

EOT NON-AMPLIFIED HIGH SPEED PHOTODETECTOR USER'S GUIDE

Thank you for purchasing your Non-amplified High Speed Photodetector from EOT. This user's guide will help answer any questions you may have regarding the safe use and optimal operation of your Photodetector.

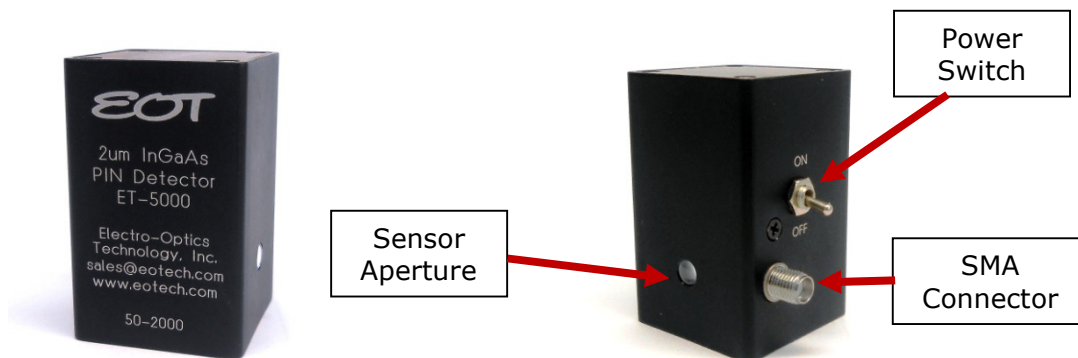
TABLE OF CONTENTS

| | |
|--|---|
| I. Non-amplified High Speed Photodetector Overview | 1 |
| II. Operation of your EOT Non-amplified High Speed Photodetector | 1 |
| III. Troubleshooting..... | 2 |
| IV. Drawings: Non-amplified High Speed Photodetectors | 3 |
| V. Specifications: Non-amplified High Speed Photodetectors..... | 3 |
| VI. Schematics: Non-amplified High Speed Photodetectors | 4 |
| VII. Warranty Statement and Repair | 4 |
| VIII. Glossary of Terms..... | 5 |

I. Non-amplified High Speed Photodetector Overview

EOT's Non-amplified High Speed Photodetectors contain PIN photodiodes that utilize the photovoltaic effect to convert optical power into an electrical current. Figure 1 below identifies the main elements of your Photodetector.

Figure 1: EOT Non-amplified High Speed Photodetector



When terminated into 50Ω into an oscilloscope, the pulsewidth of a laser can be measured. When terminated into a spectrum analyzer, the frequency response of a laser can be measured.

II. Operation of your EOT Non-amplified High Speed Photodetector

- A. Caution: Eye safety precautions must be followed when utilizing any equipment used in the vicinity of laser beams. Laser beams may reflect from the surface of the detector or the optical mount and caution must be exercised.
- B. Mount the detector to an optical stand by the mounting holes on the bottom of the detector housing.

Electro-Optics Technology, Inc.
5835 Shugart Lane Traverse City, MI 49684
(231)935-4044 • (800)697-6782 • Fax: (231)935-4046 • sales@eotech.com • www.eotech.com

- C. Adjust the voltage of the oscilloscope to 20mV/division before connecting the detector.
- D. Connect the detector to the oscilloscope using a coaxial cable designed for 10GHz operation.
- E. Use the 50Ω termination input of the oscilloscope.
- F. After being certain that the damage threshold of the detector is not exceeded, place the detector in the center of the laser beam.
- G. There is an internal 50Ω resistor at the output of the photodiode. This will cause the output current to your test equipment to be half that of the photodiode output. For example, the output to your equipment will be 450μA for a 1mW optical input at 0.9A/W.

