FDPSE2X2
Lead Selenide
Photoconductor

User Guide

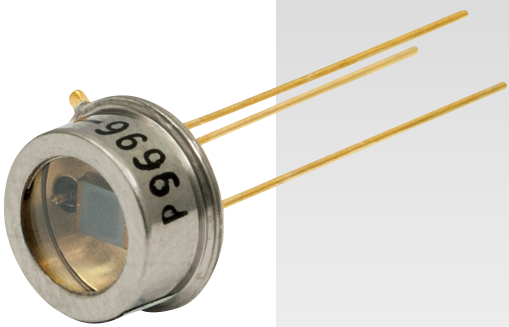
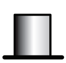


Table of Contents

Chapter 1 Warning Symbol Definitions

Below is a list of warning symbols you may encounter in this manual or on your device.

Symbol	Description
	Direct Current
	Alternating Current
	Both Direct and Alternating Current
	Earth Ground Terminal
	Protective Conductor Terminal
	Frame or chassis Terminal
	Equipotentiality
	On (Supply)
	Off (Supply)
	In Position of a Bi-Stable Push Control
	Out Position of a Bi-Stable Push Control
	Caution, Risk of Electric Shock
	Caution, Hot Surface
	Caution, Risk of Danger
	Warning, Laser Radiation
	Caution, Spinning Blades May Cause Harm

Chapter 2 Description

Thorlabs' FDPSE2X2 photoconductor is a Lead Selenide Detector (PbSe), which is ideal for measuring both pulse and chopped infrared light sources. The photoconductor is housed conveniently in a TO-5 package, offering easy integration into existing setups and/or systems. The detector acts as a resistor: as the detector area is illuminated with IR radiation, the effective resistance of the photoconductor is reduced.

Chapter 3 Operation

3.1. Theory of Operation

Lead Sulfide (PbS) and Lead Selenide (PbSe) photoconductive detectors are widely used in detection of infrared radiation from 1000 nm to 4800 nm. Unlike standard photodiodes, which produce a current when exposed to light, the electrical resistance of the photoconductive material is reduced when illuminated with light. PbS and PbSe detectors can be used at room temperature. However, temperature changes affect dark resistance, sensitivity, and response speeds (see Section 3.4 below).

Incident light causes the number of charge carriers in the active area to increase, thus decreasing the resistance of the detector. This change in resistance leads to a change in measured voltage, and so photosensitivity is expressed in V/W. An example operating circuit is shown below. Please note that the circuit depicted below is not recommended for practical purposes since low frequency noise will be present.

The detection mechanism is based upon the conductivity of the thin film of the active area. The output signal of the detector with no incident light is defined as the following:

$$V_{OUT} = \frac{R_{LOAD}}{R_{DARK} + R_{LOAD}} * V_{BIAS}$$

A change ΔV_{OUT} then occurs due to a change ΔR_{Dark} in the resistance of the detector when light strikes the active area:

$$\Delta V_{OUT} = -\frac{R_{LOAD} V_{BIAS}}{(R_{DARK} + R_{LOAD})^2} * \Delta R_{DARK}$$

