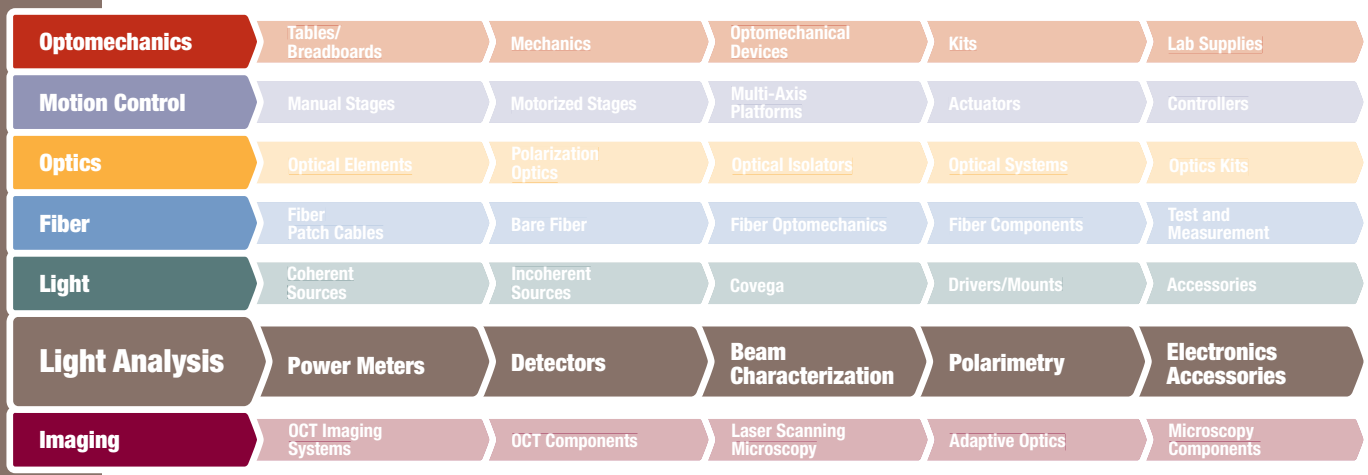
# Light Analysis Catalog




The same categories can be found online: www.thorlabs.com

## Light Analysis

# Power Meter Selection Guide

Pages 1265-1284


### Power and Energy Meter

- Large 4" Digital Display
- Over 25 Compatible Sensors
- USB2.0 Interface

**See Pages 1266-1269**


### Power Meter with Analog Needle

- Optimized Power Tuning
- Integrated Graphical LCD
- USB2.0 Interface

**See Pages 1270-1271**


### Power and Energy Meter

- USB2.0 Interface
- Over 25 Compatible Sensors
- Powered via USB2.0 Interface

**See Pages 1271-1273**


### Power and Energy Benchtop Meter

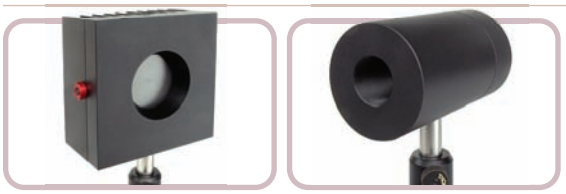
- Programmable Comparison Functions
- 4.4" Graphical Display
- USB2.0 Interface

**See Pages 1274-1275**

### Photodiode Power Sensors

- 200-1800 nm; 100 pW - 20 W
- Standard Free-Space and Specialized Fiber Sensors

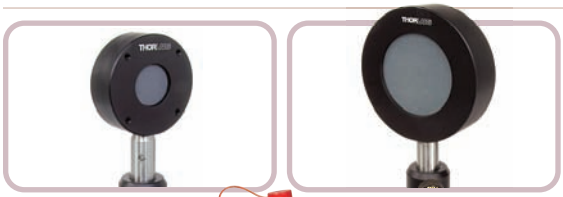
**See Pages 1276-1279**



### Thermal Power Sensors

- 190 nm - 25 µm; 100 µW - 200 W
- For General-Purpose Applications or High Peak Powers

**See Pages 1280-1281**



### Pyroelectric Energy Sensors

- 185 nm - 25 µm; 3 µJ - 15 J
- Broadband or High Damage Thresholds

**See Pages 1282-1283**


### Fiber Power Meter with Integrated Sensor

- 400-1700 nm, 1 nW - 200 mW
- Rugged, Compact, and Easy to Use

**See Page 1284**

## 50 nW - 50 mW Power, 400-1100 nm


NEW product

Post, Post Holder, and Base Plate Included

**PM120D**
(PM100D with S120C Photodiode Sensor Head)

### Features
- 50 nW - 50 mW Power Detection
- 400 - 1100 nm Wavelength Detection
- Si Sensor, Digital Optical Power Meter
- Integrated IR Viewing Target for Easy Sensor Alignment
- Enhanced Shielding Against Electromagnetic Interference
- Over Temperature Alert Sensor
- NIST-Traceable Data Stored in Sensor Connector

Our PM120D Power Meter includes our PM100D Console and our S120C Photodiode Sensor Head. The PM100D console is a completely new design that replaces the popular PM100. While the PM100 was solely a power meter, the PM100D is capable of both power and energy measurements. It provides improved accuracy and reliability over its previous-generation counterpart. The PM120D Power is an economical and versatile meter that is ideal for everyday use.

| ITEM# | $ | £ | € | RMB | DESCRIPTION |
|---|---|---|---|---|---|
| PM120D | $ 1,265.00 | £ 877.00 | € 1.123,10 | ¥ 10,682.00 | Digital Handheld Power Meter, Si Sensor, 400 - 1100 nm, 50 nW - 50 mW |

## 500 nW - 500 mW Power, 400-1100 nm


NEW product

Post, Post Holder, and Base Plate Included

**PM121D**
(PM100D with S121C Photodiode Sensor Head)

### Features
- 500 nW - 500 mW Power Detection
- 400 - 1100 nm Wavelength Detection
- Si Sensor, Digital Optical Power Meter
- Integrated IR Viewing Target for Easy Sensor Alignment
- Enhanced Shielding Against Electromagnetic Interference
- Over Temperature Alert Sensor
- NIST-Traceable Data Stored in Sensor Connector

Our PM121D Power Meter includes our PM100D Console and our S121C Photodiode Sensor Head. The PM100D console is a completely new design that replaces the popular PM100. While the PM100 was solely a power meter, the PM100D is capable of both power and energy measurements. It provides improved accuracy and reliability over its previous-generation counterpart. The PM121D Power Meter is designed for high-power applications.

| ITEM# | $ | £ | € | RMB | DESCRIPTION |
|---|---|---|---|---|---|
| PM121D | $ 1,285.00 | £ 890.80 | € 1.140,90 | ¥ 10,851.00 | Digital Handheld Power Meter, Si Sensor, 400 - 1100 nm, 500 nW - 500 mW |

## 500 pW - 500 mW Power Meter, 400-1100 nm


NEW product

**PM130D**
(PM100D with S130C Photodiode Sensor Head)

Post, Post Holder, and Base Plate Included

### Features
- 500 pW - 500 mW Power Detection
- 400 - 1100 nm Wavelength Detection
- Si Sensor, Digital Optical Power Meter
- Integrated IR Viewing Target for Easy Sensor Alignment
- Enhanced Shielding Against Electromagnetic Interference
- Over Temperature Alert Sensor
- NIST-Traceable Data Stored in Sensor Connector

Our PM130D Power Meter includes our PM100D Console and our S130C Photodiode Sensor Head. The PM100D console is a completely new design that replaces the popular PM100. While the PM100 was solely a power meter, the PM100D is capable of both power and energy measurements. It provides improved accuracy and reliability over its previous-generation counterpart. The PM130D Power Meter is ideal for setups where space is limited.

| ITEM# | $ | £ | € | RMB | DESCRIPTION |
|---|---|---|---|---|---|
| PM130D | $ 1,425.00 | £ 987.90 | € 1.265,00 | ¥ 12,033.00 | Digital Handheld Power Meter, Si Sensor, 400 - 1100 nm, 500 pW - 500 mW |

# Analog/Digital 50 nW - 50 mW Power Meter, 200-1100 nm

**PM120VA**
(PM100A with S120VC Photodiode Sensor Head)

Post, Post Holder, and Base Plate Included

NEW product

### Features
- 50 nW - 50 mW Power Detection
- 200-1100 nm Wavelength Detection
- Si Sensor, Analog/Digital Optical Power Meter
- Integrated IR Viewing Target for Easy Sensor Alignment
- Enhanced Shielding Against Electromagnetic Interference
- Over Temperature Alert Sensor
- NIST-Traceable Data Stored in Sensor Connector

The PM120VA combines our PM100A Analog Console with our S120VC Photodiode Sensor Head. The PM100A, which is a new device based on our older PM30 and PM50 consoles, provides improved accuracy, reliability, and functionality. It offers broad current and voltage measurement ranges as well as compatibility with our photodiode and thermal sensors. The PM120VA is an economical and versatile meter designed for wide dynamic range optical power measurements in the 200 to 1100 nm range.

| ITEM# | $ | £ | € | RMB | DESCRIPTION |
|---|---|---|---|---|---|
| PM120VA | $ 1,375.00 | £ 953.20 | € 1.220,80 | ¥ 11,611.00 | Analog/Digital Power Meter, Si Sensor, 200 - 1100 nm, 50 nW - 50 mW |

# 50 nW - 40 mW Power Meter, 700-1800 nm

**PM122D**
(PM100D with S122C Photodiode Sensor Head)

Post, Post Holder, and Base Plate Included

NEW product

### Features
- 50 nW - 40 mW Power Detection
- 700 - 1800 nm Wavelength Detection
- Ge Sensor, Digital Optical Power Meter
- Integrated IR Viewing Target for Easy Sensor Alignment
- Enhanced Shielding Against Electromagnetic Interference
- Over Temperature Alert Sensor
- NIST-Traceable Data Stored in Sensor Connector

Our PM122D Power Meter includes our PM100D Console and our S122C Photodiode Sensor Head. The PM100D console is a completely new design that replaces the popular PM100. While the PM100 was solely a power meter, the PM100D is capable of both power and energy measurements. It provides improved accuracy and reliability over its previous-generation counterpart. The PM122D is an economical and versatile meter for use in the 700 to 1800 nm range.

| ITEM# | $ | £ | € | RMB | DESCRIPTION |
|---|---|---|---|---|---|
| PM122D | $ 1,535.00 | £ 1,064.00 | € 1.363,00 | ¥ 12,962.00 | Digital Handheld Power Meter, Ge Sensor, 700 - 1800 nm, 50 nW - 40 mW |

# Thermal 10 mW to 10 W Power Meter 0.19-25 µm

**PM310D**
(PM100D with S310C Thermal Sensor Head)

Post, Post Holder, and Base Plate Included

NEW product

### Features
- 10 mW - 10 W Power Detection
- 0.19 - 25 µm Wavelength Detection
- Thermal Optical Power Meter
- Integrated IR Viewing Target for Easy Sensor Alignment
- Enhanced Shielding Against Electromagnetic Interference
- Over Temperature Alert Sensor
- NIST-Traceable Data Stored in Sensor Connector

Our PM310D Power Meter includes our PM100D Console and our S310C Photodiode Sensor Head. Our PM100D console is a completely new design that replaces the popular PM100. While the PM100 was solely a power meter, the PM100D is capable of both power and energy measurements as well as improved accuracy and reliability over the previous generation. The PM310D is an economical and versatile meter for free-space optical power measurements in the 0.19 to 25 µm range.

| ITEM# | $ | £ | € | RMB | DESCRIPTION |
|---|---|---|---|---|---|
| PM310D | $ 1,660.00 | £ 1,150.50 | € 1.474,00 | ¥ 14,018.00 | Digital Handheld Power Meter, Thermal Sensor, 0.19 - 25 µm, 10 mW - 10 W |

**Fiber Power Sensor**
- Compact Sensor
- PM100D Compatible
- NIST-Traceable Data

See page 1278

# Digital Handheld Power and Energy Meter (Page 1 of 2)


PM100D

NEW product

## Features

- Power and Energy Measurements
- 4" Backlit Digital Display
- New Design for High Accuracy and Reliability
- Rechargeable Battery Lasts up to 12 Hours
- USB2.0 Connectivity
- SD Card Slot for Recording Data
- 16 Bit A/D Converter

Our new PM100D power and energy meter is a completely new design that replaces the popular PM100. While the PM100 was solely a power meter, the PM100D is capable of both power and energy measurements. Our new meter also offers improved accuracy and reliability over the previous generation. With a large, backlit 4" display and backlit buttons, it is a versatile meter that is ideal for everyday use.

The PM100D is compatible with all of the new C-Series sensors. These sensors include photodiode, thermal, and pyroelectric sensors. The current C-Series offerings cover powers from 5 nW to 250 W and energies from 3 µJ to 15 J, with wavelengths between 185 nm and 25 µm. Included in this sensor range are compact fiber sensors, which are the size of a DB9 connector and attach directly to the console, turning the PM100D into an all-in-one fiber power meter. With the PM100D, you can wire your own unamplified photodiodes (anode ground), thermopiles, and pyroelectric sensors to a DB9 connector. Many of our previous A- and B-Series sensors can be updated for a nominal fee to be compatible with our new line of power and energy meters. Contact Tech Support for a quote.

## Compatible Sensors:

- S100C Series of Photodiode Sensors
- S300C Series of Thermal Sensors
- ES100C and ES200C Series of Pyroelectric Sensors
- Photodiodes (Max 5 mA)
- Thermopiles (Max 1 V)
- Pyroelectric Sensors (Max 100 V)

The PM100D's digital screen has a number of display options including numerical, graphical, simulated analog needle, and statistics. It can be used manually or be remotely controlled via the USB2.0 computer interface. When connected to a computer, it is easy to record data using the GUI and drivers that are included on the 1 GB USB thumb drive. An SD memory card slot is on the bottom for saving data when not tethered to a computer. A 1 GB SD card is included with each unit. An SMA connector on the side provides a sensor output (0 - 2 V, 100 kHz), which is the amplified input signal (not corrected). This can be used for monitoring the signal or to control external processes.

The PM100D has an internal battery, offering up to 8 hours of operation per charge. Charge the PM100D via USB or by using the included power adapter.

A 1/4"-20 hole is at the base of the meter for post mounting (see page xxx for threading adapters). In addition, the unit has a kickstand on the back to stand the unit on a table.

### Photodiode Sensors

See Pages 1276-1279

### Thermal Sensors

See Pages 1280-1281

### Pyroelectric Sensors

See Pages 1282-1283

# Digital Handheld Power and Energy Meter (Page 2 of 2)

| | |
|---|---|
| **Photodiode Sensor Input (Current)** | |
| Measurement Ranges | 6 Decades; 50 nA - 5 mA |
| Units | W, dBm, W/cm², A |
| Accuracy | ±0.2% of Full Scale (5 µA - 5 mA)<br>±0.5% of Full Scale (50 nA) |
| Bandwidth | DC to 100 kHz, Dependent on Sensor and Settings |
| **Thermopile Sensor Input (Voltage)** | |
| Measurement Ranges | 4 Decades; 1 mV - 1 V |
| Units | W, dBm, W/cm², V |
| Accuracy | ±0.5% of Full Scale (10 mV - 1 V)<br>±1% of Full Scale (1 mV) |
| Bandwidth | DC to 10 Hz, Dependent on Sensor and Settings |
| Time Constant Correction | 1 - 30 s |
| **Analog Output** | |
| Connector | SMA |
| Voltage Range | 0 - 2 V |
| Bandwidth | Up to 100 kHz, Dependent on Sensor and Settings |
| Accuracy | ±3% |
| **Sensor Temperature Control** | |
| Supported Temperature Sensor | Thermistor |
| Temperature Measurement Range | -10 to 80 °C |
| **General** | |
| Sensor Input | Female DB9 for C-Series Connectors |
| Display | 3.20" x 2.40" (81.4 mm x 61 mm), 320 x 240 pixels |
| Display Update Rate | 20 Hz |
| Display Screens | Numerical, Bar Graph, Trend Graph, Statistics, Simulated Analog Needle |
| Memory Card | SD, 1 GB |
| A/D Converter | 16 bit |
| Computer Connectivity | USB2.0, Mini USB |
| Battery | Li-Polymer 3.7 V 1300 mAh; up to 8 hrs Operation |
| Dimensions | 183 mm x 109 mm x 40 mm (7.2" x 4.3" x 1.6") |
| Operating Temp/Storage Temp | 0 to 40 °C/-40 to 70 °C |
| Mounting | Kickstand, 1/4"-20 Mounting Hole |

PM100D with S150C Sensor and Fiber

## PM100D Includes

- PM100D Console
- Storage Case
- Power Adapter (US, UK, Europe, and Australia)
- 1 GB SD Card
- 1 GB USB Thumb Drive with Software, Drivers, and Detailed User Manual
- Calibration Certificate
- Quick-Start Manual
- USB Cable

| ITEM# | $ | £ | € | RMB | DESCRIPTION |
|---|---|---|---|---|---|
| PM100D | $ 990.00 | £ 686.30 | € 879,00 | ¥ 8,359.60 | Digital Power and Energy Meter, Digital Display |
| CAL-PM100 | $ 53.80 | £ 37.30 | € 47,80 | ¥ 454.30 | Recalibration Service |

## Analog Meter and Compact Sensor Interface


PM320E

- Two-Channel Benchtop Unit
- Power and Energy Measurements
- Differential and Ratiometric Measurement Capabilities
- USB2.0

See Page 1274


PM100A

- Analog Needle with Integrated Digital Display
- Power Measurements
- Same Compact Housing as PM100D
- USB2.0

See Page 1270


PM100USB

- Same Performance as PM100D without a Display
- Power and Energy Measurements
- Compact, Rugged Housing
- USB2.0 Sensor Interface

See Page 1272

# Power Meter with Analog Needle and LCD (Page 1 of 2)

NEW product


## Features

- Optical Power Measurements and Tuning
- Analog Needle with 132 x 32 Pixel LCD
- New Design for High Accuracy and Reliability
- Rechargeable Battery Lasts up to 8 Hours
- USB2.0 Connectivity
- Software and Drivers Included on a 1 GB USB Thumb Drive

## Compatible Sensors

- S100C Series of Photodiode Sensors
- S300C Series of Thermal Sensors
- Photodiodes (5 mA Max)
- Thermopiles (1 V Max)

Our new PM100A is a completely new digital power meter with an analog needle and small digital display. It offers improved accuracy and reliability over our previous meters. Unlike the PM100D, the PM100A only offers power measurements. Since its main display is an analog needle, it is best suited for relative power measurements, such as during laser alignment. An acoustic signal further helps with these applications. A 132 x 32 pixel LCD screen on the meter displays information such as absolute measurements, relative measurements, power tuning (with sound), statistics, and wavelength correction.

The PM100A is compatible with over 20 of our new C-Series sensors (excluding pyroelectric sensors) that together are capable of making power measurements in the 190 nm to 25 µm spectral range with power outputs from 100 pW to 200 W. Included in this lineup are fiber sensors that are contained inside a DB9 connector, making them ideal for field measurements where an all-in-one meter is preferred. Additionally, your own unamplified photodiodes (anode ground) or thermopiles can be wired to a DB9 connector and used with this meter. Many of our previous A- and B-Series sensors can be updated for a nominal fee; contact Tech Support for a quote.

While the meter includes a power adapter, it also has an internal Li-Polymer battery for up to 8 hours of remote operation. The battery can be charged either with the power adapter or with a USB2.0 connection. When connected to a USB2.0 port, the meter can be controlled remotely from a computer with the included graphical user interface (GUI). Drivers are included to help customers integrate the meter with third-party software. The GUI and drivers come on a 1 GB USB thumb drive.

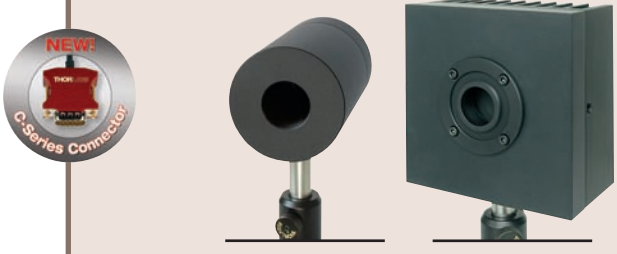
An SMA connector on the side of the meter provides a sensor output (0 - 2 V, 100 kHz), which gives the uncorrected, amplified, input signal. This signal is commonly used to monitor or control external processes.

A 1/4"-20 hole at the base of the meter allows for post mounting (see page xxx for threading adapters). The unit also has a kickstand on the back so it can rest upright on a table. The PM100A comes in a hard storage case, ideal for safely transporting the meter and one sensor.

## Photodiode Sensors


See Page 1276-1279

## Thermal Sensors




See Page 1280-1281

# Power Meter with Analog Needle and LCD (Page 2 of 2)

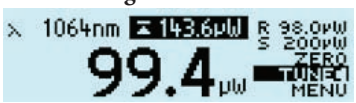
| | |
|---|---|
| **Photodiode Sensor Input (Current)** | |
| Measurement Ranges | 6 Decades; 50 nA - 5 mA |
| Units | W |
| Accuracy | ±0.2% of Full Scale (5 µA - 5 mA)<br>±0.5% of Full Scale (50 nA)<br>±3% Full Scale Analog Meter |
| Bandwidth | DC to 100 kHz, Dependent on Sensor and Settings |
| **Thermopile Sensor Input (Voltage)** | |
| Measurement Ranges | 4 Decades; 1 mV - 1 V |
| Units | W |
| Accuracy | ±0.5% of Full Scale (10 mV - 1 V)<br>±1% of Full Scale (1 mV)<br>±3% Full Scale Analog Meter |
| Bandwidth | DC to 10 Hz, Dependent on Sensor and Settings |
| Time Constant Correction | 1 - 30 s |
| **Analog Output** | |
| Connector | SMA |
| Voltage Range | 0 - 2 V |
| Bandwidth | Up to 100 kHz, Dependent on Sensor and Settings |
| Accuracy | ±3% |
| **Sensor Temperature Measurement** | |
| Supported Temperature Sensor | Thermistor |
| Temperature Measurement Range | -10 to 80 °C |
| **General** | |
| Sensor Input | Female DB9 for C-Series Connectors |
| Display | Analog Needle with 132 x 32 pixel LCD Readout |
| Display Update Rate | 20 Hz |
| Display Screens | Numerical, Relative Measurements, Tuning, Statistics, Mechanical Analog Needle |
| Memory Card | N/A |
| A/D Converter | 16 Bit |
| Computer Connectivity | USB2.0, Mini USB |
| Battery | Li-Polymer 3.7 V 1300 mAh; up to 8 hrs of Operation |
| Dimensions | 7.20" x 4.30" x 1.60" (183 mm x 109 mm x 40 mm) |
| Operating Temp/Storage Temp | 0 to 40 °C/-40 to 70 °C |
| Mounting | Kickstand, 1/4"-20 Mounting Hole |

## PM100A Includes

- Console
- Storage Case
- Power Adapter (US, UK, Europe, and Australia)
- 1 GB USB Thumb Drive with Software and Drivers
- Calibration Certificate
- Quick-Start Manual
- USB Cable

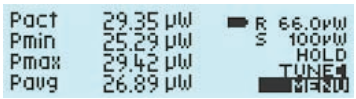
## Digital Display Screens:

**Power Tuning**




**Relative Measurements**


**Statistics**




**Absolute Measurements**


**Wavelength Correction**


| ITEM# | $ | £ | € | RMB | DESCRIPTION |
|---|---|---|---|---|---|
| PM100A | $ 780.00 | £ 540.80 | € 692,50 | ¥ 6,586.40 | Analog Power Meter, Analog Needle with Digital Display |
| CAL-PM100 | $ 53.80 | £ 37.30 | € 47,80 | ¥ 454.30 | Recalibration Service |

## Digital Optical Power Meters


**PM320E**

- Two-Channel Benchtop Unit
- Power and Energy Measurements
- Differential and Ratiometric Measurement Capabilities
- USB2.0

**See Page 1274**


**PM100D**

- 4" Graphical Display
- Power and Energy Measurements
- Handheld, Battery-Powered Meter
- USB2.0

**See Page 1268**


**PM100USB**

- Same Electronics as PM100D without a Display
- Power and Energy Measurements
- Compact, Rugged Housing
- USB2.0 Sensor Interface

**See Page 1272**

# Compact Power and Energy Sensor Interface (Page 1 of 2)

NEW product

PM100USB

## Features

- Power and Energy Measurements
- Compact, Aluminum Housing
- Connects Directly to Computer via USB2.0
- High Accuracy and Reliability
- 16-Bit A/D Converter

## Compatible Sensors

- S100C Series of Photodiode Sensors
- S300C Series of Thermal Sensors
- ES100C and ES200C Series of Pyroelectric Sensors
- Photodiodes (Max 5 mA)
- Thermopiles (Max 1 V)
- Pyroelectric Sensors (Max 100 V)

Our PM100USB power and energy sensor interface is a completely new design that allows the measurement from a power or energy sensor to be read by a computer. The device is run completely by a computer and is ideal for applications that do not require a meter with an on-unit display, such as OEM integration or automated test setups. This unit provides the same high-accuracy electronics as the PM100D for a fraction of the cost.

The compact PM100USB housing consists of an aluminum body with rubber treads to keep it from sliding on a work surface. The housing is only 3.70" x 2.50" x 1.30" (95 mm x 63.5 mm x 32.5 mm), small enough for many OEM applications.

The PM100USB is compatible with all of the new C-Series photodiode, thermal, and pyroelectric sensors. The C-Series offerings can detect powers in the 5 nW to 250 W range, energies from 3 µJ to 15 J, and wavelengths from 185 nm to 25 µm. Included in this sensor range are compact fiber sensors, which are the size of a DB9 connector and attach directly to the console, making a very compact fiber power meter. With the PM100USB, customers can wire their own unamplified photodiodes (anode ground), thermopiles, and pyroelectric sensors to a DB9 connector. Many of our previous A- and B-Series sensors can be updated for a nominal fee to be compatible with our new line of power and energy meters; please contact our Technical Support staff.

New to our power meter console lineup, the PM100USB automatically adjusts to the individual time constant of thermal sensors (1 - 30 s). This greatly improves the response time of the system (sensor and PM100USB).

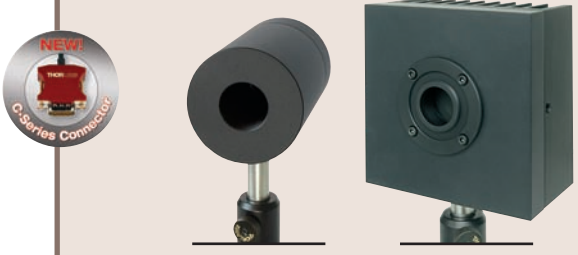
The PM100USB connects to a computer via USB2.0 and is operated with the included graphical user interface (GUI). Recording data is easy with the GUI and can also be accomplished with included drivers. Both the GUI and drivers come on a 1 GB USB thumb drive. The PM100USB is powered through the USB2.0 connection to limit the cables needed.

The GUI has one main graphical panel and two subpanels. For example, it is capable of displaying a histogram of the power or energy reading, the current numerical power or energy, and a log of the recent data points. This software can also show statistical information on the data such as minimum and maximum data points. The data collected by the software can be conveniently exported to a data file.

**Photodiode Sensors**


See Page 1276-1279

**Thermal Sensors**

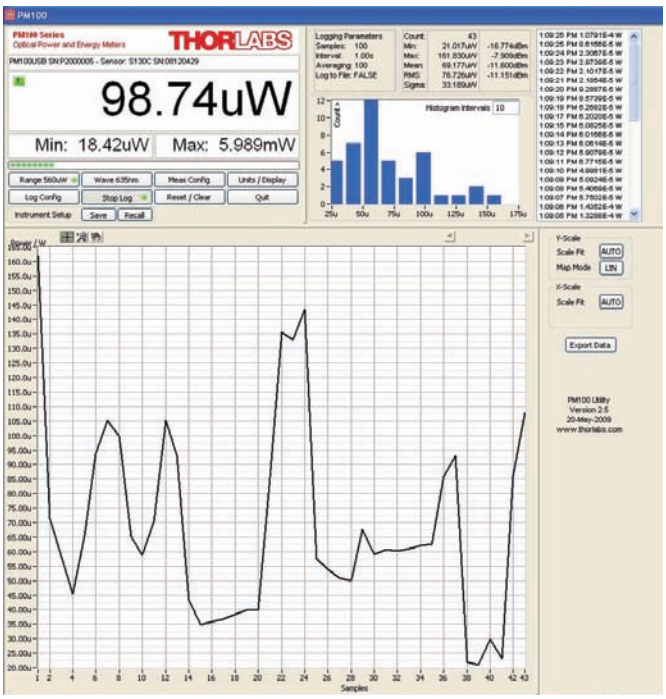



See Page 1280-1281

**Pyroelectric Sensors**


See Page 1282-1283

# Compact Power and Energy Sensor Interface (Page 2 of 2)




A sample of the graphical user interface (GUI) for the PM100USB is shown to the left. The GUI is made up of three windows that each provide a different view of the data. The main window displays power verse time, which is useful in applications where the timing of a peak is necessary. One of the smaller windows shows the current power reading with minimum and maximum power listed directly below the current reading. The second smaller window has a histogram of the data with a log of the power readings and the time that the data point was acquired. Above the histogram is more statistical information on the power reading such as the minimum, maximum, and mean power during the data logging period. This software comes on the included 1 GB USB thumb drive.

### PM100B Includes

- PM100USB Console
- 1 GB USB Thumb Drive with Software, Drivers, and Detailed User Manual
- Calibration Certificate
- Quick-Start Manual
- USB Cable

| Photodiode Sensor Input (Current) | |
|---|---|
| Measurement Ranges | 6 Decades; 50 nA - 5 mA |
| Units | W, dBm, W/cm², A |
| Accuracy | ±0.2% of Full Scale (5 µA - 5 mA)<br>±0.5% of Full Scale (50 nA) |
| Bandwidth | DC to 100 kHz, Dependent on Sensor and Settings |
| **Thermopile Sensor Input (Voltage)** | |
| Measurement Ranges | 4 Decades; 1 mV - 1 V |
| Units | W, dBm, W/cm², V |
| Accuracy | ±0.5% of Full Scale (10 mV - 1 V)<br>±1% of Full Scale (1 mV) |
| Bandwidth | DC to 10 Hz, Dependent on Sensor and Settings |
| Time Constant Correction | 1 - 30 s |
| **Analog Output** | |
| Connector | N/A |
| Voltage Range | N/A |
| Bandwidth | N/A |
| Accuracy | N/A |
| **Sensor Temperature Control** | |
| Supported Temperature Sensor | Thermistor |
| Temperature Measurement Range | -10 to 80 °C |
| **General** | |
| Sensor Input | Female DB9 for C-Series Sensors |
| Display | Customer Supplied PC |
| Display Update Rate | N/A |
| Display Screens | N/A |
| Memory Card | N/A |
| A/D Converter | 16 bit |
| Computer Connectivity | USB2.0, Mini USB |
| Battery | N/A |
| Dimensions | 3.7" x 2.5" x 1.3" (95 mm x 63.5 mm x 32.5 mm) |
| Operating Temp/Storage Temp | 0 to 40 °C/-40 to 70 °C |
| Mounting | N/A |


**PM100USB with S150C Sensor and Fiber**


**S150C**

### Compact Fiber Power Sensors

- 4 Models for the 350-1700 nm Wavelength Range and 100 pW - 20 mW Power Range
- Contained in a DB9 Connector
- Various Fiber Adapters Available

**See Page 1278**

| ITEM# | $ | £ | € | RMB | DESCRIPTION |
|---|---|---|---|---|---|
| PM100USB | $ 390.00 | £ 270.40 | € 346,30 | ¥ 3,293.20 | USB2.0 Digital Power and Energy Sensor Interface |
| CAL-PM100 | $ 53.80 | £ 37.30 | € 47,80 | ¥ 454.30 | Recalibration Service |

# Dual-Channel Power and Energy Meter (Page 1 of 2)


NEW design

**PM320E Benchtop Console**
Sensors Sold Separately

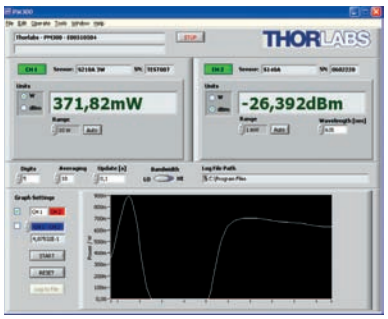
## Features

- Programmable Channels for Monitor, Difference, Ratio, Math Functions, Linear and Log Values, and Attenuation
- USB2.0 Interface
- Large 240 x 128 Pixel Graphics Display
- Programmable Responsivity for Connection of Photodiodes and Thermal Sensors
- Continuous and Single-Shot Energy Measurement of Pulsed Laser Sources
- Adjustable Trigger Threshold, Beam Diameter, and Wavelength
- Monitor and Programmable Analog Outputs
- Externally Triggered Power and Energy Measurements

## Compatible Sensors

- S100C Series of Photodiode Sensors
- S300C Series of Thermal Sensors
- ES100C and ES200C Series of Pyroelectric Sensors
- Photodiodes (10 mA Max)
- Thermopiles (1 V Max)
- Pyroelectric Sensors (100 V Max)

## Sample GUI Display




Thorlabs' dual-channel PM320E power and energy meter offers many features not found in handheld devices. It is ideal for precise optical measurements, laser and photodiode characterization, lifecycle measurements, and many more applications in the lab and on the manufacturing floor. The dual-channel design enables differential and ratiometric measurements. It is easy to integrate into a variety of applications due to its intuitive manual control with large graphics display, compatibility with conventional photodiodes, and excellent remote operation capabilities.

The PM320E is compatible with all of Thorlabs' new C-Series sensors, which include photodiode, thermal, and pyroelectric sensor types. The compatible sensors can be connected to either channel for full functionality. Each sensor is available separately. Many of our previous A- and B-Series sensors can be updated for a nominal fee by contacting Technical Support. Additionally, customers can wire their own photodiodes (anode or cathode ground), thermal elements, or pyroelectric sensors for use with the PM320E.

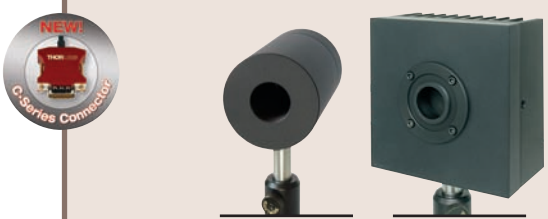
Both C-Series sensors connect via two DB9 connectors on the rear panel, which also provides two analog high-bandwidth outputs to allow monitoring of each channel. Additionally, a programmable analog output is on the rear panel. User-supplied photodiodes connect to the unit on the front panel using the BNC inputs. These inputs feature selectable polarity, switchable bandwidth, and a programmable bias voltage.

On the back of the PM320E is a BNC output, which is gain and function programmable. It provides an analog voltage proportional to the output of one of the channels or as the difference or ratio of the two power meter channels. The rear of the unit has an external trigger input (BNC) for trigger power and energy measurements. The PM320E can be controlled using the front panel, which features a large LCD, or remotely via USB2.0. A graphical user interface (GUI) and drivers are included for remote operation and integration of custom software.

### Photodiode Sensors


See Pages 1276-1279

### Thermal Sensors




See Pages 1280-1281

### Pyroelectric Sensors


See Pages 1283-1283

# Dual-Channel Power and Energy Meter (Page 2 of 2)

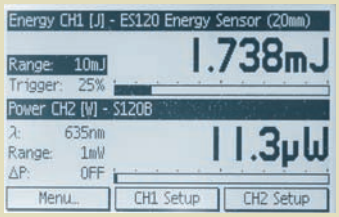
| | |
|---|---|
| **Photodiode Sensor Input (Current)** | |
| Measurement Ranges | 6 Decades; 100 nA - 10 mA |
| Units | W, dBm, W/cm² |
| Accuracy | ±0.2% of Full Screen (1 µA - 10 mA)<br>±0.5% of Full Screen (100 nA) |
| Bandwidth | DC to 100 kHz, Dependent on Sensor and Settings |
| **Thermopile Sensor Input (Voltage)** | |
| Measurement Ranges | 4 Decades; 1 mV - 1 V |
| Units | W, dBm, W/cm² |
| Accuracy | ±0.5% of Full Screen |
| Bandwidth | DC to 10 Hz, Dependent on Sensor and Settings |
| Time Constant Correction | 1 - 30 s |
| **Pyroelectric Sensor Input (Voltage)** | |
| Measurement Ranges | 4 Decades; 100 mV - 100 V |
| Units | J, J/cm², W |
| Accuracy | ±0.5% Full Screen |
| Repetition Rate | 3 kHz |
| **Analog Outputs** | |
| Connector | BNC (2), Rear |
| Voltage Range | 0 to ±10 V |
| Bandwidth | Up to 100 kHz, Dependent on Sensor and Settings |
| Accuracy | ±3% |
| **Programmable Analog Output** | |
| Connector | BNC, Rear |
| Signal | Selectable: CH1, CH2, CH1-CH2, CH1/CH2 |
| Voltage Range | 0 to ±10 V, Programmable Gain Offset |
| Bandwidth | Up to 500 Hz, Dependent on Sensor and Settings |
| **Sensor Temperature Control** | |
| Supported Temperature Sensor | N/A |
| Temperature Measurement Range | N/A |
| **General** | |
| Input | Female DB9 for C-Series Connectors |
| Display | Graphical LCD, 240 x 128 pixels |
| Display Update Rate | 20 Hz |
| Display Screens | Numerical, Bar Graph, Trend Graph |
| Memory Card | N/A |
| A/D Converter | 16 Bit |
| Computer Connectivity | USB2.0, Type B |
| Battery | N/A |
| Dimensions | 8.7" x 4.8" x 12.8" (220 mm x 122 mm x 325 mm) |
| Operating Temp/Storage Temp | 0 to 40 °C/-40 to 70 °C |
| **Power Supply** | |
| Line Voltage | 100 V, 115 V, 230 V, (±10%) |
| Line Frequency | 50 to 60 Hz |

## PM320E Includes

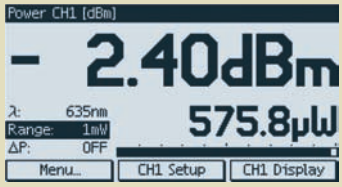
- PM320E Console
- Calibration Certificate
- Manual
- USB Cable

## Sample Display Screens

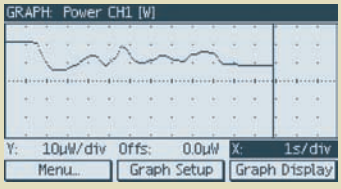
### Dual-Channel Measurements




### Single-Channel Measurement




### Trend Graph




| ITEM# | $ | £ | € | RMB | DESCRIPTION |
|---|---|---|---|---|---|
| PM320E | $ 2,200.00 | £ 1,525.00 | € 1.953,00 | ¥ 18,577.00 | Dual-Channel Benchtop Power and Energy Meter |
| CAL-PM300 | $ 200.00 | £ 138.70 | € 177,60 | ¥ 1,688.90 | Calibration Service for PM300 |

## Digital and Analog Meters

**PM100D**

- 4" Graphical Display
- Power and Energy Measurements
- Handheld, Battery-Powered Meter
- USB2.0

**See Page 1268**

**PM100A**

- Analog Needle Display
- Power Measurements
- Handheld, Battery-Powered Meter
- USB2.0

**See Page 1270**

**PM100USB**

- Power and Energy Measurements
- Compact, Rugged Housing
- USB2.0 Sensor Interface

**See Page 1272**

# C-Series of Standard Photodiode Optical Power Sensors

S120C
(Post Not Included)

NEW products

S120-FC

S120-SMA

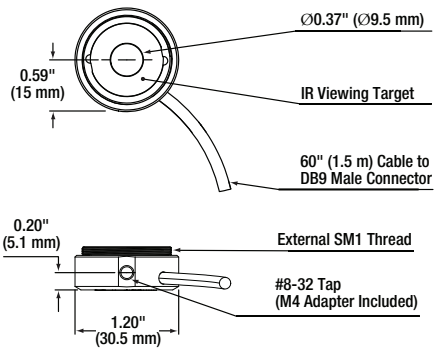

## Features

- Wavelengths from 200 to 1800 nm
- Power Measurements from 50 nW to 500 mW
- Fluorescing Target for Viewing IR or UV Beams
- Externally SM1 Threaded
- Fiber Adapters Available
- Compatible with all C-Series Power Meters
- High Temperature Alert Sensor
- NIST-Traceable Data Stored in Sensor Connector

These general-purpose, free-space and fiber photodiode sensors offer fast response for precise low-power measurements. When using these photodiode sensors, the wavelength of light must be set on the console to obtain accurate power measurements. Each sensor has an external SM1-thread, which allows it to be incorporated into a variety of applications including SM1 lens tubes and 30 mm cage systems. Compatible fiber adapters for FC, LC, SC, SMA, and ST connectors are available separately. For accurate measurements, we recommend recalibrating sensors annually; recalibration services are available for these sensors.

### C-Series Connectors

Thorlabs' new C-Series sensors use our new red DB9 connectors, which provide better data transmission (via internal chip) to our meters than our previous sensors. These new connectors, which are compatible with our complete new line of C-Series power meters presented on pages 1266-1275, firmly connect to a meter without threading screws, thereby allowing for quick sensor exchanges.




Please refer to our website for complete models and drawings.

## Compatible Power Meters

PM320E

PM100D

PM100A


PM100USB

| ITEM# | S120C | S120VC | S121C | S122C |
|---|---|---|---|---|
| Wavelength Range | 400-1100 nm | 200-1100 nm | 400-1100 nm | 700-1800 nm |
| Optical Power Range | 50 nW - 50 mW | 50 nW - 50 mW | 500 nW - 500 mW | 50 nW - 40 mW |
| Max Average Power Density | 20 W/cm² | | | 10 W/cm² |
| Detector Type | Si Photodiode | Si Photodiode | Si Photodiode | Ge Photodiode |
| Recalibration Service | CAL1 | CAL1 | CAL1 | CAL2 |
| Target Sensitivity | VIS - IR | UV - VIS | VIS - IR | VIS - IR |
| Resolution* | 1 nW | 1 nW | 10 nW | 10 nW |
| Measurement Uncertainty | ±3% (450 - 1000 nm)<br>±5% (Over Rest of Range) | ±3% (450 - 1100 nm)<br>±5% (Over Rest of Range) | ±3% (450 - 1000 nm)<br>±5% (Over Rest of Range) | ±5% |
| Response Time | <100 ns | | | <1 µs |
| Aperture | Ø9.5 mm | | | |
| Cable Length | 1.5 m | | | |
| Mounting | #8-32 Threaded Hole, M4 x 0.7 Adapter (AS4M8E) Included | | | |
| Lens Tube Compatibility | External SM1 Threads | | | |
| Cage Compatibility | SM1 Cage Plates (Available Separately) | | | |
| Console Compatibility** | PM100D, PM100A, PM100USB, PM320E, and Future C-Series Power Meters | | | |

*Measured with PM100D console in low bandwidth setting. | **Not backwards compatible.

| ITEM# | $ | £ | € | RMB | DESCRIPTION |
|---|---|---|---|---|---|
| S120C | $ 275.00 | £ 190.70 | € 244,20 | ¥ 2,322.20 | C-Series Power Sensor, 400-1100 nm, 50 nW - 50 mW |
| S120VC | $ 385.00 | £ 266.90 | € 341,90 | ¥ 3,251.00 | C-Series Power Sensor, 200-1100 nm, 50 nW - 50 mW |
| S121C | $ 295.00 | £ 204.50 | € 262,00 | ¥ 2,491.00 | C-Series Power Sensor, 400-1100 nm, 500 nW - 500 mW |
| S122C | $ 545.00 | £ 377.90 | € 483,90 | ¥ 4,602.00 | C-Series Power Sensor, 700-1800 nm, 50 nW - 40 mW |
| S120-FC | $ 26.00 | £ 18.10 | € 23,10 | ¥ 219.60 | Internally SM1-Threaded FC Fiber Adapter |
| S120-LC | $ 33.00 | £ 22.90 | € 29,30 | ¥ 278.70 | Internally SM1-Threaded LC Fiber Adapter |
| S120-SC | $ 33.00 | £ 22.90 | € 29,30 | ¥ 278.70 | Internally SM1-Threaded SC Fiber Adapter |
| S120-SMA | $ 26.00 | £ 18.10 | € 23,10 | ¥ 219.60 | Internally SM1-Threaded SMA Fiber Adapter |
| S120-ST | $ 30.00 | £ 20.80 | € 26,70 | ¥ 253.40 | Internally SM1-Threaded ST Fiber Adapter |
| CAL1 | $ 134.00 | £ 92.90 | € 119,00 | ¥ 1,131.50 | Si Recalibration Service (S120C, S120VC, and S121C)) |
| CAL2 | $ 150.00 | £ 104.00 | € 133,20 | ¥ 1,266.70 | Ge Recalibration Service (S122C) |

# C-Series of Slim Photodiode Power Sensors



**S130C**
(Post Assembly Not Included)

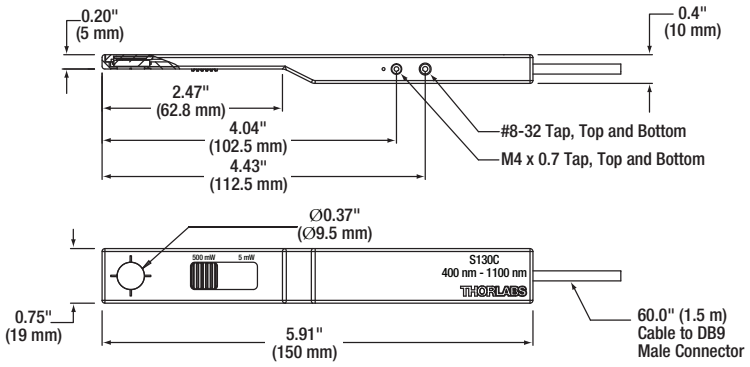
## Features

- 3 Models Detect Wavelengths from 200 to 1800 nm and Powers from 500 pW to 500 mW
- Slim Design is Only 5 mm Thick at Sensor
- Compatible with all C-Series Power Meters
- NIST-Traceable Data Stored in Sensor Connector

Thorlabs' slim, free-space photodiode sensors are only 5 mm thick at the sensor. They are ideal for power measurements when space is an issue. Each sensor has a sliding ND filter, which enables higher power measurements. When the ND filter is slid into position, our power meters automatically detect the filter and compensate for attenuation. For accurate measurements, we recommend recalibrating sensors annually. Thorlabs offers recalibration services (see price box below).

### C-Series Connectors

Thorlabs' new C-Series sensors use our new red DB9 connectors, which provide better data transmission (via internal chip) to our meters than our previous sensors. These new connectors, which firmly connect to a meter without threading screws, allow for quick sensor exchanges and are compatible with our complete new line of C-Series power meters featured on pages 1266-1275.




Please refer to our website for complete models and drawings.

