Fast

Infrared Detectors

Room Temperature and TE-cooled

PV & PC

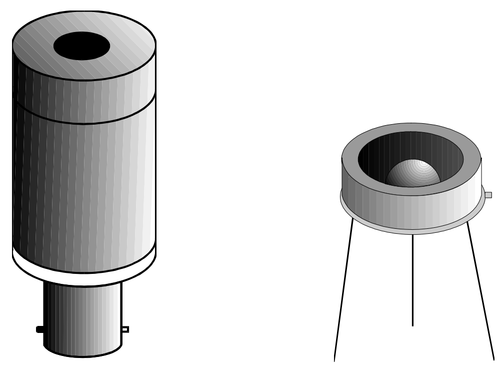
HgCdZnTe

Preamplifiers & turnkey laboratory detection sets

Boston Electronics Corporation
91 Boylston Street, Brookline MA 02445 USA
(800)347-5445 or (617)566-3821 fax (617)731-0935
www.boselec.com irdetectors@boselec.com

PD-10.6 Series
Photovoltaic CO_2 Laser Detectors

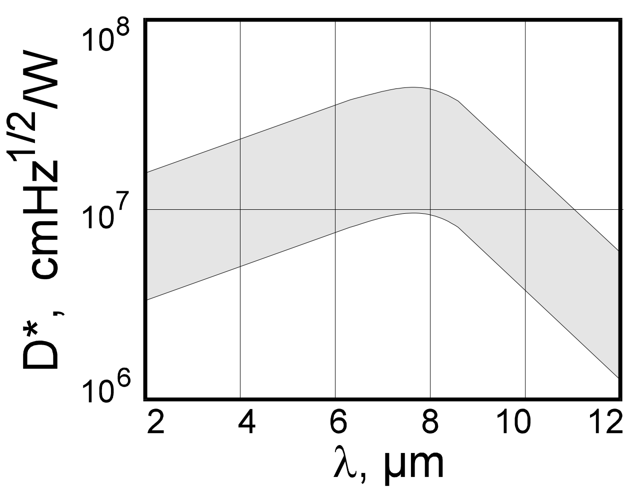
PHOTOVOLTAIC CO_2 Laser Detectors
2-12 µm IR PHOTODETECTORS
ROOM TEMPERATURE



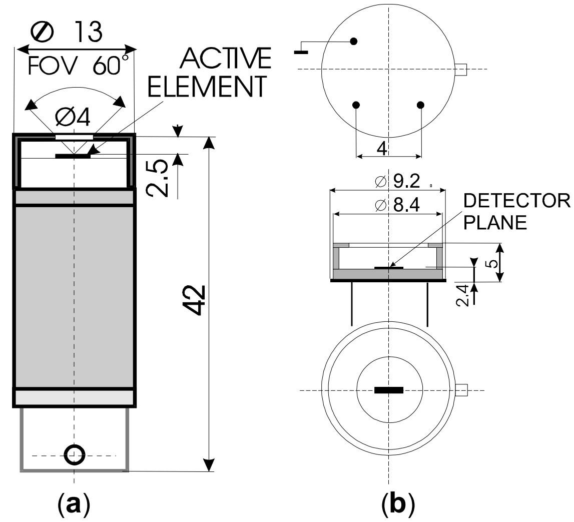
FEATURES

- Room temperature operation
- No bias required
- Wide spectral range (2-12 µm)
- D*(10.6 µm) > $2 \cdot 10^6$ $cmHz^{1/2}/W$
- Time constant τ < 1 nsec
- No *1/f* (flicker) noise
- Operation DC to > 800 MHz
- Lightweight and rugged
- Convenient and reliable

SPECTRAL RESPONSE



Typical spectral detectivity of PD detectors as a function of wavelength.



Devices are packaged in specialized packages with BNC connectors (**a**) for broadband applications and in inexpensive modified TO-5-style packages (**b**) for low frequency operation (0-20 MHz). The devices are usually mounted with no windows. Packages with customer specified connectors and windows are also available.

DESCRIPTION

PD series detectors operate by the photodiffusion effect, producing photovoltage in the semiconductor. The devices are optimized for 10.6 µm and are useful at all shorter wavelengths. Recent improvements include use of the newly developed quaternary semiconductor (Hg-Cd-Zn-Te) with selected composition and profiled doping. PD series detectors offer improved performance and speed. They are housed in small, lightweight, rugged packages. Measured performance data are provided with each detector.

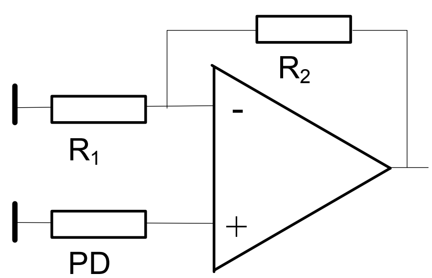
PD series detectors are exceptionally well suited for high frequency and heterodyne detection of 10.6 µm radiation due to their very short response time. Exhibiting no 1/*f* (flicker) noise, they can also be used for detection of CW and low frequency modulated radiation anywhere in the 2-12 µm spectral range.

SPECIFICATIONS

Specifications are subject to change without notice. Specifications measured @20°C, 1x1 active area.

Characteristics	Units	PD-10.6-3	PD-10.6-5	PD-10.6-8
Spectral range	µm	2 – 12		
Response time	nsec	<1		
Detectivity (peak)	$cmHz^{1/2}/W$	$>8\cdot10^6$	$>2\cdot10^7$	$>3.2\cdot10^7$
Detectivity (10.6 µm)	$cmHz^{1/2}/W$	$>3\cdot10^6$	$>5\cdot10^6$	$>8\cdot10^6$
Responsivity-Width product (10.6 µm)	V·mm/W	>0.03	>0.05	>0.08
Area	mm^2	0.1×0.1; 0.2×0.2, 0.5×0.5; 1×1, 2×2, 3×3; 4×4		
Field of view	deg	>60		
Sheet Resistivity	Ω	50 – 120		
Max. signal per mm of element length, Single Pulses <1 µsec..... CW....................................	V/mm	>0.60 >0.01	>1.0 >0.015	>1.6 >0.024

TYPICAL OPERATING CIRCUIT



CAUTION

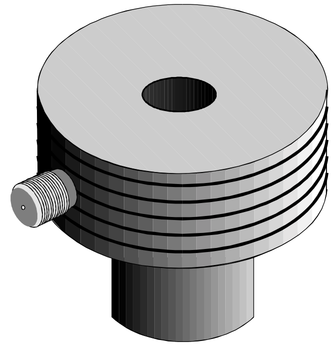
- CW optical power must not exceed $100W/cm^2$!
- Pulses shorter than must not exceed $1MW/cm^2$!

More Information: see J. Piotrowski et al., “New generation of near-room temperature photodetectors”, Optical Engineering, May 1994, Vol. 33 No. 5, pages 1413-1421

We supply compatible low-noise preamplifiers with bandwidths from DC to 200 MHz or, AC-coupled, to 500^+ MHz. These detectors require no bias voltage and exhibit no *1/f* (flicker) noise and thus have optimum performance from DC to very high frequencies.

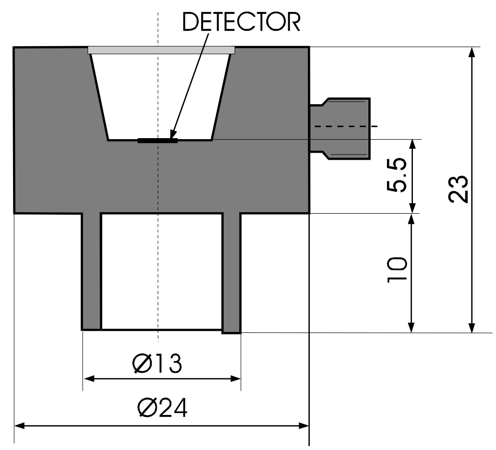
PEM-L Series
Photovoltaic CO_2 Laser Detector

FAST CO_2 LASER DETECTORS
2-12 µm PHOTOVOLTAIC
ROOM TEMPERATURE

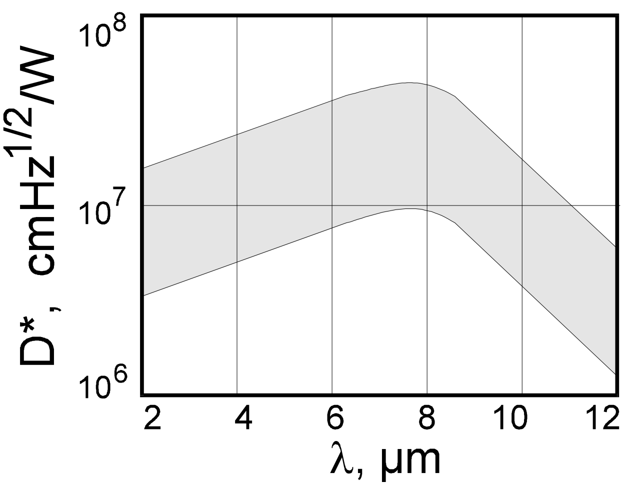


FEATURES

- Ambient temperature operation
- No bias required
- Wide spectral range (<2-12 µm)
- D*(10.6 µm) >4x10^6 cmHz$^{1/2}$/W
- Response time of <0.5 nsec
- No flicker (*1/f*) noise
- Operation from DC to >800MHz
- Lightweight, rugged and reliable
- Very convenient to use



SPECTRAL RESPONSE



Typical spectral detectivity of PEM-L detectors as a function of wavelength. Spectral detectivities can be tailored upon request within the range indicated.

Devices are mounted in specialized packages with SMA connectors designed for wide bandwidth applications. A permanent magnet bias circuit is incorporated in the package. A BaF_2 window is supplied as a standard.

DESCRIPTION

PEM-L series detectors operate on the photoelectromagnetic effect, and produce photovoltage in response to incoming photons. The devices are optimized for performance at 10.6 µm but are useful at other wavelengths also. Recent improvements include the newly developed quaternary semiconductor (HgCdZnTe) with selected composition and doping profiles, and use of miniature rare-earth permanent magnets to produce very strong magnetic fields. The PEM-L series detectors offer both sensitivity and speed against laser sources. Measured performance data are provided with each detector.

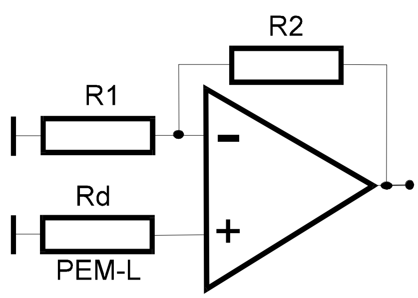
PEM-L detectors are well suited for heterodyne detection of 10.6 µm radiation due to their very short response time and to their perfect match to fast electronics. Exhibiting no *1/f* (flicker) noise, they can also be used for detection of CW and low frequency modulated radiation in the whole 2-12 µm spectral range.

SPECIFICATIONS

Specifications are subject to change without notice. Specifications measured @20°C, 1x1 active area.

Characteristics	Units	PEM-L-3
Spectral range	µm	2 - 12
Response time	nsec	<0.5
Detectivity (peak)	$cmHz^{1/2}/W$	$>8x10^6$
Detectivity (10.6 µm)	$cmHz^{1/2}/W$	$>4x10^6$
Responsivity-Width product (10.6 µm)	Vxmm/W	>0.04
Element Area	mm^2	0.05x0.05, 0.1x0.1, 0.2×0.2; 0.5×0.5; 1×1; 2×2
Field of View	deg	>60
Resistivity	Ω	40 - 80
Max. signal per unit length Single Pulses, τ<1 µsec CW	V/mm	>0.60 >0.008

TYPICAL OPERATING CIRCUIT



CAUTION

- CW optical power must not exceed $100W/cm^2$!
- Pulses shorter than 1µs must not exceed $1MW/cm^2$!
- Avoid biasing!

We supply compatible low-noise preamplifiers with bandwidths from DC to 200 MHz or, AC-coupled, to 500+ MHz. These detectors require no bias voltage, exhibit no *1/f* (flicker) noise, and thus have optimum performance from DC to very high frequencies.

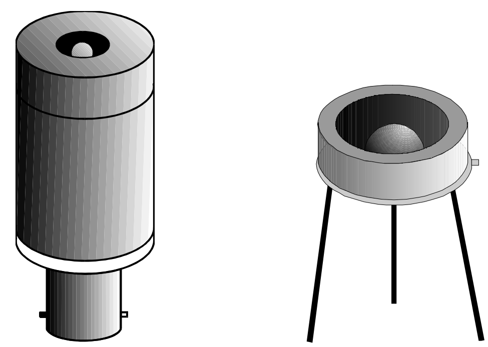
VIGO SYSTEM Ltd.

PDI Series
Photovoltaic IR Photodetectors

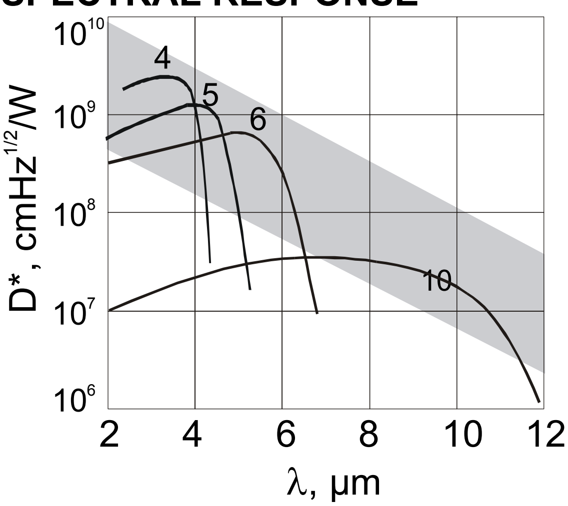
2-12µm IR PHOTODETECTORS
Fast PHOTOVOLTAIC

FEATURES

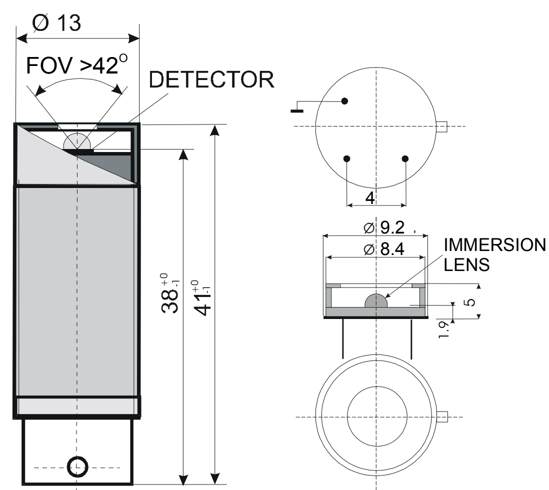
- Ambient temperature operation
- No bias required
- *Fast* response time
- No *1/f* (flicker) noise
- Operation from DC to VHF
- Perfect match to fast electronics
- Wide dynamic range



SPECTRAL RESPONSE



Spectral detectivities of PDI detectors.



a b

Devices are typically mounted in specialized packages with BNC connectors: **(a)** for broadband applications and **(b)** in modified TO-5-style packages for low frequency operation (DC to 20 MHz). The devices are usually delivered without windows.

Boston Electronics Corporation, 91 Boylston Street, Brookline MA 02445
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DESCRIPTION

The PDI-*n* series photodetectors (where n is wavelength λ_{op}, in micrometers, for which the detector is optimized) are photovoltaic IR detectors which have been optically immersed to high refractive index CdZnTe hemispherical or hyperhemispherical lenses. These devices can be optimized for the maximum performance anywhere from 2 to 12 µm. High performance and stability are achieved by using a newly developed variable gap semiconductors (Hg-Cd-Zn-Te) as well as graded composition and doping level profiles and optimization of surface processing. Custom devices are available on request.

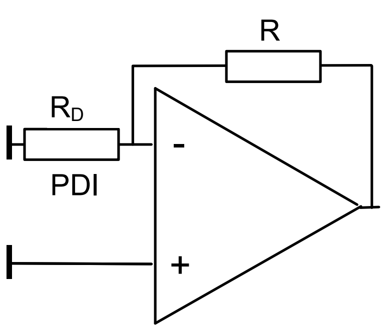
SPECIFICATIONS

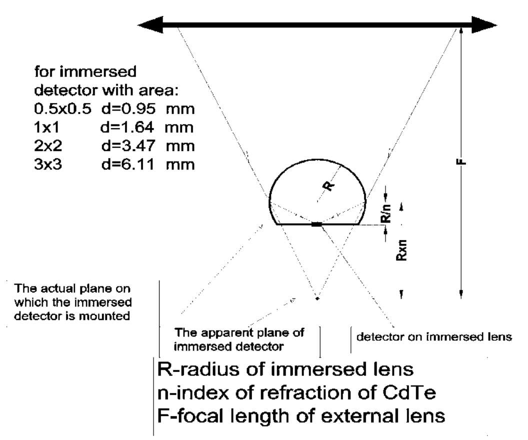
Specifications are subject to change without notice. Specifications measured @20°C, 1x1 active area.

Characteristics	Units	PDI-4	PDI-5	PDI-6	PDI-8	PDI-10.6
Optimization λ	µm	4	5	6	8	10.6
Detectivity at λ_p at λ_{op}	cmHz$^{1/2}$/W	$\geq 3\cdot10^9$ $\geq 1.5\cdot10^9$	$\geq 1.5\cdot10^9$ $\geq 5\cdot10^8$	$\geq 8\cdot10^8$ $\geq 3\cdot10^8$	$\geq 3\cdot10^8$ $\geq 1\cdot10^8$	$\geq 5\cdot10^7$ $\geq 1.5\cdot10^7$
Responsivity	V/W	≥30	≥6	≥2	≥1.5	≥0.15
Response Time	Nsec	≤15	≤15	≤12	≤7	≤1
Resistance	Ω	200 – 1500	60 – 250	10 – 150	<300	<150
	Deg	42				
	mm^2	0.2×0.2; 0.5×0.5; 1×1; 2×2				

≥42° FOV devices are available only for hemispherically immersed devices with D reduced by a factor of ≈3

TYPICAL OPERATING CIRCUIT





CAUTION

- CW optical power must not exceed 20W/cm^2!
- Pulses shorter than 1µs must not exceed 10kW/cm^2!
- Do not bias these detectors!

