External Gating mode. lower the gating pulse frequency).

Measurement speed also depends on the viewed panel and CPU load. The fastest panel is Alignment, followed by Table, Graph and Bar. The larger the total GUI size, the higher becomes CPU load.

In certain cases, the USB performance can be improved by connecting of a High Speed USB 2.0 hub between SPCMxxA and the control PC.

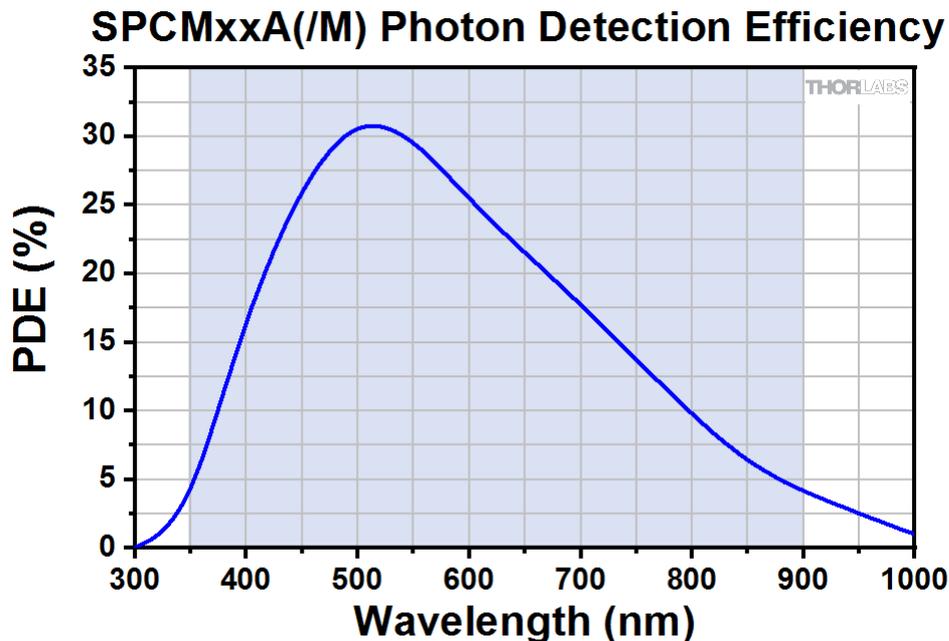
**No external triggering / gating possible**

The signal level at Gate / Trigger In is TTL compatible, however (see Technical Data) this input has an impedance of 50  $\Omega$ , so that pulse amplitudes from a standard function generator may be lowered.

Make sure, your trigger / gating pulse source is capable to work on a 50  $\Omega$  load.

## 6 Appendix

### 6.1 Typical Photon Detection Efficiency



### 6.2 Definitions

**Active Quenching** occurs when a fast discriminator senses the steep onset of the avalanche current, released by photon, and quickly reduces the bias voltage so that it is below breakdown momentarily. The bias is then returned to a value above the breakdown voltage in preparation for detection of the next photon.

**Afterpulsing:** During an avalanche, some charges can be trapped inside the high field region. When these charges are released, they can trigger an avalanche. These spurious events are called afterpulses. The life of those trapped charges is on the order of 0.1 ... 1 $\mu$ s. Hence, it is likely that an afterpulse occurs directly after a signal pulse.

#### Array size

When using the Array Measurement mode, a max. of 10,000 bins can be measured. For fast measurements (Bin Length + Time between Bins < 0.020 ms), the max. array size is limited to 1,000.

**Dead Time** is the time interval the detector spends in its recovery state. During this time, it is effectively blind to incoming photons.

