

LynX™ Silicon Photomultiplier Module - LynX-A-33-W50-T1-X

A User Guide

Understanding the Silicon Photomultiplier Module for improving system performance



Overview

Excelitas' new LynX™ Silicon Photomultiplier Module is a compact, easy-to-use, analogue low light level detection (L³D) module employing Excelitas' leading-edge C30742 Series Silicon Photomultiplier (SiPM) chip in a hermetic TO-8 package with thermoelectric cooler, a stable voltage power supply circuit, and a low noise transimpedance amplifier.

With this compact voltage output module, the preamplifier gain has been optimized to obtain maximum dynamic range and linearity with the SiPM at pre-set operating voltage. This module outperforms other SiPM solutions in key performance such as higher photon detection efficiency (PDE) and better signal-to-noise ratio across the full 400 nm – 900 nm wavelength spectrum.

Excelitas' new LynX™ SiPM Module is offered as a standard, commercial-off-the-shelf (COTS) product. It contains a 3x3 mm² active area SiPM with 50x50 μm² microcells for optimum fill factor and PDE. Other chip configurations are available on a custom basis.

In addition to our standard, off-the-shelf SiPM module, Excelitas also offers customized modules tailored from our standard designs. Depending upon customer requirements, modifications can include bandwidth optimization, FC-connectorized packaging, photon counting digital output and customized testing.

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- Operating instructions

Applications

- Fluorescence measurement
- Analytical instrumentation
- Flow Cytometry

Electro-optical characteristics

Table 1. Electro-optical characteristics: Case temperature = 22°C, $V_{in} = +5V$, $R_L = 50\Omega$ DC coupled

Detector					
Parameter	Condition	Min.	Typ.	Max.	Unit
Effective Active Area			3 x 3		mm
Num. Of Microcells			3600		
Microcell Size			50 x 50		μm
Spectral Bandwidth		350		950	nm
Peak Wavelength			500		nm
Module					
Parameter	Condition	Min.	Typ.	Max.	Unit
Positive Supply Voltage		4.5	5.0	5.5	V
Positive Supply Current			350	1000	mA
Power Up Settling Time			15		s
Output Voltage Swing	High impedance 50 Ohm			+5	V
				+1	V
Responsivity	@525 nm		0.75		V/nW
Bandwidth			1.5		MHz
NEP			1.0		$\text{fW}/(\text{Hz})^{1/2}$
Output offset voltage			1.5		mV
Storage Temperature		-10		+50	°C
Operating Temperature		+5		+50	°C

How to Operate the LynX™

Similarly to a photomultiplier tube (PMT), the LynX™ SiPM module operates at very high gains (>100 000) and is sensitive to optical powers ranging from 0.1 pW to 10 nW. It is thus recommended to operate the LynX™ in the dark. Since the LynX™ is based on solid-state technology, the sensitive surface of the photodetector won't be permanently damaged by exposure to ambient light. Exposing the LynX™ module to ambient light while in operation will simply saturate the module output.

Applying the +5V supply turns on the module and makes it sensitive to light. The responsivity and NEP (Noise Equivalent Power) will be as written in the specification sheet at the specified wavelength (see Table 2). When operated in complete darkness, the output offset voltage and current read from the power source should be the values in the specification sheet.

Table 2 – Specification of LynX™ Module

Characteristic	Measured Value	Units	Comment
Factory set Vop		V	Vbias mon value
Responsivity		V/nW	measured at Vop
NEP		fW/(Hz) ^{1/2}	measured at Vop
Output offset voltage		mV	measured at Vop
+5V current		mA	measured at Vop

If the gain of the LynX™ is to be adjusted to lower or higher the responsivity, it is recommended to use one of the two wiring schemes illustrated in the spec sheet (see Figure 1 and 3 below).