More Information: see J. Piotrowski et al., “New generation of near-room temperature photodetectors”, Optical Engineering, May 1994, Vol. 33 No. 5, pages 1413-1421

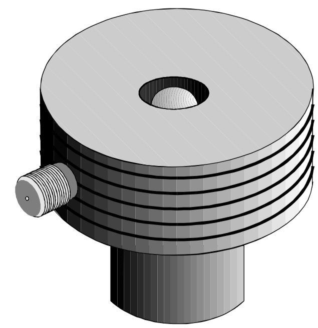
We supply compatible low-noise preamplifiers with bandwidths from DC to 200 MHz or, AC-coupled, to 500$^+$ MHz. These detectors require no bias voltage, exhibit no 1/f (flicker) noise, and thus have optimum performance from DC to very high frequencies.

PEMI-L Series
Photovoltaic CO_2 Laser Detectors

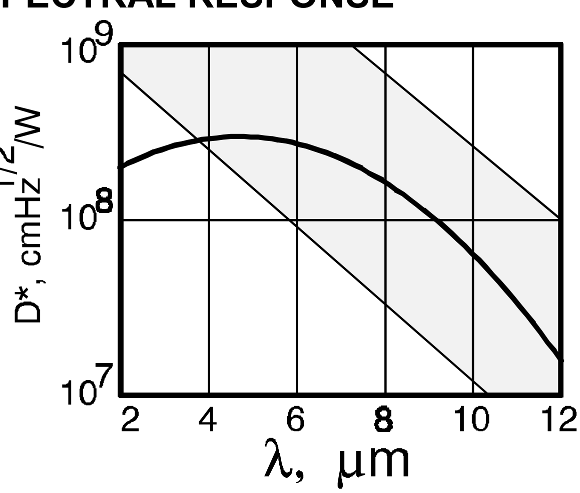
2-12 µm PHOTOVOLTAIC CO_2 LASER DETECTORS
ROOM TEMPERATURE, OPTICALLY IMMERSED

FEATURES

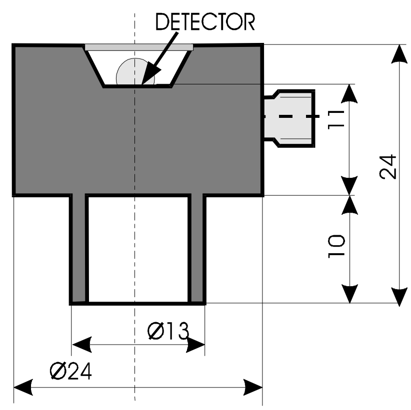
- Ambient temperature operation
- No bias required
- Wide spectral range (2-12 µm)
- D*(10.6 µm) to >$3 \ast 10^7$ cmHz$^{1/2}$/W
- Response time <0.5nsec
- No *1/f* (flicker) noise
- Operation from DC to >320 MHz
- Lightweight, rugged and reliable
- Very convenient to use



SPECTRAL RESPONSE



Typical spectral detectivity of PEMI-L detectors as a function of wavelength. Spectral detectivities can be tailored upon request within the shaded region.



These devices are mounted in specialized packages with SMA connectors designed for wide band applications. A permanent magnet bias circuit is incorporated into the package.

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DESCRIPTION

PEMI-L series detectors operate on the photoelectromagnetic effect and produce a photocurrent in response to incoming photons. The devices are optimized for the best performance at 10.6 µm but are useful at other wavelengths as well. Recent improvements include the newly developed quaternary semiconductor (HgCdZnTe) with selected composition and doping profiles, optical immersion of the detector on a high refractive index lens and inclusion of miniature permanent magnets to produce very strong magnetic bias fields. They are housed in rugged packages of small size and weight. Measured performance data are provided with each detector.

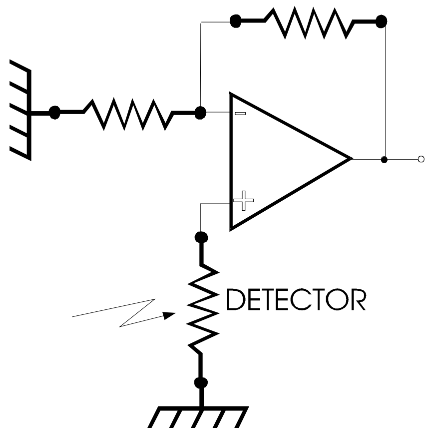
The PEMI-series are well suited for heterodyne detection of 10.6µm radiation due to a very short response time and to the perfect match to fast electronics. Exhibiting no flicker noise, they can also be used for detection of CW and low frequency modulated radiation in the whole 2-12µm spectral range.

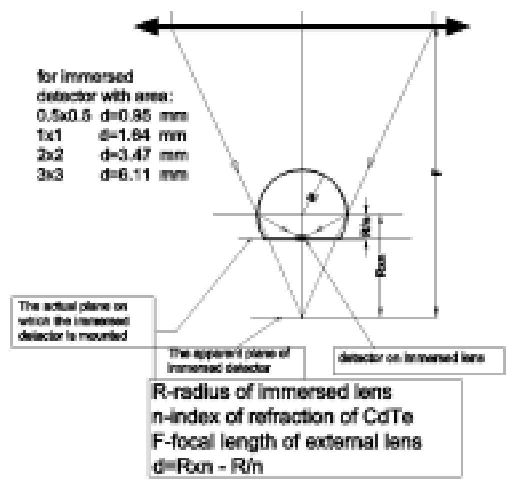
SPECIFICATION

Specifications are subject to change without notice. Specifications measured @20°C, 1x1 active area.

Characteristics	Units	PEMI-L-1	PEMI-L-2	PEMI-L-3
Spectral range	µm	2 - 12		
Time Constant	nsec	<0.5		
Detectivity (peak)	$cmHz^{1/2}/W$	$>3x10^7$	$>6x10^7$	$>1x10^8$
Detectivity (10.6 µm)	$cmHz^{1/2}/W$	$>1x10^7$	$>2x10^7$	$>3x10^7$
Responsivity-Width Product (10.6 µm)	Vxmm/W	>0.1	>0.2	>0.3
Area (optical)	mm^2	0.1×0.1; 0.2×0.2; 0.5×0.5; 1×1; 2x2		
Field of View	deg	>40		
Resistivity	Ω	40 - 80		

TYIPCAL OPERATING CIRCUIT



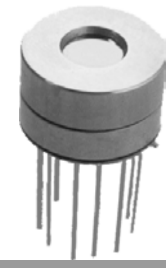


CAUTION

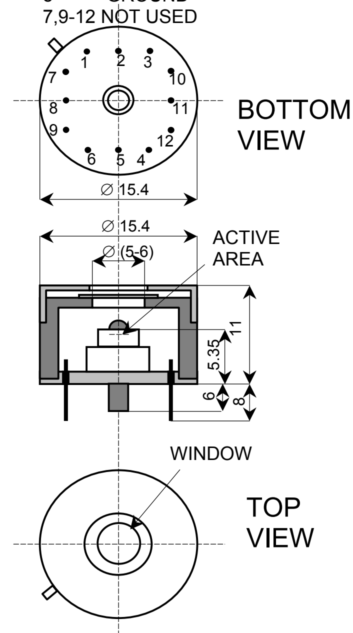
- CW optical power must not exceed $20W/cm^2$!
- Pulses shorter than 1µs must not exceed $10kW/cm^2$!
- Avoid electrical biasing!

We supply compatible low-noise preamplifiers with bandwidths from DC to 100 MHz or, AC-coupled, to 500+ MHz. These detectors require no bias voltage and exhibit no *1/f* (flicker) noise and thus have optimum performance from DC to very high frequencies.

2-12 µm IR
PHOTOVOLTAIC DETECTORS
THERMOELECTRICALLY COOLED
OPTICALLY IMMERSED
SERIES PDI-2TE



1	DETECTOR (+)
3	DETECTOR (-)
2	TE COOLER (+)
5	TE COOLER (-)
4-6	THERMISTOR
8	GROUND
7,9-12	NOT USED

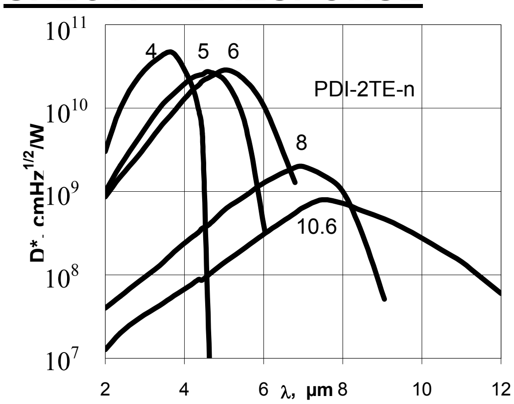


T0-8 STYLE HOUSING

FEATURES

- High performance in the 2-11 µm range withoutLN$_2$-cooling!
- Fast response
- No flicker (*1/f*) noise
- Convenient to use
- Wide dynamic range
- Compact, rugged and reliable

SPECTRAL RESPONSE



Typical spectral detectivities of PDI-2TE photovoltaic detectors (with BaF$_2$ windows)

PDI-2TE photodetectors are typically mounted on two-stage low-power thermoelectric coolers and packaged in modified T0-8-style cans. Standard devices are delivered with BaF$_2$ windows. Packages with ZnSe, CdTe, CaF$_2$, sapphire, AR-coated Si and Ge windows and with variety of connectors are available upon request. For proper operation, the units must be mounted on an appropriate heat sink to dissipate the heat generated by TE cooler.

APPLICATIONS

Detection of low and high frequency modulated 2-12 µm IR radiation ✹ IR spectroscopy ✹ fourier transform spectroscopy ✹ fast and multicolor pyrometry ✹ thermal imagers and scanners ✹ remote sensing ✹ gas analysis ✹ fire and flame detection ✹ human body detection ✹ laser beam diagnostics ✹ laser warning receivers ✹ laser radar, range finders and communications.

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DESCRIPTION

The PDI-2TE-n series detectors (where n is wavelength λ_{op}, in micrometers, for which the detector is optimized) are two-stage TE-cooled IR photovoltaic detectors, which have been optically immersed to high refractive index CdZnTe hemispherical or hyperhemispherical lenses. These devices can be optimized for the maximum performance anywhere from 2 to 12 μm. High performance and stability were achieved by using variable gap semiconductors (Hg-Cd-Zn-Te) as well as graded composition and doping level profiles and optimized surface processing. Custom devices such as quadrant cells, multi-element arrays, specialized packages, connectors, windows and optical filters are available on request.

SPECIFICATION @ 20

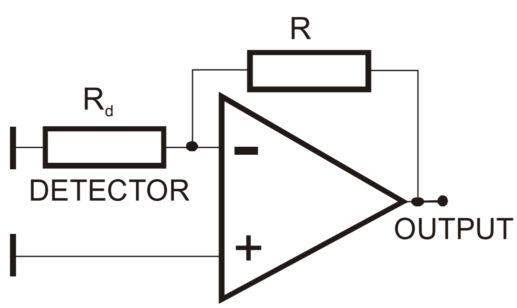
CHARACTERISTICS	UNITS	PDI-2TE-4	PDI-2TE-5	PDI-2TE-6	PDI-2TE-8	PDI-2TE-10.6
λ_{op}	μm	4	5	6	8	10.6
Detectivity: at λ_p at λ_{op}	$cmHz^{1/2}/W$	$\geq 1 \cdot 10^{11}$ $>4 \cdot 10^{10}$	$\geq 5 \cdot 10^{10}$ $>2 \cdot 10^{10}$	$\geq 3 \cdot 10^{10}$ $\geq 1 \cdot 10^{10}$	$\geq 3 \cdot 10^{9}$ $\geq 1 \cdot 10^{9}$	$\geq 6 \cdot 10^{8}$ $\geq 2 \cdot 10^{8}$
Responsivity ($1 \times 1 mm^2$)	V/W	≥900	≥290	≥50	≥7	≥1
Response Time	ns	≤20	≤20	≤10	≤7	≤3
Resistance ($1 \times 1 mm^2$)	Ω	500- 9000	200-1500	40-400	40-300	30-200
Area (optical)	mm × mm	0.25×0.25; 0.5×0.5; 1×1; 2×2;				
Field of View*	deg	42 (60)*				
Operating Temperature***	K	220–240				

* 60º FOV available only for hemispherically immersed devices with D* reduced by a factor ≈2.7

** Recommended cooler current is specified with each detector.

*** TE-cooled devices require heat sinks with thermal resistances ≤3K/W

OPERATING CIRCUIT



Typical circuitry

CAUTION!

- **CW OPTICAL POWER MUST NOT EXCEED 20 W/cm²!**
- **PULSES SHORTER THAN 1 μs MUST NOT EXCEED 10 kW/cm²!**
- **AVOID STEADY-STATE OR TRANSIENT OVERBIASING OF DETECTOR!**
- **AVOID OVERBIASING AND REVERSING POLARITY OF TE-COOLER!**

We offer optimized preamplifiers and cooler controllers for these detectors

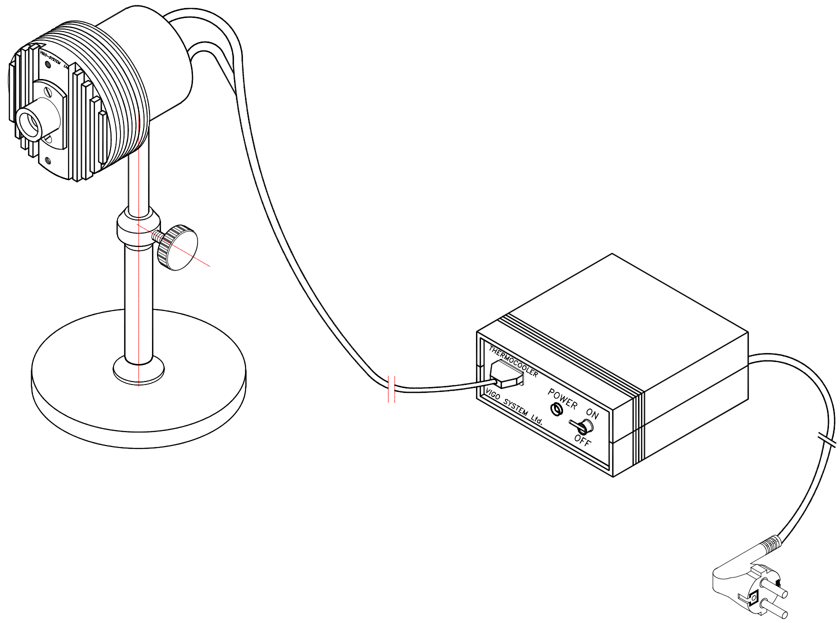
The PDI-2TE photodetectors are low resistance devices, compatible with a wide range of low noise preamplifiers and power supplies. Requiring no bias, they can be DC coupled to the electronics. For best performance they should be used with specialized electronics, in dependence on the frequency band. Resistor R should have resistance of at least 5 times greater than that of detector R_d.

STCC, CTTC, and DR
Thermoelectric Cooler Controllers

GENERAL DESCRIPTION

The STCC-01 temperature controller designed for use with Vigo-TE-cooled HgCdZnTe detectors. Its is an inexpensive way to maintain of the temperature of thermoelectrically cooled detectors with stability not worse than 1 °C.

The CTTC-02 and CTTC-03 are also temperature controllers designed for use with Vigo-TE-cooled HgCdZnTe **detectors**. Their main feature is the ability to maintain high stability of the temperature of thermoelectrically cooled detectors – not worse than 0.1 °C (0.05 °C typically).



These controllers are for detectors mounted on our standard heat sink Model DR-1. The stability of the temperature is better when the thermoelectric cooler is connected to a large thermal mass such as the DR-1.

Model STCC-01 is for maximizing the signal and signal to noise ratio of Vigo detectors operating at a nominal 230 K [-43 °C]. It gives optimum performance of the detector and 1 °C stability but heat sink temperature must not exceed 25°C. Consult us if your ambient / heat sink will be warmer than 25°C.

Model CTTC-02 is for Vigo detectors that do not require low temperature for their operation. Instead, the detector is cooled for the purpose of maintaining stable operating temperature. Unstabilized, these devices typically exhibit a temperature coefficient of output signal around –3% per degree C. Temperature stabilization allows elimination of this thermal drift, which is important for some applications.

The temperature of the detector is maintained at +5°C unless otherwise agreed. For maximum stability, ambient temperatures should be in the range of +10°C to +40 °C. The controller will operate and maintain high stability at higher temperatures (up to +70°C or above), but the reliability of the electronic circuitry will start to decrease.

Model CTTC-03 is for maximizing the signal and signal to noise ratio of Vigo detectors operating at a nominal 230 K [-43 °C]. It gives optimum performance of the detector and 0.1 °C stability but heat sink temperature must not exceed 25°C. Consult us if your ambient / heat sink will be warmer than 25°C.

Note: One very important advantage of using detectors, preamplifiers and TE controllers/power supplies from Boston Electronics is our ability to guarantee the safe interoperability of the components and subsystems. Infrared detectors require very careful handling (some models have high susceptibility to electro-static discharge!). Misconnection may lead to permanent damage. Our settings of input power parameters maximize performance without danger of overloading or shortening the useful life of the component.