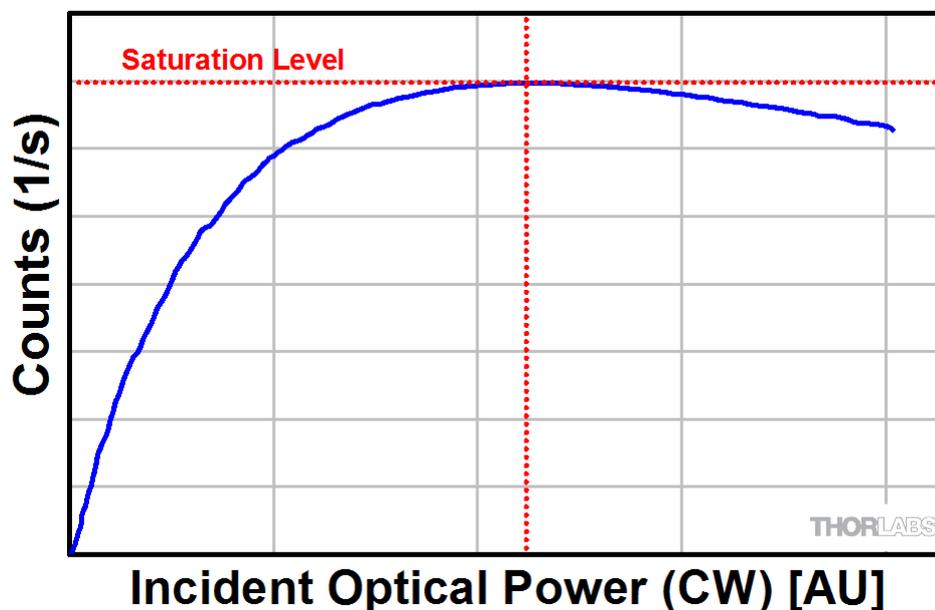
**Dark Count Rate:** This is the average rate of registered counts in the absence of any incident light and determines the minimum count rate at which the signal is dominantly caused by real photons. The false detection events are mostly of thermal origin and can therefore be strongly suppressed by using a cooled detector.

**Geiger Mode:** In this mode, the diode is operated slightly above the breakdown threshold voltage. Hence, a single electron-hole pair (generated by absorption of a photon or by a thermal fluctuation) can trigger a strong avalanche.

**Pulse Blind Time:** As explained in section [Operating Principle](#)<sup>10</sup>, spontaneously triggered avalanches may be correlated in time with a pulse caused by a photon, which then is called after-pulse. To ignore such afterpulses in the measurement, an additional **Pulse Blind Time** can be set in the software, which will cause the internal counter of the SPCM to ignore all pulses occurring during the set **Pulse Blind Time**. This additional **Pulse Blind Time** starts at the moment when a photon was registered by the counter.

### Saturation of the APD:

The photon count by an APD is not exactly linearly proportional to the incident optical CW power, the deviation increases smoothly with increasing optical power. This non-linearity leads to wrong photon count at high input power levels. At a certain input power level, the photon count begins even to decrease with further raise of optical power.

