

High Performance Balanced Photodetector (BPD-1)



- ▶ High sensitivity; selectable 5 V/mW and 10 V/mW
- ▶ Wide bandwidth; DC to 400 MHz
- ▶ Very low noise, NEP <math>< 5 \text{ pW}/\sqrt{\text{Hz}}</math>
- ▶ Ideal for low-noise or high-speed detection, dual-balanced or single-ended
- ▶ Optimized for high-speed swept source OCT with low harmonic distortion and low group delay
- ▶ High speed dual balanced output and positive and negative monitor outputs
- ▶ Small body size
- ▶ Easy installation with optional flange or post mount

The BPD-1 differential photodetector is a DC to 400 MHz dual balanced photodetector optimized for swept source OCT (SS-OCT) imaging systems. By careful design, the BPD-1 supports high speed SS-OCT, minimizing factors that other detectors do not even specify, such as harmonic distortion and group delay. Importantly, with high speed and low noise applications such as with new generation lasers, the laser noise can be an order of magnitude below older lasers, so the detector may limit the overall system noise performance and resulting image quality. The NEP of less than 5 pW/Hz is exemplary, and is roughly 75% lower than comparable devices.

Since signal levels in SS-OCT systems can vary from setup to setup, a selectable 5 V/mW or 10 V/mW gain can be selected with little performance impact. Selectable gain allows the signal level to be adjusted to maximize the use of the analog-to-digital conversion dynamic range, avoiding loss of effective bits of resolution.

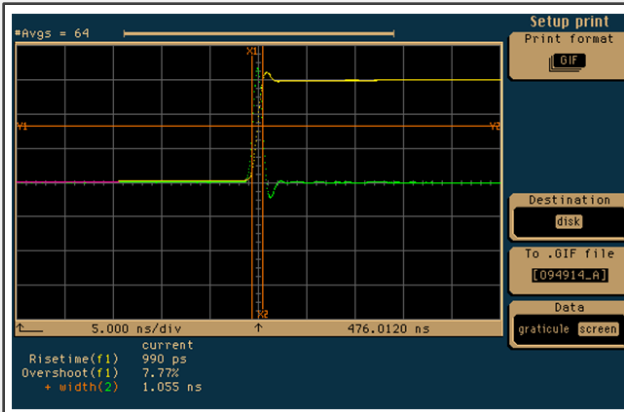
The BPD-1 is configured as a dual-balanced receiver by subtracting the two optical input signals from each other, resulting in the cancellation of common mode noise. Dual balanced detection allows small changes in the signal path to be extracted from the interfering noise floor.

The detector consists of two balanced photodiodes and an ultra-low-noise, high-speed transimpedance amplifier. Matching the two photodiodes results in an excellent common mode rejection ratio (CMRR), leading to better noise reduction. The detector a balanced RF-output from the transimpedance amplifier, and the Monitor+ and Monitor- ports allow the response of each photodiode to be observed individually to verify performance of each leg independently.

The detectors are fiber coupled with SMF-28 fiber, reducing the chance of image artifacts that can occur with detector coupling optics.

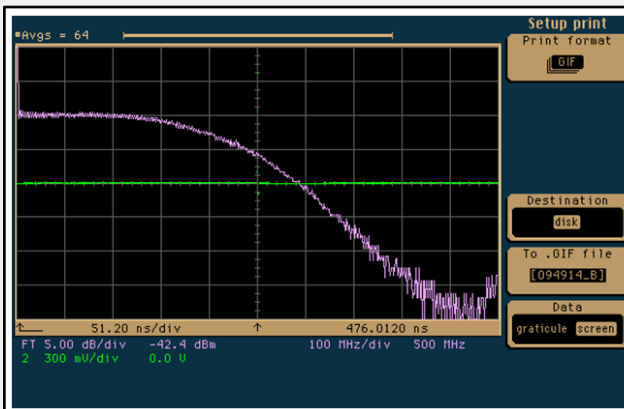
Insight has worked with one of the world's top analog design teams at Graviton in Japan to create the BPD-1. Graviton, and their founder and top designer, Nagatomo-san, have created some of the world's best audio amplifiers for decades, Nagatomo has also built some of the world's best photodetector devices, including precision devices up to 8 GHz. By careful attention to parts, layout, topology and design, critical factors such as parasitic capacitance is reduced by multiples, supporting overall performance substantially better than other devices.

