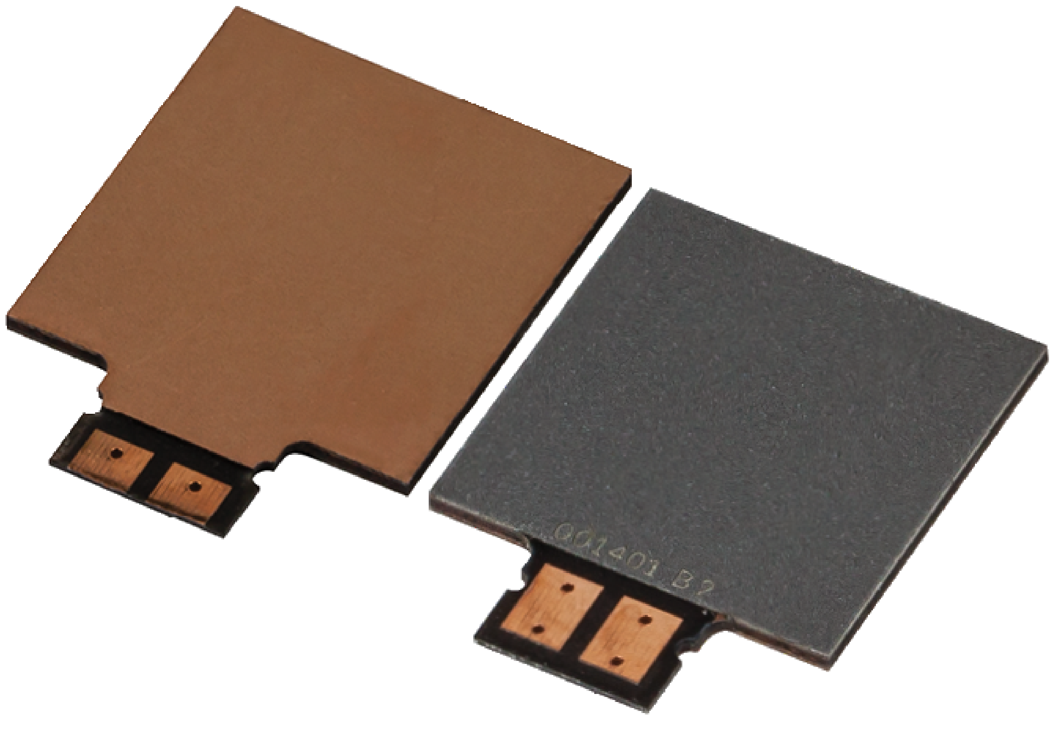
THORLABS

Thermal Detectors

TD2X, TD4X, TD10X,
TD2XP, TD4XP, TD10XP, TD15A,
TD4HP18XA, TD4HR18XP

Handling Instructions



2019

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Contents

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

Thermal detectors measure the optical power of incident light radiation. The absorber on the detector surface converts the incident light into heat energy. The heat flows from the absorber, across the sensor, and into a heat sink mounted to the back side of the detector, where it is dissipated. Due to the thermoelectric effect, the resulting temperature gradient across the multiple thermocouples in the sensor generates a voltage that is proportional to the optical power of the incident radiation. The voltage can be measured with a voltmeter connected across the terminals on the thermal detector.

Since a thermal gradient across the sensor is required for voltage generation, it is crucial that the back side of the Thermal Detector is mounted to an appropriate heat sink 7.

Thorlabs' thermal detectors are available as unmounted sensors for flexible integration, "ready-to-use" mounted sensors that are mechanically stabilized, and position sensitive devices.

The advantage of the Thorlabs thermal detectors over photodiodes is that thermal detectors have a spectrally flat response over a broad wavelength range that extends from the UV through the mid-IR. Additionally, the thermal detectors have negligible dependency on the angle of incidence.

This document contains the handling instructions for the Thorlabs unmounted and mounted Thermal Detectors, including the position sensitive thermal detector devices (PSD).