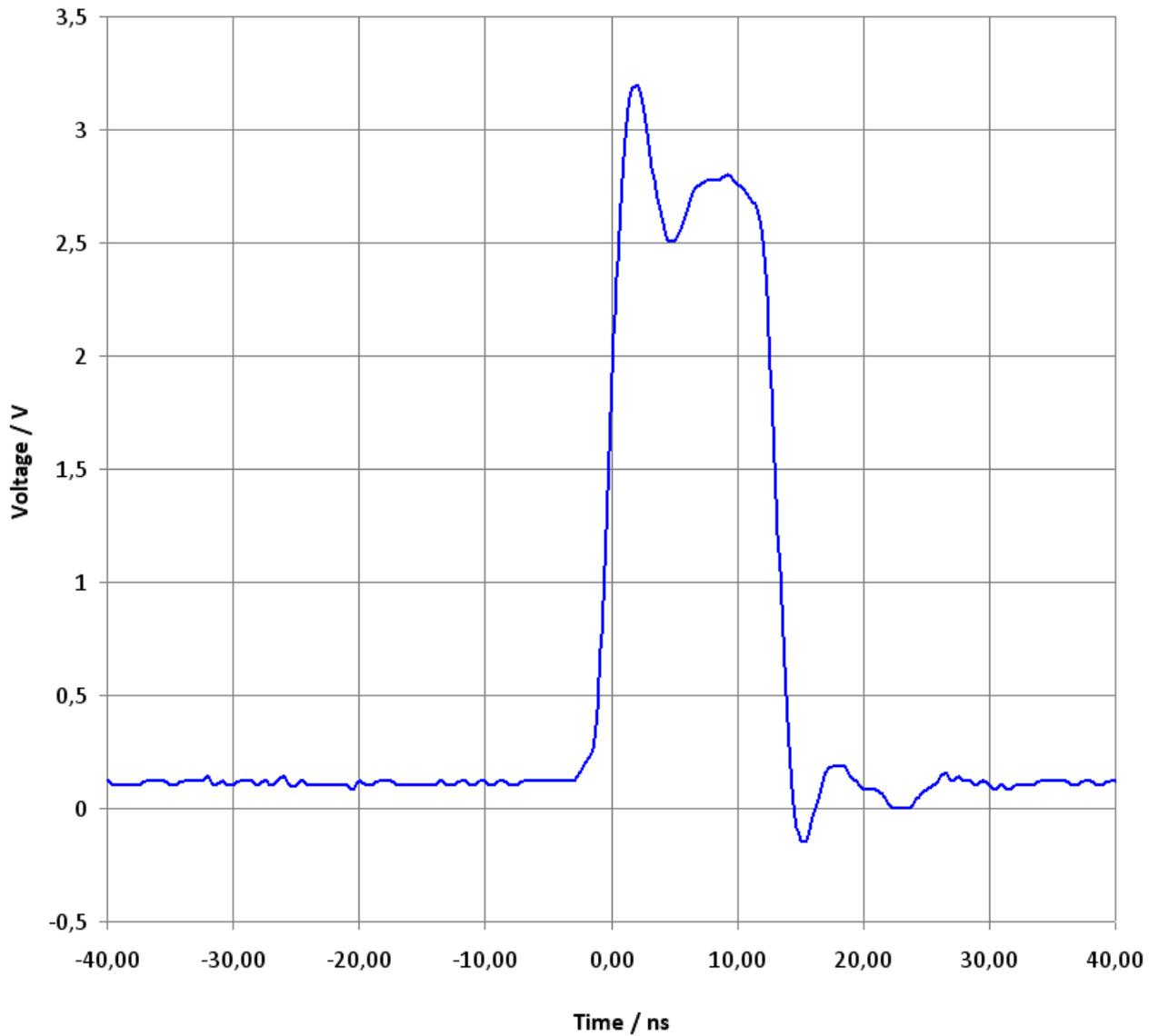


As for this reason, a saturation alert is displayed as soon as the photon count is no more increasing with increasing incident CW power.

⚠ APD Saturated

## 6.3 Pulse Out

Below a typical pulse shape at the Pulse Out SMA connector is shown:



## 6.4 Technical Data

	SPCM20A	SPCM20A/M	SPCM50A	SPCM50A/M
<b>Detector Type</b>	Si APD			
<b>Electrical Data</b>				
Wavelength Range	350 - 900 nm			
Active Detector Diameter	20 $\mu$ m		50 $\mu$ m	
Typical Max Responsivity	35 % @ 500 nm			
Dark Count Rate	60 Hz max (25 Hz Typ)		200 Hz max (150 Hz Typ)	
Max. Count rate	28 MHz		22 MHz	
Dead Time (Typical)	35 ns		45 ns	
APD Gating Delay <sup>1)</sup>	typ. 18 ns			
Gate/Trigger In to Pulse Out Delay <sup>2)</sup>	typ. 28 ns			
Afterpulsing probability	3%			
APD Temperature Set Point	(0 $\pm$ 1) °C			
APD Temperature Stability	better 0.1 K			
Gating / Trigger Input	TTL 50			
Pulse Output	TTL 50			
<b>General</b>				
Power Supply	6 VDC / 1.5 A			
Operating Temperature Range <sup>3)</sup>	0 - 40 °C			
Storage Temperature Range	-40 to 70 °C			
Dimensions (W x H x D), overall	76.5 x 85 x 36.2 mm			
Mounting thread	8-32	M4	8-32	M4

