PDAPC10
Black Si Switchable Gain Photodetector, OEM Package

User Guide



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Chapter 1 Introduction

1.1 Intended Use

This product is intended to be used to monitor light signals ranging from 240 nm to 1170 nm and create an appropriate electrical signal in a laboratory environment. The OEM style PCB is intended to be used in tight places, with the Thorlabs 30 mm cage systems, or embedded in user systems. The photodiode is centered on the 30 mm spacing. These mounting holes can be used for mounting into custom housings and devices. A 10-pin header is provided to supply power, retrieve the detector voltage, and set gain control on switchable gain versions.

1.2 Explanation of Safety Warnings

NOTICE Indicates information considered important, but not hazard-related, such as possible damage to the product.


Shock Warning


ESD Component Caution


The CE/UKCA markings on the product are the manufacturer's declaration that the product complies with the essential requirements of the relevant European health, safety, and environmental protection legislation.


The wheelie bin symbol on the product, the accessories or packaging indicates that this device must not be treated as unsorted municipal waste but must be collected separately.

1.3 Description

The PDAPC10 amplified, switchable-gain, black silicon (b-Si) photodetector is in an OEM package with an operating wavelength range of 240 to 1170 nm. A DIP switch allows the user to vary the gain in 10 dB steps. A buffered output drives 50 Ω load impedances up to 5 V. The output signal is readable from the MMCX connector. We provide MMCX to BNC cables (Item # CA3339) or MMCX to SMA cables (Item # CA3439). Users can also access the digital pins of the gain switch or the output through an on-board header.


This produce is ESD sensitive. Take all appropriate precautions to discharge personnel and equipment before making any electrical connections to the unit.

1.4 Technical Data

All performance specifications are typical, performed at 25 °C ambient temperature, and assume a 50 Ω load, unless stated otherwise.

1.4.1 Specifications

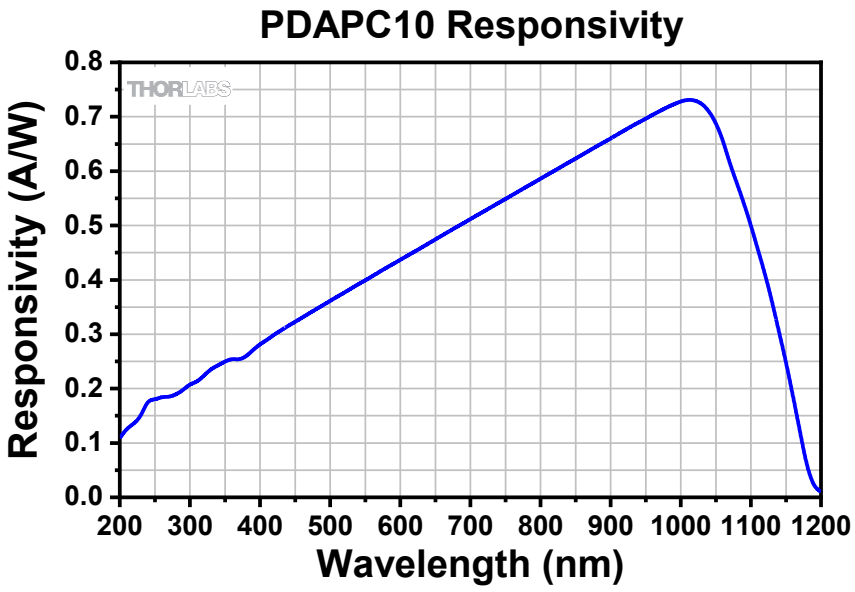
Performance Specifications[a]			
0 dB Setting		**40 dB Setting**	
Gain (Hi-Z)	1.51 x 10^3 V/A ±2%	**Gain (Hi-Z)**	1.51 x 10^5 V/A ±2%
Gain (50 Ω)	0.75 x 10^3 V/A ±2%	**Gain (50 Ω)**	0.75 x 10^5 V/A ±2%
Bandwidth[b]	11 MHz	**Bandwidth[b]**	110 kHz
Noise (RMS)	234 µV	**Noise (RMS)**	245 µV
Noise Equivalent Power (@ λ_p)	6.0 x 10^{-11} W/√Hz	**Noise Equivalent Power (@ λ_p)**	3.36 x 10^{-12} W/√Hz
Offset	±8 mV (Typ.) ±12 mV (Max)	**Offset**	±8 mV (Typ.) ±12 mV (Max)
10 dB Setting		**50 dB Setting**	
Gain (Hi-Z)	4.75 x 10^3 V/A ±2%	**Gain (Hi-Z)**	4.75 x 10^5 V/A ±2%
Gain (50 Ω)	2.38 x 10^3 V/A ±2%	**Gain (50 Ω)**	2.38 x 10^5 V/A ±2%
Bandwidth[b]	1.3 MHz	**Bandwidth[b]**	40 kHz
Noise (RMS)	238 µV	**Noise (RMS)**	250 µV
Noise Equivalent Power (@ λ_p)	6.15 x 10^{-12} W/√Hz	**Noise Equivalent Power (@ λ_p)**	5.95 x 10^{-12} W/√Hz
Offset	±8 mV (Typ.) ±12 mV (Max)	**Offset**	±8 mV (Typ.) ±12 mV (Max)
20 dB Setting		**60 dB Setting**	
Gain (Hi-Z)	1.5 x 10^4 V/A ±2%	**Gain (Hi-Z)**	1.5 x 10^6 V/A ±5%
Gain (50 Ω)	0.75 x 10^4 V/A ±2%	**Gain (50 Ω)**	0.75 x 10^6 V/A ±5%
Bandwidth[b]	1.4 MHz	**Bandwidth[b]**	11 kHz
Noise (RMS)	249 µV	**Noise (RMS)**	253 µV
Noise Equivalent Power (@ λ_p)	3.27 x 10^{-12} W/√Hz	**Noise Equivalent Power (@ λ_p)**	7.52 x 10^{-12} W/√Hz
Offset	±8 mV (Typ.) ±12 mV (Max)	**Offset**	±8 mV (Typ.) ±12 mV (Max)
30 dB Setting		**70 dB Setting**	
Gain (Hi-Z)	4.75 x 10^4 V/A ±2%	**Gain (Hi-Z)**	4.75 x 10^6 V/A ±5%
Gain (50 Ω)	2.38 x 10^4 V/A ±2%	**Gain (50 Ω)**	2.38 x 10^6 V/A ±5%
Bandwidth[b]	430 kHz	**Bandwidth[b]**	4 kHz
Noise (RMS)	246 µV	**Noise (RMS)**	265 µV
Noise Equivalent Power (@ λ_p)	3.9 x 10^{-12} W/√Hz	**Noise Equivalent Power (@ λ_p)**	5.01 x 10^{-12} W/√Hz
Offset	±8 mV (Typ.) ±12 mV (Max)	**Offset**	±8 mV (Typ.) ±12 mV (Max)