Model DR-1 is a heat sink on which we deliver the detector, already mounted.

Model DRB-1 the base that supports the DR-1.

Model DR-1B is a combination of DR-1 and DRB-1.

SPECIFICATIONS

Model STCC-01	
Power requirements	
Model: STCC-01/110	110 VAC, +/- 10%, 47-63 Hz
Model: STCC-01/230	230 VAC, +/- 10%, 47-63 Hz
Model STCC-01/24	24 Volts DC
Temperature of the detector:	approx. 230 K
Ambient temperature	0°C to +25°C
Storage temperature	-25°C to +70°C
Temperature stability	< 1°C
Warm up	1 hour to rated accuracy
Package	52x155x177 mm with 9-pin D connector to cooler
Model CTTC-02	
Power requirements	
Model: CTTC-02/110	110 VAC, +/- 10%, 47-63 Hz
Model: CTTC-02/230	230 VAC, +/- 10%, 47-63 Hz
Temperature of the detector:	approx. +5°C
Ambient temperature	+10°C to +40°C
Storage temperature	-25°C to +70°C
Stability	< 0.1°C
Warm up	1 hour to rated accuracy
Package	same as standard TE cooler controller type STCC-1
Model CTTC-03	
Power requirements	
Model: CTTC-03/110	110 VAC, +/- 10%, 47-63 Hz
Model: CTTC-03/230	230 VAC, +/- 10%, 47-63 Hz
Temperature of the detector:	approx. 230 K
Ambient temperature	0°C to +25°C
Storage temperature	-25°C to +70°C
Temperature stability	< 0.1°C
Warm up	1 hour to rated accuracy
Package	same as standard TE cooler controller type STCC-1
Model DR-1 Heat sink	
Dimensions	74 mm dia, 90 mm long from entrance port to connector mounting plane
Model DRB-1 Base only	
Dimensions	120 mm diameter base, 94 mm tall hollow shaft, contains 108 mm long 13.7 mm diameter mounting

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Accessories and Complete Lab Bench Instruments

We now offer complete Lab Bench IR Measuring Sets based on Vigo detectors. These consist of:

- The detector itself
- Mounted on a heat sink with stalk support with
- Appropriate preamp integrated within the heat sink and
- External power supply for the preamp and/or
- TE-cooler power supply/controller (if detector is TE-cooled) mounted in same external housing with preamp power supply plus
- Interconnecting cable at no additional cost

The system is powered by 110VAC (24VDC or 230VAC optional). The amplified output of the detector is presented on a BNC connector for oscilloscope display or further processing.

The photo at left shows the heat sink with a TE-cooled detector mounted. The dimensions of the heat sink are 74 mm diameter and the length is 90 mm from front of detector shield to output connector mounting surface. Allow 10 mm more for 9-pin "D" power/control and BNC output connectors. A ¼-20 thread accepts the stalk.

The external controller/power units measure 210 x 150 x 52 mm max. An interconnecting cable is supplied.

- Available detectors: ALL p/ns
- Heat Sink with mounting stalk and weighted base: p/n DR-1B
- Power supply with TE-cooler controller for +/-1C stability: p/n STCC-01
- Power supply with TE-cooler controller for +/-0.1C stability: p/n CTCC-03
- Power supply for preamp only without cooler controller: p/n PPS
- Preamps available packaged INSIDE the Heat Sink: any VPAC or VPDC series unit from the table on the following page.

To order: specify (1) detector model and active area, (2) Heat Sink DR-1B, (3) if TE-cooled, specify either STCC-01 (+/-1C) or CTCC-03 (+/-0.1C) controller, and input power if other than 110VAC; if uncooled specify PPS power supply, and input power if other than 110VAC, (4) specify one preamp from the table following. The measuring set will be delivered with actual measured data for the detector and preamp at the operating temperature achieved by the system.

A note on operating temperature: the STCC and CTCC controllers are factory set to maintain a stable detector temperature of about 230K as long as the ambient temperature experienced by the heart sink is at or below 25C. If your ambient may be higher, you can specify this at time of order in which case the detector will be stabilized at the corresponding higher operating point (constant delta-T) with respect to your maximum ambient.

The available preamps are as follows:

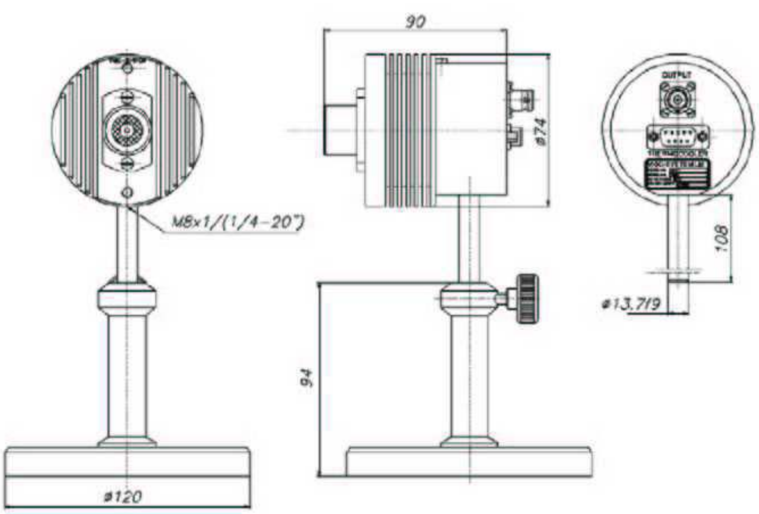
VPAC series	VPAC-01	VPAC-03	VPAC-1	VPAC-5	VPAC-10	VPAC-20	VPAC-50	VPAC-100
Bandwidth: 10 Hz to	100 kHz	300 kHz	1 MHz	5 MHz	10 MHz	20 MHz	50 MHz	100 MHz
Trans-impedance	100K	100K	100K	24K	10K	5K	4K	2K
Max output voltage	14	14	10	4	4	4	4	4
Input noise current [$pA/Hz^{1/2}$]	$I_n = 1200/R_d$ where R_d is detector resistance in Ω			$I_n = 3000/R_d$ where R_d is detector resistance in Ω			$I_n = 2000/R_d$ where R_d is detector resistance in Ω	
Output impedance	50 ohms							
VPDC-series	VPDC-01	VPDC-03	VPDC-1	VPDC-5	VPDC-10	VPDC-20	VPDC-50	VPDC-100
Bandwidth DC to	100 kHz	300 kHz	1 MHz	5 MHz	10 MHz	20 MHz	50 MHz	100 MHz

Prices are as follows:
Detector: see separate price list
DR-1B heat sink and base with detector mounted and tested on it: $250
STCC-01 (+/-1C) power supply/controller: $400
CTCC-03 (+/-0.1C) power supply/controller: $700
PPS power supply (if detector not TE-cooled): $195
Any VPDC- or VPAC-series preamp integrated within DR-1B heat sink: $795.
These prices are valid worldwide.

Terms: Above prices are in US$ and are Ex-Works (EXW) Brookline MA USA. We accept credit cards (Visa, MasterCard, American Express) and we ship on net 30 day payment terms to customers whose credit we approve.

Other options: for external preamps, for preamps with lower noise figures (detector noise limited performance) and wider bandwidths (to 500 MHz), see our separate data sheet with description of stand alone units from a US manufacturer.

More information: request our 33 page brochure titled “Vigo Laboratory IR Measuring Sets”, available by mail or by email in .pdf format (900kB).

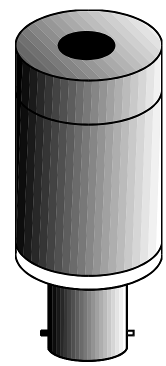


R005 Series
IR Photodetector

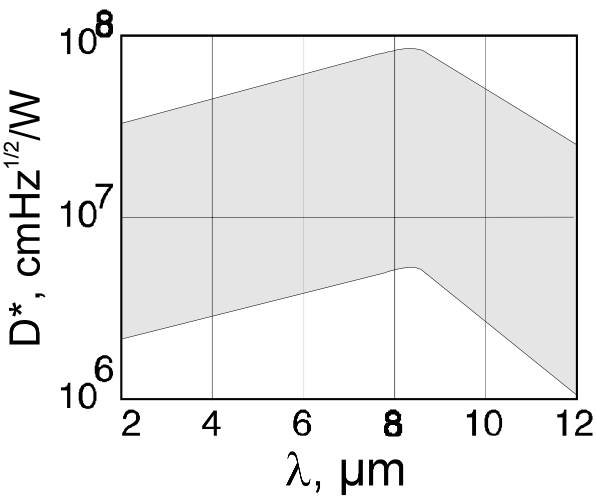
CO_2 Laser Detectors
2-12 µm IR PHOTODETECTORS
PHOTOCONDUCTIVE MODE, ROOM TEMPERATURE

FEATURES

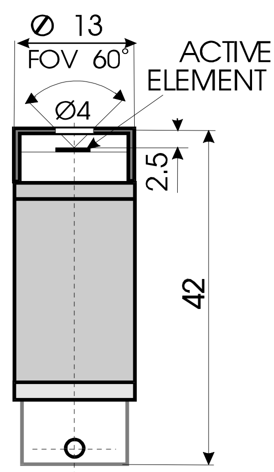
- Ambient temperature operation
- D*(10.6 µm) to > $6x10^6 cmHz^{1/2}/W$
- Response time of <1 nsec
- Perfect match to fast electronics
- Wide dynamic range



SPECTRAL RESPONSE



Typical spectral detectivity range of R005 detectors as a function of wavelength.



Devices are mounted in housings with BNC connectors and are designed for wideband applications. They are usually supplied without any window.

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DESCRIPTION

The R005 series are high speed, ambient temperature photoconductive mode IR photodetectors optimized for the best possible performance at 10.6 µm. Their performance has been recently improved by the use of the newly developed quaternary semiconductor (Hg-Cd-Zn-Te) with selected composition and doping profiles. They are housed in rugged packages of small size and weight. Measured performance data are provided with each detector.

The detectors are well suited for heterodyne detection of 10.6 µm radiation at high frequencies due to their very short response time and to the perfect match to fast electronics.

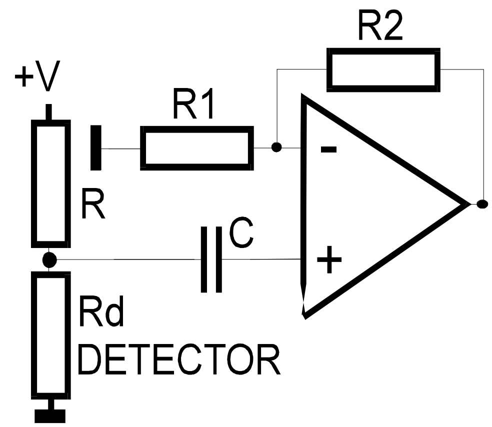
SPECIFICATIONS

Specifications are subject to change without notice. Specifications measured @20°C, 1x1 active area.

CHARACTERISTICS	UNITS	R005-2	R005-3	R005-5	R005-6
Spectral Range	µm	2 - 12			
Detectivity at λ_p	$cmHz^{1/2}/W$	$>5x10^6$	$>8x10^6$	$>2x10^7$	$>2x10^7$
Detectivity at 10.6 µm	$cmHz^{1/2}/W$	$>2x10^6$	$>3x10^6$	$>5x10^6$	$>6x10^6$
Responsivity-Width Product (λ=10.6 µm}	Vxmm/W	>0.02	>0.05	>0.1	>0.12
Maximum Signal per Length	V/mm	1			
Response Time	nsec	<1			
1/f Corner Frequency	kHz	10 - 100			
Active Area, Length × Width	mm × mm	0.1×0.1; 0.25×0.25; 05×0.5; 1×1; 2×2; 3×3; 4×4			
Bias current-Width Ratio*	A/mm	0.02 - 0.10			
Resistance	Ω	30 - 80			
Field of View	deg	>60			

*The recommended max bias current is specified with each detector

TYPICAL OPERATING CIRCUIT



CAUTION

- CW optical power must not exceed 100 W/cm^2!
- Pulses shorter than 1µs must not exceed 1 MW/cm^2!
- Avoid overbiasing of detector!

We also supply compatible low-noise preamplifiers with bandwidths to 500$^+$ MHz.

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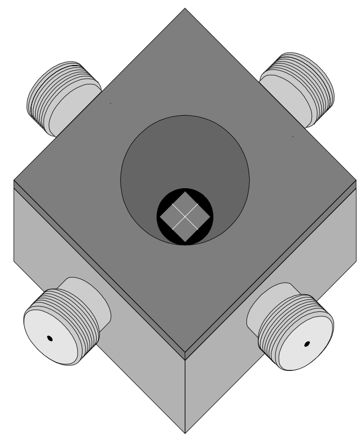
PCQ-L Series
IR Quadrant

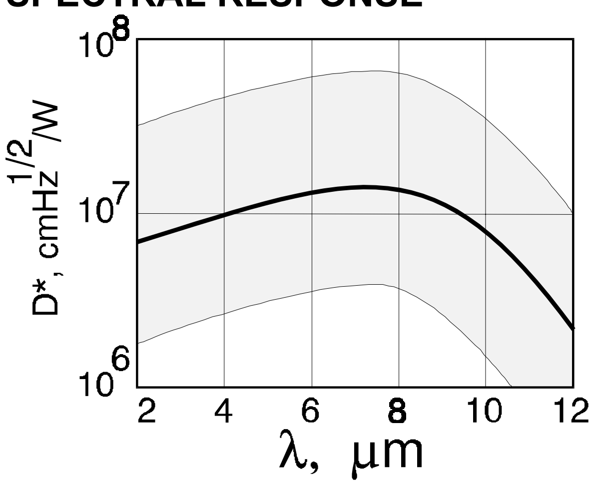
2-12 µm IR QUADRANTS
ROOM TEMPERATURE



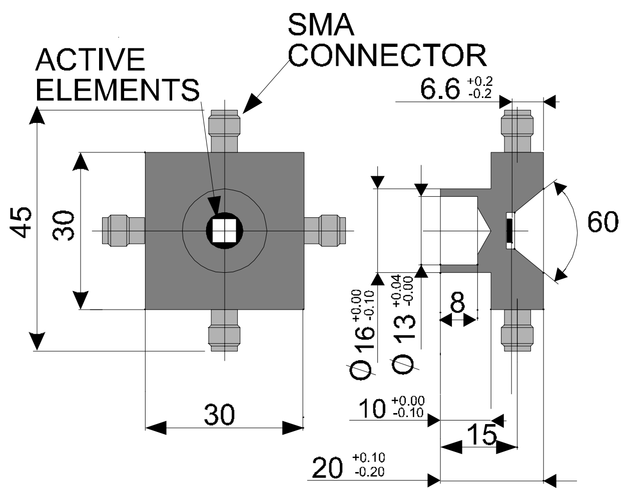
FEATURES

- Ambient Temperature Operation
- Wide Spectral Range (2-12 µm)
- D*(10.6 µm, 100 MHz) up to $1x10^7$ $cmHz^{1/2}/W$
- Response Time of 1 nsec or Less
- High Output Signal
- Perfect Match to Fast Electronics
- Lightweight, Rugged And Reliable
- Convenient to Use

SPECTRAL RESPONSE



Typical spectral detectivity PCQL detectors as a function of wavelength.



Devices are mounted in specially designed packages supplied with SMA connectors, suitable for wide band applications.

DESCRIPTION

PCQL series detectors are quadrant uncooled long wavelength IR photoconductors optimized for performance at 10.6 µm. These device are based on the newly developed variable gap semiconductor (HgCdZnTe) with optimized graded composition and doping level profiles. Measured performance data are provided with each detector. Due to very short response times and their perfect match to fast electronics they are ideal for pulsed or modulated CO_2 laser application over an extremely wide frequency band.

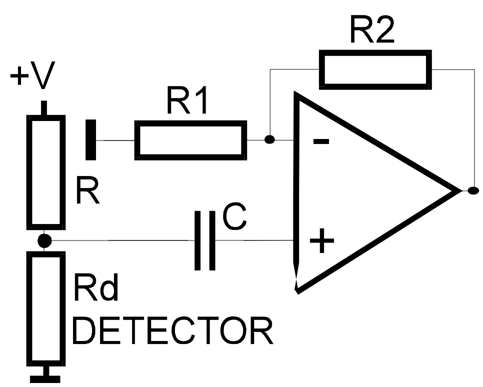
SPECIFICATIONS

Specifications are subject to change without notice. Specifications measured @20°C, 1x1 active area.

Characteristics	Units	PCQ-L-3	PCQ-L-5	PCQ-L-6
Detectivity (λ_p, 20 kHz)	$cmHz^{1/2}/W$	$>1x10^7$	$>1.5x10^7$	$>2x10^7$
Detectivity (10.6 µm, 20 kHz)	$cmHz^{1/2}/W$	$>3x10^6$	$>5x10^6$	$>6x10^6$
Response time	nsec	<1		
Corner frequency	kHz	10 - 100		
Area (each quadrant element)	mm^2	0.1×0.1; 0.25×0.25; 0.5×0.5; 1×1; 2×2;		
x/y separation	µm	20 - 50		
Common lead width	µm	20 - 50		
Resistivity	Ω	30 - 80		
Responsivity×width	mVxmm/W	>50	>100	>120
Maximal signal per length	V/mm	>1		
Bias current per width	mA/mm	20 - 100*		

* recommended bias current is supplied with each detector

TYPICAL OPERATING CIRCUIT



CAUTION

- CW optical power must not exceed $100W/cm^2$!
- Pulses shorter than 1µS must not exceed $1MW/cm^2$!
- Avoid steady state or transient overbiasing or detector!