Voltage – Gain adjustment

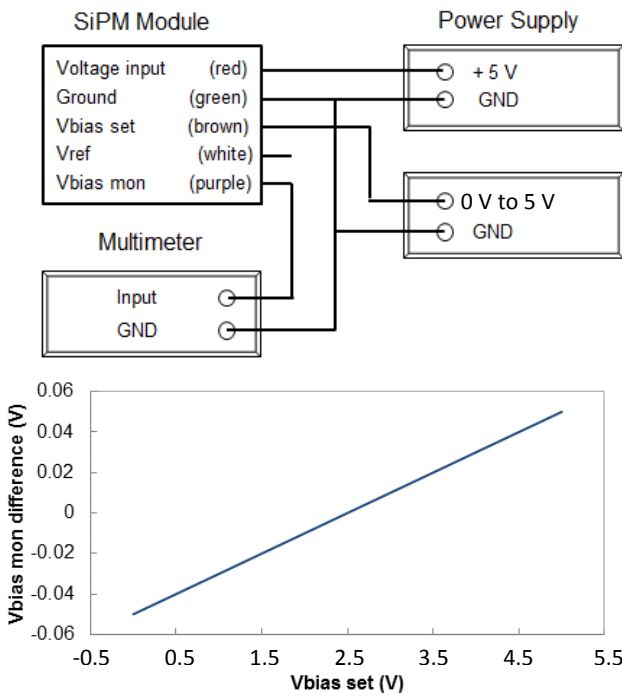


Figure 1: Voltage-Gain adjustment

Wiring scheme to control the gain with an additional voltage applied on the module. Useful if the gain of various module has to be matched or modified.

Figure 2: Vbias set impact on monitoring voltage

By applying an external voltage (Vbias set) from 0 V to 5 V one can change the gain of the LynX™ module.

Resistance – Gain adjustment

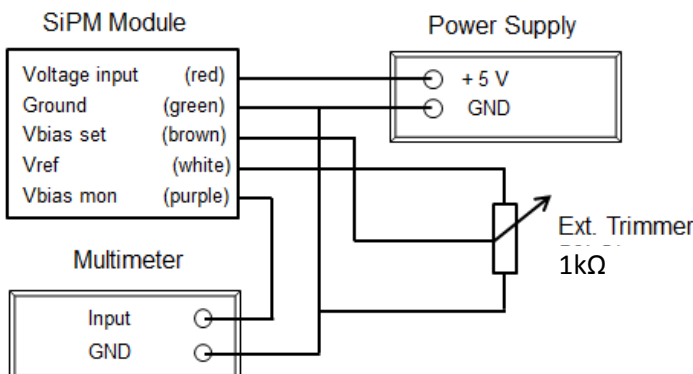


Figure 3: Resistance-Gain adjustment

Wiring scheme to control the gain with an external resistance.

The change of voltage can be monitored by reading $V_{bias\ mon}$ with a multimeter.

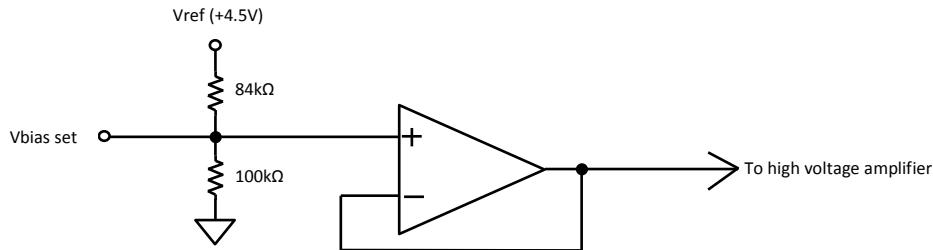
When using the voltage – gain adjustment method, $V_{bias\ set}$ input adjusts the voltage of the SiPM chip approximately as

$$V_{bias\ mon} = 0.019 V_{bias\ set} + V_{factory\ offset}$$

$V_{factory\ offset}$ is an internal offset that is set at the factory to achieve the default the responsivity when $V_{bias\ set}$ is left unconnected.

$V_{bias\ mon} \times 63.62$ is then the real bias applied on the chip.

$V_{bias\ set}$ input impedance is approximately 45kΩ as provided in the input port equivalent schematic:



It is recommended to keep $V_{bias\ set}$ within 0 V to 4.5 V providing a variation of approximately +/- 3 V on the SiPM detector. Although the responsivity change with the external bias applied is not a true linear relationship, it can be approximated by 0.45 V/nw x $V_{bias\ set}$ (see Figure 3 and 4). The reasons for this non-linear relationship are caused mainly by the increase of cross-talk and afterpulsing with the voltage applied on the chip and the logarithmic relationship between photon detection efficiency and the voltage applied.