a. The PDAPC10 has a 50 Ω series terminator resistor (i.e. in series with amplifier output). This forms a voltage divider with any load impedance (e.g. 50 Ω load divides signal in half).
b. Tested at 650 nm wavelength. For NIR wavelengths, the rise time of the photodiode element will become slower which may limit the effective bandwidth of the amplified detector.

Electrical Specifications		
Detector	-	Black Silicon (b-Si)
Active Area	-	2.0 mm x 2.0 mm (4.0 mm^2)
Wavelength Range	λ	240 nm to 1170 nm
Peak Wavelength	λ_p	1010 nm (Typ.)
Peak Response	$\Re(\lambda_p)$	0.73 A/W (Typ.)
Amplifier GBP	-	600 MHz
Output Impedance	-	50 Ω
Max Output Current	I_{out}	100 mA
Load Impedance	-	50 to Hi-Z
Gain Adjustment Range	-	0 dB to 70 dB
Gain Steps	-	8 x 10 dB Steps
Output Voltage	V_{out}	0 V to 5 V (50 Ω) 0 V to 10 V (Hi-z)

General	
Package Size	1.47" x 1.47" x 0.76" (37.3 mm x 37.3 mm x 19.3 mm)
Operating Temperature	10 °C to 40 °C
Storage Temperature	-20 °C to 70 °C