## Compatible Power Meters


PM320E


PM100D


PM100A

PM100USB

| ITEM# | S130C | S130VC | S132C |
|---|---|---|---|
| Wavelength Range | 400-1100 nm | 200-1100 nm | 700-1800 nm (1200-1800 nm)[a] |
| Optical Power Range | 500 pW - 5 mW (5 - 500 mW)[a] | 500 pW - 5 mW (5 - 50 mW)[a] | 1 nW - 5 mW (5 - 500 mW)[a] |
| Average Power Density (Max) | 20 W/cm² | | 10 W/cm² |
| Detector Type | Si Photodiode | Si Photodiode | Ge Photodiode |
| Recalibration Service | CAL-S130 | CAL-S130 | CAL-S132 |
| Sliding ND Filter | Absorptive ND (Schott NG9) | Reflective ND (OD1) | Absorptive ND (Schott NG1) |
| Resolution[b] | 100 pW | | 1 nW |
| Measurement Uncertainty | ±3% (450-1000 nm) ±5% (Over Rest of Range) | | ±5% |
| Response Time | <1 µs | | |
| Aperture | Ø9.5 mm | | |
| Cable Length | 1.5 m | | |
| Mounting | #8-32 and M4 x 0.7 Threaded Holes | | |
| Lens Tube Compatibility | N/A | | |
| Cage Compatibility | N/A | | |
| Console Compatibility[c] | PM100D, PM100A, PM100USB, PM320E, and Future C-Series Power Meters | | |

[a]Values in parentheses are valid when the sliding ND filter is in front of the sensor. [b]Measured with PM100D console in low bandwidth setting. [c]Not backwards compatible.

| ITEM# | $ | £ | € | RMB | DESCRIPTION |
|---|---|---|---|---|---|
| S130C | $ 435.00 | £ 301.60 | € 386,20 | ¥ 3,673.20 | C-Series Slim Power Sensor, 400-1100 nm, 500 pW - 500 mW |
| S130VC | $ 545.00 | £ 377.90 | € 483,90 | ¥ 4,602.00 | C-Series Slim Power Sensor, 200-1100 nm, 500 pW - 50 mW |
| S132C | $ 645.00 | £ 447.20 | € 572,70 | ¥ 5,446.40 | C-Series Slim Power Sensor, 700-1800 nm, 1 nW - 500 mW |
| CAL4 | $ 155.00 | £ 107.50 | € 137,70 | ¥ 1,308.90 | Si Recalibration Service (S130C or S130VC) |
| CAL5 | $ 165.00 | £ 114.40 | € 146,50 | ¥ 1,393.30 | Ge Recalibration Service (S132C) |

# C-Series of Photodiode Power Sensors for Fiber

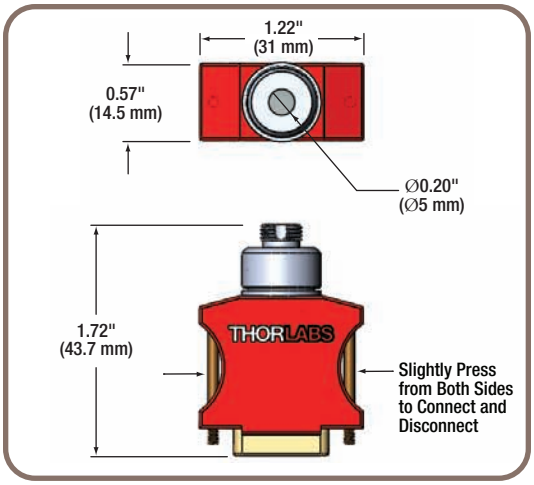


NEW products



## Features

- Ultra-Compact Sensor Attaches Directly to Meter
- 4 Models for Wavelengths from 350 nm to 1700 nm and Powers from 100 pW to 20 mW
- FC, LC, SC, SMA, and ST Fiber Adapters Available
- Compatible with All C-Series Power Meters
- NIST-Traceable Data Stored in Sensor Connector




Thorlabs now offers ultra-compact fiber power sensors that house a photodiode within the connector and are roughly the size of a DB9 connector. The outside of the connector is equipped with external SM05 threading to accept a range of SM05-threaded fiber adapters designed for various connector types. The S150C and S151C include FC and SMA adapters, while the S154C and S155C include an FC adapter. Other fiber adapters are available separately. For accurate measurements, we recommend recalibrating sensors annually; a recalibration service is offered below for these sensors.

### C-Series Connectors

Thorlabs' new C-Series sensors use our new red DB9 connectors, which provide better data transmission (via internal chip) to our meters than our previous sensors.

## Compatible Power Meters


PM320E


PM100A


PM100D


PM100USB

| ITEM# | S150C | S151C | S154C | S155C |
|---|---|---|---|---|
| Wavelength Range | 350-1100 nm | 400-1100 nm | 800-1700 nm | 800-1700 nm |
| Optical Power Range | 100 pW - 5 mW (-70 to 7 dBm) | 1 nW - 20 mW (-60 to 13 dBm) | 100 pW - 3 mW (-70 to 5 dBm) | 1 nW - 20 mW (-60 to 13 dBm) |
| Max Average Power Density | 100 mW/cm² | 10 W/cm² | 100 mW/cm² | 10 W/cm² |
| Max Pulse Energy Density | 0.1 µJ/cm² | | | |
| Detector Type | Si Photodiode | Si Photodiode | InGaAs Photodiode | InGaAs Photodiode |
| Recalibration Service | CAL1 | CAL1 | CAL2 | CAL2 |
| Resolution[a] | 10 pW (-80 dBm) | 100 pW (-70 dBm) | 10 pW (-80 dBm) | 100 pW (-70 dBm) |
| Measurement Uncertainty | ±3% (450-1000 nm) ±5% (Over Rest) | ±3% (530-1000 nm) ±5% (Over Rest) | ±5% | |
| Response Time | <50 ns | | <70 ns | |
| Aperture | Ø5 mm | | | |
| Cable Length | N/A | | | |
| Mounting | Directly to Power or Energy Meter | | | |
| Lens Tube Compatibility | External SM05 Threads[b] | | | |
| Cage Compatibility | N/A | | | |
| Fiber Connector[c] | FC, SMA | | FC | |
| Console Compatibility[d] | PM100D, PM100A, PM100USB, PM320E, and Future C-Series Power Meters | | | |

[a]Measured with PM100D console in low bandwidth setting.
[b]Provides compatibility with fiber adapters
[c]Additional adapters available separately.
[d]Not Backwards Compatible

| ITEM# | $ | £ | € | RMB | DESCRIPTION |
|---|---|---|---|---|---|
| S150C | $ 280.00 | £ 194.20 | € 248,60 | ¥ 2,364.40 | C-Series Fiber Sensor, 350-1100 nm, 100 pW - 5 mW |
| S151C | $ 320.00 | £ 221.90 | € 284,10 | ¥ 2,702.10 | C-Series Fiber Sensor, 400-1100 nm, 1 nW - 20 mW |
| S154C | $ 400.00 | £ 277.30 | € 355,20 | ¥ 3,377.70 | C-Series Fiber Sensor, 800-1700 nm, 100 pW - 3 mW |
| S155C | $ 460.00 | £ 318.90 | € 408,40 | ¥ 3,884.30 | C-Series Fiber Sensor, 800-1700 nm, 1 nW - 20 mW |
| PM20-FC | $ 26.00 | £ 18.10 | € 23,10 | ¥ 219.60 | FC Fiber Adapter* |
| PM20-LC | $ 33.00 | £ 22.90 | € 29,30 | ¥ 278.70 | LC Fiber Adapter |
| PM20-SC | $ 33.00 | £ 22.90 | € 29,30 | ¥ 278.70 | SC Fiber Adapter |
| PM20-SMA | $ 26.00 | £ 18.10 | € 23,10 | ¥ 219.60 | SMA Fiber Adapter** |
| PM20-ST | $ 30.00 | £ 20.80 | € 26,70 | ¥ 253.40 | ST Fiber Adapter |
| CAL1 | $ 134.00 | £ 92.90 | € 119,00 | ¥ 1,131.50 | Si Recalibration Service (S150C and S151C) |
| CAL2 | $ 150.00 | £ 104.00 | € 133,20 | ¥ 1,266.70 | InGaAs Recalibration Service (S154C and S155C) |

*Included with S150C, S151C, S154C, and S155C.
**Included with S150C and S151C.

# C-Series of Integrating Sphere Photodiode Sensors

NEW products


**S140C and S144C Dimensions**
Ø1.8" x 1.2" (Ø45 x 30.5 mm)



**S142C, S145C, and S146C Dimensions**
2.9" x 2.8" x 2.8"
(74 mm x 70 mm x 70 mm)

## Features

- 5 Models for the 350-1700 nm Wavelength Range and the Powers from 1 µW to 20 W
- Includes Externally SM1-Threaded Adapter
- FC Fiber Adapter Included
- Compatible with All C-Series Power Meters
- High Temperature Alert Sensor
- NIST-Traceable Data Stored in Sensor Connector
- Bare Fiber Adapter Available

Integrating spheres are designed to provide precise optical power measurements independent of beam shape and entrance angle. These sensors have a faster response time than thermal heads, while also offering a high damage threshold. We added an external SM1 threading adapter to each integrating sphere, allowing these sensors to be used with an array of optics, adapters, and lens tubes. For accurate measurements, we recommend recalibrating sensors annually. Thorlabs offers a recalibration service for these sensors (see the price box below).

### C-Series Connectors

Thorlabs' new C-Series sensors, which are easily recognizable by their red DB9 connectors, provide better data transmission (via internal chip) to our meters than our previous sensors. These new connectors firmly connect to a meter without the nead for threaded screws, allowing for quick sensor exchanges. These sensors are compatible with our complete new line of C-Series power meters on pages 1266-1275.

### Bare Fiber Adapter

The S140-BFA Adapter attaches directly to these integrating spheres and can provide power measurements for bare fibers with buffer diameters in the 250 - 450 µm range.

## Compatible Power Meters





| ITEM# | S140C | S144C | S142C | S145C | S146C |
|---|---|---|---|---|---|
| Wavelength Range | 350-1100 nm | 800-1700 nm | 350-1100 nm | 800-1700 nm | 900-1650 nm |
| Optical Power Range | 1 µW - 500 mW | 1 µW - 500 mW | 5 µW - 5 W | 1 µW - 3 W | 10 µW - 20 W |
| Max Average Power Density | 1 kW/cm² | | 2 kW/cm² | | |
| Detector Type | Si Photodiode | InGaAs Photodiode | Si Photodiode | InGaAs Photodiode | InGaAs Photodiode |
| Recalibration Service | CAL1 | CAL2 | CAL1 | CAL2 | CAL2 |
| Resolution* | 1 nW | | | | 10 nW |
| Measurement Uncertainty | ±3% (450 - 1000 nm)<br>±5% (Over Rest) | ±5% | ±3% (450 - 950 nm)<br>±5% (Over Rest) | ±5% | |
| Response Time | <100 ns | | <200 ns | | |
| Aperture | Ø5 mm | Ø5 mm | Ø12 mm | Ø12 mm | Ø12 mm |
| Cable Length | 1.5 m | | | | |
| Mounting | #8-32 and M4 x 0.7 Threaded Holes | | | | |
| Lens Tube Compatibility | External SM1 Threads | | | | |
| Cage Compatibility | N/A | | | | |
| Fiber Connector | FC Adapter Included | | | | |
| Console Compatibility** | PM100D, PM100A, PM100USB, PM320E, and Future C-Series Power Meters | | | | |

*Measured with PM100D console in low bandwidth setting. **Not backwards compatible.

| ITEM# | $ | £ | € | RMB | DESCRIPTION |
|---|---|---|---|---|---|
| S140C | $ 650.00 | £ 450.60 | € 577,10 | ¥ 5,488.70 | C-Series Integrating Sphere, 350-1100 nm, 1 µW - 500 mW |
| S142C | $ 895.00 | £ 620.50 | € 794,60 | ¥ 7,557.50 | C-Series Integrating Sphere, 350-1100 nm, 5 µW - 5 W |
| S144C | $ 750.00 | £ 520.00 | € 665,90 | ¥ 6,333.10 | C-Series Integrating Sphere, 800-1700 nm, 1 µW - 500 mW |
| S145C | $ 930.00 | £ 644.70 | € 825,70 | ¥ 7,853.00 | C-Series Integrating Sphere, 800-1700 nm, 1 µW - 3 W |
| S146C | $ 930.00 | £ 644.70 | € 825,70 | ¥ 7,853.00 | C-Series Integrating Sphere, 900-1650 nm, 10 µW - 20 W |
| S140-BFA | $ 120.00 | £ 83.20 | € 106,60 | ¥ 1,013.30 | Bare Fiber Adapter for Integrating Spheres |
| S120-FC | $ 26.00 | £ 18.10 | € 23,10 | ¥ 219.60 | Internally SM1-Threaded FC Adapter |
| S120-LC | $ 33.00 | £ 22.90 | € 29,30 | ¥ 278.70 | Internally SM1-Threaded LC Adapter |
| S120-SC | $ 33.00 | £ 22.90 | € 29,30 | ¥ 278.70 | Internally SM1-Threaded SC Adapter |
| S120-SMA | $ 26.00 | £ 18.10 | € 23,10 | ¥ 219.60 | Internally SM1-Threaded SMA Adapter |
| S120-ST | $ 30.00 | £ 20.80 | € 26,70 | ¥ 253.40 | Internally SM1-Threaded ST Adapter |
| CAL1 | $ 134.00 | £ 92.90 | € 119,00 | ¥ 1,131.50 | Si Recalibration Service (S140C and S142C) |
| CAL2 | $ 150.00 | £ 104.00 | € 133,20 | ¥ 1,266.70 | InGaAs Recalibration Service (S144C, S145C, and S146C) |

# C-Series General-Purpose Thermal Sensors

NEW products


S302C S310C S314C S322C

Thorlabs' new general-purpose thermal sensors cover broad wavelength ranges and are for use with high-power lasers. These thermal sensors have a high temperature alert sensor, which will provide a warning to our power meters when the sensor overheats. While thermal sensors typically have slow response times, Thorlabs' new sensors have been optimized to reduce this time. For instance, the response times of the S310C and S314C thermal sensors have been minimized to less than one second.

The S302C, S310C, S314C, and S322C are our general purpose thermal sensors. Their flat spectral response is ideal for broadband measurements from 0.19 to 25 µm. The S310C, S314C, and S322C come with an externally SM1-threaded adapter, which is compatible with the S120 series of fiber connector adapters, allowing power measurements from FC, LC, SC, SMA, and ST connectorized fibers. Additionally, these three sensors are 30 mm cage system compatible (see pages 155-175).

With the exception of the S322C, our general-purpose sensors are convection cooled. The S322C has forced air cooling via a fan on the back of it. A separate 12 VDC power supply is included with it. Each sensor is individually calibrated and shipped with a NIST-traceable calibration certificate. The calibration data is stored in the sensor's connector so that the meter's readings are wavelength corrected and accurate.

## Features

- 4 Models for the 190 nm to 25 µm Range and Powers from 100 µW to 200 W
- High Temperature Alert Sensor
- Minimized Response Times
- Compatible with All C-Series Meters
- NIST-Traceable Data Stored in Connector

## Compatible Power Meters


PM320E


PM100D


PM100A


PM100USB

| ITEM# | S302C | S310C | S314C | S322C |
|---|---|---|---|---|
| Wavelength Range | 0.19-25 µm | 0.19-25 µm | 0.19-11 µm | 0.25-11 µm |
| Optical Power Range | 100 µW - 2 W | 10 mW - 10 W | 10 mW - 40 W | 100 mW - 200 W |
| Max Intermittent Power (2 min Max) | 2.5 W | 15 W | 60 W | 250 W |
| Max Energy | N/A | 10 J (Long Pulses) | 40 J (Long Pulses) | 200 J (Long Pulses) |
| Max Average Power Density | 200 W/cm² | | 2 kW/cm² | 4 kW/cm² |
| Max Energy Density | 0.2 J/cm² (1 µs pulse), 2 J/cm² (1 ms pulse) | | 0.5 J/cm² (1 ns pulse), 10 J/cm² (1 ms pulse) | |
| Detector Type | Stabilized Thermal Absorber | Thermal Surface Absorber | | |
| Cooling | Convection | | | Forced Air w/ Fan[a] |
| Resolution[b] | 1 µW | 200 µW | 1 mW | 5 mW |
| Measurement Uncertainty | ±3% (1064 nm), ±5% (Over Rest) | | | |
| Response Time[c] | 3 s | <1 s | <1 s | 1 s |
| Active Area | Ø12 mm | Ø20 mm | Ø25 mm | Ø25 mm |
| Cable Length | 1.5 m | | | |
| Mounting | M4 x 0.7, 60 mm Post Included | M6 x 1.0, 75 mm Post Included (TR75/M) | | |
| Lens Tube Compatibility | External SM1 Threads | | | |
| Fiber Connector | Compatible with S120 Series Adapters | | | |
| Cage System Compatibility | N/A | 30 mm | | |
| Console Compatibility[d] | PM100D, PM100A, PM100USB, PM320E, and Future C-Series Power Meters | | | |

[a] 12 VDC power supply included.
[b] Measured with PM100D console; acceleration circuit switched off.
[c] Measured with display (0 – 90%).
[d] Only compatible with listed consoles.

| ITEM# | $ | £ | € | RMB | DESCRIPTION |
|---|---|---|---|---|---|
| S302C | $ 670.00 | £ 464.50 | € 594,90 | ¥ 5,657.50 | C-Series Thermal Sensor, 0.19-25 µm, 100 µW - 2 W |
| S310C | $ 670.00 | £ 464.50 | € 594,90 | ¥ 5,657.50 | C-Series Thermal Sensor, 0.19-25 µm, 10 mW - 10 W |
| S314C | $ 830.00 | £ 575.40 | € 736,90 | ¥ 7,008.60 | C-Series Thermal Sensor, 0.19-11 µm, 10 mW - 40 W |
| S322C | $ 1,240.00 | £ 859.60 | € 1.100,90 | ¥ 10,471.00 | C-Series Thermal Sensor, 0.25-11 µm, 100 mW - 200 W |
| S120-FC | $ 26.00 | £ 18.10 | € 23,10 | ¥ 219.60 | Internally SM1-Threaded FC Fiber Adapter |
| S120-LC | $ 33.00 | £ 22.90 | € 29,30 | ¥ 278.70 | Internally SM1-Threaded LC Fiber Adapter |
| S120-SC | $ 33.00 | £ 22.90 | € 29,30 | ¥ 278.70 | Internally SM1-Threaded SC Fiber Adapter |
| S120-SMA | $ 26.00 | £ 18.10 | € 23,10 | ¥ 219.60 | Internally SM1-Threaded SMA Fiber Adapter |
| S120-ST | $ 30.00 | £ 20.80 | € 26,70 | ¥ 253.40 | Internally SM1-Threaded ST Fiber Adapter |
| CAL6 | $ 170.00 | £ 117.90 | € 151,00 | ¥ 1,435.50 | Recalibration Service for S300, S200, ES100, and ES200 |

# C-Series Excimer and YAG Thermal Sensors

Thorlabs' specialized high-peak-power thermal sensors cover broad spectral ranges and are for use with lasers such as Excimer or YAG. These thermal sensors have a high-temperature alert sensor, which will provide a warning to our power meters when the sensor overheats from use with high-power lasers.

### Specialized Sensors

The S350C was specifically designed for use with high-power excimer lasers. It has been optimized for large beam diameters (Ø40 mm aperture), high power densities, and detection in the 190 nm to 400 nm range. It offers flat spectral response from the UV to the NIR (up to 10.6 µm) and can be used up to 11 µm.

The S370C sensor, designed for high-peak-power lasers such as YAG and $CO_2$, has a volume absorber for pulsed energy densities up to 10 J/cm².

Each sensor is individually calibrated and shipped with a NIST-traceable calibration certificate. The calibration data is stored in the sensor's connector so that the meter's readings are wavelength corrected and accurate.

### C-Series Connectors

Thorlabs' new C-Series sensors use our C-Series red DB9 connectors. The new connectors firmly connect to a meter without needing to thread screws, which reduces the time it takes to swap sensors. These sensors are compatible with our complete line of power meters on pages 1266-1275.


NEW products

S370C

S350C

## Features

- 2 Models Cover the Wavelength Range from 190 nm to 5.2 µm and Powers from 10 mW to 40 W
- Designed for use with Excimer or YAG Lasers
- Enhanced Shielding for Noise Reduction
- High Temperature Alert Sensor
- Minimized Response Times
- Compatible with All C-Series Meters
- NIST-Traceable Data Stored in Connector

## Compatible Power Meters

PM320E

PM100D

PM100A

PM100USB

| ITEM# | S350C | S370C |
|---|---|---|
| Wavelength Range | 190-1100 nm | 0.4-5.2 µm |
| Optical Power Range | 10 mW - 40 W | 10 mW - 10 W |
| Max Intermittent Power (2 min Max) | 60 W | 15 W |
| Max Energy | 40 J (Long Pulses) | 20 J (Single Pulse) |
| Max Average Power Density | 2 kW/cm² | 35 W/cm²<br>100 GW/cm² (Peak) |
| Max Energy Density | 0.7 J/cm² (1 ns pulse)<br>10 J/cm² (1 ms pulse) | 1 J/cm² (repetitive)<br>10 J/cm² (1 pulse) |
| Detector Type | Thermal Surface Absorber | Thermal Volume Absorber |
| Cooling | Convection | |
| Resolution[a] | 1 mW | 250 µW |
| Measurement Uncertainty | ±3% (351 nm)<br>±5% (Over Rest) | ±3% (1064 nm)<br>±5% (Over Rest) |
| Response Time[b] | 1 s | 3 s |
| Active Area | Ø40 mm | Ø25 mm |
| Cable Length | 1.5 m | |
| Mounting | M6 x 1.0, 75 mm Post Included (TR75/M) | |
| Lens Tube Compatibility | N/A | |
| Fiber Connector | N/A | |
| Cage System Compatibility | N/A | |
| Console Compatibility[c] | PM100D, PM100A, PM100USB, PM320E, and Future C-Series Power Meters | |

[a] Measured with PM100D console; acceleration circuit switched off.
[b] Measured with display (0 - 90%)
[c] Only compatible with listed consoles.

| ITEM# | $ | £ | € | RMB | DESCRIPTION |
|---|---|---|---|---|---|
| S350C | $ 1,010.00 | £ 700.20 | € 896,70 | ¥ 8,528.50 | C-Series Thermal Sensor, 0.19 - 11 µm, 10 mW - 40 W |
| S370C | $ 1,045.00 | £ 724.50 | € 927,80 | ¥ 8,824.10 | C-Series Thermal Sensor, 0.4 - 5.2 µm, 10 mW - 10 W |
| CAL6 | $ 170.00 | £ 117.90 | € 151,00 | ¥ 1,435.50 | Recalibration Service for S300, S200, ES200, ES100 |

# C-Series General-Purpose Pyroelectric Energy Sensors

NEW products


ES111C ES120C ES145C

## Features

- Wavelength Measurements from 185 nm to 25 µm
- Energy Measurements from 10 µJ to 2 J
- Flat Response Over Wavelength Range
- Large Sensor Areas
- Connect to C-Series Energy Meters or Oscilloscope via a BNC Connection
- NIST- and PTB-Traceable Data Stored in Sensor Connector
- Isolating Post Adapters Included
- ES120C is 30 mm Cage System Compatible
- Custom Sensors Available through Technical Support

The ES100C series of general-purpose energy sensors can be used for detection in the 185 nm to 25 µm range. A black coating on the sensor provides high and flat absorption over the spectrum, allowing the sensor to measure energies from 3 µJ to 2 J. These sensors are available with an Ø11 mm, Ø20 mm, or Ø45 mm aperture. When using pyroelectric energy sensors, it is best to fill ~80% of the aperture with your beam, which is important to keep in mind when selecting a sensor. We individually calibrate these sensors and have stored NIST- and PTB-traceable data on EEPROM inside the C-Series connector. When connected to a C-Series energy meter, this calibration data is automatically downloaded by the meter for highly accurate measurements.

### Meter Compatibility

Our energy sensors are compatible with our new C-Series energy meters, which currently include the PM100D, PM100USB, and PM320E. They can also be used with an oscilloscope via a BNC connection (1 MΩ), but the signal will only be calibrated to the responsivity of the sensor and not to the amplitude. A BNC to C-Series DB9 adapter is included with each sensor.

### Mechanical

Each sensor features an #8-32 threaded hole for post mounting, typically with a Ø1/2" TR post (see page 88). For sensitive applications, we have included electrostatic insulating adapters with all of our energy sensors. A metric threading adapter for mounting on an M4 x 0.7 threaded post is included.

### C-Series Connectors

Thorlabs' new C-Series sensors use our new red DB9 connectors, which provide better data transmission (via internal chip) to our meters than our previous sensors. These new connectors firmly connect to a meter without threading screws, allowing for quick sensor exchanges.

## Compatible Power Meters


PM320E


PM100D

PM100USB

| ITEM# | ES111C | ES120C | ES145C |
|---|---|---|---|
| Wavelength Range | 185 nm - 25 µm | | |
| Optical Energy Range | 10 µJ - 150 mJ | 100 µJ - 500 mJ | 500 µJ - 2 J |
| Max Repetition Rate | 40 Hz | 30 Hz | 30 Hz |
| Max Energy Density | 0.15 J/cm² | | |
| Max Power Density | 8 MW/cm² | | |
| Max Average Power | 0.15 W | 0.5 W | 0.5 W |
| Resolution* | 100 nJ | | 1 µJ |
| Measurement Uncertainty | ±5% | | |
| Detector Type | Standard Pyroelectric Energy Sensor | | |
| Thermal Time Constant | 20 ms | | |
| Laser Types | Low Energy YAG and $CO_2$, Pulsed Diode, Ruby, Small Excimer | | |
| Aperture | Ø11 mm | Ø20 mm | Ø45 mm |
| Cable Length | 1.5 m | | |
| Mounting | #8-32 Threaded Hole, M4 x 0.7 Adapter Included | | |
| Lens Tube Compatibility | N/A | | |
| Cage Compatibility | N/A | 30 mm | N/A |
| Console Compatibility** | PM100D, PM100USB, PM320E, Future C-Series Energy Meters, and Oscilloscopes | | |

*Measured with PM100D console **Not backwards compatible.

| ITEM# | $ | £ | € | RMB | DESCRIPTION |
|---|---|---|---|---|---|
| ES111C | $ 1,100.00 | £ 762.60 | € 976,60 | ¥ 9,288.50 | C-Series Pyroelectric Sensor, 185 nm - 25 µm, 10 µJ - 150 mJ |
| ES120C | $ 1,150.00 | £ 797.30 | € 1.021,00 | ¥ 9,710.70 | C-Series Pyroelectric Sensor, 185 nm - 25 µm, 100 µJ - 500 mJ |
| ES145C | $ 1,350.00 | £ 935.90 | € 1.198,60 | ¥ 11,400.00 | C-Series Pyroelectric Sensor, 185 nm - 25 µm, 500 µJ - 2 J |
| CAL6 | $ 170.00 | £ 117.90 | € 151,00 | ¥ 1,435.50 | Recalibration Service for S300, S200, ES200 and ES100 |

# C-Series Excimer and YAG Pyroelectric Energy Sensors

## Features

- Wavelengths from 185 nm to 25 µm
- Energy Measurements from 500 µJ to 15 J
- High Damage Threshold Ceramic Coating
- Flat Response Over Wavelength Range
- Large Sensor Areas
- Connect to C-Series Energy Meters or Oscilloscope via a BNC Connection
- NIST- and PTB-Traceable Data Stored in Sensor Connector
- Isolating Post Adapters Included
- ES220C is 30 mm Cage System Compatible
- Custom Sensors Available through Technical Support

NEW products


ES220C ES245C

The ES200C series of energy sensors was designed for high energy densities and is capable of wavelength detection in the 185 nm to 25 µm spectral range with wavelength correction. A ceramic coating on the sensor allows for beams up to 0.45 J/cm$^2$ to be measured. The large Ø20 mm aperture on the ES220C enables usage with beam energies up to 3 J, while the ES245C's Ø45 mm aperture can measure beam energies up to 15 J. These sensors have been specifically designed for excimer, $CO_2$ TEA, and Nd:YAG lasers. When using pyroelectric energy sensors, it is best to fill ~80% of the aperture with the incident beam, which is an important consideration when choosing a sensor.

We individually calibrate these sensors and have stored NIST- and PTB-traceable data on EEPROM inside the C-Series connector. When connected to a C-Series energy meter, this calibration data is automatically downloaded by the meter for highly accurate measurements.

### Meter Compatibility

Our energy sensors are compatible with our new C-Series energy meters, which currently include the PM100D, PM100USB, and PM320E. They can also be used with an oscilloscope via a BNC connection (1 MΩ), but the signal will only be calibrated to the responsivity of the sensor and not to the amplitude. A BNC to C-Series DB9 adapter is included with each sensor.

### Mechanical

Each sensor has an #8-32 threaded hole for post mounting, typically with a TR post (see page 88). For sensitive applications, we have included electrostatic insulating adapters with all of our energy sensors. A metric threading adapter for mounting on an M4 x 0.7 threaded post is included.

### C-Series Connectors

Thorlabs' new C-Series sensors use our new red DB9 connectors, which provide better data transmission (via internal chip) to our meters than our previous sensors.

| ITEM# | ES220C | ES245C |
|---|---|---|
| Wavelength Range | 185 nm - 25 µm | |
| Optical Energy Range | 500 µJ - 3 J | 1 mJ - 15 J |
| Max Repetition Rate | 30 Hz | 30 Hz |
| Max Energy Density | 0.45 J/cm² (7 ns pulse @ 355 nm) | |
| Max Power Density | 65 MW/cm² (7 ns @ 355 nm) | |
| Max Average Power | 5 W | 10 W |
| Resolution* | 25 µJ | 50 µJ |
| Measurement Uncertainty | ±5% | |
| Detector Type | High Energy Pyroelectric Sensor | |
| Thermal Time Constant | 20 ms | |
| Laser Types | Excimer, $CO_2$ TEA, Nd:YAG | |
| Aperture | Ø20 mm | Ø45 mm |
| Cable Length | 1.5 m | |
| Mounting | #8-32 Threaded Hole, M4-0.7 and Insulating Adapters Included | |
| Lens Tube Compatibility | N/A | |
| Cage Compatibility | 30 mm | N/A |
| Console Compatibility** | PM100D, PM100USB, PM320E, Future C-Series Energy Meters, and Oscilloscopes | |

*Measured with PM100D console. **Not backwards compatible.

## Compatible Power Meters


PM320E


PM100D

PM100USB

| ITEM# | $ | £ | € | RMB | DESCRIPTION |
|---|---|---|---|---|---|
| ES220C | $ 1,500.00 | £ 1,040.00 | € 1.331,50 | ¥ 12,667.00 | C-Series Pyroelectric Sensor, 185 nm - 25 µm, 500 µJ - 3 J |
| ES245C | $ 1,700.00 | £ 1,178.50 | € 1.509,50 | ¥ 14,355.00 | C-Series Pyroelectric Sensor, 185 nm - 25 µm, 1 mJ - 15 J |
| CAL6 | $ 170.00 | £ 117.90 | € 151,00 | ¥ 1,435.50 | Recalibration Service for S300, S200, ES200, ES100 |

# Handheld Fiber Optic Power Meters

**PM20-SMA**
Fiber Adapter


**PM20A**

## Features

- 3 Models for the 400-1700 nm Range and -60 dBm (1 nW) to 23 dBm (200 mW) Power Range
- Interchangeable Fiber Adapter (FC Included)
- 50 hr Battery Operating Time
- Auto Shutoff
- Absolute and Relative Power Measurements
- NIST-Traceable Wavelength Calibration in 5 nm Steps

The PM20 Series of Fiber Optic Power Meters are full-featured, handheld instruments, ideal for use in the field. Three models are available and cover wavelengths from 400 to 1700 nm and powers from -60 dBm (1 nW) to 23 dBm (200 mW). As the PM20 power meters were designed for field use, they have a low-power circuitry and an internal NiMH battery for over 50 hours of operation between each charge. When the battery is low, connect the meter to the included power supply, and the battery will be charged in only 3 hours.

A large, 8-digit, alphanumeric LCD is easy to read and displays the power reading with units. Power can be displayed in absolute values (dBm or W) or as a relative value (dB). The power meter's overlay has a simple, 5-button layout for power, display units, delta for setting relative measurements, and an up/down selection for setting the wavelength correction.

The meter is housed in a rugged enclosure with a protective rubber jacket. For lab use, the meter has a kickstand on the back that, when extended, tilts the meter so that the display is easy to read.

Each meter comes with an FC fiber adapter, but adapters for LC, SC, SMA, or ST can also be ordered. These adapters are internally SM05 threaded so that they can be simply threaded onto the meter. A replacement power supply is also offered below.

| ITEM# | PM20A | PM20C | PM20CH |
|---|---|---|---|
| Sensor Specifications | | | |
| Wavelength Range | 400-1100 nm | 800-1700 nm | |
| Optical Power Range | -60 dBm to 16 dBm (1 nW - 40 mW) | -60 dBm to 13 dBm (1 nW - 20 mW) | -50 dBm to 23 dBm (10 nW - 200 mW) |
| Optical Damage Threshold | 50 W/cm² | | |
| Detector Type | Silicon | InGaAs | |
| Active Area | 3.6 mm x 3.6 mm | Ø2 mm | Ø2 mm |
| Measurement Uncertainty | ±0.25 dB | | |
| General Specifications | | | |
| Display Type | Alphanumeric 8 Digit LCD | | |
| Display Format | 4-Digit Readout with Units and Symbols | | |
| Power Units | dBm, dB, nW, µW, mW | | |
| Resolution | 14 Bit | | |
| Sample Rate | 10 Hz | | |
| Dimensions (H x W x D) | 4.9" x 3.1" x 1.5" (125 mm x 80 mm x 39 mm) | | |
| Weight | 0.2 kg (0.44 lbs) | | |
| Operating Temperature | 5 to 40 °C | | |
| Storage Temperature | -20 to 70 °C | | |
| Battery | Internal NiMH Battery Pack, 150 mAh, 6 V | | |
| Operating Time | 50+ Hours | | |
| Charger | 3 Hour Charger Included | | |
| Charger Power Supply | Input: 100 - 240 VAC ±10%, 50 - 60 Hz; Output: 12 VDC, 0.85 A | | |

| ITEM# | $ | £ | € | RMB | DESCRIPTION |
|---|---|---|---|---|---|
| PM20A | $ 450.00 | £ 312.00 | € 399,60 | ¥ 3,799.90 | Fiber Power Meter, 400-1100 nm, -60 to 16 dBm |
| PM20C | $ 550.00 | £ 381.30 | € 488,30 | ¥ 4,644.30 | Fiber Power Meter, 800-1700 nm, -60 to 13 dBm |
| PM20CH | $ 595.00 | £ 412.50 | € 528,30 | ¥ 5,024.20 | Fiber Power Meter, 800-1700 nm, -50 to 23 dBm |
| PM20-FC | $ 26.00 | £ 18.10 | € 23,10 | ¥ 219.60 | FC Fiber Adapter, Internally SM05 Threaded |
| PM20-LC | $ 33.00 | £ 22.90 | € 29,30 | ¥ 278.70 | LC Fiber Adapter, Internally SM05 Threaded |
| PM20-SC | $ 33.00 | £ 22.90 | € 29,30 | ¥ 278.70 | SC Fiber Adapter, Internally SM05 Threaded |
| PM20-SMA | $ 26.00 | £ 18.10 | € 23,10 | ¥ 219.60 | SMA Fiber Adapter, Internally SM05 Threaded |
| PM20-ST | $ 30.00 | £ 20.80 | € 26,70 | ¥ 253.40 | ST Fiber Adapter, Internally SM05 Threaded |
| PMPS12 | $ 30.00 | £ 20.80 | € 26,70 | ¥ 253.40 | Replacement 12 VDC Power Supply for PM20 Series |

# Detector Selection Guide

Pages 1285-1308


### Photodetectors

- Biased Photodetectors
- Amplified Photodetectors
- Integrating Spheres

**See Pages 1286-1292**

### Photomultiplier Tubes

- Head-on PMT Configuration
- Wavelength Ranges from 280-850 nm
- Electrostatic and Magnetic Shielding

**See Page 1293**


### Balanced Detectors

- Free-Space and Fiber Detectors
- Wavelength Ranges from 320-1700 nm
- OCT Proven

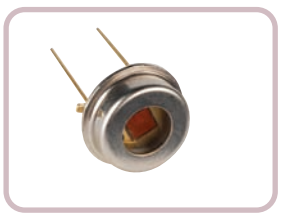
**See Pages 1294-1296**



### Position-Sensing Detectors

- Lateral Effect and Quadrant Detectors
- Wavelength Ranges from 320-1700 nm
- Closed-Loop Compatible Hub

**See Pages 1297-1299**



### Photodiodes

- Wavelengths from 150-2600 nm
- Gap, Si, Ge, and InGaAs Photodiodes, Dual Band Available
- Fiber-Coupled Detectors

**See Pages 1300-1303**


### Photocurrent Amplifiers

- BNC Input
- Low Noise Operation
- Adjustable Bias Voltage

**See Page 1304**

### Cameras

- Color, Black & White, and Line Cameras
- New Cost Effective CMOS Cameras

**See Pages 1305-1308**

# High-Speed Photodetectors

DET10C

DET10A/M

Posts Not Included

## Broad Bandwidth, High Gain, Low Noise

### Features

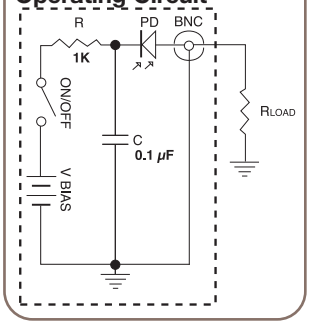
- Rise Times as Low as 1 ns
- Detectors for 150-2600 nm
- Low-Profile Housing (2.1" x 2.8" x 1.9")
- Includes Threaded Mount for Ø1" (Ø25 mm) Optics
- Compatible with SM1- and SM05-Threaded Components
- Battery-Level Check Included
- Internal A23 +12 V Bias Battery Included

The DET series of photodetectors are compact, versatile, high-speed optical detectors. Each model comes complete with a fast PIN photodiode and an internal bias battery, packaged in a rugged aluminum housing. With a wide-bandwidth, DC-coupled output, these detectors are ideal for monitoring fast pulsed lasers as well as DC sources. The direct photodiode anode current is provided on a side panel BNC. This output is easily converted to a positive voltage using a terminating resistor.

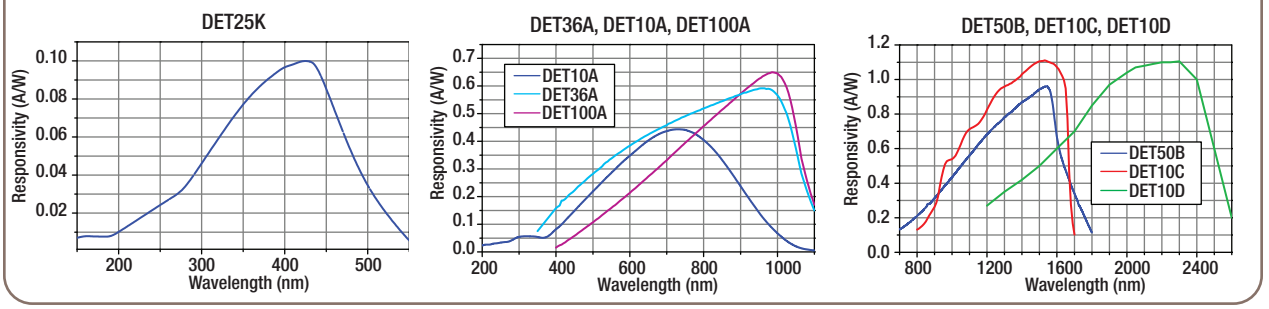
We recommend a 50 Ω load resistance for fastest response times such as the T4119 shown on the following page.

These photodetectors have a thin profile, enabling use in tight spaces. All connections and controls have been moved away from the light path. Each DET housing includes a detachable Ø1" lens tube coupler (SM1T1) to aid in the installation of neutral density filters, spectral filters, and lenses. The optical head is compatible with Thorlabs' SM05- and SM1-threaded components such as lens tubes and cage systems. Compatible fiber optic adapters are available on page 304.

### Operating Circuit




### Typical Spectral Responsivity




| ITEM# | METRIC ITEM# | $ | £ | € | RMB | TYPE | NEP[a] (W/√Hz) | RISE TIME | ACTIVE AREA | WAVELENGTH RANGE |
|---|---|---|---|---|---|---|---|---|---|---|
| DET25K | DET25K/M | $ 194.90 | £ 135.20 | € 173,10 | ¥ 1,645.80 | GaP | 1.6 x $10^{-14}$ | 1 ns[b] | 4.8 mm² (2.2 x 2.2 mm) | 150-550 nm |
| DET36A | DET36A/M | $ 107.10 | £ 74.30 | € 95,10 | ¥ 904.40 | Si | 1.6 x $10^{-14}$ | 14 ns (Max) | 13 mm² (3.6 x 3.6 mm) | 350-1100 nm |
| DET10A | DET10A/M | $ 139.40 | £ 96.70 | € 123,80 | ¥ 1,177.10 | Si | 1.9 x $10^{-14}$ | 1 ns (Max) | 0.8 mm² (Ø1 mm) | 200-1100 nm |
| DET100A | DET100A/M | $ 143.40 | £ 99.50 | € 127,40 | ¥ 1,210.90 | Si | 5.5 x $10^{-14}$ | 43 ns (Max) | 75.4 mm² (Ø9.8 mm)[c] | 400-1100 nm |
| DET50B | DET50B/M | $ 341.40 | £ 236.70 | € 303,10 | ¥ 2,882.80 | Ge | 4 x $10^{-12}$ | 440 ns (Max) | 19.6 mm² (Ø5.0 mm) | 800-1800 nm |
| DET10C | DET10C/M | $ 276.70 | £ 191.90 | € 245,70 | ¥ 2,336.50 | InGaAs | 1.6 x $10^{-14}$ | 10 ns (Max) | 0.8 mm² (Ø1.0 mm) | 700-1800 nm |
| DET10D | DET10D/M | $ 462.60 | £ 320.70 | € 410,70 | ¥ 3,906.30 | InGaAs | 2 x $10^{-12}$ | 25 ns (Max) | 0.8 mm² (Ø1.0 mm) | 1200-2600 nm |

[a] At peak response wavelength [b] Fall time: 140 ns [c] Based on the aperture size; detector size is 10 mm x 10 mm square

# Replacement Batteries

NEW products

The A23 battery is the replacement battery for the current DET series of photodetectors (see above). The T505 replaces batteries used in our older, discontinued detector series.



The DET1A AC Power Adapter is a replacement for the battery on our DET line of detectors that allows the DETs to be used with our LDS2 9 V Power Supply. The DET1B kit includes both the DET1A and LDS2.

| ITEM# | $ | £ | € | RMB | VOLTAGE | USED WITH |
|---|---|---|---|---|---|---|
| A23 | $ 4.30 | £ 3.00 | € 3,90 | ¥ 36.40 | 12 V | DET Series |
| T505 | $ 16.10 | £ 11.20 | €14,30 | ¥ 136.00 | 22.5 V | DET1-SI and DET2-SI |
| NEW DET1B | $ 99.00 | £ 68.70 | €87,90 | ¥ 836.00 | | Any DET |
| NEW DET1A | $ 19.40 | £ 13.50 | €17,30 | ¥ 163.90 | — | Any DET |
| LDS2 | $ 83.10 | £ 57.70 | €73,80 | ¥ 701.70 | 9 V | DET1A |
| SBP20 | $ 73.00 | £ 50.70 | €64,90 | ¥ 616.50 | 20 V | Replacement Battery Pack for SV2-FC, SIR5-FC |

# 1.2 GHz to 2 GHz Fiber Optic Detectors

**DET02AFC**
Cables Not Included

**DET01CFC**

## Specifications

| | DET02AFC(/M) | DET01CFC(/M) |
|---|---|---|
| **Detector** | Si | InGaAs |
| **Wavelength Range** | 400-1100 nm | 800-1700 nm |
| **Bandwidth** | 1.2 GHz | 2 GHz |
| **Max. Peak Power** | 18 mW | 70 mW |
| **Peak Response** | 0.46 A/W @730 nm | 0.95 A/W @1550 nm |
| **Rise/Fall Time** | 50 ps (Min) | 100 ps (Min) |
| **NEP @1550 nm** | 9.5 x $10^{-14}$ W/√Hz | 1.5 x $10^{-14}$ W/√Hz |
| **Dark Current** | 50 pA (500 pA Max) | 0.7 nA (2.5 nA Max) |

Thorlabs' DET02AFC and DET01CFC are biased fiber optic detectors that offer bandwidths of 1.2 GHz and 2 GHz, respectively. Both feature FC/PC-terminated fiber inputs. The DET02AFC utilizes a silicon detector, which is sensitive to light in the 400-1100 nm spectral region, while the DET01CFC has an InGaAs detector for operation in the 800-1700 nm range. Post mounting is possible via the #8-32 (M4 x 0.7) mounting hole.

## Features

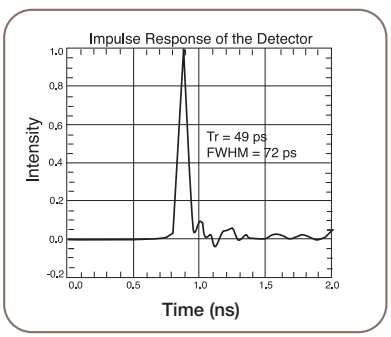
- Fast Detectors with 50-100 ps Rise Time
- 1.2 to 2 GHz Bandwidth
- FC/PC Fiber Connectors
- SMA Output Connectors

| ITEM# | METRIC ITEM# | $ | £ | € | RMB | DESCRIPTION |
|---|---|---|---|---|---|---|
| DET02AFC | DET02AFC/M | $ 260.10 | £ 180.40 | € 231,00 | ¥ 2,196.30 | High-Speed Si Detector, 400-1100 nm |
| DET01CFC | DET01CFC/M | $ 276.70 | £ 191.90 | € 245,70 | ¥ 2,336.50 | High-Speed InGaAs Detector, 800-1700 nm |

# 5 GHz Optical Detector Package

This 5 GHz InGaAs Photodetector Package provides the same ease of use as our popular DET family of products. They are manufactured with state-of-the-art microwave-qualified parts. Each unit is individually tested to ensure compliance with our specifications; a complete test report comes with every serialized detector package.

**SIR5-FC**
Fiber Input




## Specifications

| | |
|---|---|
| **Material** | InGaAs |
| **Bandwidth** | 5 GHz |
| **Wavelength Range** | 900-1650 nm |
| **Fiber Input** | FC/PC |
| **Output Impedance** | 50 Ω |
| **Maximum Safe Output** | 1.0 V |
| **Minimum Rise Time (Typ)** | 70 ps |
| **Dark Current** | 0.1 nA |

| ITEM# | $ | £ | € | RMB | DESCRIPTION |
|---|---|---|---|---|---|
| SIR5-FC | $ 1,013.50 | £ 702.60 | € 899,80 | ¥ 8,558.10 | InGaAs Detector Package, 5 GHz FC Fiber Input, 900-1650 nm |

# Terminators

**50 Ω Terminator**
Ideal termination for DET Series of detectors to achieve maximum bandwidth.

**T4119**

**Variable Terminator**
Adjust from 50 Ω to 50 kΩ in discrete steps: 50 Ω, 100 Ω, 500 Ω, 1 kΩ, 5 kΩ, 10 kΩ, and 50 kΩ.

**VT1**

| ITEM# | $ | £ | € | RMB | DESCRIPTION |
|---|---|---|---|---|---|
| T4119 | $ 35.70 | £ 24.80 | € 31,70 | ¥ 301.50 | In-Line Terminator |
| VT1 | $ 131.10 | £ 90.90 | € 116,40 | ¥ 1,107.10 | Variable Terminator |

See page 373 for more BNC components and page 374 for BNC cables.

# 150 nm to 4.8 µm Amplified Photodetectors (Page 1 of 2)

Power Supply Included


**PDA36A**
Post and Base
Sold Separately

The PDA series of amplified photodetectors utilizes a thin profile to allow access to light paths where there is minimal space. All connections and controls are located perpendicular to the light path. In addition, the PDA series includes a low-noise transimpedance or voltage amplifier capable of driving 50 Ω loads. The housing features both external SM1 threads and internal SM05 threads, each of which are each compatible with a large array of our threaded accessories, allowing convenient mounting of external optics, fibers, and apertures. Each housing provides two #8-32 tapped mounting holes (M4 x 0.7 for –EC versions) An internally SM1-threaded adapter ring is also included. A switchable power supply is included with each unit (120 VAC, 230 VAC).

Thorlabs' line of switchable gain detectors provide gain adjustment over a 70 dB range to take full advantage of the photodiode response range. Gains are adjustable from 1.5 kV/A to 4.7 MV/A in eight 10 dB steps. Our selection of wideband detectors increase the bandwidth range from DC to 150 MHz, while still maintaining low noise.