Vbias Adjustment example

Here is an example of the variation that the adjustment of the $V_{bias\ set}$ has on the output of the LynX. The LynX is illuminated with very little light. Figure 5 represent the module with no adjustment to the $V_{bias\ set}$. Figure 4 is with the adjustment at 0V and Figure 6 is at 4.5V.

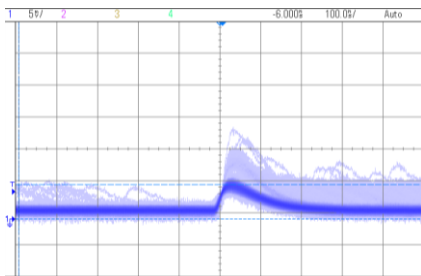


Figure 4 : 0V

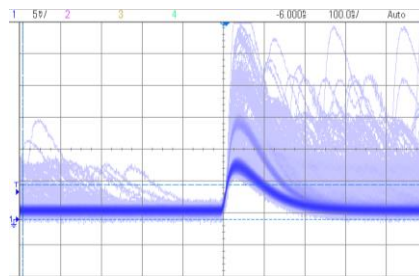


Figure 5 : 2.5V

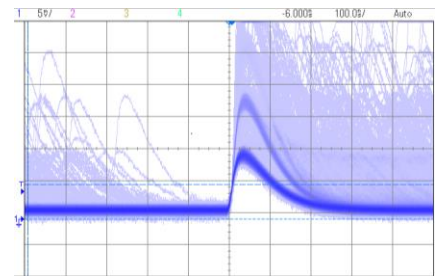


Figure 6 : 4.5V

For Figure 1:

$V_{bias\ set} = 0V$ (Set by user)

$V_{bias\ mon} = 1.499V$ (Measured with multimeter)

Real bias on chip = $1.499V \times 63.62 = 95.37V$

Typical Performance

To exploit as much as possible the dynamic range of the LynX™ module, it is important to adjust the light spot size to cover the whole SiPM since it is composed of a multitude of distinct microcells which, when triggered, will take some tens of nanoseconds to recharge. Having a larger spot size will make better use of the module linearity as shown in Figure 4.

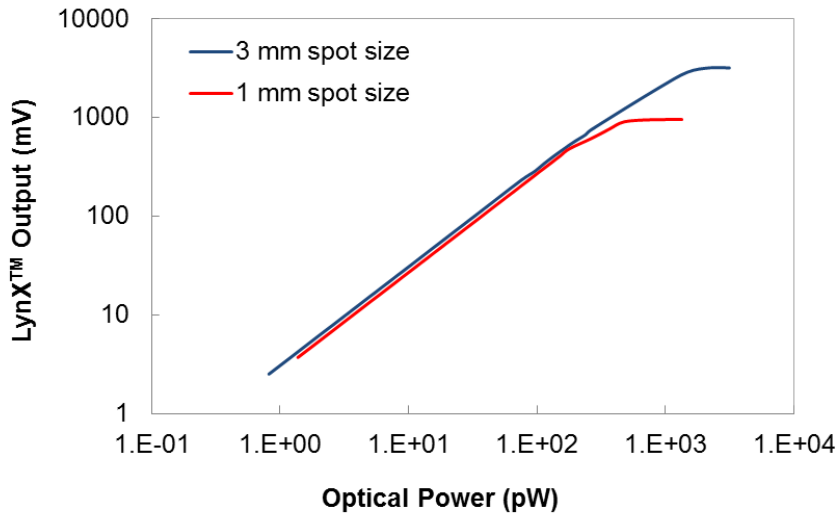


Figure 7: Linearity for two different spot size of 1mm and 3mm

By applying an external voltage, the responsivity, NEP and linearity of the module can be modified as follows (Figure 5 and 6)