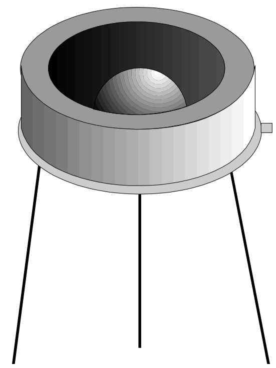
We also supply compatible low-noise preamplifiers with bandwidths to 500^+ MHz

PCI-M Series
IR Photoconductors

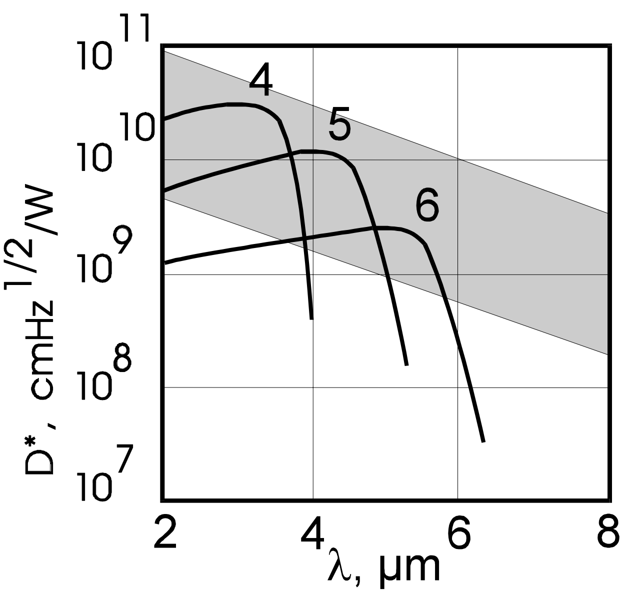
FAST 2-6 µm IR PHOTOCONDUCTORS
ROOM TEMPERATURE, OPTICALLY IMMERSED

FEATURES

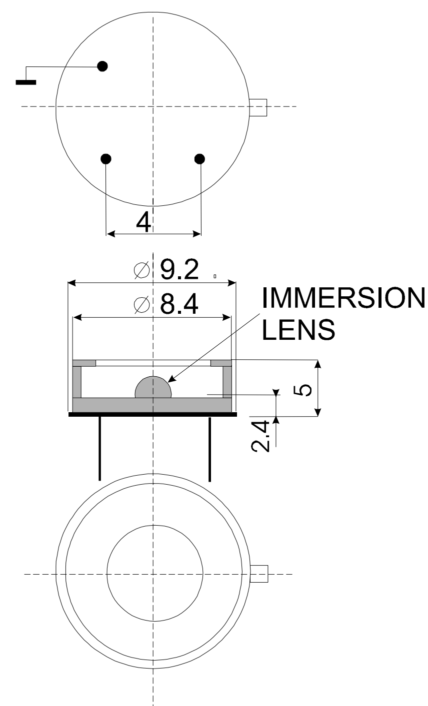
ambient temperature operation
∗spectral range of 2-6 µm
∗$D^*=10^8-10^{11}$ $cmHz^{11}/W$
fast response time
low bias power requirements
wide dynamic range
lightweight, rugged and reliable



SPECTRAL RESPONSE



Spectral detectivity of PCI-4, -5 and -6 detetectors.



Devices are typically mounted in modified TO-5 cans, with no windows. Other housings with different windows are available upon request.

DESCRIPTION

The PCI series photodetectors are uncooled IR photoconductors optically immersed on high refractive index CdTe hyperhemispherical lenses. These devices can be optimized for maximum performance anywhere from 2 to 12 µm. In this spectral region, these detectors perform better than all other uncooled detectors at moderate to high frequencies, but exhibit 1/f noise below 10kHz.

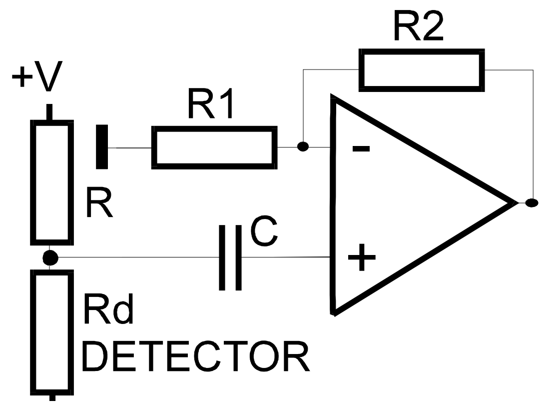
Such extraordinary performance is achieved by using a newly developed variable gap semiconductor (Hg-Cd-Zn-Te) as well as with graded composition and doping level profiles and optimization of surface processing.

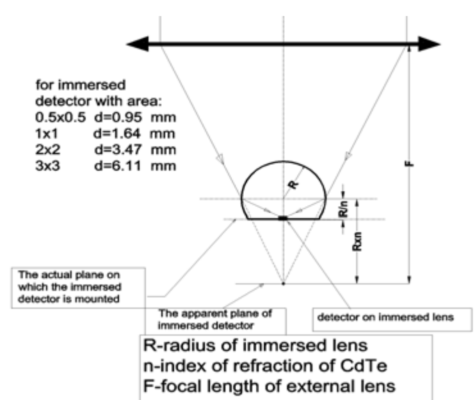
SPECIFICATIONS

Specifications are subject to change without notice. Specifications measured @20°C, 1x1 active area.

Characteristics	Units	PCI-M-4	PCI-M-5	PCI-M-6
Optimization Wavelength	µm	4	5	6
Detectivity (λ_p, 20 kHz)	$cmHz^{1/2}/W$	$>2x10^{10}$	$>6x10^{9}$	$>1x10^{9}$
Detectivity (λ_{op}, 20 kHz)	$cmHz^{1/2}/W$	$>6x10^{9}$	$>2x10^{9}$	$>5x10^{8}$
Responsivity × Widths at λ_p	V mm/W	700	180	20
Responsivity × Widths at λ_{op}	V x mm/W	>200	>60	>10
Response time	nsec	<1000	<300	<200
1/f Corner Frequency	kHz	0.5 - 5	0.5 - 5	1 - 10
Resistivity	Ω	300 - 500	150 - 300	50 - 200
Area (optical)	mm^2	0.05×0.05;0.1×0.1;0.2×0.2; 0.5×0.5; 1×1, 2×2; 3×3		
Field of view	deg	>40		

TYPICAL OPERATING CIRCUIT





CAUTION

- CW optical power must not exceed 20 W/cm^2!
- Pulses shorter than 1 µs must not exceed 10 kW/cm^2!
- Avoid overbiasing of detector!

More Information: see J. Piotrowski et al., “New generation of near-room temperature photodetectors”, Optical Engineering, May 1994, Vol. 33 No. 5, pages 1413-1421

We supply compatible low-noise preamplifiers with bandwidths AC-coupled, to 500+ MHz.

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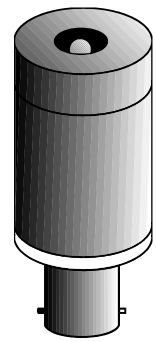
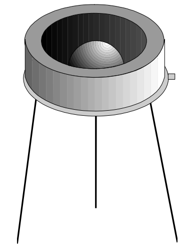
PCI-L Series
IR Laser Photoconductors

2-12µm Fast IR Laser Detectors Photoconductors
Room Temperature, Optically Immersed

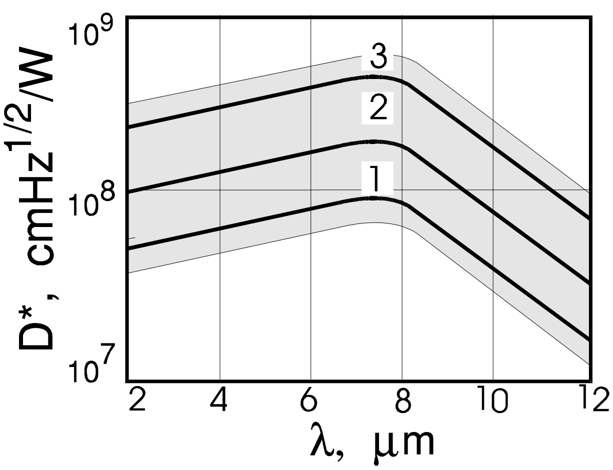




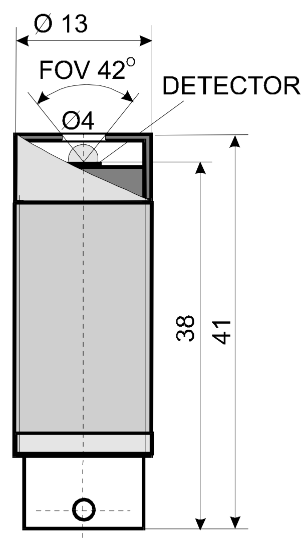
FEATURES

- Ambient temperature operation
- D*(10.6 µm) > 1×10^8 $cmHz^{1/2}/W$
- Response time <1 nsec
- Perfect match to fast electronics
- Wide dynamic range

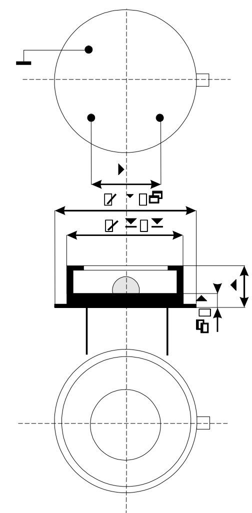
SPECTRAL RESPONSE



Typical spectral detectivities (f=100 kHz) of PCI-L photoconductors.



a



b

Devices are mounted in specialized packages with BNC connectors (**a**) for broadband applications and in modified TO-5-style packages (**b**) for low frequency operation (0-20 MHz). The devices are usually packaged without windows.

DESCRIPTION

PCI-L series devices represent a new generation of high speed, ambient temperature IR photoconductors and are usually optimized for the best performance at 10.6 µm. Their performance has been improved by optically immersing the active detector elements on CdZnTe hyperhemispherical lenses. Optical immersion reduces bias power requirements by a large factor. The active elements are prepared of the quaternary semiconductor (HgCdZnTe) with selected composition and doping profiles. Housing are rugged packages of small size and weight. Measured performance data are provided with each detector.

These devices are well suited for heterodyne detection of 10.6 µm radiation at high frequencies due to their very short response time and to their perfect match to fast electronics.

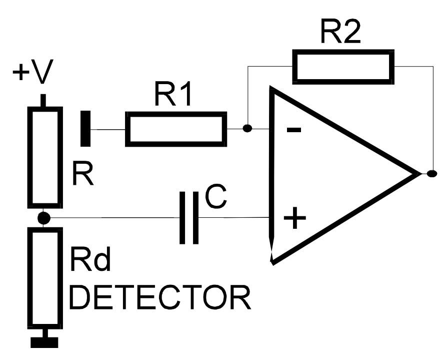
SPECIFICATIONS

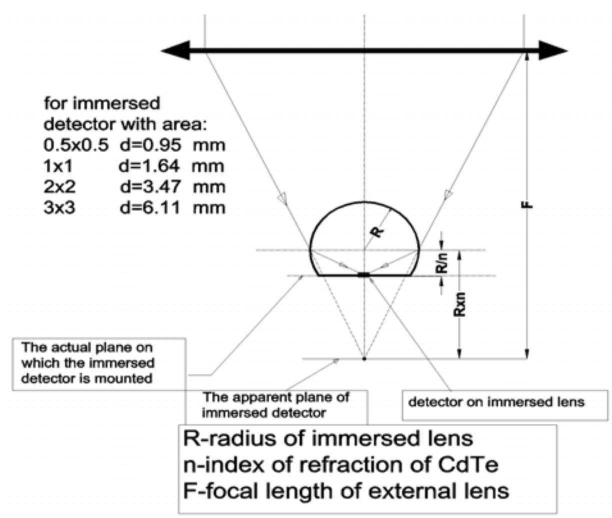
Specifications are subject to change without notice. Specifications measured @20°C, 1x1 active area.

Characteristics	Units	PCI-L-1	PCI-L-2	PCI-L-3
Spectral Range	µm	2 - 12		
Detectivity at λ_p Detectivity at 10.6µm	$cmHz^{1/2}/W$	$>6x10^7$ $>2x10^7$	$>2x10^8$ $>5x10^7$	$>3x10^8$ $>1x10^8$
Responsivity-Width Product at λ=10.6µm	Vxmm/W	>0.2	>0.5	>1
Response Time	nsec	<1		
1/f Corner Frequency	kHz	10 - 100		
Active Area, Length × Width	mm × mm	0.1×0.1; 0.25×0.25; 05×0.5; 1×1; 2×2		
Bias current-Width Ratio*	A/mm	0.003 - 0.02		
Resistivity	Ω	30 - 80		

*Recommended bias current is specified with each detector

TYPICAL OPERATING CIRCUIT





CAUTION

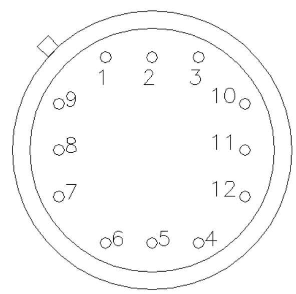
- CW optical power must not exceed 20 w/cm^2!
- Pulses shorter than 1 µs must not exceed 10 kw/cm^2!
- Avoid overbiasing of detector!

We also supply compatible low-noise preamplifiers with bandwidths to 500$^+$ MHz

PC-L-2TE Series

CO_2 Laser Detector IR Photoconductor

2-12 µm IR PHOTOCONDUCTORS THERMOELECTRICALLY COOLED

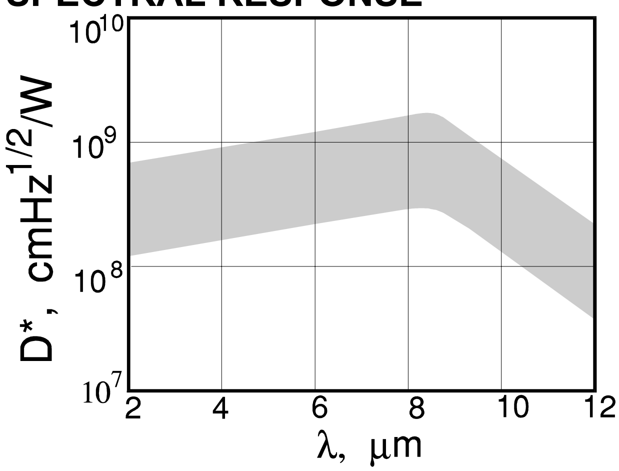


1 – Detector (+)
2 – TE Cooler (+)
3 – Detector (–)
4 – Thermistor
5 – TE Cooler (–)
6 – Thermistor
7 – Not in use
8 – Ground
(BOLT-DOWN ONLY)
9 – Ground
(ALL OTHER)
10 – Not in use
11 – Not in use
12 – Not in use

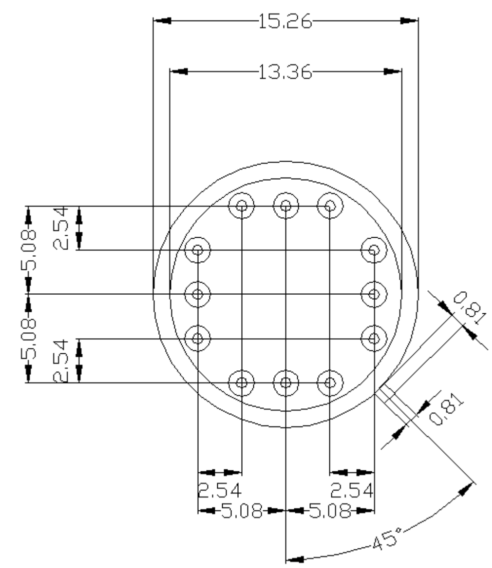
FEATURES

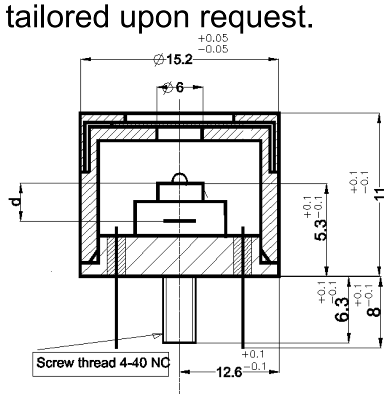
- D*(10.6 µm) >$1x10^8$cmHz$^{1/2}$/W
- <10 nanosecond time constant
- high output signal
- wide dynamic range
- compact, rugged and reliable
- low cost

SPECTRAL RESPONSE



Typical spectral detectivity range of PC-L-2TE photoconductors as a function of wavelength. Spectral detectivity can be tailored upon request.





PC-L-2TE photodetectors are typically mounted on industry standard two stage low power thermoelectric coolers and packaged in modified T0-8-style cans.

For proper operation, the units **must** be mounted on an appropriate heat sink to dissipate the heat generated by the TE cooler.

DESCRIPTION

The PC-L-2TE is a 2-stage thermoelecrically cooled photoconductive mode IR photodetector optimized for the best performance at 10.6 µm. Its performance has been highly improved by the use of newly developed quaternary semiconductor (HgCdZnTe) with selected composition and doping profiles. Devices are housed in rugged packages of small size and weight. The thermoelectric cooler requires approx. 1 A × 1 V DC power. A built in thermistor monitors detector temperature. Performance data are provided with each detector.