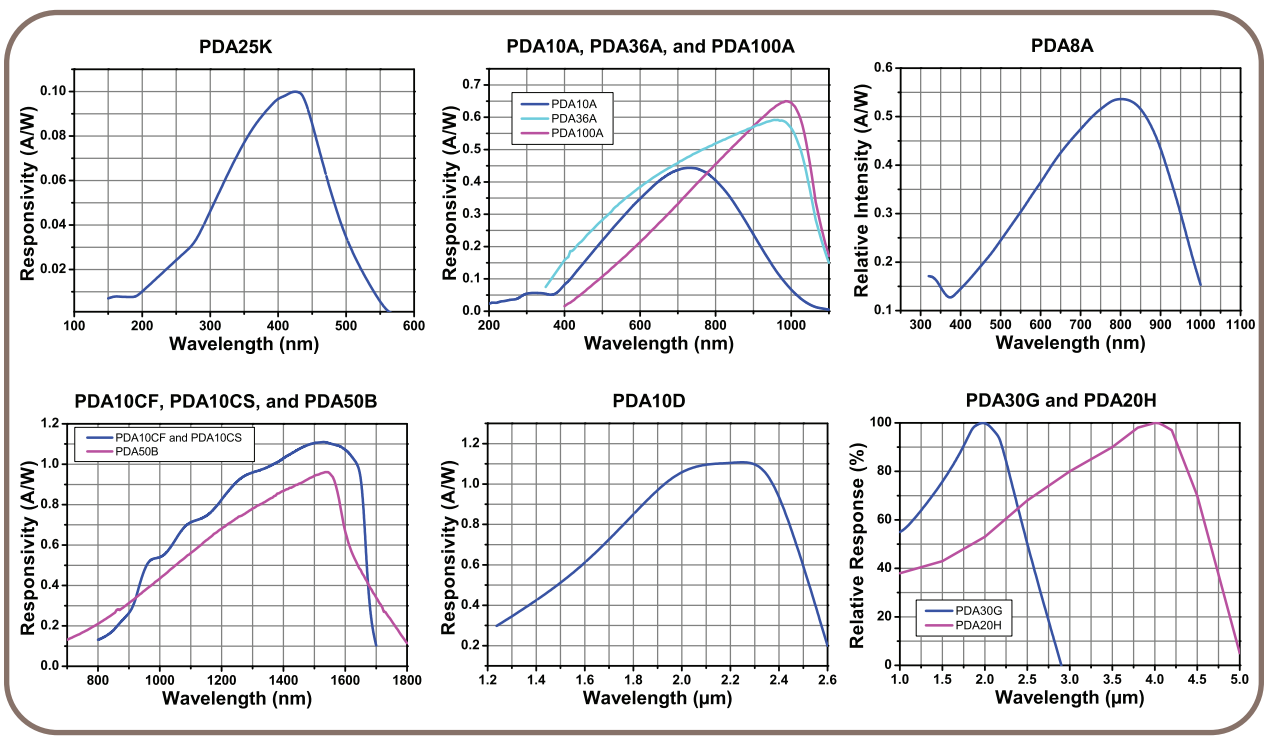
## All Detectors Come Complete with Power Supply

**SM1FC**
SM1-Threaded Fiber Adapters

### PDA Series General Specifications

| ITEM#[a] | SENSOR | BANDWIDTH[b] | WAVELENGTH RANGE | ACTIVE AREA | GAIN |
|---|---|---|---|---|---|
| PDA25K | GaP | 7.5 MHz | 150-550 nm | 6.25 mm² (2.5 x 2.5 mm) | 1.5 x $10^3$ to 4.75 x $10^6$ V/A[c] |
| PDA10A | Si | 150 MHz | 200-1100 nm | 0.8 mm² (Ø1 mm) | 1 x $10^4$ V/A |
| PDA8A | Si | 50 MHz | 320-1000 nm | 0.5 mm² (Ø0.8 mm) | 1 x $10^6$ V/A |
| PDA36A | Si | 17 MHz | 350-1100 nm | 13 mm² (3.6 x 3.6 mm) | 1.5 x $10^3$ to 4.75 x $10^6$ V/A[c] |
| PDA100A | Si | 1.5 MHz | 400-1100 nm | 75.4 mm² (Ø9.8 mm) | 1.5 x $10^3$ to 4.75 x $10^6$ V/A[c] |
| PDA10CF | InGaAs | 150 MHz | 700-1800 nm | 0.2 mm² (0.5 mm) | 1 x $10^4$ V/A |
| PDA10CS | InGaAs | 17 MHz | 700-1800 nm | 0.8 mm² (Ø1 mm) | 1.5 x $10^3$ to 4.75 x $10^6$ V/A[c] |
| PDA50B | Ge | 400 kHz | 800-1800 nm | 19.6 mm² (Ø5 mm) | 1.5 x $10^3$ to 4.75 x $10^6$ V/A[c] |
| PDA10D | InGaAs | 15 MHz | 1200-2600 nm | 0.8 mm² (Ø1 mm) | 1 x $10^4$ V/A |
| PDA30G | PbS | 0.2 kHz to 1 kHz[d] | 1000-2900 nm | 9 mm² (3.0 x 3.0 mm) | 100X |
| PDA20H | PbSe | 0.2 kHz to 10 kHz[d] | 1500-4800 nm | 4 mm² (2.0 x 2.0 mm) | 100X |

[a] Same specs apply to the –EC versions
[b] Applies to lowest gain setting on switchable gain versions
[c] Switchable gain, 8 steps, 70 dB total adjustment
[d] AC-coupled output only



# 150 nm to 4.8 µm Amplified Photodetectors (Page 2 of 2)

NEW versions

| ITEM# | METRIC ITEM# | $ | £ | € | RMB | DESCRIPTION |
|---|---|---|---|---|---|---|
| PDA25K | PDA25K-EC | $ 369.00 | £ 255.80 | € 327,70 | ¥ 3,115.90 | 150-550 nm Switchable Gain, GaP Detector |
| PDA10A | PDA10A-EC | $ 278.00 | £ 192.80 | € 246,90 | ¥ 2,347.50 | 200-1100 nm Fixed Gain, Si Detector |
| PDA8A | PDA8A/M | $ 600.00 | £ 416.00 | € 532,70 | ¥ 5,066.50 | 320-1000 nm Fixed Gain, Si Detector |
| PDA36A | PDA36A-EC | $ 299.00 | £ 207.30 | € 265,50 | ¥ 2,524.80 | 350-1100 nm Switchable Gain, Si Detector |
| PDA100A | PDA100A-EC | $ 305.00 | £ 211.50 | € 270,80 | ¥ 2,575.50 | 400-1100 nm Switchable Gain, Si Detector |
| PDA10CF | PDA10CF-EC | $ 369.00 | £ 255.80 | € 327,70 | ¥ 3,115.90 | 700-1800 nm Fixed Gain, InGaAs Detector |
| PDA10CS | PDA10CS-EC | $ 369.00 | £ 255.80 | € 327,70 | ¥ 3,115.90 | 700-1800 nm Switchable Gain, InGaAs Detector |
| PDA50B | PDA50B-EC | $ 469.00 | £ 325.20 | € 416,40 | ¥ 3,960.30 | 800-1800 nm Switchable Gain, Ge Detector |
| PDA10D | PDA10D-EC | $ 460.00 | £ 318.90 | € 408,40 | ¥ 3,884.30 | 1.2-2.6 µm Fixed Gain, InGaAs Detector |
| PDA30G | PDA30G-EC | $ 364.00 | £ 252.40 | € 323,20 | ¥ 3,073.70 | 1.0-2.9 µm Fixed Gain, PbS Detector |
| PDA20H | PDA20H-EC | $ 398.00 | £ 276.00 | € 353,40 | ¥ 3,360.80 | 1.5-4.8 µm Fixed Gain, PbSe Detector |
| PDA-C-72 | — | $ 17.30 | £ 12.00 | € 15,40 | ¥ 146.10 | 72" PDA Power Supply Cable, 3-Pin to Unterminated End |
| SM1FC | — | $ 26.00 | £ 18.10 | € 23,10 | ¥ 219.60 | Externally SM1-Threaded FC/PC Fiber Adapter |

# Mid-IR Amplified Photodetector with Temperature Control

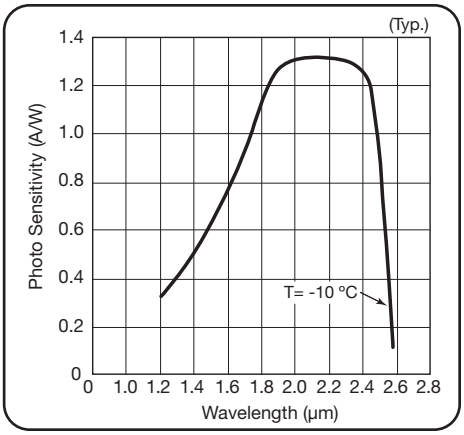
### Features
- Mid-IR Operation (1200-2570 nm)
- Built-in TEC Controller
- Variable Gain Transimpedance Amplifier
- Variable Low-Pass Filter (500 Hz to 1 MHz)
- Internal SM1 Thread


PDA10DT

The PDA10DT uses an extended-range InGaAs detector, making it suitable for detection of light in the 1200-2570 nm spectral range. This detector includes a built-in TEC element and thermistor, which stabilizes the temperature at 10 °C and significantly reduces the detector's dark current and the noise associated with ambient temperature changes. These features allow larger gains and lower DC offsets.

The PDA10DT has an eight-position gain switch, allowing the user to set the gain from 1.51 kV/A to 4.7 MV/A (70 dB); an additional eight-position switch adjusts circuit bandwidth from 500 Hz to 1 MHz for improved noise performance. To further increase performance, the photodetector uses a bias voltage for the first two gain steps and an unbiased (photovoltaic) mode for the remaining six positions. This combination allows high-speed operation in the lower gain setting and high-precision measurements in the higher gain settings.

The PDA10T housing features internal SM1 threading, is post-mountable via an #8-32 thread (M4 x 0.7 on -EC versions), and has 50 Ω drive capability using a BNC output.




### Specifications
- **Detector Material:** Extended Range InGaAs
- **Active Diameter:** 1 mm
- **Wavelength Range:** 1200 to 2570 nm
- **Peak Responsivity:** 1.1 A/W
- **Number of Gain Steps:** 8
- **Gain Range:** 70 dB or 1.51 kV/A to 4.7 MV/A
- **Low Pass Filter Bandwidth Range:** 500 Hz to 1 MHz
- **Output Voltage:** 0 - 5 V at 50 Ω, 0 - 10 V at Hi-Z
- **Output Impedance:** 50 Ω
- **Output Current:** 100 mA
- **Output Offset:** <10 mV (All Gain Steps)
- **Detector Temperature:** -10 °C
- **TEC Current:** 0.6 A Typical (1 A Max)
- **Thermistor:** 10 kΩ

| ITEM# | METRIC ITEM# | $ | £ | € | RMB | DESCRIPTION |
|---|---|---|---|---|---|---|
| PDA10DT | PDA10DT-EC | $ 1,895.00 | £ 1,313.50 | € 1.682,50 | ¥ 16,002.00 | Amplified Photodetector with Temperature Controller |

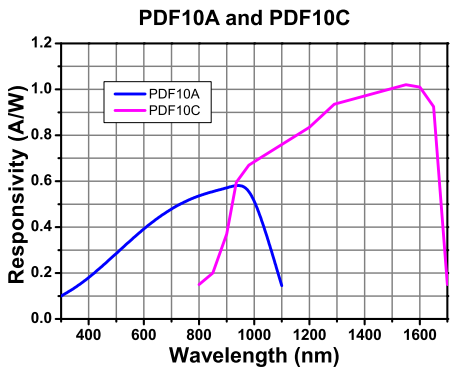
# Femtowatt Amplified Photodetectors


NEW design


Post Assembly Not Included

## Features

- Femtowatt Sensitivity
- High-Gain, Low-Noise Detectors
- Two Detectors for the 320-1700 nm Range




The PDF series of femtowatt amplified phtodetectors combine an ultra-low noise Si or InGaAs photodiode with a transimpedance amplifier, offering extremely high gain up to $10^{12}$ V/A; together these features provide a unique photodetector with femtowatt sensitivity and an exceptionally low minimum NEP of 1.4 fW/√Hz. The PDF series is designed for direct detection of optical powers of ~10 fW; sub-femtowatt detection is possible when the detector is used with a lock-in amplifier.

The thin-profile housing of these photodetectors has a removable SM1-threaded cap, which can be used to cover the sensor for zero input calibration. In addition, it features external SM1 threads, internal SM05 threads, and an internally SM1-threaded adapter ring; these features are ideal for incorporating the detector into lens tube or cage system setups. These threadings are also compatible with our fiber coupling adapters (see below). The PDF series includes a power supply (Imperial: 120 VAC, Metric: 230 VAC) and is post mountable via an #8-32 (M4 x 0.7) taps.

| ITEM# | PDF10A | PDF10C |
|---|---|---|
| Detector Type | Si | InGaAs/PIN |
| Wavelength Range | 320-1100 nm | 800-1700 nm |
| Responsivity (Max) | 0.6 A/W @ 960 nm | 1.0 A/W @ 1550 nm |
| Active Area | 1.21 mm² | 0.2 mm² |
| Transimpedance Gain | 1 x $10^{12}$ V/W ± 10% | 1 x $10^{11}$ V/W ± 10% |
| Max Conversion Gain | 0.6 x $10^{12}$ V/W ± 10% | 1 x $10^{11}$ V/W ± 10% |
| Output Bandwidth (3 dB) | DC - 20 Hz | DC - 25 Hz |
| Rise/Fall Time (10 - 90%) | 22 ms | 19 ms |
| CW Saturation Power | 16 pW | 100 pW |
| Damage Threshold | 10 mW | 10 mW |
| Min NEP (DC - 20 Hz) | 1.4 fW/√Hz | 7.5 fW/√Hz |
| Electrical Output, Impedance | BNC, 200 Ω | |
| Maximum Output Voltage | 10 V | |
| DC Offset Electrical Output | <±150 mV | |
| Dimensions (W x H x D) | 53.4 mm x 43.2 mm x 21 mm | |

| ITEM# | METRIC ITEM# | $ | £ | € | RMB | DESCRIPTION |
|---|---|---|---|---|---|---|
| PDF10A | PDF10A/M | $ 800.00 | £ 554.60 | € 710,30 | ¥ 6,755.30 | Femtowatt Photodetector, Si Detector, 320-1100 nm |
| PDF10C | PDF10C/M | $ 850.00 | £ 589.30 | € 754,70 | ¥ 7,177.50 | Femtowatt Photodetector, InGaAs Detector, 800-1700 nm |

## Fiber Adapters


While the Femtowatt Amplified Photodetectors above are for free space, these fiber adapters can be threaded into the detector for fiber applications. Each adapter features external SM1 threading. Adapters are available for FC/PC, FC/APC, SMA, and ST fiber connectors.


| ITEM# | $ | £ | € | RMB | DESCRIPTION |
|---|---|---|---|---|---|
| SM1FC | $ 26.00 | £ 18.10 | € 23,10 | ¥ 219.60 | External SM1 to FC Fiber Connector Adapter |
| SM1FCA | $ 30.00 | £ 20.80 | € 26,70 | ¥ 253.40 | External SM1 to FC/APC Fiber Connector Adapter |
| SM1SMA | $ 26.00 | £ 18.10 | € 23,10 | ¥ 219.60 | External SM1 to SMA Fiber Connector Adapter |
| SM1ST | $ 26.00 | £ 18.10 | € 23,10 | ¥ 219.60 | External SM1 to ST Fiber Connector Adapter |

# 8 GHz Amplified Photodetector

PDA8GS

## Features

- Wide Wavelength Range of 700-1650 nm
- Frequency Response of DC to 8 GHz
- Data Rates up to 10.7 Gb/s
- Fast 50 ps Pulse Response

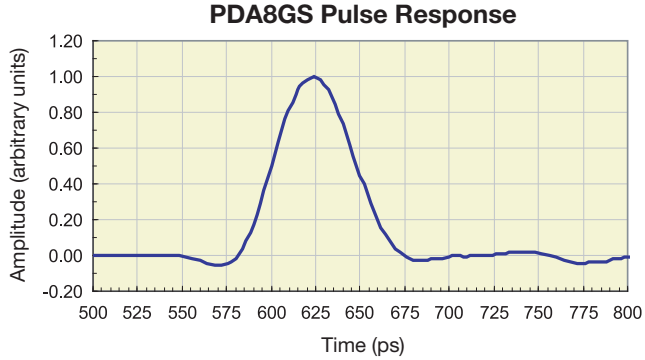
## Specifications

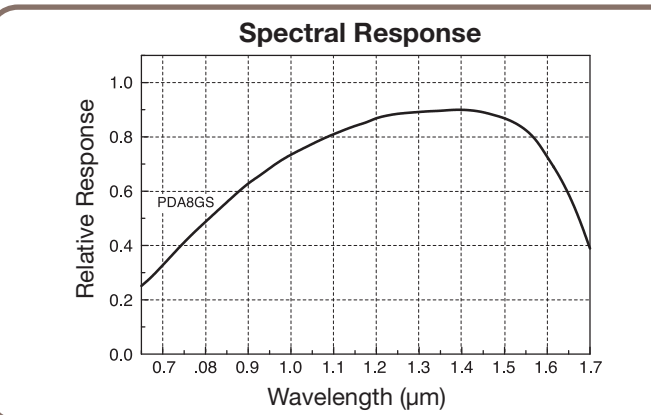
- **Spectral Response:** 700-1650 nm
- **Bandwidth:** DC to 8 GHz
- **Data Rate:** 10.7 Gb/s
- **Low Frequency Cutoff:** DC
- **Conversion Gain**
  - At 850 nm: 275 V/W
  - At 1310 nm: 450 V/W
- **Sensitivity**
  - At 850 nm: -17 dBm
  - At 1310 nm: -20 dBm
- **Optical Return Loss:** -14 dB (Max)
- **Rise Time:** 50 ps
- **Input Connector:** FC/PC
- **Output Impedance:** 50 Ω
- **Output Connector:** SMA
- **Package Size:**
  95.5 mm x 60.5 mm x 28 mm
- **Power Supply:** 12 VDC, 750 mA,
  (Included) 100/230 VAC 50/60 Hz
- **Mounting:** #8-32 and M4 x 0.7

**Introduction**

The PDA8GS is a versatile, high-speed, amplified photodetector designed to perform in a wide range of test and measurement applications involving fast optical signals. The detector's high bandwidth and high sensitivity make it an ideal measurement instrument for both pulse response measurements in the time domain and frequency response measurements in the frequency domain. The frequency response range, DC to 8 GHz, supports data rates up to 10.7 Gb/s. The wide bandwidth makes it ideal for evaluating pulsed laser and high-frequency modulation applications. Communication applications include 10 Gb Ethernet, OC192, and analog satellite microwave systems.

The unit incorporates a high-performance InGaAs PIN photodiode coupled with a transimpedance amplifier (TIA) that has a gain of 450 V/A and a maximum input power of 20 mW (peak-to-peak) for 60 ms or 1.0 mW (CW). The 50 Ω output is DC coupled through a female SMA connector. For applications that require AC coupling, an external DC block (feed through SMA) can be ordered with the unit (T8535). The fiber input is an FC/PC connector. This detector uses an internal 62.5 µm multimode fiber for easy coupling into the receiver.




| ITEM# | $ | £ | € | RMB | DESCRIPTION |
|---|---|---|---|---|---|
| PDA8GS | $ 3,998.00 | £ 2,771.50 | € 3.549,50 | ¥ 33,760.00 | Amplified Photodetector, DC to 8 GHz, 700-1650 nm |

## DC Block Adapter

The T8535 is a wide-bandwidth DC blocking filter incorporated directly into an SMA feed-through connector.

- **-3 dB Bandwidth:**
  7 kHz to 23 GHz
- **Impedance:** 50 Ω
- **Insertion Loss:**
  - 100 kHz to 12.4 GHz:
    0.5 dB (Max)
  - 12.4 to 23 GHz:
    0.75 dB (Max)

| ITEM# | $ | £ | € | RMB | DESCRIPTION |
|---|---|---|---|---|---|
| T8535 | $ 96.90 | £ 67.20 | € 86,10 | ¥ 818.30 | Female-to-Male SMA DC Block, 7 kHz to 23 GHz |

# Integrating Spheres

## SMA, FC, and SM05PD Adapters Included

**IS236A**
(Post and Post Holder not Included)

### IS200 Series Features

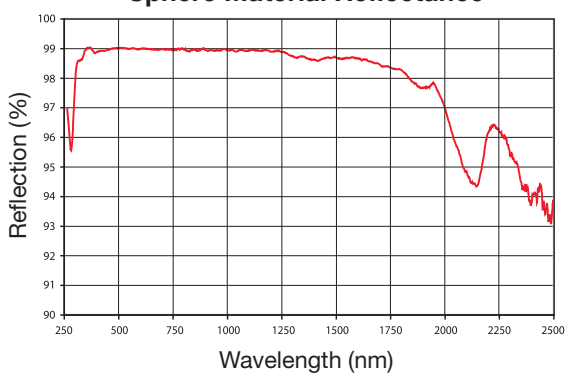
- Ø2" Sphere
- Ø0.5" Clear Aperture Input Ports
- 3 mm Port for Direct Connection of SM05PD Photodiodes
- SM05-Threaded and 30 mm Cage System Compatible
- Durable, High-Reflectance Sphere
- 350-1100 nm (IS236A) or 800-1700 nm (IS210C) Wavelength Range
- Metric and Imperial Threads for Post Mounting
- 3 or 4 Port Plugs,* FC and SMA Fiber Adapters, and SM05PD Series Adapter Included (SM05FC, SM05SMA, SM05CP2C)
- Available with or without Si or InGaAs Photodiode
- Calibration of the Detectors Upon Request

*Model Dependent

The IS200 Integrating Sphere is a general-purpose sphere for many applications such as laser power, flux, reflectance, and radiance measurements. The sphere is manufactured from PTFE-based high-reflective bulk material, making it resistant to heat, humidity, and high levels of radiation. The sphere is compatible with Thorlabs' SM05 series of lens tubes (see page 118) and 30 mm cage system (see page 155).

The port for the direct connection of our SM05PD photodiodes (see page 1303) has been specially arranged and limited to a diameter of 3 mm in order to prevent direct irradiation of the detector, even for large divergent input beams. The IS200 and the IS236A are available in 3 or 4 port versions.

### Sphere Material Reflectance




### Specifications

| | |
|---|---|
| **Dimensions** | 61 mm x 61 mm x 65 mm (2.4" x 2.4" x 2.56") |
| **Sphere Diameter** | 2" |
| **Port Diameter** | 0.5" |
| **Ports** | 3 or 4 (0°, 90°, 180°, NorthPole)* |
| **Photodiode Port** | Ø3 mm for SM05PD |
| **Wavelength Range** | 350-1100 nm (IS236A), 800-1700 nm (IS210C) |
| **Reflectance** | ~99% @ 350-1300 nm >95% @ 250-2500 nm |
| **Thermal Stability** | 250 °C (Max) |
| **Laser Damage Threshold** | 7 J/cm$^2$ |
| **Weight** | 0.35 kg (0.77 lb) |

*180° Port is for the 4 Port Version Only

| ITEM# | $ | £ | € | RMB | DESCRIPTION |
|---|---|---|---|---|---|
| IS200 | $ 950.00 | £ 658.60 | € 843,50 | ¥ 8,021.90 | Ø2" Integrating Sphere, 3 Port without Detector |
| IS200-4 | $ 970.00 | £ 672.50 | € 861,20 | ¥ 8,190.80 | Ø2" Integrating Sphere, 4 Port without Detector |
| IS236A | $ 990.00 | £ 686.30 | € 879,00 | ¥ 8,359.60 | Ø2" Integrating Sphere, 3 Port with Si Detector, 350-1100 nm |
| IS236A-4 | $ 1,005.00 | £ 696.70 | € 892,30 | ¥ 8,486.30 | Ø2" Integrating Sphere, 4 Port with Si Detector, 350-1100 nm |
| IS210C | $ 1,140.00 | £ 790.30 | € 1.012,10 | ¥ 9,626.20 | Ø2" Integrating Sphere, 3 Port with InGaAs Detector, 800-1700 nm |

# Photomultiplier Modules

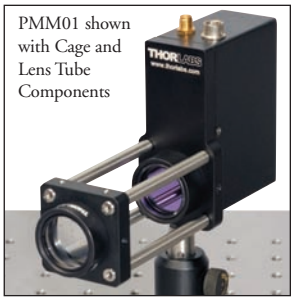
## Features

- Two Spectral Ranges
  - 280-630 nm
  - 280-850 nm
- Head-On Configuration
- Electrostatic and Magnetic Shielding
- Conversion Gain of 1 V/µA of Anode Current
- Circular Dynode Chain Configuration
- Housing Equipped with Internal SM1 Threads
- Four Threaded Holes for Cage Rods
- Post Mountable in Three Different Configurations


Thorlabs offers two photomultiplier modules (PMM) that combine a head-on photomultiplier tube with a housing and a high-gain, DC-coupled, transimpedance amplifier. The PMM01 features a semi-transparent bialkali photocathode and offers a higher gain, lower dark current, and higher quantum efficiency for λ < 500 nm than the PMM02. In contrast, the PMM02 features a semi-transparent multialkali (type S20) photocathode and offers a higher quantum efficiency for λ >500 nm and a wider spectral range than its counterpart.

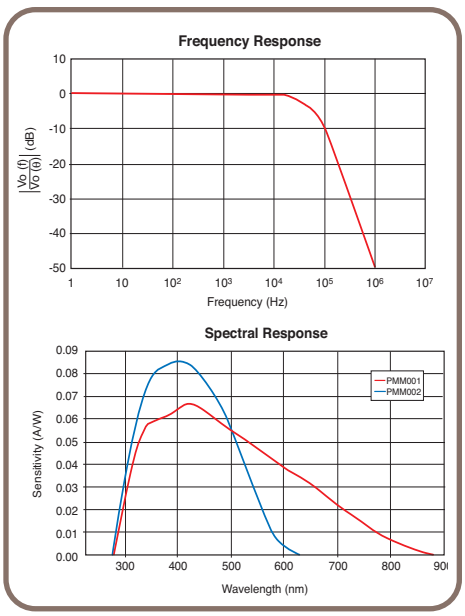
Bialkali photocathodes are widely used for scintillation light detection since their sensitivity is well matched to the most common scintillation materials. Multialkali photocathodes are commonly used for broadband spectrophotometers and photon counting applications.

Both models can be mounted to our standard imperial or metric TR posts (see page 88). Additionally, there are four tapped holes on each module's front face to facilitate integration into our 30 mm cage systems (see page 155). The front aperture is tapped with our standard SM1 thread, making it compatible with our line of SM1 lens tubes (see page 123). This enables one to mount imaging optics and filters directly on the PMM. Furthermore, by using lens tubes, stray and scattered light can be prevented from reaching the detector, which is particularly advantageous when working with weak or noisy signals.



PMM01 shown with Cage and Lens Tube Components

| ITEM# | PMM01 | PMM02 |
|---|---|---|
| Photocathode Type | Bialkali | Multialkali (S20) |
| Photocathode Geometry | Head On | |
| Dynode Chain Orientation | Circular | |
| Photocathode Active Diameter | 22 mm | |
| Wavelength Range | 280-630 nm | 280-850 nm |
| Gain (Max) | 7.1 x $10^6$ | 3.1 x $10^6$ |
| Peak Responsivity (Max) | 86 mA/W | 67 mA/W |
| Quantum Efficiency at Peak | 28% | 21% |
| Transimpedance Gain | Hi-Z: 1 x $10^6$ V/A | 50 Ω: 5 x $10^5$ V/A |
| Dark Current (@20 °C) | 0.3-3 nA | 0.5-5 nA |
| Dark count Rate (@20 °C) | 100 Hz | 3000 Hz |
| Bandwidth (6 dB) | 0-20 kHz | |
| Amplifier Noise (Typ.) | 2 mV RMS | |
| Amplifier Offset (Typ.) | 1 mV | |
| Output Rise and Fall Times | 15 µs | |
| Output Impedance | 50 Ω | |
| Output Signal | Unterminated: 0-10 V<br>Terminated into 50 Ω: 0-5 V | |
| Anode Current (Max) | 100 µA | |
| Tube Voltage (Anode to Cathode) | 0 to -1500 V | 0 to -1800 V |
| Tube Voltage Control | 0 to 1.5 V | 0 to 1.8 V |
| HV Control Sensitivity | -1000 V/V | |
| HV Control Volts | 1.8 V Max | |
| Warm-Up Time | <10 s | |
| Output Connector | SMA | |
| Dimensions | 3.66" x 1.6" x 2.46"<br>(93.0 mm x 40.6 mm x 62.5 mm) | |
| Operating Temperature | 5 to 55 °C | |
| Storage Temperature | -40 to 55 °C | |

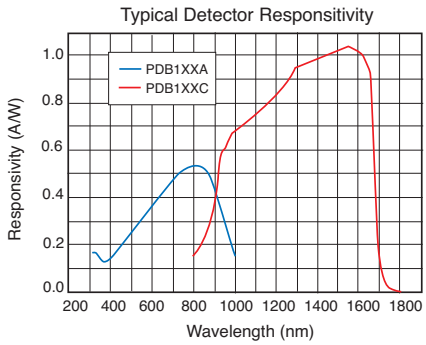



| ITEM# | $ | £ | € | RMB | DESCRIPTION |
|---|---|---|---|---|---|
| PMM01 | $ 2,100.00 | £ 1,456.00 | € 1.864,50 | ¥ 17,733.00 | Photomultiplier Module, 280-630 nm |
| PMM02 | $ 2,400.00 | £ 1,663.50 | € 2.130,50 | ¥ 20,266.00 | Photomultiplier Module, 280-850 nm |

# Fiber-Coupled Balanced Amplified Photodetectors (Page 1 of 2)


**PDB150**
(Switchable Gain)


**PDB120**
(Fixed Gain)




## Applications

- Optical Coherence Tomography (OCT)
- THz Detection
- Spectroscopy
- Heterodyne Detection
- LIDAR

**Introduction**

The PDB100 Balanced Detector Series subtracts two input signals from each other, resulting in the cancellation of common mode noise. This allows small changes on the signal path to be extracted from the interfering noise floor. Versions offered include those with bandwidths of DC to 15 MHz, DC to 75 MHz, DC to 100 MHz, and DC to 350 MHz, along with a switchable version (PDB150) with selectable transimpedance gain. Each model is available with either Si (A versions) or InGaAs (C versions) photodiodes. To improve the measurement capabilities in applications where it is desirable to measure a comparably weak frequency modulated signal over a strong CW background signal, an AC-coupled version of the PDB Series is offered.

The PDB100 series of detectors use two balanced photodiodes and an ultra-low noise, high-speed transimpedance amplifier. The design allows an improved matching of the balanced photodetectors to achieve an excellent common mode rejection, leading to better noise reduction. For the PDB140 and PDB145, an additional active filter to suppress aliasing effects is also included.

The detectors have two optical inputs with removable and interchangeable connectors – either FC/PC or FC/APC – for easy adaptation to either fiber-coupled or free-space applications. However, the FC adapter on the PDB130C is not removable.

## Specifications

- **Optical Inputs:*** FC/PC or FC/APC (Removable)
- **Photodiode Damage Threshold:** 20 mW
- **Electrical Outputs:** SMA
- **RF Output Impedance:** 50 Ω
- **Size:** 85 mm x 80 mm x 30 mm
- **Switchable Power Supply Included:** 110 VAC, 230 VAC
- **Conversion Gain Monitor Output (V/mW):**
  10 V/mW at 820 nm for Item Numbers Ending in A or at 1550 nm for Item Numbers Ending in C**

*For PDB130C models, FC adapter is not removable.

Three electrical SMA connectors provide the balanced output signal and a power monitor for each of the two input signals. These two monitors make it possible to control the input power levels and can be used as an independent power meter for each channel.

The unit is housed in a shielded, rugged, aluminum enclosure. The housing has an #8-32 and M4 x 0.7 threaded mounting adapter plate that can be positioned by the user so that it is located on either the bottom or the back of the detector. The latter allows the unit to be mounted onto a post by using the included screws and allen wrench. A ±12 V DC power supply is included with each unit.


**PDB150C**

# Fiber-Coupled Balanced Amplified Photodetectors (Page 2 of 2)

## Features

- 320-1700 nm Wavelength Ranges
- Excellent Common Mode Rejection
- DC to 350 MHz Bandwidth
- Ultra Low Noise
- Si or InGaAs Detector
- Free-Space or Fiber Input (FC/PC or FC/APC)
- Direct Detector Monitor Outputs
- Power Supply Included
- Switchable Gain Version Available

| ITEM# | PDB140A | PDB140C | PDB145A | PDB145C | PDB120A | PDB120C |
|---|---|---|---|---|---|---|
| Detector Type | Si/PIN | InGaAs/PIN | Si/PIN | InGaAs/PIN | Si/PIN | InGaAs/PIN |
| Wavelength Range (nm) | 320-1000 | 800-1700 | 320-1000 | 800-1700 | 320-1000 | 800-1700 |
| Max Responsivity (A/W) | 0.53 | 1.0 | 0.53 | 1.0 | 0.53 | 1.0 |
| Active Detector Diameter (mm) | 0.8 | 0.3 | 0.8 | 0.3 | 0.8 | 0.3 |
| Conversion Gain[a] (kV/W) | 297 | 560 | 27 | 51 | 95 | 180 |
| CW Saturation Power[b] (µW) | 12 | 6.5 | 130 | 70 | 38 | 20 |
| NEP, Min[b] (pW/PHz) | 5.7 | 3.2 | 5.7 | 3.2 | 6 | 3.2 |
| Transimpedance Gain[d] (V/A) | $560 \times 10^3$ | | $51 \times 10^3$ | | $180 \times 10^3$ | |
| Bandwidth, 3 dB (MHz) | DC - 15 | | DC - 15 | | DC - 75 | |
| CMRR[c] | >35 dB | | >35 dB | | >35 dB | |

[a] Specified for DC to 10 MHz
[b] RF output; specified at 820 nm for A versions and 1550 nm for C versions
[c] Specified for DC to 10 MHz
[d] Transimpedance Gain is reduced by a factor of two for 50 Ω
[e] Common Mode Rejection Ratio

| ITEM# | PDB110A | PDB110C | PDB130A | PDB130C | PDB150A | PDB150C |
|---|---|---|---|---|---|---|
| Detector Type | Si/PIN | InGaAs/PIN | Si/PIN | InGaAs/PIN | Si/PIN | InGaAs/PIN |
| Wavelength Range (nm) | 320-1000 | 800-1700 | 320-1000 | 800-1700 | 320-1000 | 800-1700 |
| Max Responsivity (A/W) | 0.53 | 1.0 | 0.50 | 1.0 | 0.53 | 1.0 |
| Active Detector Diameter (mm) | 0.8 mm | 0.3 mm | 0.4 mm | 0.15 mm | 0.8 mm | 0.3 mm |
| Conversion Gain[a] (kV/W) | 26.5 | 50 | 5 | 10 | 0.53 - 5,300 | 1 - 10,000 |
| CW Saturation Power[b] (µW) | 130 | 70 | 700 | 400 | 10,000 | 5,000 |
| NEP, Min[c] (pW/√Hz) | 6.9 | 3.6 | 14.7 | 7.4 | 0.6 | 0.3 |
| Transimpedance Gain[d] (V/A) | $50 \times 10^3$ | | $10 \times 10^3$ | | $10^3$, $10^4$, $10^5$, $10^6$, $10^7$ | |
| Bandwidth, 3 dB (MHz) | DC-100 | | DC-350 | | DC-150, 50, 5, 0.3, 0.1 | |
| CMRR[c] | >25 dB (Typical >35 dB) | | >20 dB (Typical >25 dB) | | >25 dB (Typical >30 dB) | |

[a] Specified for DC to 10 MHz
[b] RF output; specified at 820 nm for A versions and 1550 nm for C versions
[c] Specified for DC to 10 MHz
[d] Transimpedance Gain is reduced by a factor of two for 50 Ω
[e] Common Mode Rejection Ratio

| ITEM# | $ | £ | € | RMB | DESCRIPTION* |
|---|---|---|---|---|---|
| PDB110A | $ 1,050.00 | £ 727.90 | € 932,20 | ¥ 8,866.30 | Balanced Amplified Photodetector, Si, 100 MHz |
| PDB110C | $ 1,100.00 | £ 762.60 | € 976,60 | ¥ 9,288.50 | Balanced Amplified Photodetector, InGaAs, 100 MHz |
| PDB120A | $ 1,176.00 | £ 815.30 | € 1.044,10 | ¥ 9,930.20 | Balanced Amplified Photodetector, Si, 75 MHz |
| PDB120C | $ 1,260.00 | £ 873.50 | € 1.118,70 | ¥ 10,640.00 | Balanced Amplified Photodetector, InGaAs, 75 MHz |
| PDB130A | $ 1,344.00 | £ 931.70 | € 1.193,30 | ¥ 11,349.00 | Balanced Amplified Photodetector, Si, 350 MHz |
| PDB130C | $ 1,440.00 | £ 998.30 | € 1.278,50 | ¥ 12,160.00 | Balanced Amplified Photodetector, InGaAs, 350 MHz |
| PDB140A | $ 1,276.00 | £ 884.60 | € 1.132,90 | ¥ 10,775.00 | Fixed-Gain Balanced Detector, Si, 15 MHz |
| PDB140C | $ 1,360.00 | £ 942.80 | € 1.207,50 | ¥ 11,484.00 | Fixed-Gain Balanced Detector, InGaAs, 15 MHz |
| PDB145A | $ 1,276.00 | £ 884.60 | € 1.132,90 | ¥ 10,775.00 | Fixed-Gain Balanced Detector, Si, 15 MHz |
| PDB145C | $ 1,360.00 | £ 942.80 | € 1.207,50 | ¥ 11,484.00 | Fixed-Gain Balanced Detector, InGaAs, 15 MHz |
| PDB150A | $ 1,344.00 | £ 931.70 | € 1.193,30 | ¥ 11,349.00 | Balanced Amplified Photodetector, Si, Switchable Gain |
| PDB150C | $ 1,440.00 | £ 998.30 | € 1.278,50 | ¥ 12,160.00 | Balanced Amplified Photodetector, InGaAs, Switchable Gain |

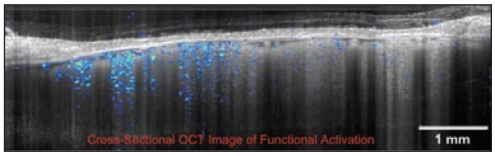
*Add -AC to the item number for a version with AC-coupling.

## OCT-Proven Balanced Detectors

See Page 1374

- Polarization Insensitive (320-100 nm and 800-1700 nm)
- Polarization Sensitive (1270-1350 nm)

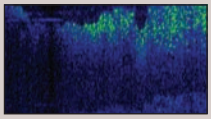
Our OCT-Proven Balanced Detectors are Ideal for Use in OCT Imaging Systems




OCT image of a rat brain superimposed with functional imaging.

Ref: A.D. Aguirre, Y. Chen, J. G. Fujimoto, L. Ruvinskaya, A. Devor, D. A. Boas, Optics Letters, 31(23), 34559-3461 (2006).

**Visit our laser imaging web page for up-to-date imaging research and applications:**



**www.thorlabs.com**

# Free-Space Balanced Amplified Detectors

## Features

- Large Active Areas for Free-Space Beams
- Detectors for the 320-1700 nm Range
- Excellent Common Mode Rejection
- Fast Monitor Outputs
- Power Supply Included
- External SM1 Threads and Internal SM05 Threads

NEW products


**PDB210C**
Post Assembly Not Included


Top View

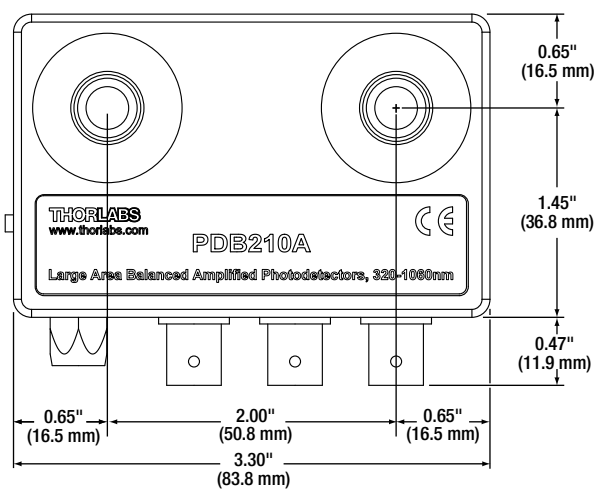
The PDB210 series of balanced amplified photodetectors utilize two large-area Si or InGaAs detectors to detect signal path differences in two beams. The detectors are spaced 2" (50.8 mm) apart, making beam alignment an easy task on an optical table.To further simplify the use of these detectors, the housing has external SM1 and internal SM05 threads around each detector to attach components such as lens tubes, cage systems, mounted optics, and fiber adapters.

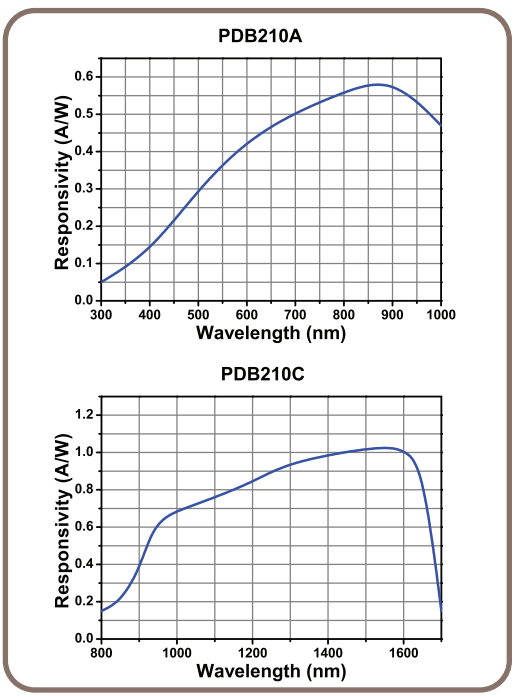
The design uses two matched photodiodes to achieve an excellent common mode rejection, leading to better noise reduction. These photodiodes are combined with an ultralow noise, high-speed transimpedance amplifier to provide low noise-equivalent power (NEP).

The PDB210 series has two BNC monitor outputs to monitor the photodiodes individually and a BNC RF output to monitor the difference between the photodiodes. Each detector includes a switchable power supply for 100 – 120 VAC or 220 – 240 VAC. One #8-32 (M4) tap is centered along the length of the body and one #8-32 (M4 x 0.7) tap is located on each side of the body, centered along the optical axis of the detector.

| ITEM# | PDB210A | PDB210C |
|---|---|---|
| Detector Type | Si/PIN | InGaAs/PIN |
| Wavelength Range | 320-1060 nm | 800-1700 nm |
| Responsivity (Max) | 0.6 A/W @ 920 nm | 1 A/W @ 1550 nm |
| Detector Diameter | 5 mm | 3 mm |
| Bandwidth, 3 dB | DC-1 MHz | |
| Common Mode Rejection Ratio | 40 dB | 30 dB |
| Transimpedance Gain | 5 x $10^5$ V/A, 1.75 x $10^5$ V/A with 50 Ω Termination | |
| Conversion Gain (RF Output) | 3 x $10^5$ V/W | 5 x $10^5$ V/W |
| Conversion Gain (Monitor Outputs) | 10 V/mW @ 920 nm | 10 V/mW @ 1550 nm |
| CW Saturation Power (RF Output) | 33 µW @ 920 nm | 20 µW @ 1550 nm |
| Minimum NEP (DC - 10 MHz) | 2.2 pW/√Hz | 16 pW/√Hz |
| Damage Threshold | 20 mW | |
| Electrical Outputs | BNC, 100 Ω | |
| Dimensions | 3.3" x 2.1" x 0.8" (83.9 mm x 53.4 mm x 21 mm) | |
| Power Supply | ±12 V @ 200 mA | |

Mechanical Drawings Available on the WEB




| ITEM# | METRIC ITEM# | $ | £ | € | RMB | DESCRIPTION |
|---|---|---|---|---|---|---|
| PDB210A | PDB210A/M | $ 900.00 | £ 623.90 | € 799,10 | ¥ 7,599.70 | Balanced Photodetector, Si, 320-1060 nm |
| PDB210C | PDB210C/M | $ 1,700.00 | £ 1,178.50 | € 1.509,50 | ¥ 14,355.00 | Balanced Photodetector, InGaAs, 800-1700 nm |

# Lateral Effect Detector

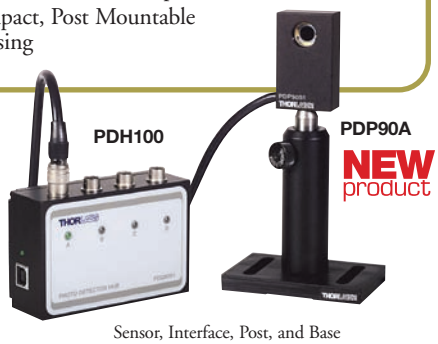
## Features

- 2D Lateral Effect Position-Sensing Detector
- Insensitive to Beam Shape and Power Density
- Ideal Spot Sizes Between Ø0.2 mm and Ø7 mm
- Broad, 320-1100 nm Wavelength Range
- SM05 Lens Tube Compatible
- Compact, Post Mountable Housing

The PDP90A Position Sensor utilizes a pincushion tetra lateral sensor to accurately measure the displacement of an incident beam relative to the calibrated center. It is ideal for measuring the movement of a beam or the distance traveled; it can also provide feedback for alignment purposes.

A large detection surface can accommodate beam diameters up to 9 mm; however, our recommend range is Ø0.2 to Ø7 mm. Unlike quadrant sensors, which require beam overlap in all quadrants, the lateral sensor provides positional information of any spot within the detector region, independent of beam shape, size, or power distribution. The PDP90A has a very low noise figure of <2 $mV_{pp}$, which corresponds to a peak-to-peak detection error of <2.3 µm.

Our PDP90A is post mountable via an #8-32 threaded hole, but an M4 x 0.7 adapter is included for metric applications. While the 2D lateral effect detectors are sold individually, they must be used in conjunction with the PDH100 or TQD001 interfaces, which provide stand-alone operation for a computer interface via USB.




Sensor, Interface, Post, and Base Sold Separately

### Optical Power Handling

When using the PDP90A, it is necessary to have an appropriate amount of optical power. Graphs of the suggested optical power versus wavelength and the responsivity of the sensor are shown below. As the responsivity of the sensor increases, the maximum power decreases. The minimum power that will ensure a sufficient photocurrent for accurate beam position detection is also shown on the graph. As a note, the 0.675 µm resolution is specified with a 40 µA photocurrent, which is also the maximum photocurrent.