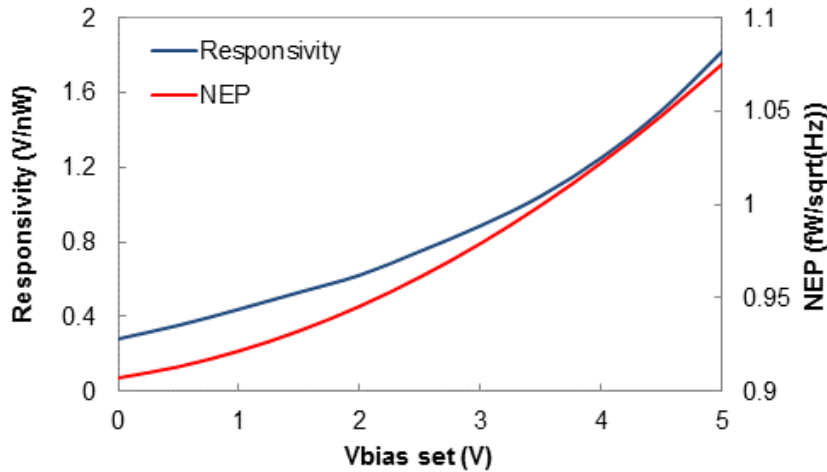


Figure 8: Responsivity and NEP vs. Vbias Set at 525 nm for a typical LynX™ module.

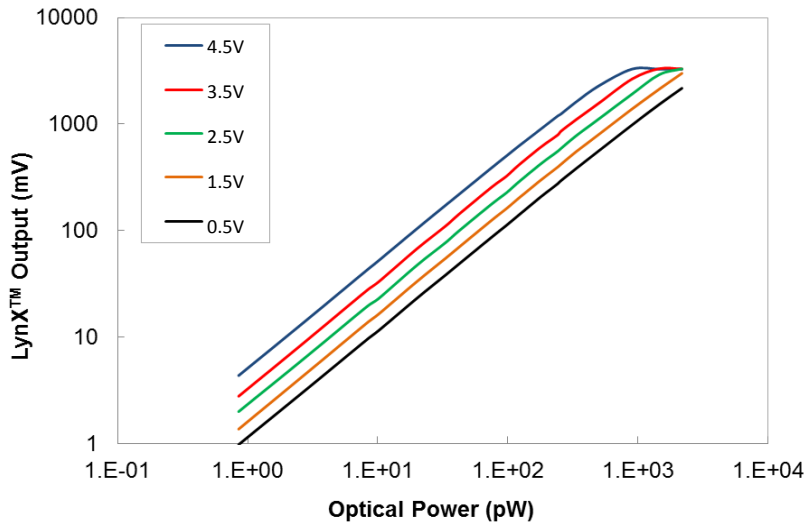


Figure 9: Linearity for different Vbias settings.

The Responsivity vs Wavelength is given by the following:

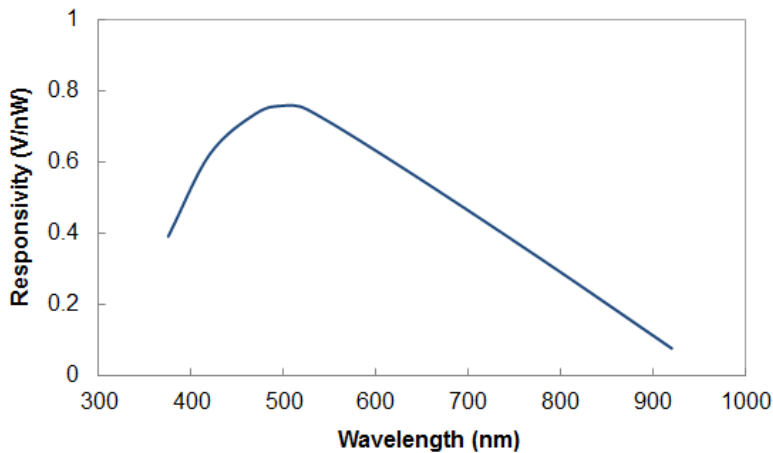


Figure 10: Spectral responsivity of the LynX™ module

Typical output signal

Below is a typical signal from the LynX module under a very small amount of light. The screenshot is composed of many traces stacked on top of each other. The signal is composed of pulse of distinct levels. These levels represent avalanche events from one, two or more photons hitting the detector or electron from thermally generated electrons. On the image below, the two first levels of photo-electrons on the detector can be clearly distinguished. The distance between levels is linear, the level of a two photo-electron event is twice as high as the level of one photon.