Typical Performance Data



Impulse / Step Response
Positive Optical Input
5V/mW Gain

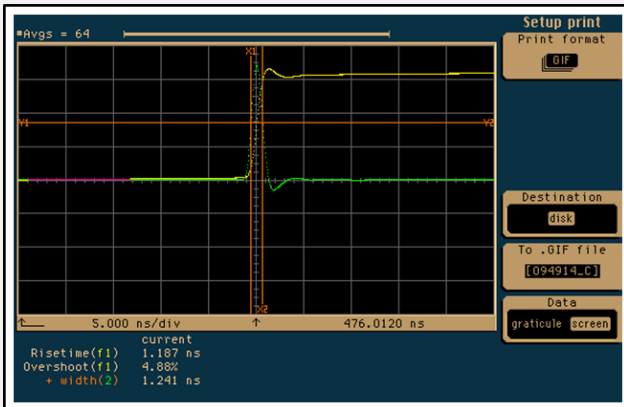
X-axis: 5 ns/div
Y-axis: 300 mV/div



Frequency Response
Positive Optical Input
5V/mW Gain

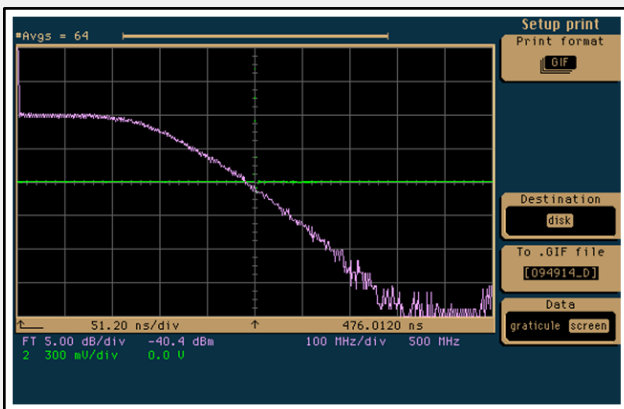
(Calculated from the impulse response shown above.)