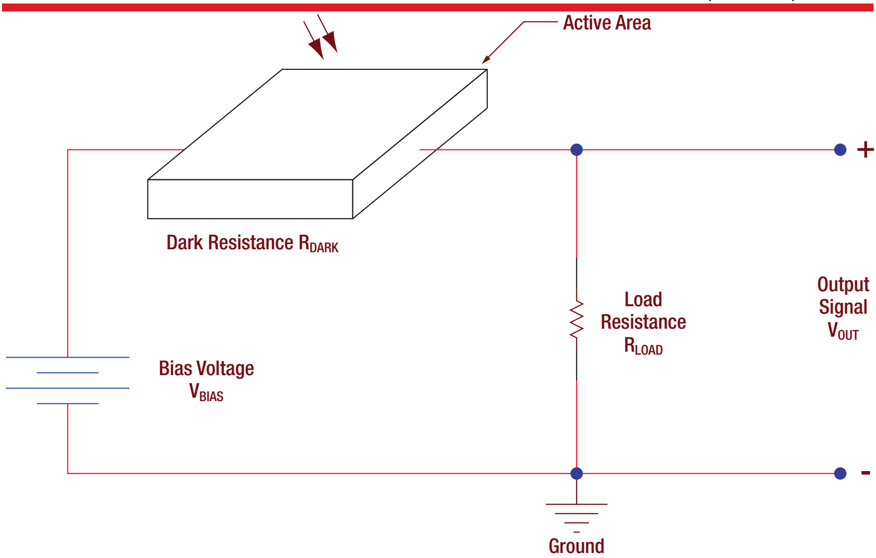


Figure 1: Photodiode Model

3.2. Frequency Response

Photoconductors must be used with a pulsed signal to obtain AC signals. An optical chopper, such as Thorlabs' MC2000, is recommended for use with CW light. The detector responsivity (R_f) when using a chopper can be calculated using the equation below:

$$R_f = \frac{R_0}{\sqrt{1 + 4\pi^2 f_c^2 \tau_r^2}}$$

f_c = *chopping frequency*
R_0 = *response at* 0 *Hz*
τ_r = *detector rise time*

3.3. Effects of Chopping Frequency

The photoconductor signal will remain constant up to the time constant response limit. PbS and PbSe detectors have a typical 1/f noise spectrum (i.e., the noise decreases as chopping frequency increases), which has a profound impact on the time constant at lower frequencies.

The detector will exhibit lower responsivity at lower chopping frequencies. Frequency response and detectivity are maximized at

$$f_c = \frac{1}{2\pi\tau_r}$$

The characteristic curve for Signal vs. Chopping Frequency for this particular detector is provided in Chapter 4.

3.4. Temperature Considerations

These detectors consist of a thin film on a glass substrate. The effective shape and active area of the photoconductive surface varies considerably based upon the operating conditions, thus changing performance characteristics. Specifically, responsivity of the detector will change based upon the operating temperature.

Temperature characteristics of PbS and PbSe band gaps have a negative coefficient, so cooling the detector shifts its spectral response range to longer wavelengths. For best results, operate the photodiode in a stable, temperature-controlled environment. See Section 4.5 for characteristic curves of Temperature vs. Sensitivity for a particular detector.

3.5. Signal to Noise Ratio

Since the detector noise is inversely proportional to the chopping frequency, the noise will be greater at low frequencies. The detector output signal is linear to increased bias voltage, but the noise shows little dependence on the bias at low levels. When a set bias voltage is reached, the detector noise will increase linearly with applied voltage. At high voltage levels, noise tends to increase exponentially, thus degrading the signal to noise ratio (SNR) further. To yield the best SNR, adjust the chopping frequency and bias voltage to an acceptable level. Provided in Chapter 4 are characteristic curves for SNR vs. Chopping Frequency and SNR vs. Supply Voltage.

3.6. Noise Equivalent Power

The noise equivalent power (NEP) is the generated RMS signal voltage generated when the signal to noise ratio is equal to one. This is useful since the NEP determines the ability of the detector to detect low level light. In general, the NEP increases with the active area of the detector and is given by the following equation:

$$NEP = \frac{Incident\ Energy * \ Area}{\frac{S}{N} * \sqrt{\Delta f}}$$

$\frac{S}{N} = Signal\ to\ Noise\ Ratio$

$\Delta f\ = Noise\ Bandwidth$

$Incident\ Energy = Power/Area$

3.7. Dark Resistance

Dark Resistance is the resistance of the detector under no illumination. It is important to note the dark resistance will increase or decrease with temperature.

Cooling the device will increase the dark resistance. Chapter 4 provides a Dark Resistance vs. Temperature characteristic graph for the particular detector.

3.8. Detectivity (D) and D*

Detectivity (D) is another criteria used to evaluate the performance of the photodetector. Detectivity is a measure of sensitivity and is the reciprocal of NEP.

$$D = \frac{1}{NEP}$$

Higher values of detectivity indicate higher sensitivity, making the detector more suitable for detecting low light signals. Detectivity varies with the wavelength of the incident photon.

NEP of a detector depends upon the active area of the detector, which will also affect detectivity, making it difficult to compare the intrinsic properties of two detectors. To remove the dependence, Specific Detectivity (D^*), which is not dependent on detector area, is used to evaluate the performance of the photodetector.

$$D^* = \frac{\sqrt{A * \Delta f}}{NEP}$$

Where A is the area of the photosensitive region of the detector, Δf is the effective noise bandwidth, and NEP is the noise equivalent power.