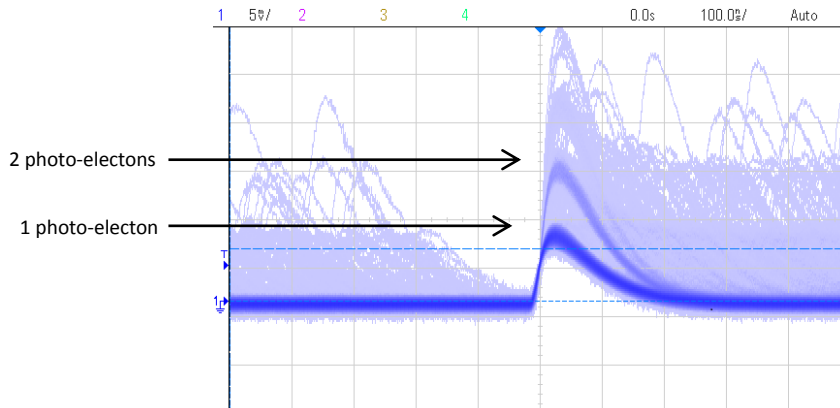


Figure 11: Typical output signal

These various levels can be used to filter out the background noise and get only the desired data just by setting an appropriate trigger level on oscilloscope or frequency counter. Usually, the signal is presented as counts/sec, which is the amount of pulse of above a certain level integrated during one second.

Light level

This module needs a very little light to behave in the way described above. Below are examples of the output signal under various light levels. The figure 11 shows a normal low light level pulse. The figure 12 shows a light level where the pulses start piling up on top of each other, making it harder to distinguish between individual pulses and pulse levels. Figure 13 presents a light level that is too high to see individual pulses. The DC level of this signal still represents the amount of light hitting the detector but heavy filtering is necessary to get a clean signal.

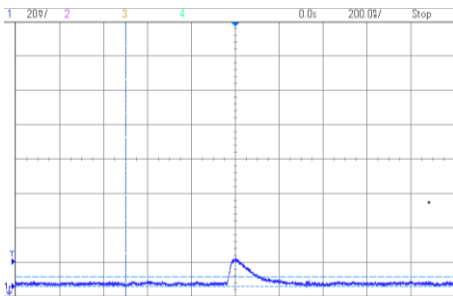


Figure 12: Typical low light level

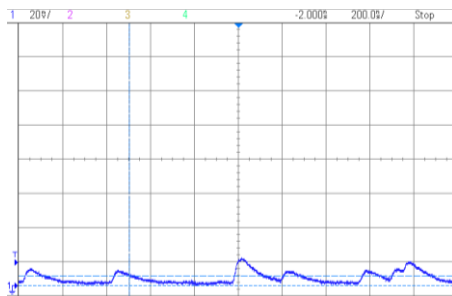


Figure 13: Higher light level

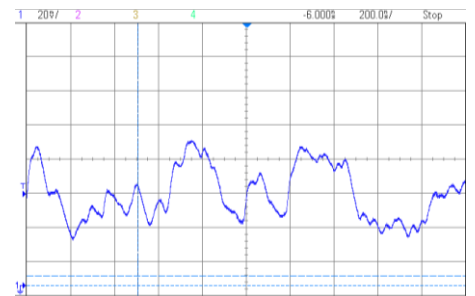
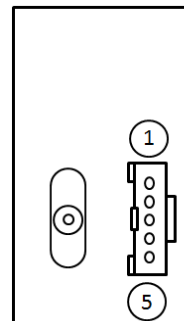
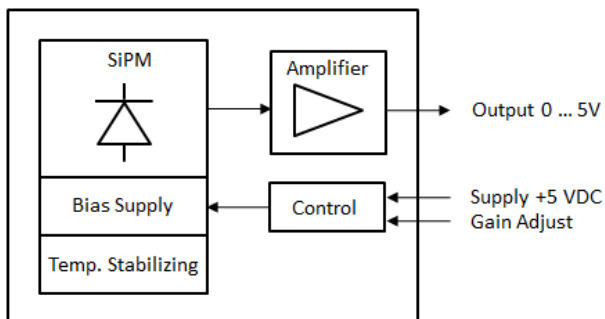


Figure 14: Too much light for pulses

Pin description



- | | |
|--------------|---------|
| 1. Vref | (white) |
| 2. Vbias mon | (blue) |
| 3. Vbias set | (brown) |
| 4. GND | (green) |
| 5. +5 VDC | (red) |

Signal output connector: SubMiniature version C (SMC)

Voltage input and control connector: Molex #90156-0145

(1) Vref (white wire)

This wire can be connected to a potentiometer if the resistance gain adjustment scheme is used. Voltage is approximately 4.5V.