III. Troubleshooting

A. No signal is seen the first time the detector is used.

- 1. Is the power switch on?
- 2. Be certain that the signal is not high off scale on the oscilloscope.
- 3. Is the wavelength of the laser within the spectral range of the detector?
- 4. Has a 50Ω termination input been used?
- 5. Try moving the detector within the laser beam.
- 6. Is there enough light (see sensitivity spec on the data sheet) incident on the detector to generate a signal? The detector's small active area makes alignment somewhat difficult.

B. A signal has been previously obtained, but not currently.

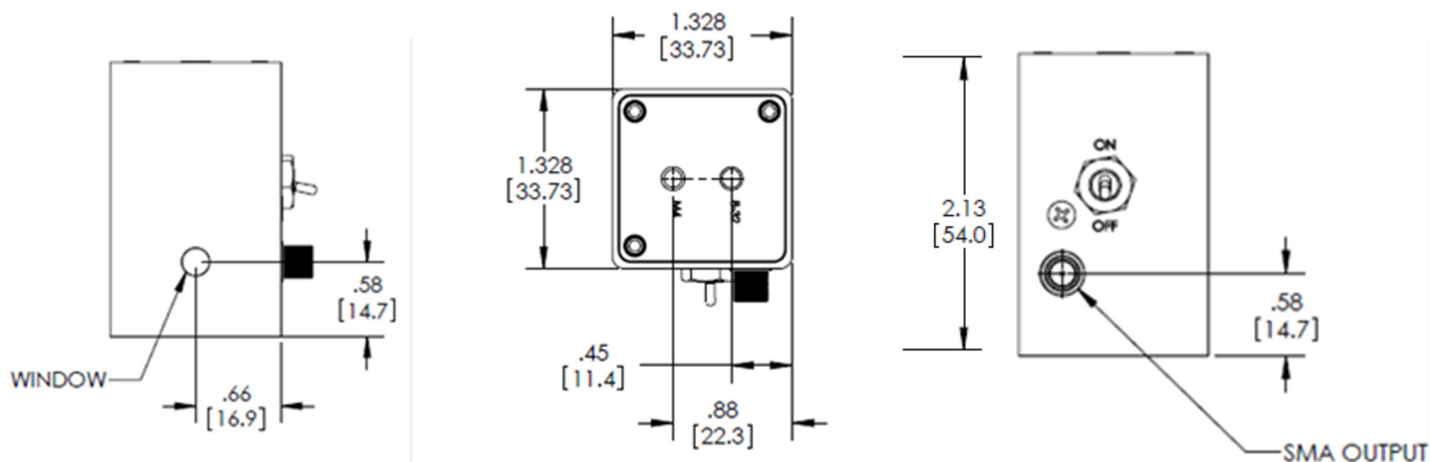
- 1. Try steps listed under A.
- 2. Inspect the active area of the photodiode for any signs of damage.
- 3. Test the power supply:
 - a. Units with internal batteries will typically operate for several years, but operation with CW or high rep rate lasers can drain the batteries much faster. **If a load is present at the output, current will be drawn from the batteries, so disconnect the BNC when not in use.** Remove top cover to replace the 3V lithium cells with Duracell Model DL2430, positive side down.
 - b. Units with an external power supply should at least receive the voltage that is printed on the plug.

C. Increasing the power incident on the detector does not result in a higher voltage signal on the oscilloscope:

1. The detector is probably saturated. You should lower the power incident on the detector to a level below the saturation point.