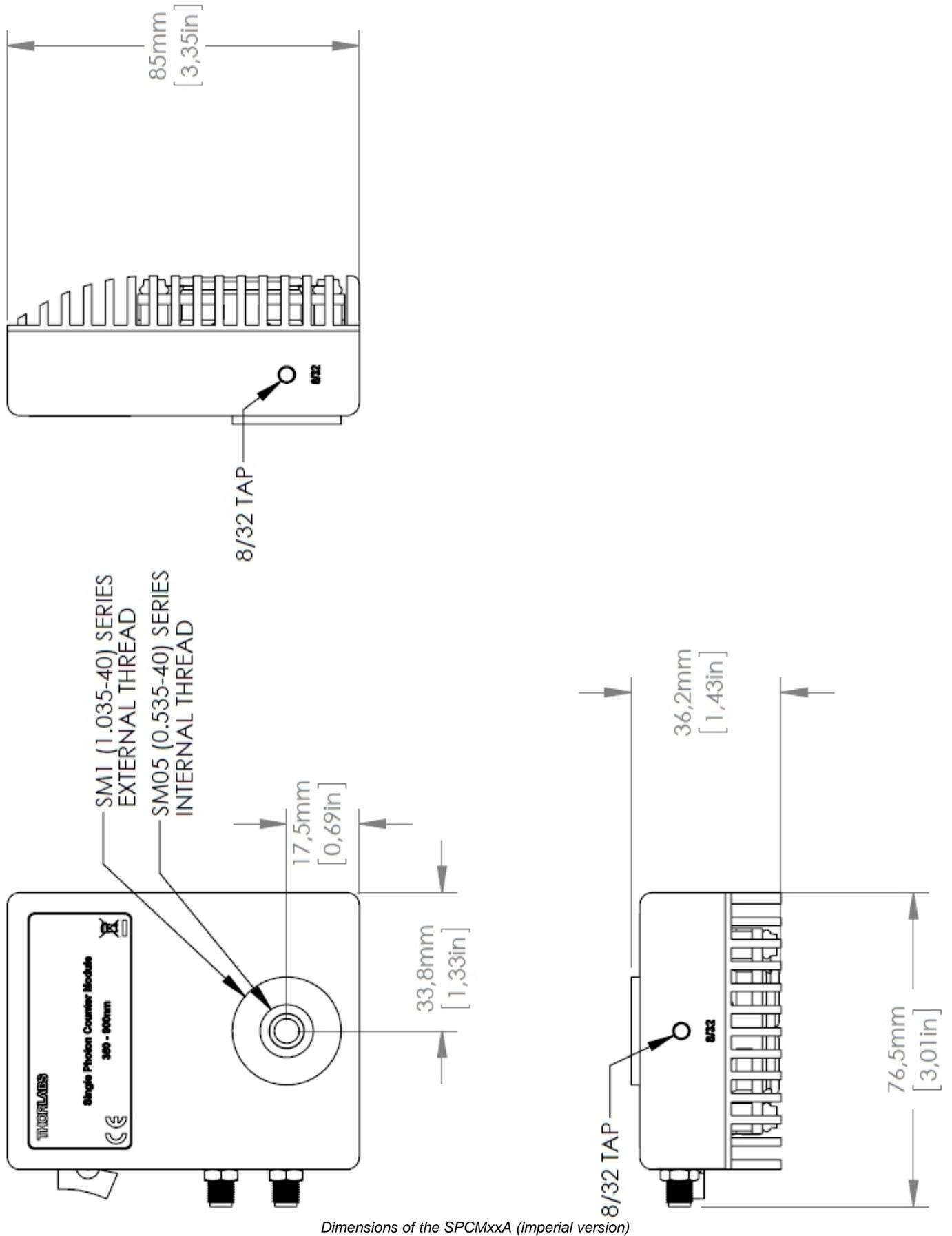
<sup>1)</sup> In External Gating mode; delay between trigger signal (at Gate / Trigger In) and activating the APD gating

<sup>2)</sup> In External Gating mode; delay between trigger signal (at Gate / Trigger In) and enabling Pulse Out