Attention

All devices of the Thorlabs Thermal Detector Series are of high quality. To maximally benefit from their outstanding performance, please comply with the instructions for storage, assembly and packaging, as well as mounting 6 and thermal integration 7. Prior to installing a device of the Thorlabs Thermal Detector Series, please read the respective information in this handling instructions manual.

Attention

All safety information and warnings concerning these products can be found in the Safety 13 section of the Appendix.

1.1 Unmounted Thermal Detectors

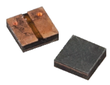
The unmounted thermal detectors are the smallest thermopile detectors that Thorlabs offers and are particularly suitable for integration into limited space. Both mechanical and electrical integration methods can be freely chosen to meet the needs of the application, given that enough cooling is provided. The copper solder pads allow for easy electrical connection and the bottom layer of solderable copper facilitates attachment to a heat sink.

Each of these unmounted thermal detectors is also available as a Mounted Thermal Detector 4.

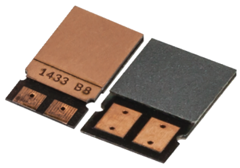
Please follow the here described handling instructions to ensure appropriate thermal integration 7, mechanical 6 mounting and electrical 9 connections.

Available unmounted Thermal Detectors

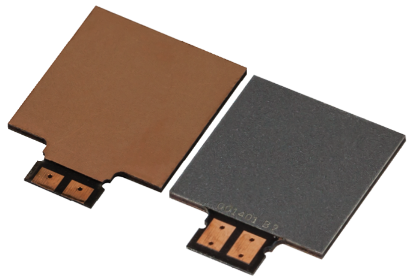
TD2X:	Thermal Detector, Active Area: 2.0 x 2.0 mm^2
TD4X:	Thermal Detector, Active Area: 4.4 x 4.4 mm^2
TD10X:	Thermal Detector, Active Area: 10.0 x 10.0 mm^2



TD2X



TD4X



TD10X

Note

Please find detailed technical data on the Thermal Detector Series in the respective Specification Sheet, to be downloaded from the Thorlabs website.

1.2 Mounted Thermal Detectors

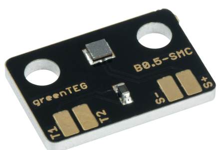
Thorlabs' mounted thermal detectors are specifically designed to be readily integrated into systems where space is limited.

Each mounted thermal detector includes a thermopile-based sensor mounted on a substrate. The TD2XP, TD4XP and TD10XP have rectangular active areas and are mounted on PCBs, while the TD15A has a circular active area and is mounted on an aluminum substrate.

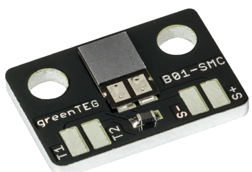
All models include solder terminals and mechanical features for mounting them to a heat sink: the TD2XP, TD4XP, and TD10XP have two Ø3.3 mm mounting holes, and the TD15A has 4 mounting points with 1.6 mm radii. In addition, the TD2XP, TD4XP, and TD10XP include an NTC thermistor, which has its own solder pads.

Available mounted Thermal Detectors

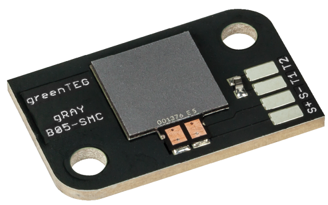
TD2XP:	PCB Mounted Thermal Detector, Active Area: 2.0 x 2.0 mm^2 (TD2X), Mounting Holes: ∅ 3.3 mm, NTC Thermistor
TD4XP:	PCB Mounted Thermal Detector, Active Area: 4.4 x 4.4 mm^2 (TD4X), Mounting Holes: ∅ 3.3 mm, NTC Thermistor
TD10XP:	PCB Mounted Thermal Detector, Active Area: 10.0 x 10.0 mm^2 (TD10X), Mounting Holes: ∅ 3.3 mm, NTC Thermistor
TD15A:	Round Thermal Detector on Aluminum Substrate, Active Area: ∅ 15.0 mm, Mounting Points: Radius = 1.6 mm



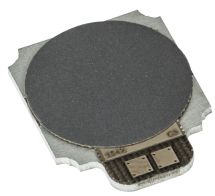
TD2XP



TD4XP



TD10XP



TD15A

Note

Please find detailed technical data on the Thermal Detector Series in the respective Specification Sheet, to be downloaded from the Thorlabs website.