3.9. Typical Amplifier Circuit

Due to the noise characteristic of a photoconductor, it is generally suited for AC-coupled operation. The DC noise present with the applied bias will be too great at high bias levels, thus limiting the practicality of the detector. For this reason, IR detectors are normally AC-coupled to limit the noise. A pre-amplifier is required to help maintain the stability and to provide a large gain for the generated current signal.

Based on the schematic below, the op-amp will try to maintain point A to the input at B via the use of feedback. The difference between the two input voltages is amplified and provided at the output. It is also important to note the high-pass filter that AC couples the input of the amplifier blocks any DC signal. In addition, the resistance of the load resistor (R_{LOAD}) should be equal to the dark resistance (R_{DARK}) of the detector to ensure maximum signal is acquired. The supply voltage (+V) should be at a level where the SNR is acceptable and near unity. Some applications require higher voltage levels; as a result the noise will increase. Chapter 4 provides an SNR vs. Supply Voltage characteristic curve to help to determine the best operating condition. The output voltage is derived as the following:

$$V_{out} = \left(1 + \frac{R_f}{R_i}\right) * I_S R_D$$

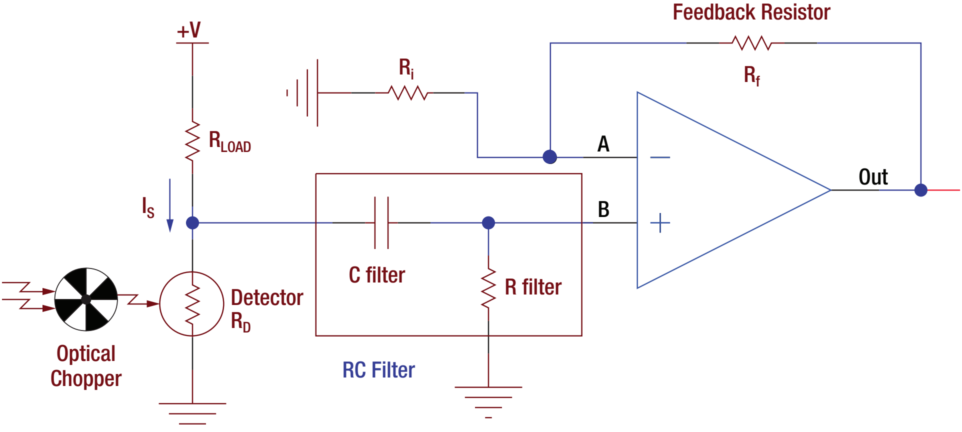


Figure 2: Amplifier Model

Chapter 4 Specifications

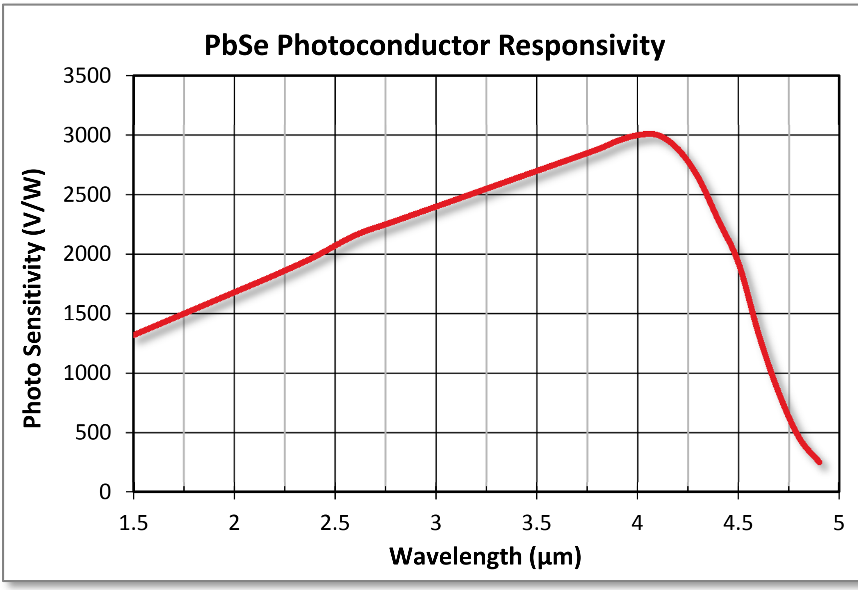
All measurements performed with 25 °C element temperature unless stated otherwise.