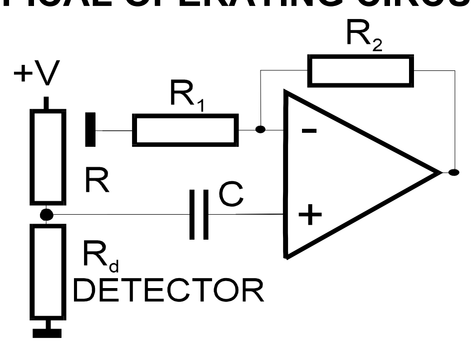
SPECIFICATIONS

Specifications are subject to change without notice. Specifications measured @20°C, 1x1 active area.

Characteristics	Units	PC-L-2TE
Spectral Range	µm	2 - 12
Detectivity at λ_p	$cmHz^{1/2}/W$	$>3x10^8$
Detectivity at 10.6 µm	$cmHz^{1/2}/W$	$>1x10^8$
Response Time	nsec	<10
Active Area, Length × Width	mm × mm	0.25×0.25; 0.5×0.5; 1×1; 2x2
Resistivity	Ω	from 50 to 200
Bias current-Width ratio*	A/mm	0.02 - 0.10
Responsivity-Width Product at λ_p	Vmm/W	>5
Responsivity-Width Product at 10.6 µm	Vmm/W	>1
1/f Corner frequency	kHz	1 - 10
Operating Temperature	K	230

* recommended detector and cooler bias currents are specified with each detector

TYPICAL OPERATING CIRCUIT



CAUTION

- CW optical power must not exceed 100 W/cm^2!
- Pulses shorter than 1 µs must not exceed 1 MW/cm^2!
- Avoid overbiasing of detector!
- Avoid overbiasing and reverse polarity operation of TE-cooler!

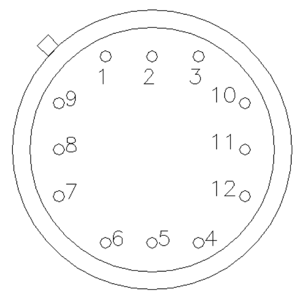
We also supply compatible low-noise preamplifiers with bandwidths to 500^+ Mhz

PCI-2TE Series
IR Photoconductor

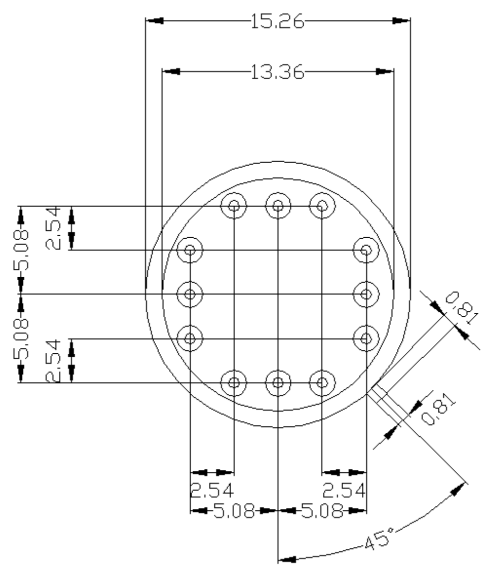
2-12μm Spectrally Tailored IR Photoconductors
Themoelectrically Cooled, Optically Immersed

FEATURES

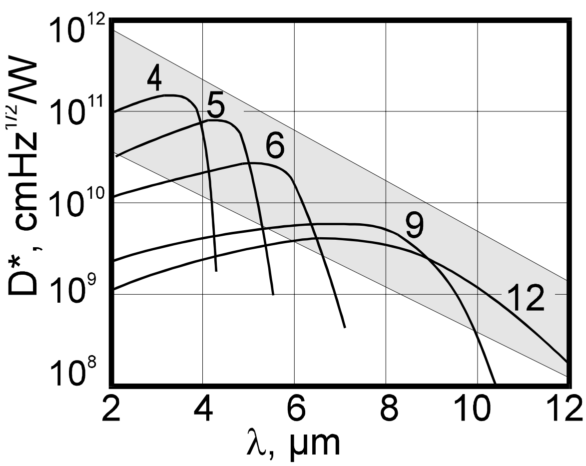
- high performance in the 2-12μm range *without* LN_2-cooling!
- fast response
- convenient to use
- wide dynamic range
- compact, rugged and reliable
- low cost



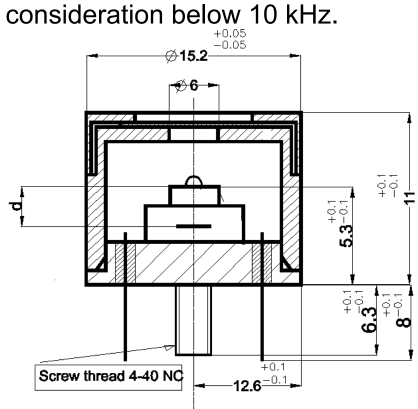
1 – Detector (+)
2 – TE Cooler (+)
3 – Detector (–)
4 – Thermistor
5 – TE Cooler (–)
6 – Thermistor
7 – Not in use
8 – Ground
(BOLT–DOWN ONLY)
9 – Ground
(ALL OTHER)
10– Not in use
11– Not in use
12– Not in use



SPECTRAL RESPONSE



Typical spectral detectivities of PCI-2TE-series photoconductors at 100 kHz. 1/f noise is a consideration below 10 kHz.



PCI-L-2TE photodetectors incorporate industry standard two-stage low-power thermoelectric coolers and are packaged in modified TO-8-style cans. For proper operation, the units **must** be mounted on an appropriate heat sink to dissipate the heat generated by TE cooler.

DESCRIPTION

PCI-2TE-n series photodetectors (where n is wavelength λ_{op}, in micrometers, for which the detector is optimized) are two-stage TE-cooled IR photoconductors which have been optically immersed on high refractive index CdZnTe hyperhemispherical lenses. These devices can be optimized for maximum performance anywhere from 2 to 12 µm. High performance and stability are achieved by using newly developed variable gap semiconductor Hg-Cd-Zn-Te as well as graded composition and doping level profiles and optimized surface processing.

SPECIFICATIONS

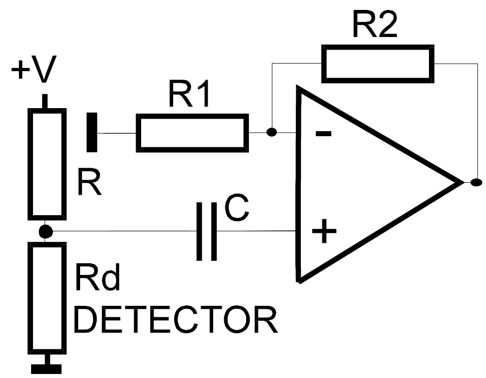
Specifications are subject to change without notice. Specifications measured @20°C, 1x1 active area.

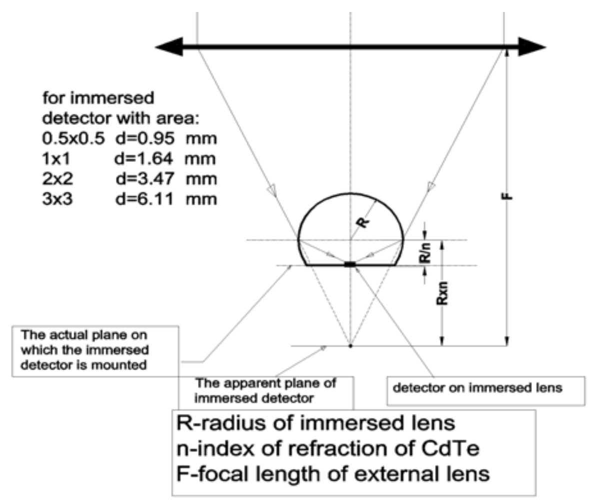
Characteristics	Units	PCI-2TE-4	PCI-2TE-5	PCI-2TE-6	PCI-2TE-9	PCI-2TE-12
Optimization Wavelength	µm	4	5	6	9	12
Detectivity at λ_p	$cmHz^{1/2}/W$	$>1\cdot10^{11}$	$>5\cdot10^{10}$	$>3\cdot10^{10}$	$>2\cdot10^{9}$	$>1\cdot10^{9}$
Detectivity at λ_{op}	$cmHz^{1/2}/W$	$>7\cdot10^{10}$	$>2\cdot10^{10}$	$>1\cdot10^{10}$	$>7\cdot10^{8}$	$>1\cdot10^{8}$
Responsivity × Width at λ_p	Vxmm/W	>1000	>900	>500	>150	>10
Responsivity × Width at λ_{op}	Vxmm/W	>500	>400	>100	>30	>1
Response Time	nsec	<3000	<1000	<100	<30	<10
1/f Corner Frequency	kHz	0.4 - 4	0.6 - 6	0.8 - 8	1 - 10	1 - 10
Sheet resistivity	Ω per □	300 – 400	180 - 300	150 - 200	80 - 160	50 - 80
Bias Current-Width Ratio*	mA/mm	1 - 8	2 - 10	2 - 12	3 - 15	4 - 25
Active Area, Length × Width	mm × mm	0.1×0.1; 0.25×0.25; 0.5×0.5; 1×1; 2×2				
Field of View	deg	42 (60)**				
Operating Temperature.	K	220-230				

*Recommended detector and cooler bias currents are specified with each detector.

**60^{o} FOV available only for hemispherically immersed devices; D* reduced by a factor of 2.

TYPICAL OPERATING CIRCUIT





CAUTION

- CW optical power must not exceed 20 w/cm^2!
- Pulses shorter than 1 µs must not exceed 10 kw/cm^2!
- Avoid overbiasing of detector!
- Avoid overbiasing and opposite polarity biasing of te-cooler!

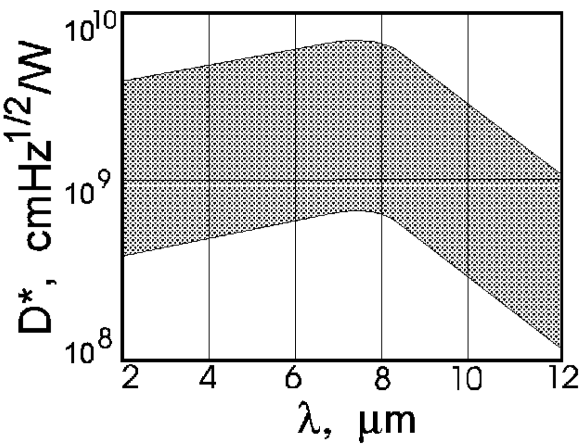
PCI-L-2TE Series
IR Laser Photoconductors

Fast, Sensitive 2-12µm CO_2 Laser Detectors Photoconductors
Room Temperature, Optically Immersed

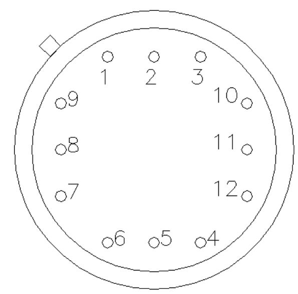
FEATURES

- D*(10.6 µm) > 1x10^9 cmHz$^{1/2}$/W
- 10 nanosecond response time
- Wide dynamic range
- Compact, rugged, and reliable

SPECTRAL RESPONSE



Typical spectral detectivities of PCI-L-2TE photoconductors as a function of wavelength.



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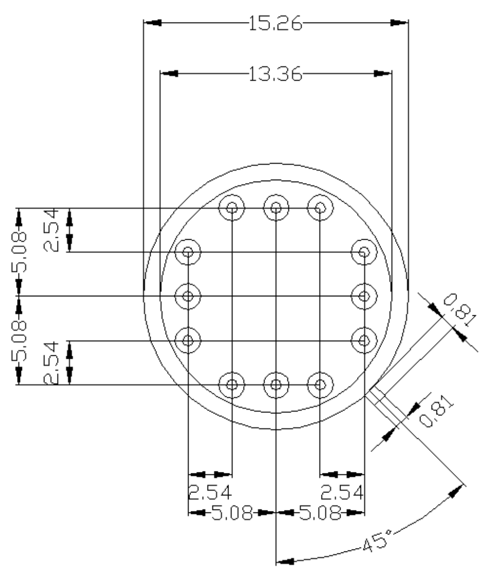
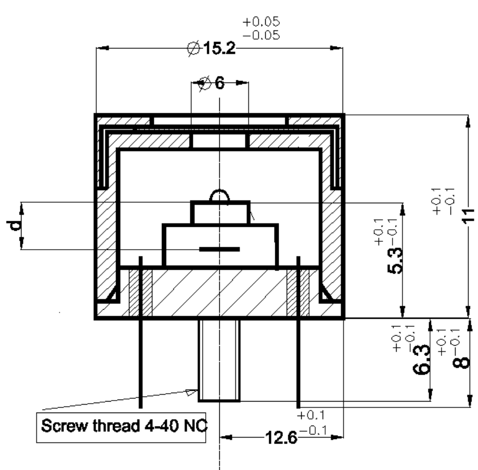




PCI-L-2TE photodetectors incorporate industry standard two-stage low-power thermoelectric coolers and are packaged in modified TO-8-style cans. For proper operation, the units **must** be mounted on an appropriate heat sink to dissipate the heat generated by TE cooler.

DESCRIPTION

PCI-L-2TE series devices are high performance and high speed 2-stage thermoelectrically cooled IR photoconductors, operating in the 2-12 µm range. They are optimized for the best performance at 10.6µm. Their performance has been improved by use of the quaternary semiconductor (Hg-Cd-Zn-Te) with selected composition and doping profiles for active elements and by monolithic optical immersion of the element to CdTe lenses. They are housed in rugged packages of small size and weight. The thermoelectric cooler temperature requires approximately 1 A x 1 V DC power. A built in thermistor monitors detector temperature. Measured performance data are provided with each detector.

SPECIFICATIONS

Specifications are subject to change without notice. Specifications measured @20°C, 1x1 active area.

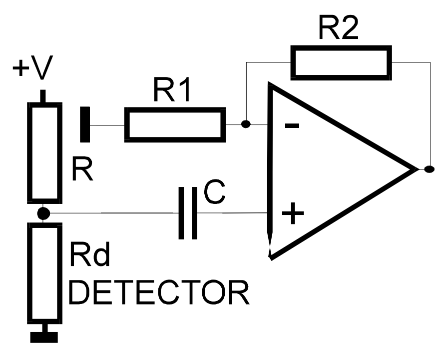
Characteristics	Units	PCI-L-2TE-1	PCI-L-2TE-2	PCI-L-2TE-3
Spectral Range	µm	2 - 12		
Detectivity* at λ_p Detectivity at 10.6µm	$cmHz^{1/2}/W$	$\geq 6x10^8$ $\geq 2x10^8$	$\geq 2x10^9$ $\geq 5x10^8$	$\geq 3x10^9$ $\geq 1x10^9$
Response Time	nsec	<10		
Active Area, Length × Width	mm × mm	0.25×0.25; 05×0.5; 1×1; 2×2		
Bias current-Width Ratio**	A/mm	from 0.003 - 0.02		
Resistivity	Ω	from 50 to 200		
Responsivity – Width Product at λ_p	Vxmm/W	≥4	≥20	≥30
Responsivity-Width Product at λ=10.6µm	Vxmm/W	≥2	≥5	≥10
1/f Corner Frequency	kHz	1 - 20		
Operating Temperature	K	230***		

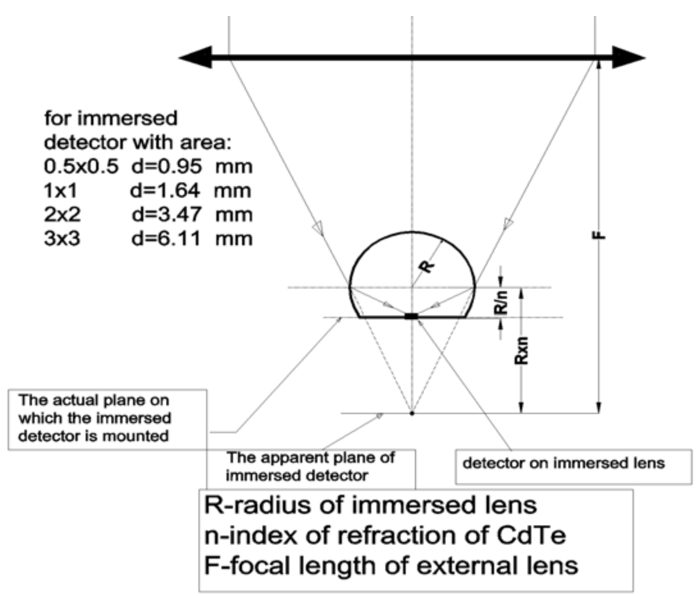
*f ≥2kHz

**Recommended bias current is specified with each detector

***TE-cooled devices require heat sinks with thermal resistances ≤3K/W

TYPICAL OPERATING CIRCUIT





CAUTION

- CW optical power must not exceed 20 w/cm^2!
- Pulses shorter than 1 µs must not exceed 10 kW/cm^2!
- Avoid steady-state or transient overbiasing of detector!
- Avoid overbiasing and opposite polarity biasing of TE-cooler!