1.3 Thermal Position Detectors

Thorlabs' Thermal Position Detectors are based on four contiguous thermopile-based sensors arranged as quadrants of a square. Their mechanical integration thermally couples the four quadrants. However, the sensor in each quadrant is electrically independent with its own solder terminals, electrically connected to only the thermocouples in that quadrant. This mechanical integration and electrical separation forms a position sensitive device (PSD).

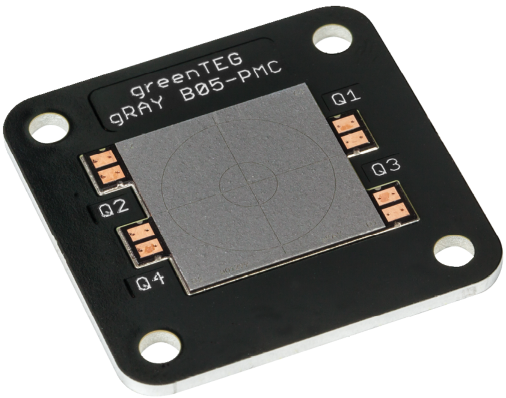
If the beam spot is incident on one quadrant, the output signal from this quadrant will be higher than the output signals of the other three quadrants. If the beam moves towards the center of the PSD, the signals from the four quadrants will become more similar. The X and Y position of the beam is determined by comparing the signal intensities of all four quadrants.

The TD4HR18XP includes four Ø3.4 mm mounting holes, and the TD4HP18XA includes four 1.6 mm radii mounting points. Please follow the setup and data acquisition 9 instructions to use these thermal position sensors.

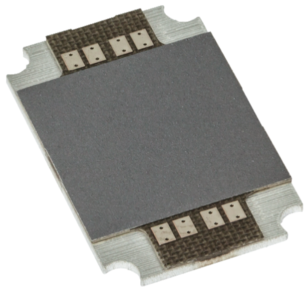
Available Thermal Position Detectors:

TD4HR18XP: PCB-Mounted Thermal Position Detector, Active Area: 18 x 18 mm^2

TD4HP18XA: Aluminum Substrate mounted Thermal Position Detector, Active Area: 18 x 18 mm^2



TD4HR18XP


TD4HP18XA

Note

Please find detailed technical data on the Thermal Detector Series in the respective Specification Sheet, to be downloaded from the Thorlabs website.

2 Thermal Detector Setup

Note

Inspect the shipping container for damage.

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

Thermal detectors must be both mechanically stabilized and mounted on an appropriate heat sink which dissipates heat from the incident laser light and prevents overheating of the detector. To ensure sufficient cooling, choose a heat sink with high thermal conductivity and minimized thickness and follow the thermal integration 7 instructions. To adequately mount the heat sink, follow the instructions in mounting methods 6.

Mounted thermal detector

When the thermal detector is mounted 4 on a holder that provides mechanical stabilization but is not an adequate heat sink, the holder should be mounted onto an appropriate heat sink. This applies to all mounted detectors 4, including the thermal position detectors 5.

Unmounted thermal detector

When the thermal detector is unmounted 3 and the heat sink does not provide adequate mechanical stabilization, the detector must first be mounted on a holder that provides the necessary mechanical stabilization. This holder should then be mounted on an appropriate heat sink.

An unmounted 3 thermal detector can be mounted directly on the heat sink, given that the heat sink provides adequate mechanical stabilization.

Electrical Connections

After the thermal detector is mechanically stabilized and mounted to its heat sink, establish electrical connections 9 to the detector.