X-axis: 100 MHz/div
Y-axis: 5 dB electrical/div
Center frequency: 500 MHz



Impulse / Step Response
Positive Optical Input
10V/mW Gain

X-axis: 5 ns/div
Y-axis: 300 mV/div

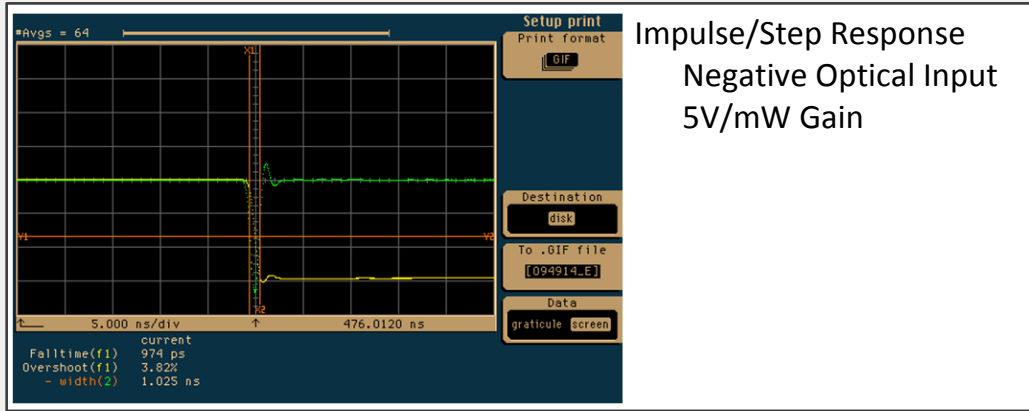


Frequency Response
Positive Optical Input
10V/mW Gain

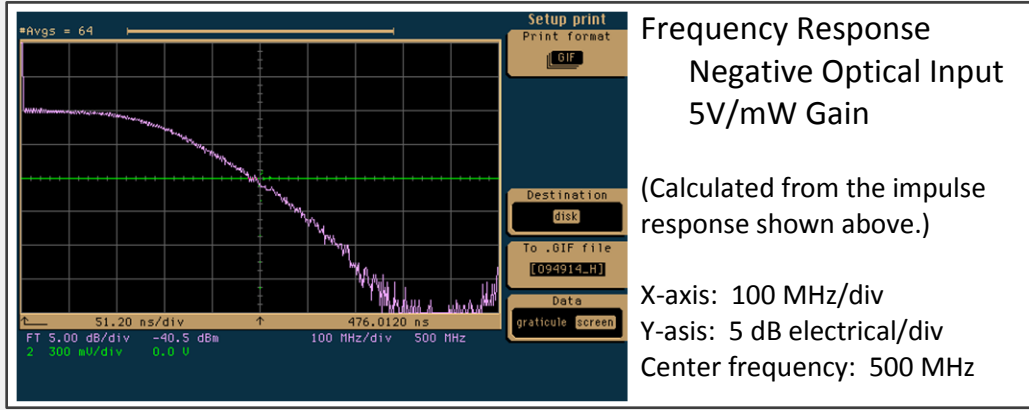
(Calculated from the impulse response shown above.)

X-axis: 100 MHz/div
Y-axis: 5 dB electrical/div
Center frequency: 500 MHz

Typical Performance Data (cont.)



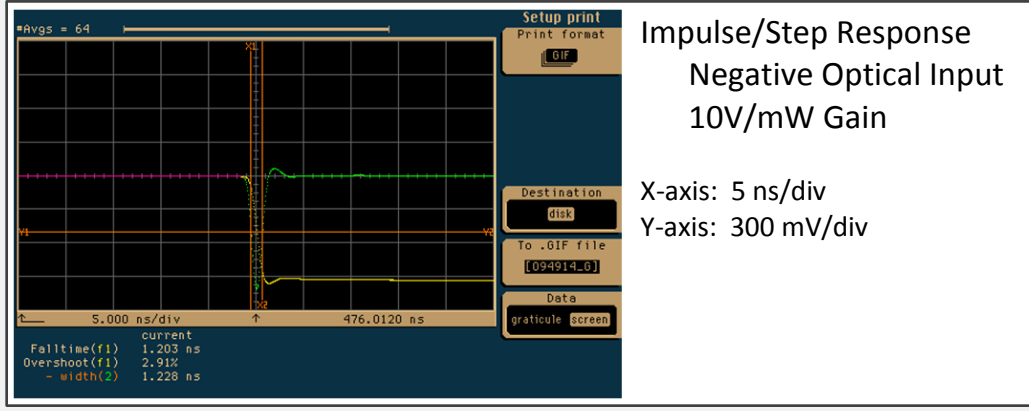
Impulse/Step Response
Negative Optical Input
5V/mW Gain



Frequency Response
Negative Optical Input
5V/mW Gain

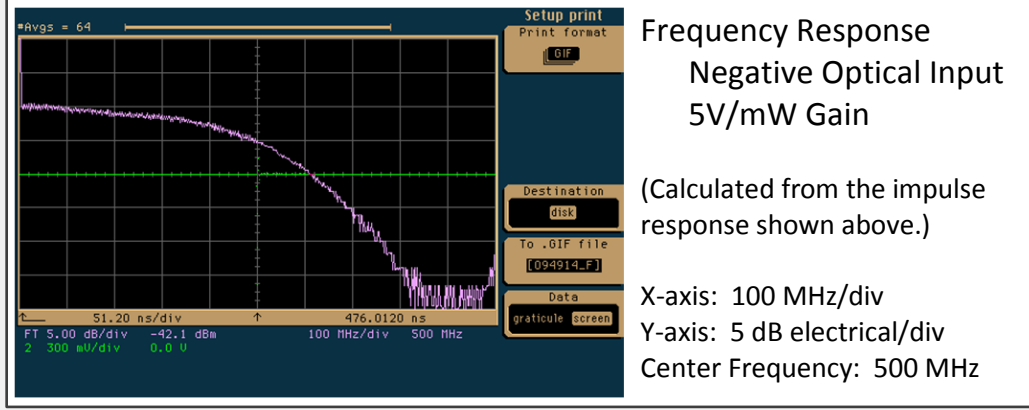
(Calculated from the impulse response shown above.)