(2) Vbias mon (blue wire)

This wire can be connected to a multimeter in order to monitor the applied voltage on the SiPM chip. If gain adjustment has to be applied on the LynX™ or optimization procedures of responsivity are implemented, the reading of this value with a multimeter can be useful.

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(3) Vbias Set (brown wire)

This wire is used in both voltage and resistance gain adjustment. If used in the voltage gain adjustment, a value of 0 V to 5 V can be applied to it to lower or higher the gain. See Figure 1 for the wiring scheme.

(4) Ground (green wire)

Ground signal normally connected to power supply.

(5) +5 V (red wire)

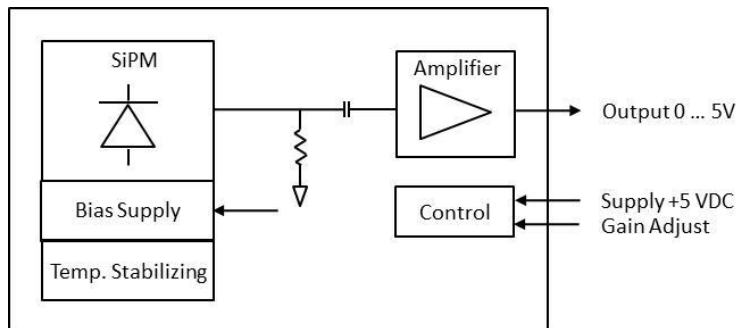
This wire is connected to a +5V dc power supply.

Operating Instructions

1. Connection to incorrect voltage or reverse voltage may damage or destroy the module. The warranty is invalid where such damage occurs.
2. These modules are not qualified for shock or vibration other than normal instrumentation environments.
3. The module dissipates a mean power of 1.5W and a maximum power of 4W at higher light intensity. Adequate heat sinking must be provided by clamping the module to a suitable heat sink via the holes in the module.

AC coupled Lynx™ model

The LynX™ is also available with DC signal blocked from reaching the amplifier. This is achieved by putting a load resistor on the SiPM and a capacitor to couple the AC signal from the SiPM to the amplifier as show in the next figure.



Typical low frequency cut off is about 3kHz meaning that signal having frequency of less than 3kHz will not be visible at the output of the module.

It also means that the DC output voltage will not vary with continuous light impinging the SiPM detector but the noise associated with the light signal will still be present at the output.

All other parameters of the module remain the same.

Part numbers useable with this application note:

LynX-A-33-050-T1-A
LynX-A-33-050-T1-B
LynX-A-33-A50-T1-A
LynX-A-33-A50-T1-B

LynX-A-11-050-T1-A
LynX-A-11-050-T1-B
LynX-A-11-A50-T1-A
LynX-A-11-A50-T1-B

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Safety Warning



The LynX™ contains a **high voltage power supply**. Users may be injured if the case is opened. All internal settings are pre-set; there are no internal user adjustments.



Units that appear defective or have suffered mechanical damage should not be used because of possible electrical shorting of the high voltage power supply. Opening the case may damage sensitive components and expose the user to the risk of electrical shock. Please contact the factory for repairs.

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About Excelitas Technologies

Excelitas Technologies is a global technology leader focused on delivering innovative, customized solutions to meet the detection, lighting, and other high-performance technology needs of OEM customers.

From analytical instrumentation to clinical diagnostics, medical, industrial, safety and security, and aerospace and defense applications, Excelitas Technologies is committed to enabling our customers' success in their end-markets. Excelitas Technologies has approximately 5,000 employees in North America, Europe and Asia, serving customers across the world.

Excelitas Technologies
22001 Dumberry Road
Vaudreuil-Dorion, Quebec
Canada J7V 8P7
Telephone: (+1)
450.424.3300
Toll-free: (+1) 800.775.6786
Fax: (+1) 450.424.3345
Detection.na@excelitas.com

**European Headquarters
Excelitas Technologies
GmbH & Co. KG**
Wenzel-Jaksch-Str. 31
D-65199 Wiesbaden
Germany
Telephone: (+49) 611 492 430
Fax: (+49) 611 492 165
detection.europe@excelitas.com

Excelitas Technologies Singapore, Pte. Ltd.
8 Tractor Road
Singapore 627969
Telephone: (+65) 6775 2022 Main number)
Telephone: (+65) 6770 4366 (Customer Service)
Fax: (+65) 6778-1752
detection.asia@excelitas.com

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