2.1 Mounting Methods

2.1.1 Thermally Conductive Tape

Thermally conductive tape should only be used for experiments where a quick setup is first priority and the thermal coupling is of secondary importance.

Follow these steps:

1. Clean the surface of your heat sink according to manufacturers instructions.
2. Do not touch the gray surface of the sensor absorber coating with bare skin! Use a protective layer (e.g. thin, clean polymer foil or wear powder-free gloves) for protection of the absorber coating.
3. Clean the detector backside surface with ethanol or isopropanol.

   Attention

   Do not use acids or bases for cleaning the detector!

2. Apply the tape to the backside of the sensor. Mount the sensor onto the surface of the heat sink by applying gentle pressure to establish adhesion. Use a force below 2 kg/cm^2.
3. Remove the protective layer prior to detector operation.

2.1.2 Thermally Conductive Glue

Thermally conductive glue is suitable for applications where additional mechanical stability is required and a good thermal contact is important. It ensures strong thermal coupling and adapts to surface inhomogeneities.

Follow these steps:

1. Clean the surface of your heat sink according to manufacturers instructions.
2. Do not touch the sensor with bare skin! Use a protective layer (e.g. thin, clean polymer foil or wear powder-free gloves) for protection of the absorber coating.
3. Clean the detector backside surface with ethanol or isopropanol.

   Attention

   Do not use acids or bases for cleaning the detector!

2. Spread a thin layer of thermal glue according to manufacturer instructions onto the backside of the sensor.
3. Press the sensor onto the surface of the heat sink and follow the curing instructions of the glue. Use a force below 2 kg/cm^2.
4. Remove the protective layer prior to detector operation.

2.1.3 Soldering

The unmounted thermal detectors 3 can be integrated as an SMD component onto a metal-core PCB to ensure both good thermal coupling with a heat sink and electric interface. The unmounted thermal detectors include a bottom layer of solderable copper which enables a reflow solder process.

Follow these steps:

1. Prepare a metal-core PCB to include the required land pattern of the unmounted detector. Dimensions of the unmounted thermal detectors are provided in their respective specification sheets.
2. Do not touch the sensor with bare skin! Use a protective layer (e.g. thin, clean polymer foil or wear powder-free gloves) for protection of the absorber coating.
3. Clean the detector backside surface with ethanol or isopropanol.
4. For enhanced solderability, pre-tinning the two solder pads of the detector prior to the reflow process is recommended. Spread a ~120 mm thick layer of low temperature solder paste onto the predefined PCB land pattern.
5. Place the detector component on the PCB aligned with the land pattern and cure the solder.
6. Remove any used protective layer before placing the detector inside the oven. The reflow temperature should not exceed 180 °C.

2.2 Thermal Integration

This section describes the recommended thermal integration for Thorlabs thermal detectors, both mounted and unmounted.

Thermal detectors generate a voltage in response to temperature changes induced by incident light and thus rely on a stable, sufficiently sharp temperature gradient between the absorber surface and the detector back side. Both the incident light and the background environment temperature influence this gradient and the measurement results.

Provide active or passive cooling to maintain the temperature gradient and stabilize the temperature of the module close to room temperature throughout the measurement.

The method of thermal stabilization depends on the incident power expected during the measurement. Use the following table as a guideline for selecting the thermal stabilizer.

Incident Power on Detector	Thermal Stabilizer
Up to 1 W	Heat Sink (e.g. Aluminum Block) of 25 cm^3
1 W - 5 W	Passive Heat Sink e.g. 5 x 5 x 2.5 cm^3 (thermal resistance < 5 K/W)
5 W - 50 W	Passive Heat Sink e.g. 10 x 10 x 4 cm^3 (Thermal Resistance < 2.5 K/W)
> 50 W	Active Cooling with a Fan or Water Cooling through an Externally Supplied Cooling Circuit

Note

The values given in the table are guidelines. Other important factors, such as the room temperature and air convection, need to be taken into account for each system individually.