We also supply compatible low-noise preamplifiers with bandwidths to 500$^+$ MHz

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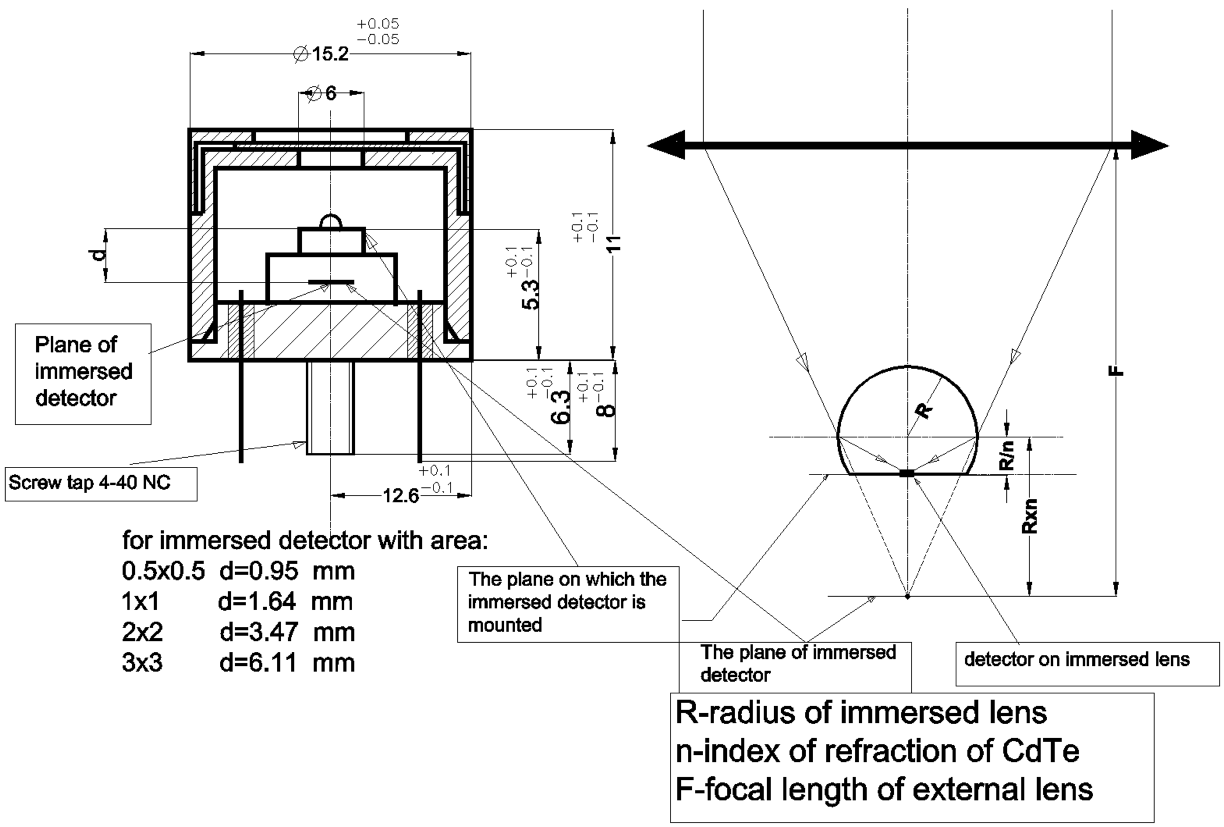
Photovoltaic versus photoconductive detectors: which is better?

Q: We offer both photovoltaic and photoconductive detectors. Which should you choose?

A: Usually we suggest photovoltaic (PV). The advantages of PV over photoconductive (PC) are generally --

1. **PV devices require no external power supply. Instead, they are current sources like solar cells. In contrast, photoconductive devices require low noise DC bias power.**
2. **PV devices are good and useful down to DC (0 Hz) whereas PC devices exhibit excess noise at low frequencies called 1/f or flicker noise. Therefore, S/N is degraded at low frequencies in PC devices and DC operation is not desirable generally and requires special wiring to eliminate the DC bias offset voltage if absolutely required.**
3. **PV detectors are faster than comparable PC devices.**
4. **On the other hand, for our longest wavelength detectors, PC sensitivity (D*) is 2 to 5 times better than available PV devices and therefore PC finds application.**

TO-8 Package and Immersion Lens Details (for 2TE models)



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When do I need to use a preamp? (and other comments on signal levels and device saturation)

One of the very convenient things about Vigo MCT detectors is that many users will not require a preamplifier but can instead go directly into an oscilloscope for display of fast transients, usually laser pulses. When is this the case and when not? Briefly, the answer is, for a CW signal, you probably need a preamp, and for short pulses widely spaced in time, you probably do not need a preamp.

The question relates to saturation levels in the detector. We consider "saturation" to be the point at which the detector output deviates from linear by 20%. You might want to choose another percentage deviation from linearity, but the idea remains the same and in fact, once saturation begins it seems to happen quickly so there will not be a large difference whether we speak of 1%, 20% or 50% deviation.

Saturation is most easily described NOT in terms of input optical signal but in terms of output electrical signal. For example, for the model PD-10.6-3, we expect output saturation at about 10 millivolts for a CW signal, and at about 600 millivolts for a single short pulse. These represent the extreme cases. Since few if any users have oscilloscopes that will display a signal of 10 millivolts with much deflection on the CRT, those users trying to see a CW signal will pretty much always need a preamp. However, users whose input signals are short and strong (say < 1 μsec and > 5 watts peak) should be able to dispense with the amplifier and go direct to the scope using the PD-10.6-3. A certain amount of experimentation around these levels to optimize them should be expected.

Many users in fact have input waveforms that can be considered neither CW nor "short single shot" pulses. This gets us into the intermediate "quasi-CW" regime. There are no firm rules here, but some guidance is available from experience:

- Many CO_2 lasers are called "pulsed" but are in fact better described as modulated. Duty cycle is in the range of 50% and the modulation frequency is in the kHz region. These should be considered CW sources and a preamp used.
- Pulsed lasers with short pulses and duty cycles <<1% (for example pulses less than 1 μsec duration repeated at 1000 Hz) will probably act like single shot sources and the preamp can usually be omitted.
- Intermediate values of pulse length and duty cycle may act in an intermediate fashion.

How can you determine whether you are in the intermediate regime? Clue number one, if you cannot get more than a few millivolts out, despite raising the input power level, you are likely saturated and you had better reduce that input power ASAP before you fry the detector. A good way of seeing whether you are in saturation is to attenuate the input optical signal and see if the output electrical signal reduces proportionally. This is valid whether there is a preamp in the system or not. You do not need a calibrated optical filter to try this. For example, one piece of uncoated germanium 1 mm thick will transmit about 50% from 2 to 20 μm or so. So two pieces (not too close together to avoid interference effects) will transmit about 25%. Try one, then two, and if you do not see the expected T and T^2 reductions, back that input power off. No Ge on hand? Try a piece of window screen. Or take your input as the reflection from a scattering surface and increase the distance to reduce the signal. A diffuse reflector will attenuate as $1/r^2$ where r is the distance. A sometimes confusing symptom of saturation is appearance of a slower than expected fall time despite apparently credible rise of a pulse measurement. This can be due to thermal effects, and again the cure is to lower the power on the detector and if necessary, use a preamp.

These comments are directed specifically at the PD-10.6-series of detectors although they apply generally to all our devices. However, saturation is not so well know for most of the others, especially the immersed devices. Immersion is a tool to improve signal to noise and saturation concerns imply that you have excess signal and hence plenty of S/N. Therefore, the question is usually moot.

For sample numerical calculations on saturation levels, see the end papers to our publication "Predicting the Performance of a Photodetector"

Thermal Target Detection Using Vigo Detectors

The appropriateness of a detector for use in pyrometry or thermal imaging is a function of its spectral response, its absolute sensitivity within the wavelength region of its spectral response, and the temperature of the target.

For example, the Vigo PD-10.6-series devices cover the region 1 to 11+ microns. A 300K body radiates ~35% of its energy in this band. The weighted average D* of the PD-10.6-3 in this region is $>4 \times 10^6$, so we can compute that the effective D* of the PD-10.6-3 against a 300K target is 35% of $>4 \times 10^6 \geq 1.4 \times 10^6$. This is the "300K blackbody D*" of the detector. The fraction of energy radiated by a 500K body that the PD-10.6-series will see is ~65%. For a 1000K body the fraction is ~93%. With these values we can make a table of 'black body D*' for the PD-10.6-3 as follows.

Target temp	Fraction of energy in spectral range of PD-10.6-series	Average D* of PD-10.6-3 in spectral range	Blackbody D* of PD-10.6-3
300K	35%	$>4 \times 10^6$	$>1.4 \times 10^6$
500K	65%		$>2.6 \times 10^6$
1000K	93%		$>3.7 \times 10^6$

Table 1.

This is an interesting result, since it is not intuitively obvious that in absolute terms this relatively long wavelength detector is better against hot targets than against room temperature targets. This result can easily be extended to other devices in the PD-10.6-3 series and to any other device with this spectral response such as the PDI-10.6, PDI-2TE-10.6, etc by simply substituting appropriate values of D* into the above table.

Pursuing this further, we have computed these figures for detectors with other cutoff wavelengths such as the PDI-n-series, PCI-n-series, and their TE-cooled variations. See **Table 2** following.

Table 1 clearly shows that as the target gets hotter the detector blackbody D* improves even for a detector seemingly matched to longer wavelengths. **Table 2** shows that, in the Vigo product line, the 6-micron cutoff devices are the most sensitive against real-world thermal targets. **Our recommendation is to use the PDI-2TE-6 for best system performance against targets at or above ambient temperature.**

For 300K body detection				
Detector Model	**Spectral Range**	**Fraction of energy in spectral range of this model**	**Average D* of this model in spectral range**	**300K Blackbody D* of this model**
	(microns)		($cm.Hz^{1/2}W^{-1}$)	
PDI-4	1.5 to 4	0.25%	>1.6 x 10^9	>4 x 10^6
PCI-M-4			>7 x 10^9	>1.7 x 10^7
PDI-2TE-4			>5 x 10^{10}	>1.7 x 10^8
PCI-2TE-4			>8 x 10^{10}	>2 x 10^8
PDI-5	1.5 to 5	1.4%	>6 x 10^8	>8 x 10^6
PCI-M-5			>3 x 10^9	>4 x 10^7
PDI-2TE-5			>3 x 10^{10}	>4 x 10^8
PCI-2TE-5			>3 x 10^{10}	>4 x 10^8
PDI-6	**1.5 to 6**	**4.3%**	>4 x 10^8	>1.7 x 10^7
PCI-M-6			>6 x 10^8	>2.5 x 10^7
PDI-2TE-6			**>1.3 x 10^{10}**	**>5 x 10^8**
PCI-2TE-6			**>1.3 x 10^{10}**	**>5 x 10^8**
PDI-8	1.5 to 8	15%	>2 x 10^8	>3 x 10^7
PDI-2TE-8			>1 x 10^9	>1.5 x 10^8
PCI-2TE-9	1.5 to 9	21%	>7 x 10^8	>1.4 x 10^8
PDI-10.6	1 to 11	35%	>4 x 10^7	>1.4 x 10^7
PDI-2TE-10.6			>2 x 10^8	>7 x 10^7
PD-10.6-3			>4 x 10^6	>1.4 x 10^6
PCI-2TE-12	1 to 13	42%	>1 x 10^8	>4 x 10^7

Table 2.

Additional Notes and Comments:

1. Atmospheric transmission effects usually can be ignored at target distances less than 100 meters.
2. 1/f 'flicker' noise in photoconductive versions of these devices will degrade sensitivity in many instances. Therefore, photovoltaic types will be generally preferred.
3. The D* usually quoted is 'spectral D*' "D^*_λ", whereas this discussion is about 'Black Body D*', "D^*_{BB}", and the calculations are primarily D^*_{300K}. For a more rigorous discussion see Optical Radiation Detectors by Dereniak & Crowe, Wiley & Sons, 1984.
4. Fractions of blackbody energy in the various wavelength bands were taken from a GE Radiation Calculator slide rule.
5. The military thermal imaging community thinks that the sensitivity of thermal imagers operating in the 3 to 5 and 8 to 12 micron regions are roughly equal. They are correct. The large difference between 6-micron and 11 or 12-micron cut off devices indicated above for Vigo devices derives from the fact that Vigo's best 6-micron devices are very nearly as sensitive as the best LN_2 cooled types the military community uses, while the room temperature long wavelength Vigo devices are as much as 10^4 less sensitive than military-quality LN_2 cooled types (though 10^4 times faster).

By Fred Perry Printed 8-Apr-02

Heterodyne NEP Calculations for Room Temp & TE-cooled HgCdTe Photodetectors

Consider the case when detector noise dominates. We assume that detector parameters do not depend on optical power up to the maximum allowable optical power densities. The optical signal at intermediate frequency due to optical power P and power of radiation of local oscillator P_{LO} is $V_{IF} = R_v (2PP_{Lo})^{1/2}$ where R_v- is the voltage responsivity of the detector. NEP is the optical power that generated the signal equal to noise voltage V_n

$$NEP = \frac{V_n^2}{2P_{LO}R_v^2}$$

but $D* = R_v \frac{\sqrt{A\Delta f}}{V_n}$ Therefore

$$NEP = \frac{A\Delta f}{2P_{LO}D*^2}$$

Note: Other system noise sources are likely to dominate, resulting in degraded Heterodyne NEP performance. Caution should be used in raising the LO power above 0.1 W/mm^2 in unimmersed detectors and above 0.01 W/mm^2 in immersed devices (detectors built on the plano face of hyperhemispherical micro lenses).

NEP per 1 Hz is equal to

$$NEP / \Delta f = \frac{A}{2P_{LO}D*^2} = \frac{1}{2\frac{P_{LO}}{A}D*^2}$$

$$NEP / \Delta f = \frac{1}{2p_{LO}D*^2}$$

p_{LO} is the power density of the Local Oscillator.

Therefore, the normalized NEP is directly related to the product of detectivity squared and optical power density. Increasing p_{LO} reduces NEP until D* is independent of p_{LO} or the decrease of $D*^2$ is lower than increase of p_{LO}.

Examples:
Calculated NEP as a function of D* and p_{LO}.

D*, cmHz$^{1/2}$/W	p_{LO}, W/mm^2	NEP/Δf, W/Hz
$1\cdot10^7$	0.1	$5\cdot10^{-16}$
$1\cdot10^7$	1	$5\cdot10^{-17}$
$1\cdot10^8$	0.1	$5\cdot10^{-18}$
$1\cdot10^8$	1	$5\cdot10^{-19}$
$1\cdot10^9$	0.01	$5\cdot10^{-19}$
$1\cdot10^9$	0.1	$5\cdot10^{-20}$

Some conclusions:

1. **Heterodyne NEP can be easily calculated for known D* and p_{LO}**
2. **Heterodyne NEP is dependent on detector size. The dependence is not strong however. Smaller devices make possible achievement of better NEP because of higher maximum p_{LO} due to 3D power dissipation**
3. **The use of optical hyper immersion increases D* by a factor of n^2. The increase of optical power density is by a factor of n^2. For the same optical area, optically immersed devices make it possible to obtain better NEP due to 3D power dissipation.**
4. **TE coolers greatly improve the performance of heterodyne devices due to increased D* and p_{LO}.**
5. **Heterodyne photodetectors should be optimized for high p_{LO}. Measures should be taken to prevent parasitic absorption of LO radiation under and around active area.**

Predicting the performance of a photodetector

by Fred Perry, Boston Electronics Corporation, 91 Boylston Street, Brookline, MA 02445 USA.
Comments and corrections and questions are welcome in order to insure the correctness, clarity and usefulness of this document. Phone (800)347-5445 or (617)566-3821; fax (617)731-0935; e-mail boselec@world.std.com

The performance of a photodetector system can be predicted from the parameters D* (detectivity), Responsivity, time constant and saturation level, and from some knowledge about the noise in the system. No photodetector should be purchased until a prediction has been made.

- Detectivity and NEP

The principal issue usually facing the system designer is whether the system will have sufficient sensitivity to detect the optical signal which is of interest. Detector manufacturers assist in making this determination by publishing the figure of merit "*D**". *D** is defined as follows:

$$D^* \equiv \frac{\sqrt{A \times \Delta f}}{NEP} \qquad \text{(equation 1)}$$

where A is the detector area in cm^2
Δf is the signal bandwidth in hertz
and NEP is an acronym for "Noise Equivalent Power", the optical input power to the detector that produces a signal-to-noise ratio of unity (S/N=1).

*D** is a "figure of merit" and is invaluable in comparing one device with another. The fact that S/N varies in proportion to $\sqrt{A}$ and $\sqrt{\Delta f}$ is a fundamental property of infrared photodetectors.

- Active Area

Consider a target about which we wish to measure some optical property. If the image of the target is larger than the photodetector, some energy from the target falls outside the area of the detector and is lost. By increasing the detector size we can intercept more energy. Assuming the energy density at the focal plane is constant in watts/cm^2, doubling the linear dimension of the detector means that the energy intercepted increases by $2^2 = 4$ times. But *NEP* increases only as $\sqrt{4} = 2$. Conversely, if the image of the target is small compared to the detector size, and if there are no pointing issues related to making the image of the target fall on the photodetector, then halving the linear dimension of the photodetector will similarly double S/N, since the input optical signal S stays constant while the NEP DECREASES by a factor of $\sqrt{4} = 2$. The moral of this story is: Neither throw away photons nor detector area. Know your system well enough to decide on an optimized active area.