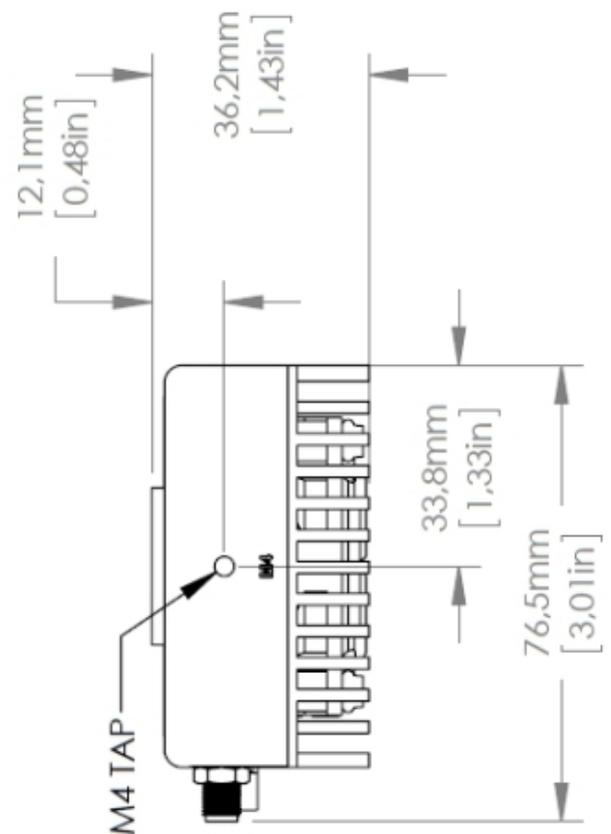
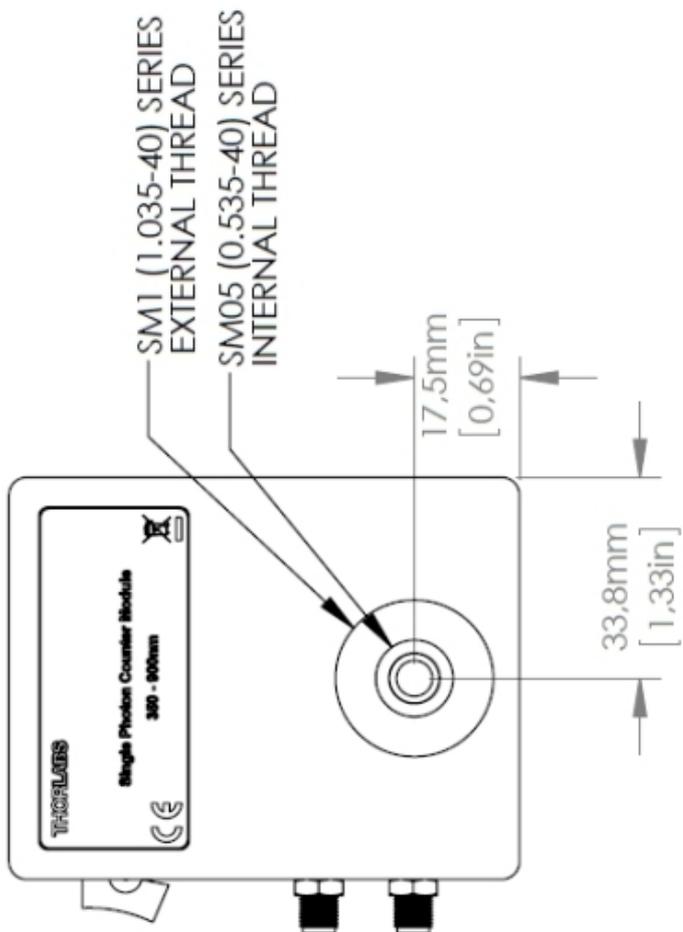
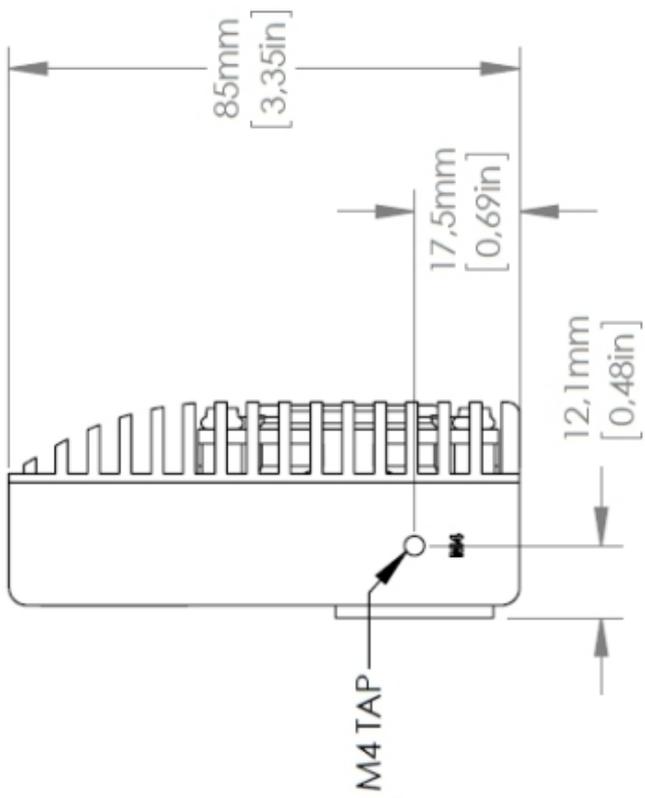
<sup>3)</sup> non-condensing