The following three mounting methods are suitable for mounting the detectors 8 onto a heat sink and mechanical holder:

- Thermally Conductive Tape 6
- Thermally Conductive Glue 7
- Soldering 7

When the detector is thermally integrated and mechanically stabilized, establish the electrical connection 9.

Note

Because the output voltage provided by the sensor is a product of both the light signal and the background temperature, integrate the Temperature Corrected Radiant Sensitivity (Z) 11 into your calculation to convert the output voltage into incident light power 11.

2.2.1 Mounting the Detector on a Heat Sink

Follow these steps:

1. Ensure that the surface of the stabilizer is flat, dry, and free of dust and grease. Clean the detector backside surface with ethanol or isopropanol and mount the detector on the thermal stabilizer.

   Attention

   Do not use acids or bases for cleaning the detector! Do not expose the gray sensor side to isopropanol or ethanol.

2. To ensure good thermal coupling between the detector and the heat sink, use one of the above described mounting methods 6. Air gaps are thermally insulating and greatly distort the cooling efficiency of the heat sink.

Note

If the detector will be mechanically mounted to an element of the optical system setup, the holder needs to have sufficiently low thermal resistance 7.

2.2.2 Active Cooling with Water

- Use any water/liquid cooling circuit of your liking and mount the detector onto it as described in the section Mounting the Detector on a Heat Sink 8.
- Follow the instructions of the respective cooling system.
- The water/liquid temperature must be maintained at temperatures between 15 °C and 25 °C to ensure accurate measurement results based on the calibration at 20 °C. Temper-

ature changes on the time scale of minutes can be misinterpreted as power fluctuations and need to be avoided.

- Maintain a constant water/liquid flow rate. This can be controlled by a valve or the pump settings. Notice that fluctuations or very high flow rates may cause noise on the output signal of the detector.

2.3 Electrical Connection

Following mounting onto a heat sink, connect the thermal detector to an appropriate milli-voltmeter to measure small voltages in the µV range.

1. Solder two wires to the solder pads of the thermal detector.
2. Hook up the detector electrically by connecting the two wires to your voltmeter and record the analog voltage signal while the detector is illuminated.

Attention

Never expose the detector to a power density above 1.5 kW/cm² and keep pulses below 0.3 J/cm² (1 ns pulse) or 5 J/cm² (1 ms pulse), respectively, as exceeding these limits will damage the absorber!

2.4 Setup of Thermal Position Detectors

The X and Y position of the incident laser beam can be determined by comparing the signal measured in each quadrant of the sensor. This produces a direct readout of the beam position.

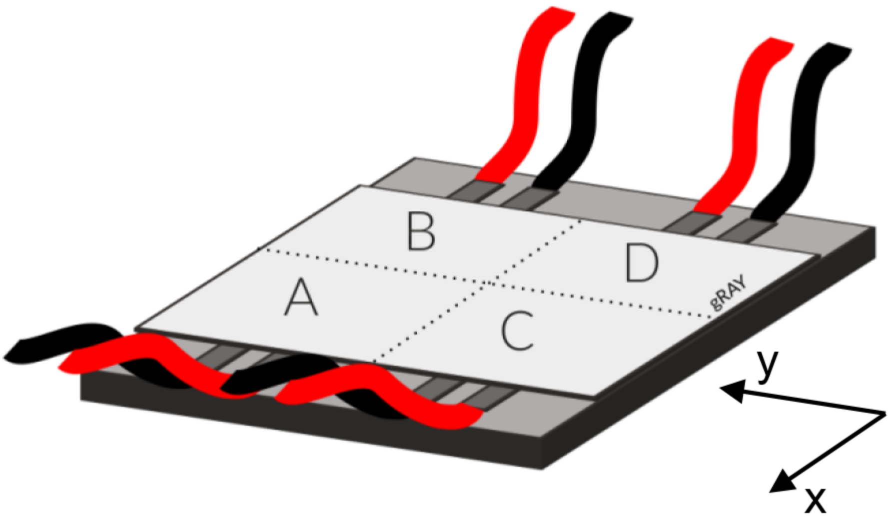


Figure 1: Thermal Position Detector Schematic

Set up the x-y read-out by following these steps:

1. Mount the detector onto a mechanical and thermal stabilizer 7.
2. Connect each of the four PSD segments to different channels of your voltage read-out unit (A=channel 1; B = channel 2; C = channel 3; D = channel 4). The polarity is indicated in Figure 1, where **RED** marks the positive and **BLACK** indicates the negative pole of the respective sensor element. For instructions, refer to the section electrical connection 9.
3. Record the voltage signals for each segment A, B, C and D while illuminating the sensor surface with a laser beam.
4. To determine the normalized x and y position of the laser beam, use the following equations:

$$X = \frac{(A+C)-(B+D)}{(A+B+C+D)} \qquad Y = \frac{(A+B)-(C+D)}{(A+B+C+D)}$$

5. A coordinate of (X , Y) = (0 , 0) corresponds to the center position.
6. In order to obtain the absolute position of the laser beam, multiply the normalized coordinates by the edge length of one segment (half the total sensor edge length "a", given in the respective Specification Sheet).

   Note

   This absolute position is only valid close to X = Y = 0 with increasing deviations towards the edge of the position sensor due to intrinsic nonlinearity.

3 Data Analysis

This section contains an example of the basic analysis methods needed to interpret data from the Thermal Detector Series.

3.1 Laser Measurement

The power Φ [W] of the laser incident on the detector surface is proportional to the voltage output of the detector and is calculated using the following formula:

$$\Phi = U/Z \quad [W]$$

U = detector output voltage in [V]

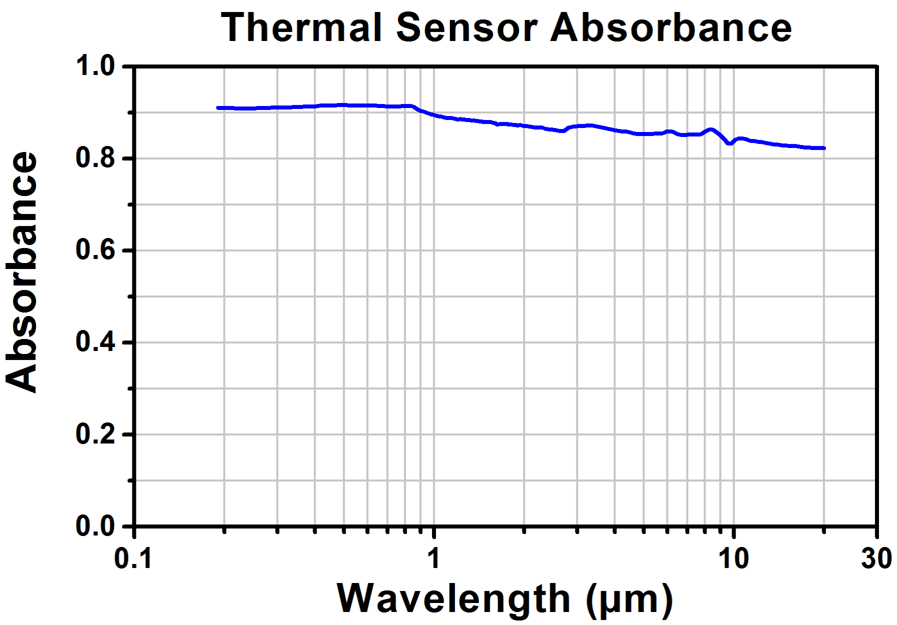
Z = temperature corrected radiant sensitivity of the detector [V/W]

The value of Z should be determined with a reference sensor after mechanical integration. For the following thermal detector sensor components, typical values are:

TD4X:	Z = 100 mV/W
TD10X:	Z = 100 mV/W
TD15A:	Z = 1 mV/W

3.2 Wavelength Corrected Sensitivity

The coating on the detector surface determines the percentage of incoming light that is absorbed. The absorber coating is an inorganic absorber designed for high damage threshold and broad-band absorption characteristics. Although the spectral absorption is designed to be flat throughout the wavelength range from UV to MIR, a small variation of absorptivity cannot be entirely excluded.