- Bandwidth

Error theory tells us that signal increases in a linear fashion but noise (if it is random) adds 'RMS'. That is, Signal increases in proportion to the time we observe the phenomenon, but Noise according to the square root of the observation time. This means that if we observe for a microsecond and achieve signal-to-noise of β, in an integration time of 100 microseconds we can expect S/N of $\sqrt{100}\beta = 10\beta$. Bandwidth is related to integration time by the formula

$$\Delta f = \frac{1}{2\pi\tau} \qquad \text{(equation 2)}$$

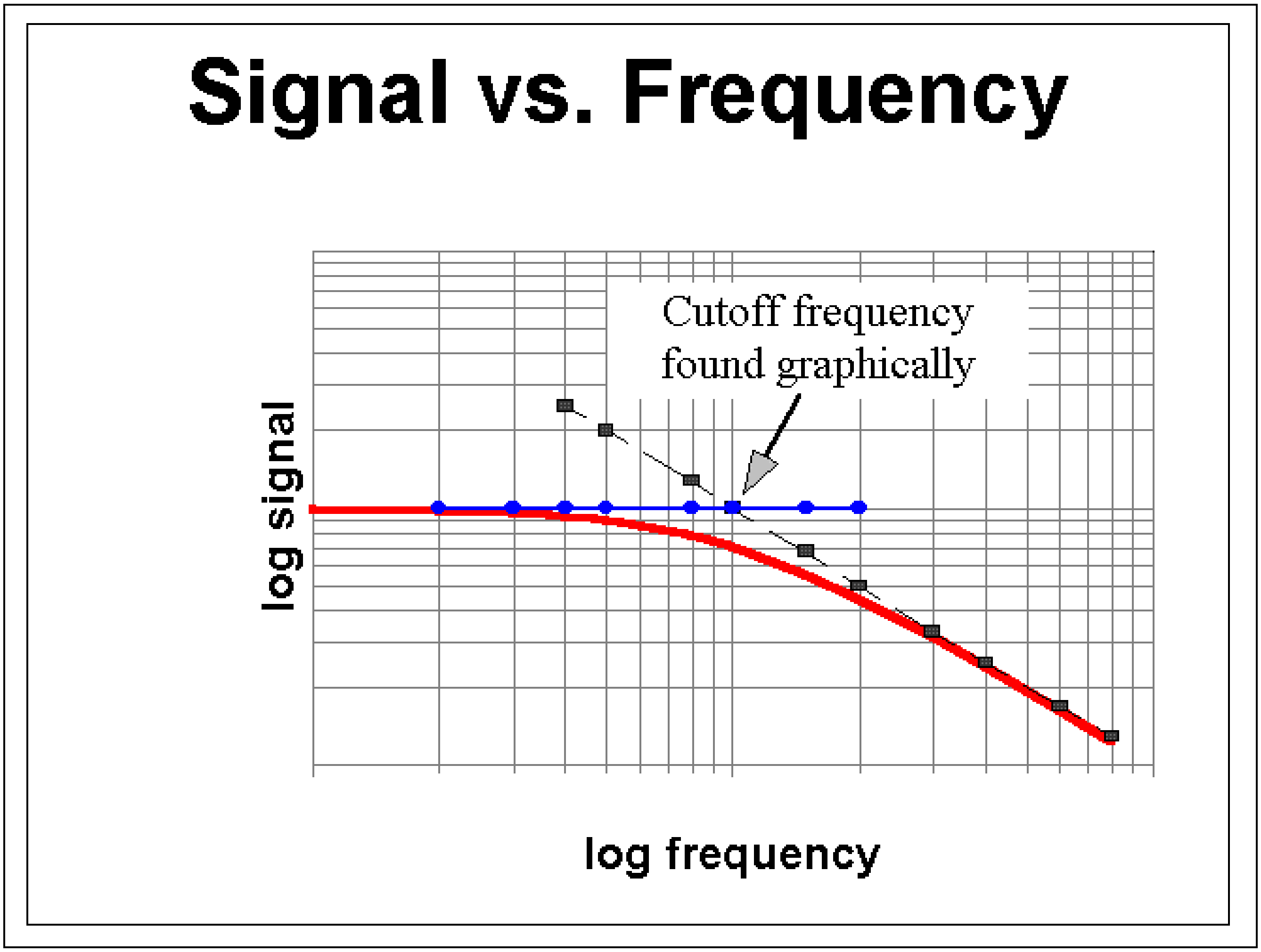
where τ is the integration time or "time constant" of the system in seconds. Time constant τ is the time it takes for the detector (or the system) output to reach a value of $\left(1 - \frac{1}{e}\right) \cong 63\%$ of its final, steady state value.

- Signal

Signal in all quantum photodetectors is constant versus frequency at low frequencies but begins to decline as the frequency increases. The decline is a function of the time constant. If S_{low} is the signal at f_{low}, a few hertz, the signal at arbitrary frequency f » f_{low} is

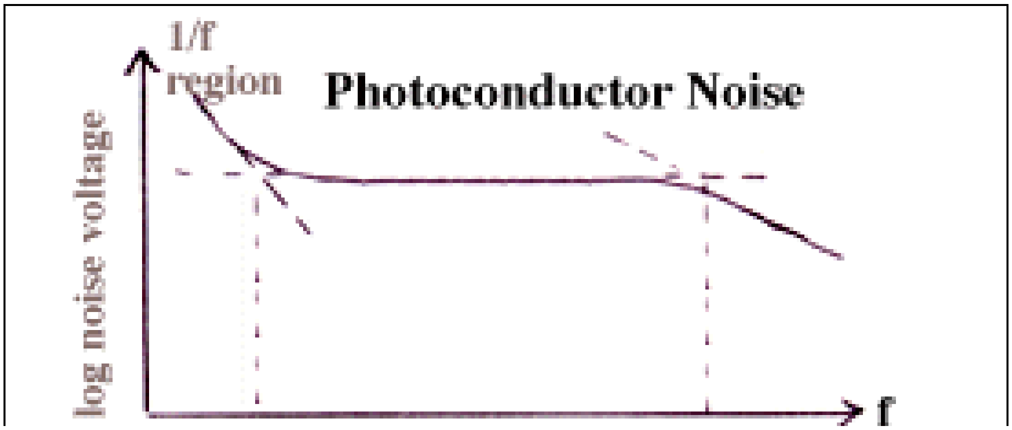
$$S_f = \frac{S_{low}}{\sqrt{1+(2\pi\tau)^2}} \qquad \text{(equation 3)}$$

This is graphically illustrated below. Frequency f_c is the point at which $S_f = \frac{1}{\sqrt{2}} S_{low}$.



- Noise

Noise is not as simple as signal. Photoconductive devices like PbS, PbSe, and most HgCdTe exhibit "flicker" or 1/f noise, which is excess noise at low frequencies. Consequently, Signal-to-Noise ratio and D^* are degraded at these frequencies. 1/f noise actually varies as $\sqrt{\frac{1}{f}}$ in voltage terms. At high frequencies, the detector noise actually decreases according to the same relationship as signal decreases. However, the difficulty in constructing following amplifier electronics that are significantly lower in noise than the photodetector results in system always having a noise at high frequencies that is no better than noise at low frequencies. The following set of graphs illustrates this.

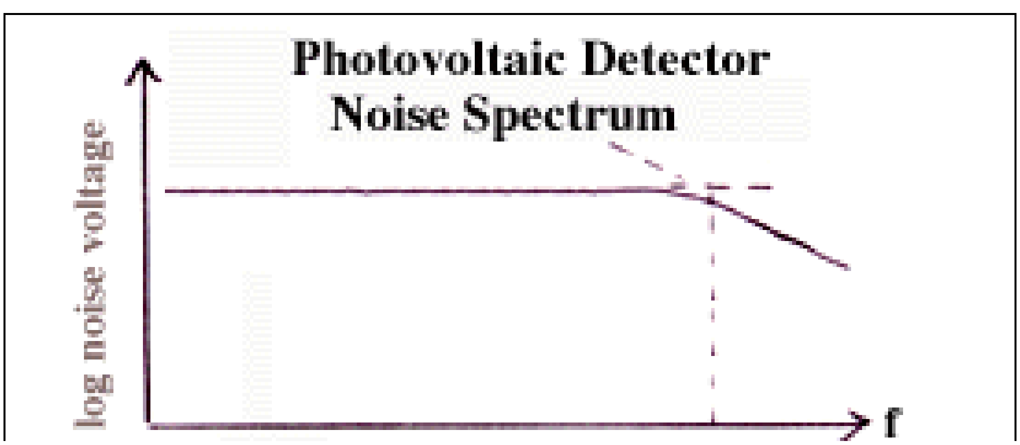


To predict low frequency performance of a photoconductor, the extent to which D^* is degraded by 1/f noise must be estimated. Either of the following ways is applicable:

1. use the manufacturer's published graphical data of D^* versus frequency to determine the multiplication factor N_{excess} to use to convert minimum guaranteed D^* at its measured frequency to D^* at the frequency of interest.
2. use the 1/f "corner frequency" $f_{corner} > f_{low}$ reported by the manufacturer to estimate the degradation factor at f_{low} as

excess noise factor $N_{excess} = \sqrt{\frac{f_{corner}}{f_{low}}}$ (equation 4)

In contrast to photoconductors, photovoltaic detectors normally have no 1/f noise. Signal is flat to or near DC and therefore D^* is constant below the high frequency roll-off region, so no low frequency correction need be made.



- Spectral response correction

The *D** of a quantum detector varies with wavelength λ. The detector manufacturer typically guarantees *D** at the wavelength of peak response, *D*(peak)*. When using the device at another wavelength λ, the *D** should be corrected by an appropriate factor:

$$R_\lambda = \frac{(response - at - \lambda)}{(response - at - peak)}$$

$$D_\lambda^* = D_{peak}^* \times R_\lambda \qquad \text{(equation 5)}$$

where the relative response at wavelength λ is estimated by inspection of spectral response curves or other data supplied by the manufacturer.

Therefore, the optical input power required to produce a signal-to-noise ration of 1:1 for a stated system response time and wavelength becomes:

Case 1: Photoconductor at low frequency:

$$NEP_\lambda = \frac{\sqrt{A \times \Delta f}}{D_\lambda^*} \times N_{excess} \qquad \text{(equation 6)}$$

Case 2: Photovoltaic detector at low to moderate frequency:

$$NEP_\lambda = \frac{\sqrt{A \times \Delta f}}{D_\lambda^*} \qquad \text{(equation 7)}$$

Case 3: Photoconductor or photovoltaic frequency at higher frequency:

$$NEP_\lambda = \frac{\sqrt{A \times \Delta f}}{S_f \times D_\lambda^*} \qquad \text{(equation 8)}$$

This yields an estimate of the input optical power to achieve a voltage output with S/N=1.

- Upper Limits

Another important question is the dynamic range of the system, e.g. the ratio of the maximum signal available to the *NEP* of the system. The upper limit of the system is typically set by the electrical gain of the preamp or the vertical gain of the oscilloscope used to display the signal, combined with the maximum output signal of the preamp or the maximum vertical deflection of the oscilloscope. The dynamic range of the system is then expressed in multiples of the system *NEP*.

Let the preamp gain be G. Let the responsivity of the detector in volts per watt (or volts per division in the case of an oscilloscope) at low frequency be R_{low} and at frequency f let it be R_f where

$$R_f = R_{low} \times S_f \qquad \text{(equation 10)}$$

The voltage signal from the detector into the preamp or oscilloscope when S/N=1 corresponding to this responsivity will be

$$V_f = NEP \times R_f \qquad \text{(equation 11)}$$

Then the output of the preamp at frequency f and S/N=1 will be

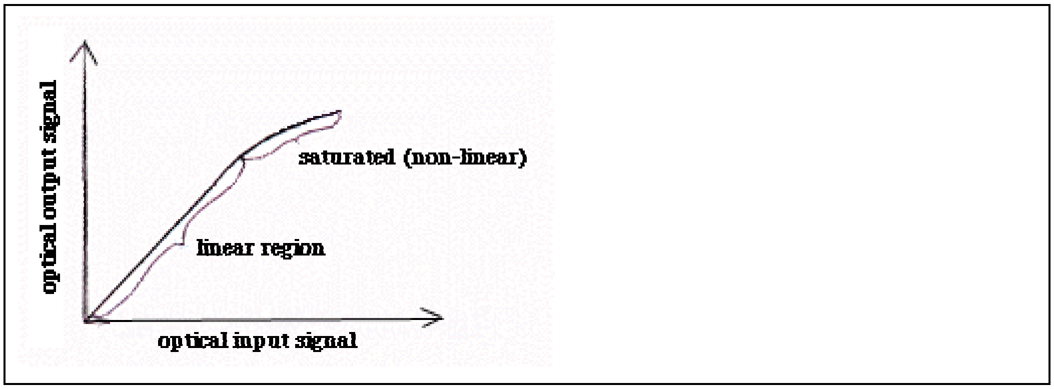
$$V_{preamp} = V_f \times G \qquad \text{(equation 12)}$$

Let the maximum output of the system be Ψ_{preamp} volts (or Ψ_{vertical} vertical divisions in the case of an oscilloscope). The multiple of the NEP that corresponds to the maximum output Ψ_{preamp} will therefore be

Preamp Dynamic Range $$D = \frac{\Psi_{preamp}}{V_f \times G} \qquad \text{(equation 13)}$$

Of course, with an oscilloscope it is usually possible to turn down the gain and thus increase the dynamic range. However, preamps usually have fixed gain. In that case the input optical must be attenuated in order to keep the output from the preamp from saturating.

Sometimes the photodetector itself will saturate before the preamp. Some process, thermal or photonic, intrinsic to the photodetector may limit it's output. In this case, the maximum available (saturation) output signal should be specified by the device manufacturer, typically as a not-to-exceed output voltage $\Psi_{detector}$.. Graphically the situation is illuatrated as follows:



Case 1: Dynamic Range limited by the preamp

$$D = \frac{\Psi_{preamp}}{V_f \times G} < \frac{\Psi_{\det ector}}{V_f} \qquad \text{(equation 14)}$$

Case 2: Dynamic Range limited by the detector

$$D = \frac{\Psi_{\det ector}}{V_f} < \frac{\Psi_{preamp}}{V_f \times G} \qquad \text{(equation 15)}$$

This completes our prediction of system performance. We have calculated the input optical signal that corresponds to S/N=1, and the maximum output that can be extracted from the system in terms of a multiplier of the minimum input signal. The multiplier is “dynamic range”.

- System options

The designer has the following additional degrees of freedom in designing his system:

1. He may increase the size of his optics in order to deliver more optical energy to the photodetector. The key concept to remember is that throughput in any optical system, defined as $T = A \times \Omega$, where A is area in cm^2 and Ω is solid angle field of view in steradians, is a constant in the system. If A_D is detector area and Ω_D is

detector FOV, then collector area A_C and collector FOV Ω_C are at best satisfy $A_C \times \Omega_C = T = A_D \times \Omega_D$. Increasing the collector aperture decreases the FOV.

2. He may increase the efficiency of his optics (transmittance and reflectance optimization, etc).

3. He may increase the power of his source in a cooperative, active system (though not in a passive one).

4. He may increase the time he observes the signal, that is decrease the bandwidth and increase the time constant.

==

Appendix 1: Sample Calculations

Appendix 2: D* versus wavelength and frequency for some photodetectors.

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11/21/2001 12:11

PD-10.6-3	Responsivity	D*(10.6 um)
	30	3E+06
	mV/W	cm.Hz1/2/watt

Assume saturation for CW signal is *10* *mV*

Assume saturation for fast pulse is *600* *mv*

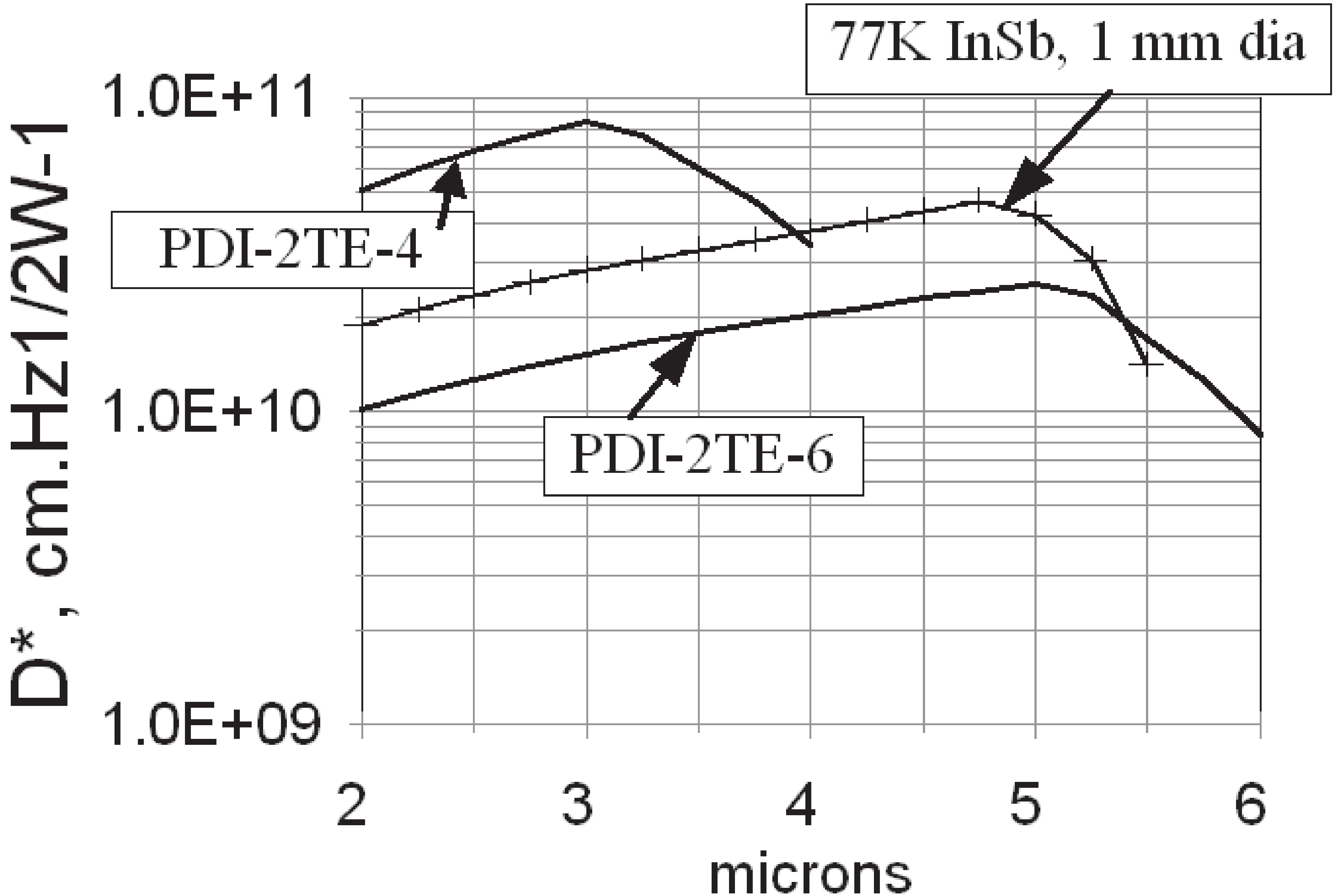
Amplifier 481-1 to 481-20 saturates at...........	**volts** 5
Amplifier 481-50 to 481-200 saturates at	**1**
493A saturates at.............	**4**