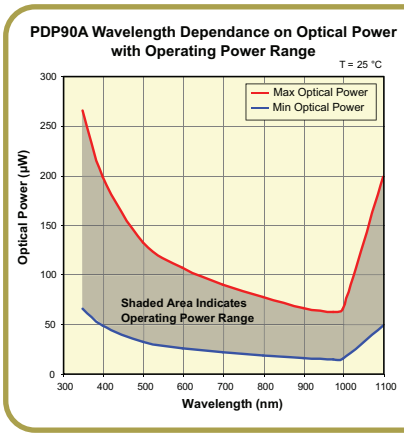
TQD001

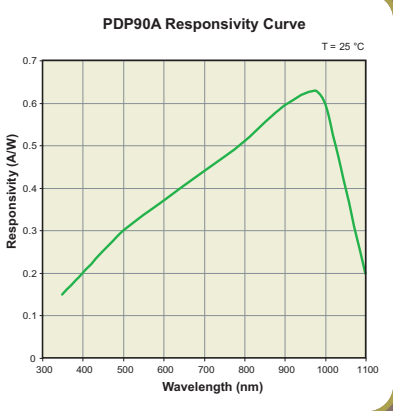
### PDH100 and TQD001 Interfaces

To use the PDP90A, an interface is required. The PDH100 interface can accommodate any combination of up to four PDP90A or PDQ Quadrant Detectors. With detectors connected to the PDH100, stand-alone or remote operation via a computer is possible. Stand-alone operation provides an indicator light to signify when the beam is centered on the sensor, while the computer interface offers more detailed information including numerical beam displacement data of up to four sensors at one time. The TQD001 is also compatible with all position detectors but only provides one detector connection. When used manually, nine LEDs denote the X or Y position of the beam incident on the detector. The detector can also connect to a computer via USB for remote operation. The TQD001 is sold without a power supply since we offer a variety of power supply options. The TPS002 is capable of powering two TQD001 T-Cubes, while the TCH002 is a T-Cube USB hub and power supply for up to 6 T-Cubes.

| ITEM# | PDP90A |
|---|---|
| Wavelength Range | 320-1100 nm |
| Peak Responsivity | 0.6 A/W @ 960 nm |
| Resolution* | 0.675 µm |
| Voltage Noise | <2 m $V_{pp}$, <300 µ$V_{rms}$ |
| Displacement Noise | <2.25 µm |
| Transimpedance Gain | 100 kV/A |
| Max Photocurrent | 40 µA |
| Output Voltage Range | ±4 $V_{min}$ |
| Signal Output Offset | 0.3 $mV_{typ}$ (7 $mV_{max}$) |
| Bandwidth | 15 kHz |
| Recommended Spot Size | Ø0.2 mm - Ø7 mm |
| Operating/Storage Temperature | 10 to 40 °C/ -20 to 80 °C |
| Mounting | #8-32 (M4 Adapter Included) |
| Cable Length | 5' (1.5 m) |
| **PDP90A with PDH100** | |
| A/D Resolution | ±1462 bits |
| Displacement Resolution | 3.08 µm |
| Accuracy** | <0.3% |

*Resolution is dependent on input optical power and assumes a photocurrent of 40 µA.
**Accuracy is dependent on input signal power and assumes a photocurrent >10 µA.




| ITEM# | $ | £ | € | RMB | DESCRIPTION |
|---|---|---|---|---|---|
| PDP90A | $ 380.00 | £ 263.50 | € 337,40 | ¥ 3,208.80 | Lateral Effect Detector, 320-1100 nm |
| PDH100 | $ 446.00 | £ 309.20 | € 396,00 | ¥ 3,766.10 | 4-Port Interface for Position Sensing Detectors |
| TQD001 | $ 637.50 | £ 442.00 | € 566,00 | ¥ 5,383.10 | T-Cube Interface for Position Sensing Detectors |
| TPS002 | $ 105.00 | £ 72.80 | € 93,30 | ¥ 886.70 | Power Supply for up to Two TQD001 |
| TCH002 | $ 726.90 | £ 504.00 | € 645,40 | ¥ 6,138.00 | Power Supply/Hub for up to Six T-Cubes |

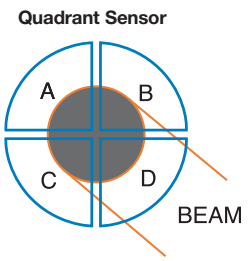
# Quadrant Detectors (Page 1 of 2)

Our quadrant detectors are based on quadrant photodiodes, which are segmented into four quadrants, each of which produces a photocurrent that is proportional to the power of the incident beam. By closely spacing the four quadrants of the detector, the X and Y displacement of a laser beam can be calculated by comparing the photocurrent produced by each quadrant. Note that since the detector locates the center of the power distribution, these detectors are best suited for use with beams that have even power distributions.

**Features:**

- Measure X and Y Coordinates of a Beam's Position
- Auto Alignment of Beam Possible in Closed-Loop Mode
- 2 Models for the 400-1700 nm Range
- SM05 Lens Tube Compatible
- Two Quadrant Detector Interfaces Offered
- 100 mW/cm² Damage Threshold

A beam's position is determined based on the sum of the X and Y signal components. For example, in the image to the right that shows four quadrants, the Y position of the beam is calculated by (A + B) – (C + D), while the horizontal location of the beam is (A + C) – (B + D). These difference signals, along with the sum signal (A + B + C + D) are outputted via a 6-pin Hirose connector.




### PDQ Series Detectors

Thorlabs offers two quadrant detectors, each with broad wavelength ranges. The PDQ80A utilizes a Ø7.8 mm silicon detector for light detection in the 400-1050 nm range. Its large sensor is ideally suited for use with beams between Ø1 mm and Ø3.9 mm. An InGaAs version is also available, which has a Ø3 mm detector for light in the 1-1.7 µm. Due to its smaller sensor, this version should be used with beams between Ø0.2 mm and Ø0.5 mm. Focusing optics may be used to achieve the necessary beam diameter.

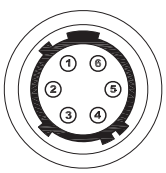
The PDQ series of detectors are SM05 lens tube compatible (see pages xxx – xxx), which allows for simple system integration and compatibility with many mounted optics such as ND filters.

These position sensing detectors are sold without an interface, which is necessary for operation. We offer two interface options, a 4-port interface or a T-Cube interface, that can be used with any of our PDP or PDQ position sensing detectors.

### 4-Port Interface

The PDH100 4-Port Interface has connections for up to four PDP lateral effect or PDQ quadrant detectors. In its stand-alone mode, the PDH100 interface will light an LED when the beam is centered on the sensor. Alternatively, the PDH100 can be connected to a computer via its USB2.0 connection, and the position of each beam can be viewed graphically with the included graphical user interface (GUI); a screen shot is shown below. The PDH100 is powered through its USB2.0 connection; thus when used in stand-alone mode, it will need to be connected to an AC-to-USB power supply (5 VDC, 500 mA) or to a computer for power.

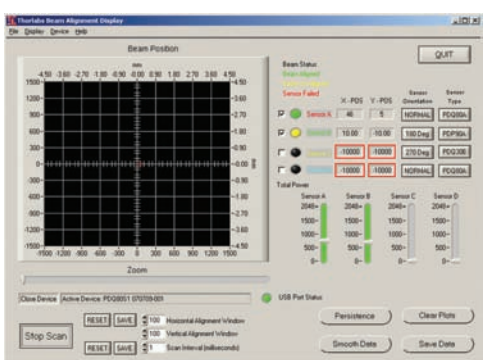
### Pin Configuration




6 Pin HIrose

| PIN# | ASSIGNMENT |
|---|---|
| 1 | X-Axis |
| 2 | Y-Axis |
| 3 | Sum |
| 4 | +V (5 to 15 V) |
| 5 | Common |
| 6 | -V (-5 to -15 V) |

| ITEM# | PDH100 |
|---|---|
| Interface | USB2.0 |
| A/D Resolution | 12 Bit |
| Maximum Scan Rate | 1000 Scans per Second |
| LED Accuracy | 3.8% of Sensor Range |
| Position Sensing Connection | 6 Pin Hirose (4X) |
| Dimensions | 3.6" x 2.4" x 1.3" |
| Operating Temperature | 10 to 40 °C |
| Input Voltage | +5 VDC (from USB) |


PDH100 GUI

# Quadrant Detectors (Page 2 of 2)

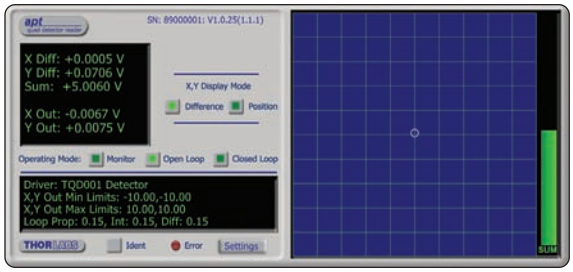
TQD001

**T-Cube Interface**

The TQD001 is a T-Cube Interface for our position sensing detectors. Its top overlay has a 9-light display that indicates a beam's position on the sensor. Unlike the PDH100, only one detector can be connected to the T-Cube at a time. However, the unit has three SMA connections for monitoring the X and Y difference signals as well as the sum signal. These connections allow a position detector to be used in a closed-loop application, such as with our new Galvo Scanning Mirror (see page 1384). The T-Cube can also interface with a computer via USB1.1 and uses our APT software; a screen shot is shown below. Due to the variety of power supply options available for our T-Cubes, we do not include a power supply with the unit. Two power supply options, the TPS002 two connection supply and the TCH002 six connection power supply and USB hub, are offered below.

| ITEM# | TQD001 |
|---|---|
| Interface | USB1.1 |
| X & Y Difference Outputs* | -10 to 10 V |
| Sum Output* | 0 to 10 V |
| Position Sensing Connection | 6 Pin Hirose |
| X & Y Position Demand Outputs* | 0 to 10 V |
| Closed-Loop X & Y Position Control | PID |
| Closed-Loop Bandwidth | 1 kHz |
| Dimensions (W x D x H) | 60 mm x 60 mm x 47 mm |
| Weight | 160 g (5.5 oz) |

*SMA Connectors




TQD001 GUI

| ITEM# | PDQ80A | PDQ30C |
|---|---|---|
| Sensor Type | Si | InGaAs |
| Wavelength Range | 400-1050 nm | 1000-1700 nm |
| Photodiode Diameter | Ø7.8 mm | Ø3.0 mm |
| Gap Size | 42 µm | 45 µm |
| Detector Bandwidth | 150 kHz | |
| Responsivity | 0.45 A/W (@ 633 nm) | 1 A/W (@ 1630 nm) |
| Dark Current ($V_{Reverse}$ = 10 V) | 5 nA | 2.0 nA (Typ.)<br>100 nA (Max) |
| Rise Time @ 5 V | 40 ns | 24 ns (Typ.) |
| Breakdown Voltage | 15 V | 10 V |
| Housing Dimensions | 2.0" x 1.2" x 0.65" | |
| Damage Threshold | 100 mW/cm$^2$ | |
| Cable Length | 5 Feet | |
| Mounting Threads | #8-32 (M4 Adapter Included) | |



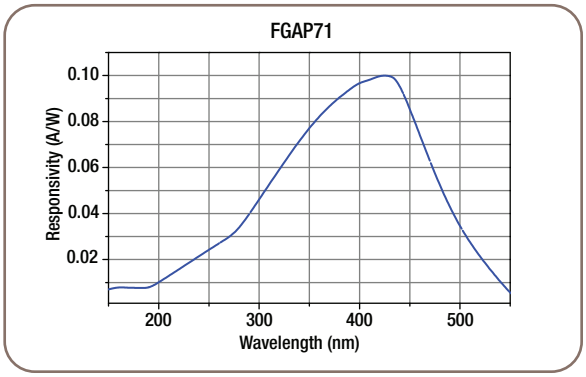
| ITEM# | $ | £ | € | RMB | DESCRIPTION |
|---|---|---|---|---|---|
| PDQ80A | $ 480.00 | £ 332.80 | € 426,20 | ¥ 4,053.20 | Si Quadrant Detector, 400-1050 nm |
| NEW PDQ30C | $ 795.00 | £ 551.20 | € 705,90 | ¥ 6,713.00 | InGaAs Quadrant Detector, 1000-1700 nm |
| PDH100 | $ 446.00 | £ 309.20 | € 396,00 | ¥ 3,766.10 | 4-Port Interface for Position Sensing Detectors |
| NEW TQD001 | $ 637.50 | £ 442.00 | € 566,00 | ¥ 5,383.10 | T-Cube Interface for Position Sensing Detectors |
| TPS002 | $ 105.00 | £ 72.80 | € 93,30 | ¥ 886.70 | Power Supply for up to Two TQD001 |
| TCH002 | $ 726.90 | £ 504.00 | € 645,40 | ¥ 6,138.00 | Power Supply/USB Hub for up to Six T-Cubes |

# GaP Photodiodes

- High Responsivity of 0.12 A/W @ 440 nm
- 1 ns Rise Time/140 ns Fall Time
- 150-550 nm Spectral Range

The FGAP71 has a wide bandwidth and high spectral sensitivity in the UV and visible ranges (150-550 nm). The diode is mounted in hermetically sealed packages with a sapphire window.


FGAP71

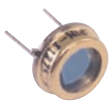



| ITEM# | $ | £ | € | RMB | RISE/FALL TIME* | ACTIVE AREA | NEP | DARK CURRENT | SPECTRAL RANGE |
|---|---|---|---|---|---|---|---|---|---|
| FGAP71 | $ 85.90 | £ 59.60 | € 76,30 | ¥ 725.40 | 1 ns /140 ns | 4.8 mm² | 1.0 x $10^{-14}$ W/√Hz | 10 nA (5 V) | 150-550 nm |

*Photodiodes measured with 50 Ω load

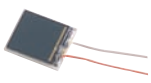
# Si Photodiodes

The FDS100-CAL and FDS1010-CAL calibrated photodiodes come with device-specific calibration data. Thorlabs' calibrated photodiodes have a measurement uncertainty of ±5% and are NIST traceable. The FDS02 is in an FC/PC housing for fiber coupling.

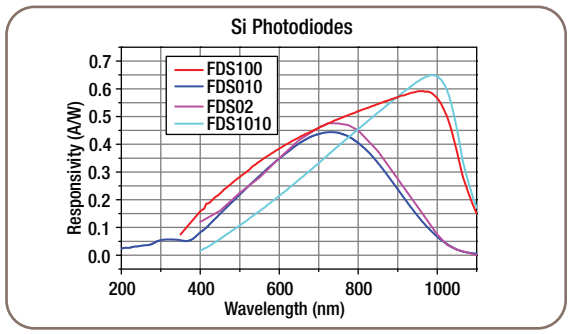

FDS100
TO-5 Package


FDS010
TO-5 Package


FDS02
FC/PC Package


FDS1010
Ceramic Wafer

## NEW Calibrated Photodiodes!



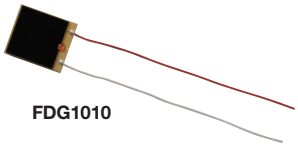

| ITEM# | $ | £ | € | RMB | RISE TIME* | ACTIVE AREA | NEP | DARK CURRENT | SPECTRAL RANGE |
|---|---|---|---|---|---|---|---|---|---|
| FDS100 | $ 11.90 | £ 8.25 | € 10,60 | ¥ 100.50 | 10 ns | 13 mm² (3.6 x 3.6 mm) | 1.2x$10^{-14}$ W/√Hz | 20 nA (20 V) | 350-1100 nm |
| FDS010 | $ 42.10 | £ 29.20 | € 37,40 | ¥ 355.50 | 1 ns | 0.8 mm² (Ø1 mm) | 5x$10^{-14}$ W/√√Hz | 2.5 nA (20 V) | 200-1100 nm |
| FDS02 | $ 73.50 | £ 51.00 | € 65,30 | ¥ 620.70 | 47 ps | Ø0.25 mm | 9.3x$10^{-5}$ W/√Hz | 35 pA (5 V) | 400-1100 nm |
| FDS1010 | $ 43.80 | £ 30.40 | € 38,90 | ¥ 369.90 | 45 ns | 94.1 mm² (9.7 x 9.7 mm) | 4x$10^{-13}$ W/√Hz | 0.6 µA (5 V) | 400-1100 nm |
| FDS100-CAL | $ 146.60 | £ 101.70 | € 130,20 | ¥ 1,237.90 | 10 ns | 13 mm² (3.6 x 3.6 mm) | 1.2x$10^{-14}$ W/√Hz | 20 nA (20 V) | 350-1100 nm |
| FDS1010-CAL | $ 176.30 | £ 122.30 | € 156,60 | ¥ 1,488.70 | 45 ns | 94.1 mm² (9.7 x 9.7 mm) | 4x$10^{-13}$ W/√Hz | 0.6 µA (5 V) | 400-1100 nm |

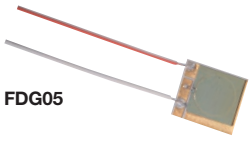
*Photodiodes measured with 50 Ω load and 12 V Bias

# Ge Photodiodes

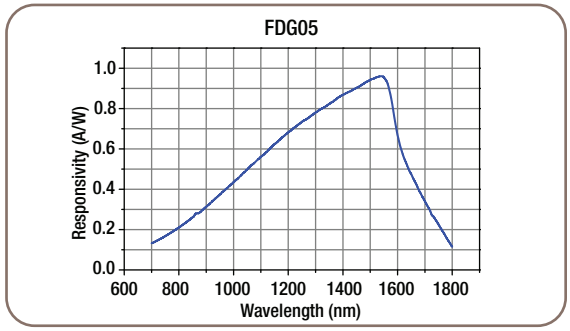
- Large Active Area
- Ideal for Pulsed and CW Sources
- 800-1800 nm Spectral Range
- AR Coated for 1300-1550 nm

The FDG03-CAL and FDG05-CAL calibrated photodiodes come with device-specific calibration data. All of Thorlabs' calibrated photodiodes have a measurement uncertainty of ±5% and are NIST traceable.


FDG1010


FDG05

## NEW Calibrated Photodiodes!




| ITEM# | $ | £ | € | RMB | RISE TIME* | ACTIVE AREA | NEP | DARK CURRENT | SPECTRAL RANGE |
|---|---|---|---|---|---|---|---|---|---|
| FDG03 | $ 96.50 | £ 66.90 | € 85,70 | ¥ 814.90 | 500 ns @3 V | 7 mm² (Ø3 mm) | 1 x $10^{-12}$ W/√Hz | 4.0 µA (1 V) | 800-1800 nm |
| FDG05 | $ 232.40 | £ 161.20 | € 206,40 | ¥ 1,962.40 | 220 ns @5 V | 19.6 mm² (Ø5 mm) | 4.0 x $10^{-12}$ W/√Hz | 40 µA (3 V) | 800-1800 nm |
| FDG1010 | $ 405.30 | £ 281.00 | € 359,90 | ¥ 3,422.40 | 3.5 µs @1 V | 100 mm² (10 x 10 mm) | 4.0 x $10^{-12}$ W/√Hz | 40 µA (0.5 V) | 800-1800 nm |
| FDG03-CAL | $ 246.00 | £ 170.60 | € 218,50 | ¥ 2,077.30 | 500 ns @3 V | 7 mm² (Ø3 mm) | 1.0 x $10^{-12}$ W/√Hz | 4.0 µA (1 V) | 800-1800 nm |
| FDG05-CAL | $ 374.00 | £ 259.30 | € 332,10 | ¥ 3,158.10 | 220 ns @5 V | 19.6 mm² (Ø5 mm) | 4.0 x $10^{-12}$ W/√Hz | 40 µA (3 V) | 800-1800 nm |

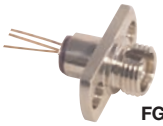
*Photodiodes measured with 50 Ω load

# High-Speed InGaAs Photodiodes

- **FGA04:** TO-46, Direct FC/PC Coupled, High Responsivity
- **FGA10:** TO-5, Low Capacitance, High Responsivity
- **FGA21:** TO-5, Large Active Area

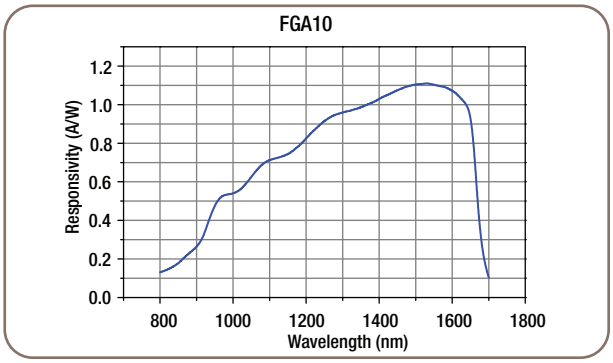
The FGA21-CAL calibrated photodiode comes with device-specific calibration data. All of Thorlabs' calibrated photodiodes have a measurement uncertainty of ±5% and are NIST traceable.

FGA10



FGA04

## NEW Calibrated Photodiode!



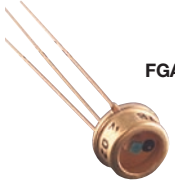

| ITEM# | $ | £ | € | RMB | RISE TIME* | ACTIVE AREA | NEP | DARK CURRENT | SPECTRAL RANGE |
|---|---|---|---|---|---|---|---|---|---|
| FGA04 | $ 140.00 | £ 97.10 | € 124,30 | ¥ 1,182.20 | 100 ps @ 12 V | Fiber Input | 1.5 x $10^{-15}$ W/√Hz | 0.5 nA (5 V) | 800-1800 nm |
| FGA10 | $ 158.10 | £ 109.60 | € 140,40 | ¥ 1,335.00 | 5 ns @ 12 V | 0.8 mm² (Ø1 mm) | 2.5 x $10^{-14}$ W/√Hz | 25 nA (5 V) | 700-1800 nm |
| FGA21 | $ 192.00 | £ 133.10 | € 170,50 | ¥ 1,621.30 | 66 ns @ 0 V | 3.14 mm² (Ø2 mm) | 3 x $10^{-14}$ W/√Hz | 200 nA (1 V) | 800-1800 nm |
| FGA21-CAL | $ 336.00 | £ 233.00 | € 298,40 | ¥ 2,837.20 | 66 ns @ 0 V | 3.14 mm² (Ø2 mm) | 3 x $10^{-14}$ W/√Hz | 200 nA (1 V) | 800-1800 nm |

*Photodiodes measured with 50 Ω load

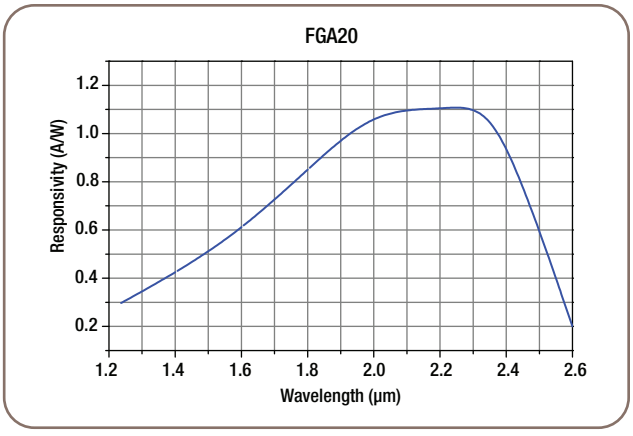
# Long Wavelength InGaAs Photodiode

- 1200-2600 nm Spectral Range
- High Responsivity
- TO-18 Package

The FGA20 photodiode provides high responsivity from 1200-2600 nm, allowing detection of wavelengths beyond the 1800 nm limit of typical InGaAs photodiodes.



FGA20

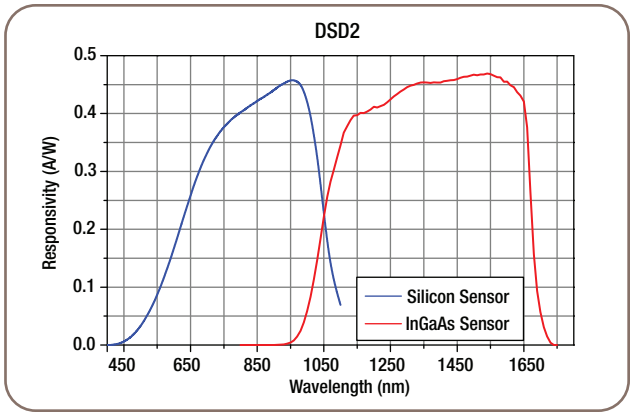



| ITEM# | $ | £ | € | RMB | PEAK WAVELENGTH | ACTIVE AREA | NEP | DARK CURRENT | SPECTRAL RANGE |
|---|---|---|---|---|---|---|---|---|---|
| FGA20 | $ 242.40 | £ 168.10 | € 215,30 | ¥ 2,046.90 | 2.3 µm | 0.790mm² (Ø1 mm) | 2 x $10^{-12}$ W/√Hz | 75 µA (1 V) | 1200-2600 nm |

# Dual-Band Detector

The DSD2 is a two-element photodiode, which uses Si and InGaAs detectors stacked on top of each other, providing a very wide spectral response. The DSD2 has four pins, two for each sensor. This TO-5 package detector is ideal for remote temperature measurements where an extremely wide wavelength range needs to be monitored.

DSD2

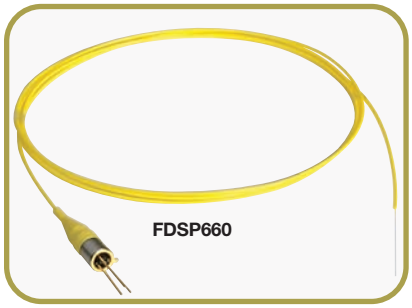



| ITEM# | $ | £ | € | RMB | PEAK WAVELENGTHS | ACTIVE AREA | RISE TIME | SPECTRAL RANGE |
|---|---|---|---|---|---|---|---|---|
| DSD2 | $ 414.10 | £ 287.10 | € 367,70 | ¥ 3,496.70 | 950/1300 nm | Ø2.54 mm / Ø1.5 mm | 4 µs typ. Both Layers | 400-1700 nm |

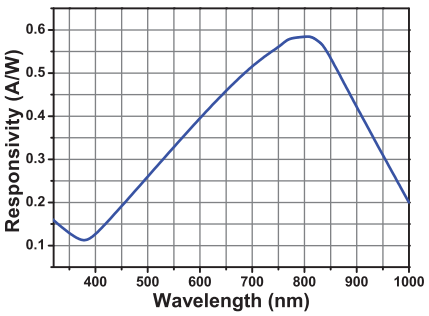
# Fiber-Coupled Photodiodes

- Coupled to 1 m of SM or MM Fiber
- High-Speed PIN Photodiode
- Low Bias Voltage
- Fiber End Unterminated
- Stainless Steel Outer Housing
- Ø900 µm Loose Tube Outer Jacket
- Rubber Strain Relief Boot

NEW products

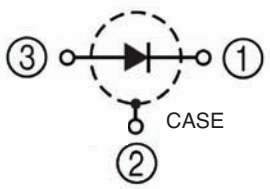



Typical Detector Responsivity




## Photodiode Specifications:

- **Peak Responsivity:** 0.58 A/W @ 800 nm
- **Max Input Power:** 50 mW
- **NEP:** 3.1 x $10^{-15}$ W/√Hz




Fiber-coupled photodiodes are available for wavelengths from the UV to the NIR. Each photodiode is pigtailed to 1 m of unterminated fiber. The FDSP Series of Pigtailed Photodiodes utilize a high-speed Si PIN photodiode that provides wideband characteristics at a low bias voltage, which is ideal for use in optical communications, high-speed photometry, and monitoring applications.

| ITEM# | FDSP625 | FDSP660 | FDSP780 |
|---|---|---|---|
| Wavelength Range | 320-1000 nm | 610-770 nm | 780-970 nm |
| Fiber | Graded-Index, Multimode | Nufern 630-HP, Single Mode | Nufern 780-HP, Single Mode |
| Core Diameter | 62.5 µm | 4 µm | 5 µm |
| Numerical Aperture NA | 0.27 | 0.13 | 0.13 |

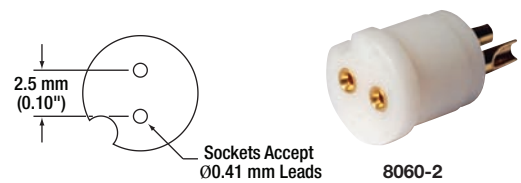
| ITEM# | $ | £ | € | RMB | DESCRIPTION |
|---|---|---|---|---|---|
| FDSP625 | $ 91.80 | £ 63.70 | € 81,60 | ¥ 775.20 | Pigtailed Silicon Photodiode, GIF625 Fiber, 320-1000 nm |
| FDSP660 | $ 96.90 | £ 67.20 | € 86,10 | ¥ 818.30 | Pigtailed Silicon Photodiode, 630HP SMF, 610-770 nm |
| FDSP780 | $ 96.90 | £ 67.20 | € 86,10 | ¥ 818.30 | Pigtailed Silicon Photodiode, 780-HP SMF, 780-970 nm |

# Sockets for Ø5.6 mm and Ø9 mm Diodes

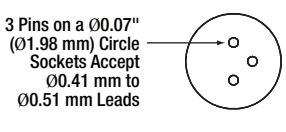
- 2-, 3-, and 4-Pin Sockets Offered
- For Ø5.6 mm (TO-18) or Ø9 mm (TO-5) Packages
- Gold-Plated BeCu Contacts
- RoHS Compliant

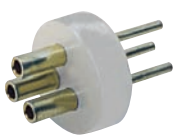
A range of sockets are offered for use with Ø5.6 mm or Ø9 mm laser diode packages. The S8058, S8060, S8060-4, and 8060-2 feature gold-plated BeCu contacts. Please note that the color of each socket may vary.

| ITEM# | $ | £ | € | RMB | # OF PINS | PACKAGE SIZE |
|---|---|---|---|---|---|---|
| 8060-2 | $ 7.00 | £ 4.85 | € 6,30 | ¥ 59.20 | 2 | Ø5.6 mm |
| S7060R | $ 4.30 | £ 3.00 | € 3,90 | ¥ 36.40 | 3 | Ø5.6 mm |
| S8058 | $ 9.00 | £ 6.25 | € 8,00 | ¥ 76.00 | 3 | Ø9 mm |
| S8060 | $ 6.00 | £ 4.15 | € 5,40 | ¥ 50.70 | 3 | Ø9 mm |
| S8060-4 | $ 7.30 | £ 5.05 | € 6,50 | ¥ 61.70 | 4 | Ø5.6 mm |

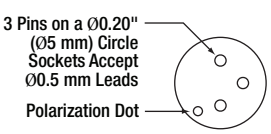


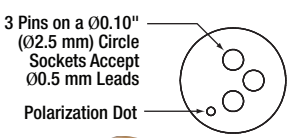

8060-2



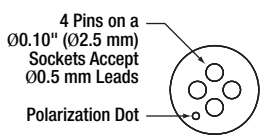
S7060R




**S8060**
Use with FDS100, FDS010, and FGA10

**S8058**
Use with FGA04 and FGA20



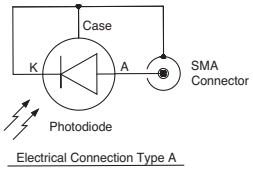

S8060-4

Please refer to our website for complete models and drawings.

# Mounted Photodiodes with SM05 or SM1 Threads

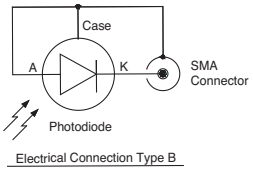
The SM05PD and SM1PD series of photodiodes consist of InGaAs, Ge, Si, or GaP photodiodes mounted in convenient housings with external SM05 or SM1 threading. The electrical output of the sensor is through a standard SMA connector (SM05PD) or BNC connector (SM1PD) mounted directly to the housing for quick connection to the measuring circuit. The photodiodes come in either a type A (cathode grounded) or type B (anode grounded) electrical configuration and are compatible with all Thorlabs SM05 (Ø0.535"-40) and SM1 (Ø1.035"-40) mounting adapters.

**SM05PD1A**




Electrical Connection Type A

**SM1PD1B**




Electrical Connection Type B

Please refer to our website for complete models and drawings.

| ITEM# | $ | £ | € | RMB | DESCRIPTION |
|---|---|---|---|---|---|
| SM05PD1A | $ 50.00 | £ 34.70 | € 44,40 | ¥ 422.30 | Si Detector, FDS100, 350-1100 nm, Type A |
| SM05PD1B | $ 50.00 | £ 34.70 | € 44,40 | ¥ 422.30 | Si Detector, FDS100, 350-1100 nm, Type B |
| SM05PD2A | $ 81.20 | £ 56.30 | € 72,10 | ¥ 685.70 | Si Detector, FDS010, 200-1100 nm, Type A |
| SM05PD2B | $ 81.20 | £ 56.30 | € 72,10 | ¥ 685.70 | Si Detector, FDS010, 200-1100 nm, Type B |
| SM05PD4A | $ 206.10 | £ 142.90 | € 183,00 | ¥ 1,740.40 | InGaAs Detector, FGA10, 700-1800 nm, Type A |
| SM05PD5A | $ 279.90 | £ 194.10 | € 248,50 | ¥ 2,363.50 | InGaAs Detector, FGA21, 800-1800 nm, Type A |
| SM05PD6A | $ 168.30 | £ 116.70 | € 149,50 | ¥ 1,421.20 | Ge Detector, 0.8 MHz BW, 800-1800 nm, Type A |
| SM05PD7A | $ 126.50 | £ 87.70 | € 112,40 | ¥ 1,068.20 | GaP Detector, FGAP71, 150-550 nm, Type A |
| SM1PD1A | $ 117.30 | £ 81.40 | € 104,20 | ¥ 990.50 | Si Detector, FDS1010, 400-1100 nm, Type A |
| SM1PD1B | $ 117.30 | £ 81.40 | € 104,20 | ¥ 990.50 | Si Detector, FDS1010, 400-1100 nm, Type B |
| SM1PD2A | $ 201.96 | £ 140.10 | € 179,40 | ¥ 1,705.40 | Si Detector, FDS010, 200-1100 nm, Type A |
| SM1PD5A | $ 505.92 | £ 350.80 | € 449,20 | ¥ 4,272.00 | Ge Detector, FDG1010, 800-1800 nm, Type A |

# Benchtop Photodiode Amplifier


PDA200C

- Transimpedance Photocurrent Amplifier
- Extremely Low Noise Operation Over Entire Dynamic Range of 100 pA to 20 mA
- 5-Digit Display with 10 pA Resolution
- Supports Single-Point Power Calibration
- Supports Both Diode Polarities (CG and AG)
- Offset Compensation of the Photocurrent and Dark Current

The PDA200C Photocurrent Amplifier is ideally suited for ultralow noise amplification of very small photodiode currents. It offers five current ranges from 100 nA to 10 mA full scale. The unit supports either cathode grounded (CG) or anode grounded (AG) photodiodes. The adjustable bias voltage allows for an improvement in the linearity of the responsivity and frequency response.

## Parameters

- **Current Measurement Range:** 100 nA to 10 mA
- **Polarity of the Photodiode:** Anode Grounded (AG) or Cathode Grounded (CG)
- **Display Range:** 0 to 10,000 (CG), 0 to -10,000 (AG)
- **Bias Voltage:** 0 to 10 V (AG), 0 to -10 V (CG)
- **Photodiode Sensitivity (Power Display):** 0.05-2 A/W
- **Temperature Coefficient:** <50 ppm/°C
- **Input Impedance:** ≈0 Ω (Virtual Ground)
- **Noise (rms):** 0.02% Full Scale
- **Output Voltage (CTRL Output):** 0 to 10 V (CG), 0 to -10 V (AG)
- **Mains Voltage:** 100 V, 115 V, 230 V (-10%, +15%) (Selectable)
- **Mains Frequency:** 50-60 Hz
- **Operating Temperature:** 0-40 °C

RoHS COMPLIANT


Back Pannel

| MEASUREMENT RANGE | RESOLUTION | AMPLIFICATION | ACCURACY | BANDWIDTH |
|---|---|---|---|---|
| 10 mA | 1 µA | 1 x $10^3$ V/A | ±0.05% fs | 500 kHz |
| 1 mA | 100 nA | 1 x $10^4$ V/A | ±0.05% fs | 250 kHz |
| 100 µA | 10 nA | 1 x $10^5$ V/A | ±0.05% fs | 70 kHz |
| 10 µA | 1 nA | 1 x $10^6$ V/A | ±0.05% fs | 20 kHz |
| 1 µA | 100 pA | 1 x $10^7$ V/A | ±0.05% fs | 5 kHz |
| 100 nA | 10 pA | 1 x $10^8$ V/A | ±0.1% fs | 1 kHz |

| ITEM# | $ | £ | € | RMB | DESCRIPTION |
|---|---|---|---|---|---|
| PDA200C | $ 828.00 | £ 574.00 | € 735,20 | ¥ 6,991.70 | Benchtop Photodiode Amplifier |

# PDA8000 Photocurrent Measurement Modules


**Modules for Optical Power Measurement**
The PDA8000 is designed as a plug-in module for the PRO8000 chassis detailed on page 976. The module is recognized by the chassis when powered. All of the control functions of the photocurrent amplifier can be used in manual or remote modes.

The PDA8000 series single- or dual-channel photocurrent measurement modules enable high-precision measurement of photocurrents with 16-bit resolution. Seven measurement ranges are available; on the most sensitive 10 nA full scale setting, the resolution is 0.1 pA.

If your photodiode is calibrated, the photocurrent module can be used as a precise optical power meter with high resolution and a large dynamic range.


**PRO800 with PDA8000-2 and ITC8022 Modules**
(Sold Seperately)

**Introduction – Photocurrent Measurement Module**
The PDA8000 photocurrent measurement module is an ideal companion for our other PRO8000 series plug-in modules. It provides precise photocurrent measurements from a few pA to 10 mA. An over-sampled 16-bit A/D converter is used to ensure a measurement resolution of ±0.025% of the full scale reading. These features, combined with the built-in, low noise photodiode bias, make this instrument an ideal photodiode current amplifier.

**Calibrated Optical Power Measurements**
Using the PDA8000, a photodiode can be calibrated to accurately measure optical power. A photodiode responsivity value can be entered on screen. This allows the direct entry of standard calibration data provided by photodiode manufacturers when a calibrated diode is purchased.

**Computer Control IEEE-488.2**
As with all of our PRO8000 compatible modules, the PDA8000 module commands can be accessed via an IEEE-488 interface. This includes access to the calibration factor, the photodiode bias voltage, all of the measurement control parameters, and the measurement results.

## PDA8000 Measurement Range

| Measurement Range | Resolution | Accuracy |
|---|---|---|
| 10 mA | 0.1 µA | ±0.025% Full Scale |
| 1 mA | 10 nA | ±0.025% Full Scale |
| 100 µA | 1 nA | ±0.025% Full Scale |
| 10 µA | 0.1 nA | ±0.025% Full Scale |
| 1 µA | 10 pA | ±0.025% Full Scale |
| 100 nA | 1 pA | ±0.25% Full Scale |
| 10 nA | 0.1 pA | ±0.8% Full Scale |

## Features
- Seven Current Measurement Ranges from 10 nA to 10 mA with 16-Bit Resolution
- Resolution of 0.1 pA on the 10 nA scale
- Accuracy is ±0.025% of Full Scale Reading
- Single- and Dual-Channel Modules

## Photocurrent Module Specification
- **Photodiode Current Range:** 10 nA to 10 mA
- **Photodiode Polarity:** Selectable
- **Setting Range of Bias Voltage (Can be Switched Off):** 0.1 to 10 V
- **Setting Range of Sensitivity for Power Display:** Programmable
- **Input Impedance:** Virtual Ground
- **Temperature Coefficient:** ≤50 ppm/°C

## General Data
- **Module Width:** 1 Slot
- **Photodiode Connectors:**
  PDA8000-1 BNC (1x)
  PDA8000-2 BNC (2x)

All data are valid at 23 ± 5 °C and 45 ± 15% relative humidity.

**Precision Optical measurements**
The variable photodiode bias allows for operating in either a photovoltaic or photoconductive mode. The bias also reduces the junction capacitance of the diode, thus improving the linearity of the detector when making long-term measurements. Additionally, there is a front panel trim-pot that is used to null out the photodiode dark currents that are found in semiconductor optical sensors.

**The PDA8000 is designed as a plug-in module for the PRO8000 chassis detailed on page 976. The module is recognized by the chassis when powered. All control functions of the photocurrent amplifier can be used in manual or remote modes.**

| ITEM# | $ | £ | € | RMB | DESCRIPTION |
|---|---|---|---|---|---|
| PDA8000-1 | $ 918.00 | £ 636.40 | € 815,10 | ¥ 7,751.70 | Photocurrent Measurement Module, 1 Channel |
| PDA8000-2 | $ 1,041.00 | £ 721.70 | € 924,30 | ¥ 8,790.30 | Photocurrent Measurement Module, 2 Channels |

# High-Resolution USB 2.0 CMOS Cameras

NEW products

DCC1545M

**Features**

- 1280 x 1024 Pixel Resolution (SXGA)
- Full Frame Rate of 25 fps
- B&W and Color Cameras Offered
- SM1 and C-Mount Threading Adapters Included
- 1/4"-20 Threaded Mounting Hole
- USB2.0 Connectivity

The DCC1545M and DCC1645C are High-Resolution CMOS Cameras, each of which features a USB2.0 interface. The cameras have CMOS sensors with 1280 x 1024 pixel resolution and a maximum full frame rate of 25 fps. If a higher frame rate is needed, the pixels can be subsampled to significantly increase this rate. The DCC1545M is a black and white camera, while the DCC1645C is a color camera with an IR filter in front of the sensor. Both have a 1/4"-20 mounting hole; please see page 338 for metric threading adapters.

These cameras, which are an economical alternative to our DCU cameras on the next page, are ideal for applications where a trigger input is not necessary. Please see the Camera Selection Guide to the right for a quick comparison of our camera series.

While the cameras have a CS-threaded objective mount, threading adapters are included for external SM1, internal SM1, and internal C-Mount standards. By using the SM1 adapters, the cameras can be incorporated into lens tube and cage systems. With the C-Mount adapter, the camera can be used with our MVL Series lenses offered below. Many mounted filters are also available in SM1 housings.

Standard drivers such as Direct Show (WDM), ActiveX®, CVB, HALCON, and TWAIN are provided as well as interfaces for popular machine vision software. Over 20 demonstration programs (including source code) are supplied with these cameras. Windows and Linux drivers and an SDK (C++, C#, VB, and LabVIEW support) are also available.

**Camera Selection Guide**

| CAMERA SERIES | DCC | DCU223 | DCU224 |
|---|---|---|---|
| Pixel Resolution | 1280 x 1024 | 1024 x 768 | 1280 x 1024 |
| Sensor Type | CMOS | CCD | CCD |
| Full Frame Rate (Max) | 25 fps | 30 fps | 15 fps |
| Trigger Input | No | Yes | Yes |

| ITEM# | DCC1545M | DCC1645C |
|---|---|---|
| Pixel Resolution | 1280 x 1024 | |
| Sensor Type | 1/2", Black and White | 1/3", Color |
| Sensor Model | Micron MT9M001 | Micron MT9M131 |
| Sensor Size | 6.66 mm x 5.32 mm | 4.61 mm x 3.69 mm |
| Pixel Size | 5.2 µm x 5.2 µm | 3.6 µm x 3.6 µm |
| Exposure Mode | Electronic Rolling Shutter | |
| Read Out Mode | Progressive Scan | |
| Full Frame Rate (Max) | 25 fps | |
| Subsampling | Horizontal, Vertical | |
| Subsampling Frame Rate (Max) | 511 fps (8X) | 248 fps (4X) |
| AOI (Partial Scan) | Horizontal, Vertical | |
| Max AOI Frame (320 x 240 px) | 231 fps | 262 fps |
| Pixel Clock Frequency (Min/Max) | 5/40 MHz | |
| Gain | 13X (Master) | 3X/3.1X (Master/RGB) |
| Hardware Trigger | NA | |
| Objective Connector | CS (C-Mount and SM1 Adapters Included) | |
| Window | Glass | IR Filter |
| Computer Interface | USB2.0 | |
| Power Supply | <1.0 W via USB | |
| Operating Temperature | 0-50 °C (32-122 °F) | |
| Security Labels | CE, FCC, Class A | |
| Dimensions | 48.6 mm x 44.0 mm x 25.7 mm (1.9" x 1.7" x 1.0") | |
| Weight | 0.07 lbs (32 g) | |

| ITEM# | $ | £ | € | RMB | DESCRIPTION |
|---|---|---|---|---|---|
| DCC1545M | $ 315.00 | £ 218.40 | € 279,70 | ¥ 2,659.90 | USB2.0 CMOS Camera, Black & White |
| DCC1645C | $ 315.00 | £ 218.40 | € 279,70 | ¥ 2,659.90 | USB2.0 CMOS Camera, Color |

# Imaging Lenses

**Features**

- Externally C-Mount Threaded
- Manually Adjustable Focus and Aperture
- Compatible with DCC and DCU Series Cameras

The MVL series of imaging objectives are ideal for many imaging applications including machine vision. These lenses feature external C-Mount threading, making them compatible with our DCC (using adapter included with camera) and DCU series of cameras. All lenses, aside from the MVL25, have a locking screw to prevent focus and aperture settings from drifting as a result of vibrations. For more information on these lenses, including the field of view, please see page 808.

MVL50L

| ITEM# | $ | £ | € | RMB | f (mm) | APERTURE (f/#) | BACK FOCUS (mm) |
|---|---|---|---|---|---|---|---|
| MVL8L | $ 264.10 | £ 183.10 | € 234,50 | ¥ 2,230.10 | 8 | 1.4 – 16 | 11.60 |
| MVL12L | $ 256.60 | £ 177.90 | € 227,90 | ¥ 2,166.80 | 12 | 1.8 – 16 | 11.03 |
| MVL16L | $ 240.70 | £ 166.90 | € 213,70 | ¥ 2,032.50 | 16 | 1.4 – 16 | 11.85 |
| MVL25 | $ 205.10 | £ 142.20 | € 182,10 | ¥ 1,731.90 | 25 | 1.6 – 16 | 11.60 |
| MVL35L | $ 217.50 | £ 150.80 | € 193,10 | ¥ 1,836.60 | 35 | 2.1 – 16 | 15.53 |
| MVL50L | $ 256.60 | £ 177.90 | € 227,90 | ¥ 2,166.80 | 50 | 2.8 – 22 | 22.10 |
| MVL75L | $ 264.10 | £ 183.10 | € 234,50 | ¥ 2,230.10 | 75 | 3.9 – 32 | 27.12 |

# High-Resolution USB2.0 CCD Cameras

## Features

- 1024 x 768 or 1280 x 1024 Pixel Resolution
- Color and B&W Versions Available
- Removable IR Filter Included
- 30 fps or 15 fps (Full Frame Mode)
- C-Mount Objective Connector
- Global Shutter
- Universal Trigger Input via a 9-Pin, D-Sub Connector

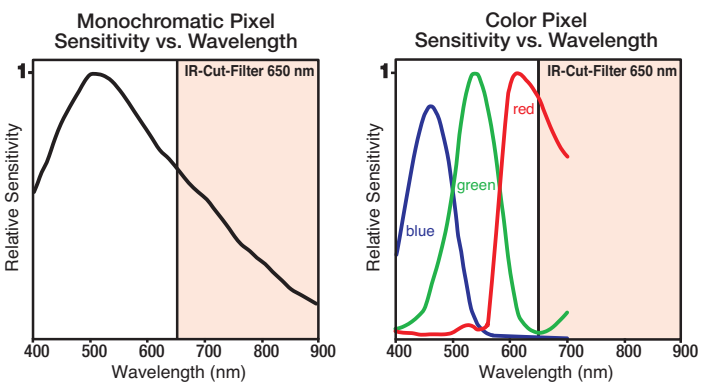
DCU223M

These ultra-compact, lightweight, CCD cameras feature USB connections, making them extremely versatile for a wide range of applications, including industrial automation, quality control, medical imaging, microscopy, and security technology. Each DCU223 model is equipped with a high-quality Sony 1/3" CCD sensor with XGA resolution (1024 x 768) that has a full frame repetition rate of 30 fps. In contrast, the DCU224 models are equipped with a 1/2" CCD sensor with SXGA resolution (1280 x 1024) that has a full frame repetition rate of 15 fps. For all models, higher frame rates can be achieved by using the Area of Interest (AOI) or Binning functions; the former increases the frame rate by only reading a selected area of the sensor, whereas the latter increases the frame rate by combining pixel readings before transferring them to the PC, but in this case, image resolution is sacrificed.