IV. Drawings: Non-amplified High Speed Photodetectors

A. ET-3500, ET-4000, ET-5000 Dimensions:



V. Specifications: Non-amplified High Speed Photodetectors

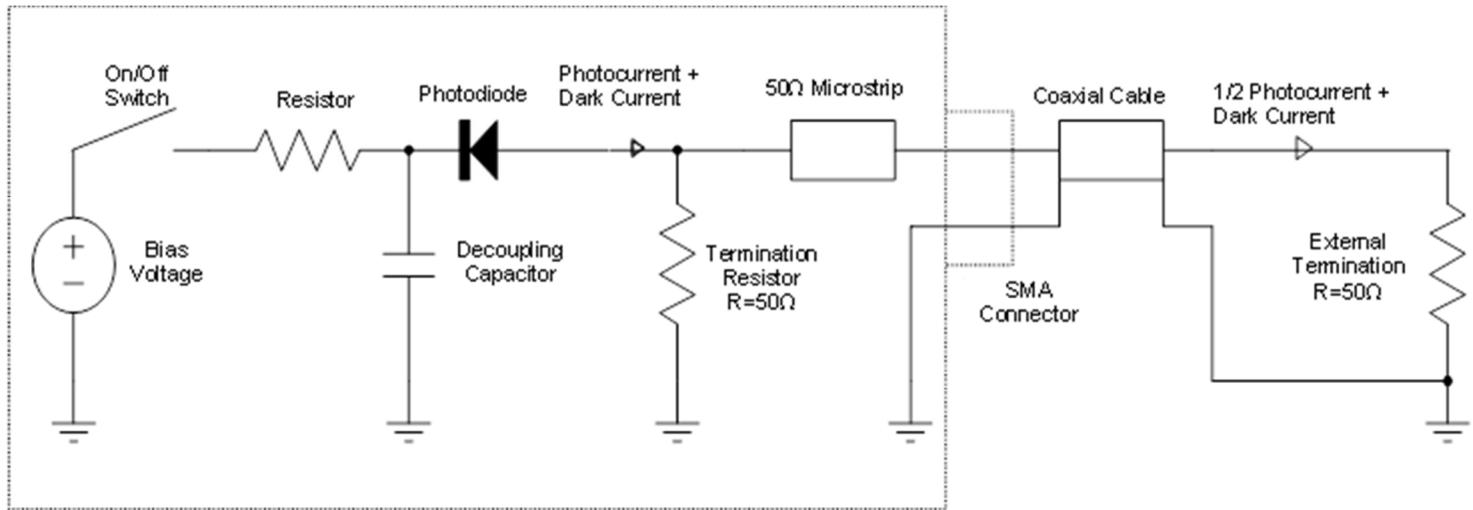
| Part No. (Model) | 120-10058-0001 ^a (ET-3500) | 120-10071-0001 ^a (ET-4000) | 120-10105-0001 ^a (ET-5000) |
|--|---------------------------------------|---------------------------------------|---------------------------------------|
| Rise Time/Fall Time (ps) | <25/<25 | <30/<30 | 28 |
| Responsivity (A/W) ^b | >0.90 at 1300nm | 0.53 at 830nm | 1.3 at 2000nm |
| Power Supply (VDC) | 6 | 6 | 3 |
| Bandwidth | >15GHz | >12.5GHz | >12.5GHz |
| Active Area Diameter (μm) | 32 | 60 | 40 |
| Dark Current | <3nA | <0.5nA | <1μA |
| Acceptance Angle (1/2 angle) | 15° | 15° | 20° |
| Noise Equivalent Power (pW/√Hz) ^c | <0.03 at 1300nm | <0.02 at 830nm | <0.44 at 2000nm |
| Mounting (Tapped Holes) | 8-32 or M4 | 8-32 or M4 | 8-32 or M4 |
| Output Connector | SMA | SMA | SMA |

^a All specifications apply for a 50Ω termination unless otherwise noted.

^b Photodetectors have an internal 50Ω termination. Responsivity data applicable to diode only. Detector output should be determined based on 1/2 the responsivity of that shown on graph.

^c Noise Equivalent Power (NEP) determined via short circuit output.

VI. Schematics: Non-amplified High Speed Photodetectors



VI. Warranty Statement and Repair

EOT warrants its products to be free from defects in material and workmanship and complies with all specifications. EOT will at its option, repair or replace any product or component found to be defective during the warranty period. This warranty applies only to the original purchaser and is not transferrable for a period of one year after date of original shipment. The foregoing warranties shall not apply, and EOT reserves the right to refuse warranty service, should malfunction or failure result from:

- a. Damage caused by improper installation, handling or use.
- b. Unauthorized product modification or repair.
- c. Operation outside the environmental or damage specifications of the product.
- d. Contamination not reported to EOT within 30 days of the original ship date.