Electrical Specifications		
Detector		PbSe
Active Area		2.0 mm x 2.0 mm (4 mm^2)
Wavelength Range	λ	1500 to 4800 nm
Peak Wavelength	λ_p	4000 nm (Typ.)
Peak Sensitivity[1]	$\Re(\lambda)$	1.5 x 10^3 V/W (Min.) 3.0 x 10^3 V/W (Typ.)
Rise Time[2] **(0 to 63%)**	τ_r	10 µs (Max.)
Detectivity[3] **(λ_P, 600, 1)**	D^*	2.5 x 10^9 $\frac{cm*\sqrt{Hz}}{W}$ (Typ.)
Dark Resistance	R_D	0.10 to 3.0 MΩ
Bias Voltage	V_B	100 V (Max)

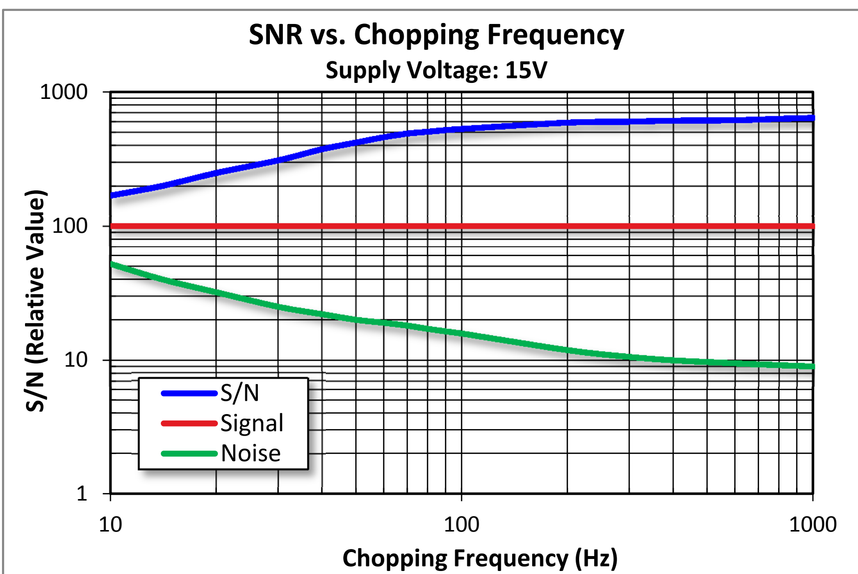
General	
Package	TO-5
Operating Temperature	-30 to 50 °C
Storage Temperature	-55 to 60 °C

[1] Measured at a chopping frequency of 600 Hz with a bias voltage of 15 V; load resistance equals R_D.
[2] Rise Time is measured from 0 to 63% of final value.
[3] Measured at a chopping frequency of 600 Hz at peak wavelength.