These CCD cameras use a USB2.0 interface for computer connectivity, thus allowing for seamless image transmission and software control of the camera settings. Each CCD camera also comes with an extensive software package that is compatible with Windows operating systems. Standard drivers like Direct Show (WDM), ActiveX®, CVB, HALCON, and TWAIN are provided, as are interfaces for popular machine vision software. In addition, over 20 demo programs (including source code) are supplied.

| ITEM# | DCU223M | DCU223C | DCU224M | DCU224C |
|---|---|---|---|---|
| Pixel Resolution | 1024 x 768 | | 1280 x 1024 | |
| Color Type | Black and White | Color | Black and White | Color |
| Chip Type/Size | 1/3" (8 mm) | | 1/2" (13 mm) | |
| Cell Size | 4.65 µm x 4.65 µm | | | |
| Shutter | Global | | | |
| Scanning System | Progressive Scan | | | |
| Frame Rate | 30 fps | | 15 fps | |
| Binning | Vertical | | | |
| AOI (Partial Scan) | Horizontal and Vertical | | | |
| Mirror/ Flip | Horizontal and Vertical | | | |
| Pixel Clock Frequence (Min/Max) | 5/30 MHz | | | |
| Shutter (Free Run) | 66 µs - 1040 ms | | 80 µs - 1460 ms | |
| Gain | Master | RGB + Master | Master | RGB + Master |
| Hardware Trigger | Async+B35 | | | |
| Objective Connector | C-Mount | | | |
| IR Filter | Included, Removable | | | |
| Interface | USB2.0 | | | |
| Power Supply | <1.5 W via USB | | | |
| Operating Temperature | 32-122 °F (0-50 °C) | | | |
| Security Labels | CE, FCC, Class B | | | |
| Measures (H x W x D) | 1.34" x 1.26" x 1.35" (34 mm x 32 mm x 34.4 mm) | | | |
| Weight | 0.16 lbs (75 g) | | | |

Pixel sensitivity versus wavelength plots are shown at the right for the black and white and color versions of these CCD cameras. The section with the shaded background indicates the spectral region that is blocked by the removable IR filter. For the color models, the popular Bayer color filter array is used to acquire digital color images. The filter is based on a repeating 2 x 2 pattern; half of the total number of pixels are green (G), and the remaining pixels are equally divided between red (R) and blue (B). Due to this arrangement, each pixel is only sensitive to one color, and as a result, the overall sensitivity of the color image is three times lower than that achievable with a monochromatic sensor. Thus, black and white CCD cameras are preferred in low-light situations. Even though only one third of the color information is obtained at each pixel, a full-color image can be achieved through the use of various demosaicing algorithms that interpolate a set of red, green, and blue values at each point.




| ITEM# | $ | £ | € | RMB | DESCRIPTION |
|---|---|---|---|---|---|
| DCU223M | $ 1,570.00 | £ 1,088.50 | € 1.394,00 | ¥ 13,258.00 | 1024 x 768, 30 fps, 1/3" Sensor, Black and White CCD Camera |
| DCU223C | $ 1,570.00 | £ 1,088.50 | € 1.394,00 | ¥ 13,258.00 | 1024 x 768, 30 fps, 1/3" Sensor, Color CCD Camera |
| DCU224M | $ 2,184.00 | £ 1,514.00 | € 1.939,00 | ¥ 18,442.00 | 1280 x 768, 15 fps, 1/2" Sensor, Black and White CCD Camera |
| DCU224C | $ 2,184.00 | £ 1,514.00 | € 1.939,00 | ¥ 18,442.00 | 1280 x 768, 15 fps, 1/2" Sensor, Color CCD Camera |

# USB2.0 CCD Line Camera with External Trigger

## Features

**Hardware Features**

- 3000 Pixel Silicon Linear CCD Array (7 µm x 200 µm Pixel Size)
- 12-Bit A/D Converter for High Intensity Resolution
- High Scan Rate (up to 190 scans/second)
- Optical Integration Time Adjustable from 1 µs to 200 ms
- Ext. Trigger Capability via BNC Input
- USB2.0 (480 Mb/s) and USB1.1 (12 Mb/s) Compatible
- No External Power Requirements

**Software Features**

- Real-Time Spectrum Measurement
- Zooming, Absorbance, Transmittance, and Relative Difference Measurements
- Gaussian Fitting Routines
- User-Defined, Real-Time Routines
- Compatible with Windows 2000/XP/Vista
- NI LabWindows/CVI™, NI LabVIEW™, MS Visual C++™, and Borland C++™



LC1-USB

Thorlabs' CCD Line Cameras have several advantages over their area-array counterparts, including high optical linear resolution. This allows system developers to use the cameras to capture two-dimensional (2D) images by moving the object or the CCD perpendicularly to the scan line. In the past, the lack of high-speed camera interfaces limited the choice to black and white camera arrays. To overcome this obstacle, Thorlabs introduced its LC1-USB Line Camera, a black and white line camera based on a single-line, 3000 pixel CCD chip with a USB2.0 (480 Mb/s) and USB1.1 (12 Mb/s) interface. The LC1-USB is a compact, plug-and-play, linear camera that is ideal for a variety of applications in industry process control, optics, biology, spectroscopy, and reflection imaging. The camera is based on a linear CCD array housed in a 3.60" x 2.60" x 1.00" (91.4 mm x 66.0 mm x 25.4 mm) enclosure. Setting up the LC1-USB Line Camera is very easy; the user simply installs the latest version of the operating software onto any desktop or notebook PC and then connects the USB cable from the line camera to the PC, eliminating the need for installing a DAQ card.

The LC1-USB accepts the NFM1LC1 F-Mount Adapters for interfacing to standard camera lenses. It has tapped holes (#4-40) at the front plate for easy connection to Thorlabs' 30 mm Cage Assemblies, allowing the user to integrate optical components in front of the camera. The LC1-USB also has five #8-32 and four M4-0.7 threaded mounting holes.

## NFM1LC1

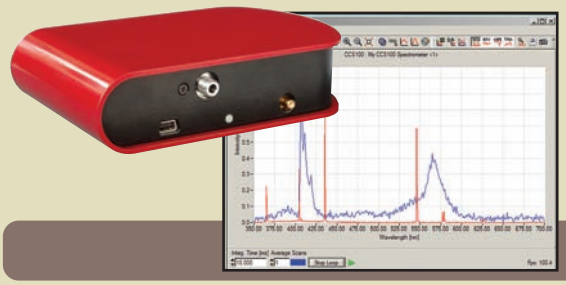
The NFM1LC1 is designed to adapt F-Mount based lens systems easily to our popular LC1-USB CCD Line Camera. It is ideal for applications requiring an adjustable zoom and focal length for imaging on the line camera.

**For other F-Mount Adapters**
**See Page 246**

| ITEM# | $ | £ | € | RMB | DESCRIPTION |
|---|---|---|---|---|---|
| LC1-USB | $ 879.00 | £ 609.40 | € 780,40 | ¥ 7,422.30 | USB2.0 Line Camera |
| NFM1LC1 | $ 125.50 | £ 87.00 | € 111,50 | ¥ 1,059.80 | Nikon F-Mount Adapter |

## Compact CCD Spectrometers

NEW products

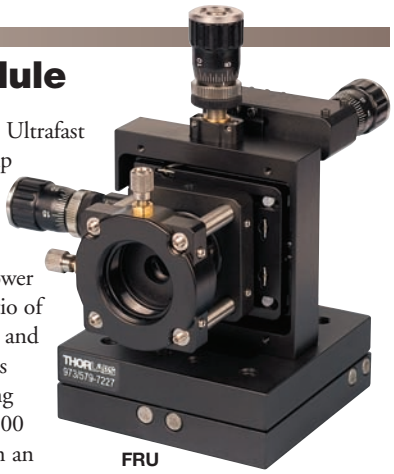


### Features

- 3 Models for the 200-1000 nm Range
- Resolution <0.5 nm FWHM
- Sensitivity of 160 V/lux·s
- Integration Time of 10 µs to 60 s
- Czerny-Turner Spectrometer
- 30 mm x 120 mm x 80 mm Footprint
- High-Speed USB Connection
- External Trigger Synchronization
- 16-Bit A/D Converter
- 3,648 Pixel CCD Line Array

**See Pages 1310-1311**

# Terahertz Transmitter/Receiver Mounting Module



FRU

Research interest in the terahertz (THz) region of the electromagnetic spectrum has been substantially increasing. This region is defined as the spectral region between the infrared and microwave spectral bands and ranges from 100 µm to 1000 µm (300 GHz to 3 THz). In this region, the photon energies range from 1.2 to 12.4 eV and the equivalent black body temperature ranges from 14 K to 140 K, which is below the earth's ambient background.

The Ultrafast Terahertz Research Group at Oklahoma State University (OSU) in Stillwater has put together a THz Time Domain Spectroscopy (THz-TDS) system based on Thorlabs' optomechanical components, as shown in Figure 1. Their system includes two FRU modules; one houses a transmitter and the other houses a receiver. A femtosecond laser is used to illuminate the THz transmitter, which has biased coplanar transmission lines fabricated on high-resistivity GaAs with a geometry similar to that shown in Figure 3. The laser is focused on the edge of the positively biased line and generates a very large number of photo-induced charge carriers in the high electric field region, creating synchronous bursts of THz radiation. Their receiver FRU includes a receiver chip that has antennae structures fabricated on an ion-implanted silicon-on-sapphire (SOS) wafer. The antennae structures have geometries similar to that shown in Figure 2.

The pulsed THz radiation is focused between the gap of an antenna and induces a transient bias voltage. The portion of the femtosecond laser beam that is directed into the receiver is also focused onto the antenna, inducing a transient photocurrent that synchronously gates the receiver. One can consider this detection process a sub-picosecond boxcar integrator.

With this system, OSU's Ultrafast Terahertz Research Group has scanned out past 5 THz. Their system generates THz radiation with ~10 nW average power with a signal-to-noise ratio of 10,000:1. The generated and detected THz radiation is coherent and the resulting receiver sensitivity is ~1000 times more sensitive than an incoherent liquid helium-cooled bolometer. The receiver module of the THz-TDS system uses the same optomechanical components as the transmitter module. Thorlabs stocks this kit (part number FRU), which includes all the optomechanical parts needed to mount a transmitter or receiver module to a teflon lens. Please see page 1258 for a transmitter and receiver antennae from Menlo Systems.

## Terahertz Kit

- THz Transmitter/Receiver Mount Module Using Thorlabs Catalog Components
- Free-Space Coupled
- Fiber Coupling by Request
- Highly Stable

## Applications

- THz-TDS: Terahertz Time Domain Spectroscopy
- THz-DTDS: Terahertz Differential Time Domain Spectroscopy
- Interferometry

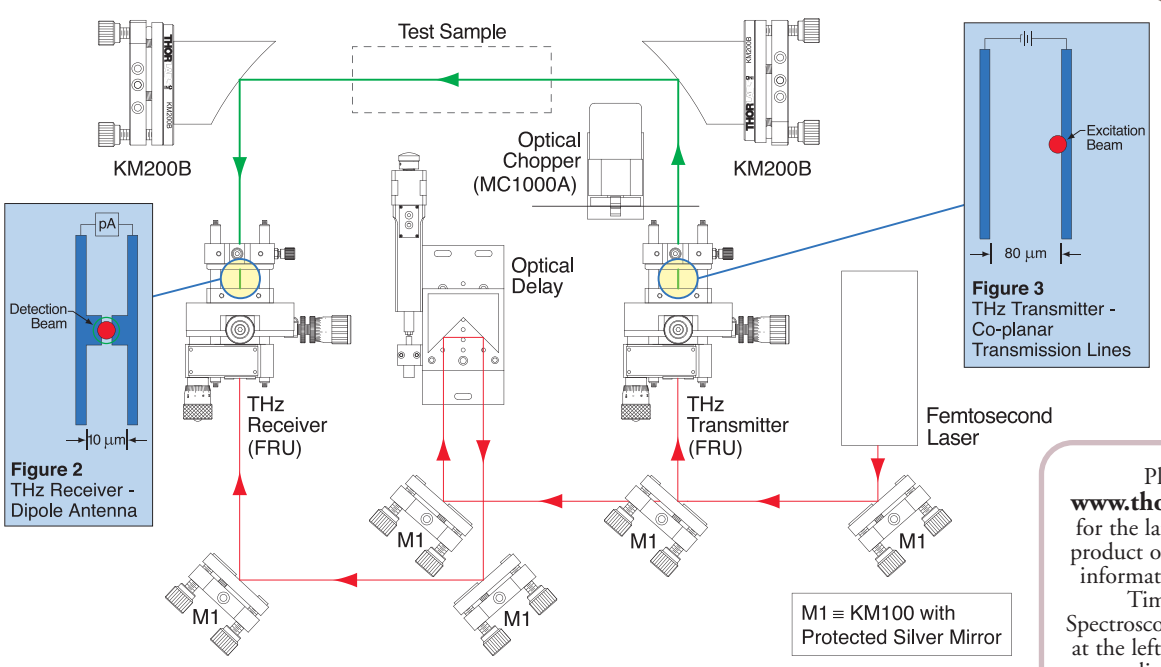



**Figure 2**
THz Receiver - Dipole Antenna

**Figure 3**
THz Transmitter - Co-planar Transmission Lines

**Figure 1**
THz-TDS System Based on Thorlabs' Standard Optomechanical Components

Please visit **www.thorlabs.com/thz** for the latest THz-related product offering and more information on the THz Time Domain Spectroscopy system shown at the left, including a full list of parts.

| ITEM# | METRIC ITEM# | $ | £ | € | RMB | DESCRIPTION |
|---|---|---|---|---|---|---|
| FRU | FRU/M | $ 950.30 | £ 658.80 | € 843,70 | ¥ 8,024.40 | THz Transmitter/Receiver Mounting Module |

# Beam Characterization Selection Guide

Pages 1309-1322

### Spectrometers

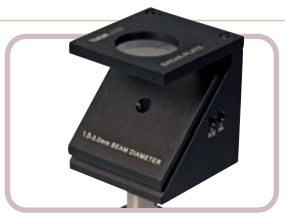
- Completely New Design
- 3 Compact Models with Wavelengths Covering 220 to 1000 nm
- External Trigger Input

**See Pages 1310-1311**

### Fabry-Perot Interferometers

- 1.5 or 10 GHz FSR
- Seven Wavelength Ranges Spaning 370 to 1625 nm
- Athermal Design

**See Pages 1312-1313**



### Shearing Interferometers

- Determine Degree of Beam Collimation
- Beams from Ø1 mm to Ø75 mm

**See Pages 1314-1315**

### Wavefront Sensor

- Real-Time Wavefront and Intensity Distribution Measurement
- For CW and Highly Repetitive Pulsed Sources
- Wavelengths from 200 to 1100 nm

**See Pages 1316-1317**

### CCD Beam Profilers

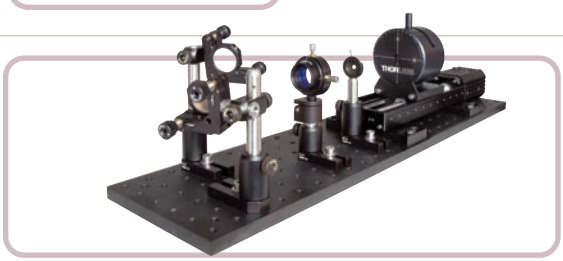
- Completely New Design
- Wavelengths from 190 to 1100 nm
- Based on High-Resolution CCD Camera

**See Pages 1318-1319**


### Scanning Slit Beam Profilers

- High-Precision Beam Analysis
- Wavelengths from 200 to 2700 nm
- Beam Diameters from 10 µm to 9 mm

**See Pages 1320-1321**



### $M^2$ Beam Quality Analysis

- Complete Kit
- Measure $M^2$, Divergence, Waist Diameter, Rayleigh Range, and Astigmatism

**See Page 1322**

# Compact CCD Spectrometers (Page 1 of 2)


CCS100

## Features

- Models Covering the 220-1000 nm Wavelength Range
- Rugged Czerny-Turner Design with no Moving Parts
- Minimum Integration Time of 10 µs
- Auto-Compensation for Dark Current Noise
- High-Speed USB2.0 Connection Offers up to 200 Scans per Second
- Trigger Input for External Synchronization (TTL)
- 16-Bit A/D Converter
- 3,648 Pixel Linear CCD Array

Thorlabs' new series of fiber-based spectrometers has three models that together provide detection in the 220 to 1000 nm range. These compact Czerny-Turner spectrometers have no moving parts, making them durable tools for use in labs or out in the field. While these spectrometers are affordable, they do not lack the features that many expensive units offer such as a TTL trigger input via an SMB connector. Inside each unit is a 3,648 pixel linear array CCD, which provides high resolution spectral data (up to 12 pixels/nm).

The simple design and quality construction of the CCS series ensure a flexible tool for everyday use and allow for very easy operation. The CCS series has three connections: one SMA fiber input, a USB Type Mini B connection, and an SMB trigger input. A user friendly software package is included and has numerous tools for analyzing data.

The spectrometers are powered directly from the USB2.0 connection, which enables them to be easily transported from one location to the next. Each unit includes a 50 µm core multimode SMA - SMA patch cable (M14L01) and a USB cable.

### Compact Housing

The compact housing of our CCS spectrometers measures only 122 mm x 80 mm x 30 mm (4.8" x 3.1" x 1.2"), roughly the size of an external hard drive. The bottom of the housing has rubber feet so that the spectrometer will not slide around on a work surface.

### Software and Drivers

The spectrometer comes with a software package, called SPLICCO, with a graphical user interface and an extensive set of drivers (C/C++, LabWindows/CVI, Dot NET, NI LabVIEW, and Visual Basic). The GUI offers the display of the spectra, background, and peaks; if required, these can all be displayed in a single window. Diverse algorithms can be applied for smoothing, averaging, or for calculating absorption and transmission. Additionally, the measurement results can be compared with other stored profiles. The included drivers allow for complete functional control of the CCS Series, allowing the user to design his or her own interface software or integrate the unit with a test and measurement setup for automated testing.

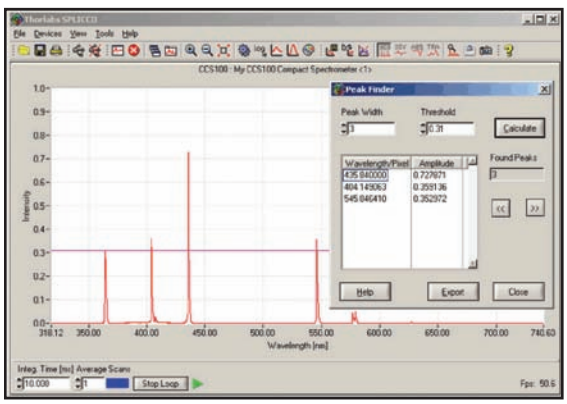



Figure 1

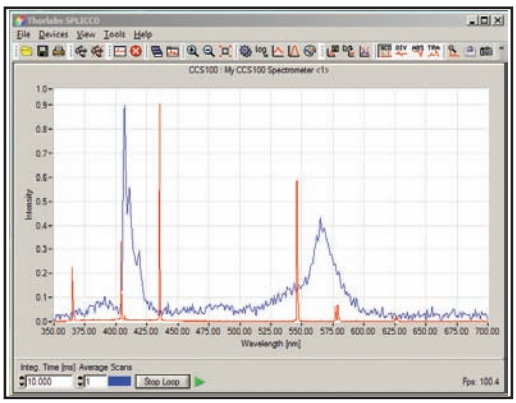
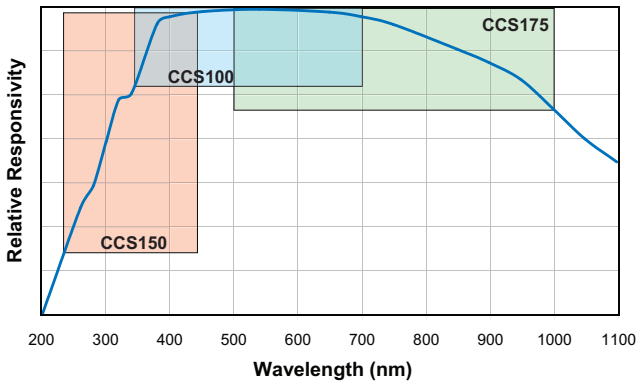


Figure 2

The graphical user interface (GUI) that is included with the CCS series of spectrometers is shown above. Data is displayed as intensity versus wavelength. Figure 1 shows the peak finder function with threshold line. Two spectrums are shown in Figure 2; one was loaded to the software for comparison, while the other is the spectrum that the spectrometer is currently reading. The GUI is very simple to use yet has a range of features and tools necessary to analyze spectrums.

# Compact CCD Spectrometers (Page 2 of 2)

### Typical Spectral Response of the CCD Sensor




## What's Included

- CCS Series Spectrometer
- User Manual
- CD ROM with SPLICCO Software and Drivers
- USB2.0 Type A to Mini B, 1.5 m
- MM Fiber, SMA to SMA, 50 µm Core, 0.22 NA, 1 m (M14L01)
- Trigger Input Cable, SMB to BNC

| ITEM# | CCS150 | CCS100 | CCS175 |
|---|---|---|---|
| Wavelength Range (nm) | 220-440 nm* | 350-700 nm | 500-1000 nm |
| Spectral Resolution | <0.5 nm FWHM @ 365 nm | <0.5 FWHM @ 435 nm | <1.0 FWHM @ 633 nm |
| Grating | 1800 Lines/mm, 240 nm Blaze | 1200 Lines/mm, 500 nm Blaze | 830 Lines/mm, 800 nm Blaze |
| CCD Pixel Size | 8 µm x 200 µm (8 µm Pitch) | | |
| Resolution | 12 px/nm | 10 px/nm | 6 px/nm |
| Integration Time | 10 µs – 60 s | | |
| Max Scan Rate | 200 Scans/s | | |
| Dynamic Range | >2000:1 | | |
| Fiber Input | SMA 905 | | |
| Included Fiber | Multimode, 50 µm Core, SMA to SMA, 1 m | | |
| Trigger Input | SMB | | |
| Trigger Signal | TTL | | |
| Trigger Frequency (Max) | 100 Hz | | |
| Trigger Pulse Length (Min) | 0.5 µs | | |
| Trigger Delay | 8.125 µs ± 125 ns | | |
| Interface | USB2.0 | | |
| Power Supply | via USB2.0 | | |
| Dimensions (L x W x H) | 122 mm x 80 mm x 30 mm (4.80" x 3.15" x 1.18") | | |
| Weight | <0.4 kg | | |

*200-400 nm available on request.

## Patch Cables

- Many Stock SM, PM, and MM Cables
- Custom Patch Cables with Same-Day Turnaround

**See Pages 843-852**

| ITEM# | $ | £ | € | RMB | DESCRIPTION |
|---|---|---|---|---|---|
| CCS150 | $ 2,200.00 | £1,525.00 | €1.953,00 | ¥ 18,577.00 | Compact Spectrometer, 220-440 nm |
| CCS100 | $ 1,950.00 | £1,352.00 | €1.731,00 | ¥ 16,466.00 | Compact Spectrometer, 350-700 nm |
| CCS175 | $ 1,950.00 | £1,352.00 | €1.731,00 | ¥ 16,466.00 | Compact Spectrometer, 500-1000 nm |


LC1-USB

## USB2.0 CCD Line Camera

- 3,000 Pixel Linear Array CCD
- 350-1000 nm Spectral Range
- External Trigger Input
- Great for Custom Spectrometers

The LC1-USB line camera has a 3,000 pixel linear CCD array. It is USB2.0 compatible and capable of taking up to 190 scans/second. The LC1-USB has an external trigger input, making it ideal for use in custom spectrometers.

**See Page 1307**

# Scanning Fabry-Perot Interferometers (High-Resolution Spectrometers)


The SA200 family includes 13 Fabry-Perot interferometers that cover six spectral regions with either a 1.5 GHz or 10 GHz Free Spectral Range (FSR). The design of the Fabry-Perot interferometer is comprised of an Invar cavity with internal piezo stacks. This design utilizes the negative thermal coefficient of the piezo stacks to create the nearly athermal cavity that is necessary for the stability of these high-resolution spectrometers.

The tutorial on pages 810-811 covers the basic theory of operation, including an explanation of the effect of the input beam diameter on the resolution of the instrument. In order for the instrument to achieve the specified resolution, the input beam diameter must not exceed the maximum diameter specification, even though the input aperture for the instrument is significantly larger than the specification.

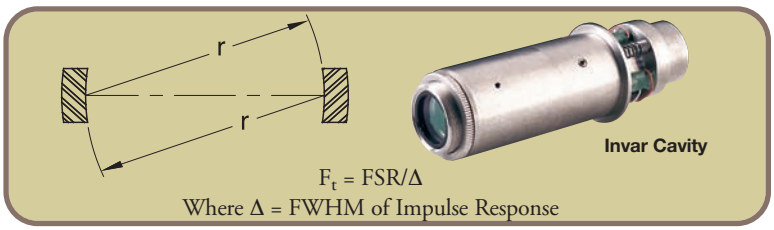
The SA200 can be mounted via a Ø2" ring near the input end of the interferometer. The KS2 is the recommended mount for the SA200 since it will hold the SA200 tightly and provide the kinematic control necessary for proper alignment in the optical cavity. In contrast, the SA210 has a Ø1" mounting ring near the input end of the interferometer, and as a result, the recommended mount is the KS1.

### Features
- Ultra-Stable Invar Cavity
- Confocal Cavity Design
- Mounted Input and Output Alignment Irises

### Specifications
- 1.5 GHz or 10 GHz Free Spectral Range
- Low Scan Voltage, 5 V per FSR @ 633 nm
- 13 Models for the 370-1625 nm Range


| MODEL | SA200 | SA210 |
|---|---|---|
| FSR[a] | 1.5 GHz | 10 GHz |
| Finesse[b] | 200 (250 Typ) | 150 (180 Typ) |
| Resolution | 7.5 MHz | 67 MHz |
| Max Beam Diameter[c] | 600 µm | 150 µm |
| Cavity Length | 50 mm | 7.5 mm |

[a] Free spectral range for a confocal cavity and defined by FSR = c/4r where c is the speed of light.
[b] Effective finesse defined by $F_t$ = FSR/Δ, where FSR is defined by FSR = c/4r and Δ=FWHM impulse response.
[c] Maximum beam diameter along the length of the cavity to obtain the typical measured finesse specified.




### 1.5 GHz Free Spectral Range, 50 mm Cavity Length, Finesse $F_t \geq 200$ (Typical $F_t = 250$)

| ITEM# | $ | £ | € | RMB | DESCRIPTION | RECOMMENDED MOUNT |
|---|---|---|---|---|---|---|
| NEW SA200-2A | $ 2,727.00 | £ 1,890.50 | € 2.421,00 | ¥ 23,027.00 | Scanning Fabry-Perot, 370-410 nm, 1.5 GHz FSR | KS2 (See Page 224) |
| SA200-5A | $ 2,535.10 | £ 1,757.50 | € 2.250,50 | ¥ 21,407.00 | Scanning Fabry-Perot, 525-650 nm, 1.5 GHz FSR | |
| SA200-6A | $ 2,828.00 | £ 1,960.50 | € 2.510,50 | ¥ 23,880.00 | Scanning Fabry-Perot, 650-800 nm, 1.5 GHz FSR | |
| SA200-7A | $ 2,747.20 | £ 1,904.50 | € 2.439,00 | ¥ 23,198.00 | Scanning Fabry-Perot, 780-930 nm, 1.5 GHz FSR | |
| SA200-9A | $ 2,939.10 | £ 2,037.50 | € 2.609,50 | ¥ 24,818.00 | Scanning Fabry-Perot, 900-1100 nm, 1.5 GHz FSR | |
| SA200-12A | $ 2,979.50 | £ 2,065.50 | € 2.645,00 | ¥ 25,159.00 | Scanning Fabry-Perot, 1250-1400 nm, 1.5 GHz FSR | |
| SA200-14A | $ 2,646.20 | £ 1,834.50 | € 2.349,50 | ¥ 22,345.00 | Scanning Fabry-Perot, 1450-1625 nm, 1.5 GHz FSR | |

### 10 GHz Free Spectral Range, 7.5 mm Cavity Length, Finesse $F_t \geq 150$ (Typical $F_t = 180$)

| ITEM# | $ | £ | € | RMB | DESCRIPTION | RECOMMENDED MOUNT |
|---|---|---|---|---|---|---|
| SA210-5A | $ 2,656.30 | £ 1,841.50 | € 2.358,50 | ¥ 22,430.00 | Scanning Fabry-Perot, 525-650 nm, 10 GHz FSR | KS1 (See Page 224) |
| SA210-6A | $ 2,838.10 | £ 1,967.50 | € 2.519,50 | ¥ 23,965.00 | Scanning Fabry-Perot, 650-800 nm, 10 GHz FSR | |
| SA210-7A | $ 2,716.90 | £ 1,883.50 | € 2.412,00 | ¥ 22,942.00 | Scanning Fabry-Perot, 780-930 nm, 10 GHz FSR | |
| SA210-9A | $ 2,706.80 | £ 1,876.50 | € 2.403,00 | ¥ 22,857.00 | Scanning Fabry-Perot, 900-1100 nm, 10 GHz FSR | |
| SA210-12A | $ 2,979.50 | £ 2,065.50 | € 2.645,00 | ¥ 25,159.00 | Scanning Fabry-Perot, 1250-1400 nm, 10 GHz FSR | |
| SA210-14A | $ 2,747.20 | £ 1,904.50 | € 2.439,00 | ¥ 23,198.00 | Scanning Fabry-Perot, 1450-1625 nm, 10 GHz FSR | |

# Scanning Fabry-Perot Controller Box

## Photo Amplifier Specifications

- **Gain Steps:** 0, 10, and 20 dB
- **Transimpedence Gain (Hi-Z):** 10 kV/A, 100 kV/A, and 1 MV/A
- **Transimpedence Gain (50 Ω):** 5 kV/A, 50 kV/A, and 500 kV/A
- **Output Voltage:** 0 - 10 V Minimum
- **Bandwidth:** 250 kHz
- **Noise (RMS):**
  - <0.1 mV @ 10 kV/A Gain
  - 0.2 mV @ 100 kV/A Gain
  - 1.5 mV @ 1 MV/A Gain

## Ramp Specifications

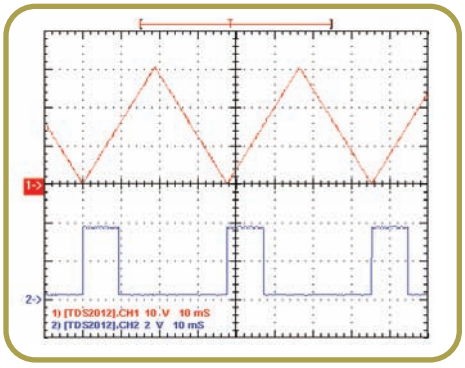
- **Waveform:** Sawtooth or Triangle
- **Output Voltage Range:** 1-45 V (Offset + Amplitude)
- **Offset Range:** 0-15 VDC
- **Amplitude Range:** 1-30 V
- **Risetime Range:** 0.01-0.1 s (1X Sweep Expansion) 1-10 s (100X Sweep Expansion)
- **Sweep Expansion:** 1X, 2X, 5X, 10X, 20X, 50X, or 100X
- **Sweep Scale Error:** ±0.5%
- **Output Noise:** 1 $mV_{RMS}$ (~6.6 $mV_{PP}$)
- **Trigger:** Ramp Start or Midpoint

SA201

The SA201 is specifically designed to control Thorlabs' Fabry-Perot Interferometers by generating a high-stability, low-noise voltage ramp. This ramp signal is used to scan the separation between the two cavity mirrors. The controller adjusts the ramp voltage and scan time, allowing the user to choose the scan range and speed, while an offset control allows the spectrum displayed on an oscilloscope to be shifted right or left. A TTL output allows the user to externally trigger an oscilloscope on either the beginning or midpoint of the ramp waveform. The ability to trigger the oscilloscope from the midpoint makes zooming in on a lineshape more convenient. Simply place the spectral component of interest on the center of the screen and increase the timebase of the oscilloscope. There is no need to use the offset to re-center the signal since the scope expands the time scale about the point of interest.

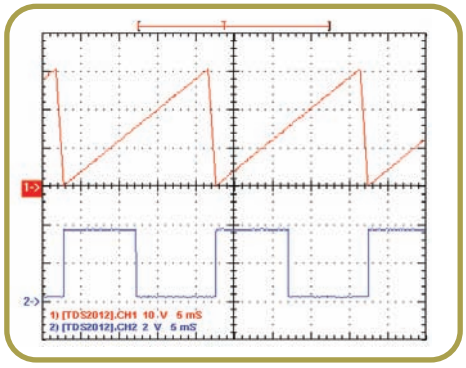
The controller also has a calibrated zoom capability that provides a 1X, 2X, 5X, 10X, 20X, 50X, or 100X increase in the period of the ramp signal, which allows for an extremely wide range of scan times.

The SA201 also includes a high-precision photodetector amplifier circuit used to monitor the transmission of the cavity. The amplifier provides an adjustable transimpedence gain of 10 kV/A, 100 kV/A, or 1 MV/A when driving a high impedance load, such as an oscilloscope. Using the output sync signal from the controller, an oscilloscope can be used to display the spectrum of the input laser. The detector circuitry incorporates a blanking circuit that disables the photodiode response during the falling edge of the sawtooth waveform. The blanking circuit can be disabled by switching a circuit board jumper as described in the manual.




⇦ Voltage Ramp ⇨

⇦ TTL Output Trigger ⇨

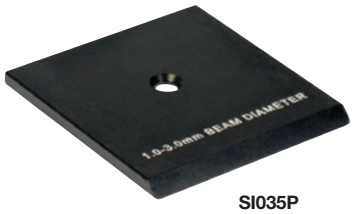



### SA201 Controller, Compatible with All SA200 and SA210 Interferometers

| ITEM# | $ | £ | € | RMB | DESCRIPTION |
|---|---|---|---|---|---|
| SA201 | $ 841.50 | £ 583.40 | € 747,10 | ¥ 7,105.70 | Control Box for the SA200 and SA210 Families of Interferometers |

# Shearing Interferometers (Page 1 of 2)


SI035




**SI035P**
Shear Plate

## Features

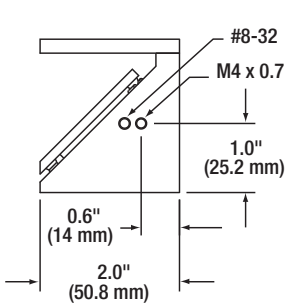
- Visual Collimation Aid for Beams from Ø1 mm to Ø75 mm
- Interchangeable Shear Plates for Varying Beam Diameters
- SIVS Screen for Viewing Small Beams
- Portion of Beam Transmitted Through Assembly

The SI series of shearing interferometers can be used to qualitatively determine if a coherent beam of light is collimated. The design consists of a wedged optical flat mounted at 45° and a diffuser plate with a reference line drawn down the middle. The diffuser plate is used to view the interference fringes created by a coherent beam of light incident at a 45° angle with respect to the normal of the optical flat (see images below). In addition to the degree of collimation, the fringes will be sensitive to spherical aberration, coma, and astigmatism. In order to produce four to six fringes on the diffuser plate, the thickness and degree to which the optical flat is wedged must change as the beam diameter changes.

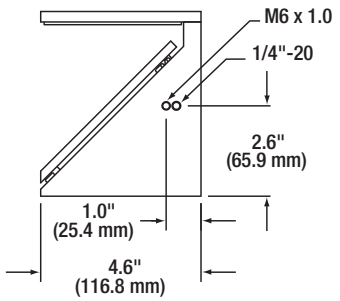
The base is made from anodized aluminum, and the plate with the wedged optical flat is held in place magnetically so that it can be easily swapped out for a plate with a different wedged optical flat. A hole is bored through the base behind the wedged optical flat to allow the transmitted portion of the incident beam to continue unimpeded. The table on the facing page summarizes the compatibility between bases and plates. The shearing interferometers have either an #8-32 and M4 x 0.7 mounting holes or a 1/4"-20 and an M6 x 1.0 mounting holes (model dependent) on the bottom of the base and on two sides (6 holes total). Again, refer to the table on the facing page for thread type.

For small beam diameters, the fringe pattern is small and can be difficult to see. For these situations, the SIVS accessory can be purchased to replace the standard diffuser plate viewing screen. The SIVS, which consists of a mounted diverging lens and diffuser plate, is designed for Ø1 - Ø10 mm beams (i.e., for use with the SI035, SI050, SI100, or SI254 shearing interferometer). The diverging lens increases the size of the fringes on the diffuser plate.

For custom applications, the SITST is available, which is an internally SM1-threaded mounting plate for use with the SI035, SI050, SI100, or SI254 shearing interferometer.



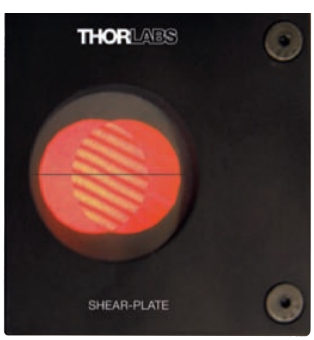

SI035, SI050, SI100, SI254




SI500, SI750

## Interference Fringes

**Converging**




**Collimated**


**Diverging**

# Shearing Interferometers (Page 2 of 2)


SITST


SIVS


**SI035**
with Shear Plate Removed

| ITEM# | INCLUDED PLATE | COMPATIBLE PLATES | COMPATIBLE ACCESSORIES | THREADED MOUNTING HOLES |
|---|---|---|---|---|
| SI035 | SI035P | SI035P, SI050P, SI100P, and SI254P | SIVS, SITST | #8-32 and M4 x 0.7 |
| SI050 | SI050P | SI035P, SI050P, SI100P, and SI254P | SIVS, SITST | #8-32 and M4 x 0.7 |
| SI100 | SI100P | SI035P, SI050P, SI100P, and SI254P | SIVS, SITST | #8-32 and M4 x 0.7 |
| SI254 | SI254P | SI035P, SI050P, SI100P, and SI254P | SIVS, SITST | #8-32 and M4 x 0.7 |
| SI500 | SI500P | SI500P and SI750P | — | 1/4"-20 and M6 x 1.0 |
| SI750 | SI750P | SI500P and SI750P | — | 1/4"-20 and M6 x 1.0 |

| ITEM# | $ | £ | € | RMB | DESCRIPTION |
|---|---|---|---|---|---|
| SI035 | $ 351.90 | £ 244.00 | € 312,50 | ¥ 2,971.50 | Shearing Interferometer Assembly, Ø1 - Ø3 mm Beams |
| SI050 | $ 362.10 | £ 251.10 | € 321,50 | ¥ 3,057.60 | Shearing Interferometer Assembly, Ø2.5 - Ø5 mm Beams |
| SI100 | $ 377.40 | £ 261.70 | € 335,10 | ¥ 3,186.80 | Shearing Interferometer Assembly, Ø5 - Ø10 mm Beams |
| SI254 | $ 402.90 | £ 279.30 | € 357,70 | ¥ 3,402.10 | Shearing Interferometer Assembly, Ø10 - Ø25.4 mm Beams |
| SI500 | $ 688.50 | £ 477.30 | € 611,30 | ¥ 5,813.80 | Shearing Interferometer Assembly, Ø25.4 - Ø50 mm Beams |
| SI750 | $ 917.00 | £ 635.70 | € 814,20 | ¥ 7,743.20 | Shearing Interferometer Assembly, Ø50 - Ø75 mm Beams |
| SI035P | $ 127.50 | £ 88.40 | € 113,20 | ¥ 1,076.70 | Shear Plate, Ø1 - Ø3 mm Beams |
| SI050P | $ 137.70 | £ 95.50 | € 122,30 | ¥ 1,162.80 | Shear Plate, Ø2.5 - Ø5 mm Beams |
| SI100P | $ 152.00 | £ 105.40 | € 135,00 | ¥ 1,283.50 | Shear Plate, Ø5 - Ø10 mm Beams |
| SI254P | $ 178.50 | £ 123.80 | € 158,50 | ¥ 1,507.30 | Shear Plate, Ø10 - Ø25.4 mm Beams |
| SI500P | $ 331.50 | £ 229.90 | € 294,40 | ¥ 2,799.20 | Shear Plate, Ø25.4 - Ø50 mm Beams |
| SI750P | $ 555.90 | £ 385.40 | € 493,60 | ¥ 4,694.10 | Shear Plate, Ø50 - Ø75 mm Beams |
| SIVS | $ 255.00 | £ 176.80 | € 226,40 | ¥ 2,153.30 | Magnified Viewing Screen for Ø1 - Ø10 mm Beams |
| SITST | $ 51.00 | £ 35.40 | € 45,30 | ¥ 430.70 | SM1-Threaded Mounting Plate |

NEW

# Shack-Hartmann Wavefront Sensor (Page 1 of 2)

## Shack-Hartmann Wavefront Sensor Specifications

NEW design

- **Wavelength Range:**
  - 400-900 nm (WFS150-7AR)
  - 300-1100 nm (WFS150-5C)
  - 400-900 nm (WFS300-14AR)
- **Wavelength Sensitivity (@633 nm):**
  - λ/15 rms (WFS150-7AR)
  - λ/15 rms (WFS150-5C)
  - λ/50 rms (WFS300-14AR)
- **Aperture Size:** 5.95 mm x 4.76 mm
- **Pixel Size:** 4.65 µm x 4.65 µm
- **Lenslet Pitch:**
  - 150 µm (WFS150-7AR)
  - 150 µm (WFS150-5C)
  - 300 µm (WFS300-14AR)
- **Lenslet Diameter:** 146 µm
- **Frame Rate:** 15 Hz (Max)
- **Exposure Range:** 77 µs – 66 ms
- **Effective Focal Length:**
  - 6.7 mm (WFS150-7AR)
  - 5.2 mm (WFS150-5C)
  - 14.0 mm (WFS300-14AR)
- **Lenslet Array Count:**
  - 39 x 31 (WFS150-7AR)
  - 39 x 31 (WFS150-5C)
  - 19 x 15 (WFS300-14AR)
- **Reflectivity:**
  - <1% (WFS150-7AR)
  - <1% (WFS300-14AR)
  - <25% (WFS150-5C)
- 1.3 Megapixel CCD Camera
- USB2.0 Interface
- **Camera Resolution:** 1280 x 1024 (Selectable)
- **Physical Size (H x W x D):** 34 mm x 32 mm x 45.5 mm


Patent Pending

### Features

- User can Easily Switch Between Pre-Calibrated Lenslet Arrays
- Real-Time Wavefront and Intensity Distribution Measurements
- For CW and Highly Repetitive Pulsed Light Sources
- Flexible Export Options
- Live Data Readout via TCP/IP

A Shack-Hartmann wavefront sensor, which can be used in an adaptive optics system to measure the wavefront deviation from a reference wavefront, uses a lenslet array to divide an incoming beam into an array of smaller beams, each of which is imaged onto a CCD camera that is placed at the focal plane of the lenslet array (Fig. 1). A uniform plane wave that is incident on a Shack-Hartmann wavefront sensor normal to the lenslet array (Fig. 1), forms a focused spot along the optical axis of each lenslet, yielding a regularly spaced grid of spots in the focal plane. A distorted wavefront, however, produces focal spots that are displaced from the optical axis of each lenslet. The amount of shift of each spot's centroid is proportional to the local slope (i.e., tilt) of the wavefront at the location of that lenslet.

*…continues on next page*

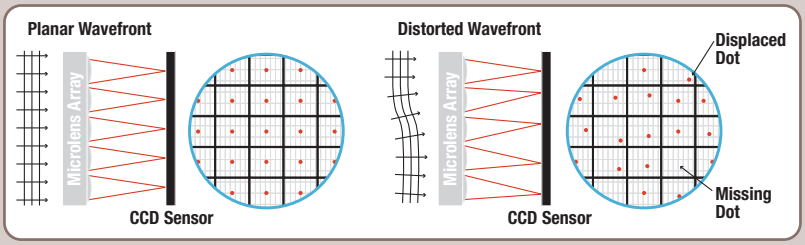



**Figure 1.** A planar wavefront incident on the Shack-Hartmann wavefront sensor's lenslet array and imaged on the CCD sensor will display a regularly spaced grid of spots. An aberrated wavefront, however, will cause individual spots to be displaced from the optical axis of each lenslet; if the displacement is large enough, the image spot may even appear to be missing. This information is used to calculate the shape of the wavefront that was incident on the microlens array.

(a) (b)

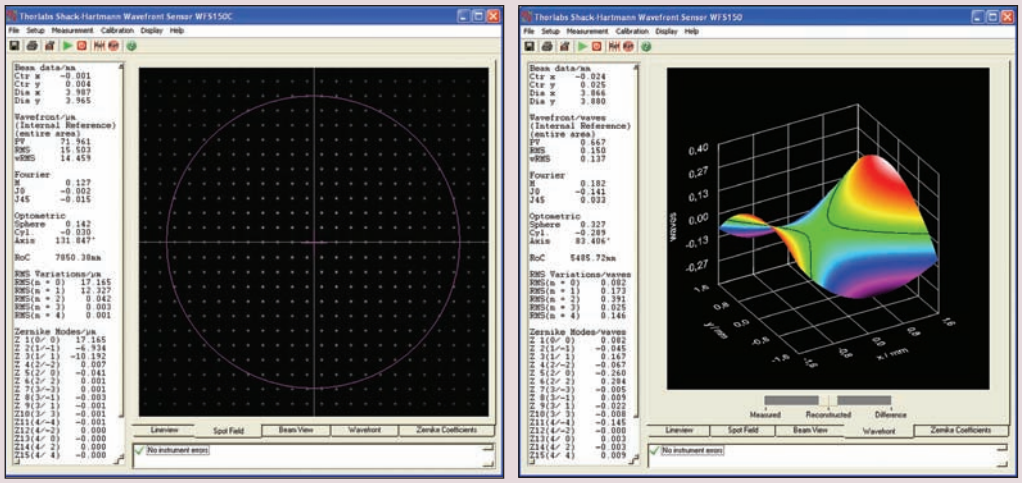


**Figure 2.** Two Shack-Hartmann wavefront sensor screen captures are shown: the spot field (a) and the calculated wavefront based on that spot field information (b).

# Shack-Hartmann Wavefront Sensor (Page 2 of 2)

The wavefront phase can be reconstructed from the spot displacement information obtained (Fig. 2).

Four parameters that influence the performance of a Shack-Hartmann wavefront sensor are the number of lenslets that cover the CCD active area, the dynamic range, the measurement sensitivity, and the lenslet focal length. The number of lenslets restricts the maximum number of Zernike coefficients that a reconstruction algorithm can reliably calculate. When selecting the number of lenslets required, consider the amount of distortion being modeled (i.e., how many Zernike coefficients are needed to effectively represent the true wave aberration).

Sensitivity ($\theta_{min}$) is a function of the minimum detectable spot displacement ($\Delta y_{min}$), as described in Fig. 3. This parameter determines the minimum detectable phase. Dynamic Range ($\theta_{max}$), however, is a measure of the maximum extent of phase that can be measured.

A Shack-Hartmann sensor's measurement accuracy (i.e., the minimum wavefront slope that can be measured reliably) depends on its ability to precisely measure the displacement of a focused spot with respect to a reference position. A conventional algorithm will fail to determine the correct centroid of a spot if it partially overlaps another spot or if the focal spot of a lenslet falls outside of the area of the sensor assigned to detect it (i.e., spot crossover). Special algorithms can be implemented to overcome these problems, but they limit the dynamic range of the sensor. The dynamic range of a system can be increased by using a lenslet with either a larger diameter or a shorter focal length. Increasing the dynamic range by increasing the lenslet diameter decreases the number of Zernike coefficients available to represent the wavefront. Conversely, increasing the dynamic range by shortening the lenslet focal length decreases the sensor's sensitivity. Ideally, a lenslet with the longest focal length that meets both the dynamic range and measurement sensitivity requirements should be used. Please see the table below for a selection of interchangeable microlens arrays.

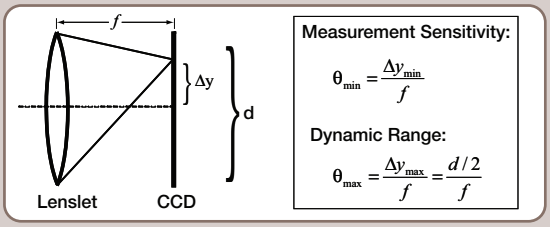



**Figure 3.** Dynamic range and measurement sensitivity are competing properties of a Shack-Hartmann wavefront sensor. Here, f, Δy, and d represent the focal length of the lenslet, the spot displacement, and the lenslet diameter, respectively. The equations provided for the measurement sensitivity $\theta_{min}$ and the dynamic range $\theta_{max}$ are obtained using the small angle approximation. $\theta_{min}$ is the minimum wavefront slope that can be measured by the wavefront sensor. The minimum detectable spot displacement $\Delta y_{min}$ depends on the pixel size of the photodetector, the accuracy of the centroid algorithm, and the signal to noise ratio of the sensor. $\theta_{max}$ is the maximum wavefront slope that can be measured by the wavefront sensor and corresponds to a spot displacement of $\Delta y_{max}$, which is equal to half of the lenslet diameter. Therefore, increasing the sensitivity will decrease the dynamic range and vice versa.