1.4.2 Graphs



1.4.3 Mechanical Drawings

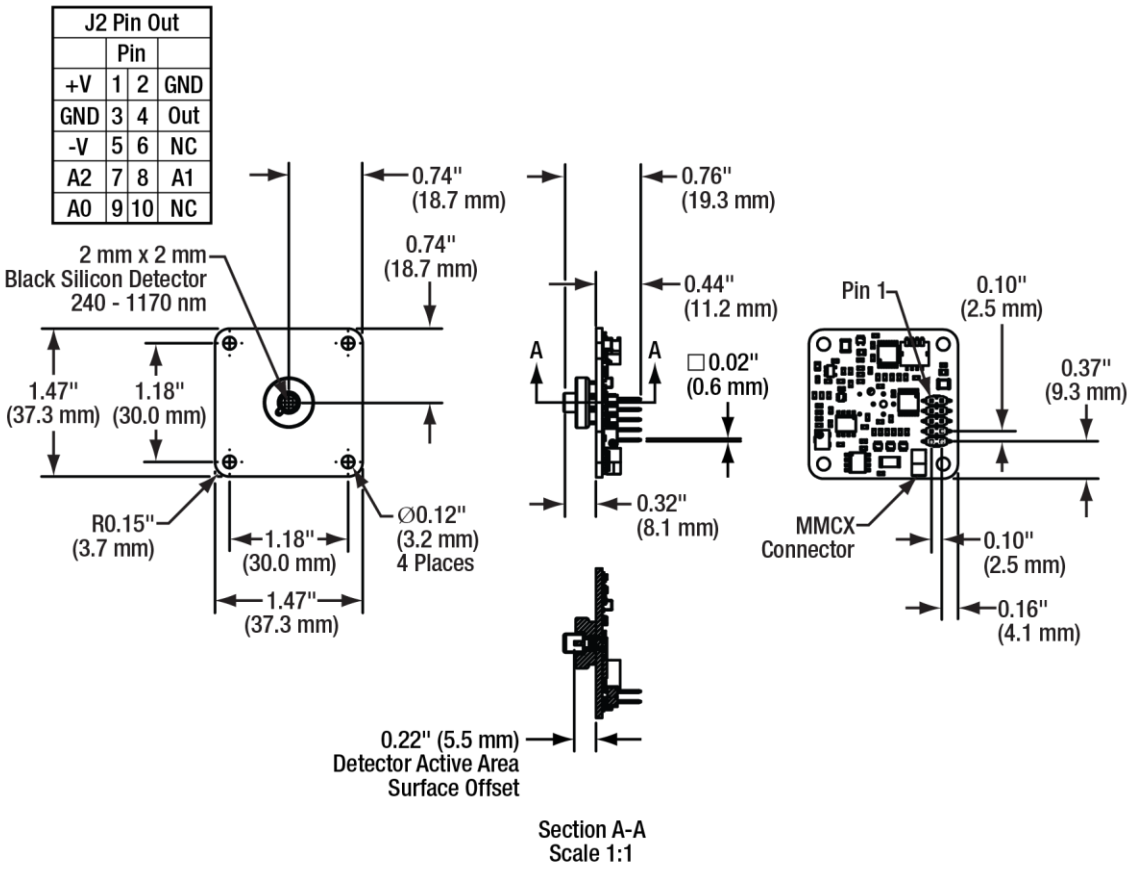


Figure 1 Mechanical Drawing

Chapter 2 Installation

2.1 Packing List/Special Tools Required for Installation

Packing List:

- Photodetector in OEM package
- Quick Start Guide
- Download Card

2.2 Installation Instructions

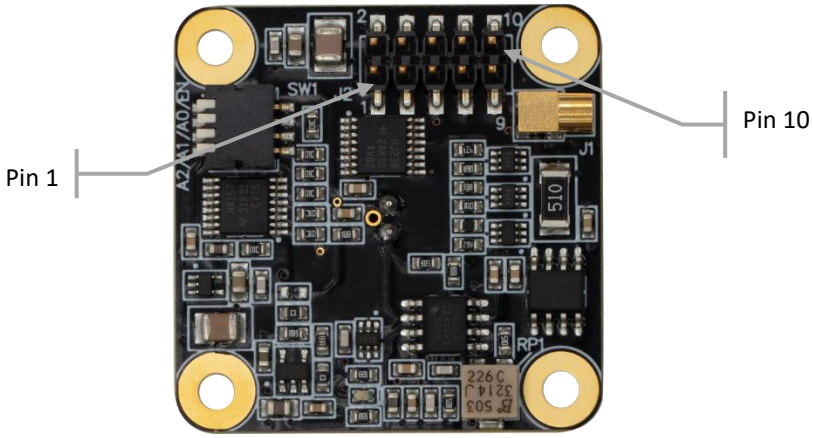


Figure 2 J2 Header

1. The pin out table for the on-board header (J2), is shown in the two tables below:

J2 PIN OUT			
PIN	**Designation**	**PIN**	**Designation**
1	+V	2	GND
3	GND	4	OUTPUT
5	-V	6	N.C.
7	A2	8	A1
9	A0	10	N.C.