All technical data are valid at 23  $\pm$  5°C and 45  $\pm$  15% rel. humidity (non condensing), after 10 min. warm-up time

## 6.5 Dimensions



Dimensions of the SPCMxxA (imperial version)



Dimensions of the SPCMxxA/M (metric version)

## 6.6 Certifications and Compliances

Category	Standards or description
EC Declaration of Conformity - EMC	Meets intent of Directive 2004/108/EC <sup>1)</sup> for Electromagnetic Compatibility. Compliance was demonstrated to the following specifications as listed in the Official Journal of the European Communities:
EN 61326:2006	EMC requirements for Class A electrical equipment for measurement, control and laboratory use, including Class A Radiated and Conducted Emissions <sup>2,3,4)</sup> and Immunity. <sup>2,3,4)</sup>
IEC 61000-4-2	Electrostatic Discharge Immunity (Performance criterion B)
IEC 61000-4-3	Radiated RF Electromagnetic Field Immunity (Performance criterion A)
IEC 61000-4-4	Electrical Fast Transient / Burst immunity (Performance criterion B)
FCC EMC Compliance	Emissions comply with the Class A Limits of FCC Code of Federal Regulations 47, Part 15, Subpart B <sup>2,3,4)</sup> .
EC Declaration of Conformity - LVD	Compliance was demonstrated to the following specification as listed in the Official Journal of the European Communities: Low Voltage Directive 2006/95/EC <sup>5)</sup>
EN 61010-1:2001	Safety requirements for electrical equipment for measurement, control and laboratory use.
UL 61010-1 2 <sup>nd</sup> ed.	Safety requirements for electrical equipment for measurement, control and laboratory use.
CAN/CSA C22.2 No. 61010-1 2 <sup>nd</sup> ed.	Safety requirements for electrical equipment for measurement, control and laboratory use.
IEC 61010-1:2001	Safety requirements for electrical equipment for measurement, control and laboratory use.
Equipment Type	Test and measuring
Safety Class	Class I equipment (as defined in IEC 60950-1:2001)

1) Replaces 89/336/EEC

2) Compliance demonstrated using high-quality shielded interface cables.

3) Emissions, which exceed the levels required by these standards, may occur when this equipment is connected to a test object.

4) Minimum Immunity Test requirement.

5) Replaces 73/23/EEC, amended by 93/68/EEC.

## 6.7 Warranty

Thorlabs warrants material and production of the SPCMxxA for a period of 24 months starting with the date of shipment. During this warranty period Thorlabs will see to defaults by repair or by exchange if these are entitled to warranty.

For warranty repairs or service the unit must be sent back to Thorlabs. The customer will carry the shipping costs to Thorlabs, in case of warranty repairs Thorlabs will carry the shipping costs back to the customer.

If no warranty repair is applicable the customer also has to carry the costs for back shipment.

In case of shipment from outside EU duties, taxes etc. which should arise have to be carried by the customer.

Thorlabs warrants the hard- and/or software determined by Thorlabs for this unit to operate fault-free provided that they are handled according to our requirements. However, Thorlabs does not warrant a fault free and uninterrupted operation of the unit, of the software or firmware for special applications nor this instruction manual to be error free. Thorlabs is not liable for consequential damages.