X-axis: 100 MHz/div
Y-axis: 5 dB electrical/div
Center frequency: 500 MHz



Impulse/Step Response
Negative Optical Input
10V/mW Gain

X-axis: 5 ns/div
Y-axis: 300 mV/div

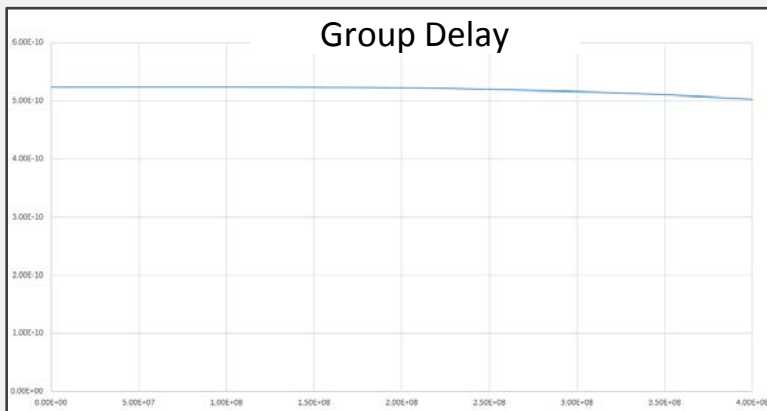
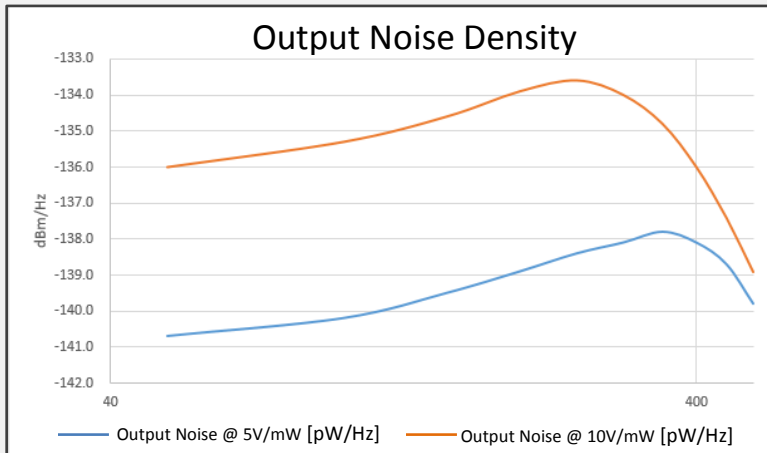
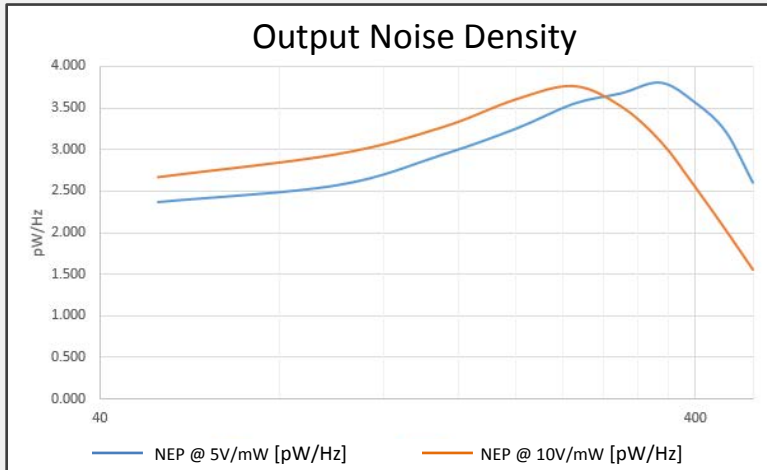