4 Maintenance and Service

Protect the Thorlabs thermal detectors from adverse weather conditions.

While the gray coating may be rinsed with distilled water, do not submerge the device in water as this will impact the soldering pads.

Attention

To avoid damage to the instrument and clean the product prior to integration, please clean the back of the unmounted sensor with isopropanol or ethanol only. Rinse the absorber surface (gray coating) of the sensor only with ddH$_2$O.

The unit does not require regular maintenance by the user. It does not contain any modules or components that could be repaired by the user himself. If a malfunction occurs, please contact Thorlabs for return instructions.

Attention

Avoid touching the absorber surface (gray surface) with bare hands! Use a protective layer (e.g. thin polymer foil or powder-free gloves) for protection of the absorber coating.

Storage

Store unused thermal detectors at ambient temperatures in a clean and dry place. In order to protect the absorber surface, place it back into the shipping package (wrap the detector in the polymer foam).

5 Appendix

5.1 Technical Data and Dimensions

Technical specifications and dimensions of the Thermal Detector Series are described in the respective Specification Sheet to be downloaded from the Thorlabs web page.

5.2 Safety

Attention

The safety of any system incorporating the here described 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.

These thermal detectors must not be operated in explosion endangered environments!

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

Users that change or modify the product described in this manual in a way not expressly approved by Thorlabs could void the user's authority to operate the equipment.

Attention

Mobile telephones, cellular phones or other radio transmitters are not to be used within the range of three meters of this unit since the electromagnetic field intensity may then exceed the maximum allowed disturbance values according to IEC 61326-1.

Attention

These products are sensitive to ESD (electro static discharge) and as a result are not covered under warranty. All herein described products are tested for functionality prior to delivery. Any applied voltage in excess of the maximum specification will cause damage to and possible complete failure of the product. The user must use handling procedures that prevent any electrostatic discharges or other voltage surges when handling or using these devices.

The user must avoid any misuse that could cause damage to the detector. Misuse includes, but is not limited to, laser exposure or high voltage exposure outside Thorlabs specifications, physical damage due to improper handling and exposure to harsh environments. Harsh environments include, but are not limited to, excessive temperature, vibration, humidity, chemicals or surface contaminants, exposure to flame, aggressive solvents and connection to improper electrical voltage.

Precautions for Use and Storage:

- Operation in 10% to 80% humidity and -20 °C to +30 °C
- Storage in dark place with 10% to 90% humidity and -20 °C to +50 °C
- Never expose the detector to a power density above 1.5 kW/cm² and keep pulses below 0.3 J/cm² (1 ns pulse) or 5 J/cm² (1 ms pulse), respectively, as this will damage the absorber!

Thorlabs, Inc. Life Support and Military Use Application Policy is stated below:

THORLABS' PRODUCTS ARE NOT AUTHORIZED FOR USE AS CRITICAL COMPONENTS IN LIFE SUPPORT DEVICES OR SYSTEMS OR IN ANY MILITARY APPLICATION WITHOUT THE EXPRESS WRITTEN APPROVAL OF THE PRESIDENT OF THORLABS, INC.

As used herein:

1. Life support devices or systems are devices or systems which, (a) are intended for surgical implant into the body, or (b) support or sustain life, and whose failure to perform, when properly used in accordance with instructions for use provided in the labeling, can be reasonably expected to result in a significant injury to the user.

2. A critical component is any component in a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system or to affect its safety or effectiveness.

3. The Thorlabs products described in this document are not intended nor warranted for usage in Military Applications.

5.3 Warranty

Thorlabs warrants material and production of the thermal detectors described in this document 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.

5.4 Copyright and Exclusion of Reliability

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.

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5.6 Thorlabs WEEE Policy

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 dissembled 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.

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