### Restriction of Warranty

The warranty mentioned before does not cover errors and defects being the result of improper treatment, software or interface not supplied by us, modification, misuse or operation outside the defined ambient stated by us or unauthorized maintenance.

Further claims will not be consented to and will not be acknowledged. Thorlabs does explicitly not warrant the usability or the economical use for certain cases of application.

Thorlabs reserves the right to change this instruction manual or the technical data of the described unit at any time.

## 6.8 Exclusion of Liability and Copyright

Thorlabs has taken every possible care in preparing this document. We however assume no liability for the content, completeness or quality of the information contained therein. The content of this document is regularly updated and adapted to reflect the current status of the hardware and/or software. We furthermore do not guarantee that this product will function without errors, even if the stated specifications are adhered to.

Under no circumstances can we guarantee that a particular objective can be achieved with the purchase of this product.

Insofar as permitted under statutory regulations, we assume no liability for direct damage, indirect damage or damages suffered by third parties resulting from the purchase of this product. In no event shall any liability exceed the purchase price of the product.

Please note that the content of this document is neither part of any previous or existing agreement, promise, representation or legal relationship, nor an alteration or amendment thereof. All obligations of Thorlabs result from the respective contract of sale, which also includes the complete and exclusively applicable warranty regulations. These contractual warranty regulations are neither extended nor limited by the information contained in this document. Should you require further information on this product, or encounter specific problems that are not discussed in sufficient detail in the document, please contact your local Thorlabs dealer or system installer.

All rights reserved. This document may not be reproduced, transmitted or translated to another language, either as a whole or in parts, without the prior written permission of Thorlabs.

Copyright © Thorlabs 2021. All rights reserved.

## 6.9 List of Acronyms

The following acronyms and abbreviations are used in this manual:

APD	Avalanche Photo Diode
CPU	Central Processing Unit
CW	Continuous Wave
DFU	Device Firmware Update
FW	FirmWare
GUI	Graphic User Interface
NI-VISA	National Instruments Virtual Instrument Software Architecture
SCPI	Standard Commands for Programmable Instruments
SPCM	Single Photon Counter Module
USB	Universal Serial Bus

## 6.10 Thorlabs Worldwide Contacts and WEEE Policy

For technical support or sales inquiries, please visit us at <https://www.thorlabs.com/locations.cfm> for our most up-to-date contact information.



### USA, Canada, and South America

Thorlabs, Inc.  
sales@thorlabs.com  
techsupport@thorlabs.com

### UK and Ireland

Thorlabs Ltd.  
sales.uk@thorlabs.com  
techsupport.uk@thorlabs.com

### Europe

Thorlabs GmbH  
europe@thorlabs.com

### Scandinavia

Thorlabs Sweden AB  
scandinavia@thorlabs.com

### France

Thorlabs SAS  
sales.fr@thorlabs.com

### Brazil

Thorlabs Vendas de Fotônicos Ltda.  
brasil@thorlabs.com

### Japan

Thorlabs Japan, Inc.  
sales@thorlabs.jp

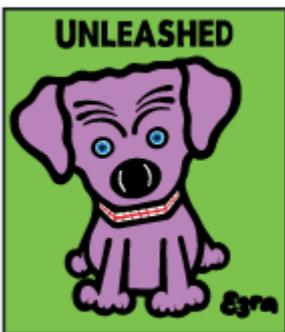
### China

Thorlabs China  
chinasales@thorlabs.com

### Thorlabs 'End of Life' Policy (WEEE)

Thorlabs verifies our compliance with the WEEE (Waste Electrical and Electronic Equipment) directive of the European Community and the corresponding national laws. Accordingly, all end users in the EC may return "end of life" Annex I category electrical and electronic equipment sold after August 13, 2005 to Thorlabs, without incurring disposal charges. Eligible units are marked with the crossed out "wheelie bin" logo (see right), were sold to and are currently owned by a company or institute within the EC, and are not disassembled or contaminated. Contact Thorlabs for more information. Waste treatment is your own responsibility. "End of life" units must be returned to Thorlabs or handed to a company specializing in waste recovery. Do not dispose of the unit in a litter bin or at a public waste disposal site. It is the users responsibility to delete all private data stored on the device prior to disposal.





**THORLABS**

[www.thorlabs.com](http://www.thorlabs.com)

---