The Shack-Hartmann wavefront sensor is capable of providing information about the intensity profile as well as the calculated wavefront. Figure 4a contains a sample intensity profile, whereas Fig. 4b shows the corresponding wavefront profile. It is possible to obtain the same intensity profile from various wavefront profiles.

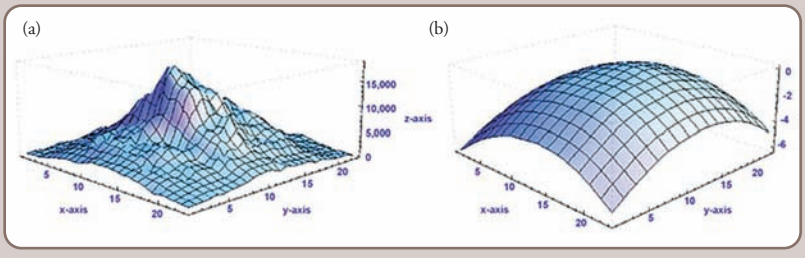



**Figure 4.** Several pieces of information are provided by the Shack-Hartmann wavefront sensor, including total power at each lenslet (a) and the calculated wavefront distribution (b).

**Mounted MicroLens Array Features**
**(See Page 670 for More Information)**

| Microlens Array | EFL | Feature |
|---|---|---|
| MLA150M-7AR | 6.7 mm | AR Coated (400-900 nm) |
| MLA150M-5C | 5.2 mm | Chrome Mask |
| MLA300M-14AR | 14.0 mm | Square Lenslet, AR Coated (400-900 nm) |

Thorlabs offers a selection of mounted microlens arrays with different focal lengths and lenslet sizes. These microlens arrays are calibrated with the wavefront sensor and can easily be exchanged by the user.

**Please contact Thorlabs' tech support for calibration details.**

**Exchange Program:** If you own a wavefront sensor from Thorlabs and would like to use a different microlens array, please contact Tech Support for details on our Exchange Program.

| ITEM# | $ | £ | € | RMB | DESCRIPTION |
|---|---|---|---|---|---|
| WFS150-7AR | $ 3,800.00 | £ 2,634.00 | € 3.373,50 | ¥ 32,088.00 | Shack-Hartmann Wavefront Sensor with MLA150M-7AR Microlens Array (AR Coated: 400-900 nm) |
| WFS150-5C | $ 3,800.00 | £ 2,634.00 | € 3.373,50 | ¥ 32,088.00 | Shack-Hartmann Wavefront Sensor with MLA150M-5C Microlens Array (Chrome Mask, 300-1100 nm) |
| WFS300-14AR | $ 3,800.00 | £ 2,634.00 | € 3.373,50 | ¥ 32,088.00 | Shack-Hartmann Wavefront Sensor with MLA300M-14AR Microlens Array (Square Lenslet, AR Coated: 400-900 nm) |
| MLA150M-7AR | $ 800.00 | £ 554.60 | € 710,30 | ¥ 6,755.30 | Mounted Microlens Array 150 µm Pitch, 6.7 mm EFL (AR Coated: 400-900 nm) |
| MLA150M-5C | $ 800.00 | £ 554.60 | € 710,30 | ¥ 6,755.30 | Mounted Microlens Array 150 µm Pitch, 5.2 mm EFL (Chrome Mask, 300-1100 nm) |
| MLA300M-14AR | $ 800.00 | £ 554.60 | € 710,30 | ¥ 6,755.30 | Mounted Microlens Array 300 µm Pitch, 14.0 mm EFL (Square Lenslet, AR Coated: 400-900 nm) |

# CCD Beam Profilers (Page 1 of 2)

BC106-UV

NEW products

**Features:**

- High, 1,360 x 1,024 Pixel Resolution
- >62 dB Signal to Noise Ratio
- Windowless Sensor Area for Best Uniformity and Linearity
- Full 2D Analysis of Complex Beam Profiles
- Power Readout
- Auto-Exposure from 20 µs to 1 s
- Gain Control from 1X to 16X
- Black Level and Ambient Light Compensation
- For CW or Pulsed Laser Beams and Single Pulse Analysis
- External Shutter Trigger Input

The BC106 Series is our new line of camera-based beam profilers. Compared to scanning slit profilers, CCD profilers offer more details and true 2D analysis of the beam's power density distribution. This allows complex mode patterns (like flat top and donut) to be identified while optimizing the laser systems. The BC106 can also be used to measure power and is perfectly suited for simultaneous power and beam shape optimization without the need of an external power meter. These profilers can be used to measure continuous wave (CW) and pulsed beams of any frequency. Several trigger modes allow flexible capturing of single pulses. A TTL input is provided for triggered single pulse detection up to a repetition rate of 50 kHz.

Ambient light correction is available by comparing a measurement against a previously measured mean value of the ambient light intensity, thereby reducing the amount of background noise.

### High-Quality CCD Camera

The BC106 Series is based on a high-quality, 12-bit CCD camera with a 2/3" (8.8 mm x 6.6 mm), windowless, 1.4 Megapixel (1360 x 1024 px) sensor. Compared to lower priced CMOS profilers, the CCD camera found in our beam profiler offers the following advantages:

- Excellent Sensitivity and Low Noise
- Enhanced Global Shutter Efficiency for Improved Exposure Accuracy and Uniformity
- Automatic Dark Level Calibration

### Frame Rates

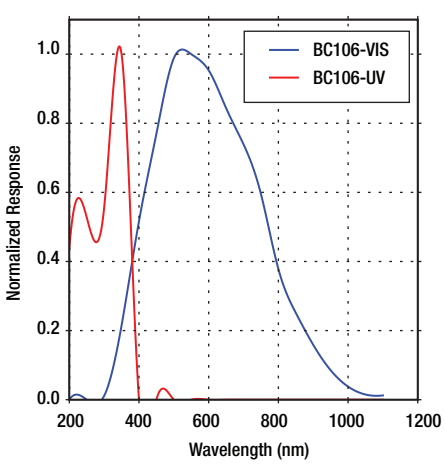
The Hi-Speed USB2.0 interface allows up to 15 full frames per second at full resolution. Measurements at higher frame rates can be achieved with reduced frame sizes to view the region of interest (ROI).

### Filter Wheel

An integrated filter wheel with four different high-quality ND filters allows the profiler to be easily adapted to beam intensities from microwatts to 1 W without extra accessories. The filters can be removed from the filter wheel when attenuation is not needed. The SM1BC adapter, included with each system, can be threaded on to the beam profiler in place of an ND filter and allows externally SM1-threaded (see pages 123-132) components to be attached.

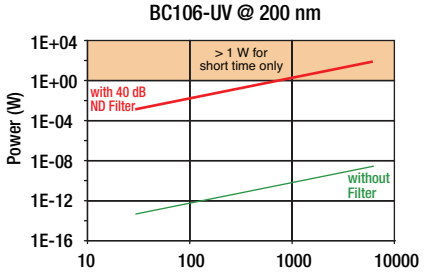
SM1BC

BC106 Series Relative Response without ND Filter

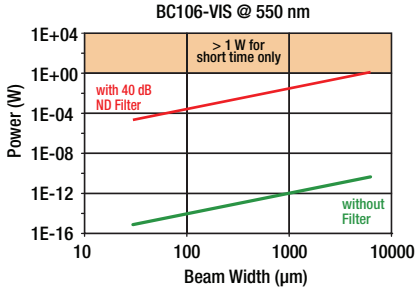



Power Handling Plots

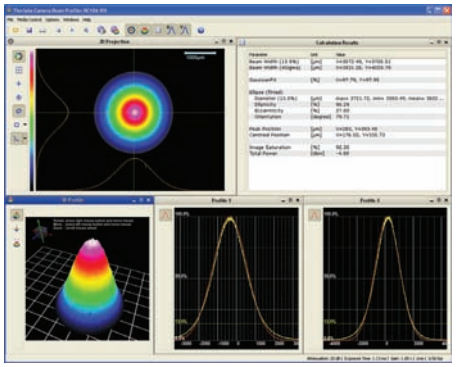
BC106-UV @ 200 nm




BC106-VIS @ 550 nm



# CCD Beam Profilers (Page 2 of 2)



## Software Features

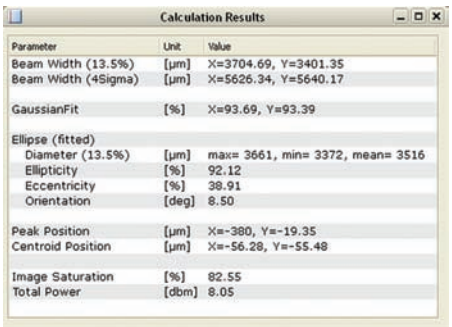
- Versatile Graphical Interface with Easy-to-Adjust Windows
- Cross-Sectional X and Y Profiles at Adjustable Locations with Gaussian Fit
- Averaging Capabilities
- 2D Power Density Diagram with Elliptical Beam Fit, Flexible 3D Graph
- Image and Text File Output
- High-Speed USB 2.0 Interface
- Direct Show Driver

The BC106 ships with a versatile software and driver package. Its GUI allows individual views of the X and Y beam cross sections, 2D projections, and 3D profiles in grey scale or color mode as well as the numerical parameters in separate windows. Many details like peak and centroid position, Gaussian approximations of the X and Y profiles, and elliptical fits of the beam's cross section can be superimposed, faded out, or displayed in many different variations. The beam diameter is calculated according to the ISO 11146 standard (i.e., 4σ, 1/e²) or at any user-defined clip level. GUI images and calculated data can be saved to different file formats. The software is based on a library of Direct Show filters and DLLs, which is also accessible to the user for writing his or her own programs.

| ITEM# | BC106-UV | BC106-VIS |
|---|---|---|
| Wavelength Range | 190-350 nm[a] | 350-1100 nm |
| Power Range | 50 fW - 1 W[b] | 1 fW - 1 W[c] |
| Attenuation Filters (Nominal Values, on Filter Wheel) | 20, 40 dB VIS<br>20, 40 dB UV | 10, 20, 30, 40 dB VIS |
| Beam Diameter | 30 µm - 6.6 mm | |
| Compatible Light Sources | CW, Pulsed | |
| Pulse Frequency | 1 Hz - 50 kHz (Single Pulse Exposure)<br>Unlimited (Multi Pulse Exposure) | |
| **Sensor** | | |
| Coating | Lumigen | N/A |
| Chip Type | 2/3" EXview HADTM CCD Sensor<br>Sony ICX285AL, Window Removed | |
| Aperture Size (Max) | 8.77 mm x 6.6 mm | |
| Pixel Size | 6.45 µm Square | |
| Resolution (Max) | 1360 x 1024 pixels, ROI Selectable | |
| **Camera** | | |
| Shutter | Global | |
| Frame Rate | 15 Hz Full Resolution[d]<br>50 Hz Reduced ROI | |
| Image Digitization | 8 Bit (0 - 255 Digits) or 12 Bit (0 - 4095 Digits) | |
| Signal-to-Noise Ratio | ≥62 dB | |
| Exposure Range | 20 µs - 1 s | |
| Gain Range | 1X - 16X | |
| Image Capture Modes | Single Frame, Continuous, Hardware Triggered | |
| **Interfaces** | | |
| Trigger Input | TTL Level, BNC | |
| Trigger Delay | 42 µs - 1 s, Programmable | |
| PC Interface | USB 2.0 (Also USB 1.1 Compatible) | |
| **General** | | |
| Physical Size (H x W x D) | 80 mm x 91 mm x 37 mm (3.2" x 3.6" x 1.4") | |
| Mounting | 1/4"-20 and M6 x 1.0 | |
| Power Supply | 2.4 W, USB Bus Powered | |

[a] Wavelength range of supplied removable UV ND filters begin at 220 nm.
[b] @ 200 nm, depending on beam diameter and ND filter.
[c] @ 550 nm, depending on beam diameter and ND filter.
[d] Highly dependent on PC processor and graphic adapter performance.

**Calculated Data**



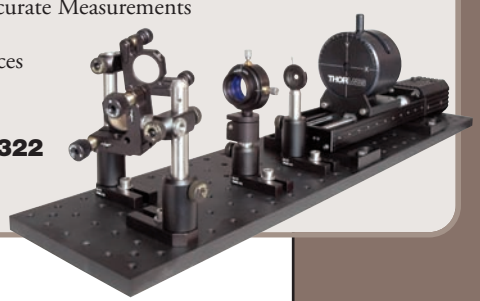

## What's Included

- BC106 Series Beam Profiler
- USB 2.0 Cable, A to Mini B, 2 m
- CD with Software Package and Driver Set
- Printed User Manual
- SM1BC Internally SM1-Threaded Adapter

## M² Beam Quality Analysis System

- Measure M², Divergence, Waist Diameter, Rayleigh Range, and Astigmatism
- Complete and Pre-Assembled
- Fast and Accurate Measurements
- For CW or Pulsed Sources

**See Page 1322**



| ITEM# | $ | £ | € | RMB | DESCRIPTION |
|---|---|---|---|---|---|
| BC106-UV | $ 3,990.00 | £ 2,766.00 | € 3.542,50 | ¥ 33,692.00 | CCD Beam Profiler, 30 µm - 6.6 mm, 190-350 nm |
| BC106-VIS | $ 3,750.00 | £ 2,599.50 | € 3.329,50 | ¥ 31,666.00 | CCD Beam Profiler, 30 µm - 6.6 mm , 350-1100 nm |
| SM1BC | $ 35.00 | £ 24.30 | € 31,10 | ¥ 295.60 | SM1 Adapter for BC106 Series CCD Camera Beam Profiler |

# Scanning Slit Beam Profilers (Page 1 of 2)

NEW versions

## Features

- **Wavelength Ranges:**
  - 200 - 1100 nm (UV)
  - 400 - 1100 nm (VIS)
  - 700 - 1800 nm (IR)
  - 1000 - 2700 nm (IR2)
- **Two Aperture and Slit Sizes:**
  - Ø4 mm with 2.5 µm Slit
  - Ø9 mm with 5 µm Slit
- **Beam Diameter Range (1/e²):**
  - 10 µm to 4 mm (BP104)
  - 20 µm to 9 mm (BP109)
- High-Precision Analysis of Beam Quality and Spatial Power Distribution
- Integrated Power Meter
- Continuous and Pulsed Sources (>10 Hz)
- Variable Scanning Speed up to 20 Hz
- High Dynamic Range
- Low-Noise Amplifier
- Automatic and Manual Gain Control (Switchable)
- **Powerful GUI:**
  - 2D and Pseudo-3D Profiles
  - Bar Graph and Trend Indicators
- Gauss Fitting
- USB 2.0 Cable Included (2 m)
- Average and Maxima-Hold Functions
- LabVIEW™/LabWindows™ and C/C++ Drivers Included


**BP100 Series**
(Post and Base not Included)

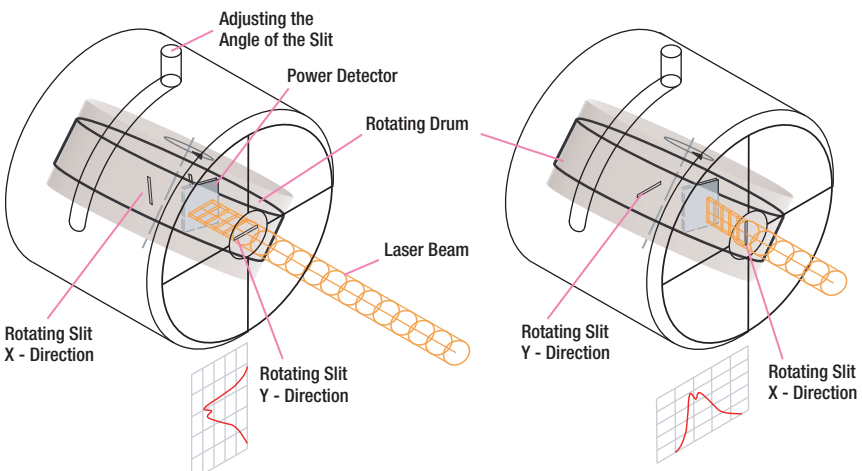
Thorlabs' BP100 Beam Profiler Series is a full-featured, high-precision instrument used to analyze the power distribution of laser beams with diameters from 10 µm to 9 mm and a dynamic range of 72 dB. It is available with a Si, Ge, InGaAs, or extended InGaAs sensor to provide detection in the 200-1100 nm, 400-1100 nm, 700-1800 nm, or 1000-2700 nm range, respectively. Designed as a single measurement head with a USB 2.0 interface, operation is easy and intuitive, and includes a graphical-user interface and drivers.

**Functionality**

A narrow slit scans the beam at two defined orthogonal directions. To determine the beam's quality and spatial characteristics, the passing light is integrated by the detector and sampled. This method allows a wide range of power and beam diameters to be analyzed without the need for attenuators or lenses. From the resulting power distributions for the X and Y directions, all analyzed beam parameters are calculated such as diameter, ellipticity, location, centroid, pseudo-3D profile, and the beam power. A Gaussian fit of the scanned profiles is displayed together with the 2D and 3D plots. The direction of X and Y is set manually by a rotation mount that allows for rotating the complete measuring system in the housing by ±60°.

A variable average function provides adjustable noise reduction and increases the measurement accuracy. The maxima-hold function allows analysis of pulsed laser sources, and the automatic or manual gain control enables the user to adapt to different beam powers. The power meter provides output in mW or dBm and can be calibrated by the user with an external power meter. The GUI shows all parameters as digital or bar graph readouts, and parameter drifts can be visualized by a trend indicator. Data can be exported as text or spreadsheet files for external processing.

Mechanical Drawings Available on the WEB



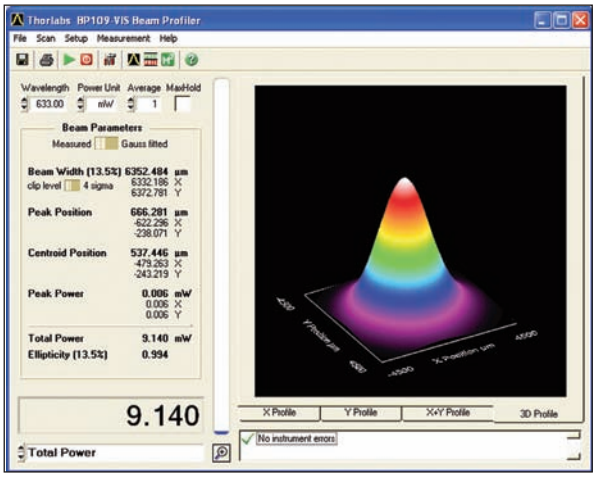

Please refer to our website for complete models and drawings.

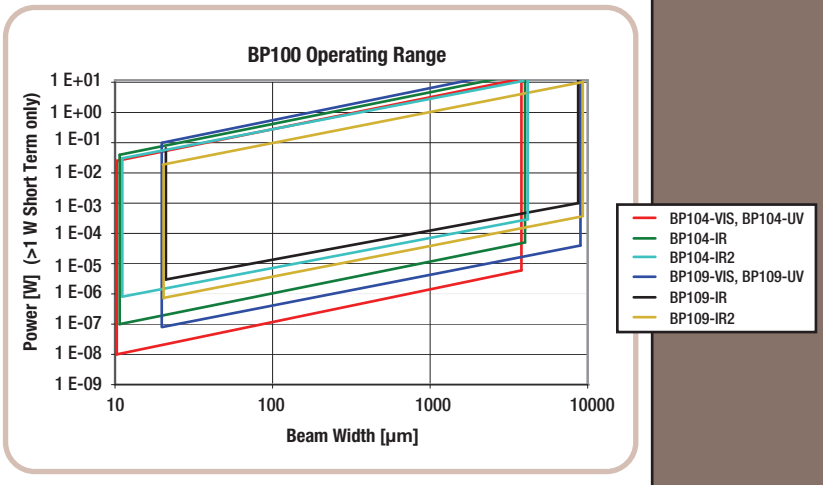
# Scanning Slit Beam Profilers (Page 2 of 2)

| ITEM# | BP104-UV | BP104-VIS | BP104-IR | BP104-IR2 | BP109-UV | BP109-VIS | BP109-IR | BP109-IR2 |
|---|---|---|---|---|---|---|---|---|
| Wavelength Range (nm) | 200-1100 | 400-1100 | 700-1800 | 1000-2700 | 200-1100 | 400-1100 | 700-1800 | 1000-2700 |
| Detector Type | Si* | Si | Ge | Extended InGaAs | Si* | Si | Ge | Extended InGaAs |
| Aperture Diameter | 4 mm | | | | 9 mm | | | |
| Slit Size | 2.5 µm | | | | 5 µm | | | |
| Minimum Beam Diameter | 10 µm | | | | 20 µm | | | |
| Maximum Beam Diameter | 4 mm | | | | 9 mm | | | |
| Scan Rate | 1.0-20.0 Hz (Continuously Variable) | | | | | | | |
| Sampling Resolution | 0.5-38 µm (Depending on Scan Rate) | | | | 1.1-38 µm (Depending on Scan Rate) | | | |
| Power Range** | 10 nW to 10 W (Depending on Beam Diameter) | | | | | | | |
| Amplifier Bandwidth | 10, 20, or 150 kHz (-1 dB) | | | | | | | |
| Sample Frequency | 0.0625-1.0 MHz | | | | | | | |
| Dynamic Range | 72 dB (Amplifier Switchable) | | | | | | | |
| Signal Digitization | 16 Bit | | | | | | | |
| Head Size | Ø80 mm x 60 mm (Ø3.15" x 2.36") | | | | | | | |
| Mounting | M4 x 0.7, M6 x 1.0, and #8-32 | | | | | | | |

*Si-UV Enhanced **Power levels between 1 W and 10 W should only be used with short exposure times (<30 seconds).

### User software showing pseudo 3D beam profile




| ITEM# | $ | £ | € | RMB | DESCRIPTION |
|---|---|---|---|---|---|
| BP104-UV | $ 3,840.00 | £ 2,662.00 | € 3.409,00 | ¥ 32,426.00 | Slit Scanning Beam Profiler, 200-1100 nm, Ø4 mm Aperture |
| BP104-VIS | $ 3,600.00 | £ 2,495.50 | € 3.196,00 | ¥ 30,399.00 | Slit Scanning Beam Profiler, 400-1100 nm, Ø4 mm Aperture |
| BP104-IR | $ 4,140.00 | £ 2,870.00 | € 3.675,50 | ¥ 34,959.00 | Slit Scanning Beam Profiler, 700-1800 nm, Ø4 mm Aperture |
| BP104-IR2 | $ 5,100.00 | £ 3,536.00 | € 4.528,00 | ¥ 43,065.00 | Slit Scanning Beam Profiler, 1000-2700 nm, Ø4 mm Aperture NEW |
| BP109-UV | $ 4,200.00 | £ 2,911.50 | € 3.729,00 | ¥ 35,465.00 | Slit Scanning Beam Profiler, 200-1100 nm, Ø9 mm Aperture |
| BP109-VIS | $ 3,960.00 | £ 2,745.00 | € 3.515,50 | ¥ 33,439.00 | Slit Scanning Beam Profiler, 400-1100 nm, Ø9 mm Aperture |
| BP109-IR | $ 4,500.00 | £ 3,120.00 | € 3.996,00 | ¥ 37,999.00 | Slit Scanning Beam Profiler, 700-1800 nm, Ø9 mm Aperture |
| BP109-IR2 | $ 5,600.00 | £ 3,883.00 | € 4.972,00 | ¥ 47,287.00 | Slit Scanning Beam Profiler, 1000-2700 nm, Ø9 mm Aperture NEW |

## Deformable Mirrors - See Page 1412


- 6 x 6 or 12 x 12 Actuator Array
- 3.5 µm Maximum Actuator Displacement
- Aluminum- or Gold-Coated Design
- Operating Wavelengths
  - 400-1100 nm (Al Coated)
  - 600-1100 nm (Au Coated)

Through our partnership with Boston Micromachines Corporation, a leading developer of advanced micro-electro-mechanical-based (MEMS-based) mirror products, Thorlabs is pleased to offer deformable mirrors with either 6 x 6 or 12 x 12 actuator arrays. These mirrors change shape to correct a highly distorted incident wavefront. MEMS-based deformable mirrors are currently the most widely used technology in wavefront shaping applications given their versatility, maturity of technology, and the high resolution wavefront correction that they provide.

# Complete M² Beam Quality Analysis System

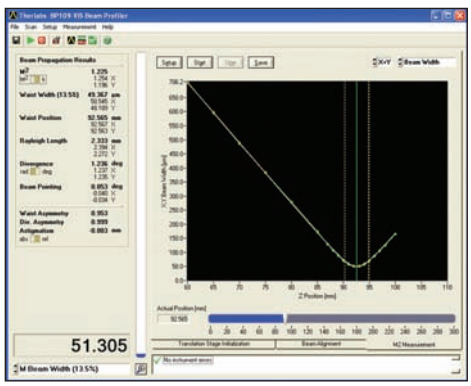
Thorlabs' M² Meters are designed for automated M² beam quality analysis. Each system allows the measurement of the diffraction-limit M² factor of a laser beam and its reciprocal beam quality, k=1/M², together with the divergence, waist diameter, Rayleigh range, and astigmatism of the beam.

NEW products
M2SET-VIS

**Functionality**

To characterize a laser beam, at least five beam measurements in the linear divergence region and another five measurements within the waist region need to be taken. Using the M2SET the required measurements can be performed fast and accurately. The system consists of a BP109 Series Beam Profiler fixed on a 150 mm long translation stage, a lens mounted in a flip mount that can be easily inserted or removed from the beam path, an iris diaphragm, and two Ø1" mirrors in adjustable mounts. All of these components are mounted on a 24" x 6" (600 mm x 150 mm) breadboard.

During operation, the profiler is automatically moved (step-wise) along the beam path, resulting in a beam analysis at various positions. The beam quality is determined via curve fitting of the beam diameter versus profiler position.




## Features

- Complete, Preassembled and Pre-Aligned System
- Fast and Accurate Beam Quality Measurements
- Measure M², Divergence, Waist Diameter, Rayleigh Range, and Astigmatism
- Compatible with CW and Quasi-CW Pulsed Laser Sources
- ISO11146 Compliant

When the measurement of a focused beam is completed, the focusing lens can be flipped out of the beam to measure the parameters of the original unfocused laser beam. Both results can be combined, and the complete parameter set for the unfocused beam, including the beam's waist diameter, position, and Rayleigh range, are derived. The supplied software has an easy-to-operate Graphical User Interface (GUI), which fully supports automated M² measurements as well as basic beam profiling measurements. Reports can be stored to a file or transmitted to another application via DataSocket.

| ITEM# | M2SET-VIS | M2SET-VIS/M | M2SET-IR | M2SET-IR/M |
|---|---|---|---|---|
| Component Type | Imperial | Metric | Imperial | Metric |
| Breadboard Footprint | 24" x 6" | 600 mm x 150 mm | 24" x 6" | 600 mm x 150 mm |
| Beam Profiler | BP109-VIS | | BP109-IR | |
| Wavelength Range | 400-1100 nm | | 700-1800 nm | |
| Beam Diameter Range[a] | 20 µm - 9 mm | | | |
| Power Range[b] | 10 nW - 10 W | | | |
| Translation Range | 150 mm; -100 to 50 mm from Focal Point | | | |
| Lens Focal Length | 200 mm | | | |
| Optical Axis Height[c] | 50-120 mm | | | |
| M² Measurement Range | 1.0 - No Upper Limit | | | |
| Typical M² and k Accuracy[d] | ±5% | | | |
| Maximum Input Beam Diameter[e] | 14 mm | | 20 mm | |
| Accepted Beam Diameter for 5% Accuracy | 20 µm - 4.5 mm at Beam Profiler Input Aperture | | | |
| Minimum Detectable Divergence Angle | <0.1 mrad | | | |
| Applicable Light Sources | CW and Pulsed Sources ≥300 kHz | | | |
| Typical Measurement Time | 20\-40 seconds Depending on Beam Shape and Settings | | | |

[a]At beam profiler input aperture [b]Depending on Beam Diameter [c]Can be extended further [d]Depending on optics and alignment [e]Depending on Wavelength

| ITEM# | $ | £ | € | RMB | DESCRIPTION |
|---|---|---|---|---|---|
| M2SET-VIS | $ 7,500.00 | £ 5,200.00 | € 6.659,00 | ¥ 63,331.00 | Complete M² Analysis Set, 400-1100 nm, Imperial |
| M2SET-VIS/M | $ 7,500.00 | £ 5,200.00 | € 6.659,00 | ¥ 63,331.00 | Complete M² Analysis Set, 400-1100 nm, Metric |
| M2SET-IR | $ 7,900.00 | £ 5,477.00 | € 7.014,00 | ¥ 66,708.00 | Complete M² Analysis Set, 700-1800 nm, Imperial |
| M2SET-IR/M | $ 7,900.00 | £ 5,477.00 | € 7.014,00 | ¥ 66,708.00 | Complete M² Analysis Set, 700-1800 nm, Metric |

* Translation stages available separately. Please contact tech support for a quote.

# Polarization Selection Guide

Pages 1323-1336


### Extinction Ratio Meter

- Measure ER of PM Fibers
- Align Axes of PM Fibers to Connector Key
- 800-1700 nm Wavelength Range

**See Page 1325**

### PAX Polarimeter

- Free-Space or Fiber Polarimetry
- DOP Measurements
- ER Measurements of PM Fiber

**See Pages 1326-1328**

### In-Line Polarimeter

- High Speed Polarization Measurements
- Feedback for Polarization Control

**See Pages 1329-1330**

### In-Line Deterministic Polarization Controller

- Deterministic Polarization Control and Locking
- Generates Precise SOP Sequence for Jones and Mueller Matrix Characterization Methods

**See Page 1331**


### State of Polarization Locker

- Deterministic Polarization Control and Locking
- Replaces Paddle Polarization Controllers
- 1510-1640 nm Wavelength Range

**See Page 1332**

### PMD/PDL Measurements

- Dynamic Polarization Measurements in Real Time
- Deterministic Polarization Control and Locking

**See Pages 1333-1336**

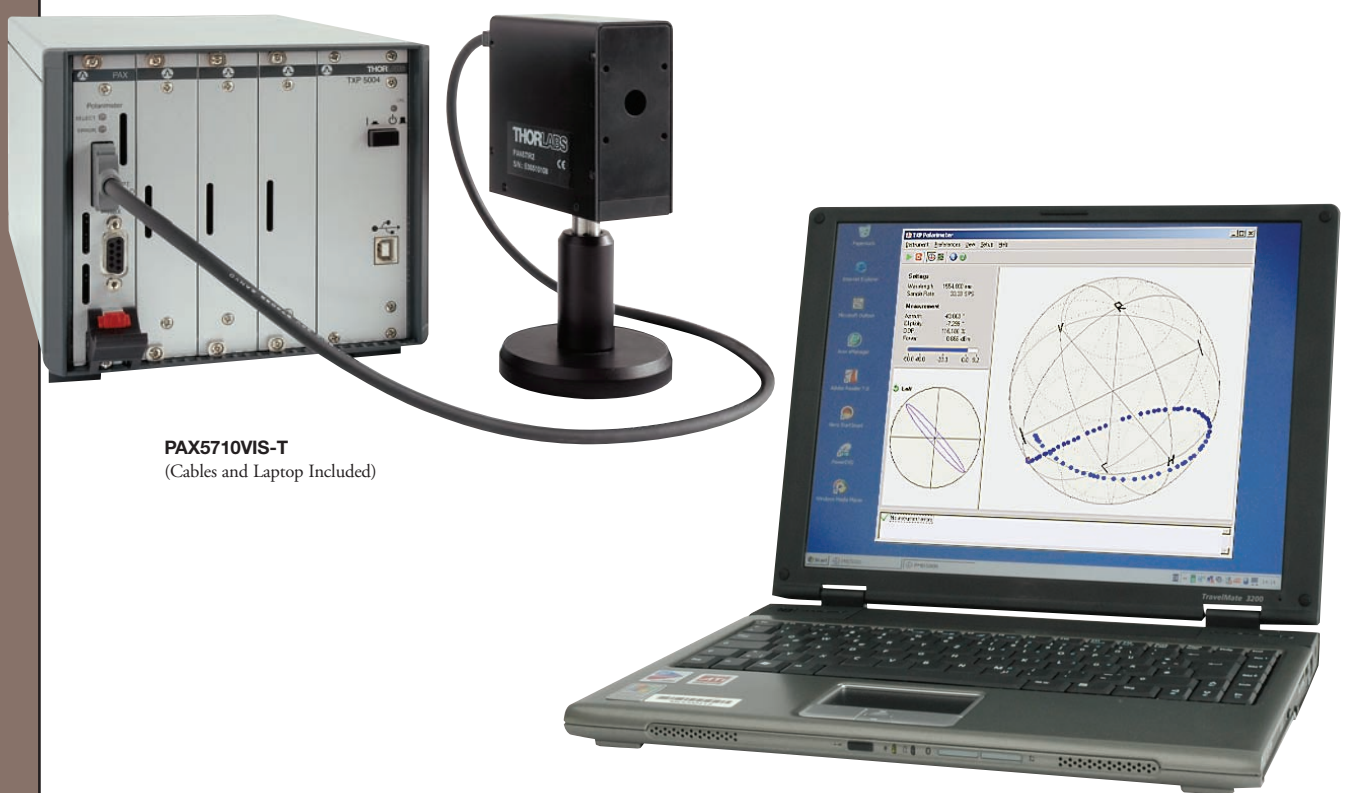
# Polarization Tools Selection Guide

## Pages 1324-1336

### Polarization Measurement and Control

| ITEM# | WAVELENGTH | ANALYZER | CONTROLLER | | TYPE | APPLICATIONS | SEE PAGES |
|---|---|---|---|---|---|---|---|
| | | | MANUAL | AUTOMATIC | | | |
| ERM100 Extinction Ratio Meter | 800-1700 | ✔ | | | Rotating Analyzer* | Measures the ER of Polarization Monitoring Fibers | 1325 |
| PAX5710 Polarimeter | 400-700 nm<br>700-1000 nm<br>1000-1350 nm<br>1300-1700 nm | ✔ | | | Rotating Wave Plate | Polarimetry, Retardance Measurements, ER-Measurements on PMF, PMD, PDL Measurements | 1326-1328 |
| IPM 5300 In-Line Polarimeter | 1510-1640 nm | ✔ | | | In-Line | Polarimetry, PMD/PDL Measurements | 1329-1330 |
| DPC5500 Polarization Controller | 1510-1640 nm | ✔ | | ✔ | In-Line | Polarimetry, SOP Control and Scrambling, PMD/PDL Measurements | 1331 |
| PL100S/PL100P SOP Lockers | 1510-1640 nm | | ✔ | ✔ | In-Line | SOP Control and Scrambling | 1332 |
| FPC Series | Fiber Dependent | | ✔ | | In-Line | SOP Control | 1014 |
| SBC Series Soleil-Babinet Compensator | 140-400 nm<br>400-1000 nm<br>1000-2000 nm | | ✔ | | Retarder | Retardance Measurment, Ellipsometry, Birefringence | 780 |

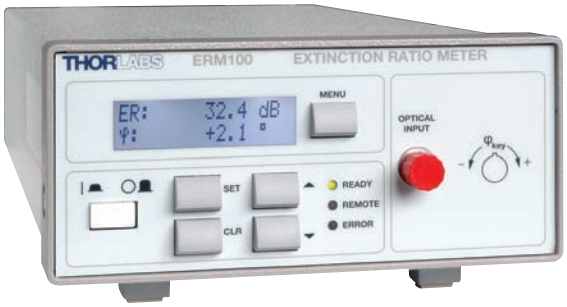
*The ERM100 is based on a rotating polarizer technique




**PAX5710VIS-T**
(Cables and Laptop Included)

# Extinction Ratio Meter

NEW product




**ERM100 with USB Interface**

## Applications

- Extinction Ratio (ER) Measurements of Polarization Maintaining (PM) Fibers
- Alignment of PM Fiber to Connector Key
- Alignment of PM Fiber to Laser Source

## Specifications[a]

- **Fiber Connector:** FC/PC
- **Wavelength Range:** 800-1700 nm
- **Max. ER[b]:** >40 dB
- **ER Accuracy:[b]** 0.5 dB
- **ER Resolution:** 0.1 dB
- **Angle Accuracy:[b]** 0.5°
- **Angle Resolution:** 0.1°
- **Dynamic Range:[c]** 50 dB (-40 to 10 dBm)
- **Operating Temperature:** 5 to 40 °C
- **Line Voltage:** 100 V, 115 V, 230 V +15%/-10%

a All specifications are valid at 23 ± 5 °C and 45 ± 15% relative humidity.

b For input power > -30 dBm at 1550 nm.

c Dynamic Range depends on specific wavelength.

The ERM100 Extinction Ratio Meter utilizes a rotating polarizer. This benchtop device offers a fast and simple way to measure the Extinction Ratio (ER) of polarization-maintaining (PM) fibers. It is an easy-to-use device that may be utilized in many applications where the alignment of polarization-maintaining fibers is required.

### How it Works

The ERM100 contains a rotating polarizer followed by a detector, which generates a photocurrent. In general, for an arbitrary elliptical input state, this photocurrent will be a sinusoidal function in time with a DC offset. By simultaneously analyzing the DC offset and the depth of modulation, the meter is able to determine the degree to which the light field is linearly polarized, thereby yielding the extinction ratio (ER).

### PM Alignment Application

Thorlabs' Extinction Ratio Meter can be used to align the axis of a PM fiber with the polarization axis of the linearly polarized incident light. This process is not trivial because the PM fiber exhibits stress-induced birefringence that affects the ellipticity of the polarization state outputted from the fiber. For proper alignment of the polarization axis, a time-varying stress needs to be applied to the PM fiber while maximizing the extinction ratio of the transmitted light (e.g., continuously change the bend of the fiber). Since the alignment between the fiber axis and the polarization axis of the incident light field is improved, the effect of the time-varying stress will be reduced, thereby stabilizing the ER. At this point, the axis of the PM fiber will be optimally aligned with the polarization axis of the linearly polarized incident light.

### Benefits

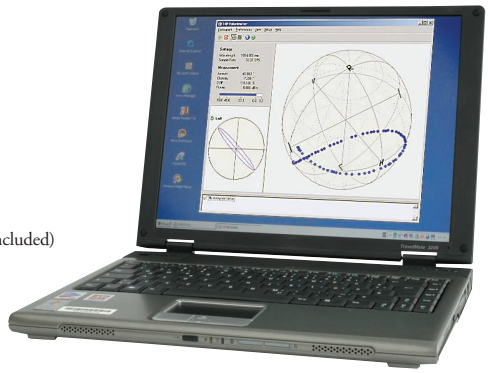
This benchtop instrument is an easy-to-use measurement device for many PM fiber alignment applications. A set of controls and the liquid crystal display on the front panel allow a quick adjustment and measurement procedure. Any PM alignment task can be performed efficiently. The ERM100 is factory calibrated and provides the ER, misalignment angle, and power. It can also be controlled via USB. Drivers for LabVIEW™, LabWindows™/CVI™, MSVC, and Borland C are included.

| ITEM# | $ | £ | € | RMB | DESCRIPTION |
|---|---|---|---|---|---|
| ERM100 | $ 2,550.00 | £ 1,767.50 | € 2.264,00 | ¥ 21,533.00 | Extinction Ratio Meter, 800-1700 nm, FC/PC |



# PAX5710-T Series of Polarimeters (Page 1 of 3)

PAX5710VIS-T
(Cables and Laptop Included)



## Applications

- Free-Space and In-Fiber Polarimetry
- ER Measurements on PMF
- DOP Measurements
- Polarimeter Unit for the PMD5000 System
- Basic Unit for Jones and Mueller Matrix Measurements

## Specifications

- **Input Power Range:**[a] -40 dBm to 0 dBm
- **Azimuth Angle Accuracy:**[b,c] ±0.25°
- **Ellipticity Angle Accuracy:**[b] ±0.25°
- **Degree of Polarization Accuracy:** ±0.5% Full Scale
- **Wavelength Range:**
  - VIS: 400-700 nm
  - IR1: 700-1000 nm
  - IR2: 1000-1350 nm
  - IR3: 1300-1700 nm
- **Maximum Measurement Rate:** 333 Samples/s
- **Fiber Input:** FC/PC (Others Available Upon Request)
- **Free-Space Input:** Ø3 mm, <3 mrad Beam Divergence
- **Analog Interface (Via Front Panel D-Sub):**
  - Outputs: S1, S2, S3, Power/dBm, and DOP (Complete Stokes Vector Plus DOP)
  - Inputs: Trigger
- **Digital Interface Outputs:** S1, S2, S3, Power, DOP, Azimuth, and Ellipticity
- **Warm-Up Time for Rated Accuracy:** <15 min
- **Operating Temperature:** 5-40 °C

a) Absolute power range depends on the current wavelength, which can be as large as -60 dBm to 10 dBm.

b) For any SOP with -30° < ellipticity < 30°

c) Azimuth angle is defined as the inclination angle of the major axis of the polarization ellipse to the horizontal axis. The ellipticity angle is given as arctan(b/a) where b is the length of the minor axis and a is the length of the major axis of the polarization ellipse.

### Introduction - PAX5710-T Polarimeter

The PAX5710-T Series polarimeter system is a flexible and powerful polarization analysis system based on our modular TXP5000 platform (see page xxx). This polarimeter system is designed for different applications ranging from classic polarization measurements to complex tasks like evaluating optical components with the Jones matrix algorithm. It is also well suited for determining the extinction ratio (ER) of polarization-maintaining fibers (PMF) and for alignment of PMF to laser modules. Furthermore, a complete PMD (Polarization-Mode Dispersion) and PDL (Polarization-Dependent Loss) analysis system can be built by combining the PAX5710-T, our DPC5500 deterministic polarization controller, and our ECL5000 Series tunable laser. The PAX5710-T series is specifically engineered for accurate measurements of polarization-related effects for high dynamic power ranges with wavelengths from 400 to 1700 nm. It consists of the analyzer with an external sensor head for free-space and fiber-based optical systems. In contrast to our IPM5000 Series, which allows transmission of the optical output, the PAX5710-T Series uses all incident light for the measurement without any optical output.

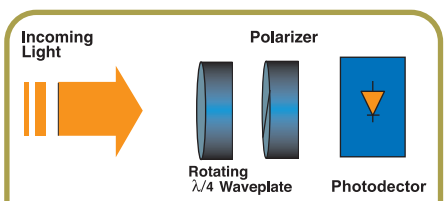



Figure 1 - Schematic of Rotating Wave Plate Technique

### How it Works

The optical unit of a PAX5710-T measurement sensor consists of a rotating quarter-wave plate, a fixed polarizer, and a photodiode (see Figure 1). The wave plate transforms the input polarization depending on the actual rotating angle. Then, the polarizer only transmits the portion of light that has its polarization parallel to the transmission axis. As a result, the polarization modulation is converted into an amplitude modulation. The photodetector supplies a current that is proportional to the optical power. A Fourier transformation is used to accurately calculate both the state of polarization (SOP) as well as the degree of polarization (DOP).

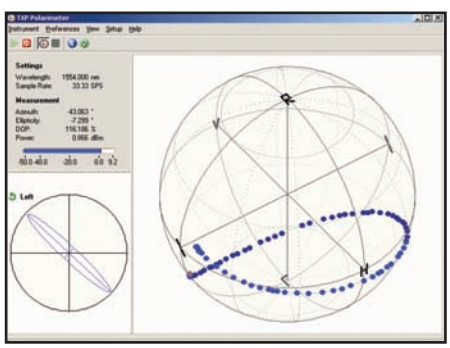


Figure 2 - Polarimeter GUI

### SOP and DOP Measurements

The PAX5710-T analyzes the state of polarization and the degree of polarization of optical signals in either free-space or optical fibers. The resulting data can be viewed using the graphical user interface that is supplied with each PAX unit. The state of the input polarization is completely characterized by different representations. As can be seen in Figure 2, the polarization data is presented in a number of forms: on the Poincaré sphere, as Stokes parameters, or as a polarization ellipse with the handedness noted. The degree of polarization and the total optical power are also provided.

# PAX5710-T Series of Polarimeters (Page 2 of 3)

### Long-Term Polarization Measurements

Another standard feature is the scope mode, which looks similar to an oscilloscope display. The polarization can be examined continuously over time or initiated with a software or hardware trigger signal. The number of data points to be acquired can be chosen by the user. Another feature is the pre-trigger function, which can be activated in each trigger mode. A user-configurable number of samples are stored in a ring buffer until the trigger pulse is given. All acquired data before and after the trigger pulse are displayed in a diagram. Therefore, real-time monitoring of the system's polarization behavior can be realized with the PAX measurement system. The measured data can be stored in an ASCII format file (CSV). The data file contents can be viewed with any text editor and can be further processed using third-party software packages such as MathCAD, Mathematica, or Excel.

### Software Features

The software for the PAX system includes drivers for LabVIEW™, LabWindows™/CVI™, MSVC, and Borland C. These drivers enable you to write your own applications to adapt the polarimeter into a complete optical setup. Included in the software are features specifically geared towards extinction ratio (ER) measurements (see below).

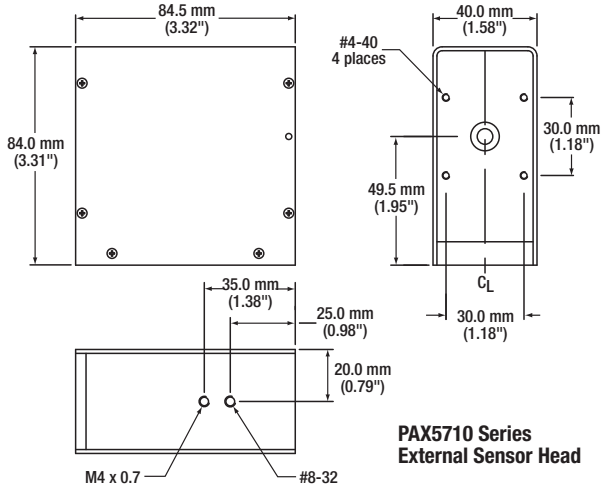
### System Configurations

Due to its modular design and the various models available, the PAX system is an ideal tool for various types of polarization-related measurement tasks in research and development laboratories as well as for final inspection in manufacturing. The PAX5710-T series can be used for free-space and fiber-based applications in the 400 to 1700 nm wavelength range. See the following page for ordering information.

The PAX5710 consists of a TXP-compatible module and an external polarization measurement sensor. The PAN5710 external measurement sensor (see next page) facilitates polarization analysis in free-space setups. It can be easily mounted to optical benches using the M4 x 0.7 or #8-32 mounting hole provided on the bottom surface of the head. It is also compatible with our extensive line of 30 mm cage system components. The optical light field to be measured should enter the aperture of the sensor nearly perpendicular to the front panel. The beam diameter should be less than 3 mm to guarantee that all of the light reaches the detector. **All sensors are supplied with a fiber collimator for FC/PC optical cables to allow polarization measurements on fiber-based systems.**

**APPLICATION IDEA**

**External PAX – Sensor Heads**




**PAX5710 Series**
**External Sensor Head**

Please refer to our website for complete models and drawings.

### Extinction Ratio Measurement on Polarization-Maintaining Fibers

Extinction ratio (ER) is a key qualifier of polarization-maintaining fibers (PMF) and PM couplings. Using the standard features built into the PAX software, ER measurements can be made quickly and reliably in the 0 to 45 dB range.

The measured ER parameter refers to the PMF directly connected to the polarimeter input.

The easiest measurement technique is to find the maximum expansion of the polarization ellipse compared to the ideal linear state. Since this expansion is dependent on the fiber stress, a lot of values have to be recorded while the fiber is stressed, pulled, or a wavelength scan is performed.

This technique requires the highest accuracy in the measurement of the ellipticity angle. With a very high ER, the setup is prone to measurement inaccuracies. The PAX5710-T uses an optimized algorithm to mitigate this issue. The data collected from fiber stressing is used to fit a circle on the Poincaré sphere. The radius of the circle, expressed in degrees, is representative of the maximum expansion of the polarization ellipse.

Only the relative polarization measurement accuracy determines the ER measurement error, since the shift of the circle to any position on the Poincaré sphere is irrelevant as long as the size of the circle remains unchanged. Errors resulting from poorly or angle-polished fibers have no influence on the final value, only the ER of the stressed fiber segment measured.