Note:
Pins 1 & 5: ±V refers to the power supply positive/negative voltages.
Pins 7, 8, & 9: A0-A2 refers to the three digital pins for the gain adjustment.

Gain Switch Table			
A2	**A1**	**A0**	**Gain**
0	0	0	0 dB
0	0	1	10 dB
0	1	0	20 dB
0	1	1	30 dB
1	0	0	40 dB
1	0	1	50 dB
1	1	0	60 dB
1	1	1	70 dB

2. Connect a power supply to pins 1, 3, and 5 of the J2 header. The required power supply voltages are:

Power Supply Voltages	
J2 PIN	**Designation**
1	+12 VDC
3	GND
5	-12 VDC

Thorlabs offers the LD1255-SUPPLY as one compatible power supply option. Connection to the board is shown below:

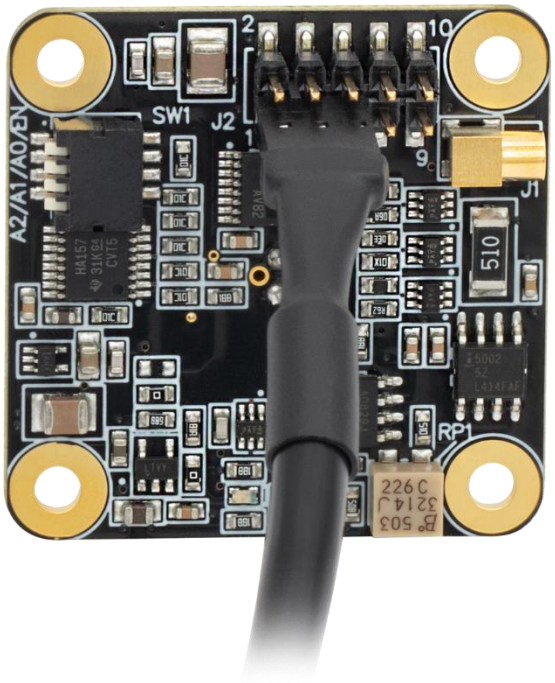


Figure 3 Power Supply Connection

3. Digital gain can be adjusted through the J2 header shown in **Figure 1** or using the on-board DIP switch shown below. Each switch is 'Off'/0 when in the up position and 'On'/1 when in the down position.

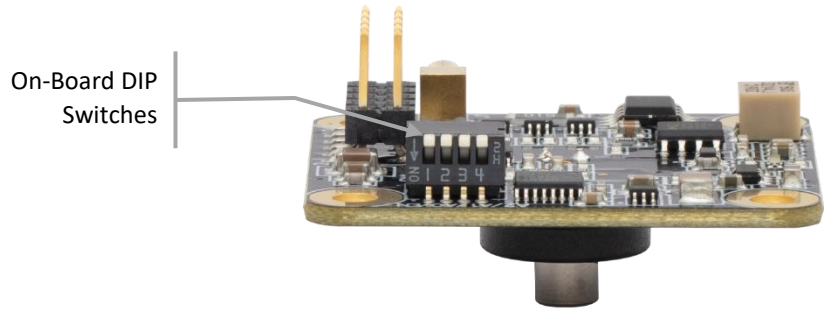


Figure 4 Location of the On-Board DIP Switches

The following table describes what each switch does:

DIP Switch Settings	
Switch Number	**Function**
1	Enable
2	A0
3	A1
4	A2

To enable the DIP switch settings, set switch # 1 to 'On'/1. See the table on page 5 for the corresponding gain settings.

NOTICE The default DIP switch settings are all in the 'Off'/0 position and customer could only use J2 Header for gain setting purposes. When the DIP switch is enabled, it would override the settings of the J2 Header.

4. The side adjusted potentiometer is used to adjust the voltage output's offset at high gain settings (e.g. 70 dB). This part is factory pre-adjusted so normally the user does not need to adjust it. However, if the output offset value has fallen out of spec, for example drift over time or temperature, then it is possible to adjust it back by turning this potentiometer. Turning the screw head clockwise decreases the offset voltage and adjusting the screw head counterclockwise increases it.