Frequency Response
Negative Optical Input
5V/mW Gain

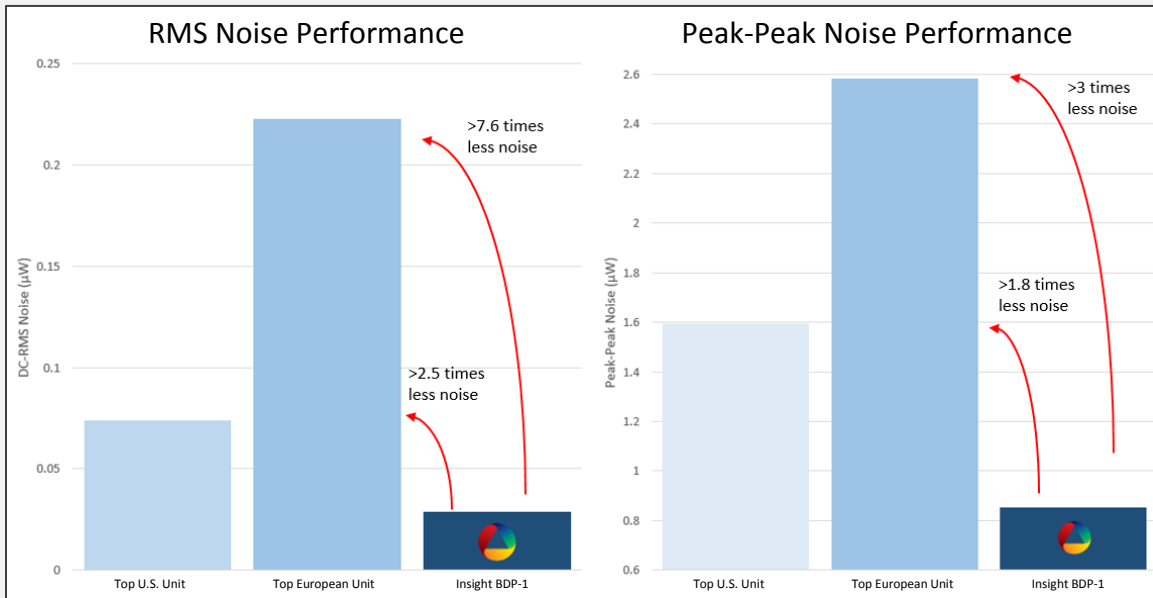
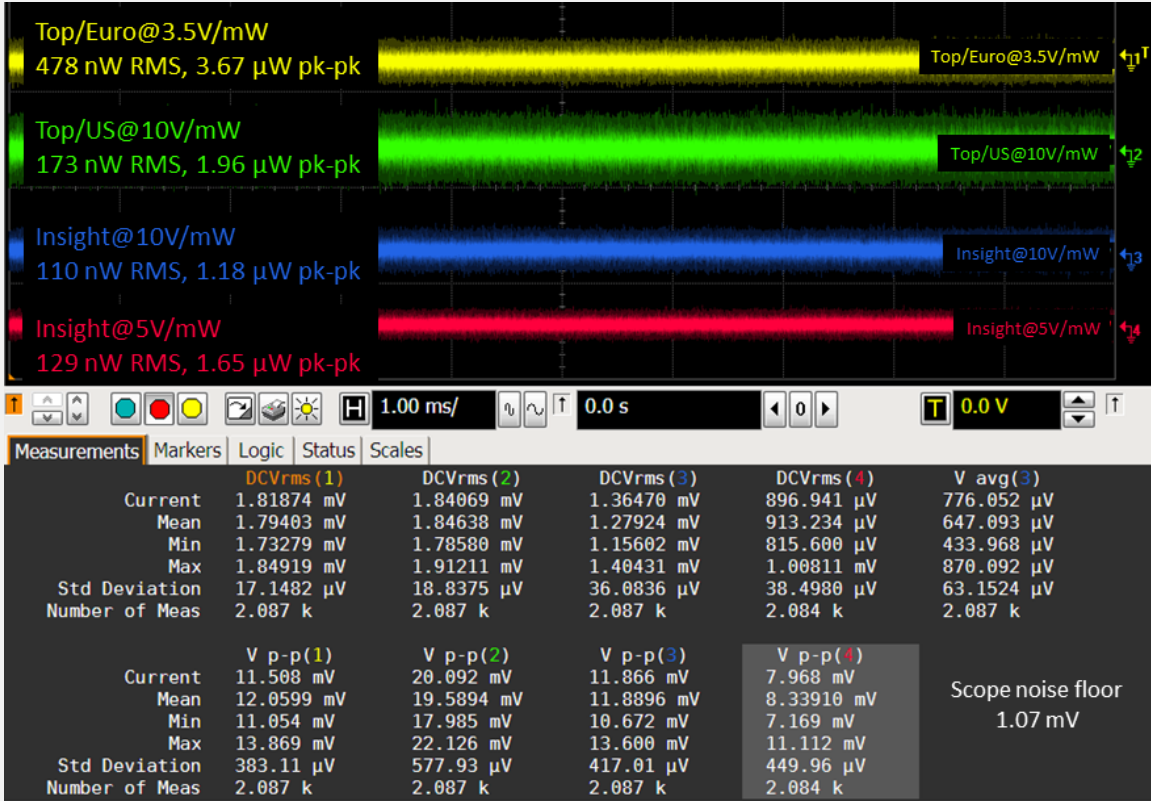
(Calculated from the impulse response shown above.)