The ER measurement on PMF is integrated in the PAX5710-T software, along with all polarimeter-related functions.

# PAX5710-T Series of Polarimeters (Page 3 of 3)

## PAX5710-T Series of Benchtop Free-Space Polarimeters

The PAX5710-T versions consist of a TXP5004 chassis with USB connection, a PAX5710 series module, one external polarimeter sensor, and pre-configured notebook computer, making this a complete free-space measurement system right out of the box. This package includes all of the necessary cables for connecting the sensor and computer.

**PAX5710VIS-T**
Cables, External Sensor Head, Chassis, and Laptop Included (All Sensor Heads are Factory Calibrated)

The wavelength range can be easily extended by purchasing new sensor heads (shown below).

| ITEM# | $ | £ | € | RMB | DESCRIPTION |
|---|---|---|---|---|---|
| PAX5710VIS-T | $ 7,991.00 | £ 5,540.00 | € 7.095,00 | ¥ 67,477.00 | TXP Polarimeter w/ External Sensor, 400-700 nm |
| PAX5710IR1-T | $ 7,991.00 | £ 5,540.00 | € 7.095,00 | ¥ 67,477.00 | TXP Polarimeter w/ External Sensor, 700-1000 nm |
| PAX5710IR2-T | $ 7,991.00 | £ 5,540.00 | € 7.095,00 | ¥ 67,477.00 | TXP Polarimeter w/ External Sensor, 1000-1350 nm |
| PAX5710IR3-T | $ 7,991.00 | £ 5,540.00 | € 7.095,00 | ¥ 67,477.00 | TXP Polarimeter w/ External Sensor, 1300-1700 nm |

## External Measurement Heads for PAX5710-T Series

The External Measurement Heads of the PAX5710 Series of Polarimeters can be exchanged to switch to a different wavelength range without the need to purchase a complete new system. The external heads of the PAN5710 Series allow free-space and fiber-based measurements with easy integration in optical setups.

**PAN5710IR2**
External Sensor Head

### Applications

- To Extend the Wavelength Range of an existing PAX5710 System
- Free-Space and Fiber Input

| ITEM# | $ | £ | € | RMB | DESCRIPTION |
|---|---|---|---|---|---|
| PAN5710VIS | $ 3,461.00 | £ 2,399.00 | € 3.072,50 | ¥ 29,225.00 | PAX External Sensor Head, 400-700 nm |
| PAN5710IR1 | $ 3,461.00 | £ 2,399.00 | € 3.072,50 | ¥ 29,225.00 | PAX External Sensor Head, 700-1000 nm |
| PAN5710IR2 | $ 3,461.00 | £ 2,399.00 | € 3.072,50 | ¥ 29,225.00 | PAX External Sensor Head, 1000-1350 nm |
| PAN5710IR3 | $ 3,461.00 | £ 2,399.00 | € 3.072,50 | ¥ 29,225.00 | PAX External Sensor Head, 1300-1700 nm |

## Putting it All Together

**PMD5000 Series - Complete PMD Analysis System** (Laptop Included)

**See Pages 1008-1011**

The PMD5000 Series combines our DPC5500 Series deterministic polarization controller, one of our IPM5300 Series or PAX5710-T Series polarimeters, and one of our ECL5000 Series tunable laser sources with a specialized software package. This combination creates a versatile polarization-mode dispersion (PMD) and a polarization-dependent loss (PDL) measurement system.

The PMD5000 series provides extensive measurement and analysis of PMD on both broadband and narrowband components, optical fibers, and installed optical systems. It is capable of determining PDL and polarization dependent gain (PDG). PMD measurements of complex optical networks can be performed as well as PMD monitoring of dark channels.

# IPM5300-T Benchtop In-Line Polarimeter (Page 1 of 2)

**Introduction - IPM5300 Fast In-Line Polarimeter**

The IPM5300 fiber optic polarimeter module enables high-speed measurements of the state of polarization (SOP). The in-line fiber design has an insertion loss of less than 0.6 dB, a dynamic range of 45 dBm, and an accuracy of ±0.25° on the Poincaré sphere with a sampling rate of 1 MHz. The IPM5300 series is available as a complete benchtop unit including preconfigured laptop and TXP Mainframe (IPM5300-T series, see page 994).

This all-fiber polarimeter is based on patented FBG technology. It provides a novel combination of in-line polarimetric measurement, low insertion loss, high speed, and accuracy that enables unprecedented measurement control of the SOP in fiber optic applications.

**IPM5300-T**
Benchtop In-Line Polarimeter
Includes a Pre-Configured Laptop and TXP 5000

**How it Works**

The IPM5300 polarimeter is designed as an in-line polarimeter that utilizes a series of custom Fiber Bragg Gratings (FBGs). Figure 1 shows the optical schematic of the polarimeter module. The device uses two pairs of FBGs with polarization-dependent reflectivity to direct very small percentages of the transmitted optical power to four detectors. A λ/4 fiber wave plate is positioned between the two pairs of FBGs to produce the two additional elliptical states of polarization that are required for a full analysis of an arbitrary state of polarization.

The IPM5300 overcomes the limitations of other fiber-based in-line polarimeter designs by eliminating the need to use tap couplers, which exhibit temperature and wavelength sensitivity. The FBG approach offers superior performance; it provides a broad wavelength range (1510-1640 nm) as well as highly accurate SOP and DOP measurements.

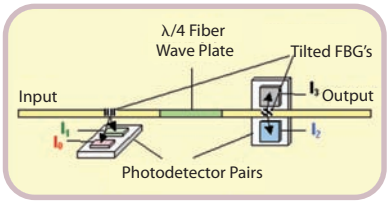



**Figure 1**
This figure shows the optical schematic of the IPM5300 polarimeter.

**Polarimeter Functionality**

All four Stokes values, which fully characterize a SOP, are provided either as analog output voltages or as digital values via USB port. The SOP measurement can be controlled via an external trigger function, thus allowing the synchronization of the IPM5300 with other devices. The 1 MHz update rate applies to the fully characterized SOP measurement. With its broad wavelength range, low loss, high speed, and accuracy, no other commercially available polarimeters can compare. Our polarization control capabilities are presented on the following page.

**No Moving Parts!**

## Applications

- High-Speed Polarization Measurement
- State of Polarization Measurements at 1 Million Samples per Second
- High-Speed DOP Measurements for Active Polarization Modal Dispersion Compensation
- High-Speed Feedback for Automatic Polarization Control

## Specifications

- **Measurement Rate:** 3 to $10^6$ samples/sec (1 Million Complete SOP Measurements per Second)
- **SOP Accuracy:** ±0.25° on Poincaré Sphere
- **DOP Accuracy:** ±0.25%
- **PDR:** ±0.005 dB
- **Insertion Loss:** <0.6 dB
- **PDL:** <0.05 dB
- **Dynamic Range:** 45 dBm (-30 dBm to 15 dBm)
- **Wavelength Range:** 1510-1640 nm
- **Analog Interface (Via Front Panel D-Sub):**
  - Outputs: S1, S2, S3, Power/(dBm), and DOP; (Complete Stokes Vector Plus DOP)
  - Input: Trigger
- **Digital Interface Outputs:** S1, S2, S3, Power/dBm, DOP, Azimuth, and Ellipticity
- **Warm-Up Time for Rated Accuracy:** 10 min (No Moving Parts, Designed for 24/7 Operation)
- **Operating Temperature Range:** 5-40 °C

**The In-Line Polarimeter is available as a benchtop version (IPM5300-T) with a preconfigured Laptop and TXP Mainframe included.**

# IPM5300-T Benchtop In-Line Polarimeter (Page 2 of 2)

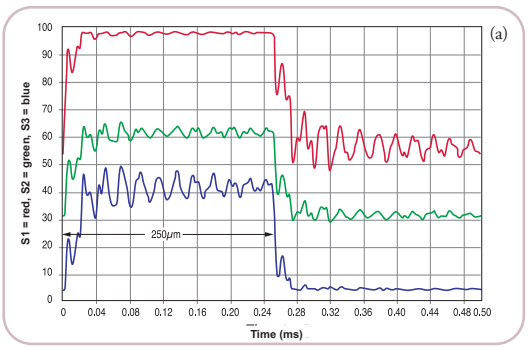



**Figure 1**
Test data was acquired using a standard piezoelectric polarization controller to change the input SOP being measured by the IPM5300 from one state to another. The ripple in the data is due to mechanical resonance in the piezo elements of the polarization controller.

a) Shows measured Stokes Vector Elements (S1, S2, and S3) versus time as the input SOP is changed from one state to another.

b) Shows the deviation in the SOP versus time as the polarization is changed from one state to another. This shows ~82° deviation on the Poincaré sphere.

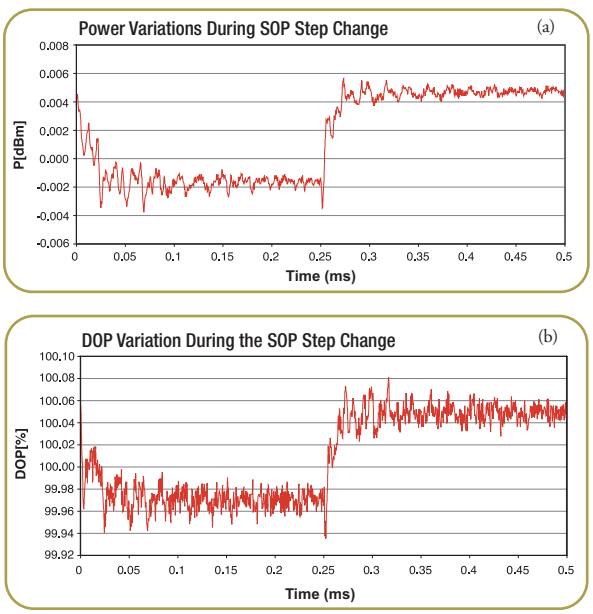



**Figure 2**
This data was taken at the same time as the data in Figure 1.
a) Shows measured optical power (dBm) versus time as the input SOP is changed from one state to another via a standard piezoelectric polarization controller.
b) Shows the DOP versus time as the polarization is changed from one state to another. This shows ~82° deviation on the Poincaré sphere.

An example of the measurement capability of the IPM5300 polarimeter is demonstrated in the data shown to the left. The experimental setup is depicted in Figure 3. A fiber-pigtailed laser was used as the input to the polarization controller. The signal from the controller was input to the IPM5300 and controlled via a local computer. The acquired data included the state of polarization (SOP), the change in the SOP, the power, and the degree of polarization (DOP). This data is shown in Figures 2 and 3.

The piezoelectric-based polarization controller was controlled with a square wave signal at 2 kHz to cause quick changes in the state of polarization into the polarimeter. The induced polarization change was 82° on the Poincaré sphere. Figure 1a shows the measured Stokes vector elements (S1, S2, and S3), while Figure 1b shows the angular deviation in the state of polarization on the Poincaré sphere.

Figure 2 shows the total measured power and the DOP versus time. One aspect of the data that is clearly evident in Figure 1 is the ripple. The polarimeter, with a data acqisition rate of $10^6$ samples per second, accurately measures the SOP as the controller changes polarization (Figure 1a). The ripple in the data has a period of 20 µs (50 kHz), which is easily resolved by the polarimeter. This ripple displays true variation in the SOP caused by variations in the mechanical stress on the fiber due to a 50 kHz mechanical resonance in the piezo controller.

Despite the resonance, the measured optical power and the DOP were constant as the polarization was changed. The deviations in the data are at the measurement uncertainties of the polarimeter, <0.02 dB and <0.1%, respectively.

This example shows the precision and accuracy of the IPM5300 series even on fast changing states of polarization.

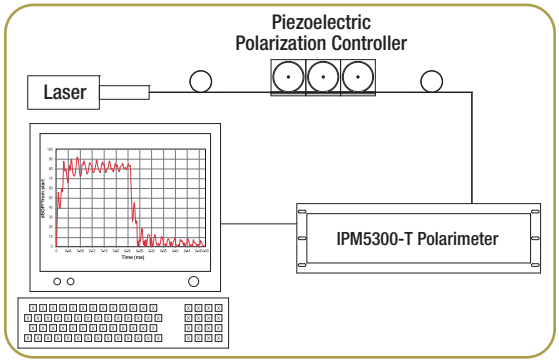



**Figure 3**
Experimental setup to measure polarimetric effects due to mechanical resonance in a piezoelectric-based polarization controller.

## High-Speed In-Line Polarimeter Module and Chassis

| ITEM# | $ | £ | € | RMB | DESCRIPTION |
|---|---|---|---|---|---|
| IPM5300-T | $ 10,457.00 | £ 7,250.00 | € 9.284,00 | ¥ 88,300.00 | Benchtop In-Line Polarimeter, Including Preconfigured PC |

# DPC5500-T Benchtop In-Line Deterministic Polarization Controller

### Introduction

The DPC5500, an in-line deterministic polarization controller for the TXP5000 systems, combines deterministic state of polarization control, high speed, low loss, and high accuracy in a unique all-fiber-based solution. It is a versatile polarization control solution that may be utilized in many applications, ranging from research and development to industrial applications. The polarization controller is available as a complete benchtop unit including a preconfigured laptop, the DPC5500 module and TXP mainframe (DPC5500-T Series).

**DPC5500-T**
Benchtop Polarization Controller
(Includes Pre-Configured Laptop and TXP5000)

The DPC5500 is based on our high-speed, low-loss IPM5300 polarimeter technology and a non-deterministic state of polarization (SOP) controller. A digital signal processor (DSP) produces a feedback signal from the polarimeter to drive the fiber squeezer-based state of polarization controller. The DPC5500 is ideal for applications that require precise deterministic control or locking of an SOP. Software modules for electronic SOP control, SOP tracing on the Poincaré sphere, and SOP scrambling are available for specific applications.

### How It Works

Central to the DPC5500 is a DSP, which enables high-speed control and locking of the SOP. The DSP monitors the polarization feedback signal from the polarimeter and drives the non-deterministic SOP controller, which is comprised of a multitude of piezoelectric-based fiber squeezers. A simple, yet robust, calibration algorithm accounts for the inherent nonlinearities in the piezoelectric elements and allows for accurate and stable deterministic SOP control. This facilitates SOP control at a user-defined location in the optical system such that the SOP can be varied to accurately and precisely follow a prescribed path on the Poincaré sphere (see Figure 1).

### Comparison to Existing Systems

The DPC5500 eliminates the inadequacies of most commercially available SOP controllers whose output SOP depends on the input SOP. Any input SOP change will implicitly lead to a corresponding output SOP rotation. In addition, most commercial high-speed SOP controllers are trial and error controllers and suffer from drift and hysteresis effects. They are non-deterministic and are dependent on environmental and prior conditions. This all-fiber technology provides deterministic control with very low insertion loss. The desired SOP may either be defined via its azimuth/ellipticity parameters or its corresponding Stokes values, which are graphically defined by a point on the Poincaré sphere or electronically defined by supplying a feedback signal from a control loop.

## Specifications

- **SOP Adjusting:** 150 µs (Typical)
- **Wavelength Range:**
  - 1510-1640 nm (Calibrated)
  - 1200-1700 nm (User-Calibrated)
- **SOP Accuracy:** ±0.25° on Poincaré Sphere
- **DOP Accuracy:** ±0.25%
- **Insertion Loss:**
  - <0.6 dB (Excuding Connectors),
  - 01.1 dB (Including Connectors)
- **PDL:** <0.05 dB
- **Dynamic Range:** 35 dB (-20 dBm to 15 dBm)
- **Operating Modes:** DPC, IPM Single-Mode, IPM Array Mode, Scrambler Mode (Optional)
- **Analog Interface:**
  - Outputs: S1, S2, S3, Power/dBm, DOP
  - Input: Trigger
- **Digital Interface Outputs:** S1, S2, S3, Power/dBm, DOP, Azimuth, and Ellipticity
- **Operating Temperature:** 5-40 °C

## Highlights

- Deterministic Polarization Control and Locking
- Generates Precise SOP Sequence for Jones and Mueller Matrix Characterization Methods
- Component for PDL/PMD Measurement
- External Trigger Allows Synchronized Measurement
- Monitoring the S Parameters by Analog Outputs
- High-Speed Feedback for Automatic Polarization Control

**The DPC5500-T includes a TXP5000 series mainframe and a pre-configured laptop. See page 994.**


**Figure 1**
The degree to which we can deterministically control the state of polarization within an optical system is shown

### SOP Scrambler

The system also includes an SOP Scrambler, which can be used to depolarize a source to minimize Polarization-Dependent Gain in fiber networks, to eliminate polarization dependencies of fiber optic sensors, or to perform PDL measurements.

The SOP Scrambler provides six modes of operation to adapt to the users application. These modes differ in the way the SOP values are generated and controlled (e.g., in a trace mode, the SOP values are randomly set along a predefined path, whereas in random distribution modes, the SOP values are randomly distributed over the Poincaré sphere without or with controlling a uniform distribution to a preset maximum distance). The options have different operation speeds depending on their involved complexity.

### Please Call or Visit Our Website for Delivery Information

| ITEM# | $ | £ | € | RMB | DESCRIPTION |
|---|---|---|---|---|---|
| DPC5500-T | $ 11,906.00 | £ 8,254.00 | € 10.571,00 | ¥ 100,535.00 | Benchtop In-Line Deterministic Polarimeter, Laptop Included |

# State of Polarization Locker


PL100S


PL100P

## Applications

- Deterministic Polarization Control and Locking
- Replacement for the Looped Fiber (Paddle) Controllers
- SOP Scrambler (PL100S)
- Coupling into PM Fiber (PL100P)

The PL100 Series State of Polarization (SOP) Lockers are stand-alone in-line deterministic polarization controllers. These benchtop devices offer accurate high-speed, low-loss control of the output polarization state, independent of the input SOP. The SOP locker can be used as a stand alone device or it can be controlled by a computer through a USB port. A USB cable and software drivers are included. Drivers for the LabVIEW™, LabWindows/CVI™, MSVC, and Borland C programming environments are included. Similar to the DPC5500 Deterministic Polarization Controller (page 1331), the PL100 Series SOP Locker controls the output polarization using a closed-loop system consisting of several piezo-electric fiber squeezers, a fast in-line polarimeter, and a digital signal processor (DSP). For low-power signals, there is a precision mode that increases the averaging time, which allows the system to maintain precise control over the output SOP. Also, a button on the front panel toggles the active control of the output polarization on/off. Note that when the active control of the output SOP is off, the output polarization will be dependent on the input polarization. The PL100 Series have a built-in calibration routine that can be initiated via a button on the front panel.

**PL100S**

The output polarization is set by using the up, down, right, and left buttons on the front panel. Pressing one of these buttons results in a 1° change in the output SOP along a longitudinal (up/down buttons) or latitudinal (right/left buttons) grid superimposed on the Poincaré Sphere. The SOP of the output light is stored in memory so that when the PL100S is turned off for some period of time and then turned back on the output SOP will not change. An additional operating mode on the PL100S produces a pseudo-depolarized output. In this mode, the polarization of the output light is rapidly changed such that all SOPs have an almost equal probability of occurring at any particular instant in time thus scrambling the polarization

**PL100P**

The PL100P is designed for use with a PM output fiber and, as a result, the SOP of the output light is linearly polarized when the PL100P is locked. A button on the front panel toggles the orientation of the linear polarized output light between the slow and fast axis of the PM fiber.

| ITEM# | PL100S | PL100P |
|---|---|---|
| Output Fiber | Single Mode | Polarization Maintaining |
| Wavelength Range | 1510-1640 nm | |
| SOP Accuracy | ±0.25° | |
| DOP Accuracy | ±0.25% | |
| Insertion Loss | <1.1 dB | |
| PDL | <0.05 dB | |
| Dynamic Range | 35 dB (-20 to 15 dBm) | |
| Accessible SOP's | Full Poincaré Sphere | |
| SOP Setting Time in Normal Mode | 150 µs for <10° Deviation<br>1 ms for <1° Deviation | |
| Regulation Period Normal Mode | 90 µs | |
| Regulation Period Precision Mode | 3 ms | |
| SOP Repeatability | <0.1° | |
| Input and Output Connectors | FC/APC | |
| Power Supply | 100-240 V ±10%, 50-60 Hz | |

| ITEM# | $ | £ | € | RMB | DESCRIPTION |
|---|---|---|---|---|---|
| PL100S | $ 9,984.00 | £ 6,922.00 | € 8.864,00 | ¥ 84,306.00 | SOP Locker for SM Fiber, FC/APC Connectors* |
| PL100P | $ 9,360.00 | £ 6,489.00 | € 8.310,00 | ¥ 79,037.00 | SOP Locker for PM Fiber, FC/APC Connectors* |

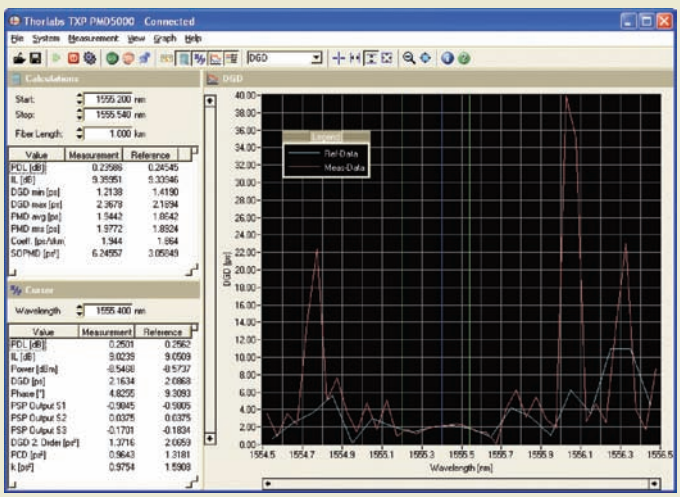
*Other connectors available upon request.

# PMD/PDL Measurement Systems (Page 1 of 4)

**PMD5000 SERIES**
Complete PMD/PDL Analyzation System, Laptop Included

**Introduction - PMD5000**

The PMD5000 Series is a high-performance polarization mode dispersion (PMD) testing system based on the Jones Matrix Eigen analysis. The modular design offers unique flexibility and adaptivity, making it ideal for all kinds of polarization-related measurements. It is especially useful for PMD analysis on broadband and narrowband components, optical fibers, and installed optical networks; these systems are capable of determining Polarization-Dependent Loss (PDL) and Polarization-Dependent Gain (PDG). Efficient PMD measurements of complex optical networks as well as PMD monitoring of dark channels are other applications that benefit from the ability to control a single transmitter unit and multiple receiver units at different locations via one remote computer.




A preconfigured laptop is included with the system. The software includes all features to analyze the PMD and PDL of fiber and optical components. It is intuitive and allows extensive analysis of the measured data set.

The transmitter module of the PMD5000 Series consists of a tunable laser source and a polarization controller. For the analyzer, different high-performance polarimeter modules are available, which allow the system to be optimized for a particular application. If the system is being used with a split transmitter analyzer configuration, the unit can be controlled remotely via TCP/IP, Ethernet, or WLAN. The system is based on the TXP architecture and offers full compatibility. See page 994 for an overview of the different configuration options. For more detailed information, please contact our tech support team.

**Modularity**

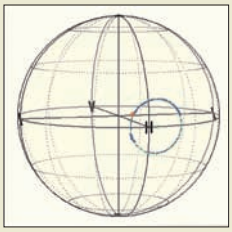
The PMD5000 measurement system includes the TXP5016 mainframe (see page 994) and is controlled by an external computer via Ethernet or TCP/IP. The TXP architechture allows a separation of the transmitter and receiver units into two mainframes. The mainframes and control PC can be connected to the local area network (LAN) and are not necessarily tied to a single location.

The transmitter unit consists of the ECL5000D Series Tunable Laser and the DPC5500 Series Deterministic Polarization Controller, which adjusts the necessary states of polarization. These modules are key components for the Jones Matrix Eigen analysis (JME). (Refer to the PMD application note on the following pages for more information).

For the analyzer unit, either the IPM5300 Series High Speed In-Line Polarimeter or the PAX5720 Series High Dynamic Range Polarimeter may be selected, depending on the application requirements.

The fast IPM5300 is especially suited for PMD measurements on fibers with rapid changes in environmental conditions, which can affect the PMD, and therefore, faster measurement speeds (PMD5000FIN) are required. The high dynamic power range of the PAX5720 Series is required for differential group delay (DGD) measurements of components with bandpass characteristics.

**For More Details on our Line of Polarimeter Tools, See Page 1323**



# PMD/PDL Measurement Systems (Page 2 of 4)

## Features

- Jones Matrix PMD Measurement Method
- Ideal for PMD and PDL on Optical Fiber
- Includes a DPC5500 Deterministic Polarization Controller and an IPM5300 Fast In-Line Polarimeter
- Integrated Tunable Laser Source ECL5000D (PMD5000FIN-1)
- DGD Meter with a 0.001-400 ps Range
- DGD Repeatability* of <0.01 ps
- 30 dB Maximum Insertion Loss of DUT**
- Typical Measurement Time for 1 (100) Data Point(s); 0.5 s (50 s)

** For PMD <0.3 ps* *** At Input Power ≥1 mW*

**General PMD Measurements**

The PMD5000FIN is recommended for general polarization mode dispersion (PMD) measurements. PMD and PDL analysis of fibers and broadband components can be performed with this model, including the PMD measurement of passive components (couplers, isolators) and active components (EDFAs and PDFAs).

**PMD Measurements on Narrow Bandwidth Components**

Narrow bandwidth components (e.g., optical filters, Bragg gratings, and OADM) are considerably more challenging to characterize. In narrowband component manufacturing, it is important to assess the PDL in the "wings" of the pass band (typically around 20 dB) to determine if the component meets the isolation requirement for adjacent channels. The PMD5000 System with a PAX5720IR3 polarimeter as a reciever, which some non-standard systems include, facilitates this assessment and thereby increases production yield.

**System Configurations - See Page 1323**

**Thorlabs is recognized throughout the photonics community for providing novel polarization measurement and control solutions. As can be seen from our selection of related products, our team of polarization experts has tackled many measurement and control problems in this specialized field. The selection guide shown on page 1323 describes the various systems offered for a broad array of PMD and PDL measurements.**

## System Capabilities

**PMD Measurement**

- PMD Measurements Based on the Jones Matrix Eigenanalysis
- PMD Monitoring of Dark Channels of an Optical Network
- PMD Measurement in Accordance with ITU-T G.650
- DGD Meter with a Range of 0.001 ps to 400 ps
- High Resolution PMD Measurement of Narrowband Components
- Mean and RMS Values of PMD, Plus 2nd Order PMD
- Long-Term PMD Measurement
- Measures the Principal States of Polarization as a Function of Wavelength
- Optional use of 3rd Party Tunable Lasers
- Integrated Tunable Laser Source

**PDL Measurement**

- PDL Measurements Based on Jones Matrix Eigenanalysis
- PDL Measurement in the Range of 0 to 50 dB with <0.02 dB Reproducibility
- Measurement of the Wavelength and Time Dependency of the PMD and PDL Changes

**Polarization Analysis**

- Dynamic Polarization Measurements in Real Time
- Fiber or Free-Space Input (Depending on Polarimeter Module)
- Long-Term Observation of Polarization Effects
- Polarimeter Measurements with Azimuth and Ellipticity Angle Accuracy <0.25°
- Large Dynamic Range: -60 dBm to 10 dBm (PAX5720IR3)
- Fast Measurement Speed of 1 Msample/s (IPM5300)
- Range: PAX5720IR3: 1300-1700 nm
  IPM5300: 1510-1640 nm

**Polarization Control**

- Deterministic Polarization Control and Locking
- Accurate and Precise SOP Tracing
- SOP Scrambling
- Wavelength Range of 1510-1640 nm
- Dynamic Range of 35 dB (-20 to 15 dBm)
- Fast SOP Adjustments are <150 µs (Typical)

**ER Measurement on PMF (only with PAX5710IR3)**

- Extinction Ratio Measurement of PM Fiber
- Measurement Range of 0 to 50 dB

# PMD/PDL Measurement Systems (Page 3 of 4)

## Application Note: PMD Measurement

### Polarization Mode Dispersion

Polarization Mode Dispersion (PMD) originates from the polarization dependency of an optical signal's propagation speed, which results in a delay in the arrival time of a bit stream for orthogonally launched polarization states and may lead to bit errors. For a given wavelength, the maximum delay between all pairs of orthogonal polarization states at a given time is called the differential group delay, DGD (see Figure 1). DGD is measured in picoseconds (ps). The polarization states associated with the fastest and slowest speeds are called principal states of polarization (PSP). In general, the PSPs are not associated with the fast and slow axes (the Eigen-Polarizations) of a birefringent component.

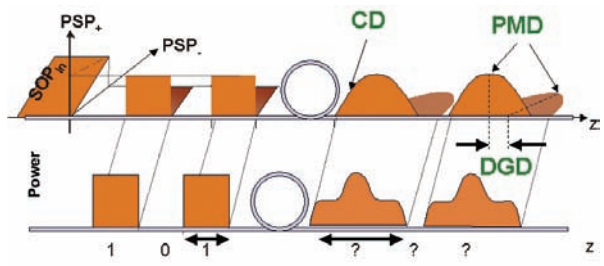



**Figure 1 - Differential Group Delay**

DGD is the primary measurement parameter for all PMD meters. The measurement of the DGD involves the determination of a phase change (arrival time difference) for a given frequency (wavelength) change. For a Jones Matrix Eigenanalysis, the polarimetric transfer function (the Jones Matrix) must be determined at two different wavelengths. The changes in the phases of the two Jones matrices divided by the wavelength difference (step size) yields the DGD value.

The PMD5000 is ideally suited for characterizing DGD and PMD in devices with random mode coupling, such as optical fibers, by using the Jones Matrix Eigenanalysis (JME) method. The JME method is the only technique providing wavelength-dependent information about the DGD and the PSP. It is also the only method that shows agreement between the measured DGD histogram and the theoretical Maxwell distribution.

### Jones Matrix Eigenanalysis

The Jones Matrix Eigenanalysis (JME) provides the most comprehensive information about fiber links and active components. Besides the DGD over wavelength and the PMD value, the JME also returns the second order PMD as well as PDL and measures insertion loss verses wavelength. In general, monochromatic light with different input polarizations is fed into the optical device, and the polarizations' responses are measured. A convenient way to measure the Jones Matrix was presented by B.L. Heffner. Linearly polarized light enters the optical element parallel to the X-axis, parallel to the Y-axis, and parallel to the bisector of the angle between the positive X- and Y-axes. The three linear input states and the three corresponding polarization output states are used to calculate the 2 x 2 complex Jones matrix. In a pure mathematical sense, only two pairs of input and output states are needed to calculate a 2 x 2 matrix; however, since optical elements feature Eigen polarization states for which the input polarization is not transformed (i.e., the output polarization is equal to the input polarization), a third unique input polarization is needed.

### PMD in Optical Fiber

**Large Number of Elementary Cells and Variable Orientation Between $PSP_1$ Polarizaion Direction of $PSP_1$ of Each Cell and DUT**

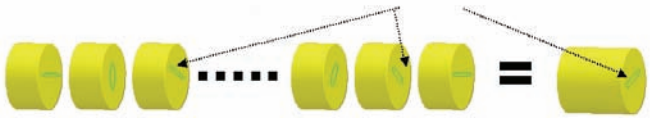


**Figure 2 - Model of a Long Fiber**

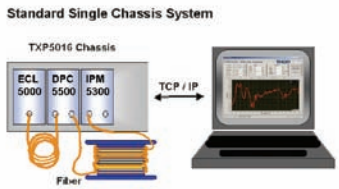
Fibers may be modeled as a collection of many infinitesimally small fiber sections, each of which have a different birefringence and Eigen-polarization axes (see Figure 2). Thermal and mechanical stresses will change the polarization properties of these sections. The large number of sections, the randomness in the transformation properties, and environmental sensitivities require a statistical analysis to account for the DGD behavior fully. In a long length of fiber, the DGD (either as a function of time at fixed wavelength or as a function of wavelength at a fixed time) has a Maxwell distribution. The average of the DGD distribution is defined by the ITU standard bodies as the PMD value. Therefore, PMD is independent of the time and wavelength range.

### PMD in Fiber Components

Fiber optic components differ from long lengths of fiber in their thermal and mechanical sensitivity of DGD and PMD. The fixed optical elements integrated in the components are significantly less sensitive to environmental conditions. Fiber optic components have DGD values that are nearly fixed with respect to wavelength. A DGD measurement instrument would therefore produce a normal (Gaussian) distribution. Depending on the test instrument, the width of the distribution is determined by the instrument's performance and not the intrinsic randomness of the polarization modes throughout the component. As in the fiber PMD, the average value of the distribution is the PMD value that quantifies the amount of delay generated by the component. For some fiber optic components, DGD/PMD cannot be measured using the same procedure as those used for systems with random mode coupling. For example, DEMUX filters, with their narrow pass bands, do not allow relatively large frequency steps for high accuracy DGD measurements. Therefore, these filter components require special measurement attention. The PMD5000 Series Polarization Measurement System is designed for analyzing narrow bandwidth components and fiber networks (e.g., single components like Fiber Bragg Gratings (FBG) as well as single channels of a complex optical network with multiplexers and active components like EDFAs).

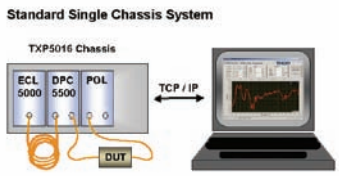
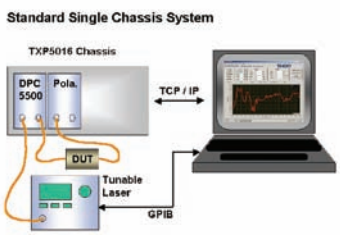
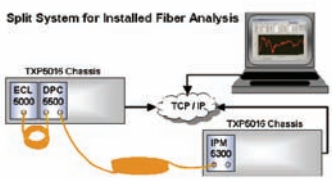
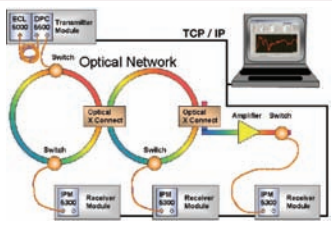
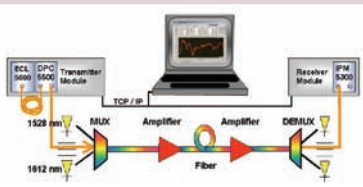
# PMD/PDL Measurement Systems (Page 4 of 4)

## Standard System

| Application | Hardware Requirements | |
|---|---|---|
| **PMD and PDL Measurements of Fibers** | **Preconfigured System:** PMD5000FIN-1<br>**Mainframe:** TXP5016<br>**Laser Source:** ECL5000D<br>**SOP Controller:** DPC5500<br>**Polarimeter:** IPM5300<br>(Fully Configured Laptop Included) |  |

| ITEM# | $ | £ | € | RMB | DESCRIPTION |
|---|---|---|---|---|---|
| PMD5000FIN-1 | $ 59,640.00 | £ 41,344.00 | € 52.949,00 | ¥ 503,602.00 | PMD/PDL Analyzer with Internal Tunable Laser and IPM5300 Polarimeter |

## Non-Standard Systems

| Application | Hardware Requirements | |
|---|---|---|
| PMD and PDL Measurements of Narrow Bandwidth Devices | **Non-Standard System:** PMD5000HDR-1<br>**Mainframe:** TXP5016<br>**Laser Source:** ECL5000D<br>**SOP Controller:** DPC5500<br>**Polarimeter:** PAX5720IR3<br>(Fully Configured Laptop Included) |  |
| PMD and PDL Measurements with External Laser Sources*<br><br>*Optional use of third party tunable lasers. | **Non-Standard System:**<br>• PMD5000FIN-2 (Fiber Measurements)<br>• PMD5000HDR-2 (Component Measurements)<br>**Mainframe:** TXP5016<br>**SOP Controller:** DPC5500<br>**Polarimeter:**<br>• IPM5300 (PMD5000FIN-2)<br>• PAX5720IR3 (PMD5000HDR-2)<br>(Fully Configured Laptop Included) |  |
| PMD and PDL Measurements on Installed Fibers with Split Transmitter and Receiver | **Non-Standard System:**<br>**Mainframes:** TXP5016<br>**Laser Source:** ECL5000D<br>**SOP Controller:** DPC5500<br>**Polarimeter:** IPM5300<br>(Fully Configured Laptop Included) |  |
| PMD and PDL Measurements on Optical Networks with a Single Transmitter and Several Receivers | **Non-Standard System:**<br>**Mainframes:** TXP5016<br>**Laser Source:** ECL5000D<br>**SOP Controller:** DPC5500<br>**Polarimeter:** IPM5300<br>(Fully Configured Laptop Included) |  |
| PMD and PDL Monitoring on a Live Fiber with Traffic | **Non-Standard System:**<br>**Mainframes:** TXP5016<br>**Laser Source:** ECL5000D<br>**SOP Controller:** DPC5500<br>**Polarimeter:** IPM5300<br>(Fully Configured Laptop Included) |  |

Please contact *Europe@thorlabs.com* for ordering non-standard systems mentioned above.

# Electronics Accessories Selection Guide

Pages 1337-1351


### Electrical Tools

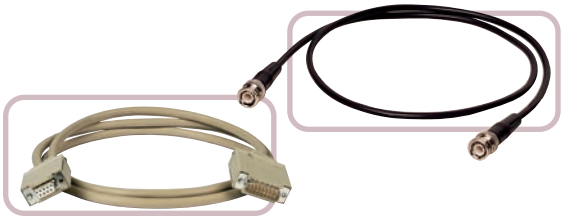
- 10-Function Multimeter
- Laser Diode Can Opener
- Laser Diode and LED Sockets

**See Pages 1338-1339**


### Adapters

- BNC Terminators (50 Ω to 50 kΩ)
- Banana, SMA, SMC, and BNC Adapters
- Adapter Kits

**See Pages 1340-1341**



### Cables

- General Purpose Cables Including BNC, SMA, and Banana
- Specialized Piezo and Motor Cables
- Cables for Laser Diode and TEC Controllers

**See Pages 1342-1345**


### Cable Management

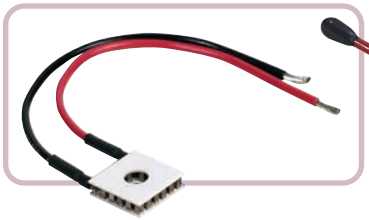
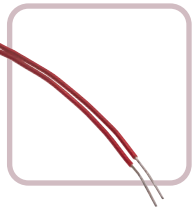
- Cable Identification
- Breadboard Cable Straps
- Cable Wraps

**See Pages 1346-1347**


### ESD Protection

- 2' x 4' ESD Table Mat
- ESD Wrist Straps

**See Page 1348**

### Thermal Components

- TEC Elements
- Resistive Heaters
- Thermistors

**See Page 1349**

### Conductive Coatings

- Aquadag E
- Electrodag 5810

**See Pages 1350-1351**

# 4-Channel Digital Lab Timer

CDLT4

NEW product

- Up to 100 Hour Countdown per Channel
- Large LCD Display
- Includes Clock, Stopwatch, and Time-Out

The CDLT4 timer features four independent channels, each capable of counting down from up to 99 hrs, 59 minutes, and 59 seconds. Once the timer reaches zero, an alarm will beep for 1 minute, and the timer will automatically begin counting up to measure the time elapsed since the countdown finished.

The unit can be mounted using the magnetic strip on the back, attached using the clip, placed on a desktop using the drop-down kickstand, or attached to a lanyard via a hole in the clip.

Each timer comes with a certificate from an ISO 17025 calibration laboratory accredited by A2LA, indicating that the instrument is NIST-traceable. The timer is powered by a GPA76 battery (included).

| ITEM# | $ | £ | € | RMB | DESCRIPTION |
|---|---|---|---|---|---|
| CDLT4 | $ 28.00 | £ 19.50 | € 24,90 | ¥ 236.50 | 4-Channel Timer |

# Lab Lights

The PSX501 consists of a white light source on a flexible arm that allows the light to be directed at the area of interest. For mounting, the unit can be attached to the work surface via the clip fastener or the magnetic base. This light is powered by three AAA batteries (included).

PSX501

| ITEM# | $ | £ | € | RMB | DESCRIPTION |
|---|---|---|---|---|---|
| PSX501 | $ 31.80 | £ 22.10 | € 28,30 | ¥ 268.60 | Mini Light w/ Flexible Arm |

# 10-Function Digital Multimeter

DVM1

**Features:**

- 0.5% Accuracy
- Data Hold and Relative Modes
- 10 A Max Current
- Dual Sensitivity Frequency Functions
- Large LCD with Backlight
- Auto Power Off


Thorlabs now offers the Extech 503 digital multimeter with 1000 V input protection on all functions. This 10-function multimeter includes two probes, a carrying case, 9 V battery, and a magnetic hanging strap. It also features a double molded housing for waterproof protection.

NEW product

**Measurements:**

- DC Voltage
- DC Current
- AC Voltage (Frequency, Duty Cycle)
- AC Current (Frequency, Duty Cycle)
- Resistance
- Continuity Check
- Capacitance
- Frequency/Duty Cycle

| SPECIFICATIONS | |
|---|---|
| Display Counts | 4,000 |
| Basic Accuracy | 0.5% |
| DC/AC Voltage | 0.1 mV to 1000 V |
| DC/AC Current | 0.1 µA to 10 A |
| Resistance | 0.1 Ω to 40 MΩ |
| Capacitance | 0.1 nF to 100 µF |
| Frequency (Electrical) | 5 Hz to 1 kHz |
| Frequency (Electronic) | 0.001 Hz to 10 MHz |
| Duty Cycle | 0.1 to 99.9% |
| Diode/Continuity | Yes |
| Dimensions | 7.25" x 3.25" x 2.25" |
| Weight | 12.3 oz (349 g) |

| ITEM# | $ | £ | € | RMB | DESCRIPTION |
|---|---|---|---|---|---|
| DVM1 | $ 89.00 | £ 61.70 | € 79,10 | ¥ 751.60 | 10-Function Digital MultiMeter |

## See Our Line of PDA-Series Photodetectors

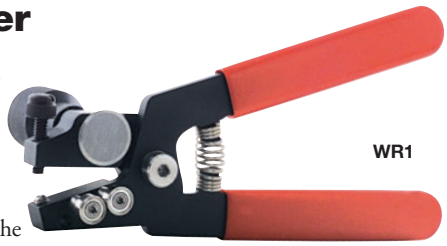

PDA10CF

- Wavelength Ranges from 150 nm to 4.8 µm
- Bandwidth up to 150 MHz
- 0 - 10 V Output
- Detector Types GaP, Si, Ge, InGaAs, PbS, and PbSe

See Pages 1288-1289

# Laser Diode Can Opener

The WR1 is a simple handheld device designed to remove the caps from standard laser packages. Many applications, such as fiber pigtailing, can be optimized by having closer access to the laser chip.




Operation is as simple as placing a diode onto the two rollers at the front of the device, lightly applying pressure with the rubber covered grips, and turning the blade actuator (as shown to the right). The precision-ground, hardened steel blade will easily cut through the wall of the diode cap, safely removing it.

- Ideal for Ø5.6 mm to Ø9 mm Packages
- Compatible with TO-3, TO-18, and TO-46 Packages Among Others

Simple manual can opener removes the cap from most transistor-style laser diode packages.

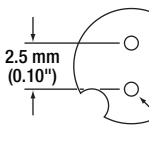
| ITEM# | $ | £ | € | RMB | DESCRIPTION |
|---|---|---|---|---|---|
| WR1 | $ 131.60 | £ 91.30 | € 116,90 | ¥ 1,111.30 | Laser Diode Can Opener |

# Sockets for Ø5.6 mm and Ø9 mm Diodes

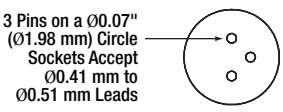
- 2, 3, and 4 Pin Sockets Offered
- For Ø5.6 mm (TO-18) or Ø9 mm (TO-5) Packages
- Gold-Plated BeCu Contacts
- RoHS Compliant

A range of sockets are offered for use with Ø5.6 mm or Ø9 mm laser diode packages. The S8058, S8060, S8060-4, and 8060-2 feature gold-plated BeCu contacts. Please note that the color of each socket may vary.

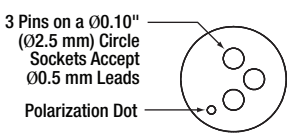
| ITEM# | $ | £ | € | RMB | # OF PINS | PACKAGE SIZE |
|---|---|---|---|---|---|---|
| 8060-2 | $ 7.00 | £ 4.85 | € 6,30 | ¥ 59.20 | 2 | Ø5.6 mm |
| S7060R | $ 4.30 | £ 3.00 | € 3,90 | ¥ 36.40 | 3 | Ø5.6 mm |
| S8060-4 | $ 7.30 | £ 5.05 | € 6,50 | ¥ 61.70 | 4 | Ø5.6 mm |
| S8060 | $ 6.00 | £ 4.15 | € 5,40 | ¥ 50.70 | 3 | Ø9 mm |
| S8058 | $ 9.00 | £ 6.25 | € 8,00 | ¥ 76.00 | 3 | Ø9 mm |

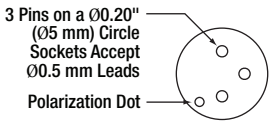



8060-2



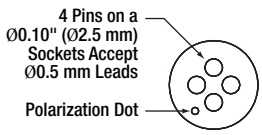

S7060R




**S8060**
Use with FGA04 and FGA20

**S8058**
Use with FDS100, FDS010, and FGA10




S8060-4

Please refer to our website for complete models and drawings.