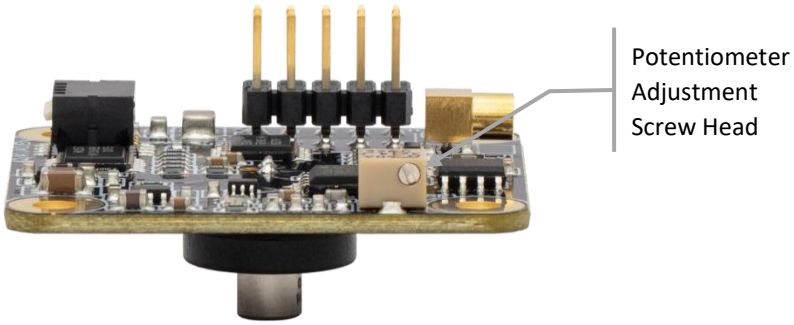


Figure 5 Side adjusted potentiometer

5. Attach a 50 Ω coax cable to the output of the PDAPC10 detector. Thorlabs offers two suitable cable options, the CA3339 MMCX to BNC cable or the CA3439 MMCX to SMA cable.

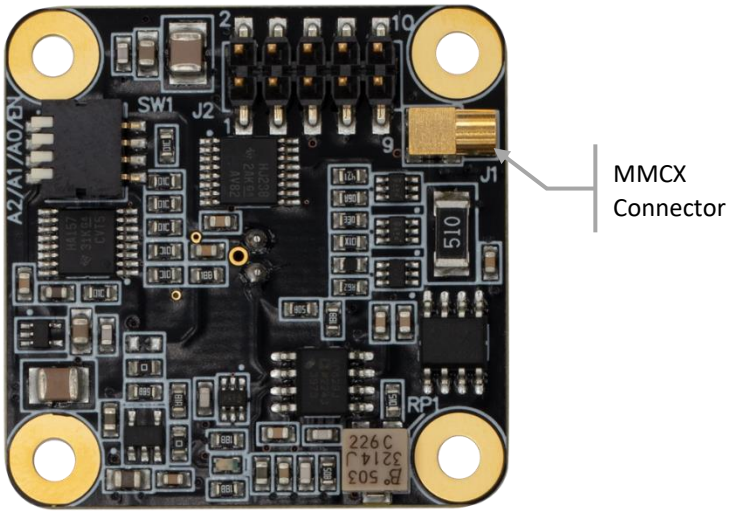


Figure 6 MMCX Connector

When running cable lengths longer than 12", Thorlabs recommends terminating the opposite end of the coax with a 50 Ω resistor for optimal performance. Thorlabs Item # T4119 is suitable for this purpose.

Connect the remaining end to a measurement device such as an oscilloscope or high-speed DAQ card.

NOTICE

Many high speed oscilloscopes have input impedances of 50 Ω. In this case, do not install a 50 Ω terminator. The combined loads will equal 25 Ω which could allow ~135 mA of output current. This will damage the output driver of the PDA.

6. Power the PDAPC10 on. When the unit is on, the power indicator LED will be illuminated yellow. If the LED is green or red, this indicates only one power rail, either positive or negative, respectively, is

connected. In that case, the user would need to check the power inputs to make sure both power rails are on and connected correctly.

7. Apply a light source to the detector, then adjust the gain controls to the desired setting.
8. During alignment, the user should take appropriate precautions. For example, ensuring the incident power is within safe operating power. Additionally, the user should have proper eye and skin protection as recommended by the light source manufacturer.

Chapter 3 Operation

3.1 Theory of Operation

Thorlabs PDA series are ideal for measuring both pulsed and CW light sources. The PDAPC10 includes a reverse-biased PIN photodiode, mated to a switchable gain transimpedance amplifier.

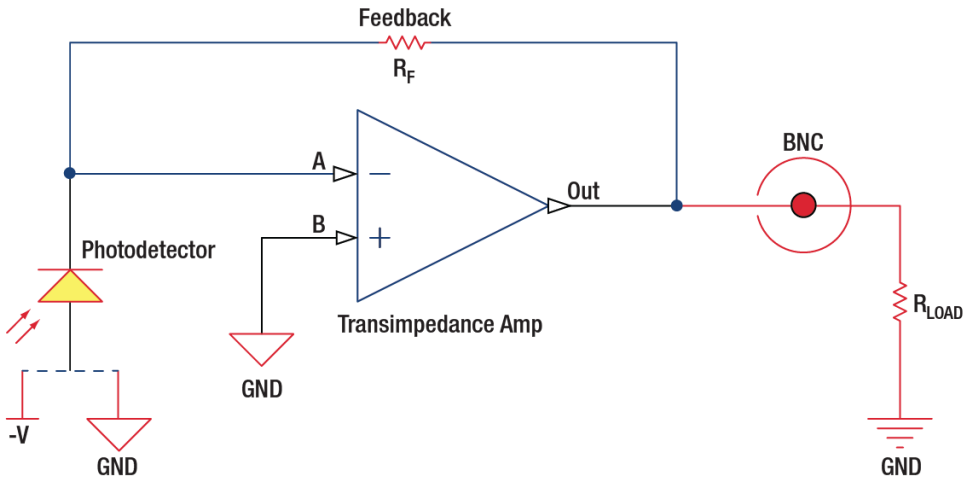


Figure 7 Photodetector with Transimpedance Amplifier Circuit Diagram

3.2 Responsivity

The responsivity of a photodiode can be defined as a ratio of generated photocurrent (I_{PD}) to the incident light power (P) at a given wavelength:

$$R(\lambda) = \frac{I_{PD}}{P}$$

3.3 Dark Current

Dark current is leakage current which flows when a bias voltage is applied to a photodiode. The PDA with Transimpedance Amplifier does control the dark current flowing out. Looking at the figure above, it can be noted that Point B is held at ground and the amplifier will try to hold point A to “Virtual Ground”. This minimizes the effects of dark current present in the system.

The dark current present is also affected by the photodiode material and the size of the active area. Silicon devices generally produce low dark current compared to germanium devices which have high dark currents. The table below lists several photodiode materials and their relative dark currents, speeds, sensitivity, and costs. Please note that sensitivity values in the table are typical values; Thorlabs offers photodetectors with sensitivity ranges that vary from those shown below.

Material	Dark Current	Speed	Sensitivity[a]	Cost
Silicon (Si)	Low	High	400 - 1000 nm	Low
Black Silicon (b-Si)	Low	Medium	240 - 1170 nm	Med
Germanium (Ge)	High	Low	900 - 1600 nm	Low
Gallium Phosphide (GaP)	Low	High	150 - 550 nm	Med
Indium Gallium Arsenide (InGaAs)	Low	High	800 - 1800 nm	Med
Extended Range: Indium Gallim Arsenide (InGaAs)	High	High	1200 - 2600 nm	High

a. Approximate values; actual wavelength values will vary.

3.4 Bandwidth and Response

For the PDA detectors, the gain of the detector is dependent on the feedback element (R_f). The bandwidth of the detector can be calculated using the following:

$$f(-3dB) = \sqrt{\frac{GBP}{4\pi R_f \times C_D}}$$

Where GBP is the amplifier gain bandwidth product and C_D is the sum of the photodiode junction capacitance and the amplifier capacitance.

3.5 Terminating Resistance

The maximum output of the PDAPC10 detector is 10 V for high impedance loads (i.e. R_{Load} > 5 kΩ) and 5 V for 50 Ω loads. Adjust the gain so that the measured signal level out of the PDAPC10 detector is below 10 V (5 V with a 50 Ω load) to avoid saturation.

For low terminating resistors, <5 kΩ or 1% error, an additional factor needs to be considered. The output of the PDA includes a 50 Ω series resistor (R_s). The output load creates a voltage divider with the 50 Ω series resistor as follows:

$$Scale\ Factor\ = \frac{R_{Load}}{R_{Load} + R_s}$$

$$V_{OUT}\ =\ \mathcal{R}(\lambda) * Transimpedance\ Gain * Scale\ Factor * Input\ Power\ (W)$$

Note that we already include the scale factor in our specification for the gain at 50 Ω. Refer to the table in Chapter 1 for additional performance specifications.

3.6 Gain Adjustment

The PDAPC10 includes a low noise, low offset, high gain transimpedance amplifier that allows gain adjustment over a 70 dB range. The gain is adjusted by selecting the correct gain switch settings (see page **5**). There are 8 gain positions incremented in 10 dB steps. It is important to note that the bandwidth will decrease as the gain increases. See the specifications table on page **2** to choose the best gain versus bandwidth for a given input signal.

Chapter 4 Troubleshooting and Repair

Below are a few checks to help in troubleshooting problems that may arise. Please contact your local Thorlabs Technical Support office with any questions.

Problem	Suggested Solutions
There is no signal response.	Verify that the power is switched on and all connections are secure.
	Verify the proper terminating resistor is installed if using a Voltage measurement device.
	Verify that the optical signal wavelength is within the specified wavelength range.
	Verify that the optical signal is illuminating the detector active area.
Output Voltage will not increase. Detector Output is skewed.	Check to make sure the detector is not saturated. Refer to the Output Voltage values in the Electrical Specifications table.

Chapter 5 Disposal



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

Chapter 6 Thorlabs Worldwide Contacts

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



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