X-axis: 100 MHz/div
Y-axis: 5 dB electrical/div
Center Frequency: 500 MHz

Typical Performance Data (cont.)



Typical Performance Data (cont.)



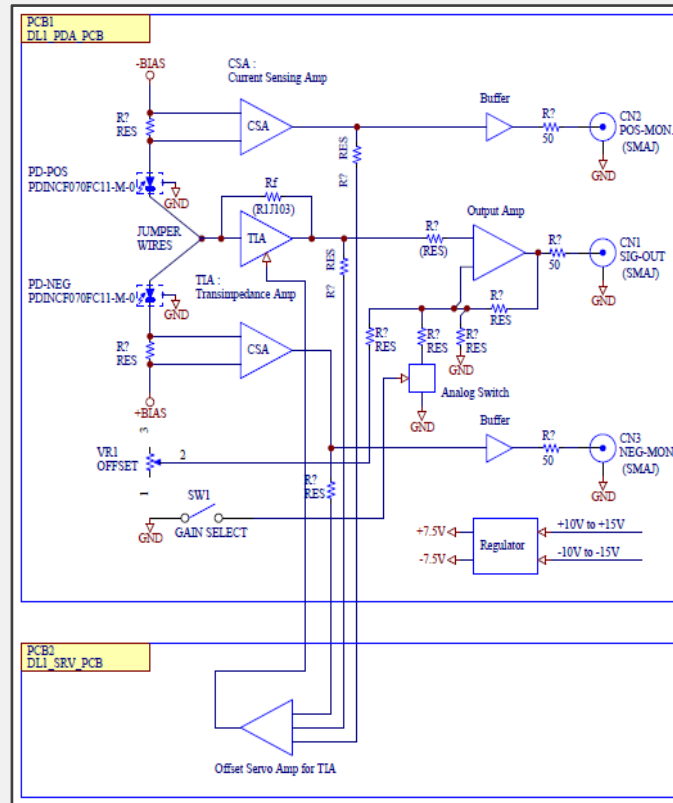
(Data with scope base noise removed.)



Specifications PRELIMINARY

Item	Conditions	Value (Design Target)
Detector type	--	InGaAs PIN photodiode
Optical inputs	--	FC/APC
Acceptable fiber	--	Single mode fiber
Operating wavelength	--	950 nm to 1650 nm
Responsivity of PD	1310 nm; FC/APC	0.85 mA/mW
Active detector diameter	--	0.075 mm
Optical back reflection	--	Less than -40 dB
PD damage threshold	--	8 mW
RF output impedance	--	50 ohm
RF output bandwidth	50 Ω load	DC to 400 MHz @ 5 V/mW; DC to 300 MHz @ 10V/mW
RF output conversion gain	1310 nm; 50 Ω load	5 V/mW; 10 V/mW; switchable
RF output CW saturation power	1310 nm; 5V/mW; 50 Ω load	400 μ W (-4 dBm)
RF output voltage swing	50 ohm load Hi-Z load	\pm 2 V \pm 4 V
RF output coupling	--	DC Coupling
RF output connector	--	SMA Jack
NEP	DC to 100 MHz; 50 Ω load	< 5 pW/ \sqrt Hz @ 5 V/mW; < 4 pW/ \sqrt Hz @ 10 V/mW
RF output voltage noise	DC to 12.4GHz, 50 Ω load	< 0.7 mV RMS @ 5 V/mW; < 1.1 mV RMS @ 10 V/mW;
RF output offset voltage	50 Ω load	Within \pm 0.1 mV
Common mode rejection	--	>25 dB
Monitor output impedance	--	50 Ω
Monitor output bandwidth	Hi-Z load	DC to 100 kHz
Monitor output conversion gain	1310 nm; Hi-Z load	10 V/mW; 20 V/mW; switchable
Monitor output voltage swing	50 ohm load Hi-Z load	\pm 5 V \pm 10 V
Monitor output voltage noise	DC to 12.4 GHz; 50 Ω load	Less than 0.6 mV RMS
Monitor output offset voltage	Hi-Z load	Within \pm 0.1 mV
DC supply voltage	--	\pm 10V to \pm 15V or 0-20V to 0-30V
AC accessory supply	Input	110-240 VAC
Consumption current	50 Ω load; full swing	Less than \pm 300 mA
Operating temperature	--	0 $^{\circ}$ C to 40 $^{\circ}$ C
Storage temperature	--	-40 $^{\circ}$ C to 70 $^{\circ}$ C
Dimensions (width x depth x height)	Without connectors; no flange	60 mm x 60 mm x 23 mm
Dimensions (width x depth x height)	Without connectors; flange	60 mm x 76 mm x 23 mm
Mounting		Dual flange or optical post
Included accessories		Power supply, flange mount
Weight	With flange	0.2 kg (<0.5 lbs)