This warranty is exclusive in lieu of all other warranties whether written, oral, or implied. EOT specifically disclaims the implied warranties of merchantability and fitness for a particular purpose. In no event shall EOT be liable for an indirect, incidental, or consequential damages in connection with its products.

If the customer believes there is a problem with the photodetector, they should immediately contact EOT's Sales/Customer department at 231-935-4044 or customerservice@eotech.com. EOT's Customer Service department will either issue an RMA for the device, or provide the customer with a procedure and authorize the customer to modify the device. All returns should reference the RMA number on the outside of the shipping container and should be sent to:

Electro-Optics Technology, Inc.
Attn: Sales/Customer Service
5835 Shugart Lane
Traverse City, MI 49684 USA

EOT reserves the right to inspect photodetectors returned under warranty to assess if the problem was caused by a manufacturer defect. If EOT determines the problem is not due to a manufacturer defect,



repairs will be done at the customer's expense. EOT will always provide a written quote for repair prior to performing repairs at the customer's expense.

VIII. Glossary of Terms

Bandwidth: The range of frequencies from 0Hz (DC) to the frequency at which the amplitude decreases by 3dB. Bandwidth and rise time can be approximately related by the equation:
Bandwidth \approx 0.35/rise time for a Gaussian pulse input.

Bias Voltage: The photodiode's junction capacitance can be modified by applying a reverse voltage. The bias voltage reduces the junction capacitance, which causes the photodiode to have a faster response.

Dark Current: When a termination is present, a dark current (nA range) will flow if the photodiode is biased. Disconnecting the coaxial cable will prevent this current from flowing.

Decoupling Capacitor: Maintains bias voltage when fast pulses cause the battery voltage to reduce (this would slow the response time of the photodiode); the capacitor allows the battery to recover to its initial voltage. It also acts as a filter for external power supplies.

Noise Equivalent Power (NEP): A function of responsivity and dark current and is the minimum optical power needed for an output signal to noise ratio of 1. Dark current is the current that flows through a reverse biased photodiode even when light is not present, and is typically on the order of nA. Shot noise (I_{shot}) is a source of noise generated in part by dark current; in the case of reversed biased diodes it is the dominant contributor. NEP is calculated from shot noise and responsivity. For example, for a responsivity @ 830nm = 0.5 A/W:

$$Shot_Noise = \sqrt{2qI_d} = \sqrt{2(1.6 \times 10^{-19} As)(20 \times 10^{-9} A)} = 0.08 pA \sqrt{s} = 0.08 pA / \sqrt{Hz}$$

$$NEP = I_{shot} / R_{830nm} = \frac{0.08 pA}{\sqrt{Hz}} * \frac{W}{0.5A} = 0.16 pW / \sqrt{Hz}$$

q = charge on an electron

Photodiode: Converts photons into a photocurrent.

Resistor: Protects the photodiode from excessive current. This could occur if an external power supply was too high in voltage, or if its polarity were reversed; this happens when a customer uses their own power supply.

Responsivity: In amps per watt (A/W), responsivity is the current output of the photodiode for a given input power, and is determined by the diode structure. Responsivity varies with wavelength and diode material.

Rise Time/Fall Time: Rise Time is the time taken by a signal to change from a specified low value to a specified high value. Fall Time is the time taken for the amplitude of a pulse to decrease from a specified value to another specified value. A larger junction capacitance will slow the detector's response time.



SMA Connector: Used to connect the customer's coaxial cable for high frequencies.

Termination Resistor (50Ω): Reduces signal reflections and balances the 50Ω microstrip/coaxial cable lines. As a result, half the photodiode current is lost to the internal resistor.