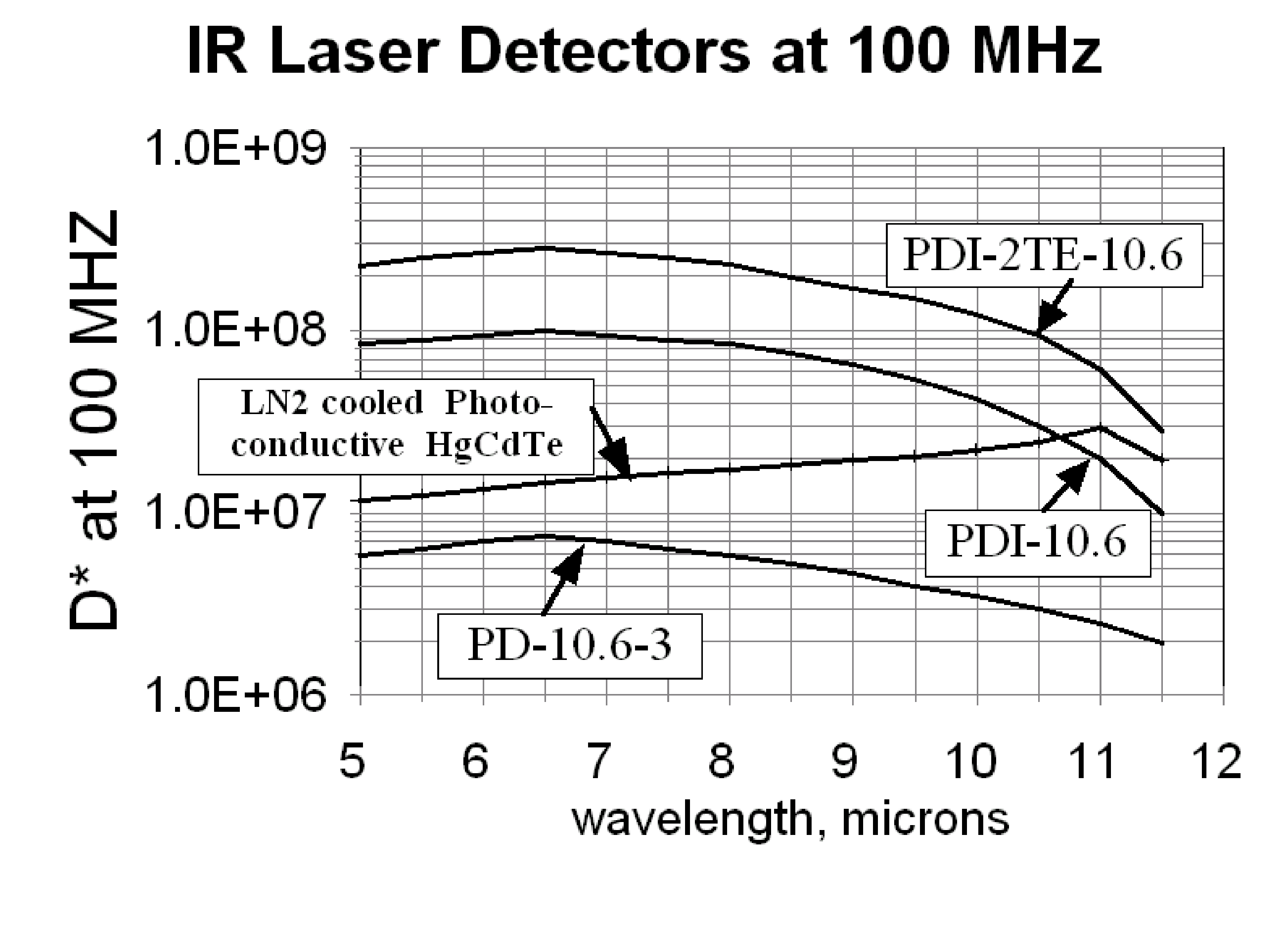
System Elements	**Time Constant (nsec)**	**3dB Frequency (MHz)**	**Gain**	**System Responsivity (V/W)**	**Optical signal for S/N=1 (microwatts)**	**Electrical signal for S/N=1 (millivolts)**	***CW case*** **S/N at Detector Saturation**	***Pulsed case*** **S/N at Detector Saturation**	**S/N at Preamp Saturation**
PD-10.6-3 unamplified	0.2	800	1	0.03	943	0.03	354	21213	xxxxx
PD-10.6-3 with 493A/40	0.3	500	100	3	745	2.24	447	26833	1789
PD-10.6-3 with 493A	0.3	500	10	0.3	745	0.22	447	26833	17889
PD-10.6-3 with 481-200	0.8	200	20	0.6	471	0.28	707	42426	3536
PD-10.6-3 with 481-100	1.5	100	40	1.2	333	0.40	1000	60000	2500
PD-10.6-3 with 481-50	3	50	80	2.4	236	0.57	1414	84853	8839
PD-10.6-3 with 481-20	8	20	100	3	149	0.45	2236	134164	11180
PD-10.6-3 with 481-10	15	10	200	6	105	0.63	3162	189737	7906
PD-10.6-3 with 481-5	30	5	400	12	75	0.89	4472	268328	5590
PD-10.6-3 with 481-1	150	1	2000	60	33	2.00	10000	600000	2500
PD-10.6-3 with 481-0.1	1500	0.1	2000	60	11	0.63	31623	xxxxx	7906
PD-10.6-3 with 481-0.01	15000	0.01	2000	60	3	0.20	100000	xxxxx	25000
	Time constant τ and 3dB frequency are related by f=1/(2πτ)		from product lit and typical detector resistance	detector responsivity times gain	Square root of the detector area times square root of the 3dB frequency divided by the D* from product lit	Optical signal at S/N=1 times System Responsivity	Saturation level for CW signal divided by Optical signal at S/N=1	Saturation level for Pulsed signal divided by Optical signal at S/N=1	Clipping level for preamp divided by electrical signal for S/N=1

Shading indicates Saturation of detector or preamp for CW case

TE-cooled MCT vs. 77K InSb at 10 MHz

Photovoltaic HgCdZnTe




IR Laser Detectors at 100 MHz
D* at 100 MHZ
1.0E+09
1.0E+08
1.0E+07
1.0E+06
5
6
7
8
9
10
11
12
wavelength, microns
PDI-2TE-10.6
LN2 cooled Photo-
conductive HgCdTe
PDI-10.6
PD-10.6-3

Boston Electronics Corporation

91 Boylston Street, Brookline, Massachusetts 02445 USA
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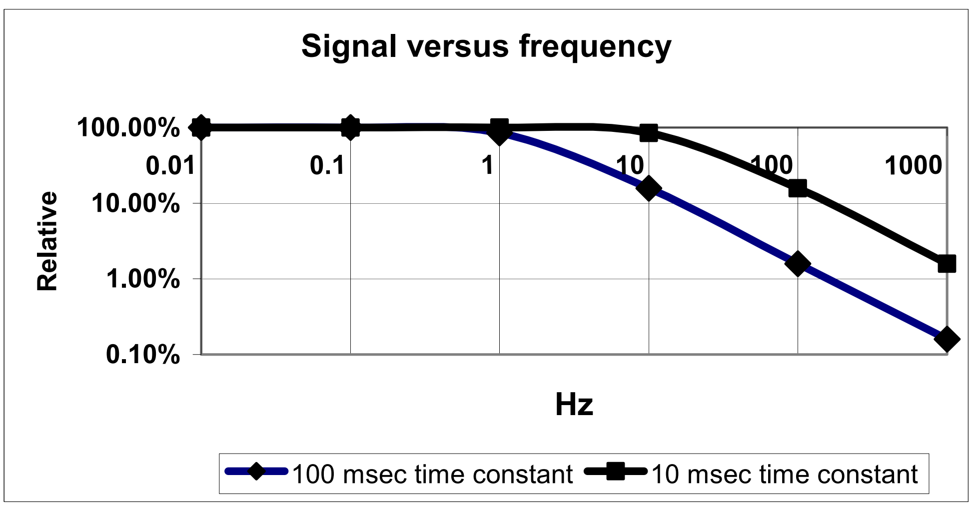
Thermopiles from Boston Electronics:
Slow but stable, sensitive and low cost.

Thermopiles are heat-sensing detectors, like bolometers and pyroelectrics. However, thermopiles are voltage generators so they require no external bias circuit, and thermopiles have a very small coefficient of change of Responsivity versus temperature (typically –0.36%/C for thin film thermopiles and –0.01% for silicon based thermopiles) so they are a good choice when ambient temperature is varying. Unlike pyroelectrics, thermopiles are useful down to DC. On the down side, thermopiles are slow in response time. Ours vary from 7 to 85 milliseconds time constant. Frequency response at the –3dB (-50% from peak) is in the range of 2 to 23 Hz. The graph below illustrates the range of signal versus frequency to be expected.



Since thermopiles are good to DC and have no excess low frequency noise (1/f noise), they find use in many applications where response times greater than a few Hz is not required. These include non-contact thermometry, flame sensing and gas concentration sensing. The spectral response is essentially flat from UV to Far IR, limited only by the spectral transmitance of the window or filter. Most thermopiles for dedicated applications are supplied with optical band-pass filters chosen by the customer with our assistance according to the “magic” wavelength corresponding to the task at hand. Many filters are in stock and available for your application. Inquire please. Thermally compensated models provide additional resistance to instantaneous changes in ambient temperature. Optional apertures are available to precisely define active area and/or field of view.

These thermopiles are manufactured by Dexter Research Center Inc, for whom Boston Electronics is an authorized distributor.

2/9/2002 18:05

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91 Boylston Street, Brookline MA 02445 USA

Thermopiles

Model	Active Area, mm x mm	Responsivity, V/W, min	D* (DC) cm.hz$^{1/2}$w^{-1}	Time constant msec	Frequency response (-3dB), Hz	Package	Price 1-9 with standard window (note 1)
M14	.92 x .4	>12.4	>.92x10^{8}	14	11	TO-18	PLEASE INQUIRE
M5	0.5 mm dia	>34	>1.9x10^{8}	28	6	TO-5	
1M	1 mm dia	>19.3	>2.1x10^{8}	32	5	TO-5	
2M	2 x 2	>15.2	>1.9x10^{8}	85	2	TO-5	
2MC Au	2 x 2	>8.3	>1.3x10^{8}	40	4	TO-5	
2MC Sb	2 x 2	>12.1	>1.6x10^{8}	58	3	TO-5	
3M	3 x 3	>13.5	>1.8x10^{8}	50	3	TO-8	
6M	6 mm dia	>3.2	>.7x10^{8}	60	3	HC-40	
1SC	1 x 1	>12.1	>.8x10^{8}	48	3	TO-5	
DR26	dual 2 x .6	> 11.4	>1.2x10^{8}	38	4	TO-5	
DR34	dual 3.16x.4	>21.6	>1.7x10^{8}	38	4	TO-5	
T34	three 3.16x.4	>21.6	>1.7x10^{8}	38	4	TO-8	
DR46	4 x .6	>21.5	>2.1x10^{8}	40	4	TO-8	
2M Quad	four 2 x 2	>15.2	>1.9x10^{8}	85	2	TO-8	
10 channel	ten 3.16 x .4	>21.6	>1.7x10^{8}	38	4	TO-8	
S25	.25 x .25	>169.7	>2x10^{8}	12	13	TO-5 or TO-18	
S60M	.6 x .6	>75.8	>1.1x10^{8}	12	13	TO-5 or TO-18	
S707	.07x.075	>115.4	>.8x10^{8}	12	13	TO-5 or TO-18	
ST60R	.67 x .67	>42.1	>.81x10^{8}	18	9	TO-5 or TO-18	
ST60R-dual	dual .67 x .67	>42.1	>.81x10^{8}	18	9	TO-5 or TO-18	
ST60R-quad	quad .67 x .67	>42.1	>.81x10^{8}	18	9	TO-5 or TO-18	
ST-150	1.5 x 1.5	>22.2	>1.0x10^{8}	32	5	TO-5	
SLA32	32 element .05 x .65, staggered	>93.2	>.42x10^{8}	7	23	0.97x1.27" DIP	
Preamp model 1010		Gain 1000 (60 dB)		low noise	DC to > 1000 Hz		

Options:

(A) Windows: TO-5 - Uncoated Si: $5.00; AR Si: $10.00; LWP 8-14 on Si (3%), $5.00; LWP 8-14 on Si (1%) $8.00; Uncoated Ge, $6.00; LWP 6.6 on Ge, $15.00; AR Ge, $25.00, LWP 8-14 on Ge, $12.00; uncoated CaF_2, $12.00; uncoated KRS-5, $30.00; UV Quartz, $8.00; uncoated ZnSe, $20.00; Diffractive lens (A2DIF01), $28.00. TO-8 packages - uncoated CaF2, $35.00. DIP - Quartz, $75.00; KRS-5, AR Ge, LWP 6.5 on Si all $100.00.

(B) Thermistors: 20kΩ 10% bead external on header near pins $21.00; 20 kΩ 5% bead external on header near pins $26.00; 30 kΩ 5% chip for ST60 or ST150 $10.00; 30 kΩ 5% chip for 10 channel; two 30 kΩ 5% chips for SLA32, $25.00.

(D) Apertures: diameters 0.5, 0.75, 1.0, 1.5 & 2.0 for single elements, $2.00

(E) Calibration: 500K blackbody, $10.00

Specs and prices subject to change without notice.

Notes:

(1) Standard windows: sapphire, KBr or 6.5 μm LWP filter on Si

(2) Flat response, UV-Far IR

(3) Operating temp range: -50 to + 85 C. Higher on request.

(4) FOV: >60 degrees. Greater available.

(5) Optional filters/windows: many in stock, inquire.

(6) Most devices have N_2 gas backfill; Ar, Xe and Ne also available. Inquire.

Prices are in US$ FOB Brookline MA. We accept VISA, MasterCard and American Express credit cards. We will ship on 30 day payment terms subject to credit approval by us.

Preamps: achieve detector-noise-limited performance

Preamps: achieve detector-noise-limited performance

DC-Coupled Preamps for **Photovoltaic** HgCdZnTe Detectors

Model	481-1	481-5	481-10	481-20	481-50	481-100	481-200	477AG gain stage	491 Video Line Driver
Gain [R_D is detector resistance]	100 K/ R_D	24 K/ R_D	10 K/ R_D	5 K/ R_D	4 K/ R_D	2 K/ R_D	1 K/ R_D	Variable X5 to 200	X2
Transimpedance Factor (V_{out}/I_{in})	100K	24 K	10 K	5 K	4 K	2 K	1 K	Input 10K	--
Bandwidth (DC to…)	1 MHz	5 MHz	10 MHz	20 MHz	50 MHz	100 MHz	200 MHz	10^+ MHz	100 MHz
Output (volts, max, p-p)	5				1			5	4
Noise (n V/Hz1/2)	1.0				1.8				--
Input (Volts @ milliAmps quiescent)	+/-12 to 15 @ 18				+/-6 @ 25			+/- 5 to +/- 12 @ 20	
Size (inches)	2 x 2 x 1								1.1 x 0.9 x 2.3
Price	$795							$795	$595

AC-Coupled Preamps for **Photovoltaic or Photoconductive** HgCdZnTe Detectors

Model	050/50	060/40	070/40	080/34	480	490	493A	493A/40	477AG gain stage	491 Video Line Driver
Gain	50 dB	40 dB	40 dB	34 dB	32 dB	26 dB	20 dB	40 dB	Variable, X5 to 200	X2
Bandwidth from:	10 Hz				1KHz				-	--
To:	1 MHz	3MHz	10 MHz	20 MHz	50 MHz	100 MHz	500+ MHz	500 MHz	10^+ MHz	100 MHz
Output (volts, max, p-p)	4				3		5		5	5
Noise figure	1dB nominal				2.8 dB nominal		50 µV RMS, wideband		--	
Input (Volts @ milliAmps quiescent)	-12 @ 10 to 20				+/-12 to 15 @ 40		+6 to 8 @ 30		+/-5 to +/-12 @ 20	
Size (inches)	2 x 2 x 1									1.1 x 0.9 x 2.3
Price	$795						$895		$795	$595

Notes:

1. We can tailor preamp bandwidth to customer requirements.
2. All units have BNC Connectors on Input and Output.
3. Output impedance is 50 ohms for all except model 491 which may be 2 ohm or 75 ohm output instead of 50 ohm on special order.
4. Cable from detector to amplifier should be less than 3 feet.
5. Use model 477AG gain stage on amp output if extra output voltage needed.
6. Use the model 491 line driver when output cable is longer than 6 feet.
7. Operating temperature range -55 to +85 C
8. Prices current as of 30 November 2002. Specifications & prices subject to change without notice.