Block Diagram

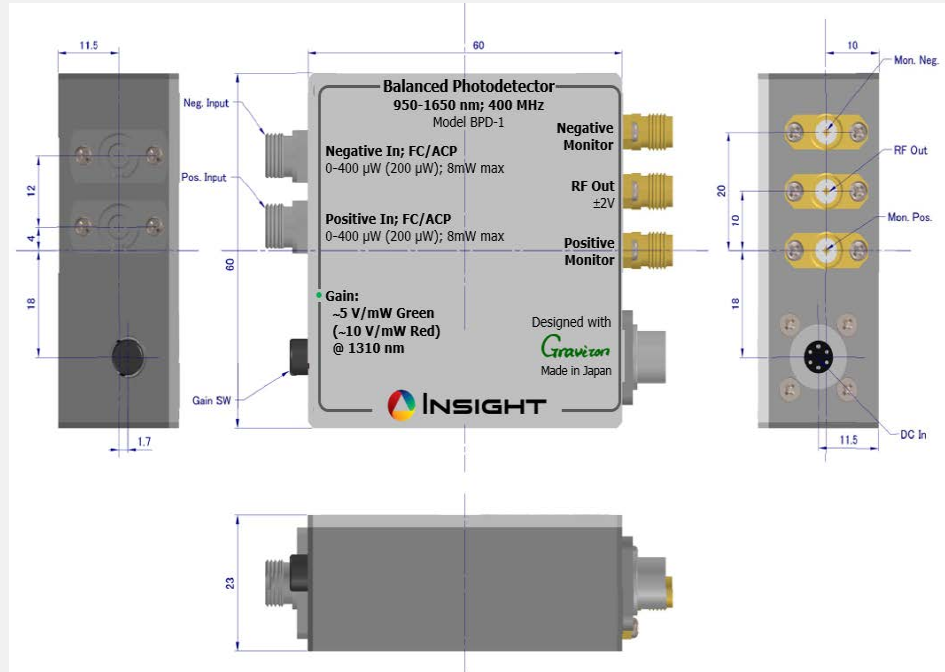


Performance Characteristics

Frequency [Hz]	DC Transimpedance [ohms]	Real part of the denominator	Im part of the denominator	Transimpedance [ohms] ²	Response [dB ohms]	Phase [deg]	Group Delay [s]
1.00E+03	9.66E+03	1.00E+00	3.29E-06	9655.17-0.03i	79.70	-0.0002	5.23E-10
1.50E+03	9.66E+03	1.00E+00	4.93E-06	9655.17-0.05i	79.70	-0.0003	5.23E-10
2.20E+03	9.66E+03	1.00E+00	7.23E-06	9655.17-0.07i	79.70	-0.0004	5.23E-10
3.30E+03	9.66E+03	1.00E+00	1.09E-05	9655.17-0.11i	79.70	-0.0006	5.23E-10
4.70E+03	9.66E+03	1.00E+00	1.55E-05	9655.17-0.15i	79.70	-0.0009	5.23E-10
6.80E+03	9.66E+03	1.00E+00	2.24E-05	9655.17-0.22i	79.70	-0.0013	5.23E-10
1.00E+04	9.66E+03	1.00E+00	3.29E-05	9655.17-0.32i	79.70	-0.0019	5.23E-10
1.50E+04	9.66E+03	1.00E+00	4.93E-05	9655.17-0.48i	79.70	-0.0028	5.23E-10
2.20E+04	9.66E+03	1.00E+00	7.23E-05	9655.17-0.71i	79.70	-0.0041	5.23E-10
3.30E+04	9.66E+03	1.00E+00	1.09E-04	9655.17-1.05i	79.70	-0.0062	5.23E-10
4.70E+04	9.66E+03	1.00E+00	1.55E-04	9655.17-1.49i	79.70	-0.0089	5.23E-10
6.80E+04	9.66E+03	1.00E+00	2.24E-04	9655.17-2.16i	79.70	-0.0128	5.23E-10
1.00E+05	9.66E+03	1.00E+00	3.29E-04	9655.17-3.18i	79.70	-0.0188	5.23E-10
1.50E+05	9.66E+03	1.00E+00	4.93E-04	9655.17-4.76i	79.70	-0.0283	5.23E-10
2.20E+05	9.66E+03	1.00E+00	7.23E-04	9655.17-6.99i	79.70	-0.0415	5.23E-10
3.30E+05	9.66E+03	1.00E+00	1.09E-03	9655.16-10.48i	79.70	-0.0622	5.23E-10
4.70E+05	9.66E+03	1.00E+00	1.55E-03	9655.16-14.92i	79.70	-0.0886	5.23E-10
6.80E+05	9.66E+03	1.00E+00	2.24E-03	9655.14-21.59i	79.70	-0.1281	5.23E-10
1.00E+06	9.66E+03	1.00E+00	3.29E-03	9655.1-31.75i	79.70	-0.1884	5.23E-10