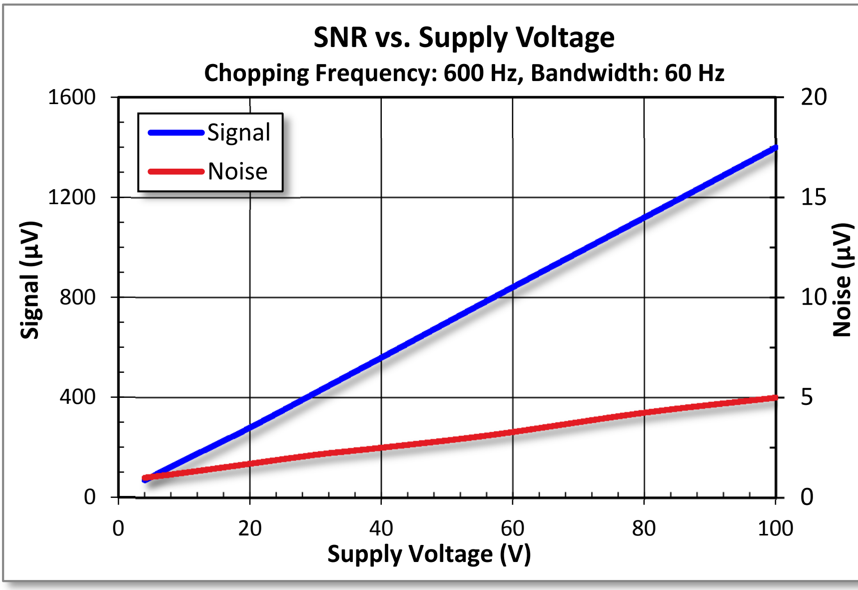
4.1. Response Curve



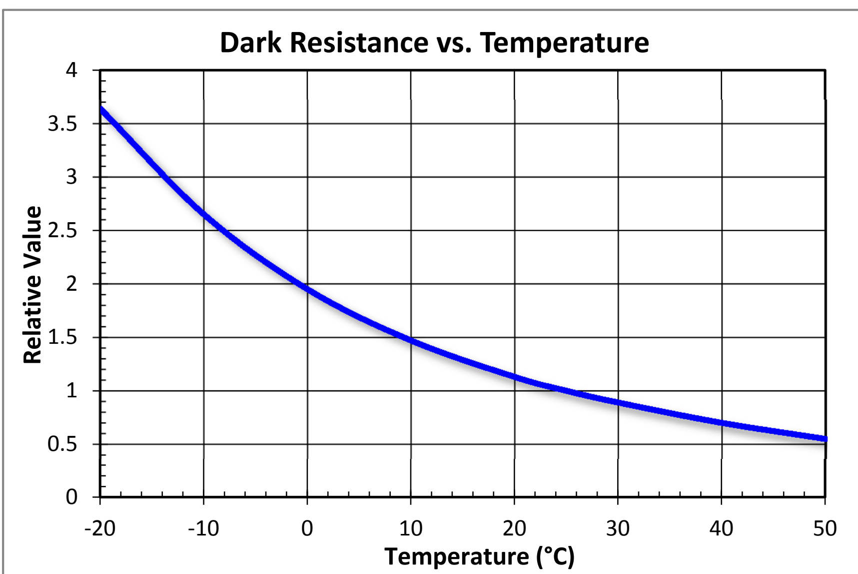
4.2. SNR vs. Chopping Frequency



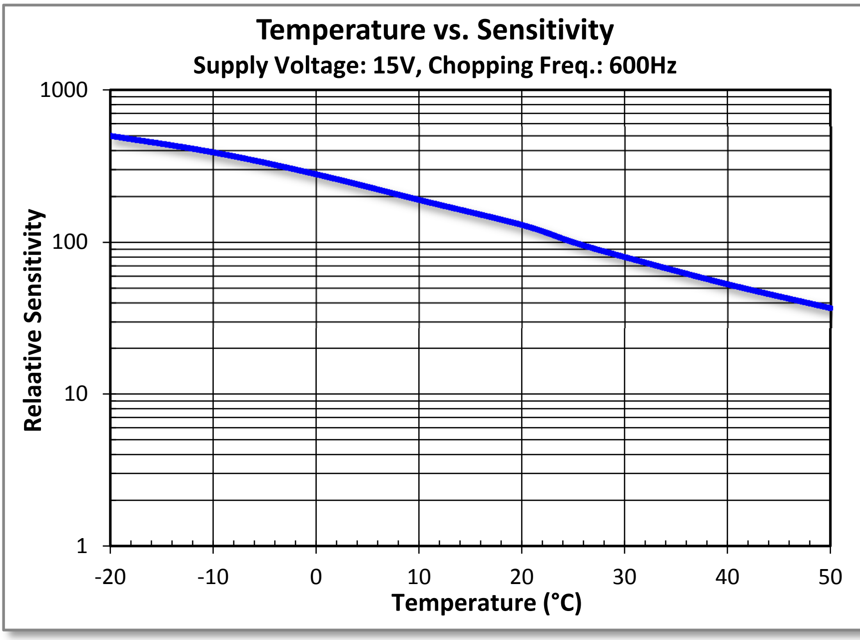
4.3. SNR vs. Supply Voltage



4.4. Dark Resistance vs. Temperature

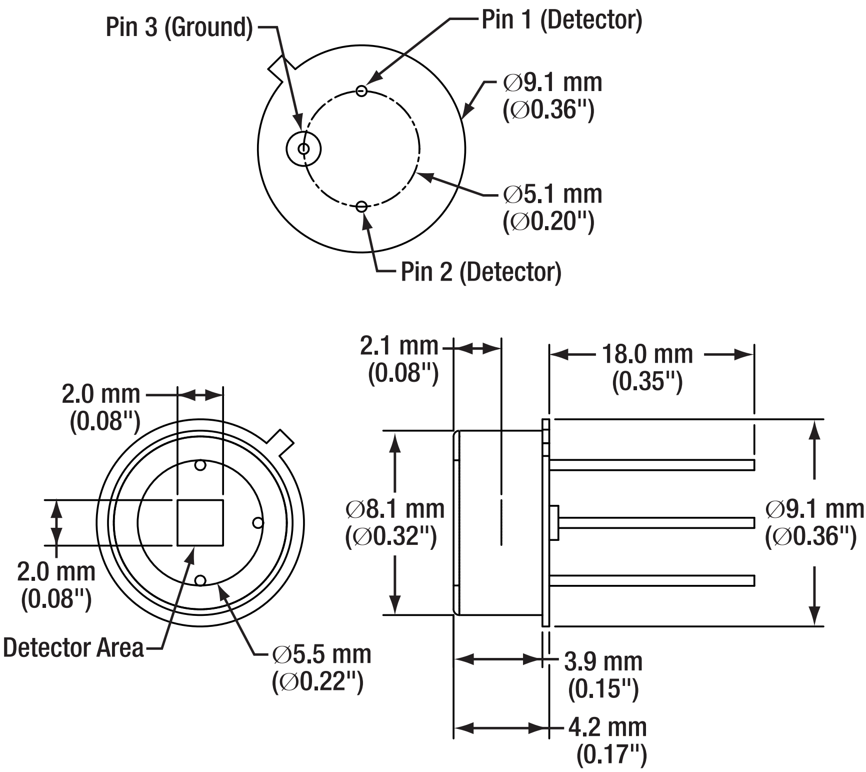


4.5. Temperature vs. Sensitivity



Chapter 5 Mechanical Drawing

Visit the web for a more detailed mechanical drawing.



Chapter 6 Regulatory

As required by the WEEE (Waste Electrical and Electronic Equipment Directive) of the European Community and the corresponding national laws, Thorlabs offers all end users in the EC the possibility to return “end of life” units without incurring disposal charges.

- This offer is valid for Thorlabs electrical and electronic equipment:
- Sold after August 13, 2005
- Marked correspondingly with the crossed out “wheelie bin” logo (see right)
- Sold to a company or institute within the EC
- Currently owned by a company or institute within the EC
- Still complete, not disassembled and not contaminated

Wheelie Bin Logo

As the WEEE directive applies to self contained operational electrical and electronic products, this end of life take back service does not refer to other Thorlabs products, such as:

- Pure OEM products, that means assemblies to be built into a unit by the user (e.g. OEM laser driver cards)
- Components
- Mechanics and optics
- Left over parts of units disassembled by the user (PCB’s, housings etc.).

If you wish to return a Thorlabs unit for waste recovery, please contact Thorlabs or your nearest dealer for further information.

6.1. Waste Treatment is Your Own Responsibility

If you do not return an “end of life” unit to Thorlabs, you must hand it to a company specialized in waste recovery. Do not dispose of the unit in a litter bin or at a public waste disposal site.

6.2. Ecological Background

It is well known that WEEE pollutes the environment by releasing toxic products during decomposition. The aim of the European RoHS directive is to reduce the content of toxic substances in electronic products in the future.

The intent of the WEEE directive is to enforce the recycling of WEEE. A controlled recycling of end of life products will thereby avoid negative impacts on the environment.

Chapter 7 Thorlabs Worldwide Contacts

For technical support or sales inquiries, please visit us at www.thorlabs.com/contact 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
www.thorlabs.com