## Laser Diodes

- Ø5.6 mm and Ø9 mm Packages
- Wavelengths from 405 nm to 1550 nm
- Output Powers up to 1 W
- Variety of Standard Pin Configurations

See Page 1032

## Benchtop Current Controller

- Drive Currents from 20 mA to 4 A Available
- Compatible with All Laser Diode Polarities
- Constant Current and Constant Power Modes

See Page 1178

# BNC Adapters

**T3283**
BNC (F/F)

**T3285**
BNC "T" (F/M/F)

**T3533**
BNC (M/M)

**T3534**
BNC Elbow (F/M)

**T3788**
BNC to Test Clips

**BNCB1**

**BNCB2**
BNC Brackets for Optical Tables

**T4119**
Feed-Through Terminator
50 Ω

**VT1**
Step Variable Terminator
50 Ω to 50 kΩ

Steps:
50 Ω, 100 Ω,
500 Ω, 1 kΩ, 5 kΩ,
10 kΩ, 50 kΩ

| ITEM# | $ | £ | € | RMB | DESCRIPTION |
|---|---|---|---|---|---|
| T3283 | $ 6.80 | £ 4.70 | € 6,10 | ¥ 57.50 | F/F Straight Adapter |
| T3285 | $ 9.50 | £ 6.60 | € 8,50 | ¥ 80.30 | F/M/F Tee Adapter |
| T3533 | $ 12.70 | £ 8.80 | € 11,30 | ¥ 107.30 | M/M Straight Adapter |
| T3534 | $ 15.20 | £ 10.55 | € 13,50 | ¥ 128.40 | F/M Elbow Adapter |
| T4119 | $ 35.70 | £ 24.80 | € 31,70 | ¥ 301.50 | 50 Ω Feed-Through Terminator |
| T3788 | $ 11.90 | £ 8.25 | € 10,60 | ¥ 100.50 | BNC to Test Clips |
| VT1 | $ 131.10 | £ 90.90 | € 116,40 | ¥ 1,107.10 | Variable Terminator |
| BNCB1 | $ 15.00 | £ 10.40 | € 13,40 | ¥ 126.70 | BNC Bracket, Terminating |
| BNCB2 | $ 16.70 | £ 11.60 | € 14,90 | ¥ 141.10 | BNC Bracket Pass-Through |

# Banana, SMA, SMC, BNC Adapters, and SMA DC Blocking Filter

**T4282**
SMA Elbow (M/F)

**T4283**
SMA (M/M)

**T4285**
SMA (F/F)

**T4286**
SMA (M/F)

**T4288**
SMA (M) to BNC (M)

**T4291**
SMA (F) to BNC (F)

**T4289**
SMA (F) to BNC (M)

**T4290**
SMA (M) to BNC (F)

**T8535**
SMA (M/F) DC Blocking Filter
(7 kHz to 23 GHz)*

**MDC40211**
BNC (M) to SMC (M)

**T4292**
BNC (F) to SMC (F)

**T1269**
BNC (F) / Banana plug

**T1270**
BNC (M) / Banana plug

**T1452**
BNC (F) / Binding post

| ITEM# | $ | £ | € | RMB | DESCRIPTION |
|---|---|---|---|---|---|
| T4282 | $ 15.20 | £ 10.55 | € 13,50 | ¥128.40 | SMA Elbow (M/F) |
| T4283 | $ 17.90 | £ 12.50 | € 15,90 | ¥151.20 | SMA Straight (M/M) |
| T4285 | $ 23.20 | £ 16.10 | € 20,60 | ¥196.00 | SMA Straight (F/F) |
| T4286 | $ 12.30 | £ 8.55 | € 11,00 | ¥103.90 | SMA Straight (M/F) |
| T4288 | $ 14.20 | £ 9.85 | € 12,70 | ¥120.00 | SMA (M) to BNC (M) |
| T4291 | $ 11.60 | £ 8.05 | € 10,30 | ¥ 98.00 | SMA (F) to BNC (F) |
| T4289 | $ 12.70 | £ 8.80 | € 11,30 | ¥107.30 | SMA (F) to BNC (M) |
| T4290 | $ 12.70 | £ 8.80 | € 11,30 | ¥107.30 | SMA (M) to BNC (F) |
| T8535 | $ 96.90 | £ 67.20 | € 86,10 | ¥818.30 | DC Blocking Filter |
| MDC40211 | $ 29.10 | £ 20.20 | € 25,90 | ¥245.80 | BNC (M) to SMC (M) |
| T4292 | $ 55.70 | £ 38.70 | € 49,50 | ¥470.40 | BNC (F) to SMC (F) |
| T1269 | $ 8.20 | £ 5.70 | € 7,30 | ¥ 69.30 | BNC (F) to Banana Plug |
| T1270 | $ 15.10 | £ 10.45 | € 13,50 | ¥127.60 | BNC (M) to Banana Plug |
| T1452 | $ 15.10 | £ 10.45 | € 13,50 | ¥127.60 | BNC (F) to Binding Post |
| T5026 | $ 12.30 | £ 8.55 | € 11,00 | ¥103.90 | SMC (M/M) |
| T5025 | $ 12.30 | £ 8.55 | € 11,00 | ¥103.90 | SMC (F/F) |

**T5026**
SMC (M/M)

**T5025**
SMC (F/F)

*DC Blocking Filter IL: <0.5 dB (100 kHz to 12.4 GHz), 0.75 dB (12.4-23 GHz)

# ESK09 BNC/SMA Adapters: 76-Piece Set

The ESK09 Kit contains 76 of our most popular BNC and SMA adapters, all of which are conveniently housed in a cabinet. Every drawer is clearly labeled with product icons in order to locate desired parts quickly. The contents of the kit are shown below.

- Contains 76 Adapters
- Heavy-Duty, Welded Steel Frame Cabinet
- Fully Stocked and Labeled Drawers
- Cabinets can be Wall Mounted or Stacked

16-Drawer Cabinet: 11" x 17" x 11" (279 mm x 432 mm x 279 mm)
Drawer Size: 4" x 2.1" x 10.6" (102 mm x 53 mm x 269 mm)

**SAVE 10%**
**Off the Price of the Individual Components**

## ESK09 KIT — Master Electrical Connector Kit

| PART# | T4290 | T4291 | T4289 | T4288 | T4282 | T4283 | T4285 |
|---|---|---|---|---|---|---|---|
| QTY | 2 | 2 | 2 | 2 | 2 | 2 | 2 |

SMA (M) to BNC (F) | SMA (F) to BNC (F) | SMA (F) to BNC (M) | SMA (M) to BNC (M) | SMA Elbow (M/F) | SMA (M/M) | SMA (F/F)

## ESK09 KIT

| PART# | T3533 | T3534 | T3285 | T4119 | T3283 | T1269 | T1270 | T1452 | T3788 |
|---|---|---|---|---|---|---|---|---|---|
| QTY | 10 | 10 | 10 | 2 | 10 | 5 | 5 | 5 | 5 |

BNC (M/M) | BNC Elbow (M/F) | BNC Tee (F/M/F) | 50 Ω BNC (M/F) | BNC (F/F) | BNC (F) to Banana Plug | BNC (M) to Banana Plug | BNC (F) to Binding Post | BNC (F) to Test Clips

| ITEM# | $ | £ | € | RMB | DESCRIPTION |
|---|---|---|---|---|---|
| ESK09 | $ 981.10 | £ 680.20 | € 871,10 | ¥ 8,284.50 | BNC and SMA Adapters Essentials Kit |

# ESK11 BNC Adapters: 62 Piece Set

The ESK11 Kit contains 62 of our most popular BNC adapters, all conveniently housed in a completely labeled cabinet. Every drawer is clearly labeled with product icons in order to locate desired parts quickly. The contents of the kit are shown below.

- Contains 62 BNC Adapters
- Heavy-Duty, Welded Steel Frame Cabinet
- Fully Stocked and Labeled Drawers
- Cabinets can be Wall Mounted or Stacked

**SAVE 10%**
**Off the Price of the Individual Components**

9-Drawer Cabinet: 11" x 17" x 11" (279 mm x 432 mm x 279 mm)
Drawer Size: 5.2" x 3.1" x 10.6" (132 mm x 79 mm x 269 mm)

## ESK11 KIT — Starter Electrical Connector Kit

| PART# | T3533 | T3534 | T3285 | T4119 | T3283 | T1269 | T1270 | T1452 | T3788 |
|---|---|---|---|---|---|---|---|---|---|
| QTY | 10 | 10 | 10 | 2 | 10 | 5 | 5 | 5 | 5 |

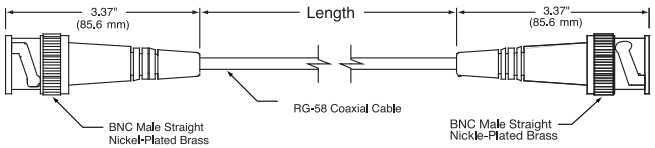
BNC (M/M) | BNC Elbow (M/F) | BNC Tee (F/M/F) | 50 Ω BNC (M/F) | BNC (F/F) | BNC (F) to Banana Plug | BNC (M) to Banana Plug | BNC (F) to Binding Post | BNC (F) to Test Clips

| ITEM# | $ | £ | € | RMB | DESCRIPTION |
|---|---|---|---|---|---|
| ESK11 | $ 787.60 | £ 546.00 | € 699,30 | ¥ 6,650.60 | BNC Adapters Essentials Kit |

# BNC Male Straight to BNC Male Straight Cable

## Features

- Tarnish-Resistant Brass Body
- Stress-Relieved
- Weather-Proof Cable Assemblies
- 50 Ω Impedance
- Frequency Range: DC - 4.0 GHz
- Working Voltage: 500 V (RMS)

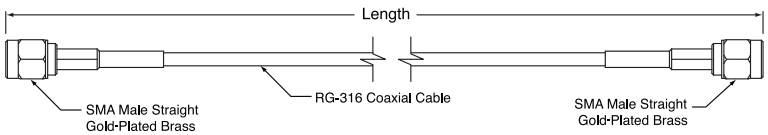



| ITEM# | $ | £ | € | RMB | LENGTH |
|---|---|---|---|---|---|
| 2249-C-12 | $ 13.60 | £ 9.45 | € 12,10 | ¥ 114.90 | 12" (0.3 m) |
| 2249-C-24 | $ 14.90 | £ 10.35 | € 13,30 | ¥ 125.90 | 24" (0.6 ) |
| 2249-C-36 | $ 17.30 | £ 12.00 | € 15,40 | ¥ 146.10 | 36" (0.9 m) |
| 2249-C-48 | $ 12.80 | £ 8.85 | € 11,40 | ¥ 108.10 | 48" (1.2 m) |
| 2249-C-60 | $ 16.00 | £ 11.10 | € 14,30 | ¥ 135.20 | 60" (1.5 m) |
| 2249-C-120 | $ 20.80 | £ 14.50 | € 18,50 | ¥ 175.70 | 120" (3.0 m) |


# SMA Male Straight to SMA Male Straight Cable

## Features

- 50 Ω Impedance
- Frequency Range: DC - 12.4 GHz
- Dielectric Withstanding Voltage: 750 V (RMS)
- Working Voltage: 250 V (RMS)

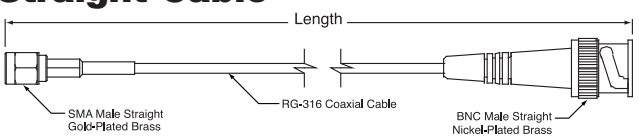



| ITEM# | $ | £ | € | RMB | LENGTH |
|---|---|---|---|---|---|
| CA2906 | $ 13.00 | £ 9.00 | € 11,60 | ¥ 109.80 | 6" (0.15 m) |
| CA2912 | $ 13.70 | £ 9.50 | € 12,20 | ¥ 115.70 | 12" (0.3 m) |
| CA2918 | $ 14.00 | £ 9.70 | € 12,50 | ¥ 118.30 | 18" (0.5 m) |
| CA2924 | $ 14.30 | £ 9.90 | € 12,70 | ¥ 120.80 | 24" (0.6 m) |
| CA2936 | $ 15.50 | £ 10.75 | € 13,80 | ¥ 130.90 | 36" (0.9 m) |
| CA2948 | $ 16.60 | £ 11.60 | € 14,80 | ¥ 140.20 | 48" (1.2 m) |


# SMA Male Straight to BNC Male Straight Cable

## Features

- 50 Ω Impedance
- Frequency Range: DC - 4.0 GHz
- Dielectric Withstanding Voltage: 750 V (RMS)
- Working Voltage: 250 V (RMS)

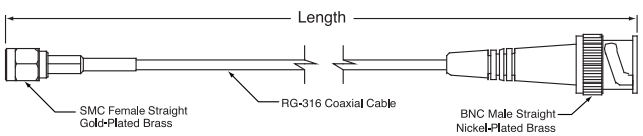



| ITEM# | $ | £ | € | RMB | LENGTH |
|---|---|---|---|---|---|
| CA2806 | $ 12.20 | £ 8.45 | € 10,90 | ¥ 103.10 | 6" (0.15 m) |
| CA2812 | $ 12.60 | £ 8.75 | € 11,20 | ¥ 106.40 | 12" (0.3 m) |
| CA2818 | $ 13.00 | £ 9.00 | € 11,60 | ¥ 109.80 | 18" (0.5 m) |
| CA2824 | $ 13.30 | £ 9.20 | € 11,90 | ¥ 112.40 | 24" (0.6 m) |
| CA2836 | $ 14.30 | £ 9.90 | € 12,70 | ¥ 120.80 | 36" (0.9 m) |
| CA2848 | $ 15.50 | £ 10.75 | € 13,80 | ¥ 130.90 | 48" (1.2 m) |


# SMC Female Straight to BNC Male Straight Cable

## Features

- 50 Ω Impedance
- Frequency Range: DC - 4.0 GHz
- Dielectric Withstanding Voltage: 750 V (RMS)
- Working Voltage: 250 V (RMS)



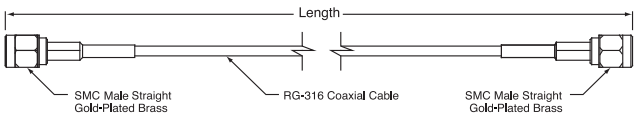

| ITEM# | $ | £ | € | RMB | LENGTH |
|---|---|---|---|---|---|
| CA2606 | $ 39.90 | £ 27.70 | € 35,50 | ¥ 337.00 | 6" (0.1 m) |
| CA2612 | $ 40.20 | £ 27.90 | € 35,70 | ¥ 339.50 | 12" (0.3 m) |
| CA2618 | $ 40.50 | £ 28.10 | € 36,00 | ¥ 342.00 | 18" (0.5 m) |
| CA2624 | $ 40.70 | £ 28.30 | € 36,20 | ¥ 343.70 | 24" (0.6 m) |
| CA2636 | $ 41.30 | £ 28.70 | € 36,70 | ¥ 348.80 | 36" (0.9 m) |
| CA2648 | $ 41.80 | £ 29.00 | € 37,20 | ¥ 353.00 | 48" (1.2 m) |
| CA2660 | $ 42.40 | £ 29.40 | € 37,70 | ¥ 358.10 | 60" (1.5 m) |
| CA2672 | $ 42.90 | £ 29.80 | € 38,10 | ¥ 362.30 | 72" (1.8 m) |


Please refer to our website for complete models and drawings.

# SMC Male Straight to SMC Male Straight Cable

## Features

- 50 Ω Impedance
- DC - 12.4 GHz Frequency Range
- 750 V (RMS) Dielectric Withstanding Voltage
- 250 V (RMS) Working Voltage



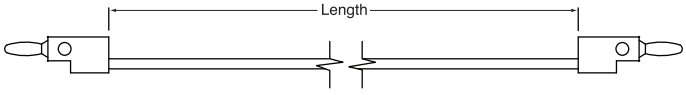

CA2736

| ITEM# | $ | £ | € | RMB | LENGTH |
|---|---|---|---|---|---|
| CA2736 | $ 43.60 | £ 30.30 | € 38,80 | ¥ 368.20 | 36" (0.9 m) |
| CA2760 | $ 46.10 | £ 32.00 | € 41,00 | ¥ 389.30 | 60" (1.5 m) |

# Banana Patch Cords

## Features

- Stackable
- Available in Black or Red




### Banana Patch Cords Red

| ITEM# | $ | £ | € | RMB | LENGTH |
|---|---|---|---|---|---|
| T13122 | $ 6.60 | £ 4.60 | € 5,90 | ¥ 55.80 | 12" (0.3 m) |
| T13242 | $ 7.00 | £ 4.85 | € 6,30 | ¥ 59.20 | 24" (0.6 m) |

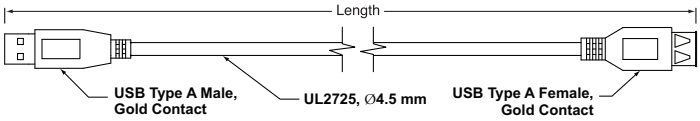
### Banana Patch Cords Black

| ITEM# | $ | £ | € | RMB | LENGTH |
|---|---|---|---|---|---|
| T13120 | $ 6.60 | £ 4.60 | € 5,90 | ¥ 55.80 | 12" (0.3 m) |
| T13240 | $ 7.00 | £ 4.85 | € 6,30 | ¥ 59.20 | 24" (0.6 m) |

# USB 2.0A Male to USB 2.0A Female Cable

## Features

- USB 2.0
- Hi-Speed 480 Mbps Transmission
- 28 Gauge Conductor



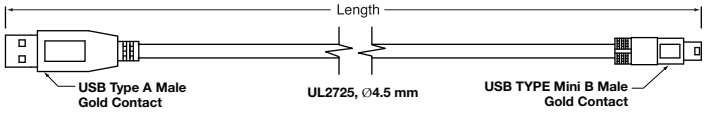

| ITEM# | $ | £ | € | RMB | LENGTH |
|---|---|---|---|---|---|
| USB-C-36 | $ 6.00 | £ 4.15 | € 5,40 | ¥ 50.70 | 36" (0.9 m) |
| USB-C-72 | $ 6.90 | £ 4.80 | € 6,20 | ¥ 58.30 | 72" (1.8 m) |
| USB-C-180 | $ 8.50 | £ 5.90 | € 7,60 | ¥ 71.80 | 180" (4.6 m) |

Mechanical Drawings Available on the WEB

# USB 2.0A Male to USB 2.0 Mini-B Male Cable

## Features

- USB 2.0
- Compatible with T-Cube Controllers

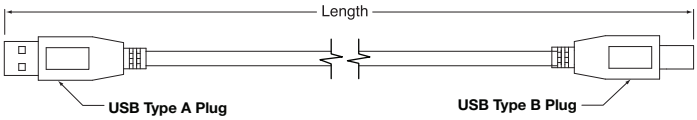



| ITEM# | $ | £ | € | RMB | LENGTH |
|---|---|---|---|---|---|
| USB-AB-72 | $ 8.00 | £ 5.55 | € 7,20 | ¥ 67.60 | 72" (1.8 m) |

# USB 2.0A Male to USB 2.0B Male Cable

## Features

- USB 2.0
- Double Cable Shielding
- Color May Change Without Notice




| ITEM# | $ | £ | € | RMB | LENGTH |
|---|---|---|---|---|---|
| USB-A-79 | $ 8.00 | £5.55 | € 7,20 | ¥ 67.60 | 79" (2.0 m) |

Please refer to our website for complete models and drawings.

# Power Cables and Surge Protector


SP610


IEC Plug


NEMA 5-15P

| ITEM# | $ | £ | € | RMB | DESCRIPTION |
|---|---|---|---|---|---|
| T17251 | $ 32.70 | £ 22.70 | € 29,10 | ¥ 276.20 | 7'6" NEMA to IEC Power Cord (Package of 5) |
| SP610 | $ 21.50 | £ 15.00 | € 19,10 | ¥ 181.60 | 6-Outlet NEMA Surge Protected Power Strip |

# Piezoelectric Drive Cables

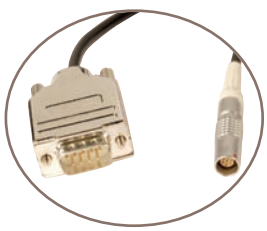
The PAA100 and PAA101 drive cables are the standard SMC-terminated cables used with all the Thorlabs 75 V piezoelectric actuators and nanopositioning stages with internal piezoelectric actuators. These cables are compatible with Thorlabs' MAX and NF series of stages as well as our full line of piezo actuators and extenders.


PAA101

| ITEM# | $ | £ | € | RMB | DESCRIPTION |
|---|---|---|---|---|---|
| PAA100 | $ 32.80 | £ 22.80 | € 29,20 | ¥ 277.00 | Drive Cable for Piezo Actuators, 3 m |
| PAA101 | $ 37.10 | £ 25.80 | € 33,00 | ¥ 313.30 | Drive Cable for Piezo Actuators, 1.5 m |

# Piezoelectric Feedback Cables

The feedback cable, PAA622, can be used to connect any Thorlabs stage equipped with strain gauge feedback to Thorlabs' wide range of controllers.




PAA622

| ITEM# | $ | £ | € | RMB | DESCRIPTION |
|---|---|---|---|---|---|
| PAA622 | $ 96.95 | £ 67.30 | € 86,10 | ¥ 818.70 | Piezo Feedback Cable, Male D-Type to Female LEMO Converter, 3.0 m |

# Piezoelectric Feedback Cable Extension

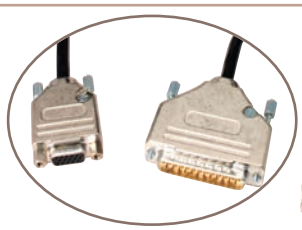
The PAA606 feedback cable is for use with the internal piezoelectric actuators of the APT600 six-axis stage that can be found on pages 488 - 494. The cable is fitted with 9-pin D-type connectors on both ends (one male, one female) and is 3 m long.


PAA606

| ITEM# | $ | £ | € | RMB | DESCRIPTION |
|---|---|---|---|---|---|
| PAA606 | $ 54.90 | £ 38.10 | € 48,80 | ¥ 463.60 | Feedback Cable Extension for Piezo Actuators, 3.0 m |

# Stepper Motor Drive Cables

These cables are fitted with 15-pin D-type connectors on both ends; the male end connects to the controller, and the female end connects to the actuator. These cables can be used with any of the individual stepper motor actuators found in the separate actuator section starting on page 535 (Use with BSC101, BSC102, or BSC103 Controllers).




PAA612

| ITEM# | $ | £ | € | RMB | DESCRIPTION |
|---|---|---|---|---|---|
| PAA612 | $ 80.90 | £ 56.10 | € 71,90 | ¥ 683.20 | APT Stepper Motor Drive Cable, 1 m |
| PAA613 | $ 66.20 | £ 45.90 | € 58,80 | ¥ 559.00 | APT Stepper Motor Drive Cable, 3.0 m |

## Legacy LEMO Stepper Motor Drive Cables

The conversion cable, PAA621, can be used to connect a 15-pm D-type connector to the 8-pin LEMO connector on any of Thorlabs' stepper motor actuators.

PAA621

| ITEM# | $ | £ | € | RMB | DESCRIPTION |
|---|---|---|---|---|---|
| PAA621 | $ 96.95 | £ 67.30 | € 86,10 | ¥ 818.70 | Stepper Motor Drive Cable, Female D-Type to Male LEMO Converter, 3.0 m |

## Legacy 25-Pin D-Type Stepper Motor Cable

The PAA611 cable features a 25-pin male D-type connector on one end and a 15-pin female D-type connector on the other end. This cable can be used with the MST601, BSC001, BSC002, and BSC003 stepper motor controllers.

PAA611

| ITEM# | $ | £ | € | RMB | DESCRIPTION |
|---|---|---|---|---|---|
| PAA611 | $ 61.80 | £ 42.90 | € 54,90 | ¥ 521.90 | Legacy APT Stepper Motor Drive Cable, 3.0 m |

## Z8 DC Motor Extension Cable

The PAA632 is an extension cable for use with the Z8 series actuators (page xxx). This cable is 2.5 m (8.2') long with a 15-pin D-type male connector on one end and a female 15-pin D-type connector on the other end.

NEW product

PAA632

| ITEM# | $ | £ | € | RMB | DESCRIPTION |
|---|---|---|---|---|---|
| PAA632 | $ 52.80 | £ 36.70 | € 46,90 | ¥ 445.90 | Z8 Series Extension Cable, 2.5 m |

## Laser Diode and Temperature Controller Cables

These cables are the same cables included with many of our laser diode current and TEC controllers. The table below outlines the controller that each cable is typically used with.

CAB420-15

CAB4001

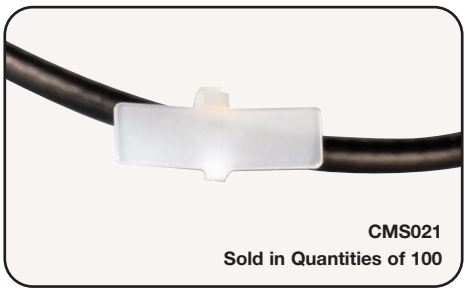
| ITEM# | USE | COMPATIBLE CONTROLLER |
|---|---|---|
| CAB400 | LD | LDC200C Series, PRO 8 Series |
| CAB420-15 | TEC | TED200C, TTC001, PRO8 Series |
| CAB430 | LD and TEC | ITC100 Series |
| CAB530 | LD and TEC | ITC5022, ITC5052, ITC5102 |
| CAB4000 | TEC | TED4015, ITC4000 Series – 5 A Max |
| CAB4001 | TEC | TED4015 ITC4000 Series – 20 A Max |
| CAB4005 | LD | LDC4000 Series, ITC4000 Series – 5 A Max |
| CAB4006 | LD | LDC4000 Series, ITC4000 Series – 20 A Max |

| ITEM# | $ | £ | € | RMB | DESCRIPTION |
|---|---|---|---|---|---|
| CAB400 | $ 66.00 | £ 45.80 | € 58,60 | ¥ 557.40 | LD Current Controller Cable, 9-Pin D-Sub, 1.5 m |
| CAB420-15 | $ 72.00 | £ 50.00 | € 64,00 | ¥ 608.00 | TEC Controller Cable, 15-Pin D-Sub, 1.5 m |
| CAB430 | $ 120.00 | £ 83.20 | € 106,60 | ¥ 1,013.30 | LD and TEC Controller Cable for ITC100, 1.5 m |
| CAB530 | $ 96.00 | £ 66.60 | € 85,30 | ¥ 810.70 | ITC5000 Series to TEC & LD Driver Mounts |
| CAB4000 | $ 65.00 | £ 45.10 | € 57,80 | ¥ 548.90 | TEC Controller Cable for TED4000, 5 A Max, 9-Pin D-Sub, 1.5 m |
| CAB4001 | $ 170.00 | £ 117.90 | € 151,00 | ¥ 1,435.50 | TEC Controller Cable for TED4000, 20 A Max, 17W2, 1.5 m |
| CAB4005 | $ 80.65 | £ 56.00 | € 71,70 | ¥ 681.10 | Cable for LDC4000 Series, 5 A, 13W3 to D-Sub-9, 1.5 m |
| CAB4006 | $ 80.65 | £ 56.00 | € 71,70 | ¥ 681.10 | Cable for LDC4000 Series, 20 A, 13W3 to 13W3, 1.5 m |

# Cable Identification Ties

The CMS021 Cable Identification Ties (supplied in bags of 100) enable electrical cables and fiber optics to be bundled and secured. They feature a 25 mm x 7 mm (0.98" x 0.28") surface for labeling and can attach to cable bundles up to 20 mm (0.79") in diameter. A pen is included with each bag.

- Tie and Identify Bundles of Cable in One Operation
- Easy Method to Clearly Label Any Cable or Bundle
- Fine-Tipped Pen Included



CMS021
Sold in Quantities of 100

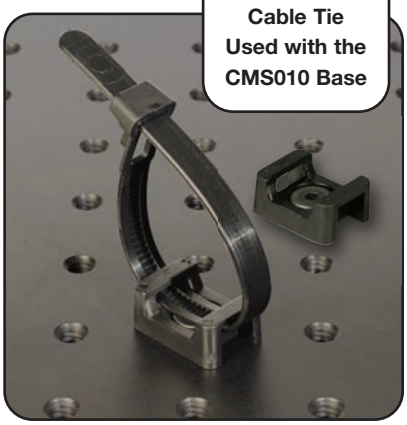
| ITEM# | $ | £ | € | RMB | DESCRIPTION |
|---|---|---|---|---|---|
| CMS021 | $ 26.50 | £ 18.40 | € 23,60 | ¥ 223.80 | Cable Identification Ties (Qty. 100) |

# Optical Table Cable Management: Cables, Ties, and Clips

The CMS011 Cable Ties (supplied in bags of 100) are releasable and are typically used to bundle cable looms. They can also be combined with the CMS010 Cable Tie Bases (supplied in bags of 250) to secure cable bundles to the optical table or work surface as shown to the right. Please note that the CMS010 bases require low-profile cap screws.

The CMS022 P-clips (supplied in bags of 10) offer an alternative method of securing cable looms up to Ø19 mm (Ø0.75")

- Cable Ties for Cable Management
- Bases and P-Clips to Assist in Keeping Cables and Fiber Optics Tidy and Secure


| ITEM# | $ | £ | € | RMB | DESCRIPTION |
|---|---|---|---|---|---|
| CMS011 | $ 16.45 | £ 11.50 | € 14,70 | ¥ 139.00 | Releasable Cable Ties, 6 mm (Qty. 100) |
| CMS010 | $ 39.95 | £ 27.70 | € 35,50 | ¥ 337.40 | Cable Tie Bases (Qty. 250) |
| CMS022 | $ 25.60 | £ 17.80 | € 22,80 | ¥ 216.20 | P-Clips, Black (Qty. 10) |

# Elliptical Cable Strap Kit

These polyester straps are designed to restrain multiple cables flat onto breadboards. The straps are slotted at one end to allow flexibilty in the number of cables being restrained. They are sold in a kit that contains five cable clamps, ten M6 nylon washers, ten 1/4"-20 (M6 x1.0) button hex drive screws, and a 5/32" (4 mm) hex key. Both metric and imperial versions are available.

- Kit of 5 Cable Clamps
- Includes Button Hex Drive Screws, Nylon Washers, and Hex Key
- Suitable for Use on Breadboards and Optical Tables
- Ideal for Complicated Routing of Cables or Fibers

| ITEM# | METRIC ITEM# | $ | £ | € | RMB | DESCRIPTION |
|---|---|---|---|---|---|---|
| CMS013 | CMS013/M | $ 16.95 | £ 11.80 | € 15,10 | ¥ 143.20 | Elliptical Cable Strap Kit |

# Optical Table Velcro Cable Straps

The CSV4 is a 4" hook-and-loop cable strap that can be attached to an optical table to keep your work space organized. The strap is long enough to go around a Ø1"(Ø25.4 mm) bundle of cables. To attach this strap to a table, a metal rivet near the end of a strap has a Ø1/4" through hole that is designed for use with a 1/4" (M6) cap screw. The CSV4 contains 5 straps.

- Quickly Bundle or Unbundle Cables
- Attaches to an Optical Table
- Accommodates Ø1" (Ø25.4 mm) Cable Bundle



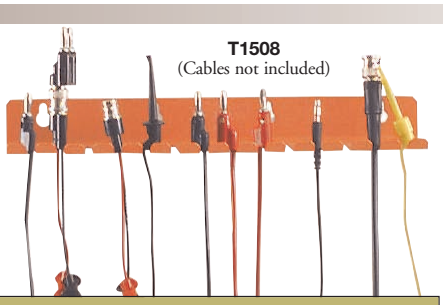
| ITEM# | $ | £ | € | RMB | DESCRIPTION |
|---|---|---|---|---|---|
| CSV4 | $ 14.60 | £ 10.10 | € 13,00 | ¥ 123.30 | Velcro Cable Straps, 5 per pack |

# Cable Racks

## Features

- Organize Loose Cables and Electrical Patch Cords
- Model T1508 is Great for Fiber Optic Cables
- Easy Mounting

T2708



T1508
(Cables not included)

| ITEM# | $ | £ | € | RMB | DESCRIPTION |
|---|---|---|---|---|---|
| T1508 | $ 12.30 | £ 8.55 | € 11,00 | ¥ 103.90 | 14 Narrow Slots for Use with BNC and SMA Cables, Orange |
| T2708 | $ 12.70 | £ 8.80 | € 11,30 | ¥ 107.30 | 9 Wide Slots for Use with Power Cords and Large Cables, Turquoise |

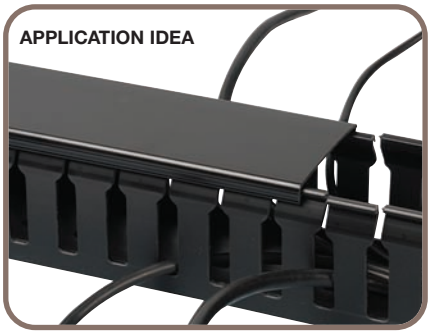
# Fixed Trunking

This trunking provides a permanent solution to routing and securing cables or fiber optics. It is supplied in lengths of 1 m (3.2 ft) with a 50 mm x 50 mm (2" x 2") cross section and is ideal for use on optical tables or similar work surfaces.

CMS002

## Features

- Rigid and Lightweight
- Snap-On Lid Allows Easy Access
- 8 mm Slot Width for Cable Exit
- Manufactured from High-Impact PVC



APPLICATION IDEA

| ITEM# | $ | £ | € | RMB | DESCRIPTION |
|---|---|---|---|---|---|
| CMS002 | $ 11.95 | £ 8.30 | € 10,70 | ¥ 101.00 | 1 m x 50 mm x 50 mm (3.2' x 2" x 2") |

# Slit Harness Wrap

This slit harness wrap simplifies the collection of cables and fiber optics. The insertion tool (supplied) enables the user to slide the wrap onto the cables quickly, with minimal effort. The harness wrap is reusable and easy to remove.

## Features

- Supplied in Reels of 5 m (16.5 ft)
- Insertion Tool Included

CMS015

CMS015
Collect Cables Easily

| ITEM# | $ | £ | € | RMB | DESCRIPTION |
|---|---|---|---|---|---|
| CMS015 | $ 32.25 | £ 22.40 | € 28,70 | ¥ 272.40 | Slit Harness Wrap, 5 m (16.5'), Tool Included |

# Reusable Fabric (Hook-and-Loop) Cable Wrap

This fabric, (hook-and-loop) cable wrap is ideal for bundling cables and fiber optics on the optical table or similar work surface. It can be cut to the required length, thereby eliminating waste.

## Features

- Allows Quick and Convenient Bundling of Cables and Fiber Optics
- Easily Cut to Required Length
- Supplied in Reels of 5 m (16.5 ft)

CMS020

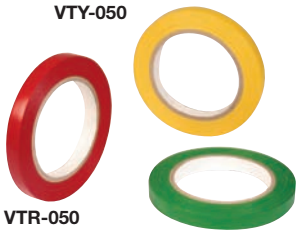
| ITEM# | $ | £ | € | RMB | DESCRIPTION |
|---|---|---|---|---|---|
| CMS020 | $ 15.70 | £ 10.90 | € 14,00 | ¥ 132.60 | Reusable Hook-and-Loop Cable Wrap |

# Colored Vinyl Tape

Colored rolls of vinyl tape are ideal for color coding cables, tools, and samples. The tape can be written on with permanent marker, and the tape can be used in environments from 40 to 170 °F, although it is best to apply the tape at room temperature.

## Features

- 1/2" Wide Vinyl Tape
- 36 Yard Long Roll (32.9 m)
- Available in Red, Green, and Yellow



VTY-050

VTR-050

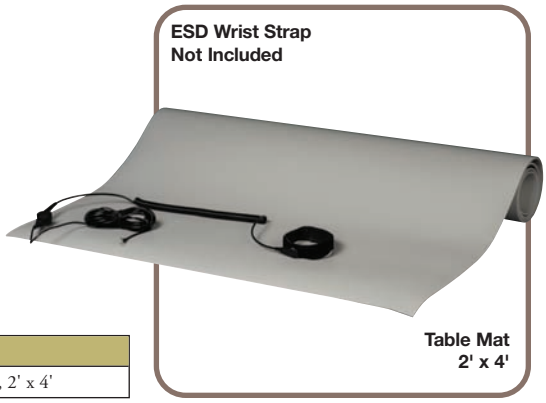
VTG-050

| ITEM# | $ | £ | € | RMB | DESCRIPTION |
|---|---|---|---|---|---|
| VTR-050 | $ 3.59 | £ 2.50 | € 3,20 | ¥ 30.30 | Red Vinyl Tape, 1/2" Wide |
| VTG-050 | $ 3.59 | £ 2.50 | € 3,20 | ¥ 30.30 | Green Vinyl Tape, 1/2" Wide |
| VTY-050 | $ 3.59 | £ 2.50 | € 3,20 | ¥ 30.30 | Yellow Vinyl Tape, 1/2" Wide |

# ESD Table Mat

- Heavy-Duty 2' x 4' (610 mm x 1219 mm) Table Mat
- 50 ms Static Charge Decay

The Thorlabs Static Control 2' x 4' (610 mm x 1219 mm) Table Mat provides a static dissipative surface to protect sensitive optoelectronic components from damaging electrostatic discharge. These heavy-duty mats have a 50 ms static charge decay time, ensuring protection under extreme conditions. The mat comes with a connector for an ESD wrist strap (available separately below).




| ITEM# | $ | £ | € | RMB | DESCRIPTION |
|---|---|---|---|---|---|
| TM2448 | $ 78.60 | £ 54.50 | € 69,80 | ¥ 663.80 | Static Control Table Mat, 2' x 4' |

# ESD Wrist Straps



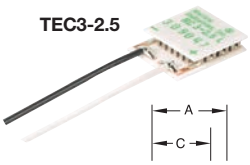
- **WS01:** Black Metal Strap with 12' Grounding Wire
- **WS02:** Blue Fabric Strap with 6' Grounding Wire
- Removes Static Charges
- Recommended for use with Thorlabs' Static-Sensitive Devices

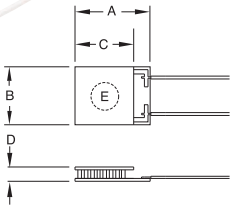
Thorlabs' Grounding Wrist Straps safely remove static charges from individuals who handle laser diodes, amplified photodetectors, and other static-sensitive devices. The ground cord has a built-in 1 MΩ resistor for user safety, and the straps work with our Static Control Table Mat featured above to protect against static discharge.

The WS01 strap consists of an expandable, metal wristband that is flexible, durable, and comfortable, allowing for extended use. The band has a relaxed (i.e., not stretched) circumference of 5.5" and includes an alligator clip that fits over the installed banana jack on the 12' long grounding cord. The WS02 adjustable fabric strap is available in one size and includes a 6' coiled cord and alligator clip to provide ground connection.

| ITEM# | $ | £ | € | RMB | DESCRIPTION |
|---|---|---|---|---|---|
| WS01 | $ 30.10 | £ 20.90 | € 26,80 | ¥ 254.20 | Metal Grounding Wrist Strap, 12' (3.6 m) Coiled Cord |
| WS02 | $ 12.20 | £ 8.45 | € 10,90 | ¥ 103.10 | Fabric Grounding Wrist Strap, 6' (1.8 m) Coiled Cord |

# TEC Elements



Our selection of thermoelectric coolers are an ideal solution for medium or large heat-pumping applications. These work well with our TED Series of Temperature Controllers (see page 1188).

| ITEM# | $I_{MAX}$ (A) | TH=27 °C | | | TH=35 °C | | | TH=50 °C | | | AC RESISTANCE @ 27 °C | DIMENSIONS | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | $Q_{MAX}$ (W) | $V_{MAX}$ (V) | $\Delta T_{MAX}$ (°C) | $Q_{MAX}$ (W) | $V_{MAX}$ (V) | $\Delta T_{MAX}$ (°C) | $Q_{MAX}$ (W) | $V_{MAX}$ (V) | $\Delta T_{MAX}$ (°C) | | A | B | C | D | E |
| TEC3-2.5 | 2.5 | 6 | 3.6 | 65 | 6 | 3.8 | 68 | 6 | 4.1 | 73 | 1.2 Ω | .807" | .630" | .630" | .159" | – |
| TEC3-6 | 5.6 | 13 | 3.6 | 65 | 14 | 3.8 | 68 | 14 | 4.1 | 73 | 0.5 Ω | .965" | .787" | .787" | .158" | – |
| TEC1.4-6 | 6.0 | 6 | 1.8 | 65 | – | – | – | 7 | 1.9 | 75 | 0.3 Ω | .560" | .560" | .560" | .150" | Ø0.20" |

Please refer to our website for complete models and drawings.

| ITEM# | $ | £ | € | RMB | DESCRIPTION |
|---|---|---|---|---|---|
| TEC3-2.5 | $ 29.30 | £ 20.40 | € 26,10 | ¥ 247.50 | 2.5 A TEC Element |
| TEC3-6 | $ 29.60 | £ 20.60 | € 26,30 | ¥ 250.00 | 5.6 A TEC Element |
| TEC1.4-6 | $ 40.10 | £ 27.80 | € 35,70 | ¥ 338.70 | 6.0 A TEC Element |

# Resistive Heaters


The HT10K is a resistive foil heater with adhesive backing and a 10 kΩ NTC thermistor integrated directly onto the heater. The HT15W is a miniature 15 W cartridge heater, which can be used for many applications requiring small areas to be heated. Both of these heaters are compatible with Thorlabs' TC200 Temperature Controller (see page 829).

Mechanical Drawings Available on the WEB


## HT10K Specifications

- **Heater Resistance:** 19.7 Ω
- **Sensor Type:** NTC10K Thermistor
- **Size:** 1" x 3" (25.4 mm x 76.2 mm)
- **Heating Capacity:** 10 W/in$^2$ @ 70 °C
- **Effective Heating Area:** 2.23 in$^2$ (14.39 cm$^2$)

## HT15W Specifications

- **Heater Resistance:** 35 Ω (Typ.)
- **Size:** Ø1/8" x 1/2" Long
- **Heating Capacity:** 15 W @ 24 V

| ITEM# | $ | £ | € | RMB | DESCRIPTION |
|---|---|---|---|---|---|
| HT10K | $ 39.40 | £ 27.40 | € 35,00 | ¥ 332.70 | Foil Heater with 10 kΩ Thermistor |
| HT15W | $ 37.90 | £ 26.30 | € 33,70 | ¥ 320.10 | 15 W Resistive Cartridge Heater |

# Thermistors and Temperature Transducers

Thorlabs offers thermisters and transducers that are compatible with our TEC controllers (found on pages 1187-1191) for precise temperature measurement, up to ±0.3 °C.

## TH10K Specifications

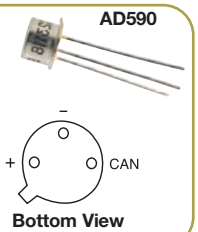
- The TH10K is a 10 kΩ Thermistor with ±1 °C Accuracy for use in Common TEC Applications
- **Temperature Accuracy:** ±1° C @ 25 °C
- **Dissipation Constant:** 1.4 mW/°C
- **Time Constant:** 15 s
- **Operating Range:** -50 to 150 °C
- **Temperature Coefficient:** -4.40%/°C @ 25 °C


## TH100PT Specifications

- 100 Ω RTD Platinum Thermistor with a Positive Linear Temperature Response
- **Rating:** 100 Ω @ 0 °C
- **Temperature Coefficient**: 3.85 x 10$^{-3}$/K
- **Accuracy:** Class B Tolerance (±0.3 °C @ 100 Ω)
- **Operating Range:** -70 to 400 °C


## AD590 Specifications

- IC Temperature Transducer with Output Current Proportional to Absolute Temperature
- **Linear Current Output:** 1 mA/K
- **Operating Range:** -55 to 150 °C
- **Power Supply Range:** 4 to 30 V




| ITEM# | $ | £ | € | RMB | DESCRIPTION |
|---|---|---|---|---|---|
| TH10K | $ 3.98 | £ 2.75 | € 3,60 | ¥ 33.60 | 10 kΩ Thermistor |
| TH100PT | $ 7.19 | £ 5.00 | € 6,40 | ¥ 60.80 | 100 Ω PlatinumThermistor |
| AD590 | $ 13.30 | £ 9.20 | € 11,90 | ¥ 112.40 | Temperature Transducer |

# Aquadag E

## Common Applications

- Electrostatic Screening
- Vacuum Environments
- Thin-Film Filter Repair
- Contact Material for Electronic Components
- Prevention from Corona Discharge
- Electrode Finishes on Glass Envelopes
- Coating for Electron Gun Components

AQE32

## Colloidal Graphite Resistance Coating

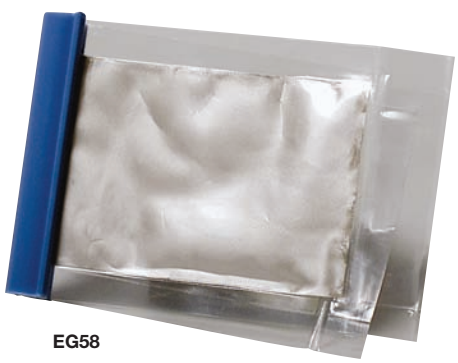
Aquadag E, a longstanding electronic industry product, is a colloidal graphite resistance coating that can be used to form very thin films on a variety of surfaces. The electrical characteristics of the coating can be varied depending on the thickness of the layer applied. In addition, the coating resistance decreases with increased temperature. Once a surface is coated, it will also benefit from the lubricating and opaquing qualities of graphite. Thorlabs offers Aquadag E in a 32 oz. bottle.

| ITEM# | $ | £ | € | RMB | DESCRIPTION |
|---|---|---|---|---|---|
| AQE32 | $ 74.50 | £ 51.70 | € 66,20 | ¥ 629.10 | Aquadag E, 32 oz. |

# Electrodag 5810

## Two-Component Silver Epoxy Adhesive

Electrodag 5810 (i.e., Silver-epoxy) is a room-temperature cure, silver-filled, 2-component epoxy that provides good electrical and thermal conductivity. With a volume resistance of 0.0007 Ω-cm and a lap shear of 1000 psi, Silver-epoxy is ideal for mounting electrically and thermally conductive components when soldering is not possible. The room-temperature cure time is 24 hours, but this can be accelerated by using higher temperatures [e.g., 2 hours at 149 °F (65 °C) or 1 hour at 212 °F (100 °C)].


EG58

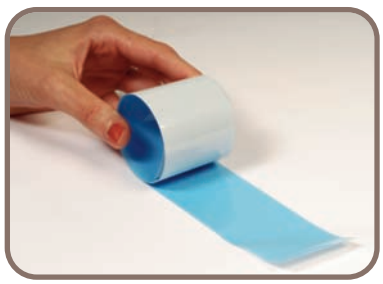
## Features

- Ideal for Mounting Conductive Components that Cannot be Soldered
- Low-Resistance Epoxy Coating or Adhesive (0.0007 Ω-cm)
- 1000 psi Lap Shear
- Maximum Operating Temperature of 250 °F (121 °C)

| ITEM# | $ | £ | € | RMB | DESCRIPTION |
|---|---|---|---|---|---|
| EG58 | $ 19.90 | £ 13.80 | € 17,70 | ¥ 168.10 | Silver Epoxy, 4.4 g |

# Thermally Conductive Double-Sided Tape

- Thermally Conductive Double-Sided Acrylic Adhesive Tape
- Provides a High Bond Strength to a Variety of Surfaces
- Can be Removed without Damaging Parts
- 1.4 W/mK Thermal Conductivity



This thermally conductive, double-sided tape offers a superior bond strength due to its pressure-sensitive acrylic adhesive, which is loaded with titanium diboride and is applied to an expanded aluminum carrier. The thermal tape is embossed with an innovative pattern for maximum conformability and minimal air pockets. It bonds heat sinks and thermal plates to components without the use of clips, screws, or other mechanical fasteners. Using the tape requires no additional thermal compound. It offers excellent thermal, mechanical, environmental, and chemical properties. The thermal tape can be removed after the application without damage to the component.

| ITEM# | $ | £ | € | RMB | DESCRIPTION |
|---|---|---|---|---|---|
| TCDT1 | $ 15.20 | £ 10.55 | € 13,50 | ¥ 128.40 | 1" x 48" Double-Sided Thermal Tape |
| TCDT2 | $ 15.60 | £ 10.80 | € 13,90 | ¥ 131.80 | 2" x 24" Double-Sided Thermal Tape |

NEW products

# Acrylic Anaerobic Adhesive

## Properties

- Acrylic Adhesive and Primer
- Superior Bonding of Metal, Glass, Ceramic, Nylon, and Wood
- Fast Cure at Room Temperature (Sets in Seconds, Strong Bond in 1-2 Minutes)
- Easy-to-Use (No Measuring or Mixing)
- Operating Termperature of -54 to 150 °C


LOC312

LOCTITE® Speedbonder™ 312 anaerobic adhesive kit contains a 10 mL bottle of adhesive and a 40 g aerosol can of primer. This adhesive provides exceptionally strong bonds between similar and dissimilar materials (metal, glass, ceramic, nylon, wood, and some plastics) in mere minutes. For instance, when bonding steel to steel, the bond strength will be ~65% after 5 minutes, ~80% after 30 minutes, and 100% after 24 hours.

Note: This product is not recommended for use in pure oxygen or oxygen-rich systems, and it should not be selected as a sealant for chlorine or other strong oxidizing materials.

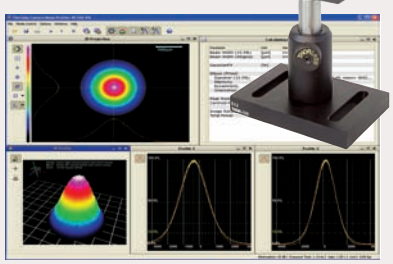
| ITEM# | $ | £ | € | RMB | DESCRIPTION |
|---|---|---|---|---|---|
| LOC312 | $ 25.40 | £ 17.70 | € 22,60 | ¥ 214.50 | Acrylic Anaerobic Adhesive |

# Beam Profilers: Scanning and CCD See Pages 1318-1322

NEW products

- Wavelength Range 190 to 1100 nm
- CW and TTL Triggered Single Pulse Detection
- High Dynamic Range CCD Camera with High Resolution and Low Noise

Thorlabs series of CCD camera based beam profilers, compared to scanning slit profilers, offers true 2D analysis of the beam's power density distribution. This greater detail allows complex mode patterns to be identified while optimizing the laser systems.



- Wavelength Range UV thru IR with a Si or Ge Sensor
- CW and Pulsed Sources ≥10 Hz
- High Dynamic Range


Thorlabs' Scanning Profiler is a high-precision instrument with a dynamic range of 72 dB that can analyze the power distribution of laser beams with diameters from 10 µm to 9 mm.