1.50E+06	9.66E+03	1.00E+00	4.93E-03	9655.02-47.63i	79.70	-0.2826	5.23E-10
2.20E+06	9.66E+03	1.00E+00	7.23E-03	9654.84-69.85i	79.70	-0.4145	5.23E-10
3.30E+06	9.66E+03	1.00E+00	1.09E-02	9654.42-104.78i	79.70	-0.6218	5.23E-10
4.70E+06	9.66E+03	1.00E+00	1.55E-02	9653.64-149.22i	79.69	-0.8856	5.23E-10
6.80E+06	9.66E+03	1.00E+00	2.24E-02	9651.97-215.87i	79.69	-1.2813	5.23E-10
1.00E+07	9.66E+03	1.00E+00	3.29E-02	9648.25-317.4i	79.69	-1.8842	5.23E-10
1.50E+07	9.66E+03	9.99E-01	4.93E-02	9639.59-475.89i	79.69	-2.8263	5.23E-10
2.20E+07	9.66E+03	9.98E-01	7.23E-02	9621.67-697.34i	79.69	-4.1453	5.23E-10
3.30E+07	9.66E+03	9.96E-01	1.09E-01	9579.87-1043.76i	79.68	-6.2181	5.23E-10
4.70E+07	9.66E+03	9.92E-01	1.55E-01	9502.73-1480.66i	79.66	-8.8563	5.23E-10
6.80E+07	9.66E+03	9.83E-01	2.24E-01	9337.41-2123.79i	79.62	-12.8139	5.23E-10
1.00E+08	9.66E+03	9.64E-01	3.29E-01	8974.62-3062.83i	79.54	-18.8436	5.23E-10
1.50E+08	9.66E+03	9.18E-01	4.93E-01	8160.67-4384.6i	79.34	-28.2484	5.23E-10
2.20E+08	9.66E+03	8.24E-01	7.23E-01	6616.84-5810.86i	78.90	-41.2894	5.21E-10
3.30E+08	9.66E+03	6.04E-01	1.09E+00	3779.38-6794.84i	77.81	-60.9166	5.13E-10
4.00E+08	9.66E+03	4.18E-01	1.32E+00	2116.91-6667.94i	76.90	-72.3866	5.03E-10



Physical Dimensions (with and without user-detachable flange)



Ordering Information

Model	Wavelength	BW	Gain	Saturation/Max Power	NEP	Delivery
BPD-1	980-1650 nm	400MHz (300MHz)	5 V/mW (10 V/mW)	400 μ W/8 mW	< 5 pW/vHz @ 5 V/mW < 4 pW/vHz @ 10 V/mW	2 days ARO after 12/15/14

* User-detachable flange included.

Document Version 2015-05-04



Insight Photonic Solutions, Inc. • 300 S. Public Road • Lafayette, CO 80026 • USA
info@sweptlaser.com • www.sweptlaser.com. • +1 (303) 604-5160